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ANALYSIS OF VEGETATION COVER DYNAMICS AND ITS IMPLICATION ON HERBIVORES SPECIES OF PANDAM WILDLIFE PARK IN NORTH-CENTRAL NIGERIA USING REMOTE SENSING AND GIS

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ABSTRACT: *Assessment of Land use/ Land cover dynamics is critical for conservation, sustainable use and development of natural resources in protected areas. In the present study Pandam Wildlife Park (PWP) has been considered for the evaluation of land use/land cover changes and the effect these could have on herbivores. Normalized Difference Vegetation Index (NDVI), an indicator of vegetation growth and coverage, has been employed to describe the spatiotemporal characteristics of land use/ land cover, including percent vegetation coverage using multi spectral remote sensing. The Land use/Land cover (LULC) classification was done based on four classes and Normalized Difference Vegetation Index (NDVI) using LANDSAT datasets of TM, ETM+ and OLI satellite imageries between 1987 and 2017 using maximum likelihood classification scheme. The result of the LULC assessment based on NDVI for PWP between 1987 and 2017 reveals that riparian habitat has been decreased drastically by 33.29 sq km and swampy area has been increased by 156.75 sq km between 1987 to 2017. Changes were noted in the aerial extents of water bodies as well. There were clear and consistent trends of land cover changes with superiority of area coverage of vegetated land completely lost over the decade. This caused a reduction in forage resources and decline in population of herbivores in the park. Thus, riparian vegetation has been on the decreasing trend whereas other land covers features especially swampy areas are on the increase as affirmed by various LULC maps affirmed to this change. There is the need to prevent logging, fuel-wood collection/charcoal production and bush burning in PWP to make forage sufficiently available for herbivores. Regular follow up to this study would provide a guideline on securing habitats and forage for PWP's fauna.*

KEYWORDS*:* GIS, Land Cover, Land Use NDVI, Herbivores

INTRODUCTION

Vegetation is formed by forage species growing as a result of long development processes consistent with the areas they inhabit and this constitutes a fundamental part of ecosystems (FGDC, 2005). Thus, vegetation is a product of plants and the combined effects of various environmental factors such as the physical environment, landforms, soils, climate and other factors (e.g. fire) on the sets of species inhabiting a determined space and period (Velázquez *et al*., 2010). Vegetation cover represents a complex assemblage of plant communities which vary considerably both in space and time. It makes up the habitat of wild animals, provides food, cover, space and other requirements for the species especially the herbivores (grazers and browsers) which depend directly on forage materials as the key resource for their survival and productivity (Dalle *et al*., 2014).

Generally, Herbivores are animals adapted to feed specifically on plant materials and are key components of the rangeland dynamics (Arild, 2002). West African savannas featured two distinct major groups of vertebrate herbivores, which are grazers that feed primary on grasses and forbs and browsers which feed primary on woody vegetation (Holdo *et al*., 2009). Proper management and the spatial distribution of range vegetation cover plays important roles for climate stability, ecosystem process, species diversity and human livelihoods within the savanna biome (Fuhlendorf and Engle, 2001; Brennan and Kuvlesky Jr, 2005; Bolger *et al*., 2008). However, range landscapes affect the distribution of herbivorous species and in turn, herbivores are crucial for rangeland ecosystem function and regeneration (Miriam, 2014). In spite of their ecosystem service value, habitat degradation due to fragmentation is extremely severe as a result of increased land use (agricultural expansion), logging, fuel wood collection and population growth (Green *et al*., 2005; Manu *et al.,* 2007; Uloko and Yager, 2017).

The Unique interdependence of forage resources and herbivores made rangelands among the most diverse ecosystems in the world (Alkemade *et al.,* 2013). The fast pace of changes on rangelands and the severe consequences of these changes emphasize the need to measure these changes on range vegetation and to better understand, predict, and possibly prevent these changes. It is important to monitor these landscapes timely and in an efficient manner. The monitoring process has to do with periodic assessment of the range resources mainly the vegetation cover, water body, soil and fauna diversity (ESGPIP, 2009). During the monitoring process, both negative and positive changes in the vegetation composition and consequently the general land conditions can be assessed. Remote sensing/ GIS have been viable tools for measuring such changes (Miriam, 2014).

Remote sensing is the art and science of obtaining information about an object without being in a direct physical contact with the object (Jensen, 2007). While a geographical information system (GIS) is a computerized system that combines spatial and descriptive data for mapping and analysis. One of the main strengths of a GIS is its ability to integrate different types of spatial data (Brooker *et al*., 2002). The concept remote sensing and GIS although evolved into separate specialist fields and software technologies. They are however, linked together in play of functions for example, data from satellite sensors provide unique input into a GIS system (Harris, *et al*., 2002). These tools provide basic datasets, quantitatively and spatial information for analysis and interpretation of land cover changes (Lambin *et al.,* 2003). Understanding the current condition and trend of vegetation composition and structure using GIS and remote sensing approaches is paramount to both range ecology and management policies. Change detection is also vital for management and conservation of protected areas like Pandam Wildlife Park (PWP) as this provide information on change dynamics of vegetation cover as it affects fauna species that exist in these protected areas. The aim of the present research is was to analyze the vegetation cover dynamic and its consequences on herbivorous species in PWP.

MATERIALS AND METHOD

Study Site

Pandam wildlife park (PWP) situated in Qu'apam Local Government Area of Plateau state, Nigeria, between latitudes 8^o 35^1 N and 8^o 55^1 N, and longitudes 8^o 00^1 E and 10^o 00^1 E

(Akosim *et al*. 2007), within the Northern Guinea Savanna (Plate 1), was established in 1972. It is bounded on the East by Namu and Kayarda towns, on the West and North, by the Dep River and on the South by Aningo, Pandam and Nasukuuk towns. The park covers a total area of 327.54sq.km. The terrain slopes gradually southwards and forms a basin, the pandam Y- shaped lake, a wetland complex of approximately 2km^2 (Audu and Shola, 2016). Major vegetation types of the Park include wooded Guinea Savannah comprising *Afzelia africana, Vitellaria paradoxum* and *Parkia biglobosa*. A riparian vegetation mostly observed along the many smaller rivers that form tributaries to the lake and all along the banks of the Pandam lake with the presence of *Elais guinensis, Berlina grandiflora* and *Bosqueia angolensise*. Marshlands form an open continuous wetland separating the lake and the Savannah vegetation. The two major features of the climate of the Park are divided into wet and dry seasons and the variability from year to year due to climate change. The wet season extends from April to October, while the dry season extends from November to March and annual rainfall in the Park is between 1,000 – 1,500 mm per annum (Ezealor, 2002).

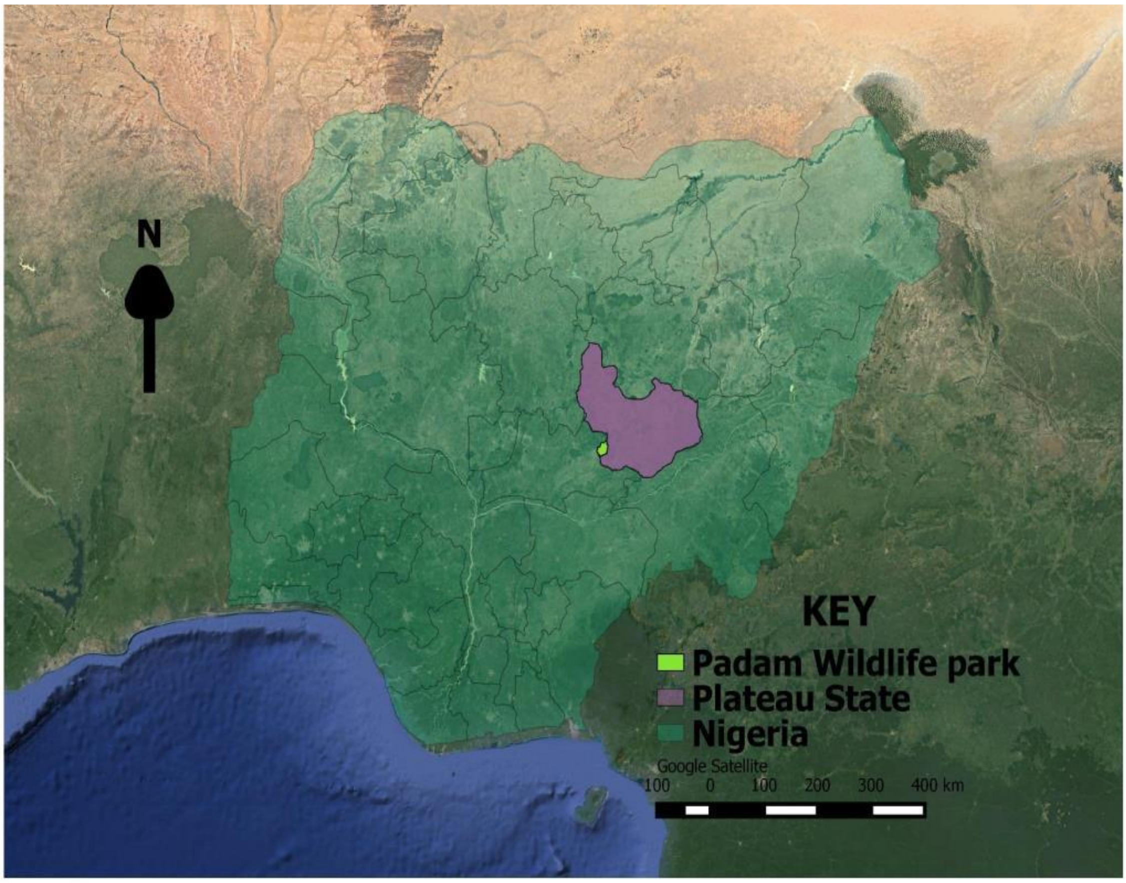

Plate. 1: Satellite image of Nigeria showing the location of Plateau state and the study site - Pandam Wildlife Park.

Source: Adapted from Samson, 2016

Data Collection Procedure

Two types of data were used in this research. Satellite data that comprised of three years multi- temporal satellite imageries (LANDSAT Thematic Mapper (TM) of 1987, Enhanced Thematic Mapper (ETM+) of 2007, and Operational Land Imager (OLI) of 2017 was used (Table 1). Ancillary data included the ground truth data for the LU/LC classes. The ground truth data was in the form of reference points collected using Geographical Positioning System (GPS) for the 2017 image analysis, used for image classification.

Table 1. Details of Satellite Data Used

S/N	Sensor	Path / Row	Source	Year of Acquisition	Scale/resolution
1	LANDSAT TM	188/054	GLCF	1987	30
2	ETM+	188/054	GLOVIS	2007	30
3	OLI	188/054	GLOVIS	2017	30

Source: Author's Analysis, 2018

Image Pre-processing and Classification

Pre-processing of satellite images before detection of changes is a very vital procedure and has a unique aim of building a more direct association between the biophysical phenomena on the ground and the acquired data (Coppin *et al*., 2004).

Image classification was done in order to assign different spectral signatures from the LANDSAT datasets to different LULC. This was done on the basis of reflectance characteristics of the different LULC types. Different color composites were used to improve visualization of different objects on the imagery. Infrared color composite NIR (4), SWIR (5) and Red (3) was applied in the identification of varied levels of vegetation growth and in separating different shades of vegetation. Other color composites such as Short Wave Infra-red (7), Near Infra-red (4) and Red (2) combination which are sensitive to variations in moisture content were applied in identifying the other land cover features. This was supplemented by a number of field visits that made it possible to establish the main land use/ land cover types. For each of the predetermined LULC type, training samples were selected by delineating polygons around representative sites. Spectral signatures for the respective LULC types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A satisfactory spectral signature the one Maximum Likelihood classifier (MAXLIKE) scheme with decision rule was used for supervised classification by taking 89 training sites for seven major LULC classes. The number of training sites varied from one LULC class to another depending on ease of identification and the level of variability. The Maximum Likelihood Classification is the most widely used per-pixel method by taking into account spectral information of land cover classes (Qian *et al*., 2007). The delineated LULC classes were; Riparian forest areas, Savannah woodland, swampy areas and water bodies.

Image Clip

The satellite image contains a very wide area. But in practical application, most of the areas in the satellite image are not necessary for the research. For the economy of time and storage space, the study area was extracted from the large satellite image. This step was realized in ArcGIS 10.3 and exported as tif to Idrisi Terrset software using polygon subset (Leica, 2012). Polygon subset was performed by setting up a polygon to clip the image.

Image Enhancement

The major purpose of image enhancement is not to maintain the fidelity of image. It turns out that image enhancement is employed to improve the visual interpretation of image, and the major purposes of it is to enhance the image definition and image contrast, and emphasize the necessary information in the image. There are two methods of image enhancement which are histogram equalization used as the main method for enhancing the images in this study and general contrast used to enhance one image in this study.

A histogram of an image shows the number of pixels with the various levels of brightness of this image, the x-axis shows all the possible pixel values which are 0-255 and the y-axis shows the amount of pixel values. The ideal condition of image is that the distribution of histogram is normal distribution. If histogram's peak value is located on the left side of brightness axial, the whole image will look dark. Histogram equalization is a convenient and common way of histogram normalization technique to enhance the image when the users want to compare two or more images on specific basis (Åhlen, 2009).

Every pixel in an image has a range of brightness from 0 to 255. Moreover, the range of peak value is excessively steep and narrow which means the brightness density of image is centralized. The above phenomena show that the contrast gradient of the image was small, the quality of image is substandard, therefore the intensification of image and change of the contrast gradient were necessary. Through the processes of choosing the band combination and enhancing the images, people can get better, clearer and more accurate understanding of terrain features during digital image processing. Meanwhile, it can further help the image classification work and improve the accuracy of classification. In addition, another image enhancement named general contrast with gamma method was used in this study. Gamma function is one method of the general contrast in Idrisi Terrset. This function can manipulate the brightness, contrast and color of the image to enhance the representation of image.

Data Analysis

Data were preprocessed using ArcGIS and Idrisi Terrset imagery for geo-referencing and sub-setting of the image on the basis of Area of Interest (AOI). The main objective of image classification was to place all pixels in an image into LU/LC classes in order to draw out useful thematic information. (Boakye *et al*., 2008).

Normalized difference Vegetation Index (NDVI). The NDVI is the most common index used in the analysis of vegetation by using satellite image data (Bakr, *et al*., 2010). It is widely used to detect the changes of the vegetation and the non-vegetation because only the red channel and near-infrared (NIR) channel of the electromagnetic spectrum are necessary to apply the NDVI performance (García-Aguirre, 2005). Furthermore, using NDVI in pixel-by-pixel classification can improve the result from classification. The absorptivity's for different wavelength of different kinds of vegetation are distinguished; the NIR light is almost reflected on the one hand, the visible light is almost absorbed by the vegetation on the other hand:

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

Where: NDVI = Normalized Difference Vegetation Index

NIR = Near-Infrared reflectance value (spectral band 0.76 – 0.9ɥm)

RED = Visible Red reflectance value (spectral band 0.6 – 0.7ɥm)

Where NIR is reflectance in the near-infrared band and RED is reflectance in the visible red band. The NDVI algorithm takes advantage of the fact that green vegetation reflects less visible light and more NIR, while sparse or less green vegetation reflects a greater portion of the visible and less near-IR.

RESULTS

This part represents the results produced from change detection in the study area. The change detection was used to monitor the changes which have occurred over space and time in the study area. The classified maps of Pandam Wildlife Park were used to extract the dynamic changes of land use and land cover from 1987 to 2007 and from 2007 to 2017.

Analysis of Land Use/Land Cover Classification of 1987 Satellite Imagery

The result of land use/ land cover map of Pandam in 1987 (Fig. 1), showed that riparian forest stratum was the most dominant area of land cover of 177.37sq. km representing (54.17%) of the total area in (1987). This was found almost everywhere on the area but concentrated more at the centre and spread towards the south east, south south and south western section of the area. This was followed by savanna woodland which covers 57.70Km^2 representing 17.62%. This land cover features can be found at the northern section of the map as well as scattered everywhere on the study area. While swampy area covers 66.68Km^2 representing 20.36% found mainly around the water body and spread around the wildlife park, and the water body covers 25.70Km^2 representing 7.85% of the area. This was found at river li and the lake within the park dam. The total land area of Pandam was 327.54sq km. The difference in the total area as obtained by other researchers in the area was due to boundary from the google earth, therefore there is bound to be variation.

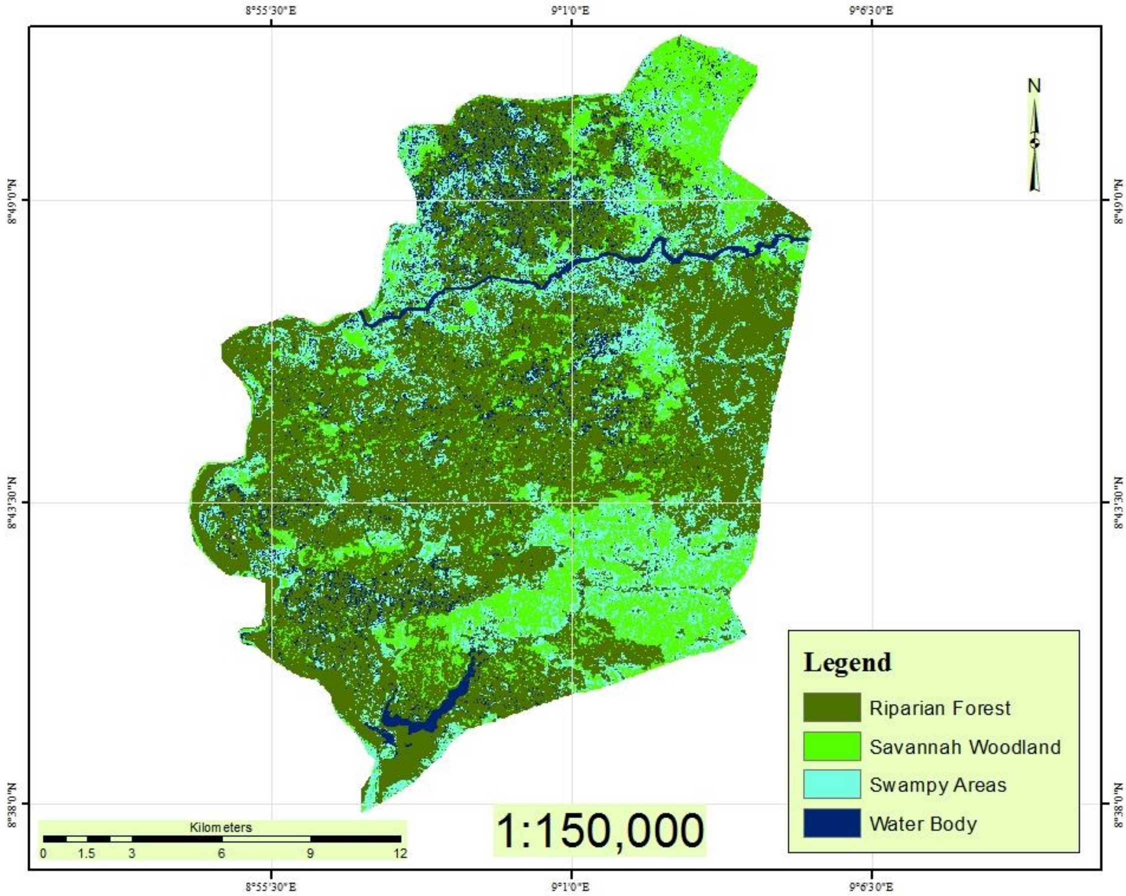

Fig. 1 Pandam 1987 Land use/Land cover distribution generated from LandSat 4 TM

Source: Author's Analysis, 2018.

Analysis of Land Use/Land Cover Classification of 2007 Satellite Imagery

Figure 2 shows the LU/LC of Pandam in 2007 which reveals that, the riparian vegetation decreased within the twenty-year time period from 177.37Km^2 (54.17%) in 1987, and now accounted for about 144.60Km^2 (44.15%). On the other hand, savannah woodland increased from 57.70Km^2 representing 17.62% to 96.38Km^2 (29.43%) which indicates some human activities in the park led to increase in savannah woodland in the area. In addition, swampy areas reduce from 66.68Km^2 representing 20.36% in 1987 to 63.70Km^2 (19.45%). This was as a result of increased in savannah woodland land cover feature. Finally, water body also reduced from 25.70Km^2 representing 7.85% to 22.82Km^2 representing 6.97%.

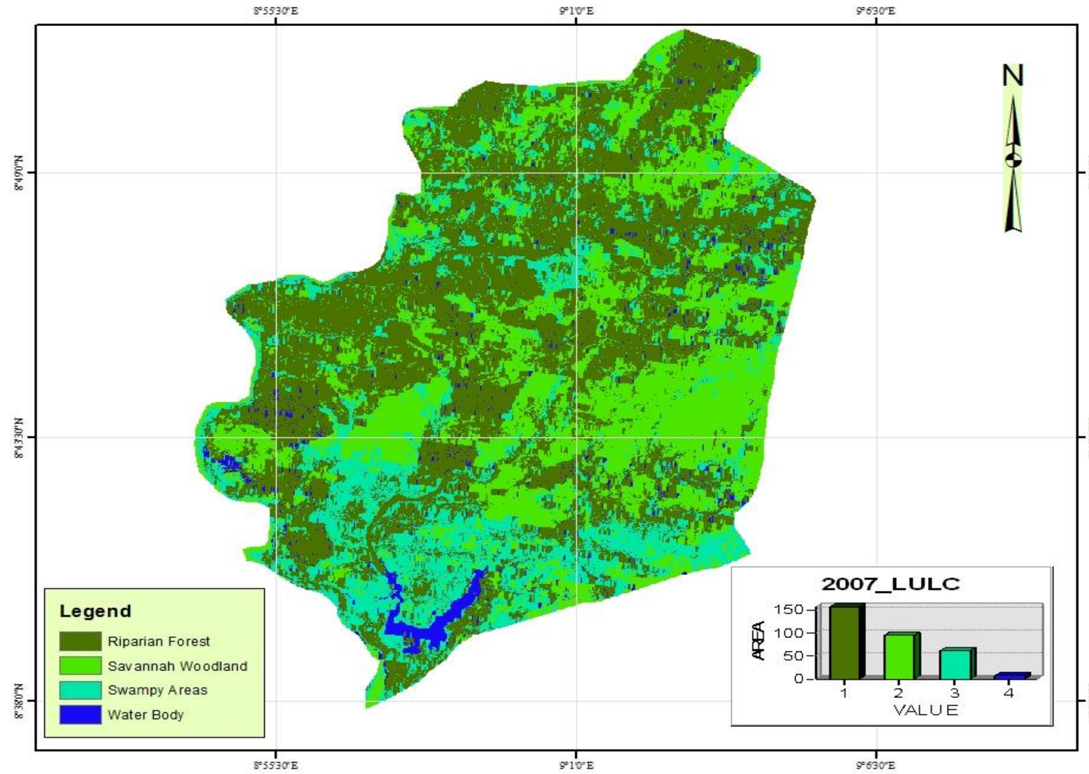

Fig. 2: Classified 2006 land use land cover distribution of the study area generated from LandSat 7 ETM+ of 2007.

Source: Author's Analysis, 2018.

Analysis of Land Use/Land Cover Classification of 2017 Satellite Imagery

The analysis of 2017 satellite image (Fig. 3), shows that there was continuous reduction of riparian strata of the park to other land cover features in the study area. There was a drastic decrease of riparian stratum from 144.60Km^2 (44.15%) in 2007 to 33.29Km^2 (10.16%) in 2017. However, savannah woodland which covered 96.38Km^2 (29.43%) in 2007 increased to 131.01Km^2 (40.00%) in 2017. While the swampy area which covered 63.70Km^2 (19.45%) in 2007 increased to 156.75Km^2 (47.86%) in 2017. Finally, water body which covers 22.82Km^2 representing 6.97% reduces to 1.98% an indication that majority of the area was covered by swamp.

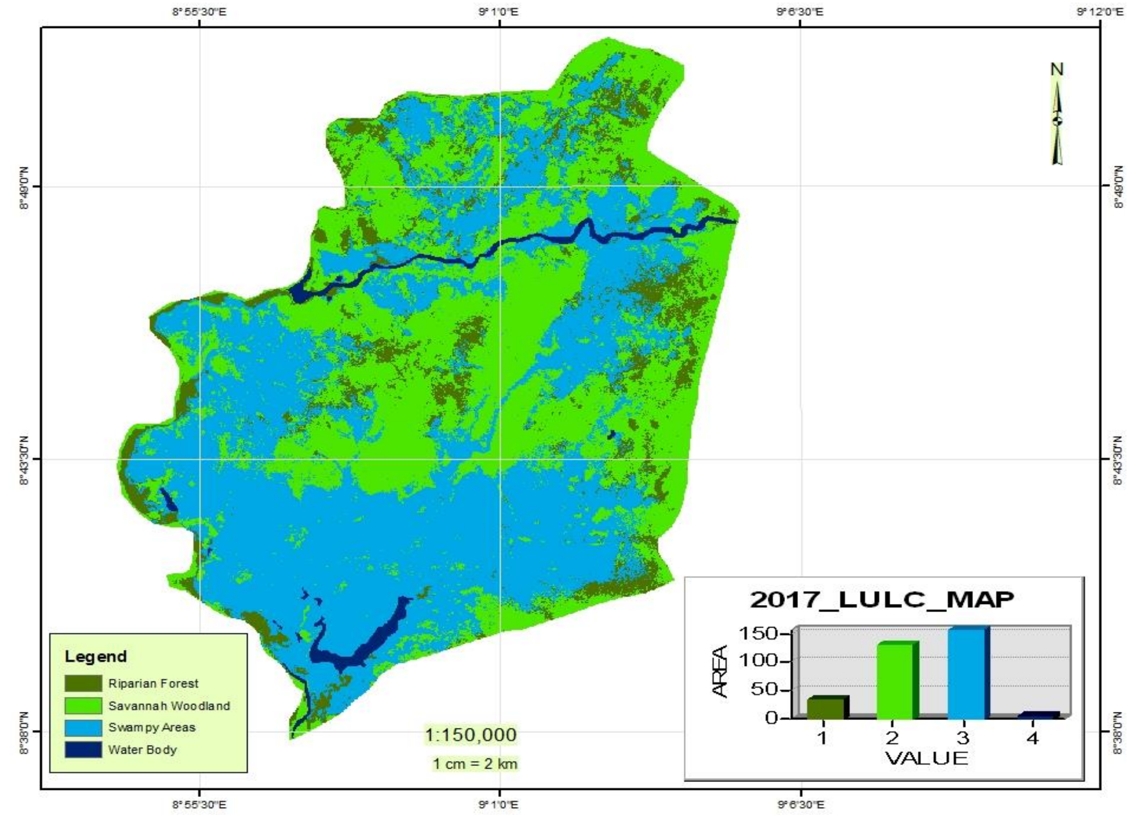

Fig. 3. Pandam 2017 land use land cover distribution generated from LandSat8 (OLI)

Source: Author's Analysis, 2018

Normalized Difference Vegetation Index (NDVI)

The values of NDVI were divided into two categories: non-vegetated land and vegetated land. The negative values represent non-vegetated land while positive values represent vegetated land (Fig. 4). The figures illustrate the image of NDVI results which display the distribution of NDVI values, and from their legends, the distribution of vegetated land and non-vegetated land are also shown. From figure 4 – 6, the changes between vegetated land and non-vegetated land from year 1987 to 2007 and to 2017 were significant.

Based on figures 4 to 6, it can be seen that in year 1987, the area coverage of vegetated land in green color with positive value was far larger than area coverage of non-vegetated land in light red color with negative value and zero value. The NDVI results indicate that with the rapid changes in the land cover of the area, more and more area coverage of vegetation was replaced by other non-vegetation features from year 1987 to 2007 and from 2007 to 2017 as Figure 4 - 6 affirmed these changes.

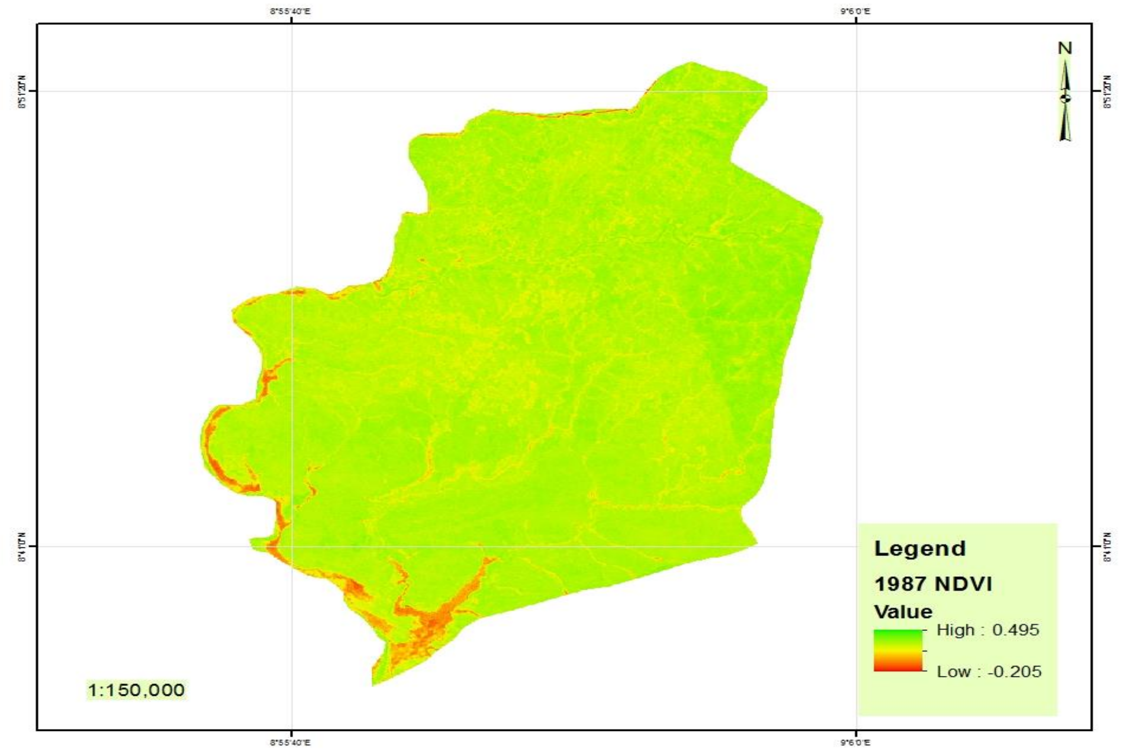

Fig. 4: The image of NDVI changes between vegetated land and non-vegetated land from year 1987

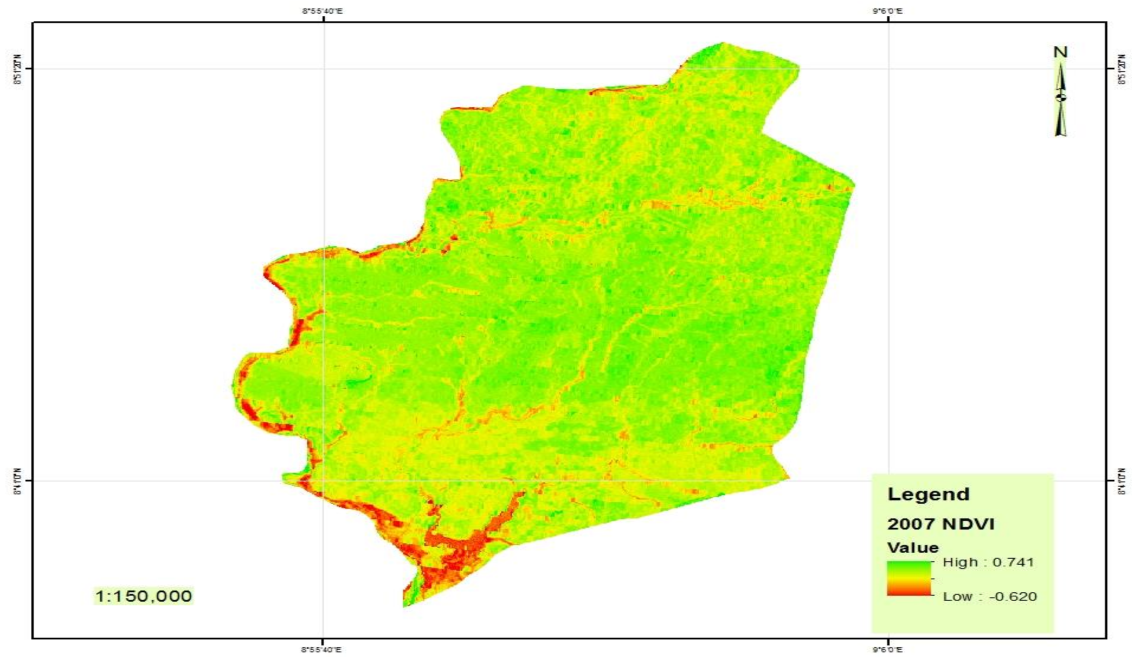

Fig. 5: The image of NDVI changes between vegetated land and non-vegetated land from year 2007.

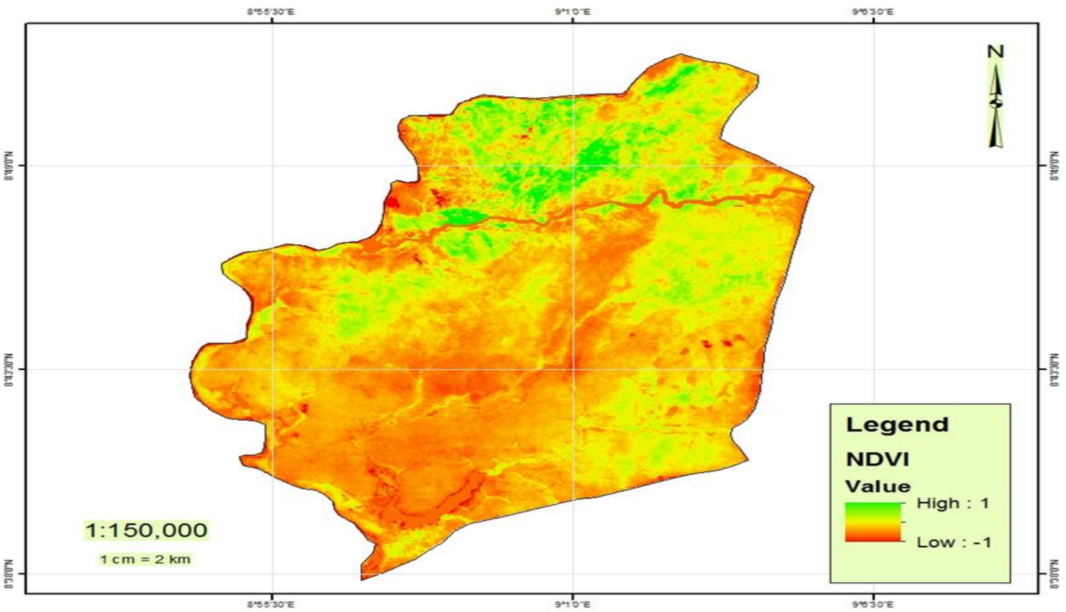

Fig. 6: The image of NDVI changes between vegetated land and non-vegetated land from year 2017.

DISCUSSIONS

The use of Landsat satellite imagery in change detection is limited by the effect of weather and other “noise” producing obstacles that interfere with the output of these passive sensors. Also, the spectrometers measure signals at several spectral bands simultaneously, resulting in multispectral images with multiple interpretations. Despite these limitations, Landsat satellite ecological application is still widely used by researchers to monitor land cover and land use changes.

The results indicated the total land area of Pandam Wildlife Park of 327.54sq km. The large proportion of the park was the riparian habitat (land cover) type, 54.17% of the total area in 1987, followed by savannah woodland (17.62%), while swampy area found mainly around the water body and spread around the wildlife park covered 20.36% and water body covers 7.85% of the area. This indicated the good condition of the whole park as at that time. There was a continuous reduction of riparian vegetation. Thus, indicating greater land coverage by swamp and savannah woodland at present. So much of vegetated land coverage has been lost. This is an indication that between 1987 and 2017 tree composition, shrub-land and grassland shrink, while marshy habitat as well as open and closed savannah woodland areas expanded at PWP. Accordingly, there will be habitat lost and shrinking forage resources for both grazers and browsers. The decrease and degradation of the vegetation cover in more than a decade may be due to corresponding increase in human activities and other factors such as cattle rustling prominent in the park. This agrees with the findings of Audu and Shola, (2016); Samson, (2016), Uloko and Yager, (2017), and Yager *et al.*, (2018).

On the other hand, persistent reduction in vegetation cover reduces productivity, leads to soil erosion and results in long term degradation. Further changes in vegetation composition causes bush encroachment and reduced floral biodiversity and habitat lost by fauna especially for herbivores (Vogel and Strohbach 2009). These degradation processes would result in a decline in the ecosystem services rangelands provide and are a considerable threat to biodiversity. Consequently, free-ranging large herbivores are disappearing from many ecosystems worldwide through land use changes, decreasing size of nature reserves and increasing habitat fragmentation (Yager *et al*., 2018). Herbivores are generally thought to enhance flora diversity by direct consumption of competitively dominant plant species while having indirect effect on plant competition. Consequently, management and improvement of the park ecosystem is top priority to enhance proper stocking of herbivores which is crucial to restore and maintain biodiversity.

CONCLUSION

The study illustrates the application of Normalized Differential Vegetative Indices to measure the vegetative vigor and assess land use/land cover and the implication on herbivores species in Pandam Wildlife Park. Drastic changes haven taken place over the past 30 years, from 1987 in the vegetation cover, at PWP and this resulted in changes in forage resources availability. Many factors including logging, fuel wood collection, charcoal production, cattle grazing and fire played major parts in the land cover changes. The changes to land cover of PWP affected large grazers in ways related to their habitat and access to forage resource (food). It is projected that land cover changes would result in habitat lost and shrinking forage for both grazers and the browsers at PWP in years to come if management action is not taken to stem the changes.

RECOMMENDATIONS

1. Effort should be made to prevent logging, bush fires and other illegal activities to facilitate availability of adequate forage for grazing herbivores and the restoration of range ecosystem of the park
2. Regular follow up to this study should be carried out to provide information for management guideline for the park.
3. Conservation education and local community participation should be intensified.
4. Range conservation and improvement strategies should be given top priorities to restore the park ecosystem.

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