FOREST COVER CHANGE OF LOWLAND RAINFOREST ECOSYSTEM OF OKOMU NATIONAL PARK, NIGERIA

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ABSTRACT

Okomu National Park is an ecological data bank of tropical flora and fauna species. Some of the flora and fauna are threatened or endemic to the tropical lowland rainforest of Okomu National Park. This study used Satellite Remote Sensing to quantify the nature and rate of forest changes in Okomu National Park. Multi-temporal 30m resolution Landsat satellite images spanning 20 years (2000, 2010, and 2020) of the study area were acquired. The images were subjected to maximum likelihood supervised classification. The results revealed that the forest cover change of Okomu National Park has reduced drastically, the forest cover which was 88.93% in 2000, reduced to 79.01% in 2010 and 67.37% in 2020. The non-Forest cover increases from 11.07% in 2000 to 20.99% in 2010 and 32.63% in 2020. The findings of the study indicate that the designation of forest-protected status for Okomu National Park did not effectively prevent deforestation during the 20 years under investigation. The fact that the deforested area expanded during these periods suggests that the existing measures and policies in place were ineffective in preventing or curbing deforestation activities within the national park. It emphasizes the urgent need for stronger and more effective conservation strategies to protect the park's forested areas. To address this issue, the Federal government must reassess and revise the existing policies and management practices related to the national park. This may involve identifying the specific drivers and causes of deforestation and implementing targeted interventions to mitigate them. Additionally, there should be a focus on improving enforcement and monitoring mechanisms to ensure the compliance of individuals and entities operating within the park.

Keywords: ***Deforestation, Lowland rainforest, Maximum likelihood, Remote Sensing***

INTRODUCTION

Okomu National Park (ONP) is part of the former 123,800ha Okomu Forest Reserve (OFR) gazetted in 1935 (Oduwaiye *et al*. 2002). Due to the abundance of white-throated monkeys (*Cercopithecus erythrogaster*) and forest elephants (*Loxodonta africana cyclotis*), the area was upgraded to the status of a wildlife sanctuary in 1985 (Oduwaiye *et al*., 2002). In 1999, its status changed to a National Park. Okomu National Park is a true representation of the Tropical Rainforest Ecosystem (Oduwaiye *et al*. 2002). The main purpose of the national park was to protect existing endangered wildlife species within the park. The ONP is a habitat for several threatened flora and fauna species, including the white-throated monkey (*Cercopithecus erythrogaster*), elephant (*Loxodonta africana cyclotis*), chimpanzee (*Pan Troglodytes*), leopard (*Panthera pardus*) and Red-capped Mangabey (*Cercocebus torquatus*) (Ajayi, 2011).

The ecological value of ONP, which serves as an ideal habitat for endangered species has necessitated the need to study the pattern of forest transition and levels of effectiveness in its forest protection status as a means to combating deforestation. Previous research indicated that the OFR is under immense pressure from large-scale illegal logging, the rapid expansion of oil palm plantations, and the pressure of a growing human population (Eguavoen, 2007; Osehobo, 2013). However, sufficient scientific research aimed at estimating the actual level of disturbance to this threatened forest reserve is currently lacking.

Ecological assessment is necessary for developing a harmonious relationship between humans and nature to attain sustainable development (Field and Ingman, 2000). There is a need to quantify the spatial extent of forest transitional changes from subsistence natural and anthropogenic pressures such as bush burning, illegal logging, hunting, indiscriminate farming, and over-harvesting of forest resources. The potentials of using Satellite Remote Sensing data for forest cover analysis, monitoring, or quantifying deforestation and forest degradation are available in several works of literature (Mitchell, *et al*., 2017).
The availability of arrays of Satellite Remote Sensing images of different spectral and spatial resolution have made deforestation analysis and continuous forest monitoring effective (Htun *et al*., 2009; Phua *et al*., 2008; Curran *et al*., 2004; Giriraj *et al*., 2008; Liu *et al*., 2001). Time series analysis of changes in forest cover over time and the spatial extent of these changes over time can be quantified using remote sensing. This study aimed at determining the spatiotemporal dynamics of forest cover changes and the annual rate of deforestation in Okomu National Park. using remotely sensed imagery (Landsat images) collected over three years (2000, 2010, 2020).

MATERIAL AND METHODS

Study Area

Okomu National Park is located at Udo, Ovia South West Local Government Area about 60km from Benin, Edo State within Latitude 6^0 15'N to 6^0 25' N and longitude of 5^0 09'E to 5^0 23'E (Figure 1). It is endowed with a complex combination of both fauna and flora species (Olaniyi, 2018). Vegetation is typical of the Guinea Congo lowland rainforest and is characterized by a mosaic of swamp forest, high forest, secondary forest, and open shrubs (Onojeghuo and Onojeghuo, 2005). The Park has an average size of 202 km^2 (202 sq km), which is only 9% of the 1200km square area covered by the Okomu forest reserve. The National Park is surrounded by a host of communities of about 45 villages and settlements; the most popular are Udo and Arahkuan villages, which are just by the fringes of the park.

The area is well-drained by the Okomu River and a few of its tributaries. There are many areas where the water table rises above ground level to form treeless freshwater pools and marshes, some of which dry up in the dry season. Mean annual rainfall is about 2100mm with most of it falling between February and November and the highest in June, July, and September. The driest period is between December and January (Orhiere, 1992; Soladoye and Oni, 2000). The mean monthly temperature is 30.2 degrees Celsius and Relative Humidity is about 65% during the afternoons throughout the year (Orhiere, 1992). Soils are acidic, with nutrients poor sandy loam with, a pH of 5.0 (Orhiere, 1992).

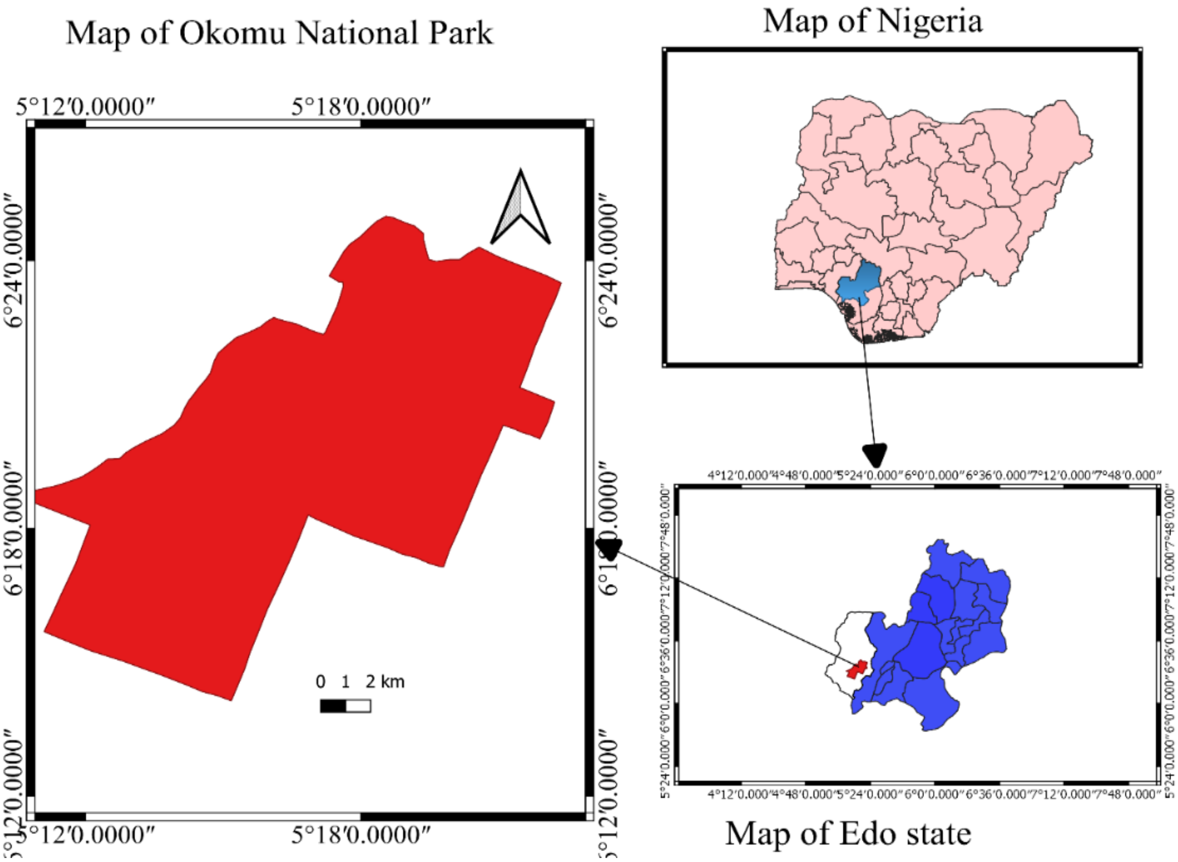

FIGURE 1: MAP OF OKOMU NATIONAL PARK.

Data collection and analysis

Landsat images of 2000, 2010, and 2020 with a spatial resolution of 30m were obtained from the United States Geological Survey (USGS) archive with a cloud cover of less than 10%. The images were acquired during the early dry season to reduce seasonal variations and were used as the main source of data for the identification and characterization of current forest cover changes in Okomu National Park.

Table 1: Attributes of images used for classification

Data types	Resolution	Spectral bands	WRS: Path/Row	Date of Acquisition
Landsat ETM	30m	1,2,3,4,5 and 7	190/056	13-12-2000
Landsat ETM +ETM SLC	30m	1,2,3,4,5 and 7	190/056	20-01-2010
Landsat 8	30m	2,3,4,5,6 and 7	190/056	28-12-2020

Landsat Satellite image pre-processing

All Landsat images collected after May 31, 2003, had scan line errors. Landsat 7 ETM + SLC of the year 2010 retrieved from the USGS was therefore corrected for scan line error using QGIS.3.14. Subsequently, all the Landsat images (Table 1) of the study area were atmospherically corrected to remove artifacts and their Digital Numbers were converted (DN) to reflectance numbers (Huang *et al*., 2002).

Image classification/analysis and Accuracy assessment

After the preprocessing of the image, the image was classified into two classes (Forest and Non-Forest) by picking regions of interest (ROIS) in the image. 150 random points were picked for Forest and Non-Forest classes to get an accurate classified image. The methods used for the classification are Maximum Likelihood. Supervised image classification was done in the QGIS 3.14 software environment to derive the land use land cover of Okomu National Park. The maximum likelihood algorithm was used for the classification which is based on both the distances toward class means and the variance-covariance matrix of each class. The Normalized Difference Vegetation Index (NDVI) was performed to detect areas prone to human activities. Vegetation health is estimated using NDVI and it also provides a means of monitoring changes in vegetation over time. The process of image classification and accuracy assessment was performed using independent training and testing data. The testing data was used in validating the accuracy of the image classification. The chart below shows the flow of processes involved in the Landsat image classification.

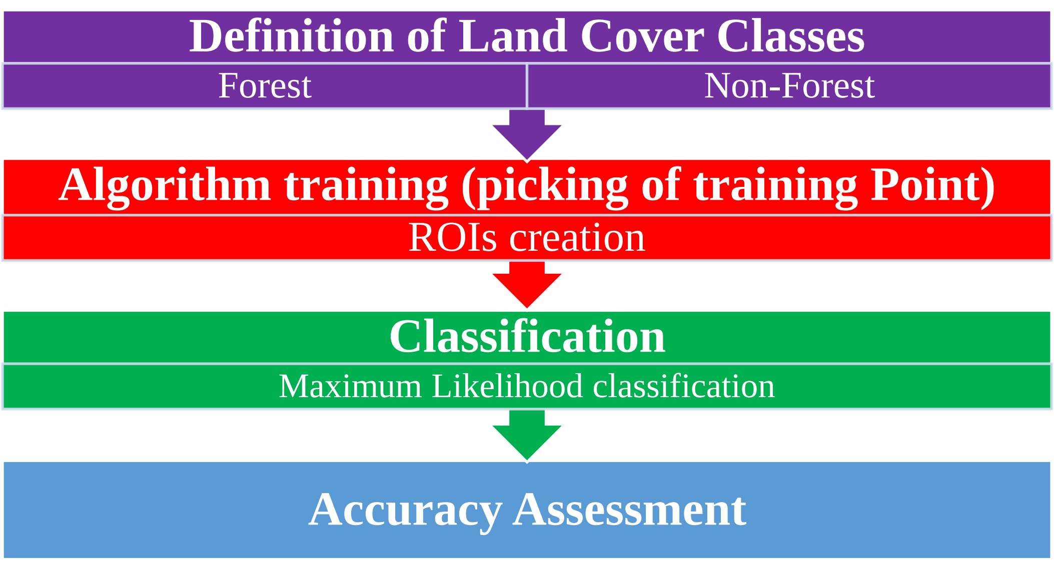

Figure 2: Chart showing the flow of process in the classification of the image

The annual rate of deforestation

The annual rate of deforestation was derived for the study area using a method proposed by the Food Administration Organization of the United Nations (FAO). The FAO deforestation rate formula was first suggested by Puyravaud (2003) and it uses the simple compound rate interest law by comparing the area of forest cover in the same region at different time intervals. Deforestation rates were calculated for the study area using the formula below:

$$r = \frac{1}{t_2 - t_1} \ln \frac{A_2}{A_1} \text{----------------------------------1}$$

Where A_1 and A_2 are the mapped forest cover area at time t_1 and t_2 respectively. The rate of forest change (r) represents the percentage rate of forest loss for the period between $t_2 - t_1$. With the value of r, it is possible to calculate the annual deforestation rate (D_t in km^2 /year) for the given reference period (Souza *et al.*, 2013) using the formula below.

$$D_t = A_{t-1} \times (1 - e^r) \text{------------------------2}$$

RESULTS

Forest cover analysis

Supervised classification using Maximum Likelihood was used in the classification of the Landsat images 2000, 2010, and 2020 into Forest and Non-Forest classes. The statics of the forest distribution for each year as derived from the analyzed images are presented in Table 2 below.

Table 2: Proportion and size of land cover classes 2000, 2010, and 2020.

Land cover type	Area in 2000		Area in 2010		Area in 2020	
	Km^2	%	Km^2	%	Km^2	%
Forest	179.61	88.93	159.57	79.01	136.07	67.37
Non-Forest	22.37	11.07	42.40	20.99	65.90	32.63
Total	201.97	100	201.97	100	201.97	100

There was a downward decrease in the forest cover of Okomu National Park from the results of forest cover analysis as shown in Table 2. Forest cover decreased by 9.92% between the year

2000 and 2010 (a decrease from 88.93% to 79.01). Similarly, a decrease of 1.64% was observed in the forest cover from the year 2010 to 2020 (79.01% and 67.37%). On the contrary, the Non-Forest cover increased from 11.07% to 20.99% between the years 2000 and 2010 and an increase from 20.99 to 32.63% was also observed between the years 2010 and 2020 respectively. The area covered by each landcover type for the years is also shown in Table 2, Forest (179.61Km^2,159.57 Km^2, 136.07 Km^2) and Non- Forest (22.37 Km^2, 42.40 Km^2, 65.90 Km^2) respectively.

The resulting images from the classification are shown in Figure 3 below.

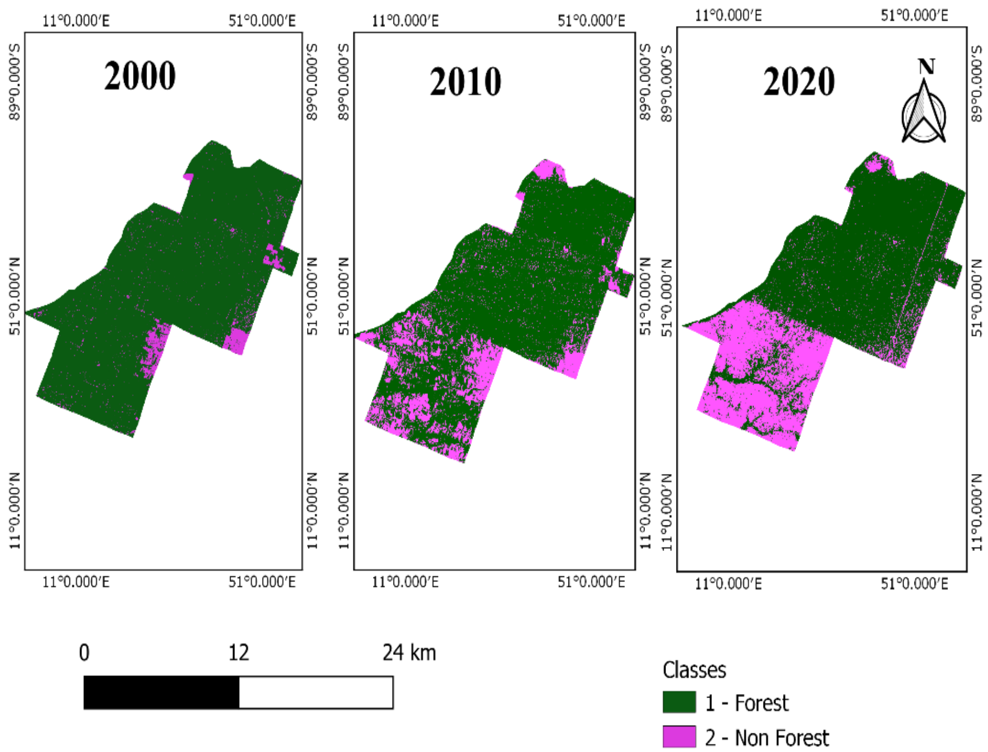

FIGURE 3: Forest Cover Distribution Maps of Okomu National Park from 2000 to 2020

Forest cover distribution.

The static land use land cover distribution for each year as derived from the image maps is presented in Table 2. The classification results shown in Table 2, indicates the land use land cover classes in the year 2000, 2010, and 2020. Forest (88.93%, 79.01%, and 67.37%) and non-forest (11.07%, 20.99%, and 32.63%) respectively. The area covered by each landcover type for the years is also shown in Table 2, Forest (179.61Km^2,159.57 Km^2, 136.07 Km^2) and Non-forest (22.37 km^2, 42.40 km^2, 65.90 km^2) respectively.

Table 3: Accuracy Statistics of the Land Use Land cover map for the year 2000 Accuracy assessment of the image

Product	Producers Accuracy	Users Accuracy	Kappa hat
Forest	99.30	96.53	0.94
Non-Forest	60.69	88.68	0.89
Overall accuracy [%]	98.18		
Kappa hat classification	0.97		

The result of the accuracy assessment indicated an excellent overall classification (98.18%) for Landsat TM image (2000). In classifying the second Landsat TM image (2010), an overall accuracy of 91.66% was achieved. In the third Landsat 8 image (2020) an overall accuracy (94.61%) was achieved. The result is shown in Table 3, Table 4, and Table 5 respectively. The higher accuracy was achieved as a result of the utilization of more ancillary data in collecting training samples for classification and the season of the image during the process of classification which was the dry season.

Table 4: **Accuracy Statistics of the Land Use Land cover map for the year 2010**

Product	Producers Accuracy [%]	Users Accuracy [%]	Kappa hat
Forest	82.74	93.77	0.90
Non-Forest	79.30	54.96	0.50
Overall accuracy [%]	91.66		
Kappa hat classification	0.86		

Table 5: **Accuracy Statistics of the Land Use Land cover map for the year 2020**

Product	Producers Accuracy	Users Accuracy	Kappa hat
Forest	93.89	88.51	0.84
Non-Forest	78.78	88.10	0.86
Overall accuracy [%]	94.61		
Kappa hat classification	0.91		

The annual rate of deforestation:

The result in Tables 6 and 7 show the annual rate of deforestation for the period used in the study. The annual rate of deforestation between the years 2000 and 2010 is − 0.012 while for the years 2010 to 2020 is − 0.016. The result reveals that the rate of deforestation between the years 2010 and 2020 is higher than that between 2000 and 2010.

Table 6: Annual rate of deforestation between 2000 to 2010.

Forest area cover of 2000 (A1)	Forest area cover of 2010 (A2)	Change in time (Δt)	The annual rate of deforestation (r) (Km^2 per year)
179.61	159.57	10	− 0.012

Table 7: Annual rate of deforestation between 2010 to 2010.

Forest area cover of 2010 (A1)	Forest area cover of 2020 (A2)	Change in time (Δt)	The annual rate of deforestation (r) (Km^2 per year)
159.57	136.07	10	− 0.016

DISCUSSION

Okomu National Park is currently experiencing a high rate of deforestation agricultural expansions and illegal logging (Olaniyi, 2018). Agricultural activities such as cocoa plantation, palm plantation, and food cropping at the southwestern edge of the park are one of the major causes of degradation in the park. This supported the view of Baniya (2008) that agricultural activity can have a great impact on natural resources such as plants, wildlife, etc. Another cause of the destruction of the forest cover of Okomu National Park is human activities such as large-scale illegal logging, industrialization, oil palm plantations, uncontrolled hunting, and a rise in human population (Ajayi, 2011). The results are consistent with a recent study by Eguavoen (2007) that Okomu

National Park is under immense threat from large-scale illegal logging, the rapid expansion of oil palm plantations, farming, and hunting activities. The area of deforested landscape increased between 2000-2010 and 2010-2020 within the National Park. The overall results of this study show that forest protected status assigned to Okomu National Park has not effectively assisted in stopping deforestation over the 20 years investigated.

CONCLUSION

The study revealed that there is a high rate of deforestation and change in forest cover at Okomu National Park which is supposed to be a protected area. There is an urgent need for the federal government charged with the responsibility of managing National parks to review some of the existing forest policies because some of the policies are obsolete and no longer in tune with current realities. The review and enforcement of the policies will help ensure the conservation and protection of the protected areas and wildlife that depend on the resources there. Forest managers and conservation organizations involved in the managing of the protected areas urgently need to improve their methods and approaches to conservation. To combat this, the government needs to work closely with local communities and make them understand the need to conserve the national park and also provide other main sources of livelihood for those who depend on the forest as their main source of livelihood.

Reforestation programs should be fully implemented and enforced which will help enhance the enrichment and natural regeneration process of forest landscapes. This study has shown the rate of deforestation in a lowland forest ecosystem in Nigeria using remote sensing and geographic information system.

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