SPATIO-TEMPORAL ASSESSMENT OF FOREST COVER CHANGE IN FEDERAL UNIVERSITY OF AGRICULTURE ABEOKUTA, OGUN STATE NIGERIA

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Abstract: This study examined spatio-temporal pattern of forest cover changes at the Federal University of Agriculture Abeokuta, Ogun State Nigeria. Landsat (TM, ETM+ and OLI) imagery for the years 1984, 2000 and 2016 respectively were subjected to both unsupervised and supervised classification in Erdas imagine 9.1 and classified the study area into five major land use/ land cover classes such as tree cover (TC), tree cover mosaic (TCM), non-tree cover (NTC), vegetation transition zone (VTZ), and non-vegetation cover (NVC) according to tree canopy density and definition of forest based on TREE project rule. The results revealed that NVC was the prevailing cover type in 1984, 2000 and 2016, accounting 36.7, 46.3 and 48.3% of the total land cover area respectively. TCM, and NTC decreases throughout the study period accounting for 16.1, 15.6, 14.7% and 18.4, 11.3, 10.0% in 1984, 2000 and 2016, respectively. Between 2000 and 2016, there was a geometric progression of TC with positive change value of 24.6% at an average rate of 1.5% per annum. Generally, between 1984 and 2016, NVC had increase to 31.7% with an average rate of 1% per annum at the expense of NTC, VTZ, TCM and TC experience negative changes of 45.5, 9.5, 8.6 and 4.6% with an average rate value of 1.4, 0.3, 0.3 and 0.1% per annum, respectively. Unsustainable forest practices such as illegal logging, charcoal burning and forest landscape encroachment were seen as key drivers of forest cover dynamics of the study area.

Keywords: Forest cover changes, spatio-temporal pattern, remotely sensed data

Introduction

Understanding the dynamics of change in land use and land cover is essential for generating valuable information for better decision making in natural resource management (Lu, 2003). This is because changes in land use and land cover have been directly linked to changes of phenomenal importance such as; biodiversity loss, climate change, food insecurity, human health, and general environmental degradation (Dunjo *et al.*, 2003; Heisternmann *et al.*, 2006). It has been substantiated that anthropogenic activities including poor land use management and over exploitation of the limited available resources are the major factors of ecological degradation all over the world. Meanwhile, Nigeria is considered the world's highest deforested country with an annual loss of about 55.7% of its primary forest at an annual rate of 3.6% between 2000 and 2010 (FAO, 2010). Among the nations with the highest deforestation rates, significant proportion of Nigeria forest losses have been reported on the savanna woodland forest that are poorly protected (FAO 2010; Green *et al.*, 2013). Deforestation and forest degradation is therefore the major ecological problems in Nigeria. This has been attributed to various socio-economic and biophysical factors, arising from the conversion of forest area (thick and healthy) into an open habitat, (Namaalwa, *et al.*, 2007). The density, composition and species richness of many forest ecosystem landscapes are fast changing on account of both anthropogenic and climatic factors. According to (IPCC 2007), Deforestation and forest degradation accounts for over 17% of global carbon dioxide emissions, it also has profound negative impacts on sustainable food production, freshwater availability, species diversity and richness, climate and human well-being (Overmars and Verburg, 2005; Potter *et al.*, 2007)

In the pursuance of infrastructural expansion and economic growth, major forest ecosystems have been destroyed leading to high fragmentation or complete habitat loss, decimation of biodiversity, huge soil erosion, and shrinking natural forest cover (Dovers, 2000; Lymburner *et al.*, 2011). Assessment and monitoring of forest cover changes has therefore become inevitable in the quest to understand the dynamics of forest ecosystem. The use of remote sensing and GIS techniques is traditional for rapid assessment and analysis of the changes in natural vegetal-cover of any region (DeFries *et al.*, 2006 & GOFC-GOLD, 2009). Time series analysis of satellite derived data have proofed to be highly useful in classifying land use and establishing changing pattern of forest cover, especially for deforestation and forest degradation assessment (Rosenqvist *et al.*, 2003; DeFries *et al.*, 2006; Gibbs *et al.*, 2007).

The present study became necessary to get a clear understanding of the ecology of the 10,000 hectare University land mass of the Federal University of Agriculture, Abeokuta, Nigeria; a once highly prolific harbor of wildlife species, but in recent time have become highly decimated by unrelenting anthropogenic activities such as; logging, poaching, extensive rain-fed agriculture, fuel-wood gathering, charcoal making and massive land clearing for building construction. The study was therefore carried out to map the status of land area of the between the 32 year period from 1984 to 2016. The change detection study was with a view to develop sustainable forest management and land use practices.

Materials and Methods

Study area

Federal University of Agriculture, Abeokuta, Nigeria (Fig. 1) is located in Odeda Local Government area, in Ogun state, southwestern Nigeria. FUNAAB as the University is fondly called is one of the three land grant Universities of agriculture established by the Federal Republic of Nigeria. FUNAAB with an estimated area of 9713.70 ha is geographically described between latitude $7^{0}12'22''$N to $7^{0}19'\ 9''$N and longitude $3^{0}19'9''$E to $3^{0}28'31''$E. The climate is humid tropical type and characterize by wet and dry seasons. The vegetation of the study area falls within the transitional zone between the derived savanna and dry low land forest featuring mainly mixed association of secondary bush re-growth and scattered economic tree, which are equally punctuated by a mixture of arable crops and comprises of degraded rainforest. The most predominant forest trees in the area are *Elais guinensis*, *Bambusa vulgaris*, *Anogeisus leocarpus* and *Daniella olliveri*. Physical structures include academic core buildings, lecture rooms, research institute, farm centre, etc. The topography of the location is greatly undulating with upland, connected to lowland areas.

Data type and source

Spatial layers on forest cover were developed using multiple data sources. Topographical and boundary maps of FUNAAB land area were acquired from the University physical planning unit; it was scanned and digitized "heads-on" in a GIS environment (Table 1). Multi-temporal satellite data (Landsat; TM, ETM+ and OLI) were also acquired from global land cover facilities and Earth explorer; United States Geological Survey (USGS) Earth Resource Observation Systems (EROS) data archive.

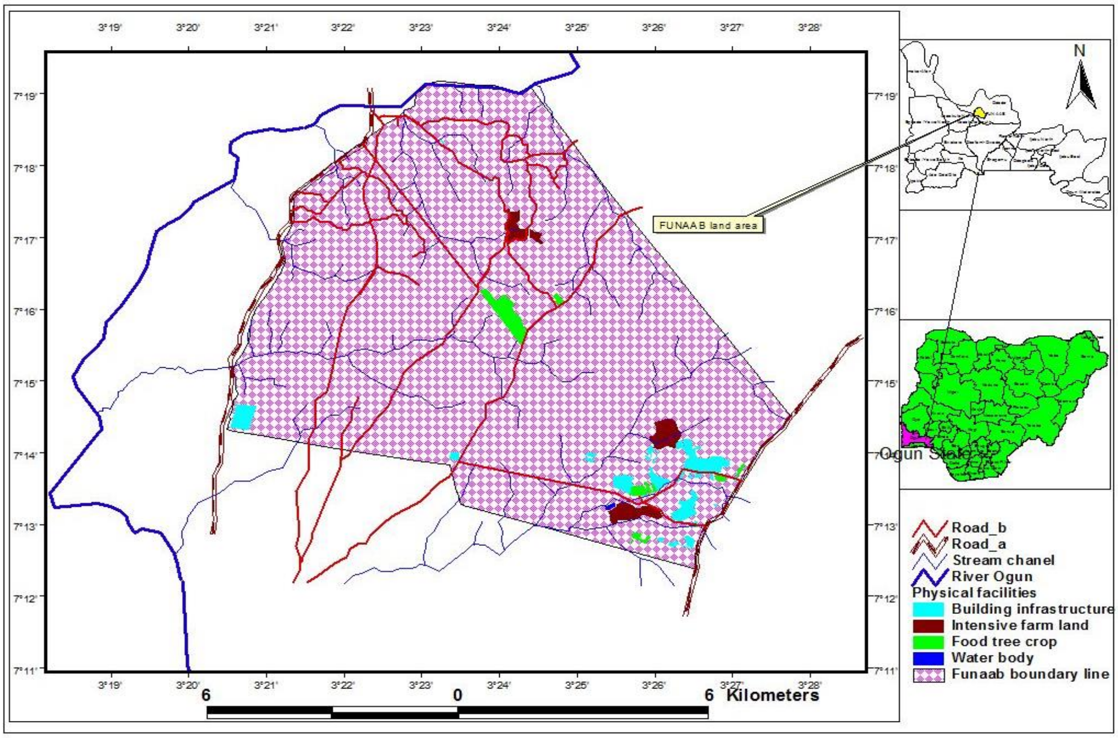

Fig. 1: Map of the study showing FUNAAB land area

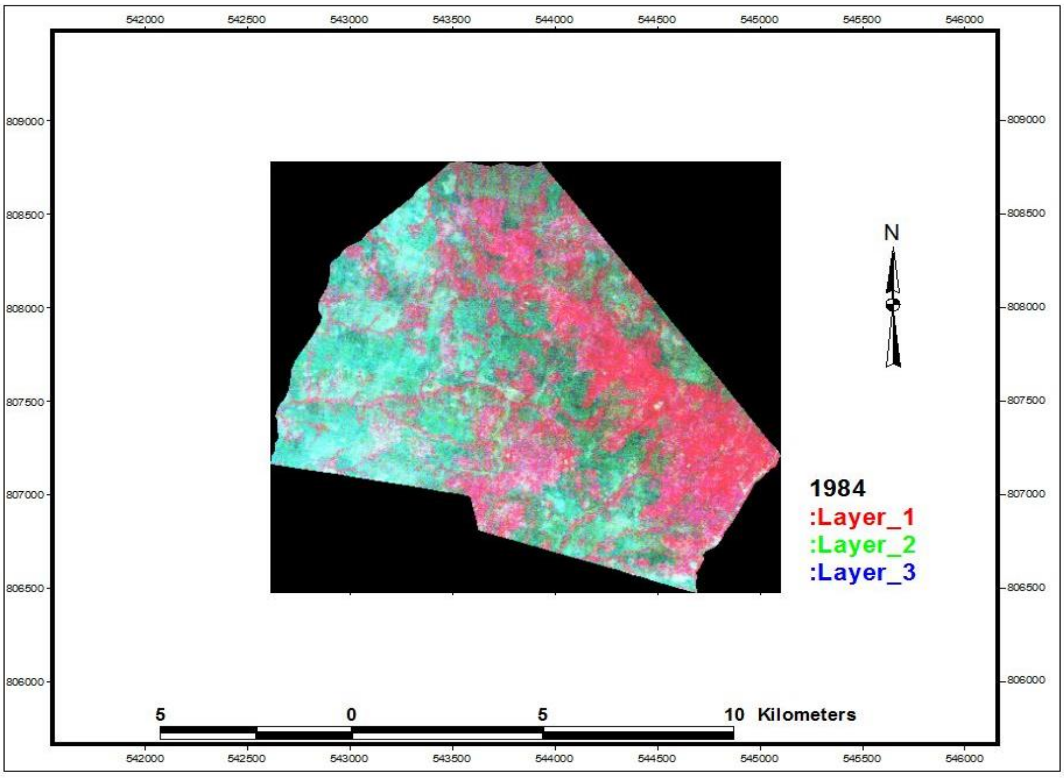

Fig. 2: Composite image (band 432) of the study area, 1984

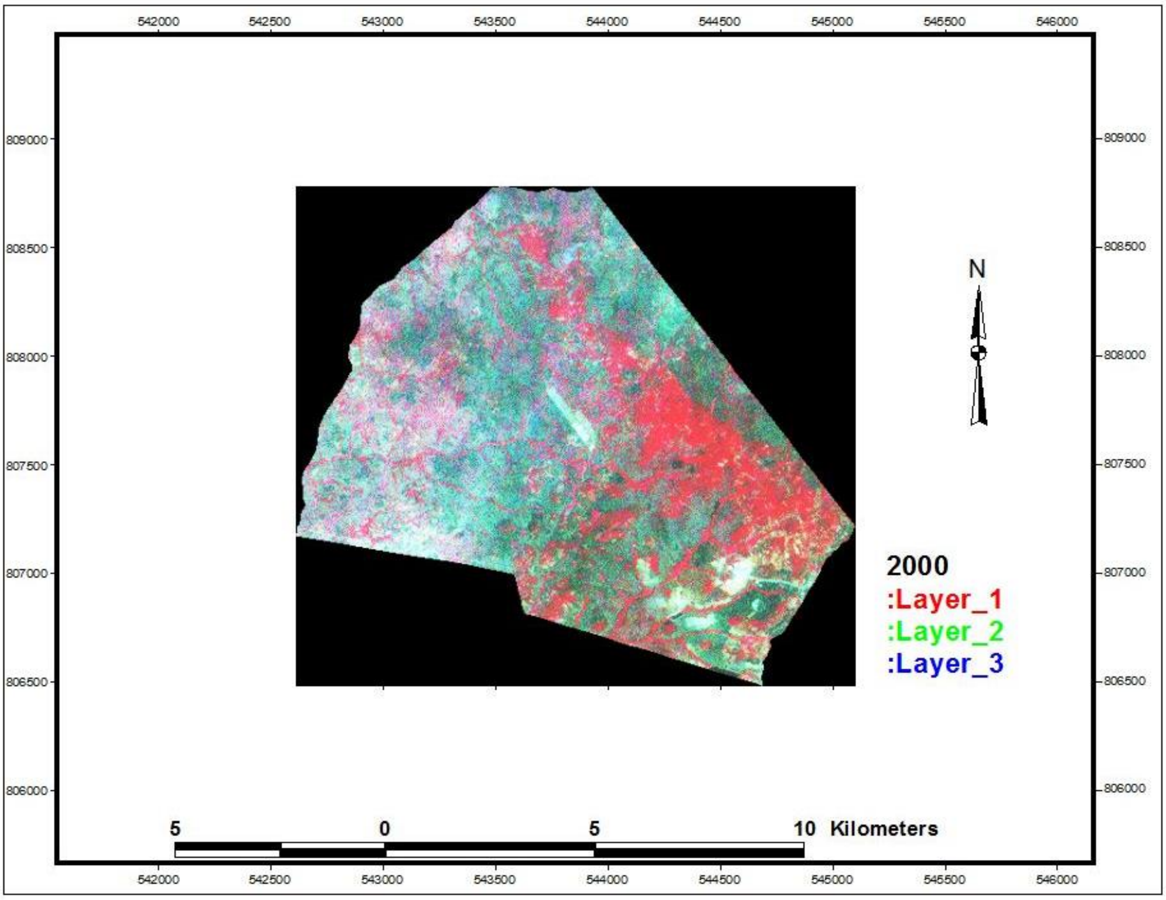

Fig. 3: Composite image (band 432) of the study area, 2000

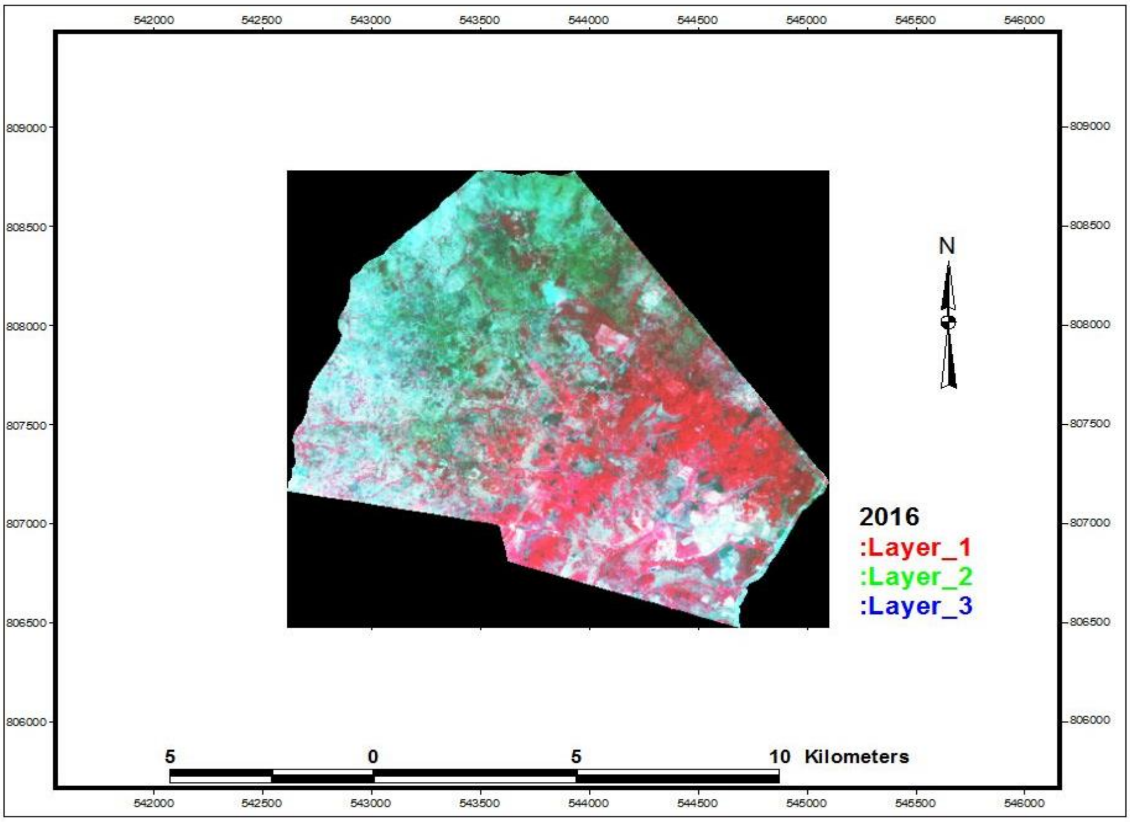

Fig. 4: Composite image (band 432) of the study area, 2016

Table 1: Data type and characteristics

Data	Type	Path and row	Date of acquisition	Scale/resolution
Landsat-TM	Spatial	191/055	December 18, 1984	30 m
Landsat ETM+	Spatial	191/055	February 06, 2000	28.5 m
Landsat-OLI-TIRS	Spatial	191/055	December 07, 2016	30 m
Google earth	Spatial	191/055	February 16, 2016	1.05 km
Printed federal survey, Nigeria	Spatial (Toposheet)		1964	1:50,000
GPS Readings	Spatial	WGS_84 Zone 31	Nov-Feb., 2015	±3

Source: Visibility study survey, 2015

Image composition and pre-processing

Subset of the study area

A shape file of the study area was imported into the (ERDAS imagine 9.1, 1997) software environment and saved as AOI with its corner coordinates. This was then followed by masking the shape file as overlaid with Landsat image so as to cut out the study area for 1984, 2000 and 2016 (Figs. 2, 3 and 4).

Forest covers classification in the study area

Multispectral classification is an information extraction process that analyses the spectral signatures and assign pixels to classes based on similar signatures. For this study, modified classification scheme used by Achard *et al.* (2009) for their TREE project rules was adopted. The vegetation was classified into four major classes base on tree and canopy density as shown in Table 2. Both unsupervised and supervised classification approached was employed. Resulting cluster was then reclassified using maximum likelihood algorithm base on ancillary data and other information obtained from the field (Manandhar *et al.*, 2009).

Table 2: Land cover classification scheme

Land cover types	Description
Tree Cover	Tree cover (canopy density of the tree layer at least 10% and tree height 5 m) greater than 5m and a cover of greater than 70%
Tree Cover Mosaic	Trees greater than 5m and a cover of between 40 and 70%
Non-tree Cover/shrub	Woody vegetation cover less than 5m can be tree re-growth
Vegetation transition zone	The degraded vegetation cover/zone such as forest-savanna transition cover (areas with scattered tree <10%)
Non vegetation cover	All non-woody land cover such as bare land, settlement, rock, etc.

Source: Modified classification system for the study area (Achard *et al.*, 2009)

Spatial data analysis

Spatio-temporal change detection analysis

The forest cover change analysis was obtained by quantifying the amount of an area occupied by a particular forest cover type relative to total forest area. The comparison of the resulting tree cover statistics aided in identifying the percentage change and relative changes between 1984, 2000 and 2016. The following mathematical formulae by Hansen *et al.*, (2013) were used.

Change = A2-A1……………………. (1)

A_2 and A_1 are the area of the vegetation cover type at $year_1$ and $year_2$.

$$\% \text{ change} = \frac{A2-A1}{A1} * 100 \quad …….. (2)$$

$$\text{Annual rate of change} = \frac{change}{time} \text{ (ha/yr)} \quad ……… (3)$$

Time = Periodic interval in between one period and the other period i.e. $year_2$ and $year_1$

% Annual Rate of change =

$$\frac{Annual\ Rate\ of\ change\ (\frac{ha}{yr})}{A1} \text{x } 100 \quad ……… (4)$$

Change detection matrix

Vegetation cover transition matrices were developed to present a comprehensive analysis of the dynamics of forest cover change. Transition matrices are tables with symmetric arrays, composed of the land cover classes from the initial period in one axis and the same classes from the subsequent period in the later (year 1 and year 2). Each compartment in the diagonal of the matrix contains the area (ha) of each class of cover types that remained unchanged during the period under consideration, while the remaining compartments contain the estimated area of a given land cover class that changed to a different class during the same period (Luenberger, 1979). Thus, the gross gain for each land use and land cover change (LULCC) category was calculated by subtracting the persistence from the column total, while the gross loss is obtained by subtracting the persistence from the row total (Pontius Jr and Malizia, 2004).

Results and Discussion

Extent of land cover categories and vegetation cover change distribution

The spatial and temporal pattern of various vegetation and other land cover types from 1984 to 2016 was presented in Figs. 5 to 7. The spatial extent for land cover types are shown in Table 3. The results reveal that Non vegetation cover (NVC) was the prevailing cover type in 1984, 2000 and 2016. However it increases throughout the study period; accounting for 36.7, 46.3 and 48.3% of the total study area, respectively. Tree covers mosaic (TCM), and Non-Tree cover (NTC) decreases throughout the study period accounting for 16.1, 15.6, 14.7 and 18.4; 11.3, 10.0% in 1984, 2000 and 2016 respectively. Furthermore, Tree cover (TC) occupied, 17.7, 13.5 and 16.9% in 1984, 2000 and 2016. Moreover, vegetation transition zone (VTZ) constituted, 11.2, 13.3 and 10.2%, respectively in 1984, 2000 and 2016. A resultant decrease in area occupied by TCM and NTC from 1984 to 2016 is an indication that forested landscape has been converted to NVC and evidence has shown in Non-vegetation cover and in the expansion of vegetation transition zone which increase from 46.3 and 13.3% in 2000. Also, the reduction can be attributed to different types of land use practices as well as timber logging tracked and deck observed during the field visual survey. This is in agreement with observation made by Kessy *et a.* (2016), Chan and Sasaki (2014), and Mayes *et al.* (2015); that, uncontrolled collection of non-timber forest products (NTFPs), climate change variability and natural human-induced forest fires in many part of Africa has reduced forest cover density.

Trend in vegetal and non-vegetal cover change from 1984 to 2016

The trend analyses of study area revealed changes in the vegetation categories over the thirty two years study period (Fig. 8). There are appreciable changes in TC, TCM, NTC, VTZ and NVC. In the first period, between 1984 and 2000, NVC and VTZ increased by 26.4 and 18.1% with an average rate of 1.7 and 1.1% per annum, while NTC, TC and TCM declined by 38.5, 23.5 and 3.0%. This suggests that NTC, TC and TCM are receding at an average rate of 2.4, 1.47 and 0.19% per annum. This was the period when the area was designated as the permanent site of the University and several development start taking place. Forest covers were removed and replace with building.

The period between 2000 and 2016, showed a geometric progression of TC with positive change values of 24.6% at an average rate of 1.5% per annum. VTZ, NTC and TCM suffer in decline of 23.4, 11.3 and 5.8% at an average value of 1.5, 0.7 and 0.4% per annum. In the same period, NVC experience slight increase with value of 4.2% at an average value of 0.3% per annum. The positive change observed in the TC area at growing tree crop (Teak, Gmelina, Cashew and Oil palm plantation) planted by the Directorate of University Teaching and Research Farm (DUFARM) as afforestation programme and food security action plan project. The observed change in size of VTZ is a reflection of contributory factor resulting from forest conservation/afforestation programme to its greener environment.

Generally, from 1984 to 2016, there was an increase in size of NVC category with an increase of 31.7%, and an average rate of 1% per annum. Moreover, NTC, VTZ, TCM and TC experience negative changes of 45.5, 9.5, 8.6 and 4.6% with an average rate value of 1.4, 0.3, 0.3 and 0.1% per annum, respectively. The reasons for the negative change is simply because these are the area where illegal timber extraction, fuel wood collection and farming activities are currently going on as observed during the field survey. Yelwa (2008) observed that conserving forest reserves serve as safety nets to immediate communities as alternative source of income and food security for households during the off-farming season. The spatial and temporal patterns of the tree cover changes are shown in Figs. 5 to 7. The classified image of the study area revealed that between 1984 to 2016, most of the area under tree cover found around streams and mostly southeastern part and north-westward had been replaced by non-vegetation cover. However, in the classified image of 1984, there was an evidence of more canopy tree density running from northeastward to southeastward and at the central portion of the study area.

In the year 2000, tree cover density had reduced but conspicuous at southeastward. This can be linked to the sacred forest conserved as community forest management. The classified image further revealed that, in 2016 tree cover density is highly extensive and as well as non-tree cover towards center region and southeastward of the study area. Due to natural regeneration, plantation mixture and community sacred forest observed and this is in perfect agreement with GoN, (2013) that Community forests combine a mixture of plantations and natural forests, and in most cases, local communities protect the community-owned forests allowing natural regeneration and growth.

Table 3: The area statistics of vegetation cover and non-vegetation cover types obtained from classified image from 1984 to 2016

	1984		2000		2016	
Vegetation/non-vegetation Types	Area (ha)	%	Area (ha)	%	Area (ha)	%
Tree cover	1716.84	17.67	1313.70	13.52	1637.37	16.86
Tree cover mosaic	1560.60	16.07	1514.39	15.59	1426.95	14.69
Non Tree cover	1785.78	18.38	1097.61	11.30	973.26	10.02
Vegetation transition zone	1090.62	11.23	1288.08	13.26	986.94	10.16
Non vegetation cover	3559.86	36.65	4499.92	46.33	4689.18	48.27
Total Area	**9713.70**	**100**	**9713.70**	**100**	**9713.70**	**100**

Source: Landsat Images 1984, 2000, and 2016, Erdas Imagine 9.1

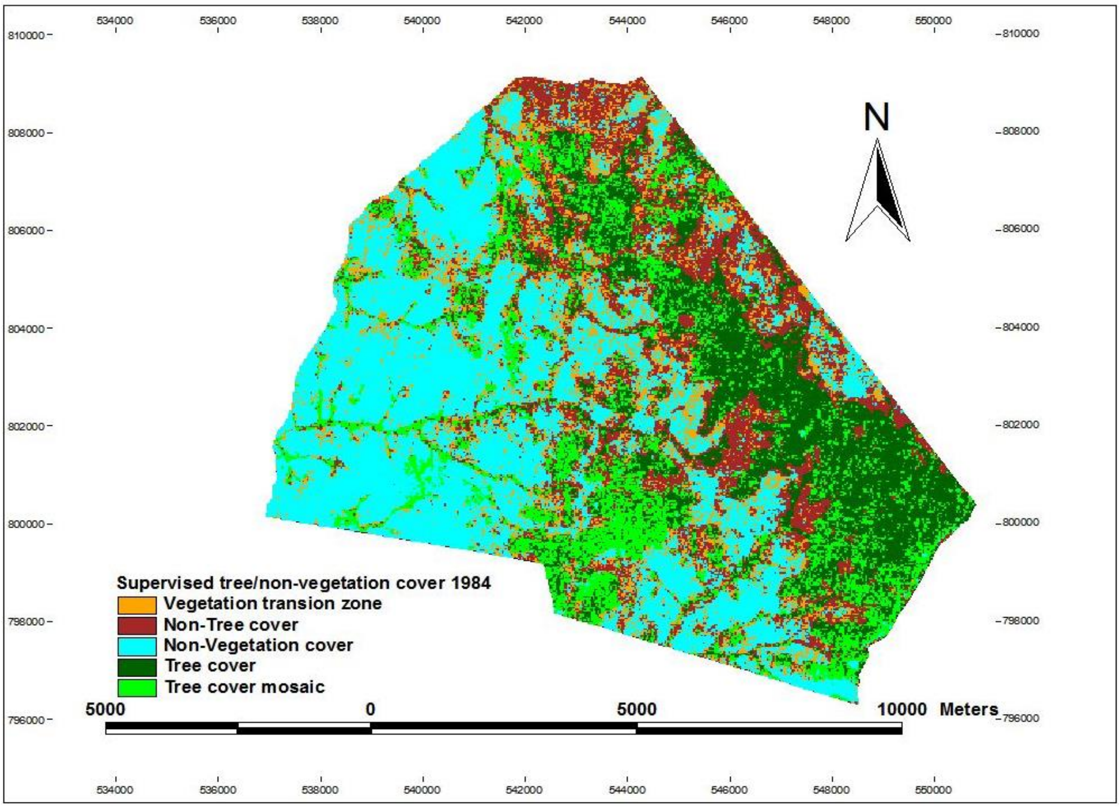

Fig. 5: Forest cover in the study area in 1984

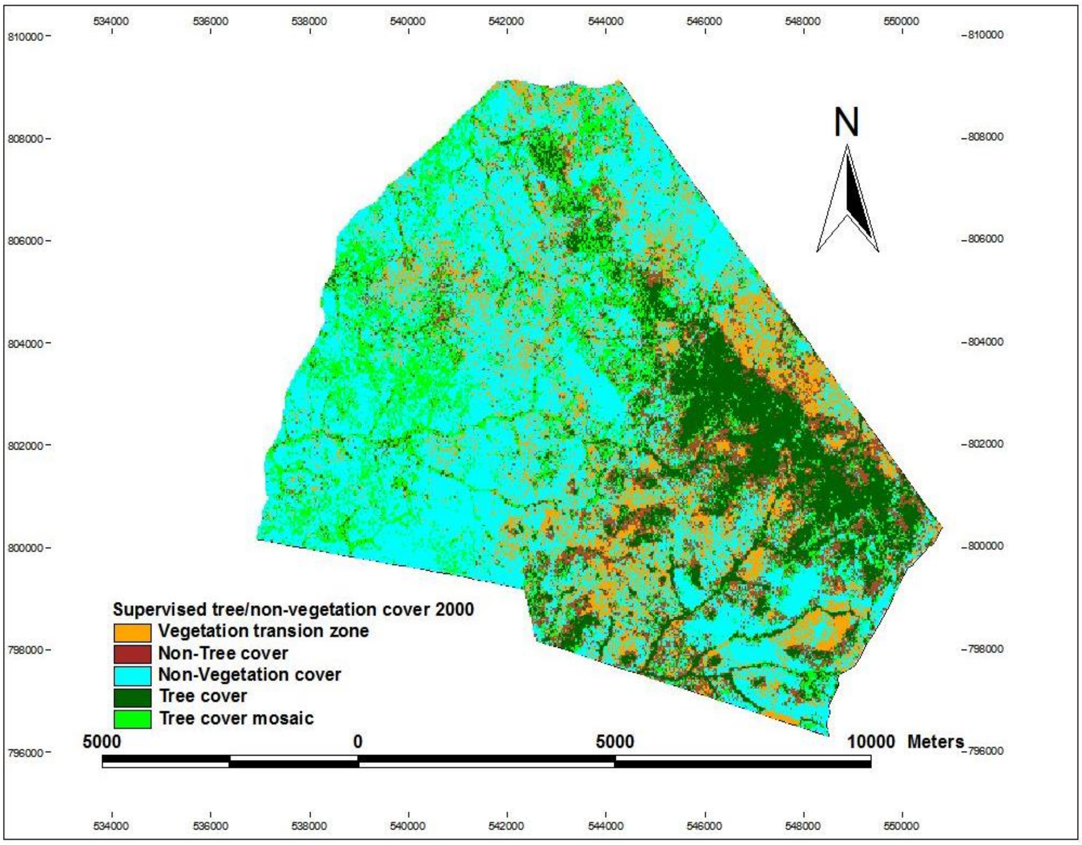

Fig. 6: Forest cover in the study area in 2000

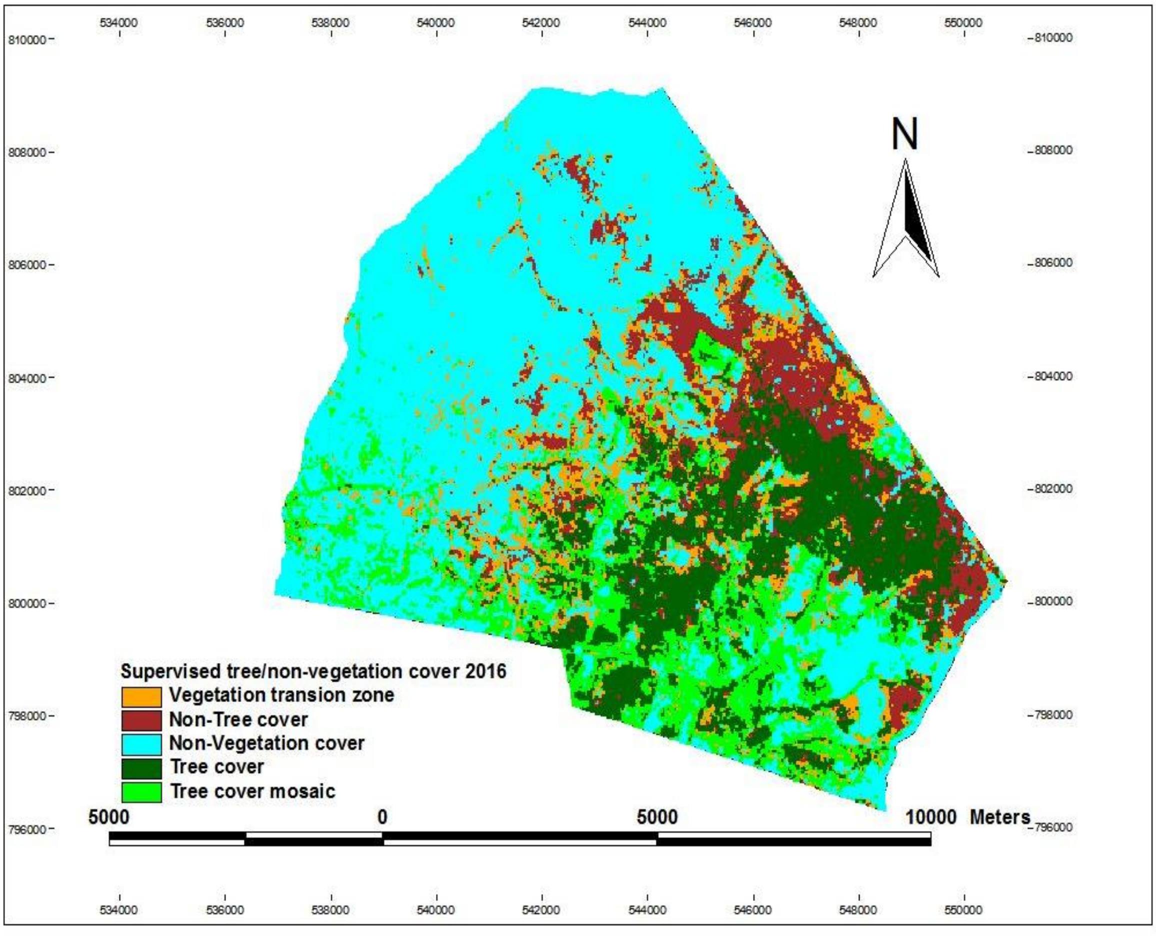

Fig. 7: Forest cover in the study area in 2016

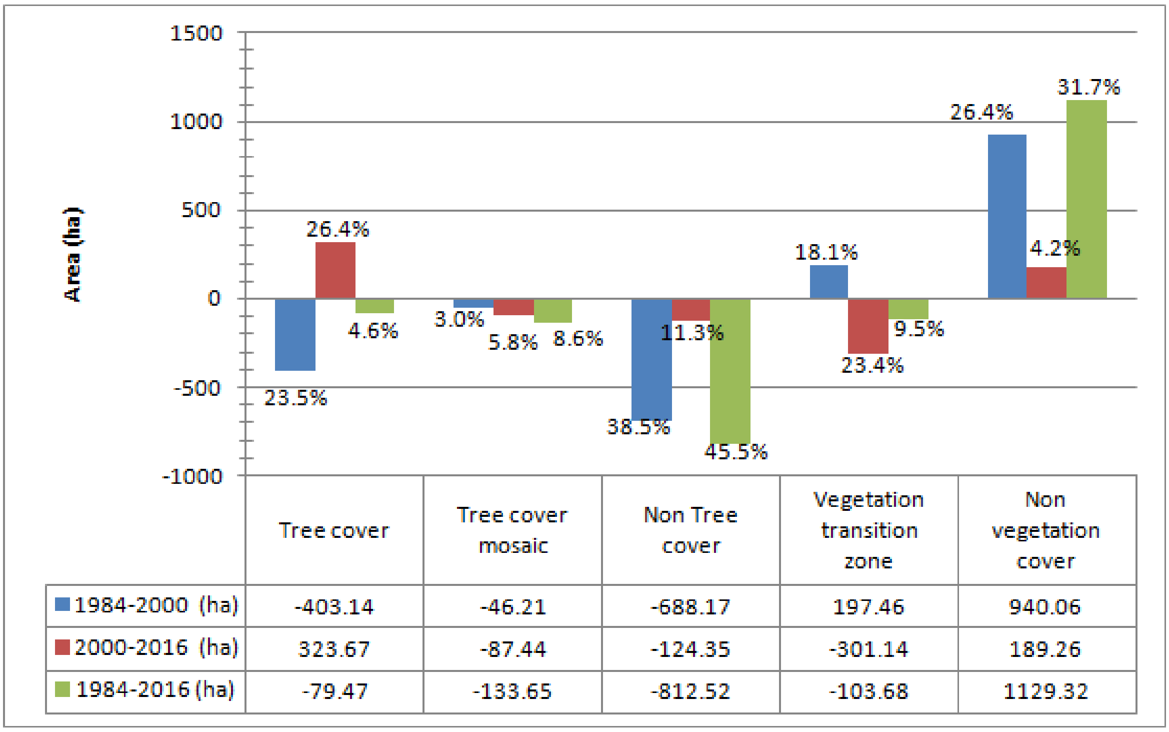

Fig. 8: Tree/non-vegetation cover gain and losses from 1984-2000, 2000-2016, and 1984-2016

Table 4: Conversion of vegetation cover to other non-vegetation cover types from 1984 to 2000

				2000				
	Classes	**VTZ**	**NTC**	**NVC**	**TC**	**TCM**	**TOTAL Area**	**Losses**
	VTZ	**184.71**	124.94	565.23	59.83	155.85	**1090.55**	**905.84**
	NTC	360.02	**253.13**	784.37	168.72	219.43	**1785.68**	**1532.55**
1984	**NVC**	372.95	224.47	**2141.64**	127.31	693.34	**3559.71**	**1418.07**
	TC	162.26	268.59	367.97	**700.41**	217.91	**1717.14**	**1016.73**
	TCM	208.13	226.48	640.71	257.44	**227.85**	**1560.61**	**1332.76**
	TOTAL Area	**1288.08**	**1097.6**	**4499.92**	**1313.70**	**1514.39**	**9713.70**	
	Gained	**1103.37**	**844.48**	**2358.28**	**613.29**	**1286.54**		

Source: Landsat Images 1984 to 2000 matrix table, Erdas Imagine 9.1
Vegetation transition zone (VTZ), Non-tree cover (NTC), Non-vegetation cover (NVC), Tree cover (TC), and Tree cover mosaic (TCM); Values in red colour depict diagonal values

Table 5: Conversion of vegetation cover to other non-vegetation cover types from 2000 to 2016

				2016				
	Classes	**VTZ**	**NTC**	**NVC**	**TC**	**TCM**	**TOTAL Area**	**Losses**
	VTZ	**156.91**	166.76	547.11	206.85	210.45	**1288.08**	**1131.17**
	NTC	126.16	**160.51**	336.12	298.39	176.44	**1097.61**	**937.10**
2000	**NVC**	473.16	271.00	**2671.10**	369.43	715.23	**4499.92**	**1828.82**
	TC	89.66	242.58	218.65	**621.76**	141.04	**1313.70**	**691.94**
	TCM	141.05	132.41	916.20	140.94	**183.80**	**1514.39**	**1330.59**
	TOTAL Area	**986.94**	**973.26**	**4689.18**	**1637.37**	**1426.95**	**9713.70**	
	Gained	**830.03**	**812.75**	**2018.08**	**1015.61**	**1243.15**		

Source: Landsat Images 2000 to 2016 matrix table, Erdas Imagine 9.1
Vegetation transition zone (VTZ), Non-tree cover (NTC), Non-vegetation cover (NVC), Tree cover (TC), and Tree cover mosaic (TCM); Values in red colour depict diagonal values

Table 6: Conversion of vegetation cover to other non-vegetation cover types from 1984 to 2016

	Classes	VTZ	NTC	NVC (2016)	TC	TCM	TOTAL Area	Losses
	VTZ	**137.43**	74.79	618.57	93.06	166.77	**1090.62**	**953.19**
	NTC	255.51	**255.69**	840.33	221.58	212.67	**1785.78**	**1530.09**
1984	**NVC**	335.88	89.82	**2312.28**	158.94	662.94	**3559.86**	**1247.58**
	TC	104.13	367.38	372.60	**736.29**	136.44	**1716.84**	**980.55**
	TCM	153.99	185.58	545.40	427.5	**248.13**	**1560.60**	**1312.47**
	TOTAL Area	**986.94**	**973.26**	**4689.18**	**1637.4**	**1426.95**	**9713.70**	
	Gained	**849.51**	**717.57**	**2376.9**	**901.08**	**1178.82**		

Source: Landsat Images 1984 to 2016 matrix table, Erdas Imagine 9.1; Vegetation transition zone (VTZ), Non-tree cover (NTC), Non-vegetation cover (NVC), Tree cover (TC), and Tree cover mosaic (TCM); Values in red colour depict diagonal values

Forest cover transition matrix during 1984 to 2016

Table 3 to 5 shown the results of transition pattern of various forest cover types in the study area during 1984 to 2016. The diagonal figures in the Tables (Table 4 to 6) shown the amounts of forest cover types that remained unchanged (persistence) at a given period, while the column ‘‘gain’’ and row ‘‘loss’’ showed the amount of increase or decrease in a particular forest cover type, as well as the trajectories of the conversions (Alo and Pontius 2008). Obviously, the result revealed that out of the 1717.14 ha of Tree cover (TC) in 1984, 700.14 ha remained unchanged, while 162.26, 268.59, 367.97 and 217.91 ha were lost to vegetation transition zone (VTZ), Non-tree cover (NTC), Non-vegetation cover (NVC), and Tree cover mosaic (TCM) in that order. However, the total loss and gain by TC during that period were 1016.73 and 613.29 ha, in that order (Table 3A). TCM occupied 1514.39 ha in 2000, out of which 183.80 ha remained unchanged while 141.05, 132.41, 916.20 and 140.94 ha had changed to VTZ, NTC, NVC and TC respectively. Similarly, out of the 1785.78 ha of NTC in 1984, only 255.69 ha remained stable in 2016, while 255.51, 840.33, 221.58 and 212.67 ha converted to VTZ, NVC, TC and TCM respectively. NTC and VTZ markedly shrunk from 1785.78 ha and 1090.62 ha in 1984 to 973.26 ha and 986.94 ha in 2016. NVC increased from 3559.86 ha in 1984 to 4689.18 ha at the expense of VTZ, NTC, TC and TCM, which decline with 618.57, 840.33, 372.60 and 545.40 ha in 2016, respectively. These transitions reflect that, there is a forest cover dynamics in the FUNAAB land area. These changes may not only responsible by anthropogenic activities such as indiscriminate felling of trees to pave way for agriculture, fuel wood extraction, and overgrazing by cattle as evidence has reflected of their scattered settlements by the Fulani herdsmen observed during the field visual survey but could also be as a result of climate factor such as rainfall. Moreover, The gains is a reflection of forest succession on non- vegetation (bared/settlements) land as well as natural regeneration of trees on sites where trees were cleared for farm land and timber extraction in the study area, while the losses could be traced to increasing demand of forest product arising from population increase and industries. Forest shift results from various trends such as natural regeneration of forests, forest plantation, and adoption of agroforestry (Meyfroidt & Lambin, 2011). Movement of farmers from rural areas to urban centre and an economic transition from agriculture to industry and services stimulate forest recovery and gain (Aide & Grau, 2004). Globally, community forest management (CFM) has been considered a promising approach to sustainable forest management over the past few decades (Arnold, 2001). The role of community forest had been acknowledged in the context of tropical countries in maintaining forest cover than protected areas; community forestry has lower deforestation rates than protected areas do (Porter-Bolland *et al.*, 2012).

Causes of forest cover change and land cover dynamics

Forest cover change can be explained by many factors such as shifting cultivation, clearing of young trees by charcoal producer and selective extraction of timber by timber contractors, also influx of people from city as a result of employment generation/source of income when the forest product is being exported to the city. In a derived savanna area, such as study area, anthropogenic activities such as agriculture has a direct impact on forest/vegetation cover as reported by many authors such like Lambin *et al.* (2003), Carpe (2005), Dibi N’Da *et al.* (2008), and Jansen *et al.* (2008). However, the most important consequences that cause forest clearing comes from intensive forest resources uses, illegal logging and trade as reported by these researchers Joshi (2001), Boltz *et al.* (2003), Atmoparwiro (2004) and Zaitunah (2004). Furthermore, it has been established that forestland use change in Nigeria is caused mainly by rural farming activities following their strong dependency on forestland as cited by FAO (2001), Park (2002), Sharma (2004), NPF (2006), Tyani (2007) and Adekunle (2011). Rising in human population and global climate change have contributed to vegetation cover losses and gains in a seasonally dry tropical ecosystem globally as reported by these authors Lambin *et al.* (2003) and Lepers *et al.* (2005). Sand and gravel mining is also a factor responsible for forest clearing in the stud area. Kori and Mathada (2012) reported that these activities impact positively local economy as well as important sources for the economic development activities of developed and developing countries.

Impacts of forest cover change

Forest clearance over a large area affects local climate condition such as temperature variation and precipitation patterns as reported by Deo (2011), Junkermann *et al.* (2009), and Pitman *et al.* (2004). As a result of vegetation cover changes, the radiant energy available for the purpose of plant transpiration, evaporation and convection between the land and the atmosphere and soil moisture feedbacks can modify local climate and local land-use change. Vegetation clearance releases large qualities of greenhouse gases into the atmosphere as it no longer serves as CO_2 sink, which increase overall carbon emissions and exacerbate anthropogenic climate change (IPCC 2007). Disappearance of riparian vegetation can have adverse effect on its catchment area and its hydrological and biochemical cycles which can eventually lead to stream bed erosion and siltation leading to water shortage. Farming activities and continuous sand mining operations in and around the study area can lead to biodiversity loss, alteration of ecosystem services, species endangerment and wildlife habitat destruction as reported by

FAO (2000), Shonekan (2004) and Don-Pedro (2009). Bell *et al.* (2007) observed that extreme weather condition arising from increase in forest savanna transition zones post high risk of health implications such as unfavorable weather condition can lead to cardiovascular diseases as well as modification of microclimate. Vegetation cover loss will eventually lead to disappearance of potential medicinal properties because; most woody species is an importance source of medicines especially to local people (Kafaru, 1994; Otegbetye and Otegbeye 2002). Flooding is a factor of land use change in FUNAAB land area resulting from deforestation thereby causing degradation of quality and amount of ecosystem services around the study area and the world, reducing biodiversity, undermining the flood retention capacity and soil stability as well as producing negative impacts on local livelihoods and regional economies as cited by Wagner *et al.* (2015).

Conclusions

It is evident that the establishment of tree crop plantation had contributed to reduce rate of forest degradation at moderate rate between 2000 and 2016. However, forest cover dynamics has taken place in the study area from 1984 to 2016. Comparatively, among the classes the percentage change of various forests covers is higher during 2000 to 2016 compare to the year 1984 to 2000 and 1984 to 2016. However, between 1984 and 2016, there was an increase in size of NVC category of land area with an increase of 31.7%, at an average rate of 1% per annum. Moreover, NTC, VTZ, TCM and TC experience negative changes of 45.5, 9.5, 8.6 and 4.6%, respectively, with average rates of 1.4, 0.3, 0.3 and 0.1% per annum, respectively. The gross loss was highest for NTC followed by TCM and while the gross gain was highest for NVC, followed by TCM and TC during the period of study. The significant portion of forest covers types during the period of study are tree cover to tree cover mosaic, tree cover mosaic to vegetation transition zone, vegetation transition zone to tree cover. These forest covers dynamics are highly linked to pressure from anthropogenic activities within and around the study area. The hotspot of deforestation in the study area is northwestward where excessive forest degradation resulting from charcoal producers, timber logging and poor fodder management has been observed. Generally, the findings from this study affirmed that study area is currently faced with forest resource degradation, a problem arising from indiscriminate clearing of land and bush burning, illegal timber extraction, expansion of shifting cultivation, sand mining operation and settlement of Fulani herdsmen. However, tree crop expansion can reduce rate of deforestation and forest degradation. It is therefore obvious that spatial distributions and changes in forest cover types could offer interesting insights into more local-scale processes and activities that are detrimental to the ecosystem services in the area.

Recommendations

The study recommends regular patrolling within and outside the study demarcated area and as well installed check points at strategic places, this will ensure maximum protection of the study area boundary and as well police the intruders causing forest resources degradation.

There is an urgent need for management to direct efforts towards protecting abandoned degraded strict nature reserve towards developing conservation strategies that would ensure effective and efficient management of forest resources in the study area.

Public campaign and seminars about the negative consequences of forest resources degradation on natural environment and human welfare is indispensable towards building the right behavior and political goodwill among the immediate communities of the University, this would promote the enforcement of conservation policies in the study area.

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Conflict of Interest

Authors declare that there are no conflicts of interest.

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