



**COLLABORATION OF STAKEHOLDERS FOR DYNAMIC  
RESTORATION OF FOREST ESTATE IN NIGERIA**



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## Land Use Mapping and Change Detection of Abayomi Forest Estate Ikoyi, Osun State, Nigeria

Abiodun Akintunde Alo and Timilehin Adewole

Department of Social and Environmental Forestry,

University of Ibadan, Nigeria.

e-mail: [akintundealodaniel@gmail.com](mailto:akintundealodaniel@gmail.com)

### Abstract

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*Incessant encroachment of log poachers, bush burning, conversion of forest for agricultural purposes and other land use contribute largely to deforestation in Nigeria. However, adequate information about the changes in most of our forest ecosystem is scarce. Therefore, this study examined the use of Geographic Information System (GIS) and Remote Sensing (RS) in mapping Land Use Land Cover (LULC) dynamics in Abayomi Forest Estate, Ikoyi, Osun State between 2006 and 2016 with a view to providing information for relevant stakeholders in forestry for sustainable management. Satellite imagery and sketch map of Abayomi Forest Estate were obtained. Coordinates of some bench mark places that could be identified on satellite imagery, sketch map and on ground were obtained. Historical imageries for 2006, 2011 and 2016 of the study area were also obtained. The coordinates of the bench mark places were used to georeference the sketch map. The georeferenced sketch map was used to develop shapefile for the study area. This was superimposed on the satellite imagery to delineate various land use through vectorisation. After vectorisation, the historical imageries of 2006, 2011 and 2016 were analysed using open layer plugin geospatial algorithm of quantum GIS to determine the changes in various land use within the forest ecosystem. Geometry algorithm was used to determine the various land use size of each year. It was observed that eight land use land cover; forest (73.16 ha), oil palm plantation (29.96 ha), bareland (0.18 ha), pineapple plantation (0.16), built up area (0.13 ha), forest road, footpaths and water bodies were delineated from a total of 103.59 ha of the study area. Forest recorded absolute change of -0.37 and 0.00 between 2006 and 2011 and between 2011 and 2016 respectively. The Oil palm Plantation recorded absolute change of -0.06 and 0.00 between 2006 and 2011 and between 2011 and 2016 respectively. Bareland and built-up area recorded 0.16 and 0.11 between 2006 and 2011 while between 2011 and 2016, both recorded zero absolute change. The forest estate was maintained in a sustainable manner between 2006 and 2011 and under strict conservation without any iota of deforestation.*

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**Keyword:** Change detection, land use, deforestation, conservation and management

### Introduction

Whenever there are continuous anthropogenic activities on land cover for a considerable long period of time, change in both the land cover and land use is inevitable. These land use land cover changes play major roles in climate change and serve as important driver of water, soil and air pollution (Skole, 1994; Zhou *et al.*, 2008; UNCCD, 2017) as well as accelerating and causing many other environmental problems (Ringrose *et al.*, 1997). Land use and land cover data are essential for planners, decision makers and those concerned with land resources management (Ndukwe, 1997; Ezeomodo, 2006). Monitoring and analysis of the environment make use of up-to-date Land Use and Land Cover (LULC) information, for sustainable management of urban areas (Ndukwe, 1997; Ezeomodo, 2006). In most of the developing countries, especially in Nigeria, there has not been adequate monitoring of most of our forest ecosystem. This has led an alarming rate of deforestation and forest degradation in these

developing countries of the world in recent times (Ezeomodo, 2006; Runge, 2006; FAO, 2010). Around 13 million hectares of forest were converted to other uses, largely agriculture, or lost through natural causes each year in the last decade (FAO, 2010). Environmental stress by disruptive deforestation has continued to impact on the rainforest ecosystem in Nigeria. (Howard, 1991) observed that “in the scenario of a rapidly expanding world population, changes in land use and declining land cover, remote sensing has the role of an emerging discipline, and provides essential tool to the field forester. As an important tool, remotely sensed data from different earth observation satellites are available to monitor the spatial evolution of tropical forest ecosystems (Runge, 2006).

Currently, technologies such as geographic information systems (GIS) and remote sensing (RS) provide ample opportunities for understanding landscape dynamics. They are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas of land (Carlson and Azoifeifa, 1999; Guerschman *et al.*, 2003; Rogana and Chen, 2004; Zsuzsanna *et al.*, 2005). The basic premise in using satellite images for change detection is that changes in land cover results in changes in radiance values that can be remotely sensed. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computing power (Rogana and Chen, 2004). Land cover/land use has been used extensively to derive a number of biophysical variables, such as vegetation index, biomass, and carbon content. More importantly, land cover/land use pattern and its change reflect the underlying natural and/or social processes, thus providing essential information for modeling and understanding many different phenomena on the Earth. Knowledge of land cover/land use and its change is also critical to effective planning and management of natural resources (Guerschman *et al.*, 2003; Rogana and Chen, 2004).

According to Skidmore, (2002), land use change is a common phenomenon in all parts of the world. Such changes may be rapid (e.g. clearing of forest for agricultural purpose) or relatively slow (e.g. tree damage and death due to acid rain) (Rogana and Chen, 2004; Naseri *et al.*, 2004) and may affect both socio-economic and ecological conditions (Naseri *et al.*, 2004). Phat *et al.*, (2004) reported that the 21st century has brought new challenges for forest management and forest ecosystems. This potentially constitutes an extremely important tool for dealing with climate change, in addition to the ameliorative actions (Cai *et al.*, 2011). Spatial dimensions of land use and land cover need to be known at all times. This will enable policy makers and scientists to be sufficiently equipped to take relevant decisions on land resources. Therefore, a wide range of researchers and practitioners, including earth systems scientists, land and water managers as well as urban planners seek information on the location, distribution, type and magnitude of land use and land cover change (Weng, 2002). Considering the increase in the need of plantation forests, reserves and the palpable land use/land cover changes, it is imperative to take advantage of the GIS and remote sensing technologies to ascertain the extent and rate of establishment of private forestry and land cover changes with time. It is expected that such information will enhance management decisions that will ensure sustainable management of forest resources (Guerschman *et al.*, 2003; Rogana and Chen, 2004; Naseri *et al.*, 2004). However, In Abayomi Forest Estate (AFE), the changes that has occurred over time has not been determined. As a result, it was impossible to know the trend of change over

time in the forest ecosystem. Information on the areas where beating up was needed was also not available. The size of each segment of the land use within the forest ecosystem was also not known, which might help to know which of them needs to be increased in size based on the management objective for which the forest estate was set up. Therefore, this study is aimed at determining the land use land cover and their dynamics between 2006 and 2016 with a view to providing reliable information for the sustainable management of the forest ecosystem.

### Methodology

Abayomi Forest Estate is located in Isokan Local Government Area of Osun State. The reserve covers approximately 103.59 ha. The forest is located between latitudes  $7^{\circ}17'47.85''\text{N}$  and  $7^{\circ}17'19.35''\text{N}$  and longitudes  $4^{\circ}7'57.65''\text{E}$  and  $4^{\circ}8'4.98''\text{E}$  (Figure 1). The forest is bordered by River Osun and a tributary of the river passes through the forest which is called River Aworin. It lies in the lowland rainforest zone of Nigeria. It is about 398.70 m above sea level (asl). The data collected for this study include: sketch map of Abayomi Forest Estate; satellite imageries (historical imagery) of the study area for 2006, 2011, and 2016; coordinates of some bench mark places like major roads and junctions, hills, and river in the forest that can be easily identified both on the satellite images with the aid of handheld Global Positioning System.

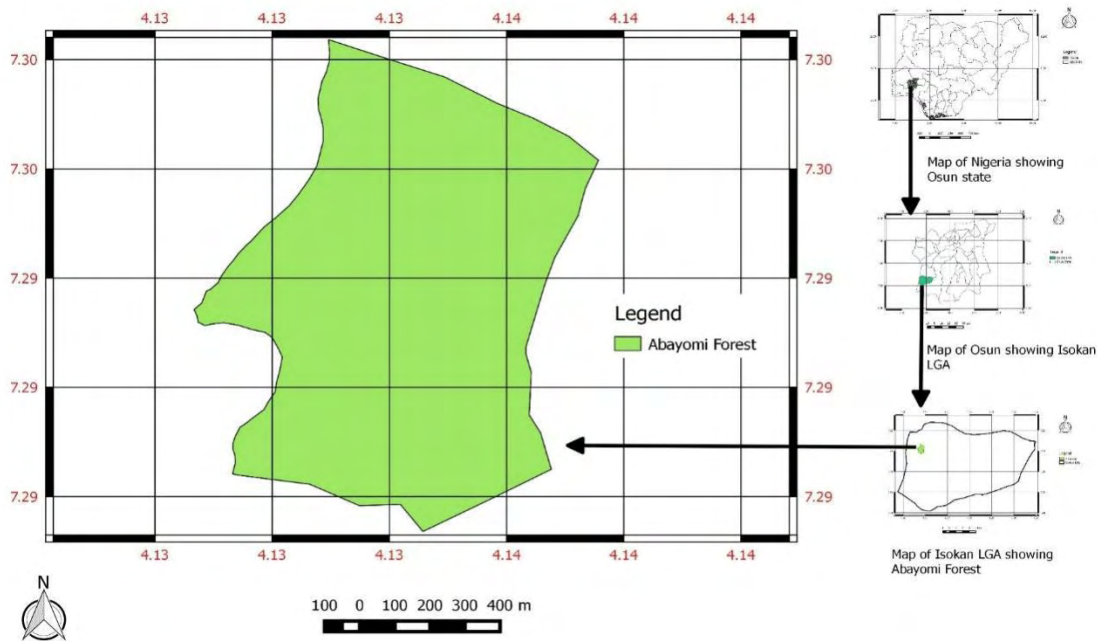


Figure 1: Abayomi Forest Estate, Ikoyi, Osun State.

## Method of Data Analysis

The coordinates of the bench mark places obtained were used to georeference the sketch map of the study area to produce the shapefile of AFE. The historical satellite imageries were also georeferenced. The shapefile was superimposed on the satellite imageries and various land use within the study area were vectorized. Lines of varying colours and sizes were used to digitize the roads and rivers while polygons of different sizes and colours were used to digitize various land use and forest types. When the historical imageries of the study area for the years under consideration, (2006, 2011 and 2016) have been vectorized in QGIS, the area for each category of mapping units was calculated through each unit measurement. Each mapping unit was measured to know the total size of the area occupied, the measured size was now used to calculate the percentage composition of the mapping unit in the forest area. After the percentage composition has been determined, absolute change between the years was calculated by subtracting the initial time matrices from the final time matrices (Equations 1 and 2). Percentage change of each year was then calculated from the absolute change (Equation 3). Furthermore, the percentage change that has occurred between the years was calculated (Equation 4). This was followed by the determination of rate of change (Equation 5).

$$\text{Percentage composition} = \frac{\text{observed area size}}{\text{total area size}} \times 100 \dots\dots\dots (1)$$

$$\text{Absolute change} = \text{final time matrices} - \text{initial time matrices} \dots\dots\dots (2)$$

$$\text{Percentage change } (\Delta) = \frac{\text{absolute change}}{\text{initial time matrixe}} \times 100 \dots\dots\dots (3)$$

$$\text{Percentage change (year)} = \frac{\% \Delta \text{year 3} - \% \Delta \text{year 1}}{\% \Delta \text{year 1}} \times 100 \dots\dots\dots (4)$$

$$\text{Rate of change} = \frac{\text{percentage change}}{\text{time difference}} \dots\dots\dots (5)$$

## Results and Discussion

### *Land Use Land Cover*

Eight (8) land use land cover classes were delineated from AFE, viz; forest, oil palm plantation, pineapple plantation, bareland, built-up areas, water bodies Forest road and foot paths (Table 1 and Figures 2 to 4). The forest comprises high forest in protected area for conservation purpose while the built-up area is the piece of land where construction of hostels is made for students coming for research purpose and workers of the forest estate. Oil palm plantation on the other hand, is the area of land where oil palm has been established and Pineapple plantation is the area that has been cleared for cultivation of pineapple. Bare land on the other hand, occurred as a result of human activities near and around the built-up area. Water bodies referred to the streams and rivers within the forest ecosystem. The forest estate covers approximately 103.59 ha. There were two major water bodies (River Osun and River Aworin) within the

forest estate (Figure 2) in 2006 with only a footpath traversing the forest. In 2011 and 2016, the numbers of footpaths and forest roads have increased tremendously to allow proper monitoring of the forest resources (Figures 3 and 4). Each of the footpaths joining each other at some points spanning almost the entire forest area. Going by the digital maps for all the years under consideration in this study (Figures 2 to 4), oil palm plantation is situated at the north while the forest occupied the south with the hostels at the eastern part of the forest estate.

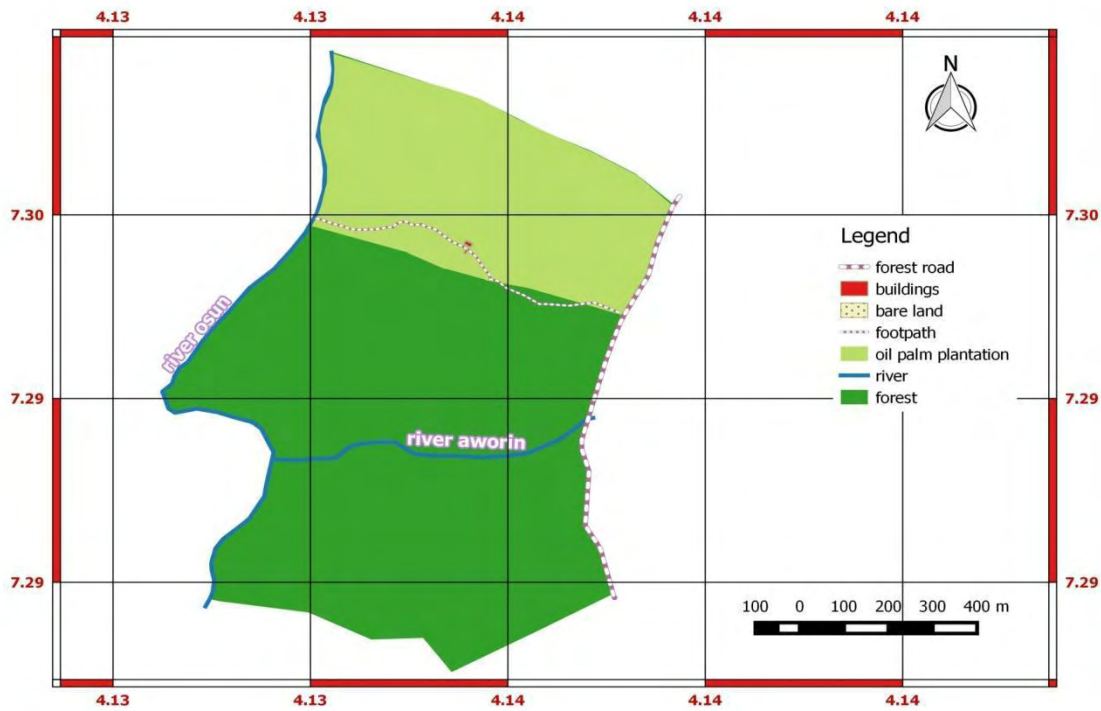


Figure 2: Abayomi Forest Estate in 2006.

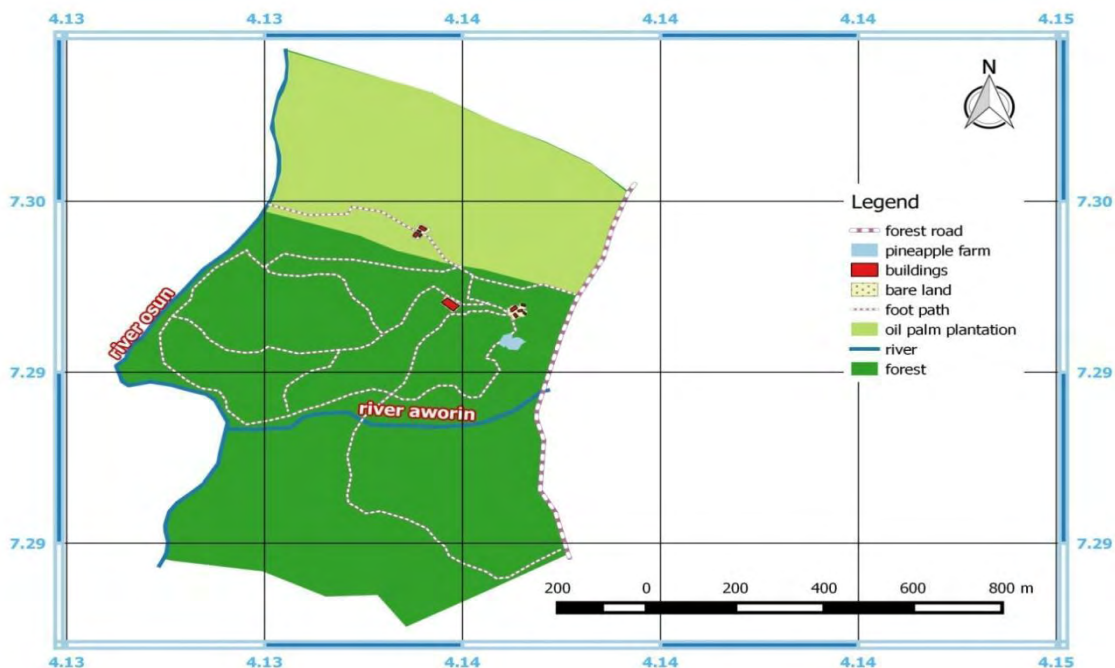


Figure 3: Abayomi Forest Estate in 2011.

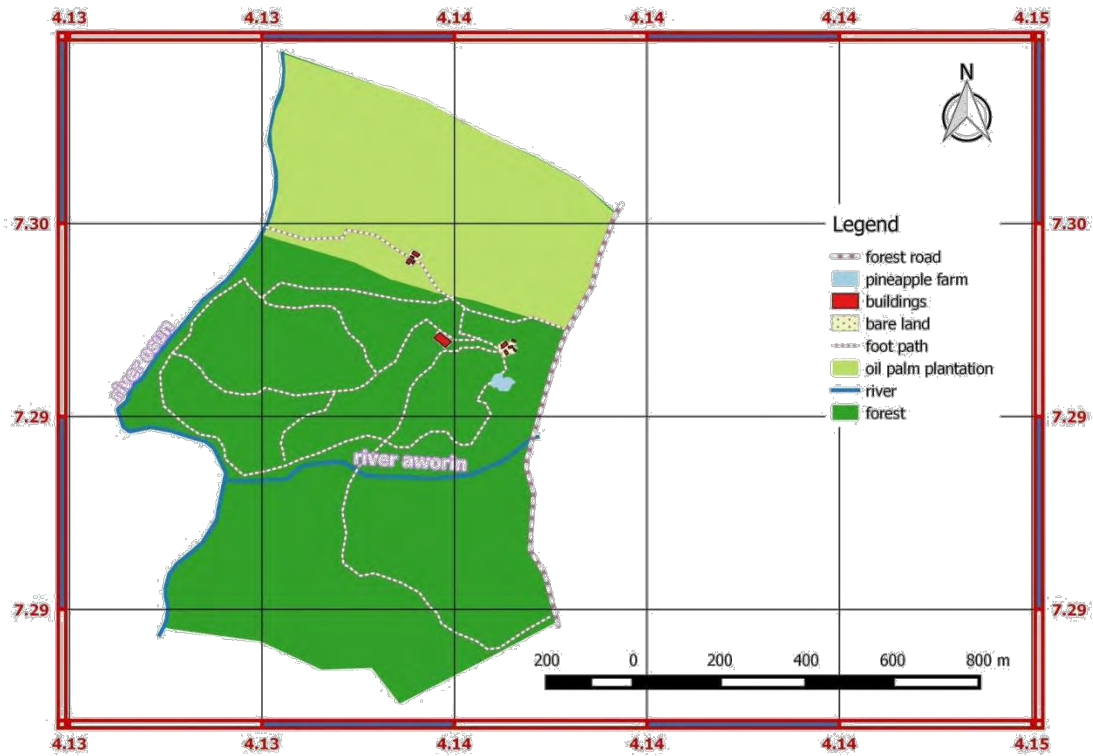


Figure 4: Abayomi Forest Estate in 2016.

From the land use delineated, forest accounted for 70.99 % (73.53 ha) of the total land area in 2006 (Table 2). This was reduced to 70.63 % (73.16 ha) and 70.63 % (73.16 ha) in 2011 and 2016 (Table 2). Another major land use identified in the study area was the oil palm Plantation, which was about 30.03 ha, 29.96 ha and 29.96 ha accounting for 28.98 %, 28.92 % and 28.92 % of the total land area for 2006, 2011 and 2016 respectively. However, there was no pineapple plantation in 2006 until 2011 and that continued to 2016. The plantation maintained the same size of 0.16 ha (0.16 %) from 2011 to 2016. Built-up area and bare land on the other hand increased from 0.02 ha and 0.01 ha in 2006 to 0.13 ha and 0.18 ha, respectively in 2011 and maintained their sizes till 2016. Going by the spatial distribution of various land use and land cover in the study area, land area cover with vegetation (forest, oil palm and pineapple) recorded about 103.56 ha, 103.12 ha and 103.12 ha accounting for 99.97 %, 99.55 % and 99.55% of the total land area for 2006, 2011 and 2016, respectively. Non-vegetation covered about 0.03 ha, 0.47 ha and 0.47 ha accounting for 0.03 %, 0.47 % and 0.47 % for 2006, 2011 and 2016, respectively (Table 1).

### Land Use Land Cover Change Matrix

Table 2 showed the change matrix of land use and land cover types in Abayomi Forest Estate between 2006, 2011, and 2016. The change matrix featured the absolute change, the percentage change and the rate of change. It was observed that the changes largely occurred between the year 2011 and 2006 because there was no changes in the land use classes between 2006 and 2011. Forest and oil palm plantation have negative absolute change, percentage change and the rate of change between 2011 and 2006 which means there was decrease in the land area they occupied. Pineapple plantation, built-up area and bareland recorded positive change matrix which implied that there was increase in the land

area. The rate of change negatively was highest in the forest area (-0.10%) while the rate of change positively was highest in the bare land followed by the built up area. Between 2006 and 2011, absolute change and rate of change were higher in forest (-0.37 and -0.10 ha) than plantation (-0.06 and -0.04 ha). Whereas, there was no change recorded between 2011 and 2016 for both forest and plantation. Built up area recorded 0.11 absolute change between 2006 and 2011.

Table 1: Land use land cover of Abayomi Forest Estate in 2006, 2011 and 2016.

Land use land cover Categories	2006		2011		2016	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Forest	73.53	70.99	73.16	70.63	73.16	70.63
Oil palm plantation	30.03	28.98	29.96	28.92	29.96	28.92
Pineapple plantation	-		0.16	0.16	0.16	0.16
Buildings	0.02	0.02	0.13	0.12	0.13	0.12
Bare land	0.01	0.01	0.18	0.17	0.18	0.17
Total	103.59	100	103.59	100	103.59	100
Vegetation	103.56	99.97	103.12	99.55	103.12	99.55
Non-vegetation	0.03	0.03	0.47	0.45	0.47	0.45
change in forest				-0.36		0.00
change in plantation <sup>1</sup>				-0.95		0.00
change in other land use <sup>2</sup>				0.26		0.00

Table 2: Change matrix of land use/land cover types in Abayomi Forest between 2006, 2011, and 2016.

Class	2006	2011	2016	absolute change	% change	rate of change	absolute	%change	rate of
	(ha)	(ha)	(ha)	(2006-2011)	(2006 - 2011)	(2006 - 2011)	Change	(2006- 2011)	change

<sup>1</sup> Plantation include both oil palm plantation and pineapple plantation

<sup>2</sup> Other land use are areas that are neither secondary forest nor plantation but include bare land, buildings, forest road and footpaths.

							(2006 - 2011)	(2006 - 2011)	(2006 - 2011)
Forest	73.53	73.16	73.16	-0.37	-0.49	-0.10	0.00	0.00	0.00
Oil palm Plantation	30.03	29.96	29.96	-0.06	-0.20	-0.04	0.00	0.00	0.00
Pineapple plantation	0.00	0.16	0.16	0.16	0.00	0.00	0.00	0.00	0.00
Building	0.02	0.13	0.13	0.11	677.71	135.54	0.00	0.00	0.00
Bare land	0.01	0.18	0.18	0.16	1303.17	253.97	0.00	0.00	0.00

## Discussion

The high percentage of land recorded by forest all through the years under consideration in this study (70.99 %, 70.63 %, and 70.63 %, for 2006, 2011 and 2016, respectively) was as a result of the fact that the primary objective for establishing AFE was for conservation of flora and fauna of the forest ecosystem so as to increase the genetic resources and biodiversity. The reduction observed in the size of the forest (-0.37 ha) between 2006 and 2011 was because of the portion of the forest that was converted to; hostel (0.11 ha) for the provision of accommodation for the practical year training programme students and other researchers that may want to conduct research in the forest estate, pineapple plantation (0.16 ha) and an increase in bare land (0.1 ha) around the hostel newly constructed. The change recorded in the forest between 2006 and 2011 was due to deliberate attempt to provide accommodation. Between 2011 and 2016, no additional accommodation was added to the existing ones (built-up area absolute change = 0.00) coupled with non-increase in the size of pineapple plantation (absolute change = 0.00), it follows that forest land will remain constant from 2011 to 2016. The result obtained in this study between 2006 and 2016 revealed that the forest estate is managed in a sustainable manner. This is in agreement with FAO, (2000) and FAO, (2016) that in spite of increase in demand of forest products, it should still be managed in a sustained manner as part of the principles of sustainable forest management. When forest ecosystem is depleted, many other animal and plant species that depend on the forest for shelter as well as its resources may go into extinction (Thakkar, 1999; Xiaomei and Rong Qing, 1999; Petit *et al.* 2001; Pearce, 2006). Furthermore, it was observed that there were no activities of poachers, illegal fellers and other activities that could lead to deforestation in the study area unlike the common practice in most of the public forest especially in the southern Nigeria. Thereby gives a tendency of increasing genetic resources and biodiversity with the forest ecosystem. This further proves that private sector manages forest more sustainably than public sector (Oriola, 2015; UNCCD, 2017).

The next land use to the forest identified in the study area was oil palm plantation. It was the second largest land use in the study area because the income generated from the production of oil palm is used to pay the wages of the forest workers. Therefore, it is an integral part of AFE. The oil palm plantation covered about 30.03 ha of land in 2006 and decreased to 29.96 ha in 2011. The decrease in size observed between 2006 and 2011 in the oil palm plantation (-0.07) was not farfetched from the increase in the bareland (0.07 ha) both around the buildings constructed at the oil palm area for palm oil production and around the newly constructed hostels. Between 2011 and 2016, there was no change in the size because of similar reason given for the forest above. The result obtained on oil palm plantation is similar to the one obtained by Abbas, (2009) and Michael and Chris, (2013) who reported that there is little or no change of forest to oil palm plantation except there is continued conversion to agricultural purpose or for other purposes like urbanization. In AFE, since, it a private forest recognized by the United Nations, conversion to agricultural and other uses may be difficult.

Information obtained from the workers in the forest estate and satellite remote sensing revealed that the forest estate is a secondary forest. In other words, it has been logged to some extent before the forest was acquired but has now recuperating to take the form of natural forest. The imagery of 2006

showed that there was possibility of the logging activities in the past. However, the logging in the forest did not affect the size of the forest but rather reduction in stand density and quality as reported by Lanly, (2003). The forest estate has shown that it is being managed in a sustainable manner in the last ten years. The changes observed from the change matrix is largely because of the construction of researchers' accommodation, which is very important for the project since researchers are expected to be using the forest estate for research from time to time and during this activities, the activities of encroachers in the forest ecosystem were checkmated. Conservation and protection of forest land use and cover are still imperative to ensure that forest resources are controlled from unsustainable land use practices at the local scale (Jackson, *et al.*, 2012)

## **Conclusion**

Eight different land use land cover classes were delineated in the study area. They include; forest, oil palm plantation, pineapple plantation, built up areas, bare land and water bodies. Geographic information system is a good tool in delineation of land use land cover of any given area. Over 99 % of the entire AFE comprise secondary forest and plantation while less than 1 % comprise built up area and other land use. Since there was no change observed between 2011 and 2016 from the forest, oil palm plantation and bareland as well as built up area, the forest estate is therefore relatively conserved with little or no anthropogenic activities that could lead to deforestation.

## **Recommendation**

The digital map of Abayomi Forest Estate obtained in this study is adequate and can be used for further research. Efforts should be made to maintain conservation of the forest estate and preclude any level of deforestation in the study area. Therefore, the management should focus on protection of the forest against external forces and improvement of the forest where possible. The acquisition of this data and interpretation is made easy with the use of geographic information system and remote sensing methods, this means more effort should be put into using remote sensing in schools and government agencies for assessing the quality of our forest for better information and better decision making process.

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