CHANGE DETECTION ANALYSIS OF LAND USE LAND COVER CHANGES OF SHASHA FOREST RESERVE, OSUN STATE, NIGERIA USING GEOSPATIAL TECHNOLOGY.

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Abstract
While land cover embraces the quantity and type of surface vegetation, water and earth materials, land use can be in form of grazing, agriculture, urban/rural development, logging, and mining among others. These activities mostly result in deforestation, particularly when there is over-exploitation. This paper analyzed the effect of land cover change on vegetation indices in Shasha Forest Reserve, Nigeria between 1984 and 2002 in order to detect the changes that had taken place within the period. The trend was studied using Landsat imageries acquired in 1984, 1991 and 2002; these were subjected to image processing using the same classification scheme in Idrisi 17.1 and ArcGIS 10.1 environment. A comprehensive map of the Forest Reserve was generated to show the array of changes in land cover and vegetation indices, quantity of change between 1991 and 2002. Differences in the values obtained from the three sets of imageries were converted to percentages. It was observed that there were five land cover classes. Over the study period, the Normalized Difference Vegetation Index (NDVI) reduced from +0.36 to +0.14 in 1984 to +0.14 to -0.22 in 2002, implying reduction in greenness of the forest reserve over the years. This study further affirmed the contribution of remote sensing and GIS in the monitoring and proper utilization of forest reserves for sustainable development and forest resources management.

Keywords: Land use, Vegetation index, GIS, Sustainable development, Shasha Forest Reserve, Nigeria.

Introduction
The forest has been noted as a provider of variety of products and performing many essential environmental/ecological functions (World Bank, 1996 and Sanusi, 1997). Non-wood forest products include gum, bark, resins, leaves, medicinal plants and wildlife species. Apart from the tangible benefits derived from forests, forest also serve as carbon sink because trees absorb carbon dioxide from the atmosphere thereby reducing global warming effect. Due to both tangible and non tangible benefits from the forest it becomes imperative to regularly monitor the forest with remote sensing technology. And this can be done by the utilization of multi-temporal remote sensing data to identify land cover change. Skidmore (2002) stated that “Land cover change is a common phenomenon in all parts of the world. Such changes may be rapid (e.g. clearing of forest for agriculture) or relatively slow (e.g. tree damage and death due to acid rain)”, and Aspinall (2006) further stresses that the change may affect both socio-economic and ecological conditions. The process is termed change detection; it includes the quantification of imageries to derive changes over two or more time periods (Coppin et al., 2004). It is a key process in monitoring and managing natural resources and urban development because it provides a quantitative analysis of the spatial distribution of the population of interest. Change detection is useful in such diverse applications as land cover change analysis, shifting cultivation, monitoring, deforestation, assessment, changes in vegetation phenology, seasonal changes in pasture, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes (Singh, 1989).

Normalized Difference Vegetation Index (NDVI) is simply a numerical indicator that is used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assessment of greenness of target being observed. Literature has documented that the NDVI is directly related to the photosynthetic capacity and hence energy absorption of plant canopies (Myneni et al., 1995). Red (R) and Near Infra Red (NIR) channels of the sensors on board satellites are suitable for the study of vegetation (Mather, 1999). NDVI is still the most widely used (Groten et al., 1999). Theoretically, NDVI value ranges between -1 to +1. Measured value range from -0.35 (water) through zero (soil) to +0.6 (dense green vegetation).

Materials and Methods
Description of Study Area
Shasha Forest Reserve is located between latitude 6°70"N and 7°70"N and longitude 4°20°N 'and 4°370°N, Ife South Local Government Area of Osun State, Nigeria. It is the largest in Osun State, covering 30,834ha while the total area under reservation is 23,064ha. The altitude of the
Data Collection and Analysis

Three Landsat imageries acquired in 1984, 1991 and 2002 from Landsat archive (Table 1) were used for the study. They were selected to allow an optimum discrimination of vegetation types, as well as for their usefulness in mapping long-term vegetation cover and studying spatio-temporal vegetation changes (Xie et al., 2008). The spatial references of all processed data sets in the study were GCS WGS 1984. Using TM bands 2, 3, 4 for 1984 and 1991 and ETM bands 2, 3, 4 for 2002, three true colour composites, a preliminary land cover map was obtained by visual interpretation and the following five (5) land cover classes were distinguished; Natural forest, Plantation, Farmland, Built up and Water body. The classification was carried out based on spectral characteristics. Supervised classification was done by training data sets, classification and output. Training samples were taken for each Land Use Land Cover (LULC) type to be classified in the image. In order to acquire accurate representation of the cover classes, training samples were repeatedly selected, assessed and carefully analyzed. Classification was done by using maximum likelihood classifier (Lillesand and Kiefer, 1994).

NDVI was calculated by using the mathematical formulae:

\[ \text{NDVI} = \frac{NIR - R}{NIR + R} \quad \text{Equation (1)} \]

where;

- \(NIR\) = the spectral reflectance measurements acquired in the near-infrared region (band)
- \(R\) = the spectral reflectance measurements acquired in the red region (band)

For Landsat Thematic Mapper remote sensing data, the formula is

\[ \text{NDVI} = \frac{TM4 - TM3}{TM4 + TM3} \quad \text{Equation (2)} \]

where;

- \(TM4\) = near infrared band
- \(TM3\) = red band

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Date of Acquisition</th>
<th>Location on WRS</th>
<th>Spatial Resolution/Scale</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat TM</td>
<td>11/12/1984</td>
<td>P190R055</td>
<td>30m</td>
<td>USGS Global Land Cover Facility (ftp.glcf.umd.edu/data/lands)</td>
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<tr>
<td>Landsat TM</td>
<td>05/01/1991</td>
<td>P190R055</td>
<td>30m</td>
<td>Same as above</td>
</tr>
<tr>
<td>Landsat ETM+</td>
<td>03/01/2002</td>
<td>P190R055</td>
<td>30m</td>
<td>Same as above</td>
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<tr>
<td>Topographical Map</td>
<td>1955</td>
<td></td>
<td>1: 250,000</td>
<td>Ministry of Environment, Osogbo</td>
</tr>
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</table>

Results

Table 2 shows all the land use types in Shasha Forest Reserve with their respective sizes. The map produced from satellite image of 1984 (Figure 1) clearly indicates that natural forest occupied the largest area (27188.00 ha), followed by farmland (2544.00ha), plantation (879.00ha), Water body (200.00ha) and Built up (30.00ha). The map produced from satellite image of 1991 (Figure 3) shows that natural forest occupied the largest area (17800.00ha), followed by plantation (9579.00ha), farmland (2560.00ha), Water body (652.00ha) and Built up (250.00ha). While the map generated from the 2002 satellite image (Figure 5) shows that natural forest occupied the largest area (16760.00ha), followed by farmland (6524.00ha), plantation (5005.00ha), Built up (1756.00ha) and Water body (796.00ha). Changes in each land cover type over the eighteen-year period (1984 - 2002) are shown in Figure 7 & 9 summarized in Table 3.
Change Detection Analysis of Land Use Land Cover Change

Figure 1: Land Use Land Cover Map 1984

Figure 2: NDVI Map 1984
Figure 3: Land Use Land Cover Map 1991

Figure 4: NDVI Map 1991
Figure 5: Land Use Land Cover Map 2002

Figure 6: NDVI Map 2002
Figure 7: LULC map for 1984, 1991 and 2002.

Figure 8: NDVI map for 1984, 1991 and 2002.
Table 2: The Spatial Extent of LULC after Classification (LULC Proportions)

<table>
<thead>
<tr>
<th>Land use Type</th>
<th>1984 Area (Ha)</th>
<th>1991 Area (Ha)</th>
<th>2002 Area (Ha)</th>
<th>1984 Percentage (%)</th>
<th>1991 Percentage (%)</th>
<th>2002 Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built up</td>
<td>30.00</td>
<td>250.00</td>
<td>1756.00</td>
<td>0.10</td>
<td>0.81</td>
<td>5.69</td>
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<tr>
<td>Water Body</td>
<td>200.00</td>
<td>652.00</td>
<td>796.00</td>
<td>8.25</td>
<td>2.11</td>
<td>2.58</td>
</tr>
<tr>
<td>Farmland</td>
<td>2544.00</td>
<td>2560.00</td>
<td>6524.00</td>
<td>8.30</td>
<td>21.15</td>
<td></td>
</tr>
<tr>
<td>Plantation</td>
<td>879.00</td>
<td>9579.00</td>
<td>5005.00</td>
<td>2.85</td>
<td>31.06</td>
<td>16.23</td>
</tr>
<tr>
<td>Natural Forest</td>
<td>27188.00</td>
<td>17800.00</td>
<td>16760.00</td>
<td>88.16</td>
<td>57.72</td>
<td>54.34</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30841.00</strong></td>
<td><strong>30841.00</strong></td>
<td><strong>30841.00</strong></td>
<td><strong>100.00</strong></td>
<td><strong>100.00</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

Table 3: LULC change trend, 1984 to 2002

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Built up</td>
<td>220.00</td>
<td>1506.00</td>
<td>0.71 Increase</td>
<td>4.88 Increase</td>
</tr>
<tr>
<td>Water Body</td>
<td>400.00</td>
<td>144.00</td>
<td>1.46 Increase</td>
<td>0.47 Increase</td>
</tr>
<tr>
<td>Farmland</td>
<td>-16.00</td>
<td>3964.00</td>
<td>-8.25 Decrease</td>
<td>8.30 Increase</td>
</tr>
<tr>
<td>Plantation</td>
<td>-8700.00</td>
<td>4574.00</td>
<td>-2.85 Decrease</td>
<td>31.06 Increase</td>
</tr>
<tr>
<td>Natural Forest</td>
<td>9388.00</td>
<td>1040.00</td>
<td>88.16 Increase</td>
<td>57.72 Increase</td>
</tr>
</tbody>
</table>

Figure 9: The graphical representation of the LULC proportions for 1984, 1991 and 2002.

Discussion

The results of this study show how modern technologies such as remote sensing and geographical information systems (GIS) can provide some of the most accurate means of measuring the extent and pattern of changes in landscape conditions over time (Miller et al., 1998; Defries and Belward, 2000). Damizadeh et al. (2000) also stated that the use of satellite imageries as an effective technique to study changes in vegetation cover is growing rapidly and it has become a major application in change detection because of the repetitive coverage at short intervals.

There was a decline in the forest cover in recent years in Shasha Forest Reserve. Similar study carried out by Oates et al. (2008) in Omo-Shasha-Oluwa Forest Reserve, estimated total area of left over natural forest in the reserves to be 112,500 hectares which is just about 40% of the reserve area. However, there was a general increase in the size of the plantation, some parts of the plantation have been degraded due to cutting of the Gmelina arborea trees for industrial wood products because about 12 sq. km of the plantation changed to non-forest between 1986 and 2002.
Related study by Adedeji and Adeofun (2014) revealed that natural forest which covers about 256,900 ha in 1986 reduced gradually to 225,300 ha by 2002. This shows a decrease in forest cover by about 10% of total land cover; in addition the spatial extent of the plantation from about 14,400 ha in 1986 to around 32,200 ha in 2002 is a 6% increase.

The increment in plantation size is due to the effort to expand exotic species such as *Gmelina arborea* and *Tectona grandis*. Since they have the capacity of generating between 3 and 10 times greater commercial biomass (timber) per ha than natural forests (Evans and Turnbull, 2004).

The loss of both Natural and Plantation Forest to *Theobroma cacao*, *Musa spp.*, *Elaeis guineensis* Farm and Farmland is a clear indication of an intensive rate of deforestation in the study area. This result correlates with the view of (Bilsborrow, 1994), that deforestation is largely due to clearance of Forest land for Agriculture and other human activities. According to World Bank (1991), the clearance of the forest each year is due to the quest of the rural dwellers for more agricultural lands. The common farming practice, which is fallow system, entails that farmers abandon a piece of land for some years to recover. While they allow the land to fallow, they seek new fertile land and the alternative place to go is the forest. Other reasons could be attributed to high rise in poverty level and population size. The increase in farmland occurred mainly at the expense of Natural Forest and Plantation. Plantation and Natural forest experienced deforestation, degradation and exploitation due to cultivation and demand for wood resources. The rich soils are more exposed to agricultural expansion because most of the soils in the Reserve are rich in nutrients and ideal for agricultural production.

Spatial extents in settlement show an overall obvious increase in settlements. Changes in this land use type depict higher changes from Plantation, Natural (Undisturbed) Forest. Most of the emerging towns, for example Ife-Tuntun, Ife-Ooye, K.S. Town portray an increase in Settlement area signifying an aspect of increment in population. The population of Ife south where Shasha Forest Reserve is situated had increased from 88,170 in 1991 to 121,306 in 2002 as captured by Federal and State Population Commission Offices (Salami et al., 2007). The high population growth has translated into rapidly increasing demands for land in terms of food, shelter, energy (in particular, fuel wood) and construction materials.

The forest reserve is suffering from deforestation, degradation and encroachment; the reduction of the area occupied by Plantation and Natural Forest is largely due to increase in population especially during the Ife-Modakeke crisis which led so many inhabitants of Ife town to take refuge in the forest. The harvesting of forest products by the occupants resulted in significant loss of forest area and increase in Settlements and Farmland. Other factors contributing to the damage of natural forests include the abandonment of cocoa farmlands for more fertile soils because most of the farmers practice shifting cultivation. Many of these crops are grown in this Reserve's soils because it supports the development of the lowland rainforest and are also suitable for tree crops particularly cocoa, kola and oil-palm (Ekanade, 2007).

The change of NDVI value of the three years analyzed is presently due to illegal and uncontrolled logging which has destroyed a lot of the forest rendering them exposed to farmers for agricultural purpose and expansion of settlements. This therefore reduces the greenness and or healthiness of the reserve from +0.36 to +0.14 in 1984 (Figure 2) to +0.14 to -0.22 in 2002 (Figure 6). It is indeed evident that the positive NDVI of 1984 has more green vegetation (Figure 2).

Conclusion
In this study, five land use/land cover classes were identified as they change through time. However, the result shows a rapid change in the vegetation cover of the study area between the period of 1984 and 2002. The study will serve as a tool or guide for monitoring, planning and effective management of the reserve. The information provided in this study show how remote sensing and GIS can be used in measuring the extent and pattern of changes in landscape conditions over time. This can be useful in the management of the forest reserve for its sustainable use, development and protection.

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References


