

## ESTIMATING VEGETATION CHANGE IN OYO TOWNSHIP USING GEOGRAPHIC INFORMATION SYSTEM (GIS) AND REMOTE SENSING

By

**ADERIBIGBE, Najeem Bayo**

geobayoribigbe@gmail.com; geobayoribigbe@eacoed.edu.ng  
+2348038335403; +2348085142461

and

**AJAGBE, Charles Adesola**

+2348035267720; +2348055339798 | adesolacharles@gmail.com

Department of Geography, School of Secondary Education  
(Arts and Social Science Programme) Emmanuel Alayande College of Education.  
P. M. B. 1010, Oyo, Oyo state, Nigeria.

### **Abstract**

*Land use dynamics in Nigeria have been studied by several scholars but most of the methodology used are either conventional or in respect of areas of intense human impact. This study was based on application of remote sensing and GIS to detect and quantify forest cover changes in Oyo for the period 1978 to 2018 using remote sensing images taken in 1978, 1998 and 2018 by Landsat of type TM (Thematic Mapper), ETM+ and OLI. The images were processed using the ArcGIS 10.6 software version. Five land use classes were identified: forests, water bodies, agricultural or cropland, built-up and bare land. The results indicated that the forest area in 1978 was 53.39 % of the total area under study. It decreased to 26.62 % in 1998 and then sharply decreased to 4.94 % in 2018. The area built up represented 2.39 % in 1978, increased to 12.65 % in 1998 and further increased to 64.19 % in 2018. Agricultural land area was 29.16 % in 1978, decreased to 28.73 % in 1998 and finally decreased to 26.30 % in 2018. Water bodies was continuously decreasing during the period 1978 to 1998 to 2018 while bare land increased between 1978 and 1998 and later decreased greatly between 1998 and 2018. The study found out that there was continuous change in land use and that the change was basically human induced. The results of the change determination performed on the image estimation in the area indicated that forests constitute the main class that witnessed major negative changes. It was revealed that there exists significant variation in land uses changes in the study area. The study indicated that application of remote sensing technology remain an efficient method to be applied for detection of forest cover and land use changes.*

**Keywords:** Remote sensing, Change detection, Vegetation GISL and use

## **Introduction**

The forest ecosystem contains the primary forests, range and agricultural lands. Extensive felling of forests for wood products, range land, foods and agricultural purposes have resulted in vast destruction of the natural forests within the woodland and savanna zones of Nigeria. Remote sensing provides convenient tools for the multi-source data estimation, quantification analysis and processing which are effective in handling change detection analysis using multi-source data. The technique requires proper knowledge of GIS before using this method in land use change analysis Coppin et al (2004), Ellis and Porter-Bolland (2008), Salamiet al.(2010), Ayanlade (2017).

Remote sensing refers to the detection and recording of values of emitted or reflected electromagnetic radiation with sensors in aircrafts or satellites (Ingle et al., 2003). A primary advantage of remote sensing datasets is that a relatively “big picture” can be captured easily in collecting datasets. In other words, quick experiment and measurement are available in identifying changes in resource conditions between dates without direct contact, compared to the on-site measurement or experiment process that usually takes a longer amount of time. Oyo a precolonial city is located on an undulating lowland in the south-western Nigeria occupy an area of about 1300km<sup>2</sup>. The town is located between latitude 0704810011 N and 0802210011 and longitude 0304710011E and 0400510011E on the geographic coordinate and between 859834mN and 726523mN and 590879mE and 622152mE on the UTM projected coordinate system Odedare and Oduyemi (2014). It is bounded in the North by Ogbomosho South LG in Oyo State, in the East by Iwo in Osun State, in the West by Iseyin Local Government Area in Oyo State and in the South by Akinyele Local Government Area in Oyo State. It is located on a wide expanse of land which is about 55km North of Ibadan, 35km South of Ogbomosho, 52km west of Iwo and 32km east of Iseyin. Oyo is the home of tradition in the present Oyo state and it is ranked among the first four precolonial cities in Nigeria after which we have Katsina, Kaduna all in North and Ilesha as the other three cities in the colonial era. It is located along the Trunk A road linking to Lagos, Ibadan and Ilorin to the Northern part of Nigeria. It has a mean annual rainfall of between 1500mm and 2000mm with an average temperature of 27°C and an annual range of 8°C. The vegetation characteristics of Oyo is that of Savanna extraction. The town experiences two seasons i.e raining and dry season with the outset of raining season commencing from late March to early April and dry season commencing from late October to early November which is also characterized by double peak maxima rainfall regime Aderibigbe (2014).

One unique feature of the population of Oyo is that it is characterised by rapid growth rates with 112,349 people recorded in 1963 and the controversial 1973 census put the figure at 147,411. The population of the town was put at 260,898 in

1991, 418,798 in 2006 (National Population Commission, 2006) and projection in 2018 stood at 563,237. The location of the town on a vast undulating plain and rich agricultural land afford it the opportunity of being a settlement where majority of her inhabitants engage in agriculture as dependable mean of livelihood. Apart from agriculture, the town is dotted with manufacturing activities at the low and medium-scaled levels. Trading also thrive in the town due to her locational advantage of being a nodal town connecting major towns in the south-west and north-central geopolitical zones in Nigeria.

Land uses and Land cover (LULC) occur mostly by the removal of vegetation through anthropogenic activities such as construction of roads and housing estates, agriculture and livestock raising, forest harvesting and mining etc. These causes are influenced by population increase, government policy, technological and economic development. In some places the occurrence of major floods can also alter the land cover though the floods are also influenced by LULC. Other causes of LULC changes include bushfires and climatic changes (Aduah, Mantey and Tagoe, 2012). LULC and its changes have been mapped extensively in the past decades through multiple techniques. The techniques include ground surveys, aerial photogrammetry and satellite remote sensing. However, the use of ground surveys and aerial photogrammetry is expensive and time consuming and less accurate and are therefore normally restricted to small areas and low temporal domains.

Today LULC is one key area where satellite images are routinely used because it provides synoptic and spatial coverage over large areas for a long period of time and repeated views of the same location can be obtained. The basis of remote sensing is that changes occurring in the land cover alter the reflected radiation which is recorded in the images. More importantly is the development of high spatial and spectral resolution sensor technology (e.g. Ikonos, Orbview, GeoEye, QuickBird e.t.c) which have also provided the opportunity to conduct detailed inventory of LULC which until recently was only possible with aerial photographic interpretation and ground surveys (Aduah and Baffoe, 2013).

Additionally, land cover classifications offer a standardized approach for measuring environmental parameters and monitoring the state of ecosystems but in highly heterogeneous ecosystems, such as forests and savannas, land cover classifications have moderate accuracy and can be inconsistent spatially and quantitatively with field observations and global land cover maps (Yapp, Walker and Thackway (2010); Dewan and Yamaguchi (2009); Southworth, Munroe and Nagendra (2004)). Furthermore, the reliance on land cover classifications has led to more emphasis on studies that examine land cover conversions rather than modifications Mondal (2011). This emphasis is accompanied by a focus on post-impact or shift landscapes, rather than highlighting approaching thresholds (Krishnaswamy, Bawa, Ganeshiah, and Kiran (2009), which are often of more

concern when employing land cover analyses to examine changes in ecosystem state (Cui, Gibbes, Southworth, and Waylen, 2013).

Land use changes according to (UNCHS, 1996) are consequences of national growth, local assessments of historical and contemporary land use change are needed to anticipate the impacts associated with change and contribute to an understanding of productive environmental sustainability. However, basic requirements for spatial and temporal monitoring and forecasting of growth in the context of urban centres are not readily available particularly in developing countries of the world. This can however be largely due to the fact that in most of the countries, the conventional method of map update still remain in vogue, and are often time and money consuming (Taiwo, 2010). Geographic Information Systems has been used extensively in the modelling of land use change as well as urban growth and this has been made easier because of the invention of computer.

Vegetation extraction from remote sensing imagery is the process of extracting vegetation information by interpreting satellite images based on the interpretation elements and association information (Xie, 2008). Assessing and monitoring the state of the earth surface is a key requirement for global change research (Lambin et al., 2001; Jung et al., 2006; Xie, 2008). Classifying and mapping vegetation is an important technical task for managing natural resources as vegetation provides a base for all living beings and it plays important role in affecting global climate change (Xiao et al., 2004; Xie, 2008).

Change detection as defined by Hoffer (1978) is examination of the temporal effects as variation in spectral response and involve situations where the spectral characteristics of the vegetation or other cover type in a given location change over time but Singh (1989) described change detection as a process which observes the differences of an object or phenomenon at different times (Adia and Rabi, 2008). Land cover composition and change are important factors affecting ecosystem condition and function (Jones et al., 1997; Lunetta et al., 2006). Extraction of land cover maps for mapping surface composition and assessment of changes in surface cover composition over time are requirements common to each of the investigation. Regularly acquired satellite data may be used for long-term surveillance of certain features (Aubrey et al., 1996; Zoran and Anderson, 2006). These data acquired by optical, infrared and microwave sensors yield information on chlorophyll content, the surface temperature, turbidity, hydrocarbon load respectively (Zoran and Anderson, 2006).

Remote sensing imagery offer unique possibilities for spatial and temporal characterization of the changes. The basic requirement is the availability of different dates of imagery which permits continuous monitoring of change and environmental developments over time and has the potential to detect and monitor changes in vegetation at a variety of spatial and temporal scales. Ground-level

sensors and high spatial resolution imaging systems can be used to monitor selected area of study in order to detect changes in vegetation composition or structure and to determine the nature of changes identified from coarser resolution satellite sensors (Stow, Hope, McGuire and Verbyla et al, 2004).

Some extensive research efforts have been made by scholars in respect of land use/land cover change detection using remotely sensed images. Daniel et al. (2002) have compared land use/land cover change detection methods and made use of 5 methods, viz., traditional post-classification cross tabulation, cross correlation analysis, neural networks, knowledge-based expert systems and image segmentation and object-oriented classification. They observed that there are merits to each of the five methods examined and that, at the point of their research, no single approach can solve land use change detection problem. To overcome the challenges associated with conventional map update in order to reflect growth and development, Geographic Information System (GIS) which helps to analyze and integrate data relating to growth and development of these cities which might be achieved from sources that are previously unconnected for decision making provides an optional means for mapping of dynamic features with city morphological dynamics inclusive at regular interval.

The use of Geographic Information System (GIS) in the estimating land use changes as well as city growth are well researched in the context highly dynamic cities with internal heterogeneity using different criteria. Johnston and Shabazian (2002) used suitability criteria for the selection of developable cities especially for transport development within cities. Taiwo (2010) also used GIS-based Markov chain urban growth models to predict and forecast internal growth within the city of Ibadan.

All these models are used in the context of first order cities of the world where various land uses compete for available land at cost which induce trade-off between competing alternatives, but the present study intends to use an approach best suited for cities that though are growing but the socio-economic characteristics of people in such cities are such that depends on the land not only for development drive but for economic prosperity because in them the use with which a piece of land is put to is determined by competition between the need of the people and the technology of extraction of the potentials of the land.

Change is therefore seen as a constant phenomenon in real life and it is inevitable in planning and resource evaluation in any contemporary society. Therefore, ability to monitor changes and account for drivers of such changes becomes verifiable tool for planners, resource managers as well as decision makers and other allied professionals in a bid to estimate or detect changes occasioned by growth and developments over time. A multi-temporal analysis of satellite imagery becomes an effective and integrated approach for detecting such changes. This study directly adopt temporal analysis of data obtained and the use of Landsat

imagery in this study is informed by its availability as an exclusive and continuous imagery achieve on earth surface and its resolution is most suited for study of this kind which could be used for detection and estimation of changes on a real time basis.

The use of remote sensing and its integration with GIS has been widely applied as earlier discussed in literature and its application have been in the context of fast growing urban centres as they are both recognized as powerful and effective tool that could be deployed in detecting urban land uses and landcover changes (Taiwo, 2010); (Oloyede-Kosoko, Adetimirin and Balogun, 2014); Harris and Ventura 1995; Treitz et al 1992; Ehlers et al, 1990. Most of the method used in change detection by these authors are either classification especially that of Oloyede-Kosoko and Adetimirin and Balogun(2014). While Taiwo(2010) used Markov chain modelling in predicting future change of Ibadan in favour of urbanization with the study of Oloyede-Kosoko and Adetimirin and Balogun, 2014 directed toward determining the growth of Oyo town using classification algorithm for growth determination. Little or no efforts have been made in the use of NDVI and VARI as effective technique of image analysis for detecting change in vegetation in favour of urbanization and also within the context of a medium- sized city of which the study area typify.

### **Statement of the problem**

Management activities executed within the natural forests are contained in the forest legislation and concerned mainly with all forms of protection and patrols exercised by forest guards but unplanned harvests of forestproducts continued unabated and are dictated by people's needs for agriculture,shelter, medicinal and other consumption of forest products and man's preference of the short run economic benefits of forests resources at the expense of the long run environmental consequences and sustainability. People living around these forests depend on wood and non-wood products for food and crop cultivation and communities living around the forests could not be spared access to these forests in spite ofenacted laws and guarding system adopted by the forest authorities. Worse still is that people are aware that agricultural productivity, onland previously covered by forests, is significantly higher than the productivity on lands already exposed to erosion and other environmental hazards. Land tenure, in relation to land use practices based on people participation, becomes an issue of interest affecting management of forests and its conversion to other uses.

In land useplanning and mapping, detection of land cover situation using remote sensing facilities and GIS technologies have becomecost effective, timely, accurate and indispensable method for determining the status of these forests and identification of land use trends. It is in view of the fact that land use planners have

to prepare new land use maps or update existing ones before embarking on actual planning that study of this nature is set to be carried out.

## **Materials and Methods**

### **Data acquisition**

The data used for the study included subset of three Landsat images of 30meter spatial resolution captured in 1978, 1998 and 2018. The images were obtained from theThematic Mapper (TM), Enhanced Thematic Mapper plus (ETM+) and Optical Land Imager (OLI) satellite image platforms. The images were ordered and downloaded from the United States Geological Survey (USGS) website. Landsat images were chosen because they covered the period under review and they have spatial resolution suitable for the study and they are images achieve on the earth and suitable for land cover classification system level 1 (Campbell, 2002; Jensen, 2000). The selection of the images was restricted to similar season to avoid seasonal differences in reflected radiation. In addition, sample land cover information was collected with reference to the 2018 (OLI) image using GPS during field work exercise. Land cover map accuracy assessment was executed for only this image. The field work was also used to measure coordinates of known ground points for geo-referencing of the images. The geo-referencing was executed with the ArcGIS software from Environmental Systems Research Institute (ESRI).

The images were registered to assign real world coordinates to them and to correct for geometric errors associated with the satellite images resulting from instrumental and attitude of the sensors with respect to the rotation of the earth and swath width of the sensor etc. Image registration was also executed to assign coordinates systems and projections to the images as this is done to ensure that the features and process found on the satellite images are allocated their correct dimensionality and planimetric positions on the earth surface. This is very important for change detection since one only compare the same geographic location at different times. The image registration in this study was done with the 10.6 version of ArcGIS software from ESRI inc international. The images were registered to the 1984 World Geodetic System Universal Transverse Mercator (WGS '84 UTM) Zone 31 North Projection. Although the images were already geo-referenced to the UTM '84 zone 31 N, they were re-projected to ensure that they are allocated their correct ground coordinates.

The use of Normalised Difference Vegetation Index (NDVI) andVegetation Area Reflective Index (VARI) are very useful because they use ratio form for analysis and they are less sensitive to atmospheric and radiometric distortion from sensor devices. Bands 3,4 and 5 were used to develop false colour composite image for each of the years used in the study.

**Table 1.2 Metal Data Information of the satellite image use in the study**

Satellite Platform	Acquisition Date	Resolution	Row and Path	Platforms
Landsat 1978	01/01/1978	30m	R054 P191	Landsat 5
Landsat 1998	01/01/1998	30m	R054 P191	Landsat 7
Landsat 2018	01/01/2018	30m	R054 P191	Landsat 8

*Source: Satellite Image Meta Data Files.*

A Normalized Difference Vegetation Index (NDVI) and Vegetation Area Reflectance Index (VARI) were computed and the bands of the imageries used are band 3 and band 4 with as shown below

$$(NDVI) = \frac{NIR_{band} - R_{band}}{NIR_{band} + R_{band}}$$

In order to determine and detect if there exist change from vegetation to other landuses between the period under review, signatures representing vegetation on the image analysis (red and orange) was isolated from that of urban structures (purple and blue) and a supervised classification algorithm which adopt maximum likelihood method was used in separating developed properties representing signs of changes from vegetation to urbanization from the undeveloped portion of the town from the imageries (Taiwo. 2010; Weng 2001).

After identification of the positive changes in favour of urbanization (built-up) as against the declining state of vegetation in the study area. The study therefore raised one hypothesis relating to changes in land uses in the study area at two time scales (1978-1998) and (1998-2018). The hypothesis was tested using Analysis of Variance (ANOVA) to ascertain if there exist significant changes in landuses in the study area between the periods under review.

### **Results and Discussion**

Considering the sensitivity of the study areato ecological pressure caused by high levels of urbanization, the primary objective of this study was to examine effect of increasing human pressure on the level of forest degradation and loss of

forested land to urbanization in the town. Remote sensing and GIS technologies were utilized to investigate pre- and post-conditions of vegetation change in this respect. Additionally, this study set out to identify the utility and capability of using remote sensing and GIS technologies to examine micro-scale vegetation changes as it represents a measure of the level of urbanization and anthropo-pressure in the area. The study

- 1) examined spatio-temporal vegetation cover changes associated with growth and development of the Oyo town using multi-spectral medium resolution remote sensing datasets for the period 1978 through 2018;
- 2) examined the impact of growth in land uses as it results in reduced vegetation impact in the vicinity of the areas experiencing rapid process of urbanization, using NDVI and VARI change detection analysis based on multi-spectral medium resolution remote sensing datasets: 1978, 1998 and 2018.

### **Change in forest area between 1978 and 2018**

Between 1978 and 1998 the forest cover in 1978 as revealed from the calculated NDVI accounted for 82.54% of the entire region leaving only 17.46% for developed of land use and others like water bodies and croplands among others but in 1998 the figure for developed land use rose against the forested landuses and thus stood not 52.33% as against 47.69% for the forest areas. The changes in the forested areas as shown from the figure revealed from the calculated NDVI value for the year revealed a value of 29.59 for forested landuse with other landuses resulting from human influence in the town claiming the remaining 70.41% of the entire region. It is shown from this study that there was steady growth in landuse development in respect of built-up and urbanised part of the cities over time. The spatial extent of the city reflect the temporal sequence of the detail used for the area extent of each landuse categories in the study were estimated from the imageries using polygon extract and calculate area toolbox in Arc GIS 10.6 software which were used to generate the areas of the respective polygons as shown in the table below.

#### **Growth in Landuses in the Area**

In 1978 the built up area represent 17.46% while in 1998 there was a progressive increase in the built up area as against vegetation. The growth in human use of the forest in 1998 over that of 1978 represent 82.69% which showed that vegetation in the town was lost to excessive human influence through encroachment occasioned by building and construction, agriculture and other human/anthropogenic influence. The growth of 2018 value over that of 1998 in terms of forest loss was 43.23%. This value indicated that the forest ecosystem in the town was constantly being threatened by human habitation and use of forest resources for consumption and other means of livelihood.

See the table below

**Table 2(a): Landuse/ cover estimate of the area of the period under review.**

Land uses	1978	Area (%)	1998	Area (%)	2018	Area (%)
Built-up	154.08	2.39	816.72	12.65	4143.78	64.19
Forest	3446.28	53.39	1718.15	26.62	319.14	04.94
Cropland	1882.62	29.16	1854.70	28.73	1697.85	26.30
Water bodies	687.79	10.65	542.75	08.40	82.54	01.28
Exposed land	284.76	04.41	1523.21	23.60	212.22	3.29
<b>Total</b>	<b>6455.53</b>	<b>100.0</b>	<b>6455.53</b>	<b>100.0</b>	<b>6455.53</b>	<b>100.0</b>

*Source: Pixel by pixel estimate of landuse/cover from Landsat image of the study area*

**Table 2(b): Change in landuses/cover between the periods under review**

Landuses/cover	Change between 1978 and 1998	Change between 1998 and 2018	Change between 1978 and 2018
Built -up	+10.26	+51.54	+61.80
Forests	- 26.77	- 21.68	- 48.45
Cropland	-0.43	-2.43	-2.86
Water bodies	-2.25	- 7.12	-9.37
Exposed land	+19.19	- 20.31	- 1.12

*Source: computed from growth analysis of the image processing*

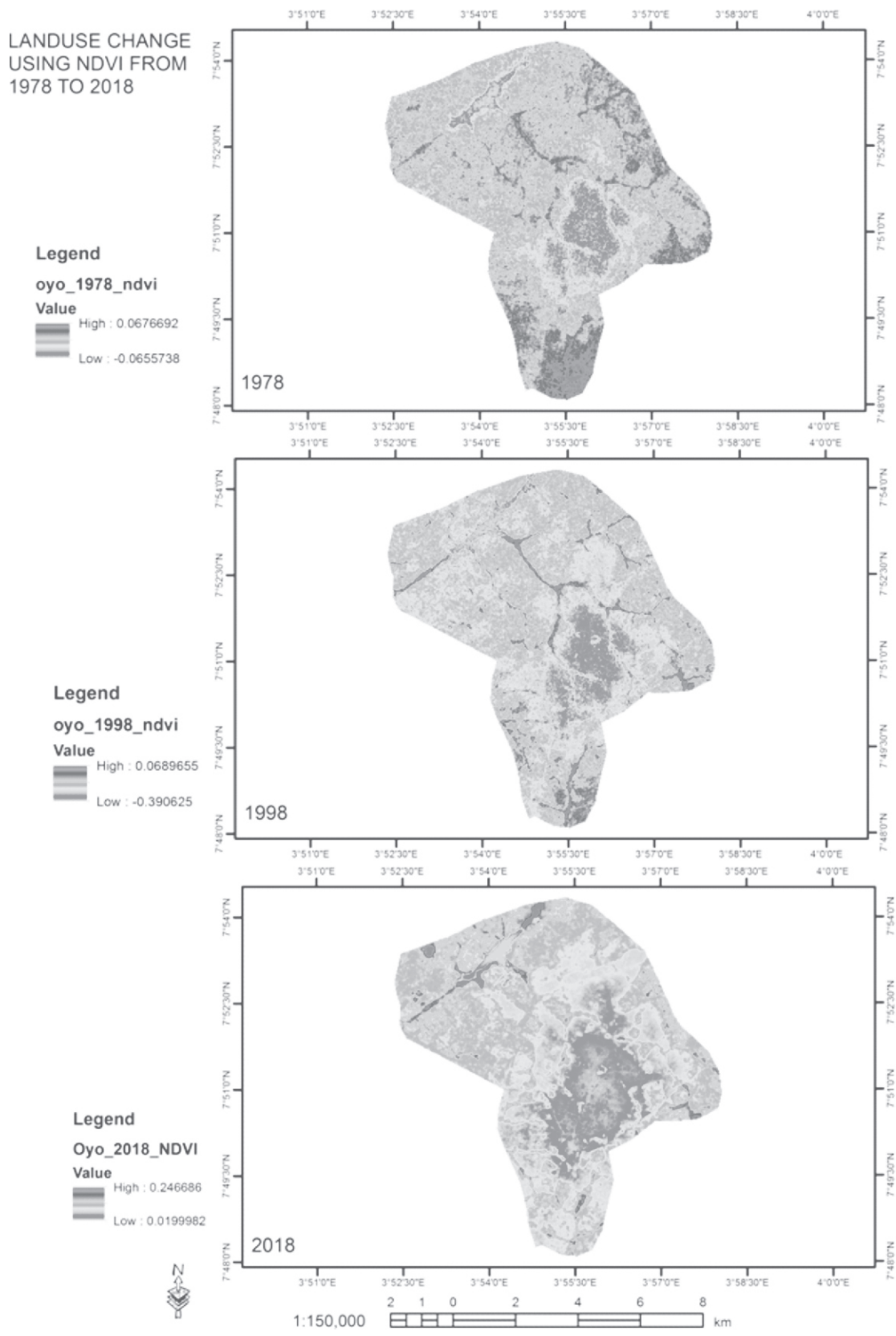
The losses in forest area is as shown in the tables 2 (a) and (b) above. Various conversion exercised by human on forest ecosystems in the study area as revealed from the study was significant and it was as shown on the maps of both the NDVI and VARI analysis in figures i and ii shown below. It was as a result of the changes revealed from the above analysis that one hypothesis was raised to establish if there exist significant variation in land use changes over time as shown from the calculated values of the areas under various uses shown on the maps in figures 1(a) and (b).

**Table 3: Showing the result of ANOVA of land use change variations over time.**

Source of variations	Sum of squares	Degree of freedom	Variance estimate	Snedecor's F
Between sample	4,354.69	4	1088.67	
Within sample	16,394.00	10	1639.40	1.51
Total	20,743.69	15		

*Source: computed from Landsat Imagery pixels.*

The result of the Analysis of Variance of vegetation changes in the study area was as presented in the table 3 above. The hypotheses raised was that there exist no significant variation in vegetation change across the study area. Pixel by pixel analysis was performed which contributed to the computed area used for the study. An F value of 1.51 was obtained from the analysis. This value was compared with  $F(4,10)$  at 0.05 significant level. This table value was 2.52 which is greater than the calculated value. This showed that the obtained value is not significant and that the value obtained could have occurred as a result of chance. Hence the null hypotheses was thus retained. Then the conclusions was that there exist no significant variations in vegetation change in the study area with respect to the level of urbanization.



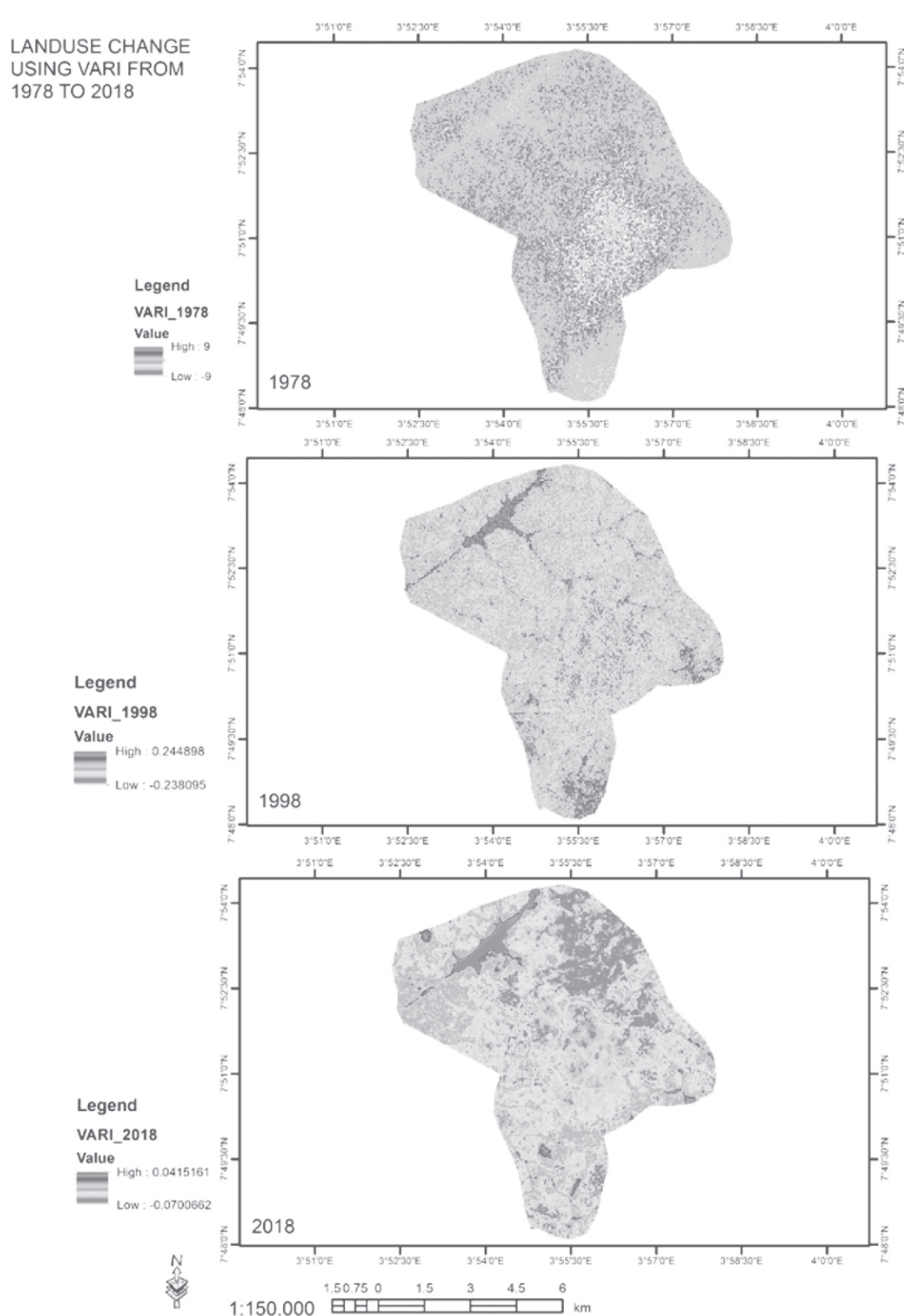


Figure 1: Map of the result of NDVI analysis performed to show change in forest cover.

## **Conclusion**

We are living off the future with our current well-being apparently dependent on drawing ecosystem capital which provides goods and services. As a result of our dependency on nature, agricultural soils erode, fish stock decline, forest shrink, and pollution of land, water and air increases. The situation is unsustainable. The dependency on nature and ecosystems is to provide conditions for a decent, healthy and a secure life.

To this end, humans have made unprecedented changes to ecosystems in recent decades to meet the growing demand for shelter, freshwater, fibre and energy and the changes have helped to improve the lives of several people but at the same time, they have weakened the ability of nature to deliver other key services such as purification of water and air, protection from disasters and the provision of medicines. The intense vulnerability of the people to this loss of ecosystems services including water supply; and the growing threats to ecosystems from climate change and nutrient pollution human activities taken the planet to the edge of massive wave of species extinction which further threaten our well-being.

The loss of services derived from ecosystems is a significant barrier to the achievement of the Millennium Development Goals to reduce poverty, hunger and diseases as submitted by Wright and Boorse (2011). This pressures on ecosystems will increase globally in no distant future unless human attitudes and actions change.

This study demonstrated the capability of Geographic Information System (GIS) and Remote sensing techniques as a spatial support system that are most effective in monitoring changes both in space and time in developing countries where there is paucity of data and map update that can be used for planning and management to cope with city dynamics. The study is in conformity with the submission of Taiwo 2010 who posited that GIS and Remote Sensing techniques have the ability of providing information and data on real time basis for planning and management especially in respect of area with paucity of data in doing so in the pace of recent growth being experienced by many of the cities. However, basic requirements for spatial and temporal monitoring and forecasting of growth in the context of urban centres are not readily available particularly in developing countries of the world. This can however be largely due to the fact that in most of the countries, the conventional method of map update still remains in vogue, and are often time and money consuming (Taiwo, 2010).

The trend of urbanization that have resulted in the depletion of forest cover and its resources have shown that Oyo is growing in spatial extent over the periods under review and therefore to be expected are problems associated with urbanization like request for more spaces for building and construction, high temperature resulting from urban heat island, transportation bottlenecks, flood related problems, waste management problems, reduction in rich agricultural lands among several other remote impacts. The present rate of urbanization and persistent loss of forest cover of the years have been attributed to the growing population of the town. This trend have often rob the city of the fertile agricultural

lands; ecosystem functions and ecological resilience potentials. The high rate of urbanization which have resulted in the present state of dwindled forest resources have made the peasant farmers in the fringes of the city to sell off their fertile agricultural lands to real estate developers, individuals and corporate bodies who offer them peanuts as proceeds of their rich economic resources the findings which is in line with the submissions of Aduah and Baffoe (2013).

Considering table 3 above, it was clearly shown that urbanization have taken its toll on the increasing rate of the loss of forest and forestry resources as there was a consistent growth in the built-up area as it recorded a positive change throughout the period under review. Throughout the periods 1978 to 2018 urban spaces keep increasing astronomically with forest, water bodies, croplands and open spaces changing in opposite direction of positive growth.

### **Recommendations**

Based on the findings the study put up the following recommendations that if honestly pursued there would be sustainable uses of environmental resources

- \* Measures aimed at conserving nature and its resources are more likely to succeed with the involvement of local communities in the ownership and management of them. Here local communities needed to be given ownership status of nature and its resources, share the benefits derivable from nature and involve them in decision making process.
- \* Better protection of natural assets also requires coordinated efforts across all sections of government, businesses and international organisations. The productivity of ecosystem depends on policy choices on investments, trades, subsidy, taxation, and regulations among several others.
- \* Improved technology and knowledge-based expert systems be embraced as this could help reduce human impact on ecosystems considerably. The knowledge needed be deployed fully to embrace sustainable human-nature interactions. Until the ecosystem services cease to be perceived as free and limitless perception of ecosystem and their full values are taken into account, forest loss is bound to be on the increase.
- \* It was also recommended that for sustainable development to be achieved, restrictions should be placed on the consumption and destruction of forest ecosystems for short term economic gains at the expense of the long term sustainable forest use that would benefit human population. This if pursued with vigour is capable in forest protection.
- \* Land tenure system of land holding title and deeds which is a common practice in the developing nation of the world especially Nigeria. Government holdings of deeds should be promoted and encouraged where ownership would be conveyed on government rather than individual ownership. In this wise allocations of land would be centrally moderated.

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