African Journal of Environmental Science and Technology Vol. 1 (5), pp. 099-109, December, 2007
Available online at http://www.academicjournals.org/AJEST
ISSN 1996-0786 © 2007 Academic Journals

Full Length Research Paper

Application of remote sensing and GIS inland use/land cover mapping and change detection in a part of south western Nigeria

Daniel Ayalew Mengistu[1] and Ayobami T. Salami[2]*

[1]Department of Geography, Bahir Dar University, Bahir Dar, Ethiopia.
[2]Space Applications and Environmental Science Laboratory, Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria.

Accepted 24 September, 2007

Mapping land use/land cover (LULC) and change detection using remote sensing and GIS techniques is an area of interest that has been attracting increasing attention. This paper is an attempt to assess the changes in land use/land cover in some parts of south-western Nigeria over a 16 year period. The study made use of LandSat imageries of 1986 and 2002. The images were classified using Maximum Likelihood classification method. The results show that disturbed/degraded forest constituted the most extensive type of land use/land cover in the study area. The increasing population and economic activities were noted to be putting pressure on the available land resources. This paper highlights the importance of remote sensing and GIS techniques in apprehending the situation in south-western Nigeria.

Key words: LULC, conversion, modification, forest reserve, change detection, classification scheme, encroachment.

INTRODUCTION

Land use/land cover change is a key driver of global change (Vitousek, 1992) and has significant implications for many international policy issues (Nunes and Auge, 1999). In particular, land use/land cover (LULC) changes in tropical regions are of major concern due to the widespread and rapid changes in the distribution and characteristics of tropical forests (Myers 1993; Houghton 1994). However, changes in land cover and in the way people use the land have become recognized over the last 15 years as important global environmental changes in their own right (Turner, 2002). To understand how LULC change affects and interacts with global earth systems, information is needed on what changes occur, where and when they occur, the rates at which they occur, and the social and physical forces that drive those changes (Lambin, 1997). The information needs for such a synthesis are diverse. Remote sensing has an important contribution to make in documenting the actual change in land use/land cover on regional and global scales from the mid-1970s (Lambin et al., 2003). In Nigeria, despite ongoing research efforts on LULC patterns; there remains a need for development of basic datasets providing quantitative and spatial land use/land cover information. Moreover, there appears to be a gap in the available information at national and local scales for use in regional and national decision making process and rational planning.

The same is true in the south-western part of Nigeria. Despite the great economic importance of this region, there have not been systematic studies of land use/land cover changes (Oyinloye et al., 2004). Adejuwon and Jeje (1973), in an earlier study mapped vegetation/land use associations in the Ife area using 1:40,000 panchromatic aerial photographs. Land use/cover studies using satellite image in this region (such as Salami, 1999; Salami et al., 1999) are a recent phenomenon. Likewise, Salami and Akinyede (2006) conducted land use/cover change studies in the region using data from LandSat satellite imagery of December, 1986 and the newly operational NigeriaSat-1 satellite imagery of December 2004. Amamoo et al. (1998) used satellite image for the same region but their concern was to differentiate between built-up and non built-up land use for population census base map revision.

*Corresponding author. Email: ayobasalami@yahoo.com.

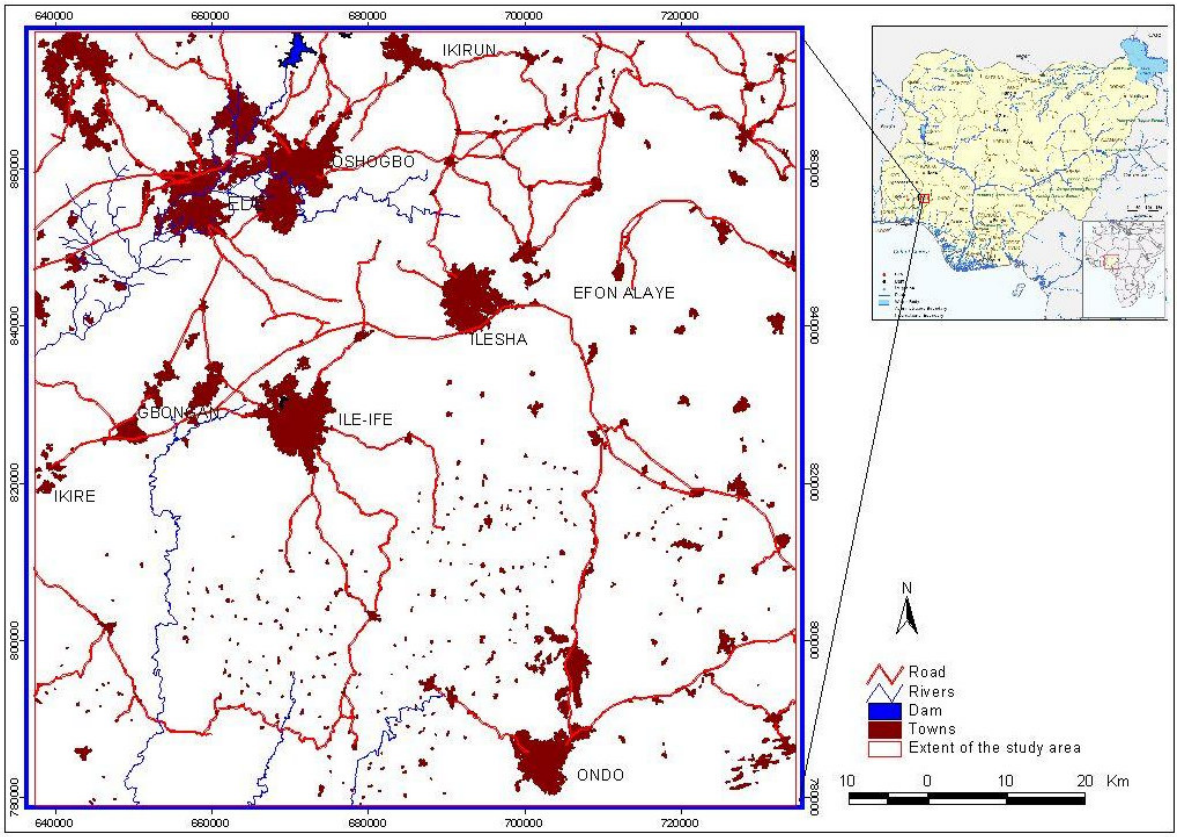

Figure 1. Study area.

The purpose of this paper was to investigate the changes in LULC over a period of 16 years in south-western Nigeria using remote sensing and GIS techniques and deriving factors behind the changes and the adverse effects of these changes on the livelihood of the people and the local environment.

Study area

The study was conducted in a part of tropical rainforest of south-western Nigeria, located between Latitudes $07^0$02'38"-$07^0$55'56" N and Longitudes $04^0$14'52"-$05^0$07'34" E (Figure 1). The area is located in the cocoa belt of Nigeria. It falls within the tropical humid climate that is characterized by wet and dry seasons. The mean annual rainfall of the area is 1220 mm, while the mean annual temperature is about 27^{o}C (Balogun and Salami, 1995). The natural or climax vegetation of the area is low-land tropical rainforest. However, the natural vegetation of the area has now been reduced to secondary forest or replaced by perennial and annual crops (Salami et al., 1999). Salami (1995) argued that the long history of agricultural colonization of the area together with increasing population density has led to significant modi-fication of the natural vegetation.

MATERIALS AND METHODS

Data sources

An area of 9558.58 km^2 was delineated on the LandSat scene covering the study area. The LULC mapping for the area was based primarily on LandSat 5 Thematic Mapper (TM) of December 1986 and LandSat 7 Enhanced Thematic Mapper (ETM) data of January 2002. The images were geometrically corrected to Universal Transverse Mercator (UTM) coordinate system. The selection of images of the same season was to minimize the influence of seasonal variations on the result.

Digital image processing

The study depended on the use of computer-assisted interpretation of LandSat imageries. Field survey was performed throughout the study area using Global Positioning System (GPS). This survey was performed in order to obtain accurate location point data for each LULC class included in the classification scheme as well as for the creation of training sites and for signature generation. In order to obtain the required information from satellite image data, processing and interpretation were made systematically. The interpretation phase was preceded by establishing preliminary legend. The 1986 LandSat TM imagery depicts a situation that existed 16 years before the recent LandSat ETM imagery. Hence, the 1986 LandSat TM imagery could not be checked against the ground truth but, the available historical data for the area were used to validate the interpretation made. However, the 2002 satellite image was directly checked against ground truths.

Table 1. Description of the land use/land covers classes identified in the study area.

LULC Types	Description
High forest	An area of land covered with mature trees and other plants growing close together.
Disturbed/ degraded forest	Areas covered with secondary forests.
Derived savanna	Area covered by grassland, sometimes with scattered trees, in a tropical or subtropical region.
Montane forest	Trees growing in mountainous or hilly region.
Shrub land/farmland complex	An area of land covered mainly with shrubby plants and/ crops
Settlement/bare surface	Areas that have been populated with permanent residents or covered with scanty grass and exposed rocks, and bare lands.
Water body	Areas covered with water such as dams and rivers.

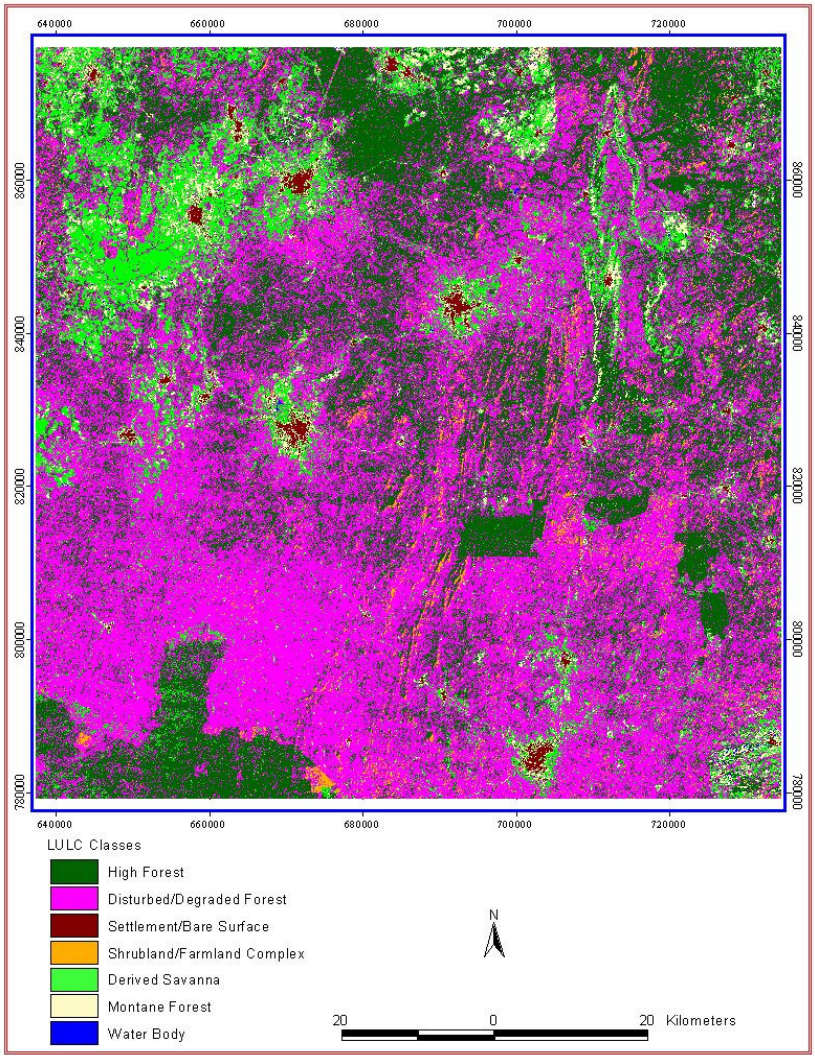

Figure 2. Land use/land cover map of the study area (1986).

Once the training sites were determined, Maximum Likelihood classification was utilized. The Maximum Likelihood classifier is considered to give very accurate results. The classification scheme utilized seven land use/land cover classes representing high forest, disturbed/degraded forest, derived savanna, montane forest, shrub land /farmland complex, settlement/bare surface and water body.

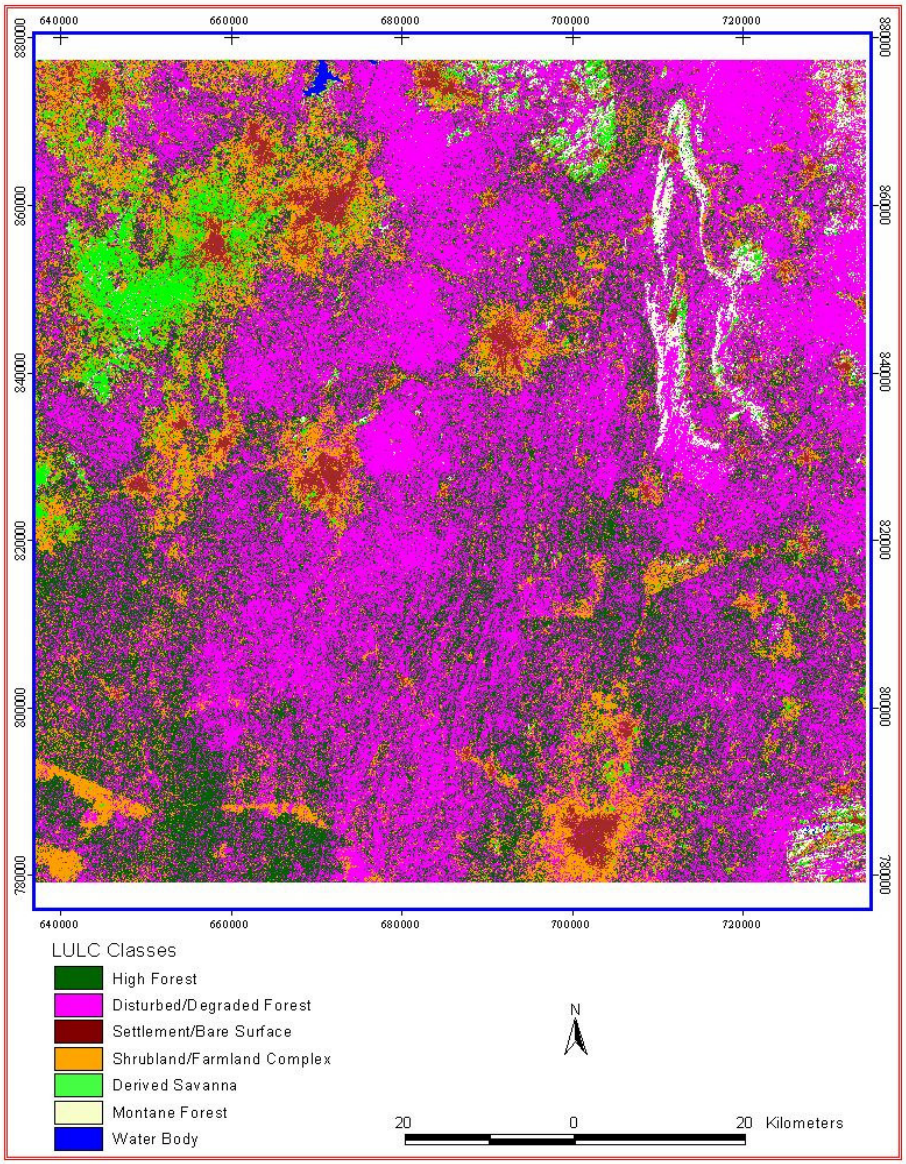

Figure 3. Land use/land cover map of the study area (2002).

The classification scheme is as described in Table 1. The post interpretation phase included preparation of LULC maps and detection of their changes. The change detection technique, which was employed in this study, was the post- classification compare-son. The overlay consisting of LULC maps of1986 and 2002 were made through ERDAS IMAGINE software.

Then a transition matrix was prepared for the overlaid land use/land cover maps of 1986 and 2002.

RESULTS AND DISCUSSION

Figures 2 and 3 show the LULC maps of the study area for 1986 and 2002. Tabulations and area calculations provide a comprehensive data set in terms of the overall landscape, the types and extent of changes, which have occurred (Tables 2, 3 and 4).

In the periods considered, disturbed/degraded forest constituted the most extensive type of land use/land cover in the study area. Accordingly, it accounted for about 49.6% of the total area in 1986, followed by high forest and derived savanna, occupying 30.6 and 12.6% of the total area respectively. Land use/land cover units under montane forest, shrub land/farmland complex, settlement/bare surface and water body covered 3.4, 2.7, 1.0 and 0.1% of the area respectively.

In 2002 however, the land under disturbed/degraded forest decreased marginally to about 48.7% of the total area. High forest and shrub land/farmland complex occu-pied 28.1 and 14.0%, respectively. The remaining area was occupied by derived savanna, settlement/bare sur-face, montane forest and water body, which accounted

Table 2. Comparison of areas and rates of change of the seven LULC classes between 1986 and 2002.

LULC Types	1986 LULC area		2002 LULC area		Change between 1986 and 2002		Average rate of change	
	ha	%	Ha	%	ha	%	ha/yr	%
Disturbed/degraded forest	473770	49.6	465592	48.7	-8178	-1.73	-511.13	-0.11
High forest	292188	30.6	268919	28.1	-23269	-7.96	-1454.31	-0.5
Shrub land/farmland complex	26122	2.7	134158	14.0	+108036	+413.6	+6752.25	+25.85
Derived savanna	120237	12.6	33840.4	3.5	-86396.6	-71.86	-5399.79	-4.49
Settlement/bare surface	9880.05	1.0	28883.9	3.0	+19003.9	+192.4	+1187.74	+12.02
Montane forest	32712.3	3.4	23345	2.4	-9367.3	-28.64	-585.46	-1.79
Water body	949.114	0.099	1119.5	0.12	+170.4	+17.96	+10.65	+1.12
Total	955858	100	955858	100	-------	---------	----------	-------

Source: LandSat TM 1986 and LandSat ETM+ 2002.
Note: decrease carries negative sign while increase carries positive sign.

Table 3. Proportions of land use/land cover units gained and/or lost between 1986 and 2002 in the study area.

Land use/land cover units	Proportion of LULC in 1986 and unchanged in 2002		Proportion of LULC in 1986 lost to other Land LULC types by 2002		Proportion of LULC in 1986 gained from other LULC types by 2002		LULC in 2002 (unchanged + gained)		Difference of LULC gained-lost (1986-2002)	
	ha	%	ha	%	ha	%	ha	%	ha	%
Disturbed/ degraded forest	245126	51.74	228644	48.26	220466.4	46.5	465592.4	100	-8178	-1.73
High forest	86833.4	29.72	205354.6	70.28	182085.6	62.3	268919	100	-23269	-7.96
Shrub land/farmland complex	2268.7	8.7	23853.3	91.3	131889.4	504.9	134158	100	+108036	+413.58
Derived savanna	21814.3	18.14	98422.9	81.86	12026.1	10.0	33840.4	100	-86396.6	-71.86
Settlement/ bare surface	8756.3	88.6	1123.8	11.4	20127.6	203.7	28883.9	100	+19003.85	+192.35
Montane forest	4751.66	14.5	27960.7	85.5	18593.4	56.8	23345.04	100	-9367.3	-28.64
Water body	121.431	12.8	827.7	87.2	998.1	105.2	1119.52	100	+170.41	+17.96
Total area	369671.8	38.7	586186.2	61.3	586186.2	61.3	955858	100	-------	-------

which accounted for about 3.5, 3.0, 2.4 and 0.12% respectively.

Changes in land use/land cover (1986-2002)

It is obvious from Table 2 and Figure 2 that the study area had been subjected to intensive human influence prior to the base year (1986), with 49.6 % of the area under disturbed/degraded forest. The pattern of the changes between 1986 and 2002 are presented in Tables 2, 3 and 4. Within the period, more land was brought under shrub land/farmland complex, at the same time settlement/bare surface expanded at the expense of other land cover types. In line with this, the land use/land cover data of the two years indicated both types of changes/conversion and modification (Figures 2, 3 and 4 and Tables 2, 3 and 4). The area under derived savanna and high forest declined by 71.9 and 8%, respectively, while those under shrub land/farmland complex and settlement/bare surface registered a net gain of 413.6 and 192.4%, respectively. This suggests that the areas covered with derived savanna and high forest were re-

Table 4. Proportion of LULC that was converted from each of the seven classes into the rest (1986-2002).

		Land use/cover units of 2002 (in ha)							
		Disturbed/degraded forest	**High forest**	**Shrub land/ farmland complex**	**Derived savanna**	**Settlement/ bare surface**	**Montane forest**	**Water body**	**Total area**
Land use/cover units of 1986 (in ha)	Disturbed/degraded forest	**245126** ***51.74***	161002 *33.98*	60103.3 *12.69*	1994.0 *0.42*	2134.51 *0.45*	3123.8 *0.66*	286.1 *0.06*	473769.62 *100*
	High forest	181888 *62.25*	**86833.4** ***29.72***	15290.4 *5.23*	928.97 *0.32*	318.08 *0.11*	6655.7 *2.28*	273.5 *0.09*	292187.99 *100*
	Shrub land/farmland complex	19184.6 *73.44*	4443.49 *17.01*	**2268.7** ***8.69***	57.1 *0.22*	104.46 *0.4*	56.61 *0.22*	6.99 *0.03*	26121.95 *100*
	Derived savanna	17727.4 *14.74*	15990.2 *13.3*	47117.2 *39.2*	**21814.3** ***18.14***	9043.1 *7.52*	8303.23 *6.91*	241.81 *0.2*	120237.24 *100*
	Settlement/ bare surface	48.25 *0.49*	35.3329 *0.36*	698.05 *7.07*	315.0 *3.2*	**8756.3** ***88.63***	20.63 *0.21*	6.50 *0.07*	9880.05 *100*
	Montane forest	1559.52 *4.77*	592.54 *1.81*	8566.15 *26.2*	8547.47 *26.13*	8511.73 *26.02*	**4751.66** ***14.53***	183.24 *0.56*	32712.31 *100*
	Water body	58.64 *6.18*	21.931 *2.32*	114.28 *12.04*	183.57 *19.34*	15.76 *1.66*	433.50 *45.67*	**121.43** ***12.79***	949.12 *100*
Total area		465592.4	268919	134158.1	33840.4	28883.9	23345.04	1119.52	**955858**

*Figures in the upper rows show areas of a particular LULC type that remained unchanged or lost to other LULC types in hectare during the study period.
*Figures in the lower rows in italics show areas of a particular LULC type that remained unchanged or lost to other LULC types in percentage during the study period.

ceding at an average rate of 4.5 and 0.5% per annum respectively, while shrub land/farmland complex and settlement/bare surface were, respectively expanding at rates of 25.9 and 12.0% per annum over the 16years period. This indicates the encroachment of agricultural land and settlement towards forest areas and derived savanna and this was confirmed by the fieldwork in the area. The finding that there was a major decline in the area of the derived savanna and high forest is in line with that of Sa-lami and Akinyede (2006), which reported a 59.4 and 24.5% decline of these cover types in the south western part of Nigeria, between 1986 and 2004. It can also be related to the findings of Akinyemi (2005), which reported a 49.1% decrease of agro-forestry/secondary regrowth in the south western part of Nigeria between 1986 and 2002.

Accordingly, Tables 3 and 4 show that only 29.72% of the area that was covered with high forest in 1986 remained the same in 2002. The rest (70.28%) was either cleared or changed to other land use/land cover types in 2002 viz: 62.3% to disturbed/degraded forest, 5.23% to shrub land/farmland complex, 0.32% to derived savanna, 0.11% to settlement/bare surface, 2.28% to montane forest and 0.094% to water body. On the other hand, conversion of other land use/land cover types to high forest totaled about 67.7% (Tables 3 and 4).

Similarly, Tables 3 and 4 show that only 18.1% of the area that was covered with derived savanna in 1986 was under the same cover in 2002. The rest (81.9%) was transformed to other land use/land cover types in 2002; 14.7% changed to disturbed/degraded forest, 13.3% to high forest, 39.2% to shrub land/farmland complex, 7.5% to settlement/bare surface, 6.9% to montane forest and 0.2% to water body. The area that changed from other land use/land cover types into derived savanna was small and accounted for only 35.5% compared to the amount lost from derived savanna to other types (Tables 3 and 4). In general, the change from natural vegetation cover

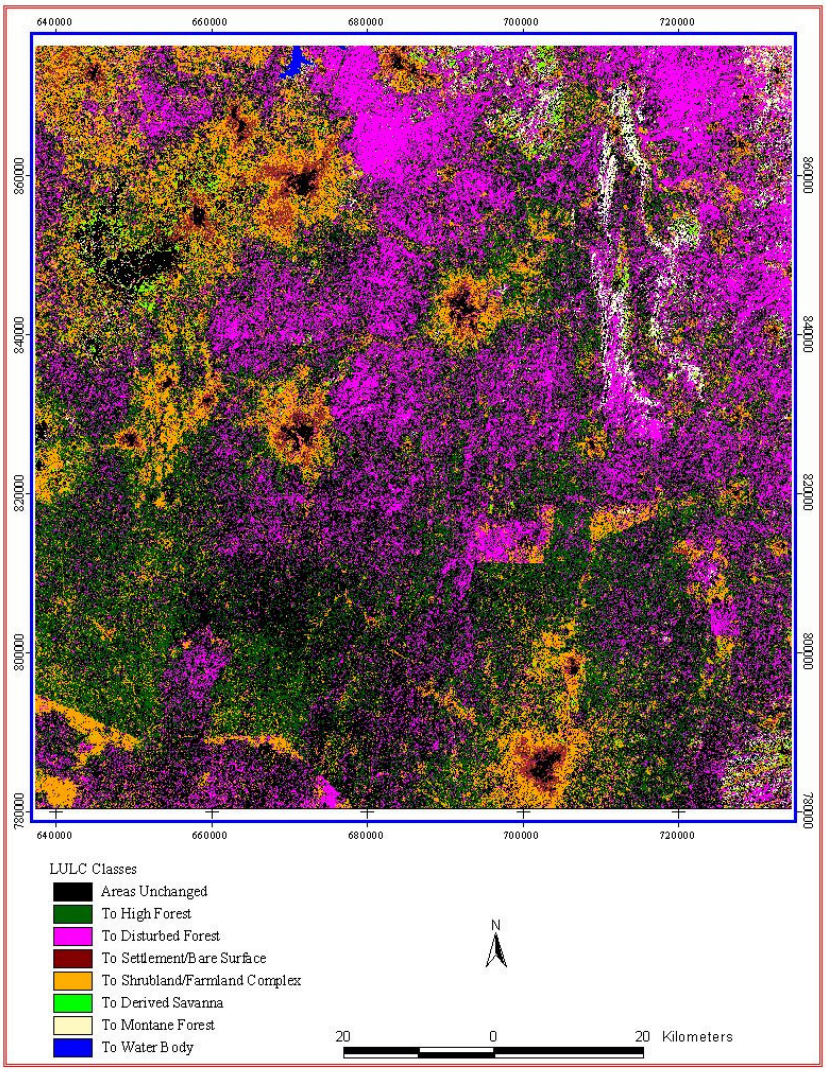

Figure 4. Land use/land cover change map (1986-2002).

to farmland was more of conversion and a significant change of this type was observed during the study period

Status of forest reserves found in the study area (1986 - 2002)

Table 5 and Figures 5 and 6 shows that the earliest Forest Reserves (FRs) of south-western Nigeria, which are apparently subject to the strict control, are under a serious onslaught of deforestation and calls the management regime of the reserves to question. In the Forest Reserves, high forest is retreating fast with over exploitation. For instance, 98.3 and 63.7% of the area covered with high forest in Ikeji FR and Akure FR respectively were converted to shrub land/farmland com-plex over the two decades. This implies that forest in all the sites is in a state that is not near equilibrium and indicates that degradational activities are going on in all the sites including the Forest Reserves (Salami and Balogun, 2006).

Causes of land use/land cover change

Land use/land cover changes reflect the dynamics observed in the socio-economic condition of a given area. Similarly, changes in the socio-economic situations cause land use/land cover changes through their influence on land management techniques used and other various aspects of the farming systems, institutional settings, environmental policy and others. As many researchers indicated in Nigeria, several factors have been modifying the original form of land cover. These include human activities such as agricultural colonization (Adejuwon, 1971; Berry, 1974); spread of rural settlements (Osunade, 1991); evolution of rural road networks (Aloba, 1983) and government policy (Ekanade et al., 1996) noted in (Salami, 2001).

Table 5. Status of forest reserves between 1986 and 2002.

Forest reserves	Area (1986)		Forest reserves	Area (2002)	
	ha	%		ha	%
Akure FR	4844.0	9.43	Akure FR unchanged	1310.4	27.05
			Changed to settlement/bare surface	63.79	1.32
			Changed to shrub/farmland	3084.1	63.67
			Changed to disturbed/degraded forest	385.7	7.96
				4844.0	***100***
Ife FR	38499.2	74.94	Ife FR unchanged	27203.3	70.66
			Changed to disturbed/degraded forest	8823.74	22.92
			Changed to shrub/farmland	2472.2	6.42
				38499.2	***100***
Ikeji FR	2244.2	4.37	Ikeji FR unchanged	38.1	1.7
			Changed to shrub/farmland	2206.1	98.3
				2244.2	***100***
Oni FR	5789.0	11.27	Oni FR unchanged	322.04	5.56
			Changed to disturbed/degraded forest	3826.05	66.1
			Changed to shrub/farmland	1640.94	28.35
				5789.0	***100***
Total	51376.4	100	Total	51376.4	------

Source: LandSat TM 1986 and LandSat ETM+ 2002.

In addition to this, the forest resource indirectly contributes to household food security through income generation and employment (FAO, 1991; Abiola, 1997). According to Meludu (2004), the forest sub-sector accounts for about 8% of the agricultural gross domestic product of the country. He also noted that the estimated benefit of biodiversity in general (in billion dollars), by the Federal Environmental Protection Agency in Nigeria amounts to $03.75 GDP. Current benefits (various species, subsistence, ecosystem, scientific and recreational) are $06.00; non-current, option, existence and inheritance uses are $01.00; and direct employment benefits are $15.60. All these will amount to about $26.35 billion. Despite these numbers, biodiversity depletion continues unchecked.

Therefore, socio-economic survey is important to identify the factors that drive changes in land use/land cover of an area. The socio-economy of Nigeria in general and the south western part in particular is changing based on the national goal of transforming the country from oil-based to agricultural-based economy during the past two decades (that is since 1991). The change in the economic system of the region puts pressure on the agricultural sector. This in turn leads to the opening up of more natural forests for cultivation. Hence, the expansion of agricultural land is partially responsible for the disappearrance of the tropical rainforest of the area in the study period.

Other important factors of the land use/land cover change in the region are the expansion of settlement and illegal logging. As shown in Table 2, settlement expanded by 192.4% in the past two decades. This has an adverse effect on the forest resources of the area. Illegal logging is particularly largely responsible for the ever decreasing area of the forest reserves. In terms of government policy, as noted by Salami (2001), the introduction of exotic species plantations into the forest reserves that were originally designed to serve as repositories of the natural species of the forest belt has modified the ecological setting of the region. The process involves extensive clearing and burning of the native species (original species) before planting exotics. All these have ecological implications in the area. The land tenure system, which originally was communal in nature and has now given way to individual tenure, also has its own impact on the existing land cover of the study area.

In addition to the above noted human factors, climate change has significant impact on land use/land cover changes observed during the study period. In this regard, Fasona and Omojola (2005) report rainfall changes, which is a critical element of climate and climatic changes in tropical Africa, in the guinea-sudan-sahel (GSS) zone of Nigeria over a six decade (1940 - 2000) period. According to their report, the decade 1950s recorded the highest rainfall while the decade 1980s had the least rainfall from the total decadal mean. The pattern of land co-

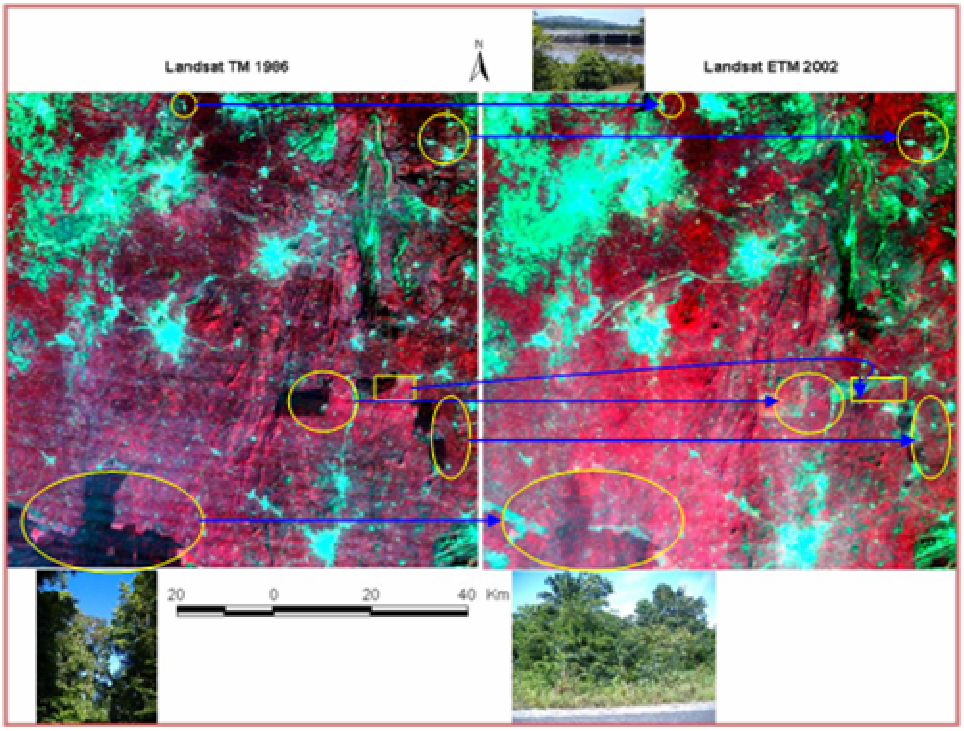

Figure 5. Areas showing significant changes during the study period.

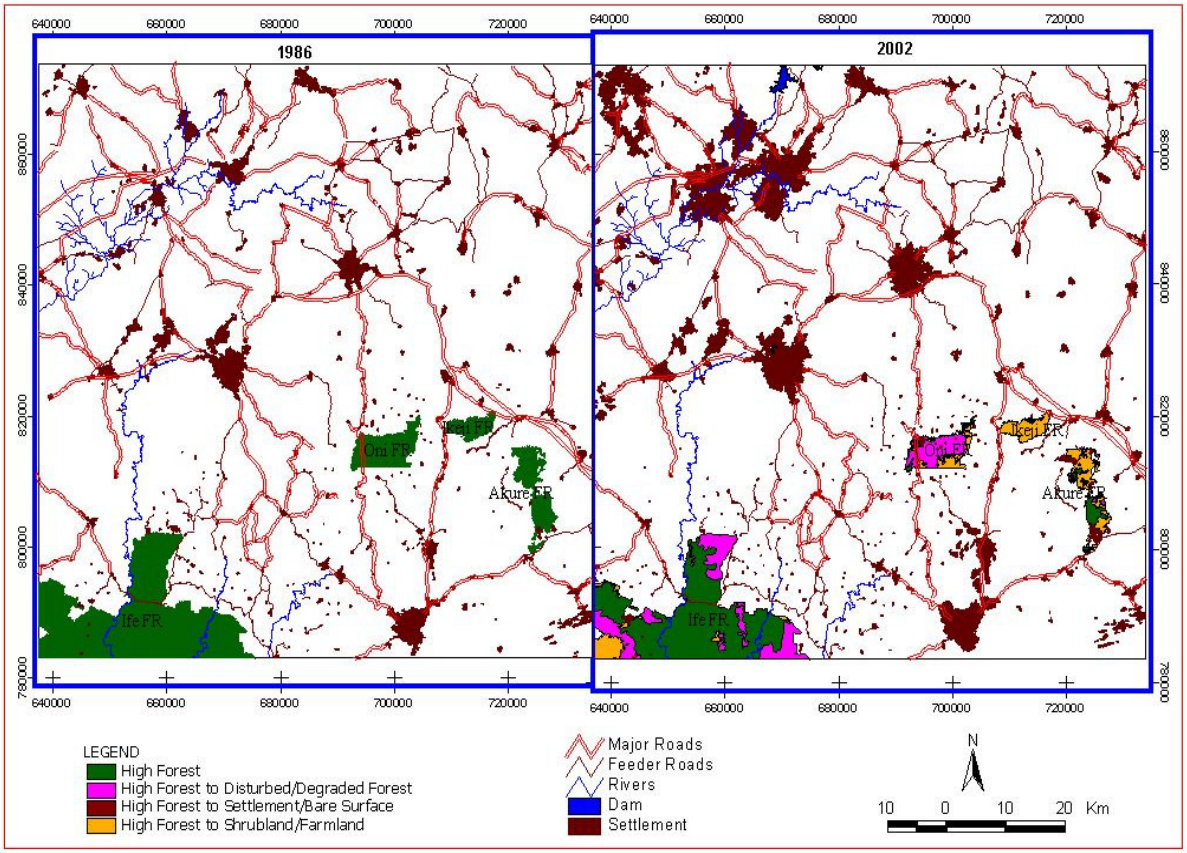

Figure 6. Status of forest reserves that fall in the study area (Left: 1986 and Right: 2002).

ver changes between 1976 and 1995 strongly indicated loss of prime arable lands resulting from climate change, which is in turn leading to opening up of new virgin lands towards the south (Fasona and Omojola, 2005).These are strong signals of the effects of climate change on land use /land cover change at local level. Generally, the increasing down-south march of the Sahara desert through the Sahelian zone of Nigeria is leading to the opening up of more natural forests for cultivation and grazing in the guinea savanna and rain forest zones.

Consequences of land use/land cover change

Tropical deforestation has been an environmental concern (Azeez, 2002) affecting both the forest areas and forest communities. The forest cover protects the environment by regulating soil water, habitat for wildlife, biodiversity, carbon fixing (UNEP, 1992) and provides other numerous natural resources. The continuous degradation of the forest has major effects on other segments of the environment. The manifestations of these have been noted to be in form of the rapid disappearance of forest cover leading to erosion, loss of biodiversity, soil degradation, and unfavorable hydrological changes. Regarding the soil degradation, Salami (1998) noted that the replacement of mature forest by plantations of exotics has negative effects on the soil. Once the tropical rain forest is disturbed, the organic matter content of the soil declines until restoration of a cropping system or forest that contributes carbon to the soil as rapidly as it is lost through oxidation. However, the high population density has led to a situation in which the land cleared from forest, is re-cultivated at repeated intervals and not allowed to regenerate into mature secondary forest.

Land use/land cover change has far reaching ecological consequences. According to Olaniran (2002), in Nigeria, deforestation has been seen to cause erosion that is affecting reservoirs, decreasing the aquatic popu-lations, reducing the navigability of canals and also the quality of soil. He also noted that the problem of deserti-fication and environmental degradation caused by land use/ land cover change threatens the country.

Land use/land cover change also has an adverse effect on the biodiversity of the study area. In this regard, Ojo (2004) in his study of Abeku sector of Omo forest reserve indicated that there were 98, 109, 95 and 71 plant species enumerated in 1985, 1987, 1997 and 2000 respectively. According to his report, the increase from 1985 to 1987 was due mainly to more species being identified in the 1987 enumeration but the subsequent decrease between 1997 and 2000 was due largely to long interval between measurement during which the plots had been encroached and some plots completely lost to cash and arable crop farming. This affected the diversity of the tree species in the forest reserve. Okigbo (1982) argued that some plant species are either rare or absent from the study area as a result of farming activities based on the practice of shifting cultivation.

Generally, it has been noted that land degradation is both a part and consequence of environmental changes leading to loss of valuable land resources. There is the need therefore to strike equilibrium in the uses to which the land is put in order to minimize the far reaching ecological consequences of land use/land cover change as highlighted in this study.

Conclusion

This study has demonstrated that the recent advancements in remote sensing and GIS technologies provide powerful tool for mapping and detecting changes in land use/land cover. This research carried out in a part of south-western Nigeria using these modern technologies in conjunction with field observation showed both land cover conversion and modification. The general trend observed by the present study is a decrease in forests and derived savanna and a corresponding increase in shrub land/farmland complex and settlement/bare surface. The implication is that the present tendency may lead to more land degradation. Thus, this trend needs to be corrected. Land use/land cover mapping and detection of changes shown here may not provide the ultimate explanation for all problems related to land use/land cover changes and cannot be an end in itself rather, it serves as a base to understand the patterns and possible causes and conesquences of land use/land cover changes in the area.

The ecological problems associated with the land use/land cover changes discussed are linked with the socio economic change of the local population as well as to a certain extent, with population growth. Settlement expansion and illegal logging are also the major factors behind the land use/land cover changes observed in the area. The findings of this study highlight the need for a comprehensive assessment of human activities in south-western Nigeria and the adaptation of sustainable forest management practices such as close supervision of forest reserves in the region and making more arable lands available through restoration of already degraded and impoverished lands.

ACKNOWLEDGMENTS

The Authors would like to thank the Africa Regional Centre for Space Science and Technology Education-English (ARCSSTEE), Ile-Ife, the National Space Research and Development Agency (NASRDA), Federal Ministry of Science and Technology, Abuja, Nigeria and the United Nations Office for Outer Space Affairs (UNOOSA), Vienna, Austria for their financial and material support to carry out this project.

REFERENCES

Abiola JO (1997). Forestry for Sustainable Development Towards the

21st Century. Proceedings of the 11th World Forestry Congress 12th –13th October, Vol. 8.
Adejuwon JO, Jeje LK (1973). Landuse map of Ife area. Federal Surveys Department, Lagos, Nigeria.
Akinyemi (2005). Mapping land use dynamics at a regional scale in southwestern Nigeria. ipi.uni-hannover.de/html/publikationen/2005/workshop/149-akinyemi.pdf.
Amamoo-Otchere E, Oyinloye RO, Ozah AP, Agbo, FB (1998). Automated discrimination between built-up and nonbuilt-up as a settlement detection technique for population census base map revision. The International Archives of Photogrammetry and Remote Sensing, Stuttgart, Germany, 32(4):700-701.
Azeez IO (2002). Evaluation of Media Mix for Disseminating Forest Conservation Information in Southwest Nigeria. A Ph.D Thesis in the Department of Forest Resources Management. Faculty of Agriculture and Forestry, University of Oibadan, Ibadan Nigeria. pp. 1-206.
Balogun EE, Salami AT (1995). Global and Regional Climate Changes and Variability: Evidence of Climate Change in Africa and Nigeria, In: Umolu, J.C. (Ed.) Global Climate Change: Impact on Energy Development. Fab Anieth Nig. Ltd., Jos. pp. 40-47.
FAO (1991). Household Food Security and Forestry an Analysis of Socio-economic Issues. Community Forestry Note 1. FAO, Rome. pp. 140-148.
Fasona MJ, Omojola AS (2005). Climate Change, Human Security and Communal Clashes in Nigeria. An International Workshop Holmen Fjord Hotel, Asker, near Oslo, pp 21–23.
Federal Office of Statistics (1988). Annual abstracts of statistics 1988 Edition. Federal Office of Statistics, Lagos, Nigeria. p. 218.
Houghton RA (1994). The worldwide extent of land-use change. BioScience 44: 305–313.
Lambin EF (1997). Modelling and monitoring land-cover change processes in tropical regions. Progress in Physical Geograph. 21: 375–393.
Lambin EF, Geist H, Lepers E (2003). Dynamics of land use and cover change in tropical regions. Annual Rev. Environ. Resour. 28: 205–241.
Meludu NT (2004). Assessment of income generating activities that influence sustainable livelihoods of forest communities in Nigeria: Implications for policy enhancement in Nigeria. In: Baumgartner, David M.; ed. Proceedings of Human Dimensions of Family, Farm, and Community Forestry International Symposium, March 29 – April 1, 2004. Washington State University, Pullman, WA, USA. Washington State University Extension MISC0526. ISBN Number 0-9721994-5-
Myers N (1993). Tropical forests: the main deforestation fronts. Environ. Conserv. 20: 9–16.
Nunes C, Auge JI (1999). Land-Use and Land-Cover Implementation Strategy (Stockholm: IGBP).
Ojo LO (2004). The fate of a tropical rainforest in Nigeria: Abeku sector of Omo forest reserve. Global Nest: the Int. J. 6 (2): 116-130.
Okigbo BN (1982). Impact of agricultural systems and rural development on Nigerian forests. In: L H MacDonald (ed.), Agro-forestry in the African Humid Tropics, Proceedings of a Workshop Held in Ibadan, Nigeria, NRTS-17/UNUP, pp.171-.???
Olaniran YAO (2002). Strategic and Policy Issues in Poverty Reduction: the forest Perspective. Proceedings of the 28th Annual Conference of the Forestry Association of Nigeria held in Akure, Ondo State. pp. 103-113.
Oyinloye RO, Agbo BF, Aliyu ZO (2004). Land Use/Land Cover Mapping in Osun State using NigeriaSat-1 Data. http://www.nasrda.gov.ng/docs/gueye.pdf (accessed 13 April 2005).
Salami AT, Akinyede J (2006). Space technology for monitoring and managing forest in Nigeria, a paper presented at the International Symposium on Space and Forests, United Nations Committee on Peaceful Uses of Outer Space (UNOOSA), Vienna, Austria.
Salami AT, Balogun EE (2006). Utilization of NigeriaSat-1 and Other Satellites for Forest and Biodiversity Monitoring in Nigeria. National Space Research and Development Agency (NASRDA) Monograph, Federal Ministry of Science and Technology, Abuja.
Salami AT (1995). Structural changes in vegetal cover in Ife and Ede regions of southwestern Nigeria between 1963 and 1993. Ph.D. thesis, Obafemi Awolowo University, Ile-Ife.
Salami AT (1998). Vegetation modification and man-induced environmental change in rural south western Nigeria. Agric. Ecosyst. Environ. 70: 159-167.
Salami AT (1999). Vegetation Dynamics on the fringes of lowland humid tropical rainforest of south western Nigeria- an assessment of environmental change with air photos and LandSat. Int. J. Remote Sensing, 20(6): 1169-1181.
Salami AT (2001). Agricultural colonization and floristic degradation in Nigeria's ecosystem. The Environmentalist, 21: 221-229.
Salami AT, Ekanade O, Oyinloye RO (1999). Detection of forest reserve incursion in south-western Nigeria from a combination of multi-data aerial photographs and high resolution satellite imagery. International J. of Remote Sensing, 20(8): 1487-1497.
Turner BL II (2002). Toward integrated land-change science: Advances in 1.5 decades of sustained international research on land-use and land cover change.: in Steffen W, Jäger J, Carson DJ, Bradhsaw C (eds). Challenges of a Changing Earth. Berlin: Springer. pp. 21–26.
UNEP (United Nations Environment Programme), (1992). Draft Plan of Action to Combat Desertification. United Nations conference on Desertification, Nairobi, 29 August.
Vitousek PM (1992). Global environmental change: an introduction. Ann. Rev. Ecol. Syst. 23: 1–14.