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LAND USE/LAND COVER CHANGE DETECTION IN IKWUANO AREA, ABIA STATE NIGERIA USING LANDSAT DATA

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ABSTRACT

The use of remotely sensed data through Geographic Information System template for land use evaluation and classification is relatively cheap with less drudgery. Landsat satellite imageries covering Ikwuano area were acquired and processed with ERDAS Imagine. These were applied in mapping land use changes in Ikwuano Local Government Area of Abia State, Nigeria. Three major LULC types: forest land, agricultural land and built - up land were identified. Over the 14 year period, the quantitative analysis of the imageries showed that 10.2% of the total land area changed from forest land to agricultural land; 4.5% changed from forest land to built- up land; 10.9% from agricultural land to forest land. About, 18.1% of agricultural land remained unchanged; 9.9% of agricultural land changed to built - up land; 4.5% from built - up to forest; 9.4% from built - up to agricultural land. Anthropogenic factors were identified as playing a significant role in land cover change. A similar remote sensing approach could be used for monitoring temporal and spatial aspects of other regions as well as employed in the development of the natural resource database of the country.

INTRODUCTION

Land is about the most important endowment of Nigeria, providing livelihood in both the agricultural and non-agricultural sectors. Thus, the nation's development is intricately tied to the efficient use and management of its land resources (Omoti, 1999). Nigeria's land area of about 924,000 km^2 supports about 150 million people (NPC, 2006). This population, which is rapidly growing at the rate of 3.5% per annum, has resulted in a great pressure on the land. More often than not, land use practices in Nigeria, do not take cognisance of the suitability of the land for the intended purpose. The increasing population in Nigeria and its associated unplanned pressure on land has led to the indiscriminate use of land without much consideration for the short and long term effects on the environment. Usually, decisions on land use are made indiscriminately based mainly on economic and political considerations, with little or no consideration for the biophysical status of the soils (Nuga, 1998).

In the scenario of a rapidly expanding world population, changes in land use and declining forest cover, remote sensing has the role of an emerging discipline, and provides essential tool of trade to the field forester. (Howard, 1991). Land use change is altering human and

natural systems globally and regionally (Solecki, 2001; Foley *et al.*, 2005). Globally, nearly 1.2 million km^2 of forest and woodland and 5.6 million km^2 of grassland and pasture land have been converted to other uses, and over the last three (3) centuries, 12 million km^2 of cropland were lost (Rahamankutty and Foley, 1999). Conversion of natural landscapes to human dominated uses alters the availability of energy, water and nutrients to ecosystems, degrades soil and water, increases the spread of exotic species, reduces biodiversity, increases exploitation of species, accelerates natural processes of ecosystem change and adversely affects the structure and functioning of ecosystems (Adger and Brown, 1994; Ojima *et al.*, 1994; Vitousek *et al.*, 1997; Pimm and Riven, 2000). Knowledge of the dynamics and patterns of typical forest loss and fragmentation may be useful for answering questions related to long sustainability of human-forest interaction and for developing management policies that protect and enhance tropical forest (Fox *et al.*, 1995).

This study was therefore carried out to identify major land use/land cover types in the area and its dynamics over a fourteen years period.

MATERIALS AND METHODS

Study Area

The study area is located in the South eastern region of Nigeria. It is one of the seventeen Local Government Areas making up Abia State. The area lies between latitudes 5° 20' and 5° 30'N, longitudes 7° 28' and 7° 42'E, with elevation ranging from 109 to 152m above mean sea level. The study area is bounded in the north by Umuahia LGA, in the south by Ikot-Ekpene, Akwa Ibom State, in the east by Bende LGA and in the west by Isiala Ngwa LGA.

Data Acquisition and Processing

Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM +) images (with path 188 and row 056) acquired on December 19th, 1986 and December 17th, 2000 respectively, were employed in the land use/ land cover mapping. The original satellite images used for this project were Landsat TM (Thematic Mapper) from the Landsat home page *http://www.landsat.org/ortho/index.htm*. These images are representations of the available features and land covers over the particular area covered. The images consist of different bands and each band register wavelengths that are used for different purposes. Tables 1 and 2, shows the basic characteristics of Landsat TM images for the two different years considered for the study.

The satellite orbits was at an altitude of 705 km providing a 16-day, 233-0rbit cycle with a swath overlap that varies from 7 percent at the equator to nearly 84 percent at 81° North or South latitude. These satellites also were designed and operated to collect data over a 185-km swath. The TM sensor primarily detects reflected radiation from the earth's surface in the visible and near- infrared (IR) wavelengths. The TM sensors have seven spectral bands. The wavelength range for the TM sensor is from visible, through the mid-IR, into the thermal-IR portion of the electro-magnetic spectrum.

The acquired images were processed using ERDAS IMAGINE 9.1 and ArcGIS 9 software. On the acquired images, water appeared deep blue, vegetation (forests and cultivated land) showed up in red and settlements and road showed up in shades of cyan.

Table 1: Different bands, wavelengths, colors main purpose and resolution of 1986 satellite image.

Band	Wavelengts	Colour	Main Purpose	Resolution
1	0.45 – 0.52 μm	Blue	Maximum penetration of water, which is useful for bathymetric mapping in shallow water, useful for distinguishing soil from vegetation and deciduous from coniferous plants	30m
2	0.52-0.60 μm	Green	Matches green reflectance peak of vegetation, which is useful for assessing plant vigor	30m
3	0.63-0.69 μm	Red	Matches a chlorophyll absorption band that is important for discriminating vegetation types	30m
4	0.76-0.90 μm	NIR	Useful for determining biomass content and for mapping shorelines	30m
5	1.55-1.75 μm	MIR	Indicates moisture content of soil and vegetation. Penetrates thin clouds, and provides good contrast between vegetation types.	30m
6	10.40-12.50 μm	TIR	Nighttime images are useful for thermal mapping and for estimating soil moisture	120m
7	2.08-2.35 μm	MIR	For mapping hydrothermally altered rocks associated with mineral deposits.	30m

Source: Note, NIR = Near Infrared, MIR = Mid Infrared, TIR = Thermal Infrared

The 2000 has two extra bands. These bands represent bands 6 and Table 2 shows the different bands, wavelengths, colors, main purpose and their resolution.

Table 2: Wavelengths, colors main purpose and resolution of bands 6 and 8, in satellite image 2000

Band	Wavelengts	Colour	Main Purpose	Resolution
6	10.40-12.50 μm	TIR	Cloud detections	60m
8	0.52-0.90 μm 15m	Panchromatic	Large area mapping and urban change studies	15m

Source: Boggione *et al.*, (2003)

Image Classification

Image classification is the process of sorting pixels into a finite number of individual classes or categories of data based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to those criteria.

In this study, the unsupervised classification was used, in which a thematic raster layer map was created by letting the software-ERDAS IMAGINE, identify statistical patterns in the data. The land use/land cover mapping was done by relying heavily on the differences of spectral characteristics of the landscape for seperation into meaningful land use and land cover classes. Multispectral reflectance data or remotely sensed imagery from satellite sensors serve as surrogate data representative of landscape feature or attributes.

A modified land – cover classification scheme that was consistent with the one developed by Anderson *et al.*, (1976) was used as the classification scheme (Table 3). This same scheme has been used by Oyinloye *et al.*, (2004) and Akinyemi (2005) for land cover classification in different parts of Nigeria. The modified scheme consists of three (3) classes with eleven (11) subclasses imbedded.

Table 3: Modified Anderson *et al.*, (1976) Land cover classification scheme used for the study

Land Cover Class	Subclass
Built up/ Open land	Settlement Residential/ office areas Roads Open land/ fields Bare soil
Forest	Natural forest Forest Plantaintion Secondary regrowth
Cropland	Cultivated Field Fallow land Open bushland Dense bushland

RESULTS AND DISCUSSION

The result of the changes in the surface area covered by each land cover type which were calculated between 1986 and 2000 is shown in Table 4. The change detection matrix is shown in Table 5 and the percentage change in one land cover to another in Table 5. It was discovered that Forest covered 18157.28 ha (37.41%) in 1986 and 18508.33 ha (38.13%) in 2000. Cropland/sparse vegetation was 18856.38 ha (38.86%) in 1986 but came down to 18292.44 ha (37.69%) in 2000. Built up/open land/roads increased from 11520.63 ha (23.73) in 1986 to 11733.52 ha (24.18%) in 2000.

The percentage changes in land cover over the period of study are shown in Table 6.Out of 18157.28 ha that was forest in 1986, 11037.02 was still forest in 2000 representing 60.79 % but 4932.47 ha (27.17%) was converted to cropland/sparse vegetation and 2187.80 ha (12.05%) to built up, open land/roads. At the same time, of the 18856.38 ha that was cropland in 1986, 5290.59 ha (28.06%) changed to forest; 8782.62 ha (46.58%) remain unchanged as cropland and 4783.18 ha (25.37%) was changed to built-up/open land

/roads. Built-up/open land / roads covered an area of 11520.63ha in 1986. By 2000, 2180.73 ha (18.93%) were changed to forest; 4577.35 ha (39.73%) to cropland and 4762.55ha (41.34%) remain unchanged. The result in Table 4 showed that net increase in Forest cover was 351.05 ha (0.72% increase over 1986 by 2000). That of cropland, sparse vegetation decreased by 563.95 ha (-1.17% decrease). The built-up/open land/roads increased by 212.89 ha (0.45% increase) over the same period .

Between 1986 and 2000, there had been significant land cover changes in the study area. The data showed a decline in area covered by cropland / sparse vegetation. As the population of the study area increased e.g. due to the establishment of a Federal University (Federal University of Agriculture, Umudike) in the area and a Federal Research Institute (National Root Crop Research Institute, Umudike), there was an influx of people to the area which necessitated the clearing of land for new dwelling places. The first to go were probably the croplands / farms near existing dwelling places. The deduction here is that as the local populace cleared more land in an attempt to accomodate the influx of people into the area . The loss in cropland as indicated in the results, most probably, was amplified by the fact that the time of image acquisition for the study falls within the dry season (off season), in which case most crops have been harvested and a large percentage of the remaining crops have shed their leaves or taken up brownish colouration which has similar spectral tone to that of openland/roads/built up areas.

Table 4: Overall percentage/ Summation of Land use /Land cover Changes over 14 years period.

LU/LC	1986	2000	Change (ha)	1986	2000	Change %
				Area coverage (%)		
Forest	18157.28	18508.33	351.05	37.41	38.13	0.72
Crop land/Sparse vegetation	18856.38	18292.44	-563.95	38.86	37.69	-1.17
Built up/open land/roads	11520.63	11733.52	212.89	23.73	24.18	0.45
Total land area	**48534.29**	**48534.29**		100%	100%	

Table 5: Change Detection Matrix for the land use/ land cover analysis of Ikwuano LGA of Nigeria.

	Land use/ Land cover 2000 (Hectares)			
Land use / land cover 1986	**Forest**	**Crop land/ Sparse vegetation**	**Built up/open land /roads**	**Grand Total**
Forest	**11037.02**	4932.47	2187.80	18157.28
Crop land/Sparse vegetation	5290.59	**8782.62**	4783.18	18856.38
Built up/open land/roads	2180.73	4577.35	**4762.55**	11520.63
Grand Total	18508.33	18292.44	11733.52	48534.29

Table 6: Percentage Change in land use/ land cover of Ikwuano LGA of Nigeria betweeen 1986 and 2000.

	Percentage change in land cover between 1986 and 2000 (%)			
Land use/land cover	**Forest**	**Crop land/ Sparse vegetation**	**Built up/open land /roads**	**Grand Total**
Forest	60.79	27.17	12.05	100
Crop land/Sparse vegetation	28.06	46.58	25.37	100
Built up/open land/roads	18.93	39.73	41.34	100

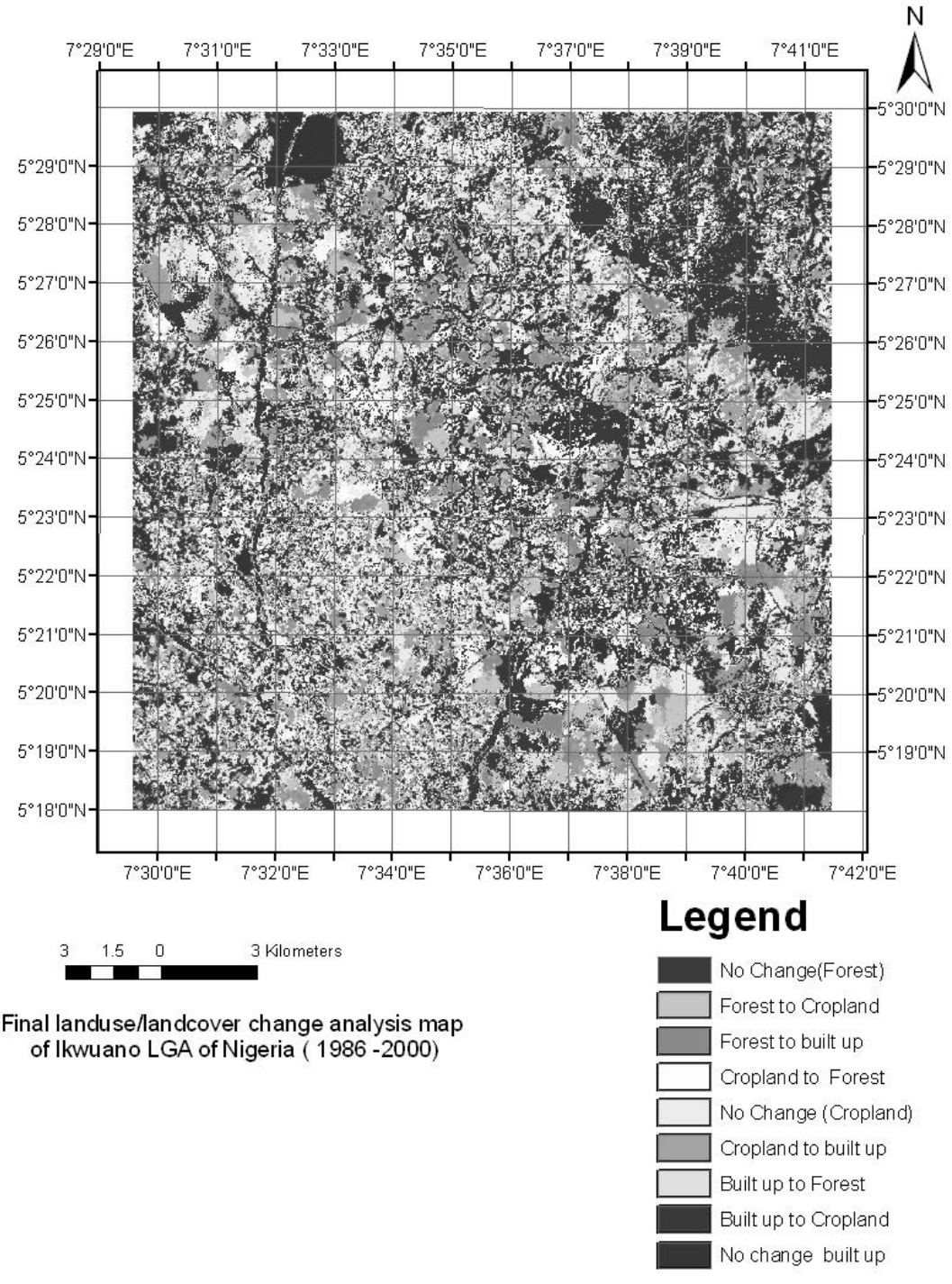


Fig 1: Land use / land cover change analysis map of Ikwuano LGA of Nigeria (1986-2000).

The area of forest lost was gained by the transformation of some cropland/ sparse vegetation to forest (probably secondary fallow). This could have been through the fallow system (of between 2-3years) which is a common practice in the area. Also a number of homes had fruit trees planted around it and this would have formed closed canopies within the study period to qualify them as forest cover. Another possibility for the seeming gain by forest would have been spectral reflectance of cassava plant which was the major crop on the field at the time of the year when the data were captured and also observed during the ground truthing exercise.

Land use/land cover change in the study area was initiated with the clearing of forest and cropland through slash and burn techniques commonly followed by the planting of annual crops and in some cases, fields are kept in cultivation continuosly. The typical nature of change is one from undisturbed forest to a landscape cleared for crop production, with a significant component of secondary regrowth on abadoned land which in a number of cases are further exploited as fuel wood. The change in forest and cropland covers is also driven by the land clearing pattern of farmers in which case farmers tend to clear more land than they can manage at the outset, which later drop as farmers realize the high cost of management. The replacement of natural vegetation by agriculture (or replacement of vegetative cover) land/open surfaces will increase the land surface albedo which will accentuate the magnitude and duration of drought. Exposing fragile soils to long periods of insolation lead to accelerated erosion.

In addition, a number of land use practices physically observed in the study area such as annual bush burning, quarrying, farming on steep slopes, are not best management practices for the landscape. It leads to soil erosion which subsequently become a major contributor to non-point source pollution in the hydrology of the area and other forms of land degradation.

Nonetheless, no single factor may be attributed to be responsible for the land cover changes; instead the dynamics of land cover is a response to many variables relating to the local economy, institution and land tenure system.

CONCLUSION

The results of this study revealed the land cover change in the study area over 14 years-time period. The result can be employed in modelling land use /land cover change and it will go a long way in assisting such environmental tasks as land use planning, policy formulations, maintenance of land resources and environmental research and monitoring. There will therefore, be a reduction in uncertainty in the selection of land use strategies since decision makers will have a complete picture of the likely impact of alternative agricultural uses of land before changes are implemented.

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