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A GIS AND REMOTE SENSING APPROACH TO ASSESSMENT OF DEFORESTATION IN UYO, AKWA IBOM STATE NIGERIA

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Abstract

This study measured and analyzed deforestation in Uyo and examined the possible effects of the deforestation on the Environment. When and where have forest lands changed in Uyo from 1969 – 2004? Aerial photographs taken from 1969 – 2001 which use was complemented with the Quick bird satellite imagery for 2004 were applied. The objectives of this study were to: interpret and digitize remote sensing data for Uyo for the periods 1969, 1978, 1988, 2001 and 2004; evaluate the deforestation changes that had taken place in Uyo over the periods of the study and to assess the effect of deforestation on the Uyo environment. Along the remote sensing technology, the geographical information system (GIS) technology was applied to carry out this research. Field studies were also carried out to arrive at appropriate results. Forestlands continually dropped in land area during the period while industrial lands, institutional, residential and transportation lands recorded increases in land areas. Reclassifying the land uses into built-up and forest lands revealed that the built-up lands constantly rose while the forest lands kept dropping. The built-up lands increased by 40.34% between 1969 and 1978, 5.63% between 1978 and 1988, and 111.45% between 1988 and 2001 and 0.16% between 2001 and 2004 at the expense of the forest portion of the town which fell by 34.08% between 1969 and 1978, 8.57% between 1978 and 1988, 47.34% between 1988 and 2001 and 0.17% between 2001 and 2004. Furthermore, between 1969/1978, the average annual rates of deforestation in Uyo Urban area were 3.79%, 0.86% between 1978/1988, 3.64% between 1988/2001 and 0.06% between 2001/2004. The largest quantity, percentage and average annual rates of loss of forest lands were made between 1988 and 2001. Increase in population, per capita income, and land use activities and by extension urban expansion were found to be the major factors causing deforestation in Uyo. The fieldwork revealed that deforestation has caused many environmental problems in Uyo like flooding, gully erosion, scarcity of agricultural land and poverty. Efforts being made to reduce the problems included conservation of the ravine area which was prone to gully erosion and other hazards, construction of the Nkemba Trough to drain most of the flood water from the area, importation of food from other Local Government areas and other States to supplement food supply in the area. The Government, people and non-governmental organizations (NGOs) in Akwa Ibom State should co-operate to assist in mitigating the deforestation in Uyo.

Keywords: *Deforestation, Reforestation, Environmental problems, Uyo.*

Introduction

Tropical rainforests are incredibly rich ecosystems that play a fundamental role in the basic functioning of the planet. Rainforests are home to probably 50 percent of the world's species, making them an extensive library of biological and genetic resources. In addition, rainforests help maintain the climate by regulating atmospheric gases and stabilizing rainfall, protect against desertification, and provide numerous other ecological functions.

However, these precious systems are among the most threatened on the planet. Although the precise area is debated, each day at least 80,000 acres (32,300 ha) of forest disappear from Earth. At least another 80,000 acres (32,300 ha) of forest are degraded. Along with them, the planet loses as many as several hundred species to extinction, the vast majority of which have never been documented by science. As these forests fall, more carbon is added to the atmosphere, climactic conditions are further altered, and more topsoil is lost to erosion (FAO, www.fao.org).

Despite increased awareness of the importance of these forests, deforestation rates have not reduced. Analysis of figures from the Food and Agriculture Organization of the United Nations (FAO) shows that tropical deforestation rates increased 8.5 percent from 2000-2005 when compared with the 1990s, while loss of

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primary forests may have expanded by 25 percent over the same period. Nigeria and Vietnam's rate of primary forest loss has doubled since the 1990s, while Peru's rate has tripled.

Overall, FAO estimates that 10.4 million hectares of tropical forest were permanently destroyed each year in the period from 2000 to 2005, an increase since the 1990-2000 periods, when around 10.16 million hectares of forest were lost. Among primary forests, annual deforestation rose to 6.26 million hectares from 5.41 million hectares in the same period. On a broader scale, FAO data shows that primary forests are being replaced by less biodiversified plantations and secondary forests, (www.fao.org). Due to a significant increase in plantation forests, forest cover has generally been expanding in North America, Europe, and China while diminishing in the tropics. Industrial logging, conversion for agriculture (commercial and subsistence), and forest fires—often purposely set by people—are responsible for the bulk of global deforestation today.

The Food and Agriculture Organization of the United Nations (FAO, 2011), the leading source for information on the status of the world's forests, defines forests as land with a tree canopy cover of more than 10 percent and an area of more than half a hectare. FAO says that "forest" includes natural forests and forest plantations but specifically excludes stands of trees established primarily for agricultural production (i.e. fruit tree and oil palm plantations) and trees planted in agroforestry systems, (FAO, www.fao.org).

Other organizations use different standards for defining forests. For example, the United Nations Environment Programme (UNEP) uses 40 percent cover as the threshold for "closed forests" and 10-40 percent cover for "open forests." This study will generally follow FAO's convention, even though it has been criticized for its generous definition of what it considers forest.

FAO defines deforestation as "the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold." Depletion of forest to tree crown cover greater than 10 percent (say from 90 percent to 12 percent) is considered forest degradation. Logging most often falls under the category of forest degradation and thus is not included in FAO deforestation statistics. For this reason, forest degradation rates are considerably higher than deforestation rates.

Globally, annual deforestation amounts to about 13.7 million hectares (an area the size of England) and it has been widely recognised that curbing this forest loss is essential for both the maintenance of biodiversity and for cutting greenhouse gas emissions, (FAO, www.fao.org).

The rate of deforestation in Nigeria is one of the highest in the world. The National population has continued to grow at a rate of about 2.8 percent per annum while urban population has been growing at 4.5 percent per annum. Since the population is still predominantly rural, if these rates remain unchecked, more than half of the people would be residing in urban centres by the year 2020 (Geoinformatics International Inc. in 1996).

In this research, deforestation has been looked into strictly from the perspective of decrease in size of the forest area due to increase in population, leading to land use changes in the area and the subsequent expansion of the size of the city. Geoinformatics International Inc. in 1996 carried out analysis on the National Land Use and Vegetation change of Nigeria between 1976/78 – 1993/95. In that report, urban land use covered an area of 2083km^2 (0.2%) of Nigeria's total land area in 1976/78 and it increased to 5444 Kilometer square (0.6%) of the total land of the nation in 1995. Thus, indicating a significant 0.4% increase of urban land use of the National land. The breakdown of urban land use as given by Allen and Shinde 1981 for the Nation showed that Cross River State had 0.20 percentage urban land. This area incorporated Uyo Urban area, which was then a local government under the Cross River State. Akwa Ibom State then was under Cross River State. Thus, Uyo had no separate data for her urban area.

In the 1996 assessment of land use and vegetation change of Nigeria, Geoinformatics International Inc. did not map out the urban land areas for each state, as was the case of Allen and Shinde 1981 assessment. Thus the land use data for Uyo urban area as at 1996 was not available. Also since the creation of the state in September 1987 up to today, Akwa Ibom State has no data on land use and vegetation change for the state not to talk of land use change data for Uyo urban area. However aerial photographs for the area have been taken for the past years but no comprehensive analysis had been done with the

photographs to assess the land use changes that had taken place within the period.

Study Area

Initially, Uyo was a small village with a dispersed settlement pattern typical of the area. It was thinly populated by peasant farmers. The village was bordered on the North by Afaha Oku, on the South by Aka village, on the east by Anua and Itiam and on the West by Oku and Iboko.

Uyo later became a Local Government Headquarters in Cross River State, Nigeria. With the creation of Akwa Ibom State as a geo-political entity on 23rd September 1987, Uyo then assumed the status of a State Capital. This transformation brought about increase in population and human activities, land use dynamics and by extension deforestation in Uyo. In view of the above, this research on deforestation in Uyo urban area and its implications on the environment were deemed necessary.

The actual area of Uyo was very small covering no more than 16 square kilometers (Akwa Ibom State, 1989). It is located between 112,000m S – 118,000mN) and 604,000m – 610,000m W in the UTM Zone 32. The Limit of Uyo as at 1989 covered an estimated radius of about 3kms and has a total area of about 60km^2. Presently, on the Longitude and Latitude basis, the area is located between latitude 4°59′ and 5°04′N and Longitude 7°53′ and 8°00′ E. Also, the area is located on an elevation of about 60.96 meters (2090ft), above sea level.

Figure 1 Map of Uyo Metropolis.

Source: Ministry of Works & Housing, Uyo, Akwa Ibom State.

Materials and Methods

All aerial photographs for 1969, 1978, 1988, and 2001 used for this study were acquired from the aerial photogrammetric unit of the Ministry of works, Housing and Land Development at Uyo, Akwa Ibom State. The satellite imagery that was used in the study was the Quick bird of 0.6 resolution procured from the National Population Commission Headquarters at Abuja, Nigeria. The remote sensing and the geographic information system (GIS) technology were applied in carrying out the deforestation analysis for Uyo Urban Area The China graph, pencils, tracing paper and the mirror stereoscope were used for the interpretation of the aerial photographs before subjecting them to GIS analysis.

The stepwise methodology followed in this analysis was careful examination of the satellite imagery and photographs, development of an interpretation key, plotting of the Uyo boundary, georeferencing of the digital data, interpretation

of the data, collection of ground truth data, editing, finalizing of maps and extraction of the statistical data for the different land use types. This was as seen applied in the works of Singh and Loshali 2005, Gourmelon, *et al*., 2004, Laymon, 2003, Acevedo *et al*., 2003, Geomatics International Inc. 1996 and Ashbindu *et al*., 2001.

An A_0 digitizing tablet was used to convert the 1969, 1978, 1988, and 2001 hard copy maps into soft copies. Correction of the digitized maps was carried out using Arc/info software. Clean and build commands in Arc/info were used to establish topology. The coding of the various land uses was done using Arcview GIS 3.2a. Predominant land use types were interpreted based on the interpretation key. Appropriate colors were used to symbolize the different land uses, layouts were created and the final maps were produced. Quantitative data for the different land use types for the different time periods were extracted.

The interpretation of the satellite imagery was onscreen using Arc View 3.2a software in a windows XP professional operating environment. This was possible because the imagery was digital. The correction of overshoots, under shoots was done using Arc/Info software. Topology was established among the lines and polygons and the coding of the various land uses was done using Arc View GIS 3.2a. Appropriate colors were given to the different land uses, layouts were developed for them and the final maps were produced. Quantitative data for the different land use types for the different time periods were then extracted.

Change detection analysis was carried out in this study (Woodwell *et al*., 1984 and Williams, 1984) and the extent of deforestation changes was calculated through simple subtraction of the previous inventory data from the current one and the rate of the changes was determined by calculating their respective percentage values.

Forest Area

Interview was organised with the Director of Forestry Department at Uyo and group discussion with the two communities living close to the forest areas to know what was currently going on in this sector. This was followed by a reconnaissance survey of the forest area and the taking of forest inventory. Twenty 5m by 10m plots were marked out and inventory of the tree species in each plot was taken, (Hopkins, 1974)). The plots were taken at 100m intervals along transects in the area. The identification of the tree species was done with the Burkill technique, (1985, 1994, 1995, 1997 and 2000). The derived data were then summarized according to the families and species, subsequently the total frequencies and their relative abundances were also calculated. Relative abundance for each species was calculated by the formula: Relative abundance =n/N x 100…8. Were n represents the number of individuals plant species and N is the total number of individuals identified at the sites.

Results and Discussion

The results of the interpretation of aerial photographs and the satellite imagery were as given in Appendix A The built-up land kept on increasing from 1969 to 2001 though it had a slight drop in 2004 at the expense of the forest land, see table 1 and 2 at Appendix A.

Table 3 again revealed clearly that built –up lands had continuous gain of land between the respective years of comparison except between 2001 and 2004 that it had loss of land. These gains in land were only made at the expense of the forest land.The deforestation rates differed for the different period because the length of time and factors that interplayed in the deforestation differed.

Assessment of Forest Areas

The forest in Uyo Urban Area was located in the North and Northwestern part of the town. It had two types of ecosystem: the most forest and bush fallow forest. Generally speaking, the area was predominantly covered by immature forest, wooded shrubland and herbaceous vegetation i.e secondary regrowth forest. It was observed that mature forest was conspicuously absent meanwhile portions of natural forest and forest enriched with planted exotic tree species like Gmelina arborea, cashew tree, Eucaluptus were found in the area. The most relatively abundant tree species in the forest areas were *Elaeis guineensis, Oxytenanthera abyssinica* (bamboo), *Anacardium occidentale, Mangifera indica* and *Harungana madagascariensis*. Meanwhile the least relatively abundant species were *Ceiba pertandra, Uapaca guineensis, Sysmphonia globulifera, Antiaris toxicaria, Celtis mildbraedi* and *Vitex donania* species.

The result of the interview held with the Deputy Director of Forestry in Akwa Ibom State revealed that the ravine area had been proposed to be Uyo Ravine game reserve. Notice had been published revoking rights of occupancy of

landowners in the area. A reserve settlement officer had been appointed to constitute the area into a reserve. What was pending was payment of compensation to owners of lands in the area. Because these compensations had not been paid, it became difficult forest officers to exercise of power over the land. This permitted owners of land in the area to use their land as they wished.
Planting of trees started in the area between 1982 -1985 to prevent and or check erosion. Cashew, Gmelina, Teak, Nauclea, Acacia and other exotic tree species were planted here then. The area had mixed plantation species and naturally growing trees. Agricultural activities were dominant in the area since the people had not been paid compensation. Encouragement was being given to individuals to get them involved in urban forestry through offering of seedlings and technical advice to private nursery businessmen and individuals interested to plant trees.

Land use changes in Uyo Urban area had caused accelerated deforestation prompted by urban household demand for wood, charcoal, water resource and growth in agriculture. This finding corresponded to the findings of the work of Adeofun and Akinsanmi (1997) on Assessment of Deforestation in Lowland areas of South-Western Nigerian using Remote Sensing techniques. This has led to serious gully erosion and land degradation in the area.

However, there are a number of steps/majors that government needs to take to be able to solve the land degradation/the ravine expansion activities that was threatening life and devastating the Uyo urban environment. These included:

- Formulation of enabling law constituting and establishing the ravine area into a game reserve and laws governing operations in the area. Some of the areas should even be designed inviolet.
- Complete purchase/payment of compensation to all individuals and families that own landed property within the ravine area. This will facilitate the possession and ownership of the area to be under the total control of the state government.
- With this, government will be courageous to exercise power over the management of the place. Forest guards can then be stationed at specific locations, to regularly patrol the area.
- Strict and difficult sanctions should be levied on people caught exploiting resources or tampering with the planted trees in the area.

While efforts are being made to carry out enrichment planting in the area, the natural vegetation should be allowed to flourish and grow. Some of the woody plant species found in the forest areas of the study were similar to those identified by Dike (2005) and Etukudo (2000).
All these efforts will bring about tremendous environmental services to Uyo urban area such as:

i. **Biodiversity Conservation and Maintenance**: through biodiversity conservation and maintenance, animal and plant species that had disappeared in Uyo Urban area will reappear. With the conducive physical and management environment, these resources will be sustainably managed and conserved.
ii. **Erosion control**: With the growth of trees, herbs and shrubs in the area, erosion activities will be arrested and the spread of the ravine will be a phenomenon of the past. This will also cause improvement in soil fertility. The African bamboo was being commonly used by government officials and individuals for erosion control in the area. There was need to step down all hanging drainage channels into the ravine to minimize or reduce future erosion activities caused by the channelling of run-off water into the ravine. Therefore all such hanging channels within the ravine area needed to be reconstructed. The method was being adopted/implemented in the overall channeling of run-off from rainstorms in Uyo Urban Area through the Nkemba trough which is strongly recommended.
iii. Watershed protection and maintenance is another wonderful environmental service that will be provided. Through this, there will be re-appearance of streams that had disappeared and the recharge of the available streams with the reappearance of fish in the streams and particularly the Ikpa River. It will also enable pure drinkable/table water to be available to the people at minimal cost and quality than the one obtained through water treatment facilities.

The conservation of the area could lead to development of recreational parks which will generate a lot of revenue for the state government. Timber may also be harvested on a

sustainable basis. Individuals, non-governmental organizations, research scientist and other arms of government can buy all the environmental services that will be rendered. In the developed countries, people pay money just to walk and recreate over a forest land. This will soon start in Nigeria and Uyo in particular. People desire to get closer to nature after the struggles in urban life. These findings corresponded with an executive summary of international tropical timber organization (ITTO) technical series 21, (2004), on market seen for environmental services rendered, which stated that markets for forest ecosystem services are expected to grow in both developed and developing countries over the next 20 years and the potential for increased demand and increased payment for watershed services is immense. Water demand is projected to double if not triple over the next 50 years, and much of this growth will be in developing countries. Alf Leslie (2005) re-emphasized this in his predictive statement which states thus "current world demand for the products and services of forests is a mix of static or only slightly increasing demand for wood, a steady but slowly increasing demand for non-timber forest products (NTFPs), and a burgeoning but largely unmentioned demand for environmental services".

Conclusion

The forests give life, not only to other species, but they help to prolong the human race. The forests have global implications not just on life but on the quality of it. Trees improve the quality of the air that species breath by trapping carbon and other particles produced by pollution. Trees determine rainfall and replenish the atmosphere. As more water gets put back in the atmosphere, clouds form and provide another way to block out the sun's heat. Trees are what cool and regulates the earth's climate in conjunction with other such valuable services as preventing erosion, landslides, and making the most infertile soil rich with life. Mother earth has given much responsibility to trees. Thus all efforts must be made to sustainably manage the forest in Uyo urban area through aforestation, reforestation and even enrichment planting of exotic tree spcies.

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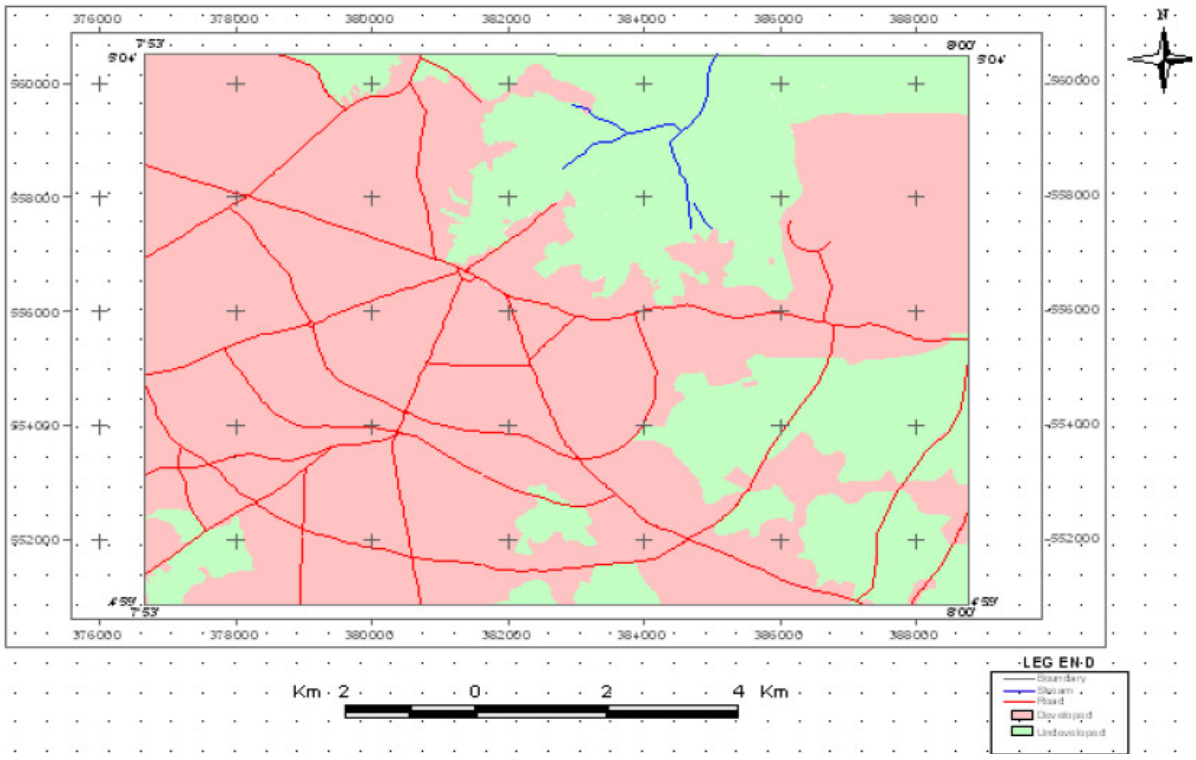

Figure 2 Built-up and Non built-up Areas of Uyo Urban: 2004

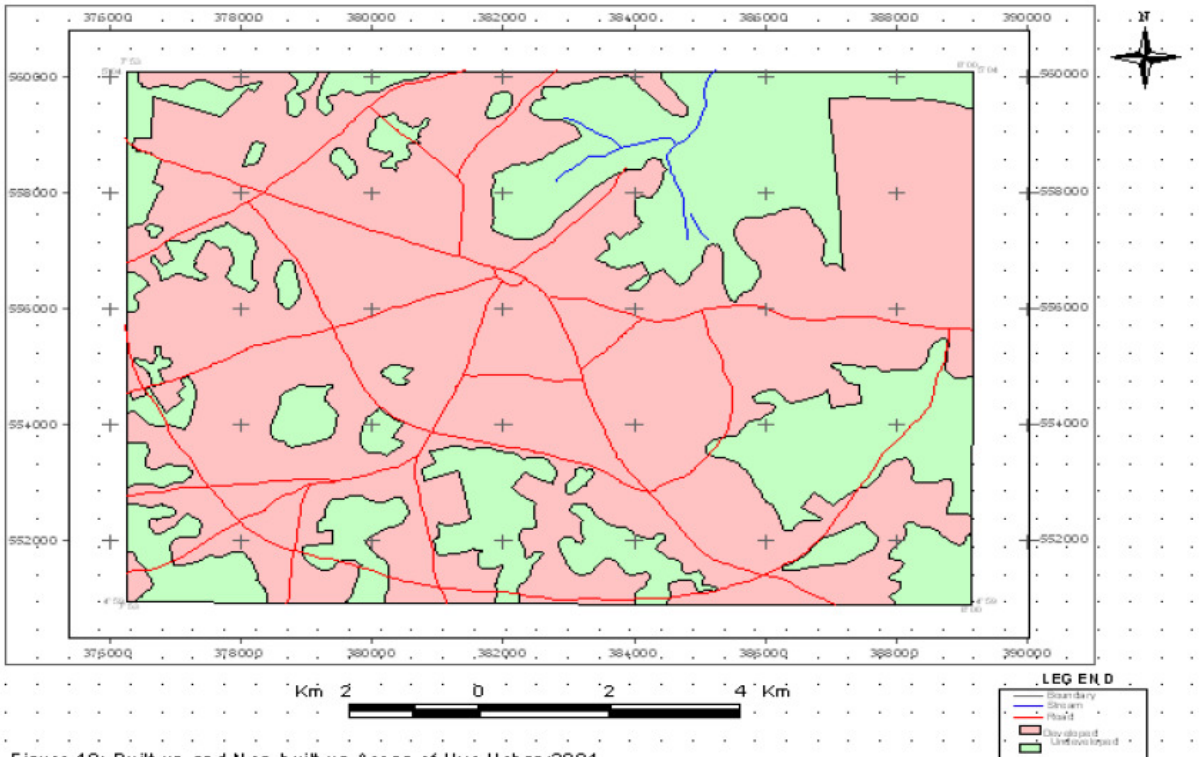

Figure 3 Built-up and Non built-up Areas of Uyo Urban: 2001

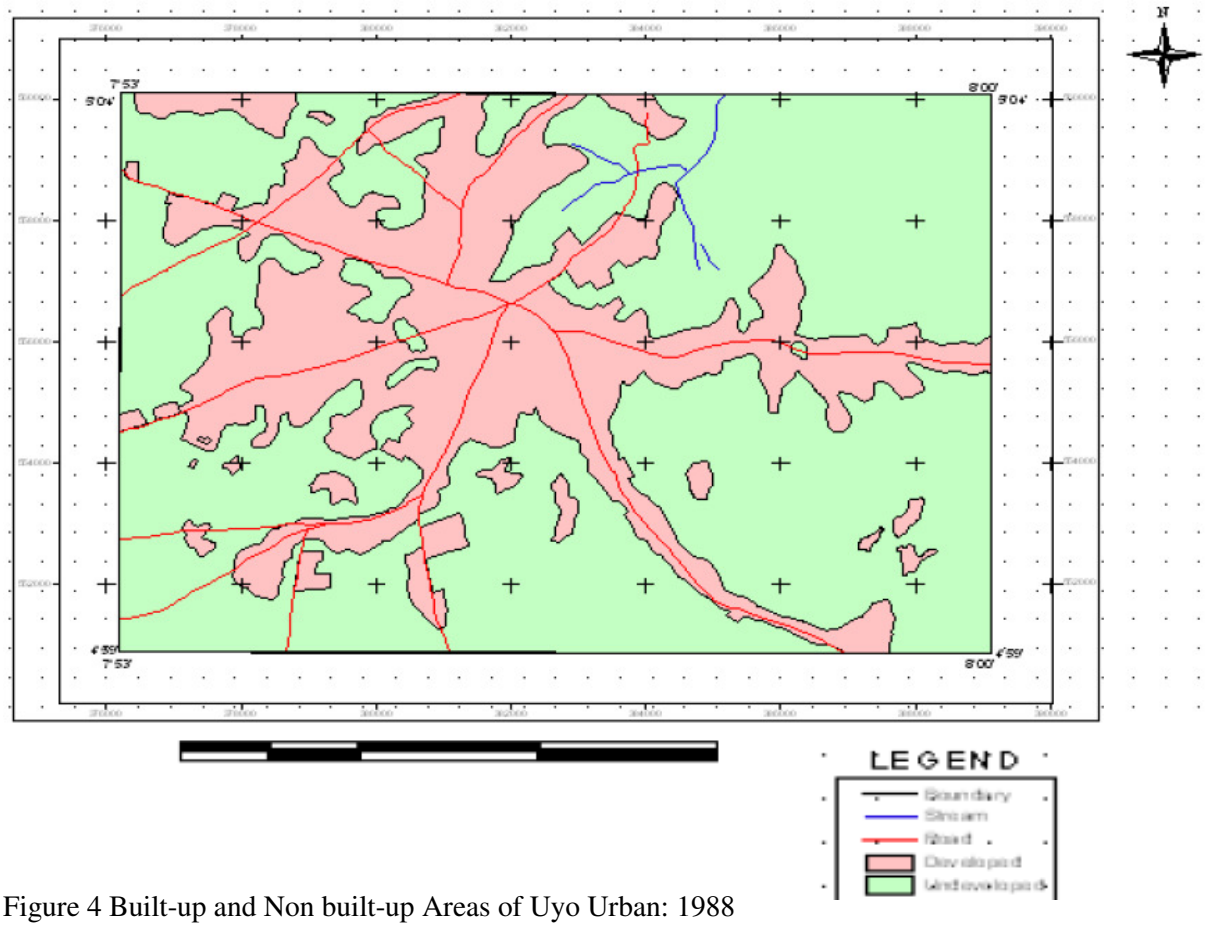

Figure 4 Built-up and Non built-up Areas of Uyo Urban: 1988

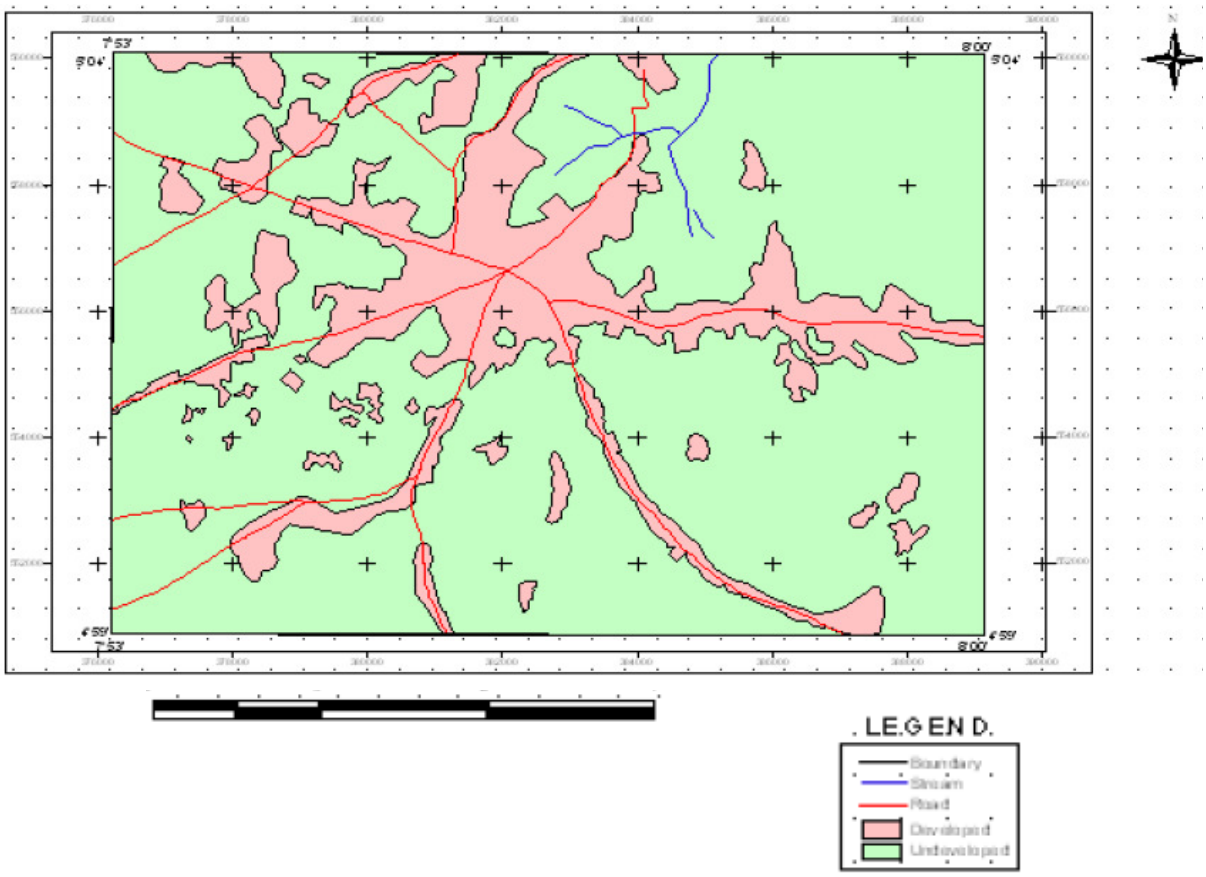

Figure 5 Built-up and Non built-up Areas of Uyo Urban: 1969

Table 1 The built-up land kept on increasing from 1969 to 2001 though it had a slight drop in 2004 at the expense of the forest land

Landuse class	1969	1978	1988	2001	2004
	(ha)				
Forest	3246.94	2140.41	1957.07	1030.60	1028.82
Built-up	2626.29	3685.62	3892.96	8231.59	8218.47

Table 2 Summary of Forest and Built-up landuse change statistics from 1969 - 2004 for the different Compared Periods

	The Quantity of forest and Built-up land that was gained or lost and their respective percentage values for the Compared Periods							
Land use Class	1969-1978	%	1978-1988	%	1988-2001	%	2001-2004	%
Forest	1106.53*	34.08*	183.34*	8.57*	926.47*	47.34*	1.78*	0.17*
Built-Up Lands	1059.33	40.34	207.34	5.63	4338.63	111.45	13.12*	0.16*

* Loss of land, both actual and percentage figures.

Table 3 Average annual rates of deforestation for the compared periods for Uyo urban.

Land use type	1969/1978 (%)	1978/1988 (%)	1988/2001 (%)	2001/2004 (%)
Forest	3.79	0.86	3.64	0.06
Built-up land	4.48	0.56	8.57	0.05

The deforestation rates differed for the different period because the length of time and factors that interplayed in the deforestation differed.