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The use of Geographic Information Systems (GIS) and Remote Sensing (RS) Techniques for Detecting Sub-Urban Growth in Federal University of Technology, Akure

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***Abstract*—This paper examined the use of GIS and Remote Sensing in detecting the sub urban growth in the Federal University of Technology Akure over a period of 28 years. In effect, the study sought to identify and explain the rate and extent of changes in the study area between 1986, 2002 and 2013; assess the impact of the university campuses on land use patterns; and the trend of sub urban growth in the study area. The growth of the Federal University of Technology, Akure and its environs as a sub urban was analyzed using multi-temporal and multi-source satellite imageries of Land SAT Thematic Mapper (TM) of 1986 and Enhanced Land SAT Thematic Mapper (ETM+) of 2002 and 2013 with an accuracy assessment of 75 %, 72 % and 75 % respectively. The study employed supervised digital image classification method using Arc Map 10.0 GIS software. The Land SAT imageries were classified into built up area, vegetation, gallery forest and bare lands area. Based on the GIS data analysis, the trend and future prediction of was modeled between 1986 and 2013. The results showed the growth of the university and its effects on the land use patterns of the sub-urban. The results obtained shows that none of these land uses were stable over time (i.e. 1986 – 2013). These results help the city planners and policy makers to identify areas where environmental and natural resources are critically threatened in the sub urban and suggest likely future directions and patterns of the sub urban growth. It also recommends sustainable forest management, sustainable residential development and spatial management information system for the sub urban.**

***Keywords*—Sub urban growth, remote sensing, GIS, Satellite images, Sustainable development**

I. INTRODUCTION

The world's rapid urbanization especially in the developing countries has been a major cause of environmental change. The number of people living in urban areas of developing countries has risen from about 30 million in 1950 to 1.7 million today. The world's population, estimated by the United Nations to be 45% urban in 1995, is projected to reach the 65% urban by the year 2025 (United Nations, 1995).

Population growth in urban centers raised both pressure on resources to satisfy basic biological needs and magnify the effect of resources in per capita consumption.

There has been an increasing emphasis on the spatial dimension of human habitation all over the world and this has led to the identification of sub urban settlements and their trend of growth in relation to the existing urban development [9], [6]. In most countries of the world, the existence of university campuses exists and the associating sub-urban development can always be observed. These sub-urban settlements do not always exists around university campuses but also at the suburb of almost every urban settlement [1].

Several studies have been conducted on sub urban growth in both developed and developing countries. Fox investigated the near-campus student housing and the growth of the town and gown movement in Canada [4s]. The research found that over 150 communities across Canada, both large and small, are home to colleges and universities with an estimated 645,000 full-time university students and an additional 410,000 full-time college students registered in various programs of study. Xiaodi pointed out that most Chinese universities are undertaking new constructions and expansion [10]. He pointed out that Chinese universities chose to relocate their campus to suburban areas where the land cost is lower and sold the campus land inner city for capital to support future development. He discovered that opening new suburban campuses to expand the scale of university campuses is also a common strategy [3]; Gillham believed that in many states, sub-urban growth exists everywhere, especially at the suburb of the major urban center [5]. This cannot be said to be totally untrue, but there is a need to scientifically and empirically find out rate and pattern of the sub-urban growth around university campuses.

Sub-urban growth around university campuses is a creative hub critical to city expansion hence increase in economic, cultural, social and political functions [10]. With this in mind, there is a need to look at these functions particularly the economic function and how this affects the development of the urban. Bhata suggested that the sub-urban growth usually occurs because authorities pay little attention to slums, land, services and transport [2]. Authorities lack the ability to predict urban growth and, as a result, fail to provide land for the urbanizing poor. In addition, the urban poor are denied land rights which are one of the main factors driving people to the periphery of towns, associated with sub-urban sprawl in developing countries [2]; [6]; [8]. Oyinloye integrated the use of Geographical information systems and remote sensing in the detection, management and analysis of sub urban and urban centers in Morocco, Kolkhata, India; Santa Barbara, California; Hyderabad-Secundrabad, India; Madurai city; Shijiazhuang City; Akure, Nigeria respectively [7]. The goal of this paper is therefore to examine and detect the associated sub urban growth around Federal University of Technology, Akure and to analyze the pattern and trend of the sub-urban growth in relation to the university over a period of years.

The objectives of this paper are to:

i. analyze the acquired remotely sensed imageries of the study area so as to establish the rate and trend of growth of the sub-urban in relation to the physical and demographic growth of the campus;

ii. spatially map out the sub-urban area using remotely sensed data and GIS techniques;

iii. identification of various land cover and land use classes in remotely sensed data sources of the sub-urban; and

iv. calculation and quantification of the basic land use and cover data in the sub-urban area in relation to the population growth of the university campus from 1986, 2002 and to 2013.

II. THE STUDY AREA

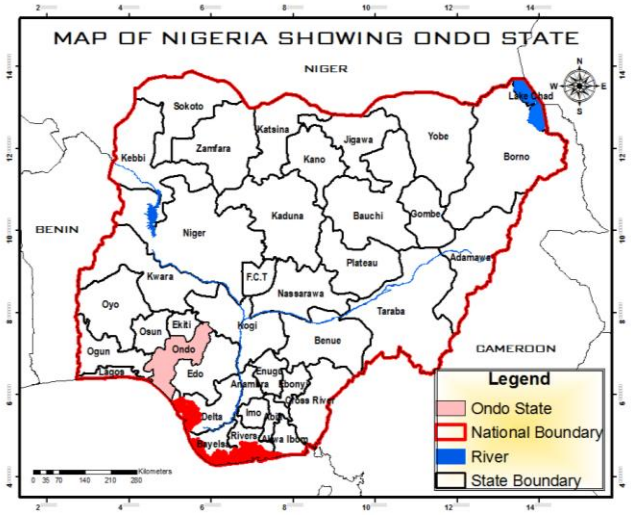

Fig. 1: *Map of Nigeria showing Ondo State.*

The study area is located in Akure South Local Government, Ondo State Nigeria (Figures 1 and 2). Akure South is a Local Government Area in Ondo State, Nigeria. Its headquarters are in the town of Akure with an area of 331 km² and a population of 353,211 at the 2006 census.

The study area (Figure 3) focuses on the Federal University of Technology, Akure and the associated suburban development approximately between longitude 5^0 8'East and 5^0 10' East of the Greenwich Meridian and between latitude 7^0 16' North and 7^0 19' North of the Equator.

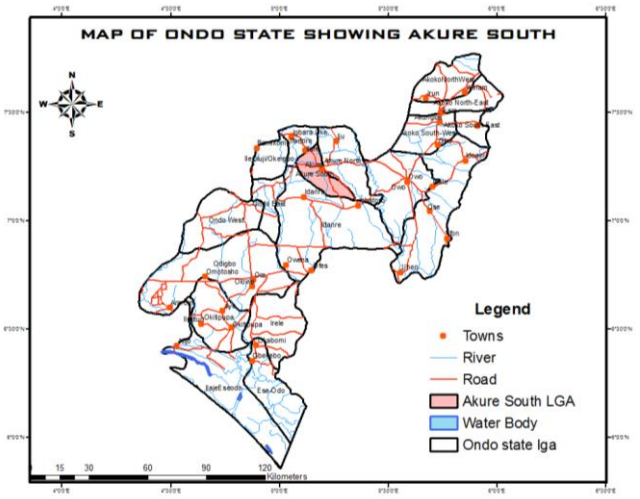

Fig. 2: *Map of Ondo State Showing Akure-South Local Government*

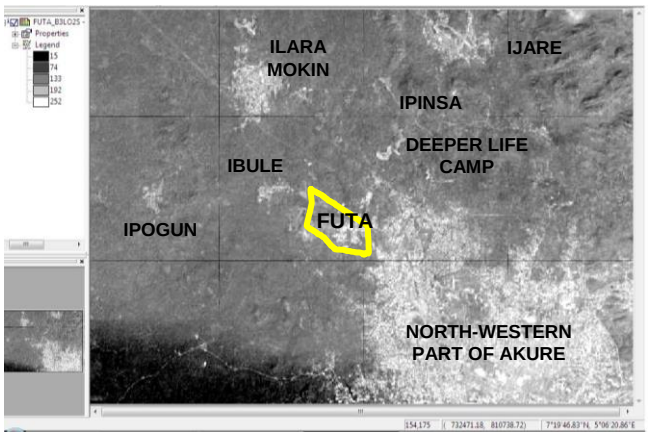

Fig. 3: *Satellite Imagery of FUTA and Its environment capture using Quick Bird*

The university campus is located along Akure-Ilesha express way with immediate surrounding communities like Aule, Ibule, and Ipinsa. The study area is accessible to almost every part of the state with a federal highway passing through the study area. The university campus covers 5,801.60 square kilometers with student enrolment population of 20,332 students as at 2012/2013 academic session. This population figure is shared among the under graduate and post graduate degree programmers in the institution. The population figure of the university campus was put at 143 students in 1997/1998

academic session, 11,662 students in 2003/2004academic session and 28,332 students in 2013/2014 academic session.

However, the population figure of the suburban is not readily available from the 1991 and 2006 population census figures, the current number of buildings were counted manually from Google earth satellite imagery dated 2014 and put the number of buildings at over 1,256 buildings in the suburban. The growth in population is due to many factors including; natural increase, immigration, development, expansion in population figures of the institution and improvement in social and environment infrastructure of the suburban.

III. Materials and Methods

Both primary and secondary data which contain both spatial and non-spatial attributes were used in this study. Multi-annual socio-economic statistical data, multi-temporal city maps, and three (3) remote sensed data. The approach adopted in this study of sub urban growth analysis was the post-classification comparison analysis which is a GIS approach of overlaying two or more produced classified images. The main aim of the study is to analyze the sub urban growth of the city, direction of change; trend and amount of changes that have occurred have to be deduced. So with the use of multi-date remote sensing images and ability to create overlays in the GIS environment, the post classification comparison method appears to be the best approach for this study. Three remote sensed data namely Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM^{+}) covering the study area were used to monitor the sub urban growth for two periods (1986-2000; 2000-2013) giving a total period of 27 years. The image processing procedure includes image-processing, classification design scheme, image classification results analysis. Since the study involved the use of multi-temporal image data, the image pass through geometric correction. This is to allow pixels of each image align to a common map projection or coordinate system. This metric correction includes georeferencing and resampling. A supervised classification was performed on false colour composites (bands 4, 3 and 2) into the following landuse and land covers classes. Built–up area, vegetation, gallery/ high forest and bareland. Information collected during the field surveys was combined with the digital topographic map which was developed for the city and was used to assess the accuracy of the classification. The digitalized topographic map and images together are manipulated in map to allow for GIS overlay creation for the purpose of comparison and qualitative visual assessment of the possible factors influencing sub urban growth.

IV. Results and Discussions

This section reports the findings on the supervised classification of the acquired Land SAT TM of 1986, ETM+ of 2002 and 2013. Among the variables examined are: built up area, bare lands, vegetation, gallery forest and the associated population growth of the university campus. The growth of the university campuses itself is also linked to the growth of the entire sub-urban; several maps have been produced both for the sub-urban and the university campus itself.

The pixel statistics of land use in Landsat TM 1986 and Landsat ETM+ of 2002 and 2013 as presented in table 1 shows the trend and pattern of the various land use indicators.

Concerning the trend, pattern and of change in built up area in the sub-urban, the entire sub-urban have witnessed a tremendous growth in the built up area land cover. The built up area from 1986 to 2013; increased with over 61 % in the suburban. As at 1986, the estimated land area for the built up area was put at 5,316.24 square kilometers and have almost doubled up with a new area of 9,961.95 square kilometers. With a lesser time period, the rate of increase is with just a thousand square kilometers lesser than the previous increase, putting the new area for built up at around 13,823.12 square kilometers. This shows that there is more development in the suburb within 12 years after year 2002 as opposed to the time period of 27 years in 1986 – 2013 (see figure 4 and table 1).

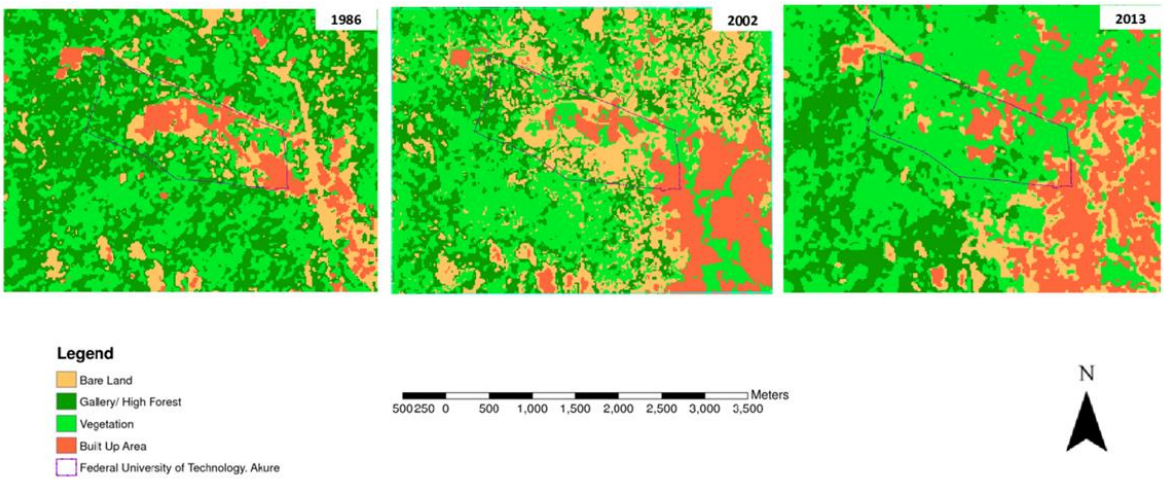

Fig. 4: *Supervised Classification of Landsat Tm of 1986, Landsat ETM+ of 2002 and 2013*

TABLE 1: Summary of land use land cover in square kilometers of the results of supervised classification of land sat tm of 1986, land sat etm+ of 2002 and 2013

Land Use indicator	1986		2002		2013	
	Area (sqkm)	%	Area (sqkm)	%	Area (sqkm)	%
Built Up Area	5,316.24	13.05	9,961.95	24.46	13,823.12	33.94
Gallery/High Forest	17,554.29	43.10	8,946.98	21.97	5,975.59	14.67
Vegetation	15,032.04	36.91	16,086.17	39.50	16,390.76	40.25
Bare land	2,824.35	6.93	5,731.82	14.07	4,537.46	11.14
Total	**40,726.92**	**100.00**	**40,726.92**	**100.00**	**40,726.92**	**100.00**

The entire sub-urban as at 1986 is covered with 6.93 percent of bare lands, this is associated with few activities and ample transportation routes that are mainly of footpaths to farms and the contributing bare lands in the university campus itself are some areas under construction and open ground for activities. Much of the previous bare lands that were at 14.07 % in 2002 have decreased with of 2.93%. This can be attributed to the fact that the much of the bare lands in 2002 are areas under construction possibly for new hostels (both off campus and on campus), new lecture theaters and other buildings needed to accommodate the increasing population of students in the school.

The percentages of gallery/ high reduced from have been decreasing steadily over the years; the high decrease was seen from 1986 to 2002 with a percentage of 21.97% while the rate of decrease from 2002 to 2013 was one third of the previous decrease (7.30%). Although the forest is been threatened at all times, the decrease of 7.31% of forest from 2002-2013 within 12 years is of serious concern as the ecosystems and wild life is seriously threatened. While the vegetation is increasing steadily with 0.75% in 2002-2013 shows the conversion of most of the forest to vegetation areas. As the suburb is increasing with population, the forest might be dangerous to live with due to security issues; most of these forests are de-forested and reduced to plain vegetation lands

The post classified image differencing image of 1986 and 2002 in figure 5 shows much increase and growth in the built up area at the south eastern part of the study area commonly referred to as Aule while that of 2002 and 2013 reveals the growth and increase in the built up area at the north eastern part of the study area, commonly referred to as road block while the population of the university campus increases. The post classified image differencing image of 1986 and 2002 shows the overthrow if the forest resources majorly the south western part of the study area initially occupied with gallery/ forest land.

In 2002 and 2013 post classified image dereferencing image, reveals a sparse change in vegetation cover to gallery/ forest, however the north majority of the forest land cover at the north eastern part of the study area have been overthrown with vegetation cover, built up area and bare land.

However, it is quite evident that the vegetation cover is increasing at the expense of the decrease in forest resources over the years. This is quite evident at the simple correlation table 1 revealing a negative correlation between the vegetation and forest resources. This encroachment might be as a result of deforestation and the clearing of the forest land due to human settlement especially at the north eastern part of the study area between years 2002–2013.

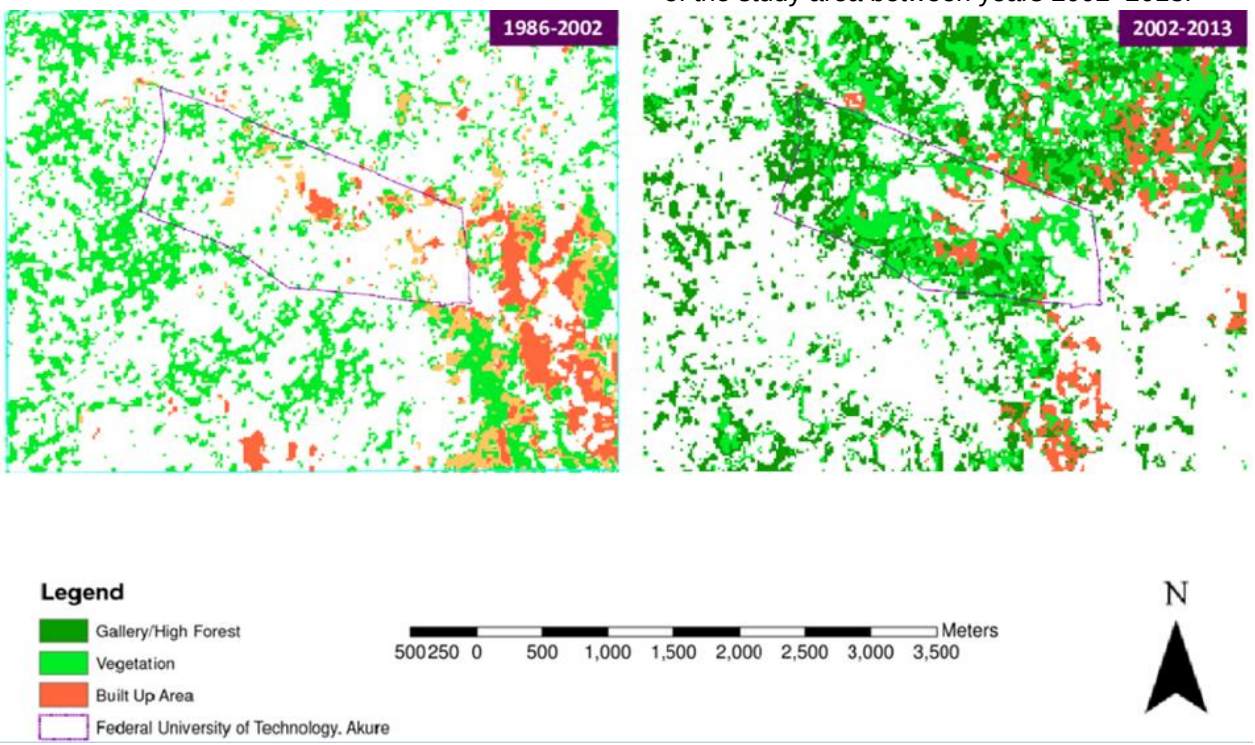

Fig 5: *Post-classification image differencing of the acquired Multi-temporal Landsat Satellite Imageries*

A. The growth of the University Campus and the Sub-urb

As at 2002, School of Sciences have moved some departments to the *Obanla* Campus, the total population of the school as at 2003/2004 session was at 11,662 students both male and female. With this, there is more pressure on the vegetation and forest resources for academic buildings, lecture theatres, student's hostels and staff hostels. Table 1 shows a decrease in 12.8 % of forest resources in the university campus while in the suburb the forest resources decrease at 22.5 percent.

With the higher number of students, more than half which are undergraduates seeks accommodation off campus and more commercial centers have developed in the suburban. The growth of the built up area in the campus that happened to rise with 21.1 percent have had serious implications on the other land uses especially the vegetation and the gallery/ high forest. It is important to note that the bare land decreased at a rate of 7.8 percent, this as a result of the previous land covered with bare land in the university campus as at 1986 have been overthrown with the built up area. Moreover, there is general increase in the land cover in the suburb at the expense of the high forest due to the expansion of the university campus in terms of built up area and population increase (see Table 1).

TABLE 2: SUMMARY OF STUDENTS ENROLMENT BY SCHOOL

School	Academic Year		
	1987/1988	2003/2004	2012/2013
Agriculture	41	1604	3225
Engineering	40	3111	4814
Environmental	0	1696	3897
Science	62	3846	5674
SEMS	0	1405	1839
Management	0	0	883
Total	**143**	**11662**	**20332**

Source: Academic Planning Unit, FUTA

Table 2 shows that as at 2013, the School of Management has been established with a total student enrolment of 883 students in 2012/2013 academic session. Meanwhile the other schools have increased in student enrolment as the School of Environmental Sciences increased from 1405 students in 2003/2004 academic session to 1839 students in 2012/2013 academic session; School of Environmental Technology increased from 1696 students in 2003/2004 academic session to 4814 students in 2012/2013 academic session; School of Agriculture Technology increased from 1604 students in 2003/2004 academic session to 3225 students in 2012/2013 academic session; School of Engineering increased from 3111 students in 2003/2004 academic session to 4814 students in 2012/2013 academic session; while School of Sciences still maintaining the highest number of student enrolment increased from 3846 students in 2003/2004 academic session to 5674 students in 2003/2004 academic session. With the higher number of students (about 69.72% are undergraduates) seek accommodation off campus and on-campus, increase number of lecture theaters and more commercial centers have developed in the suburban to meet the needs of the population.

Figure 6 shows that the growth of the built up area in the campus happened to rise with 7.6% far lesser than that of 1986-2002 which was at 21.1 % which had serious implications on the other land uses especially the vegetation and the gallery/ high forest. It is important to note that the gallery/ high forest have decreased at a rate of 5.3 percent in the campus and 7.6 percent in the suburb as a result of the encroachment of the built up, vegetation and bare lands. Moreover, there is general decrease in the vegetation cover from year 2002-2013 due to more clearing of forest for habitation, increase in farm lands and security purpose.

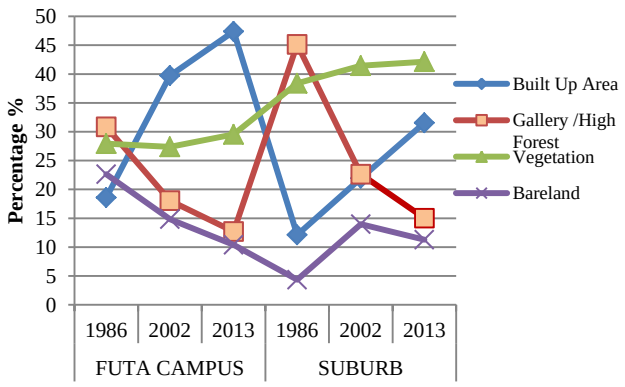

Fig. 6: *The relationship of the changes in land use and land cover in year 1986, 2002 and 2013 in the University Campus and the Suburb.*

Source: Author's Field Work (2013)

Specifically, the land use land cover changes in the suburb between 1986 to 2002 was relatively smaller than the land use land cover change between years 2002-2013 notwithstanding the difference in years between these period. The increasing population of the university campus is a major source of increase in land use and land cover of the suburb.

This interaction demands for more land for transportation road network, hostel accommodations, loss of forest resources and the overthrow of the forest land with vegetation cover. Although this interaction in turns brings money and other benefits (ideas and information etc) to the suburb from the revenue derivable from the hostel owners, commercial establishment, and associated benefits, this has serious implications on the forest resources of the suburb which have decreased from 17,554.29 square kilometers in 1986 to 5,975.59 square kilometers in 2013, over 65% decrease (see table 1).

V. SUMMARY OF FINDINGS

This study has, concerned itself with the sub-urban growth detection around university campuses using the Federal university of Technology, Akure as a case study through the use of remote sensing techniques and data. The study have been able to demonstrate that population increase and land cover changes in the university campus accounts for the growth in land cover changes in the surrounding communities as well. Detailed studies on the growth of the university campus in terms of land cover changes and the growth of the sub-urban at different years have been discussed. For instance in 1986, four years after the commencement of the university, the land use land cover changes in the campus is very much different that the land cover figures gotten form the supervised classification of Land SAT ETM+ of 2002.

One important fact that has come out of this work is that the increase in population size of the university campus has had serious implications on the land use land cover indicators of the campus and sub-urban over the past years. The growth and size of the university campus' population (see Table 2) and establishing of more schools have led to the increasing land use land cover areas for the built up areas in the university itself. The growth of land use land cover indicators in the university campus is positively correlated with the growth in the land use land cover in the outer sub urban. The gallery/ high forest land cover have been constantly decreasing in the university campus at a rate of 12.8 % from 1986 to 2002, 5.3 % from 2002 to 2013, with the same direction the forest land cover in the outer sub urban have decreased noticeably at a rate of 22.5 % from 1986 to 2002 and 7.6 % from 2002 to 2013. Other land use indicators have been at the rising category with the built up area rising tremendously at 11.41 % from 1986 to 2013 and 9.48 % from 2002 to 2013.

This interaction demands for more land for transportation road network, hostel accommodations, loss of forest resources and the overthrow of the forest land with vegetation cover. Although this interaction in turns brings money and other benefits (ideas and information etc) to the suburb from the revenue derivable from the hostel owners, commercial establishment, and associated benefits, this has serious implications on the forest resources of the suburb which have decreased from 17,554.29 square kilometers in 1986 to 5,975.59 square kilometers in 2013, over 65% decrease.

VI. CONCLUSION

This study has employed the use of Remote Sensing and Geographical Information System (GIS) to study the sub urban growth of the Federal University of Technology Akure and its environs and the growth are discernible on the processed image therefore, the quality of the image is acceptable for sub urban growth detection with an accuracy assessment of 75 %, 72 % and 75 % for Land SAT Thematic Mapper (TM) of 1986 and Enhanced Land SAT Thematic Mapper (ETM+) of 2002 and 2013 respectively.

The Land SAT Thematic Mapper (TM) of 1986, Land SAT Thematic Mapper (ETM+) of 2002 and 2013 were used to analyze the sub urban growth. The results of the processed images show the growth expanding rapidly towards the eastern part of the study area, towards Akure city metropolis with the forest land area constantly decreasing over the years while the built up area increases with the highest percentage among the land use land cover indicators. The results of the findings will assist in providing information for city planners and decision makers, also to support sustainable sub – urban development initiative.

The mapping out and identification of the growth of this sub-urban would lead to a better planning and utilization of the environmental resources as an instrument for physical, social and economic development.

VII. RECOMMENDATIONS

The Federal University of Technology, Akure has greatly influenced the birth and growth of this suburb. The major problems of most suburbs are the influx of the existing problems that occurred in the major urban setting of the city. Therefore, in order to enhance the functionality of the suburb and to control and mitigate the negative outcomes of urban growth and expansion and adequate and efficient development plan should focus on ways to sustain the present and future needs of the society through sustainable development. Sustainable development draws our attention to the need to develop the means and methods by which the human population can live in harmony with the environment, emphasizing the potential complementary relationship between economic growth and environmental improvement [11].

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