INTERNATIONAL JOURNAL OF ENGINEERING AND MANAGEMENT SCIENCES

www.scienceandnature.org

APPLICATION OF GIS AND REMOTE SENSING TECHNIQUES IN LANDUSE ANALYSIS OF AUCHI-URBAN CENTRE EDO STATE, NIGERIA

[1]OLATUNDE F.O , [2] IGBOKWE J.I.[3] OLATUNDE, M.B., &[4] ADEBOBOYE, A.J.
[1&3] Department of surveying & geoinformatics**,** School of environmental studies, Auchi polytechnic, Auchi**,** Edo state, Nigeria
[2 &4] Department of surveying & geoinformatics, Faculty of environmental sciences**,** Nnamdi azikiwe university, Awka, Anambra State,Nigeria

ABSTRACT
Human interactions on land both past and present and impacts of such interactions with the natural resources and the environment can be better understood if information on land use are made available. They equally provide adequate information for rational and sustainable allocation of land resources for future development. Over the time, land development programmes and projects have been under taken in Nigeria without considering the value of land use information and the neglect of this as posed problems in projecting the possible socio-economic and environmental consequences of such developments. This paper uses Auchi-urban center in Edo state as the case study. The different land use activities in the area were determined using satellite imagery and GIS approach. This study aimed at analyzing the land use of the study area. The imagery was acquired via Google earth and it was updated using a Hand-Held GPS and through informal interviews. ArcGIS 9.3 was the software employed for the geo-referencing and digitizing of the imagery. Classification scheme was developed. Statistical and geometrical analyses were carried out. The results show that there was imbalance in the land use structure of Auchi whereby some land uses were over represented at the expense of others. The results were analyzed statistically and queries generated. The final products were maps, bar charts and pie charts. This study showed that GIS and remote sensing techniques are effective in the creation and maintenance of an efficient and comprehensive land use database for Auchi where planners, policy makers and different stakeholders can have access to information on land use activities to enhance sustainable development which is important for a developing nation like Nigeria.

KEYWORDS: GIS, Remote Sensing, Land use, Classification Scheme, Geo-referencing and Digitizing.

INTRODUCTION

The use of land is referred to as land use. Land is a valuable possession to man. Man's activities for survival since creation have been on land where he inhabits and feeds from. He has learnt many ways and means of use, misuse, control and management of land. Land use is the human use of land. It involves the management and modification of natural environment or wilderness into built environment such as fields, pastures and settlements. It has also been defined as "the arrangements, activities, inputs people undertake in a certain land cover type to produce change or maintain it (FAO, 2012). The enactment of the radical Land Use Decree of 1978 is an attempt to introduce order into a situation that is in apparent chaos (Okpala, 1979). The decree emphasized land ownership, but did not take care of the proper use of land. As a matter of fact, the Land Use Panel of 1977, which preceded the decree was in addition aimed at to undertake a thorough review of the various land tenure systems and also required to examine the land use and land conservation practices in the country and take steps necessary for controlling future land use (Okafor, 1980). Land use is a description of how people utilize the land. Governments use land use maps to manage the development of lands within its jurisdictions. The Canadian Institute of Planners offers a definition that land use planning means the scientific, aesthetic and orderly disposition of land, resources, facilities and services with a view to securing the physical, economic and social efficiency, health and well being of urban and rural communities. The American Planning Association states that the goal of land use planning is to further the welfare of people and their communities by creating convenient, equitable, healthful, efficient and attractive environments for present and future generations. A land use plan provides a vision for the future possibilities of development in neighborhoods, districts, cities, or any defined planning area.

The rapid urbanization of the last century caused more slums in the major cities of the world, particularly in developing countries. Land use analysis plays important roles needed to address the problems of slum development, urban decay and renewal. Many planners are calling for slum improvement, particularly the Commonwealth Association of Planners (Commonwealth Association of Planners, 2012). Urban decay is a process by which a city or a part of a city falls into a state of disrepair and neglect. It is characterized by depopulation, economic restructuring, property abandonment, high unemployment, fragmented families, political

disenfranchisement, crime and desolate urban landscapes.

Rapid urban development and increasing land use changes due to population and economic growth in selected landscapes is being witnessed of late in Auchi-Nigeria and other developing countries. The cities are expanding in all directions resulting in large-scale urban sprawl and changes in urban land use. The assessments of these changes depend on the source, the definitions of the land use types, the spatial groupings and the data set used. Ndukwe, (1997) observed that remote sensing techniques are particularly suitable for the production of land use and land cover maps. There is an urgent need to accurately describe land use changes for planning and sustainable management. In the recent times, Remote Sensing and GIS is gaining importance as vital tool in the analysis and integration of spatio-temporal data. The present study highlights a coordinated significance of Remote Sensing and GIS techniques in land use analysis of the study area. Tiwari, (2003) stated that remote sensing provides reliable, timely, accurate and periodic data while GIS provides various methods of integration tools to create different planning scenarios for decision making.

There are no up-to-date and adequate maps for planning purposes in the study area for these reasons, the research problem bothers on non availability of the current land use database of Auchi, the information contained in the available maps of the study area are not current and sufficient to produce an up-to date land use database for decision makers. This research aimed at producing the land use map of Auchi. To achieve this, digital land use database was created and the land use type was represented in statistical format such as bar graph and pie chart.

THE STUDY AREA

The study area-Auchi is the Administrative headquarter of Etsako West local government area in Edo state, Nigeria. It lies between latitudes 7^{O} 14^{1} North and 7^{o} 34^{1} North of the equator and longitudes 6^{O} 14^{1} East and 6^{O} 43^{1} East of the Greenwich Meridian. Auchi is bounded by Jattu to the East, Aviele to the South, Warrake to the West and Iyuku to the North. Its fast expansion has been attributed to its centrality. It is a transit town which lies along Benin-Okene-Abuja highway. It is a gateway to the Northern part of Nigeria for people from the Eastern and Southern part of the country. The town lies on a depressed site with few valleys and it is highly susceptible to erosion effects due to its depressed nature.

The people of Auchi are known to have originated from ancient Bini kingdom from where they migrated to their present settlement. The founding father of Auchi known as Uchi was said to have migrated with his five children (sons) namely, Utsogun , Akpekpe, Aibotse, Iyekhei and Igbei. The present five quarters are named after the five sons of Uchi (Figure 1.1).

Auchi is located on a slightly undulating terrain with elevation of about 300meters above sea level. The residential buildings mainly occupy the lowland. Slopes and valleys predominantly disrupt the landscape of Auchi. The physical characteristics of the study area have influenced human activities in terms of transportation network, agricultural and commercial activities as well as population distribution thus affecting the land use patterns. These accounts for the type of land use in Auchi as the people are being restricted to building on low areas, which are already choked up with dwelling structures. The physical features of the place account for the scarcity of water, poor drainage condition, and erosion's problem.

Auchi has a tropical climate characterized by two distinct seasons, the wet and dry seasons. Despite its location it has an average annual rainfall of 800-1500mm. Its leeward position at the feet of kukuruku hill (Akoko-Edo hill) has greatly affected its local climate thus accounting for its low annual rainfall compared to other towns which lies along the same latitude (Oguntoyinbo, 1983). The wet season occurs between April and October with a peak in August and an average rainfall of 150cm. The dry season lasts from November to April with a cold harmattan spell between December and January. The temperature average is about 25^{0}c in the raining season and 28^{0}c in the dry season. The climate is sub-humid in Auchi. The vegetation cover of the Guinea Savanna part of the town supported luxuriant vegetation cover, the type that is found in Tropical Rainforest, but had been removed and disturbed by construction, farming and urbanization processes.

The soil type in the study area is classified as soils on loose sandy sediment, which are mainly brownish. They suffer from excessive internal drainage and intense leaching giving them a very strong acid reaction. The structural stability and productivity of the soil is low as a result of the low forest vegetation. The forest vegetation if thick supplies and maintains soil organic matter, and protects the soil against dislocation and erosion (Areola, 1983). As a result of low productivity rate of the soil, farmers move to areas as far as Warrake to farm since places like upper Iyekhei which has better soil and has been used for agricultural practices have been converted into residential areas.

The inhabitants of Auchi are largely farmers (especially the indigenes). However, as an administrative center, white collar jobs are available. A large number of the women are engaged in trading especially street trading and other commercial activities. Auchi has a central market called Uchi market, which is busy most days. Apart from being an administrative center, Auchi provides higher order services such as educational facilities up to tertiary level. With recent development in the political area in Nigeria coupled with ever increasing population of the area (natural increase and migration), the town has witness tremendous changes in the internal structure. Omuta (1983) pointed out that the rapid urban popularity growth in the town which has increased from 35,000 in 1979 to an estimated value of 68,000 in 1991 must have resulted in changes in the physical environment of Auchi.

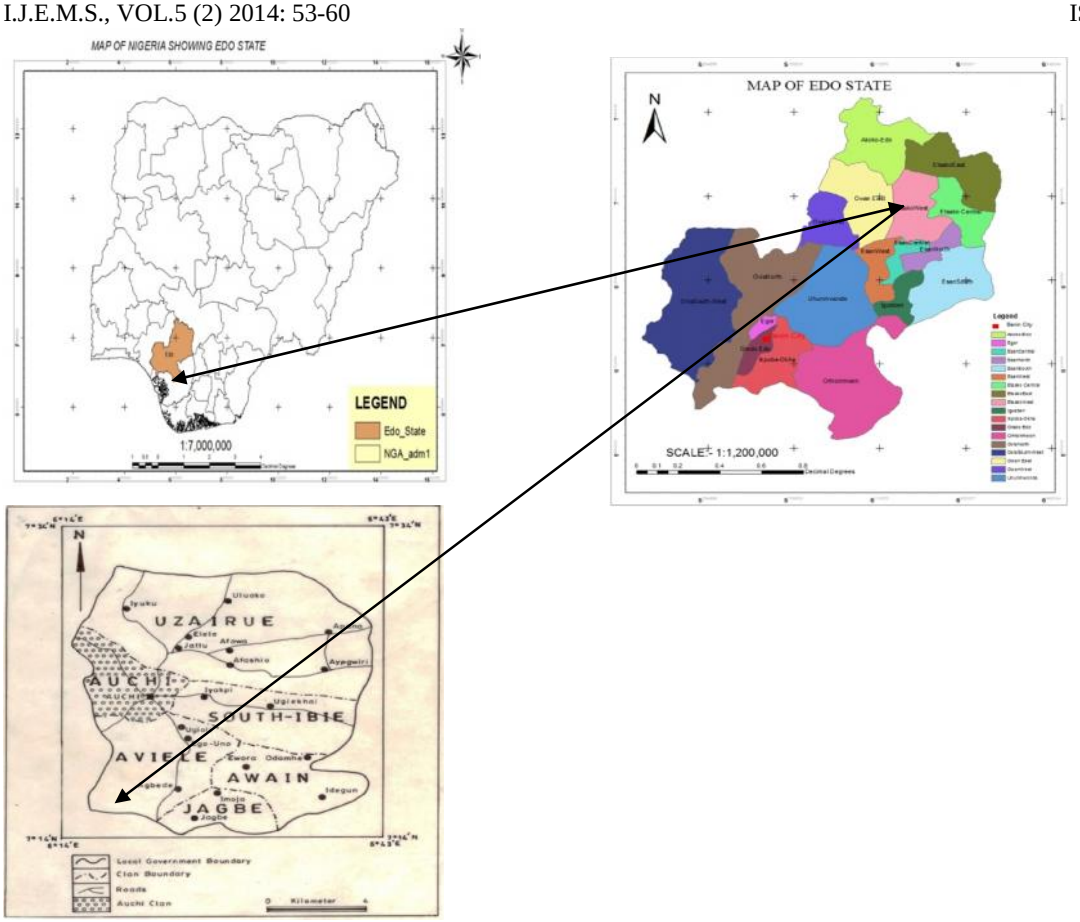

Figure 1.1 Map of the Study Area
Source: State Ministry of Lands and Surveys, Benin City, Nigeria.

METHODOLOGY

The methodology of this research is principally by remote sensing data collection, field validation, ground truthing, image processing and GIS analytical approach. It covers data sources and data acquisition, system selection, data conversion, database design and database creation. Two types of data are required for this research. These include primary and secondary data. Data needed for this research include satellite imagery of the study area (figure 1.2), which was gotten via Google Earth on the 26th of August, 2013. Image source is Quickbird with resolution of 0.61m. It was saved in Joint Photographic Expert Group (JPEG) format. Ground truthing or field validation was carried out to up-date the imagery. Primary data were collected through field observation using Global Positioning System (Garmin-76S Handheld GPS) to acquire co-ordinates of control points to be used for geo-referencing of the imagery.

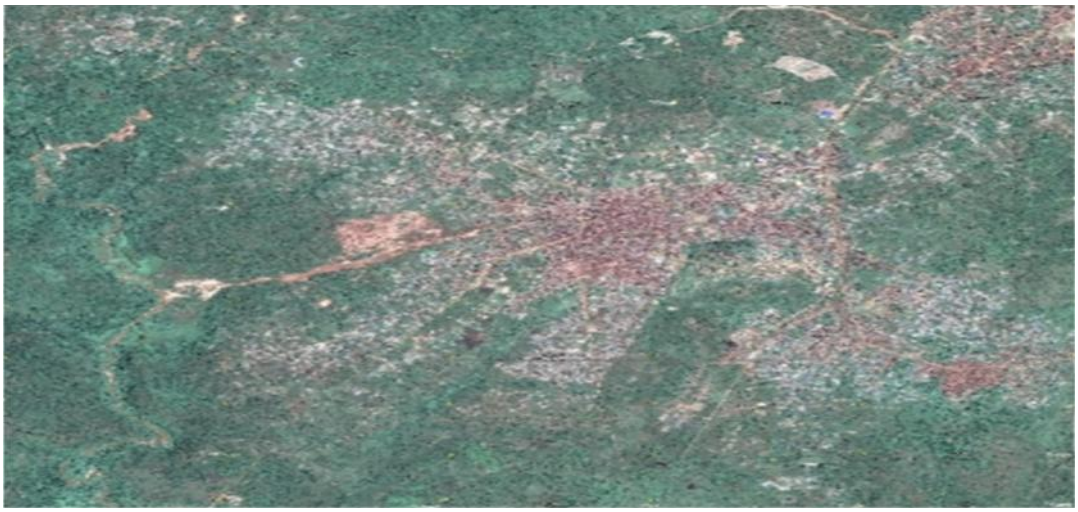

Figure 1.2: Satellite Imagery of the Study Area.
Source: Quickbird Imagery Acquired via Google Earth, 2012.

Secondary data has to do with the documentaries and observed fact about the objects within the project area. Secondary and attribute data were acquired through personal interview conducted within the study area. Attribute data such as building type, building name, building use, road name, road type and so on within the study area were obtained through field observation and informal interviews.

METHODS OF DATA CONVERSION

The satellite image of the study area was gotten via Google Earth. It was saved as individual scenes in JPEG format. It was thereafter exported to ArcGIS 9.3 environment for geo-referencing. Geo-referencing of each image scene was ensured. The computed geo-referenced parameters were stored in 'table file' of ArcGIS. The processes of image pre-processing and data editing were not necessarily carried out, since the image was gotten via from Google Earth which is a Quickbird satellite imagery that provides sufficient accuracy, high spatial resolution (o.61m) and optimum usage for land use and land cover studies. A mosaic is a composite picture that is made by piecing together two or more images to provide a continuous view of a large geographical area. The controlled approach was adopted whereby the digital mosaic was created.

FIELD VALIDATION AND CLASSIFICATION SCHEME DEVELOPMENT

Field validation also known as field checking or field verification was carried out to ascertain the accuracy of the interpretation done. This process involves determining in reality the actual presence or not presence of the features sensed. The features that were correctly interpreted were confirmed, while those confusing or uncertain during the interpretation stage were corrected and ascertained. Relevant information not available on the image such as inability to ascertain exactly the type of land use and extent in regard to area coverage of identified land use or land cover types were obtained by visiting the area in question and through interaction with people in the neighborhood. Also names of places and their particular locations were confirmed by visiting the site in order to accurately assign the appropriate land use/ land cover type. Cases of multiple land use were equally resolved during field validation whereby the predominant land use sufficed.

This exercise was embarked upon for field validation, checking and editing. After the exercise was completed, classification scheme was developed for the study area based on the purpose of the study. The different land uses and land covers identified in the area were well spelt out and categorized into individual layers. The classification scheme developed (table 1.1) is a modification of Adeniyi, 1978 classification scheme. It was developed based on the Researcher's prior knowledge of the area, aim and objectives of the study, source of the satellite imagery, spatial resolution, detail ground truthing exercise and secondary data obtained. The classification scheme of the study area (table 1.1) was accomplished through visual interpretation.

S/No.	LAND USE CATEGORIES
1	Commercial
2	Cemetery
3	Educational
4	Financial
5	Judiciary
6	Local government secretariat
7	Public services
8	Recreational
9	Religious
10	Residential
11	Royal palace
12	Security services
13	Transportation
14	Industrial
15	Farmland

Table 1.1: Land use Classification Scheme.
Source: Author's work, 2012

Layers were created based on the developed classification scheme of the study area. A layer is a subset of a geographic database with a particular theme. For this research, layers were created for residential, commercial, transportation, shrub land and so on.

The processes of geo-referencing and digitization were embarked upon after layers were created for each of the identified theme. Digitization which is the process of converting paper maps into digital files or converting raster data into vector data otherwise known as vectorization involves the following approaches: table digitizing, or scanning and on-screen digitizing. Each classified layer was digitized by on screen digitizing. Prior to digitization, the process of geo-referencing was carried out to register the geographic data set to an accepted coordinate (UTM) system.

LAND USE MAP GENERATION

The methodology adopted for this study basically involves the use of remote sensing imagery and the application of GIS for the generation of land use and land cover maps and statistics for analysis. The objective at this stage is to generate land use and land cover map sets of the study area from satellite imagery. The derived land use and land cover maps are to be subsequently used for analysis. Thus, to satisfy the objectives the procedure employed are not only to afford the generation of land use and land cover maps but also take cognizance of the subsequent use of the maps for query generation, single and multi criteria analyses. The land use and land cover maps were derived from the geo-referenced and digitized maps of the study area.

DATABASE CREATION

It is the actual creation of the database in the computer system using the acquired digital and attribute data. Tables were created for lines and polygons and populated with their attribute data. The database creation was done using ArcGIS 9.3. Different tables were populated for all the layers that were created. Database creation involved namely:

(i) Input and linking of spatial and attribute data
(ii) Building topology of spatial object that is, calculating and encoding relationships between points, links and polygons.

DATA ANALYSIS, PRESENTATION AND DISCUSSION OF RESULTS

For this study, the non-topological GIS analysis functions were performed. Functions such as spatial data display, spatial database query and statistical computation were carried out. Three main methods of data analysis were adopted in this study, these include: geometric data analysis, statistical computation and attribute data query. They are presented in both hard and soft copies which comprises of maps, statistical charts, pie charts, tables and report writing.

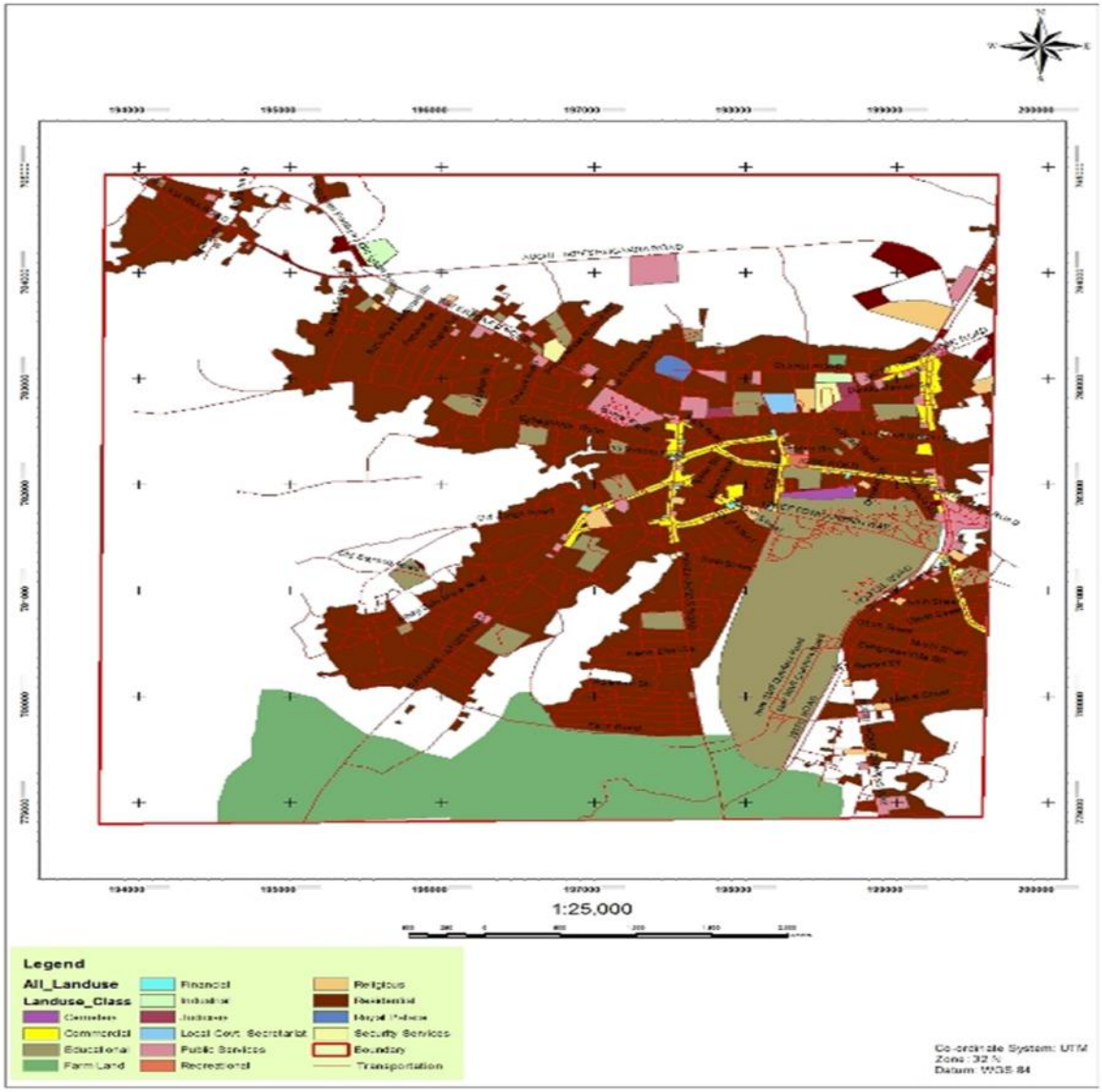

Figure 1.2: Land Use Map of Auchi.

Spatial search was efficiently carried out by topology relationships while queries were designed for the purpose of retrieving information from the database. Single and multi criteria based queries were performed. A single criteria query was carried out using one condition to design the query. The conditions retrieved depend on the required information from the database. Multiple criteria query was equally carried out. The result retrieved depends on the required information that the user requested from the database. From the analysis, it is observed that Auchi (the study area) has residential land use area coverage of 56.99%, educational 14.64%, public services 3.08% and industrial 0.43%. The land uses consist of fifteen types. Table 1.2 shows the area covered by these land uses, their bar graph and pie chart were generated for statistical analysis (Fig 1.3 to Fig 1.4).

Table 1.2: Land Use Distribution of the Study Area

Object ID	Shape	Shape Length	Area(Km^2)	Land use Class	Area (%)
1	Polyline	216345.4678	216.3454678	Transportation	1.209377129
2	Polygon	785.72704	37.64560361	Local Govt. Secretariat	0.210439962
3	Polygon	1963.5215	20.31886173	Financial	0.113582997
4	Polygon	2230.315101	75.35877126	Security Services	0.421257609
5	Polygon	758.959808	40.11144232	Royal Palace	0.224224068
6	Polygon	2150.473987	77.18089324	Industrial	0.431443321
7	Polygon	20288.98519	428.7915228	Commercial	2.396956434
8	Polygon	1166.108981	42.09433966	Cemetery	0.235308519
9	Polygon	666.888662	15.80336618	Recreational	0.088341253
10	Polygon	11024.14336	3273.899837	Farm Land	18.30119035
11	Polygon	104993.6815	1019.475103	Residential	56.98893933
12	Polygon	22963.58567	2618.289618	Educational	14.63631115
13	Polygon	18227.85333	551.4352915	Public Services	3.082538482
14	Polygon	9146.853947	244.4138513	Religious	1.366280167
15	Polygon	1469.218651	52.55953138	Judiciary	0.293809229

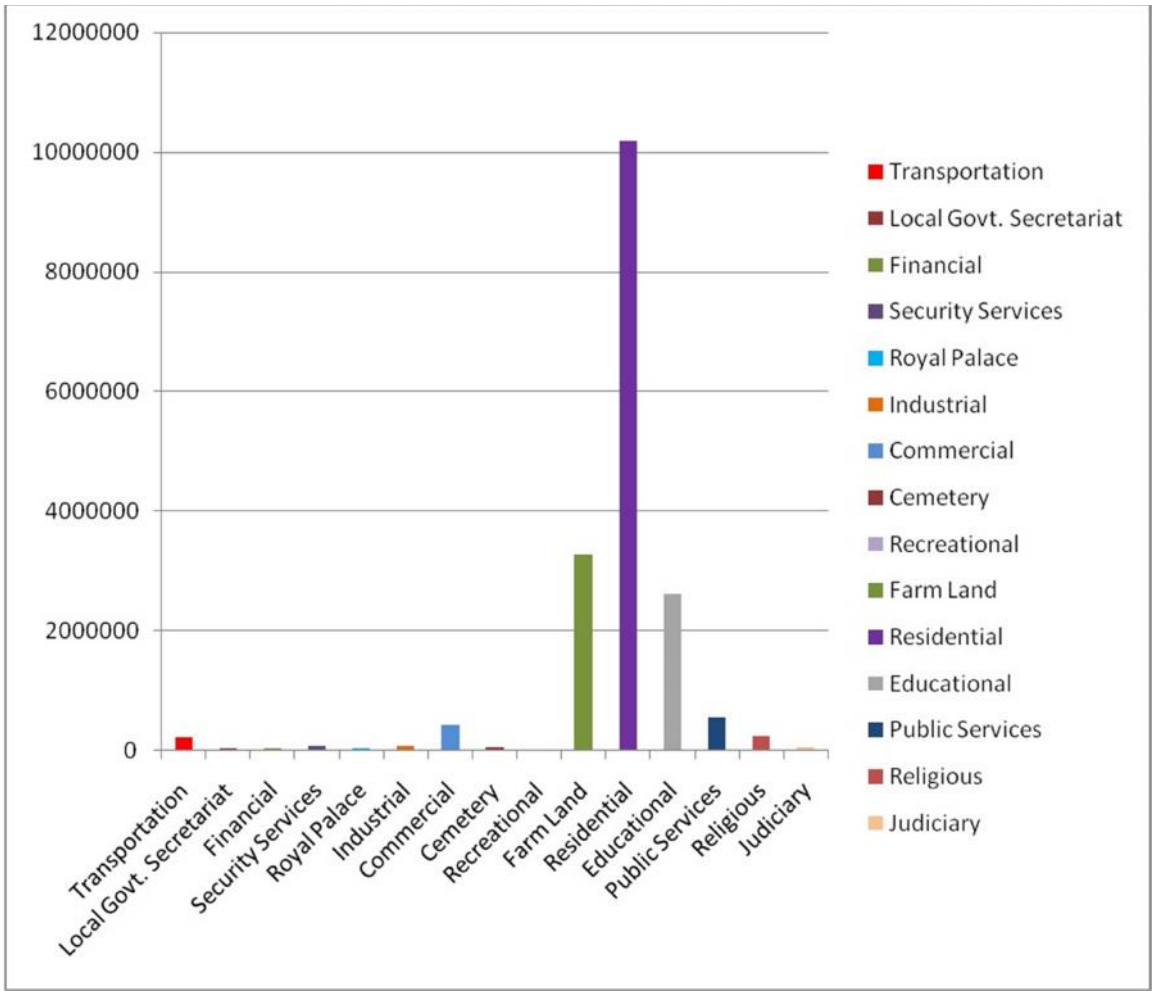

Figure 1.3 Bar graph of the study area

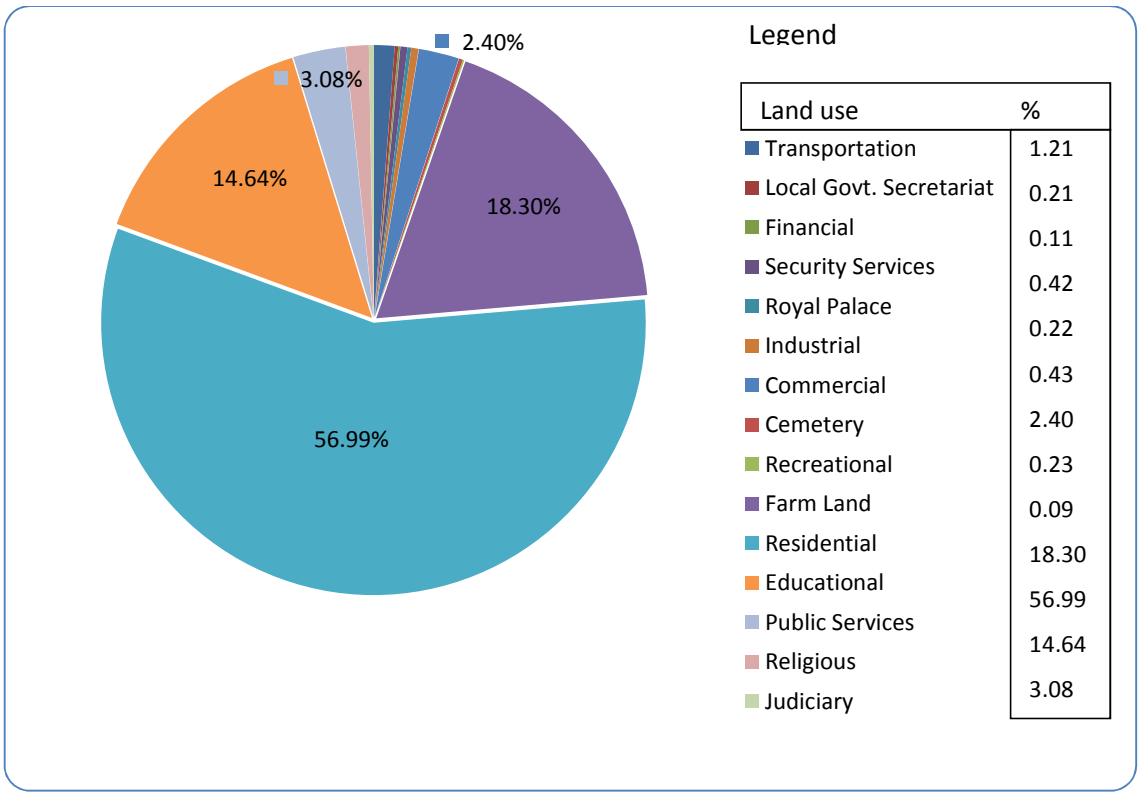

Figure 1.4 Pie chart of the study area.

The results reveal the pattern of land use in Auchi. The research indicates that the urban growth and development in Auchi has been restricted to the low-lying areas, most especially Usogun, Akpekpe and parts of Igbei and Iyekhei quarters. However, there is virtually no master plan for the development of Auchi, no land use zoning scheme is adopted and individual claim to land is still very high. All these provided the framework for the haphazard development of the city. Thus, a good number of the land use problems in Auchi are caused by lack of proper planning and monitoring of development. The above research finding is that the land use activities in the study area are un-controlled.

The imbalance in land use structure of Auchi is vivid. Some land uses are over represented at the expense of others. For instance residential land use account for 56.99 % of the built up area. Others are commercial land use 2.40%, industrial land use 0.43%, educational land use 14.64%, transportation 1.21%, recreation 0.09% and vacant land 1.60%. Among the important land use problems consequent upon this development is soil erosion. As observed that the inhabitants built along erosion paths which result to erosion menace in the study area.

CONCLUSION AND RECOMMENDATIONS

Remote Sensing techniques for data acquisition and Geographic Information System approach for data manipulation has proven effective in solving spatial problems within a short time. Land use Database of the study area was designed and created to answer some generic questions such as what is where? The various steps of this research, in-terms of data capture, database design, database creation and product presentation were followed to achieve the aim and objectives of this study. Application of remote sensing and GIS to the mapping and analysis of the land use of the study area is a very adequate method. It makes use of recent data (satellite imagery) that are adequate and up-to-date and GIS analytic approach using appropriate softwares like ArcGIS 9.3 for digital land use mapping, database creation and analysis. This study is important in the sense that there are no organizations in the country (Nigeria) saddled with the responsibility of providing land use maps. As a result of this short coming, it is therefore imperative that such studies should be undertaken to make available such maps which are veritable tools for land management, planning and implementation in order to create sustainable environment. This research show that with enough capital and man power, GIS and remote sensing techniques can be applied at a nationwide scale to create a digital land use and land cover database for the nation to enhance sustainable development and management of the nation's scarce resources.

The need to curtail the imbalance in the land use structure of Auchi cannot be over-emphasized. The responsibility for the control falls on the Government, Non-Governmental Organizations (NGOs) and individuals. However, apart from the urban issues as recommended above, the following policy implication and

recommendations proposed below will be helpful in checking the abuse of land use in Auchi.

1 Integration of all physical development activities through a comprehensive database of the study area. The State Government through the Department of Land and Surveys and GIS experts should undertake the preparation of the master/structure plan as well as the database for Auchi. The master plan and database created should show in detail how the entire land in the study area should be utilized. Development in Auchi should be controlled with the help of the existing bye-laws and codes concerned with land use development.
2 A land use/land cover database is crucial for the prosperous development of any national economy, administration and proper. Therefore the government should encourage the use of GIS techniques by training and retraining the relevant personnel in the latest techniques in the geo-spatial technology.
3 Before developmental projects are executed, environmental impact assessment studies should be carried out to ascertain whether such projects could have positive or negative impact on the environment. Developmental projects include the building of houses, road construction, pipe-laying etc.
4 The Local Government Authority and other Government agencies should notify the people of the penalties for flouting government's laws concerning physical planning.
5 Finally, a digital land use /land cover database of the country should be created and an organization set up to be a custodian of the information which will make it available to intended users with payment of some affordable fees.

REFERENCES

Adeniyi P.O (1980): *Land Use Change Analysis Using Sequential Aerial Photograph and Computer Technique". Photogrammetric Engineering and Remote Sensing 46:147*

Adeniyi P.O (1984): *Land Use and Land Cover Inventory in Nigeria, the Nigeria Geographical Journal 27 (land 2) pp 113-130.*

Areola O. (1983): *Soil and Vegetal Resources. In: J.S Oguntoyinbo, et al (eds). A Geography of Nigeria Development, Heinemann.*

Hans, S.A. (2003)*: Urban Scores: On the Interaction Between Segregation, Urban Decay and DeprivedNeighbourhoods.http://wwww.fao.org//andandwater/agllanduse/landusedef.stm* retrieved 14th April, 2013.

Ndukwe, K.N. (1997): Principles of Environmental Remote Sensing and Photo Interpretation. New Concept Publishers, Enugu.

Oguntoyinbo, J.S (1983): A Geography of Nigeria Development. Heinemann Educational Books Nigeria Limited.

Okafor, F.C (1980): The Role of Geographical Research in Environmental Resource Management and Land use Planning, paper presented at the 23rd Annual Conference of the Nigeria Geographical Association, Calabar. March 16th -21st.

Okpala, D.C.I (1979): The Nigeria Land Use Decree of 1978. Journal of Administration 18:15-21

Omuta, G.E.D. (1983): Settlement Evolution and Degradation of the Physical Environment of Auchi, Bendel state Nigeria. Third World Planning Review.

Tiwari, D.P (2003): "Remote Sensing and GIS for Efficient Urban Planning " Map, Asia. www.gisdevelopment.net. Retrieved 18th February, 2013.

Reinventing Planning: A New Governance Paradigm for Managing Human Settlement Commonwealth Association of Planners. Retrieved 22nd May,2012.