APPLICATION OF REMOTE SENSING TO LAND USE – PLAN IMPLEMENTATION AND MONITORING.

A CASE STUDY OF ABUJA – NIGERIA.

BY

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BEING

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CERTIFICATION

This dissertation entitled 'Application of Remote Sensing to Landuse plan implementation and monitoring - A case study of Abuja - Nigeria' by Takuma Suleiman Abubakar meets the regulation governing the award of degree of master of Technology (M.Tech) of Federal University of Technology, Minna, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my parents Alhaji SULAIMAN TAKUMA and Ms. R.N.W. YISA for their love and support without which this would not have been possible. And above all dedicated to the glory of Almighty God for His love and mercy.

ABSTRACT

One of the most effective and versatile means of producing basic data to undertake inventory of land as well as for temporal information required to monitor sustainable land management practices is Remote Sensing. This study strives primarily to demonstrate the capabilities of aerial photograph and SPOT imagery in the implementation and monitoring of land use plan. In the study a combination of visual and digital interpretation techniques was adopted using minor stereoscope and GIS facilities at the National Centre for Remote Sensing Jos. Abuja is the capital city of Nigeria. A territorial space of about 8000sq.km in the central part of the country, the FCT has in the past 13 – 14 years been a focal point of interest both nationally and internationally, as huge investments are made in the building of a new Federal Capital City and supportive regional superstructure in the reign of the magnitude of this project monitoring. What is happening in the Federal Capital Territory in general and the Federal Capital City in particular is a National responsibility, the importance of which can not be over emphasised. Analysis and evaluation were made using 1982 aerial photograph at scale 1:50,000 and 1974 SPOT imagery at 1:40,000 and topographic sheet 1:50,000. Ground truthing was carried out at different stages to verify doubtful areas and features, the various thematic maps were generated and the extent of each categories of thematic maps identified and were determined with the Modula (ILWIS 2:2 software package) in the simple GIS work station at NCRS Jos. The result indicates that there has been a tremendous increase in the built-up land from 422. 05 hectares in 1982 to 2441.81 hectares in 1994. A magnitude of 36 – 38 % increase and a reduction of non-built-up land from 5151.64 hectares in 1982 to 3065.57 hectares in 1994. Also, this alarming increament in the areas of built up land leads to gross deviation from the purpose and intent of the land use plan, this deviation was summarily Classified into three as Deviation by omission, Deviation by substitution and Deviation by displacement. The need to improve the quality of the urban system, in order to save the urban centre from disintegration requires a continued data collection and researches into the relationship between land use and the environment. Recommendation was advanced for the productive re-organisation of priorities for environmental management purposes, and the intergration of remote sensing into this data collection process.

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CHAPTER ONE

0. INTRODUCTION

ınd is one of the basic of all resources, as it provides the foundation for the tisfaction of most human needs (settlement development, food production, civil ɔrks etc). It is necessary therefore for the way in which land is to be used to equately be planned so that it can be put to maximal benefits, such a planning can ɜo help to ensure that land is used for what it's best fit for , and in this way conflicts tween various human needs for the same piece of land can be minimized or minated. In short, land use planning is as important as the land it self under creasing Population, especially in developing Nations, population pressure on land pand gradually and in some cases rapidly, In an urbanizing town especially where e town assumes a changing social-economic and political status, such expanding pressures tend to be quite scaring. With such expansion conflicts between competing nd uses tends to become prevalent with the result that some unwanted development ɔuld occur where they are not to. It is thus essential that in such urbanizing uation steps be taking to adequately plan the land so as to prevent or control its elopment process. By so doing the rate of population growth in the urban area be checked.

n important requirement for taken such steps is to obtain such information on the hole urban area being planned. To obtain such information on the whole urban area planned. To obtain such information means that large area be record at the same-ne (i.e by a synoptic basis). Traditional technique of land use Survey involved ect on – the –spot perdition which are however not capable of providing such a noptic view. In this case therefore, remote scissoring may proceed to be an ernative technique in the regard.

owledge about the present distribution and the areas of land uses go well as their anging Proportions is needed by legislature, planners, state as well as local vernment officials to determine better demand, to identify future development ssure, prints and to implement effective plans for regional development as Claws d Steward (1965) here stated:

In this dynamic situation meaningful accurate, meaningful current data on land use re essential if public agencies and private organizations are to know what is ppening and to make sound plans for their own future action, then reliable formation is critical"

tropolitan areas not only reflect similarities in economics structure but also ress certain pattern of location of economic rarities within the metropolis. There statically patterns, reseated with minor variations in a City, after scholars and gmont alike have long reserved a city. Burgess et al (1938) emphasized the

tter of city growth especially the residential' type is comprising five Concentric nes. Which the sector concepts of Homer Hyot (1939) how that Urban velopment takes place largely along major radial transportation routes with or tors of similar land use planning producing a star-shaped city. However a league of modern urbanization is the development of several types of land use and a mber of several types of land use around a district nuclei as set forth by Harris and man (1946)

GENERAL BACKGROUND

e varieties of land use data needed are exceedingly broad, current land uses data, e needed for planning population control. Focalization of tax, assessment. In ny states of the Federation land Federal, State and local agencies for water sources inventory also need use data, flood control, water supply planning and vastewater treatment.

any Federal agencies need current comprehend inventories of besting captivities in blic lands combined with the existing and changing use of adjacent private lands to prove the management of public lands. Federal agents, also need land use data to ss the environmental impact resulting from the development of energy resources, anage wildlife resources and minimize man-wildlife ecosystem conflicts to make

ational summarizes of land use parterres and changes for national policy rmulation and to prepare environmental quality.

emote sensing information is of great assistance for planners to prepare for either tural or men induced large in both rural urban land areas and as an efficient ethods of discoing the physical development trends of a region as well as it nformity with the land use plans. However an essential pre-requisite for any velopment efforts is the appraisal of the existing land use and as the situation has en changing over firms (Adeniyi 1976). To hundred land a particular percent land me to have its present use demand at a minimal longitudinal profile of the changes the use through twice (Rhinds and Hudson 1980).

om the forgoing the important roles played by remote sensing in land use plan plementation, monitoring has been firmly established, it is clearly the quickest and st means to obtain reliable data basic on land use. A great deal of research had focussed on the use of computer assisted technique to extract statically information of and use from Satellite Imagery while genial photograph has become the major urce of ground truth information for analysis. More recently the computer-assisted proach has been used even with aerial photography for computer land use nning.

he development of the various statistical technique to measure accurately is a ealthy significance and is conducive for a realistic appraisal of the impact of the rious error sources notably the interpretation technique the image quality and the easurement practice on the repentant product. It seems paradoxical that, while on e one and improvement on the spatial, spectral and temporal resolutions for the motely sensed data especially from the space has been advocated, on the other hand search to compress the data for fear of excessive storage requirement is also been itiated (Harris 1988).

emote Sensing is defined " as the Science and art of detecting and analyzing, using ectro magnetic means information collected at a distance from a target (an object a ather on an area of internet)" To do this there has to be a sensor positioned on a atform, which records information within one or more lands of the Electro agnetic spectrum. An important attribute of remote sensing is that it allows data capture of large and sometimes relatively in accessible area, under uniform lluminating condition. For instance the whole urban area can be captured and rought together under one illuminating condition such that an image of the area (In notographic or digital forms) can be produced.

2. VISUALIZATION OF REMOTE SENSING AND G.I.S TECHNOLOGY

emote sensing basically refers to getting information about an object or phenomena thout there being any physical control with it. Remote sensing data collection arted first in 1939 by Daguarre and Nappe. In 1949, Colonel Aime Lausedat, an ficer in French proved that photographic could be used to prepare topographic aps. Extensions use of photography was made for military purposes during the orld War I. The launch of first Forth resource technology satellite (ERTS-1), later med as land sat on July 13, 1972 was a significant milestone in orbital data llection. Imagery from a return Beau video con Camera and a multi-spectral ience with about 40m and 7gm spatial resolution respectively were collected. A ries of satellites were launched to collect the information on natural resources on e earth's surface.

In 1986, the French Space Agency launched SPOT Satellite which and the capacity to cquire spheres pairs enabling 3-d views of the terrain wit a stabile resolution of bout 10m this data proved quite useful for urban applications. The first operational dia Remote sensing Satellite (IRS – IA) was launched on Marc 17 1978. The relent S-ID satellite launched in September of 1997 is state of the art satellite and has the acity of requiring the data with a Spatial resolution of about 5.8m in panchromatic 23m. In Liss- III. This data can be used for any type of applications regarding

ban and regional planning (SAC report on development plan (Ahmedabad Urban evelopment Authority (AUDA Area – 2011).

eographic information system '(GIS) is defined as "An automated tool used to pture, storage, retrieval, and manipulation, display and querying of both spatial and n-spatial data to generate various planning scenarios for decision making. "(GIS ers Manual, 1989). Thus GIS as a tool able to answer the location, condition trends, tterns and modeling. For example. The location of features is answered with the lp of geographic reference i.e. latitude and longitude another example is, if one nts to find location where certain condition are satisfied i.e. find a land percels, th an area of about 10 ha, 500m distance from the transformation network, having ep soils with loamy features gentle slopes and no flooding hazards. GIS is role to swer thus type of complex queries good shorts the location of the percent. egration of both spatial and non-spatial data for various planning exercises was done using manuals in the past. But with the increase in the volume and dimensionality of data sets. It has becomes necessary to use automated GIS to meet e demands in natural) resource development use of an intermitted respites, has also come important as the data maintained in a physical compact format data can be rieved with much greater speed, various computerised tools allows a variety of nipulations such as map measurement, map overlay analysis, transformation from co-ordinate projection to another co-ordinate projection, graphic design and

tabase manipulation. In addition to this, graphic and non-graphic data can be erged and manipulated simultaneously in a related manner.

nus this is a very useful tool for planning processes which needs integration of both atial and non-spatial data- GIS. Has also been effective in creating a good database. nce, GIS standard has been highly used for various mapping and creating digital formation system for planning and development purposes (Pattan et'al 1996: ukund, Rao et al 1972; Pattan et, al .1973).

3. CONCEPT OF LAND USE AND LAND COVER

ere is a considerable diversity of opinion about what constitute land use. Although present use of land is one of the characteristics that is widely recognized as nificant for planning and management purpose. Concept concerning land use and d cover activity are closely related and in many cases have been used inter-changeably. The purposes for which land is been put commonly have associated type of cover. Whether they are forest, agricultural residential or industrial. Remote nsing Image forming device denotes record activities directly. The remote sensor quires responses, which is based on many characteristic of the land surface, luding natural or artificial cover. The interpreter uses pattern tone and Texture, pe, size and site association to derive information about land use activities from at is basically information about land cover.

and use is man's activities on and in relation to the land, which are usually not rectly visible from the imagery. Land use has been studied from many diverse ewpoints so that no one single definition is really appropriate in all different ntext (Campbell 1983). It is possible, for example, to look at land use from the nd capability point of view by evaluating the land in relation to the various natural aracteristics mentioned above.

me activities of man however, cannot be directly related to the type of land cover, e concept that has more advantage is that land use refers to man's activities which directly related to the land (Clawson and Stewart 1965).

leniyi (1990) defines "Land use as an imprints of people activities on and in ation to the land. It is to a large extent an abstraction, which according to mpbell (1987) is not always directly observable by even the closest inspection. It largely for thus reason that the term land cover is often used together with land use even when the objective of the mapping concerns the later.

Land cover, which describes the regulation and artificial constructions covering the nd surface (Burley 1960). These are all directly vision from the remotely in land over:

Physical structures built by human being:

Biotic phenomena such as natural vegetation, agricultural crops and animal life.

. Any type of development.

nus based on the observation of land cover as a proxy, one hope to infer human tivities and land use.

1. STATEMENT OF RESEARCH PROBLEM

veloping Countries are faced with too life practical research, too few scientist and ufficient funds for technological development (IPTRID 1991). This shortage of earch and development activity has affected many aspects of life in developing rld including irrigation land use and environmental factors, that determine the ality of our environment, the most important is the use we make of our land.

Nigeria, political development process has provided a number of policy decisions t have enormous spatial implications. Since the amalgamation of the Southern and rthern protectorates of the country into what Constitute the present Federal epublic of Nigeria. Lagos has served as both the Commercial and Industrial Nerve Center of the Country and until late Lagos as the Federal Capital. As from 1976 owever, a decision was reached to move the Capital to Abuja in view of the limited pacity of Lagos to adequately absolve the ever-expanding political and economic ivities, typical of a National Capital of a growing developing nation like Nigeria.

or to its being a new Federal Capital, Abuja has been a relatively under developed n that May not pass for a typical rural setting. As political and Socio – economic

tivities move gradually into the city however, urban expansion gradually began panding into the city, as from early 1980s. Abuja now houses virtually all Federal tablishments and numerous diplomatic service-oriented and private organizations at characterize a typical National Capital. These no doubt have stimulated further urban growth process of the City. As is the case with most developing cities, ch an urban growth process is hardly controlled even though a "land use – plan that supposed to guide such, existed. After all, 100% implementation of land use – plan not always possible for economics, political and Social Constraints. Another portant reason why such a control is difficult is lack of adequate knowledge of ban growth processes and trends in the town.

r instance information is not always available on sectors of the area that are owing at a particular rate or when growth processes are over – concentrated and ere they are not. To document these, it means the whole area has to be monitored om time to time so as to identify the growth processes of the various land uses and sectors in the area.

Data on land use are not only relevant to researchers and planners in their rofessional activities and to understand the process and formulate operational model y also provide the Federal, State and local government officials an up to-date data decision making as well as a means of monitoring the out come of past decision.

the past, researchers have relied upon governmental statistics, Census Data and metimes-sporadic land use Survey data. A lot of problems are associated with ing such a data. For instance they are mostly associated with statistical bias, mpling inaccuracies, locational errors and generally not timely available. Several search workers (such as Ester, 1970, Davis, 1973; Adeniyi, 1980 Ikhouria, 1983; nsen, 1996') have shown that remote sensing can be used in a manner that can duce or eliminate such problems, especially where remote sensing data with very e resolutions (such as large scale aerial photographs and panchromatic SPOT mote sensing data) are used. Despite such a potential, no much research have been rried out to demonstrate how remote sensing can be applied in land use planning in buja. Given the enormous important of Abuja to the Nation, information of this is ghly needed as it court provide a frame work for development of sound analytical hniques for not only planning but even monitoring of land use and population owth process in the city. The need for such information constitutes the problem of interest to this study.

.5 AIM AND OBJECTIVES OF THE STUDY

is against the background of the advantages of remote sensing applications in ource inventory, monitoring and Management that this research seeks to explore possibility of applying remote sensing technology through aerial photography and

POT Image interpretation in providing information that could be used in land use an implementation and monitoring in the phase I development area of Abuja, ederal Capital City of Nigeria.

ıe study seeks to realize this aim through the following sets of objectives.

To map out the various land use types in Abuja Federal Capital City

Using remote sensing data for 1982 and 1994.

To compare the land information for the two dates so as to detect and analysis pattern of land use change.

To use the information in (b) above, in making proposals that could facilitate effective land use and population growth process in the City.

5. SCOPE OF THE STUDY

e study area is the Federal Capital City with a case study of phases I. It is worthy note that the Federal Capital City presently consists of phase I and phase II with the hope of entering other phases in the near future, as the economy of the nation will permit. However, as of now phase I is the only one of the phases receiving evelopmental attention although, there are systematic and deliberate transition into ıse II by various government policies.

this research, phase I is the focus, it covers an area of about 54 square kilometers. s enclosed by the Northern express way, Southern express way and ring road I. ıse I of the Federal Capital City is design for a population density of about),000 people (Master plan 1979). This study is committed to phase I due to the that data for the area is what are available and the area of study (54 Sq. Km) is sidered large enough due to the density of developmental parameters (particularly ds and buildings). The developmental parameters to be assessed and measured in study are limited to roads and building development in length and area size ɔectively.

main scope lies in generating a strong information base and future management n. The Survey tries to find out the results by integrating various techniques and hods mainly related to Image interpretation and geographic information system in aining reliable database on various aspects of thematic maps. These methods tainly help to suggest remedial guidelines for the improvements over the existing tem of planning and development.

As for as the interpretation and definition of different thematic map is oncern, is done quite satisfactorily on the aerial photography and satellite image.

1.6. SIGNIFICANCE OF THE STUDY

The choice of Abuja as the site for a new Federal Capital Territory (F.C.T) for the Federal Republic of Nigeria, after a thorough National debate in the Second half of the 1970's opened a new era in the history of the Nation occupying a territorial span of about 8000 sq.km, in the central part of the country. The Federal Capital Territory has in the past 13-14 years been a focal point of interest both Nationally and Internationally as huge Investment are made in the building of a new Federal Capital City and supportive regional supper structures. In the reign of the magnitude of thus project monitoring what is happening in the Federal Capital in general and the Federal Capital City in particular is a National responsibility the importance of which cannot be over emphasized.

One of the most difficult problems to solve has been to completely map Urban land use, so that they are still of current value, the use of remotely sensed data are useful in this direction (Anderson 1971). Land use is a key term in the language of a City and town planing, but as the interest in the land use broadens, and knowledge of relevant variable expands the term land use is endowed with more and more meanings (Guttenberg 1959.)

Urban and regional planners and managers require nearly continuous acquisition of data to formulate governmental policies and programmes. These policies and

programmes might change from social, economic and cultural domain in the contest of environmental and natural resources planning. The role of planning agencies is becoming increasingly more complex and is extending to a wider range of activities. Consequently, there is an increase needs for these agencies to have timely, accurate and cost effective source of data of various forms, and several of these data needs are well served by remote sensor system like side looking air borne radar (SLAR) satellite and aerial photograph.

A Pre-requisite in over-all use of land or developing plan for improved land use is the knowledge of the current pattern, therefore, a modern nation as a modern business must have adequate knowledge and information on many inter-related aspect of it's activities in order to make decisions (Anderson et al 1976). It is believed that this study will assist in guiding not only the Federal Government but also the State Government in making timely far reaching decision on land use plan implementation and monitoring, for although remote sensing is not only a panacea for resource development and management problems. It can provide the basic tools for sound resource inventory, monitoring and management (Bale et al 1974)

The informations from land use/land cover maps are reliable, objective, durable and precise, it can easily be used with other data sets. The result makes it possible to confirm addition of details and exact planimettric positioning of land features on

Images represented in pseudo-colours and original Sketches has been revised and copied, where details of the coverage are few and where maps are obsolete. This level of correction appears to be very suitable to meet the urgent need for accurate data. Generally the knowledge of our environment is limited but precious to us. With this project work environmental resource data of Abuja is now available.

1.7. JUSTIFICATION OF THE STUDY

Abuja is the Centre of unity and a new Federal Capital City deserves an attention in order to realize the targets of development set for it which will qualify it to stand side by side with great cities like London, New-York, Washington D.C., Tokyo etc. in the nearest future.

It is necessary or important to carry out this type of study perhaps the general physical development inventories tat will provide the basic data for the development of land use plans monitoring strategies.

Another justification for carrying out this study is to assess the output or results of our policy formulation and implementation as against non-implementations, before deciding on the way forward on its status.

As postulated by Adeniyi, (1972) the economic status of any nation is always a direct formulation of the use it makes of the available natural resource and poor decisions regarding resources allocation and use can lead to decline in resource quality and economic productivity. This statement is true especially as it applies to land as

natural resources. The knowledge of the current land use pattern is a pre-requisite to monitoring changes in the overall use of land or development plans for improved land use, therefore, the administrators and the planners must have comprehensive and current information if they are to have any hope of promoting orderly use of land.

The use remotely sensed data is gradually becoming more important in everyday life, photographic product derive from data sensed by satellite Radar's, and aerial cameras are used in the planning and management of Urban environment in which this study attempt to appraise with particular focus on land use plan implementation and monitoring on the phase I development area of Abuja Nigeria.

The cost implications of remote sensing Technology is enormous in the short-run, but the long term benefits as a result of our ability to have an "Eagle eye" on our environment will far out weigh cost considerations. The result of unmonitored and uncontrolled environment especially in urban centers is the development of Slums and bad land in an open environment.

Also land use geology is seasonally dynamic and indeed is more changing from forestry. Most requirements are not only for maps of existing land use but also for a system to regularly monitor change. These changes could be Urban Sprawl and the less of agricultural land, changes in river regimes/courses the spread of erosion and desertification and so on. This therefore requires not only the identification of features but also the comparison of subsequent data in order to recognize when valid

changes have taken place. Land use and land cover information is of prime importance in the assessment of land use plan implementation. This is because increase in build-up land due to growth in population or otherwise. Remote sensing has proven its potential as a powerful tool for monitoring changes in natural resources, bi-temporal integration of the study area were carried out using aerial photographs and SPOT Image with other ancillary data.

1.8 LIMITATIONS TO THE STUDY

Lintz and Simonett (1976) summarizes the problems of land use studies in remote sensing as three fold in nature:

i. Problems of mapping land use traits

ii. Problems of classification and categorization

iii. Problems of classifying land use from various types of remote sensor Imagery.

Most common problem associated with interaction of land use from remote sensing imagery and other sources are as follows:

i. To reconcile incompatible and inconsistent terminology and

ii. To develop useful and compatible classification system (Nunnally and Witner 1970).

As far as the interpretation and definition of different thematic maps is concerned is done quite satisfactorily on aerial photograph and satellite image. Remote Sensing measure Electro Magnetic Energy (EME) emitted from the sun which is reflected, scattered, or redirected by different surface features. Detection and measurement of spectral signature enable identification of the surface features by remotely sensed data. In remote sensing, detecting these differences enables identification of ground objects from space.

The study was selected with special consideration to the availability of satellite imagery and the time constraints. The study is limited to the Phase I development area of Abuja Federal Capital City of Nigeria, comprising of Maitama, Asokoro, Central Area, Garki and Wuse districts. Image interpretation was carried out using the image interpretation elements' shape, tones, patterns, association, size, texture and characteristics of site developments.

The study is limited to the information extracted from satellite imagery scale 1:50,000 aerial photograph scale 1:25,000 topographical sheet 1:50,000. Comprehensive land use plan scale 1:2,500. The minimum delineation unit was taken as 4mm x 4mm (land use map) on the satellite imagery which is equivalent to 250mt x 250mt on ground. The delineation unit has been arrived at considering the following points:

Cartographic consideration at final maps, which has been prepared on 1:50,000 scale.

In the study area delineation unit for less than 250m x 250m will be of significance unless it is land use of spatial nature.

The prepared up-to date different thematic map will be helpful to the user department for making proposed management plan map.

Another limitations are the existence of time lag between the data (1982 and 1994) and the period of ground truthing. This time lag is not too wide to obscure any meaningful comparison. Also the conceptual land use – plan obtained has ambiguous scale. The linear scale at the bottom does not correspond with the actual scale at which the plan was drawn. Better still the conceptual plan lack any proper co-ordinate system, it was thus assumed as a mere concept of the final plan, which is not in any serious way consistent with the master plan conceptual, proposal, and lastly, the conceptual proposal plan, gives little or no credence to the land scale quality and characteristic of individual side

1.9. RATIONALE FOR THE USE OF REMOTE SENSING

Remote Sensing has been variously define by Authors these definitions differs with author's background. However, the most comprehensive definitions were drawn by Short (1982). According to him "Remote Sensing is the acquisition of data and derivative information about an object or materials (targets), located on the earth

surface or in its atmosphere by using sensors mounted on a platform located at a distance from the target to make measurement usually (multi-spectral) of interaction, between the targets and the Electro-magnetic radiation" From the above it is noted that the analysis of data and derivative information obtained through remote sensing activities determine the usability of the information and the art of deriving the information about the earth's land and water areas from Images acquired at a distance. It relies upon measurements of feature of interests.

As observed by Adeniyi (1987), The first activity of remote sensing is to help man to know the location quality and quantity of resources at his disposal at a given time. The second activity, be further noted is to detect changer occurring in the environment. The temporal resolutions of remote sensors especially the space borne one's will permit them to perform this activity better than any system. It provides the perspectives the regional problems and the repetitive coverage for forecasting seasonal changes.

Traditionally, land use planning analysis is exclusively depended on ground survey. The ability in generating the information may prove excellent but the ground survey is no doubt costly, tedious and time consuming, further more, information may be impossible or difficult to see beside the health risk and hazards involved.

One of the modern most powerful techniques for resource investigation is remote sensing because of this overriding merit.

a. *Improved vintage point.*

   Aerial photographs give "bird's eye view of large area, enabling us to See earth surface features in the spatial context. Completely different Information can be extracted. By different people looking at a Photograph.

b. *Capability to stop action:*

   Unlike the eye, aerial photographs can give us a "stop action" view of Dynamic condition, for example aerial photographs are useful in studying 'Dynamic phenomenon such as floods, moving wildlife population forest Fire, oil spills etc.

c. *Broadened Spectral Sensitivity.*

   Aerial photography is sensitive to radiation in wavelengths that are Outside the spectral sensitivity or the human eye. With remote sensing, Invisible ultra violet and reflected infra-red energy can be detected and Subsequently recorded in the form of a visual Image.

d. *Permanent Recording:*

   Aerial photographs are permanent records of existing conditions on the Earth surface, as such these records can be studied when needed and can

Keep the transition of environment from past status to the presents.

e. *Three Dimensional perspective:*

A stereoscopic view of the earth surface can be created and measured Both horizontally and vertically. In carrying out studies/researches with This medium, the photographs are interpreted and point of interest, noted. This interpretation involves examining photographic Images for the Purposes of Identifying objects or features, judging their significance and Communicating the various informations's contained in them to other users.

An interpreter usually undertakes at least some of seven tasks of detection; classification; recognition and identification, analysis, detection, idealism and accuracy determination. This is aided in many applications by the seven basic attributes of aerial photograph (shape, size, shadow, pattern, place, texture, site and association).

Thus, these possibilities of obtaining synoptic, Spatial and temporal information by remote sensing technique permits rapid in-house assessment of resources with reduce results. Field work and highly veritable and more consistent results. Comparing sequential courage can monitor even changes occurring in a region.

It is not the aim of this research however to compare the traditional methods of land use plan implementation and monitoring with the modern method, but rather to exploit the characteristic of the modern methods as a way of complimenting the

information derivable from the traditional methods of making land use planning for urban development and resource management.

CHAPTER TWO

2.0. THE STUDY AREA AND LITERATURE REVIEW

2.1 THE MAKING OF A CAPITAL

Abuja the new Federal Capital came into existence by decree No.6 of 1976, until the creation of the new Federal Capital Territory Abuja on February 5, 1976, Lagos had remained the Capital of Nigeria since the amalgamation of 1914, with time the increasing tempo of economic activities and the influx of people into Lagos were not matched with corresponding increase in the level of intrastructural facilities space and services. The result was that the City was over burdened and its facilities stretched to breaking points.

This not withstanding, the propriety of Lagos as the Capital of Nigeria had remained a contentions issue right from the time of Lord Luggard, who himself had recommended Kaduna to the British Government upon the amalgamation, because of its central location and invigorating climate and its accessibility by rail to the East, West, and far North and the middle belt. This recommendation shows however that Lugard did not understand the economic interest underlying imperial colonianism. He had based its recommendation on the mistaken idea of the need for effective administration, which was not an area of colonial interest.

To examine and advice on this national predicament the Federal Military Government under the late General Murtala Mohammed in August 9, 1975 inaugurated a seven man Committee handed by an eminent Jurist Dr. Timothy Akinola Aguda. The Committee handled the assignment with dispatch out of the over 33 sites selected a territory of 8000 km of land mass carved out from the former Kwara State (part of which is now Kogi), Plateau State (part of which is now Nasarawa State) and Niger State was marked and recommended as the Federal Capital Territory. The Federal Government accepted the recommendation and by the decree No.6 of 1976, the governance of the territory was vested on the Federal Capital development authority (F.C.D.A), as the government agent responsible for the design construction, administration and management of the new capital territory.

In his Broad cast of February 3, 1976, Proclaiming Abuja as the new Federal Capital Territory, late General Murtala Mohammed said "The site recommended satisfied the panel criteria of centrality, good and tolerable eliminate, land availability and use adequate water supply, low population density physical planning convenience, security and multi-access possibility the area is not within the control of any major ethic groups in the country. We believed that the Capital created on such a virgin land would be for all Nigerians a Symbol of their oneness and unity.

December 12, 1991 was water shed in the history of Abuja in

that on this day the seat of government of the federation finally moved to Abuja.

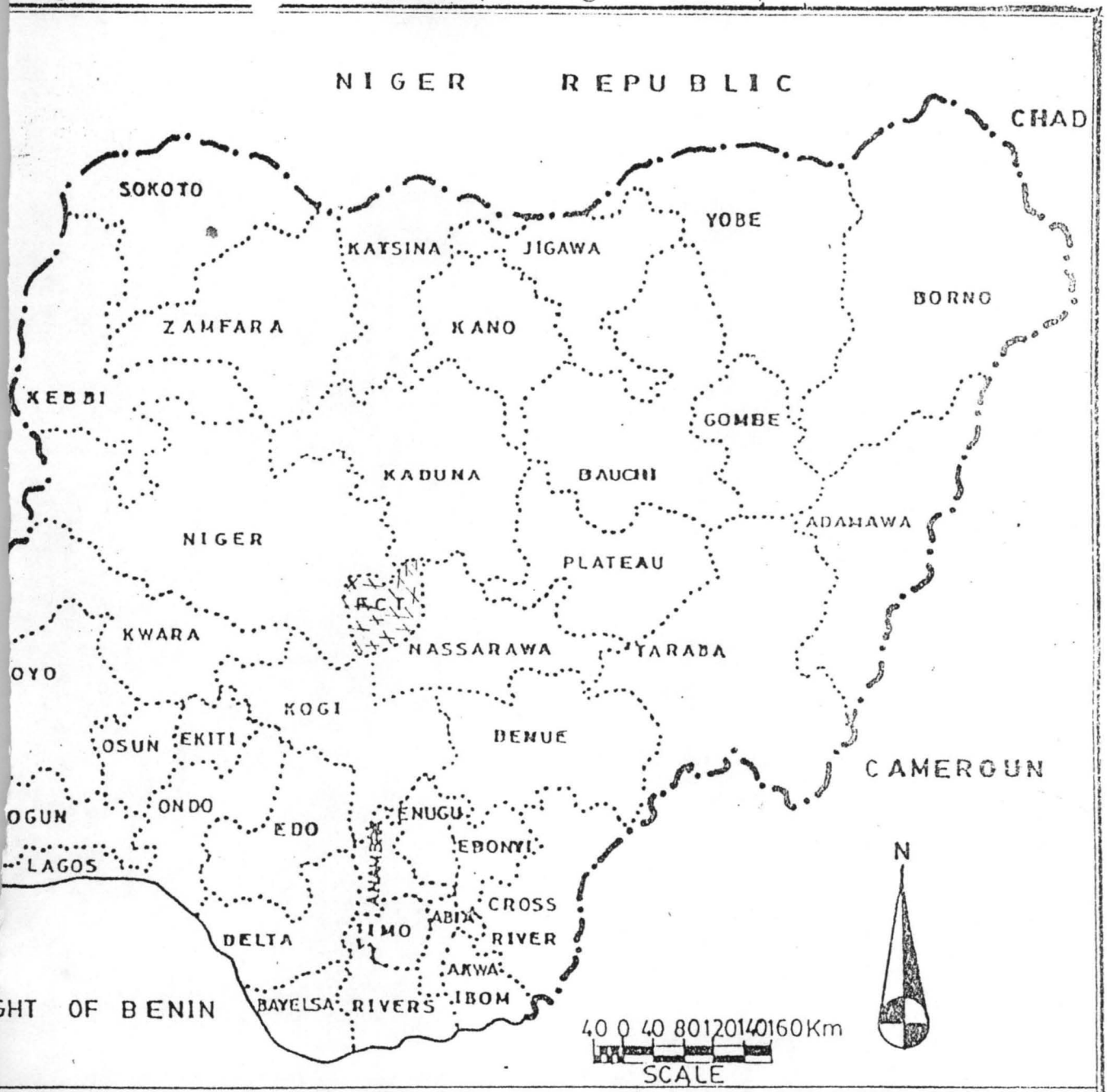
2.1.1 LOCATION

Abuja is located in the Guinea Savannah region of the middle best of Nigeria between latitude 6^0 43' and 9^0 20' East of the green which meridian. Kaduna State, Nasarawa to the East and South – East Kogi to the SouthWest and Niger to the West (see fig.2.1-2.2) bound it to the North. The total land mass is an area spanning 8000 square kilometers, greater then thrice the land mass of Lagos State (3,535 89km). The Federal Capital City is located on the eastern portion of the territory. In the Abuja Municipal Area Council (AMAC). It is an area covering 256 square kilometers of 3 percent of the total land area, The remaining 7,744 square kilometers area, constitute The City's regional components the highest points in the F.C.T located in Bwari has 750 meter above see level.

2.1.2 CLIMATE

Abuja climate is characterized by two major reasons the dry season which begins from November perpetuating through February is ruled by warm sunshine and the hazy Harmttan in the month of December and January, while rainy season begins in mid-March and terminates in November (NTDC, 1997). The average sunshine is

Fig 1.1 Map of Nigeria showing F.C.T



LEGEND

National Boundaries . . . . . ——•——•——

State Boundaries . . . . . •••••••••

Study Area . . . . . × × × ×

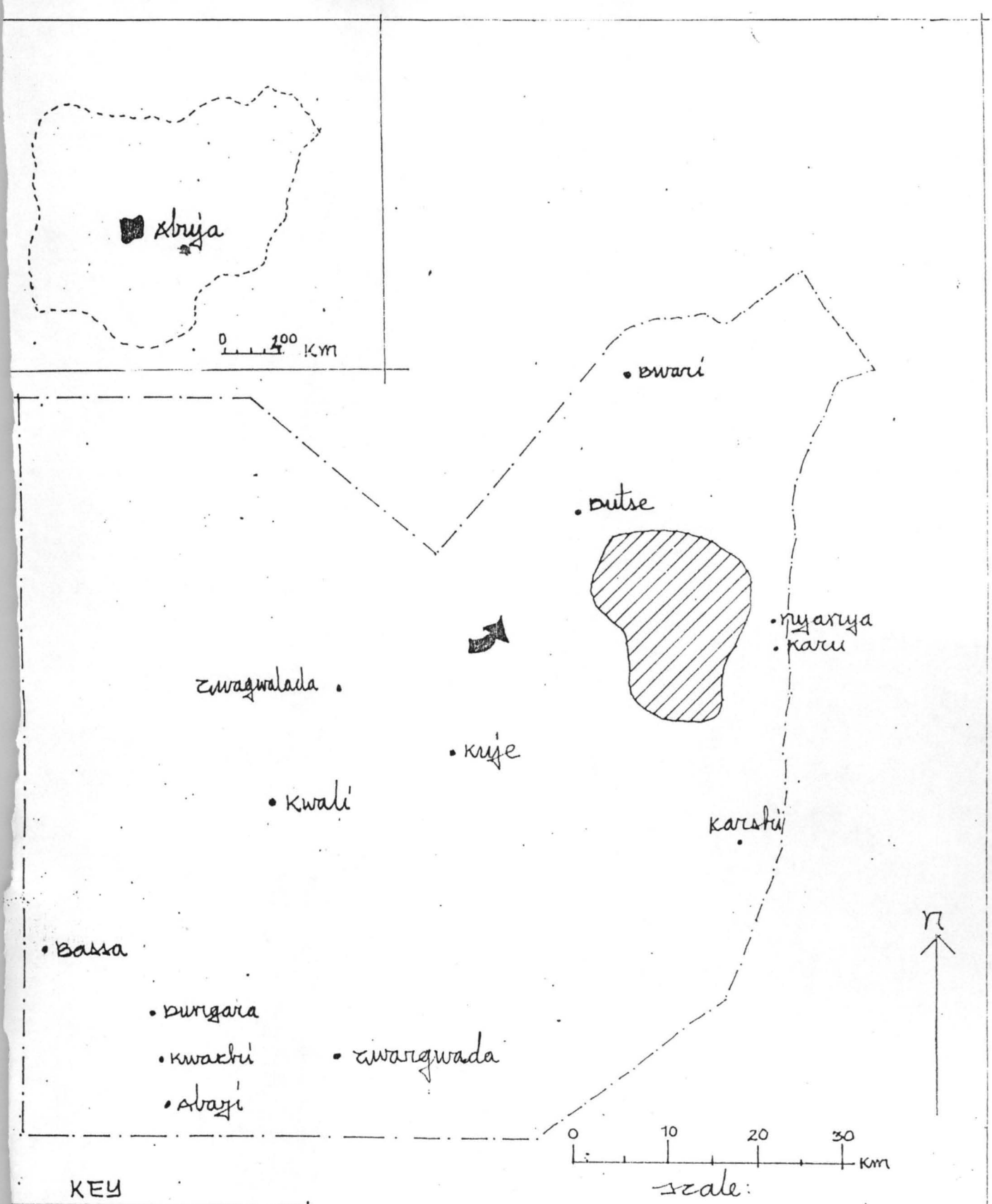


Fig. 1.2 : Map of the study area

between 6 - 8 hours per day in the South and 8-10 hours per day in the North. Temperature during the dry season is high, changes in the temperature of as much as 17^0c is recorded. The mean annual monthly values ranges between 20^0C. In the coldest month (December) and 31^0c in the hottest month (April – May). This is greatly influenced by the humidity condition in the air. Relative humility falls in the afternoon to as how as 20% in the City site zone, this relative humidity coupled with the high afternoon temperature accounts for the desiccating effects of the dry season. The length of the rainy season (LRS) of the study area is between 180 days in the North to 190 days in the South with an annual measurement of 1632 ml. The pre-dominant vegetation is guinea Savannah with catchments of woods Savannah rain forest etc

There are two major air masses predominantly the Federal Capital territory (F.C.T) these are the tropical maritime air mass and the tropical continental air mass. The former air mass, which is warm and moist, emanates from the Atlantic Ocean and moves in land. The other air mass has its origin from the Sahara desert it is warm and dry blowing from the Northeast to South – West direction. The later is a dust-laden wind, which gives the site its characteristic climate. The dust laded particles which reducing visibility to a few hundred meters during some seasons.

2.1.3.1 POPULATION TREND

The projected estimate (forum the 1963) Census by Dioxides (Nigeria) Limited (1983. P. 270) put the population of the entire territory at 124, 677 people in 1977; and rising to about 132,816 at the onset of physical development in 1980, This gives an over all positive change of 6.5 % over the 3 years period, about 2:2% per anum. Projection for those early losses or gains of population from migration processes.

On the other land data from the departments of planning research and statistics of the F.C.D.A. recognizing the new element of migration in the demography of the F.C.T suggest that the over all population had risen to 492,230 in 1980 then 516, 900 in 1987 and 555,668 in 1988 (F.C.D.A 1988b). These indicate an overall growth rate of 5.0% per annum between 1988 and 1987 and 7.5 % between 1987 and 1987 (see table 2.1): Hence a case of an increasing rate. However the 1991 census provisional figure put the population of F.C.T as a whole at 378.671 and 212.234 for the Abuja Municipal Area Council (A.M.A.C)

TABLE 2.1 ESTIMATE POPULATION OF THE F.C.T BY L.G.A 1986 – 1977

By L.G.A 1986 – 1988.

	L.G.A	**Estimated population**		**Percentage change**	
	1986 (a)	1987 (b)	1988 (c)	(a-b)	(b-a)
Abaji	62,300	65,400	71,305	4.98	7.50
Abuja Municipal	178,500	208,400	224,030	4.99	7.50
Gwagwalada	121,300	127,400	136,955	5.02	7.50
Kuje	110,200	115,700	124,878	4.99	7.50
TOTAL	**492,300**	**516,900**	**555,668**	**5.00**	**7.50**

Data Source, 1988, Federal Capital Digest of Statistics.

2.1.4 PEOPLE AND CULTURE.

Among the indigenous of Abuja Capital City the GBAGYI Constitute majority their main settlement includes. Bwari, Karu, Durumi, Garki, Ketti, Kabusa, Maitama, Kukuuaba, Mabushi Jabi, Lugbe, Ido, Toge, and Hulumi, others are Orogo, Kurudu and Jikwoyi. They are hospitable set of people whose occupation is mainly farming in the past hunting was very prominent but common in the dry season. The land is blessed with rich cultural heritage involving music dances folklore's and arts and crafts.

Another sets of the City's indigenous population were the GWANDARAS. They are commonly found in Seretti Ngaraya and Karshi etc.like the GBAGYI's "They are also peaceful and hospitable, the people are mainly farmers unlike the Gbagyis the Gwandaras women are commercially oriented, but however shares the common character of strong willed, hard working and industries. Another ethnic group in the City includes the Koros which have a separate language but share similar characteristics with their neighbours their main settlement are located in Shere and Kawu.

Presently, the movement of the Nations Capital to Abuja has brought about increase in the influx of other Nigeria's into the City, the result of which is a beautiful blend of the national and cultural landscape in the FCT and for which Abuja Capital City is a perfect representation. The various ethnic groups have continued to live together under an atmosphere of peace, friendship and cordiality

2.2. **REVIEW OF ABUJA DEVELOPMENT PLANS.**

The essential development plan is the "land use plan for Abuja, the New Federal Capital of Nigeria". This is the final report of the previous regional plan, preliminary master and site selection, and development manual (master plan, 1979). The master plan also includes proposal and studies concerning the site of the Capital City, Population and employment projection.

Determinant of form plan organisation, public service, transportation system, residential considerations, support infrastructure system, regional development and implementation (master plan 1979). This master plan is the base for all detailed plans on specific sectors. It is the full descriptions of the future of Abuja to the years 2000 as perviously monitored.

Development is planned to proceed in several steps (phases) to arrive at a maximum number of the target 3 million people of in habitants. The projected figure for 1986 (the intended year of inauguration) is 150,000 and for the year 2000 it is 1.6 million people (master plan, 1979) The 1991 Census showed that Abuja has the population of 377, 671 people (i.e 172,136 female and 206,535 males as published in Census News, 1992, courtesy of National Population Commission (NPC, 1992).

The individual areas of the Capital City are usually formed according to the various phases of the implementation of the City Development plan, but these phase are not the same as defined in the master plan, due to some official alteration by the Government. Phase I, with its size of about 54 sq km is enclosed by the water Northern express way, the outer Southern express way, and Ring road, (see fig 1.1 and 1.2 respectively).

There was an established special Survey branch of FCDA to co-ordinate the various works and place order with private Survey firms. It as to surprise the execution of the work and must check the delivered out put (Bartse and Wagner, 1983). This out put consist of maps plans and survey computation records, which must be store, kept on hand for later use, copied, up dated and sold and at certain intervals must be renewed (Bartse and Wagner, 1983)

The master plan for the City prepared by the 119 is designed around a City that is Crescent shape, centrally oriented and placed in a prominent position emphasized by an anal focus on the highest point of Aso Hill. Abuja as the Federal Capital of Nigeria which is conceived as symbol of Nigeria's aspiration for unity and progress (Bartse and Wagner 1983). However, with few exceptions urban planning agencies do not appear to be utilizing aerial photographic technique to any great extents, researches in the field of remote sensing, therefore must work closely with urban planning officials not only to keep the official master plan abreast of their researches, but also to make the result of their researches more applicable to municipal problems.

2.3. **LAND USE PLAN.**

The vogue in urban planning is the preparation of Land use plans as an instrument/tool of ensuring the orderly development of cities. Land use plan is bearing various names such as: Master plan, comprehensive land use plan, general

plans, development plans etc. Just as various names are attributed to land use plan. Variant of definitions was advanced in order to adequately define land use plan.

Kent jnr (1964) defines it as the official statement of a municipal legislature, body that sets forth its major policies concerning desirable future physical development. "The definition suggests a document that contains official decision on the direction of city growth.

Agaba J.O (1982) defines it as "The plan of future course of development of a city considering its socio- economic, physical, cultural political and administrative characteristics". This approach to define and use plan purported by Agaba is broader in scope and can consist of any governmental policy statement that aims at achieving a desirable future for a city or community.

The object of controversy is the ambiguity of the scope of land use plan, while land use plan can cover as small a piece as an estate, working drawing for a park etc it can also be as broad as the land use plan of cities, region etc. Nevertheless, the name "Land use plans" seems replaced with development plans as the scope becomes more regional (Black 1968).

In respective of the discrepancies in the choice of name as scope of land use plan, there are various characteristics that are peculiar to land use plan has generally agreed by all planners.

a. A land use plan must be comprehensive in other words, it must embrace All geographic part of the community and all functional element which bear On physical development.

b. It must be general, in the sense that the plan summarises policies and proposals and does not indicate specific locations of detailed regulations.

c. It must be long range: having to look beyond the fore ground of pressing current issues to the perspectives of problems and possibilities – 20 – 30 years in the future.

The attribute of the land use plans elevates it above other tools of urban planning. It deals with the town as a whole both in elemental context and physiographic context, taking into consideration the inter-relationship between the element of city and the geographic component (Agaba J.O 1980)

Land use plan includes sets of drawing representing designs, proposals, and reports of policies to ensure the compliance with the planning statement, the legal framework upon which the policies will be implemented and a statement of the duties of the implementing agencies.

Land use plan as a tool to ensure Desirable City setting in Nigeria, has been used as an approach where a planning agency operates a program thought to attain some objectives with certainty. It ensures general allocation of the city's space or land area

to major land user. Emphasis is however placed on the inter-relationships and implications of one type of use in relation to other uses.

Urban planners have various instruments to assist the actualization of the proposals of the land use plans. These tools are often used in the absence of master plans as ad-hoc approach (Lindolm, 1959).to Urban development. Such tools include zonning ordinance, official map and sub-division regulation which are intended to carry out the proposals of the land use plan. Other tools include, planning scheme, development control, capital improvement programs, budget allocation special purpose regulations and short or medium-term development plans. This aims at concentrating on a particular area of the city or a particular functional element. It has shorter time perspectives.

Land use plan of a city may include the planning of social, economic administrative and fiscal matters many of, which are obviously interrelated to physical planning.

The significance of land use plan to urban development can not be over emphasized as without proper regulation of the city growth, the developers will build any how, which can result to a chaotic and disorderly growth of the town. Such disorderly growth result may result to encroachment on adjoining properties denying other accesses to natural light, privacy and ventilation. Lack of access to public facilities such as water mains, sometimes, electric wires, telephone cables and other infrastructure element.

One of the effective ways of dealing with cities, preventing them from degenerating to this level is to prepare a comprehensive land use plan as a guide for future course of action and development. A well-prepared land use plan will identify inherent problem and formulate proposal for the improvement of the already built up area in the foreseeable future.

The subject of coverage of land use plan is still subject to controversy. According to Wuredu (1989) the feature of the land use plans in Nigeria is left to the continence of convenient

But generally revolves round nine subjects as follows: Existing land use Housing, population, Transportation and economics activities, Education and social feature, public utilities, industry, agriculture and communication economy.

The problem of lack of argument on the subject of coverage is a potential set back in applying a common yardstick or standard for measuring the implementation of the land use plan.

Series of agencies and statutory bodies were aimed with laws and legal provisions to ensure the total compliance with the proposals of the land use plans. Planning authorities urban development boards etc is some of the bodies responsible for the implementation of the land use plans in Nigeria.

Without effective policy to implement land use – plan, the proposal, however, brilliant they may be, remain like a glossy look that is meant only for the sheet. Hence various apparatus are usually set in motion for the implementation of master plan.

Nigerian has an interesting history of planning experiences with the characteristics fashion of evolving tools and guiding principles to ensure the right use of land in Nigeria. The first of it came in 1863 with the town's improvement ordinance, which was published in Lagos. In 1907 the scope of the ordnance was extended to cover the entire country and renamed as township ordinance. A sanitation body (Lagos Executive Development Board) was set up in 1938 following the enactment of Lagos Town planning ordinance. The body emerged as the first planning development authority with power to undertake comprehensive land use planning and development in Lagos. In 1947 a Nigeria Town and Country Planning ordinance was adapted to 1920 British town and Country planning. The different regions in the Country adopted this ordinance.

In the Northern part of Nigeria it was adopted as chapter 130 of the laws of Northern Nigeria. It was named chapter 155 in the East and Chapter 123 of the Western Laws. This law remained the major legal basis for town and Country planning in Nigeria until the 1932 town planning law of Nigeria was put in place (Ola 1977). The town and Country planning is in the concurrent list of the Nigeria constitution which

means that both the Federal and the State Government may carry out the responsibility. The Federal Ministry of works and housing, has a town and Country planning sections that takes care of implementing the Federal land use plans, such as Federal high ways constructions, major projects like Dam construction, plant installations. Some Federal Government Parastatals have their physical planning/development unit that handles implementation of their respective land use plans.

Every State in Nigeria has set-up institutions frame work for Town and country planning involving two or three tiers. These are Federal and State Ministry: which have the responsibility for town planning policy formulation and monitoring of the activities of the other area. The other tiers are the Zonal planning offices and the local planning authorities, which are responsible for town planning policy implementation. It however varies with states.

There are also some specialized bodies charged with the responsibilities of a planned tellite towns such as Abode new town development Authority Ibadan, Federal pital Development Authority (FCDA) Abuja, Ogun property and Investment orporation Opic along Lagos – Ibadan express road. Most land use plans in Nigeria performed poorly, due to lack of effective procedure and machinery for implementation. The machinery may be strong but lack tools for proper handling of task assigned to then. These has been a general bilk passing on who is responsible

for the failure in the implementation or the deviation from the original proposal of the land use plan (Onokdlaraye and Omuta 1986).

Aiterman and Hill (1978) blamed problems on the lack of proper link between plan making and plan implementation. Hobbs and Boling (1981) observed that the cause of the problem is the incompetence of the professionals whose undue concern is in making plans without a corresponding concern to see them carried out, one would readily agree with their submission or critical appraisal of most land use plan currently available in Nigeria. The plans demonstrated the vision of the professional for an ideal state without consideration of the political religious, cultural and social content of the people. Plan implementation according to MC Longhorn (1969)-can succinctly is summed up as "a control activity where control is that which provides direction. In conformance with the plan or in other words the maintenance of variation from system objectives within allowance limit. In this context, plan implementation involves series of action of action. (Or statement of actions) aimed at translating the policies stated in the plan into realities of earth, brick and concrete and the translation of development strategies and growth models into the daily life concerns of housing, shopping recreation and others Elegba (1988). The process of land use plan implementation can be categorized into 3 stages, which are:

i. The input stage, this relates to the identification of resource commitment.

ii. The action stage. This correspond to the ability to make the input realize

iii. The output stage. This is concerned with the perspective planning efforts On the ground.

All these stages can be affected by multi-factions factors ranging from economy to political, cultural etc. As mentioned earlier, land use plans are poorly handled to Nigeria in terms of implementation these stands from the following reasons.

i. Physical problem; photography, soil types, water levels, and other physical constraints makes development difficult and expensive. This in a way stands down the face of work or cause deviation by the implementation of the proposals.

ii. Economic: Revenue allocation for individual authority cannot be predicted in advance, implementation largely depend on the release of funds by policy makers who usually weigh the implementation of plans with other pressing commitments.

iii. Social problems: Pahl (1975) observed that the interest of planning authorities often conflicts with the developers. Nigeria's case is not excepted.

iv. Personnel problems: untrained hands are allowed to handle planning matters and implementation of planning proposals. Consequently the planning proposals are being politicized and incompetent people dictate the direction of implementation.

v. Technical problems: This relates to logistic problems that militate against many planning authorities, that some lack the necessary vehicles and equipment to properly handle the task.

vi. Research and Data problems: up-till now most of the planning authorities and agencies do not have effective system of storing data of land use, and land covers. When such exist the data are not dynamic enough to satisfy the need of the agencies hence, many problem and contravention reach their advance stage before they are detected.

vii. Conflicts among professionals: There is a conflict of power struggle among professionals that are involved in plan implementation. Professionals like architects, engineers, surveyors often claim to handle the work of implementation, and planners usually fail to declare their boundary of professional scope. The decree no.3 of 1988 gives the legal backing to the scope of professional planners. However these decree has not been properly implemented.

viii. Lack of co-ordination: The preparation of land use plan usually involves few agencies and persons, the consultants usually consult few agencies during the drain-up of plans.

Other problems militating against effective implementation of land use plans are: Multiplicity of agencies, inadequate development control systems political factors, legal problem and time factors, these among others have substantially contributed to non-performance of implementation of master plans.

2.4. LAND USE AND LAND COVER STUDIES.

One of the major task confronting planners and other municipal

Officials are the administration and analysis of information upon which the administration of the cities and towns depends. Today most cities are attempting to establish some types of information system. Efforts on this direction have been largely unsuccessful. Presents methods of data acquisition and analysis continue to be time consuming, costly and extremely in different. In an attempt to improve the effectiveness of urban information system researches are being undertaken to determine the possibilities of urban application of remote sensing, to date results have been very encouraging. Perhaps the most commonly used by planners is the land use maps. This categories of maps which is basically an inventory of land is presently being utilized, it illustrate the stall relationship of various land uses if accompanied by quantitative summation. It also illustrates how much land is devoted to each use. Furthermore, the land use maps, shows, the extent of the transportation network and

most importantly the relationship of transportation network to land use (David hiegreen 1979).

Research has demonstrated that urban land use surveys now can be continue from aerial photographs; Further-more; employing sequential photography, changes in the use of urban space can be detected and analyzed.

Land uses, and to some extent land cover studies have been the focus of geographers, for a long time in many ways the study of man-environment. Interaction as a central theme of geography recovers its unity through land use investigation (Lintz and Simoneth 1970). One of the most important types of resource information required for comprehensive planning is a current database of land use and land cover. According to Puidd (1974), a number of studies have shown that land use mapping for various purpose are at widely varying degree of detail is possible through remote sensing techniques

Interaction occurs between every day behavior and the future land use pattern. Existing land use arrangements in part determine where people live and where they shop in turn help to shape future land use pattern. Indeed the central position of land, in economic and social life quite apart from the political heat generated by the use of land use generally land to considerable state intervention both direct and indirect in the land use control and the land market (Rhind and Hudson Op'cit).

In Nigeria the perceived importance of the interrelationship between the supply of land and development "proper" pattern of the urban and regional development has led to such legislation intended produce effective state control of land for development process (land use decree 1978: No.6 F.G.N Officials Gazette 65 (14).

There can be no doubt of the significance of land use studies on the one land, we all require land on which to live and on the other hand the use of any given parcel of land affect not only those who reside or make use of that land for whatever purpose but also those who live on or make use of adjacent and surroundings areas (Rhind and Hudson 1980). Man had constantly been at the center of struggle over it use and control some of these involving physical aggression and war, or other more subtle means for example the bombing of dykes in the Vietnam War – a strategic attempt to disrupt land use for military ends (Lacoste 1973).

As noted earlier, the past, present and future arrangements and junta position of land use have occupied academic drawn from a number of disciplines including; Agriculturists, Economists, Geographers, planners and sociologists. The increase importance of urbanization and the growth of urban areas from the 19th Century to the present day have led to an increased study of patterns and extent of urban land use and land cover mapping above other interest.

Knowledge of a land use and land cover is important for many activities concerned with the surface of the earth. Data on land use and land cover are not only relevant for researchers and planners in their professional activities to understudy the process and formulate operational models, they also provide the Federal State and local Government officials as basis for up-to-date decision making as well as a means of monitoring the outcome of past decisions.

The subject of urban change may be partitioned into changes in the physical social and economic sub-systems of the city. Remote sensing provides a means of discerning physical changes in the distribution of activities, which in turn are related to social and economic changes within the system. In any event imagery from remote sensor is a partial input to an over all urban change detection system.

While knowledge of what currently exist is often a necessary condition for answering question relating to the use of land. It is rarely a sufficient one, to know how particular parcels of land come to have its present use through time (Rhind and Hudson op cit). In order to understand why land use change as well as how the changes occur, it is necessary to have information on the land use and land cover over different time thus it is necessary to understand the past and the present land use to be able to predict the future role of the land.

In the past the processing of over lay to produce changes have often been carried out by photographic means where two different data sets have occurred on maps of similar scale – making negative film image of each and super imposing these on a light table, give the area of co-incidence which can be measured using a planimeter (Rhind and Hudson O.p.cit). However, the use of computer has greatly eased such comparison).

2.4. APPLICATION OF REMOTE SENSING IN EVALUATING LANDUSE/LAND COVER DYNAMICS.

Land use dynamics evaluation using serial photography and other remote sensing data has been applied to both rural and urban areas and found to be an efficient method of discovering the development trend of a region. These data are useful for city planning or developments of target districts. Change detection involves the use of sequential remotely sensed data over a specific region from which the land use for each data was mapped and compared.

The series of township photography that have been produced over the years have proved useful in studying land use, residential patterns and the spatial growth of urban Centre (Areola 1986). Indeed the possibilities of using aerial photography for map making were first demonstrated in practical terms in 1913 with aerial photo mosaic of the form of Benghazi, Libya (pullan 1976). The Mosaics was however not

controlled by ground surveys, but the possibilities of using aerial photography to make time plans and maps were well demonstrated (Areola 1986)

The various colonial government in Africa became very much interested in making use of aerial photographs to produce township, photographic and other purpose maps (Areola, 1986). Sequel to these the colony of Northern Rhodesia (now Zambia) was among the first African countries to have source for their townships photographed and mapped (Areola 1986). According to Pullan (1976).

"Township photo-Mosaics of Lusaka, Broken Hill living stone and Mazabuka were produced in 1978 and those of Ndola, Luanda, Nkoana, Nchanga and Mufulira and Mpika in 1930" Major effort of urban mapping in Africa were mainly during the post-second World war Colonial Era and a large proportion of African Countries have continue to issue reprints of these maps without much revision or up dating (Areola 1986).

Aerial photography for urban mapping is done usually at Medium-to-large scale: that of Zambia the scales vary from 1,25,000 to 1,5000 (Areola 1986). For the Franco-phone countries such as the Congo Gabon, Cote-diver, Niger and Togo, Urban aerial photography is available at one or more of the following scale: 1:15,000, 1:20,000, 1:25,000 and 1:30,000 Areola(1986). There are some counties however that have provided many special photography for their urban centers apart from the general small scale aerial photography for the country as a whole (Areola 1986).

Aerial photography is used in urban studies not merely to present state pictures of urban land use but perhaps, more importantly, to assess analyses and map the temporal changes in land use and singular reason for the services of urban photography that has been provided for many urban centres on the contents is to assess the spatial changes (Areola, 1986). "It is unfortunate that not much material has been published on this type of application of aerial photography in Africa"- by Areola (1986).

According to Areola (1986): "Two cities which have been studied in some details and for which data there are references are Ibadan and Lagos in Nigeria:" Adeniyi (1978) studied the land use change, in Lagos. In his study, it was noted that Agege (NW of Lagos) is one of the urban fringe area where rapid changes are occurring. Within the area, a sample site of 400 hectares was selected for this study. Sequential aerial photographs for 1974 (1:20,000) and for 1976 (1:25,000) were acquired from the Federal Survey Department (Adeniyi 1978). The photographs were use as the main source of data and the interpretation was done with different interpreters. The data recorded for each included:

i Total number of completed building.

ii Total number of Buildings under constructions.

iii The specific use of cells without any structure.

changes in residential land use in order to be able to estimate and predict population in the city which is an integrate part of urban growth.

One thing of great interest to the urban studies of the movement, is that Adeniyi derived an urban land use classification scheme for Lagos which would appear to have potential for wider application, especially in the Southern Nigeria (e.g. Ikhouria, 1982). The classification scheme by Adeniyi (1978, 1980 1981) presents the basic requirement for proper monitoring and mapping of the spatial growth of cities and other application areas like land use changes in both urban and rural areas. Adeniyi (1978,1981) was able to determine urban growth and changes in land use in metropolitan Lagos between 1962 and 1974 using the aerial photography of the city taken in those two years.

Anderson (1975) evaluated the usefulness of side – looking air-borne radar (SLAR) for general land use mapping of a scale of 1:250,000 covering part of the mid-west of the united states. After reconnaissance Survey of the area using physical and cultural features of the environment. Interpreted from a continuous film trip radar – imagery of scale 1:80,00 that facilitate the description of the area and to detect changes using the concept of Rationalization he was able to discern five major and fourteen sub-components of a land use region at a level one and two classes respectively. It's study reveals that much of his land use region conformed with the existing classification scheme indicating the applicability of Radar Imagery to land use

change detection studies. But it should be reminded here that work of this nature could lead to double counting of land use category if not reviewed against existing ones.

In the study conducted by Poulton el al, (1977) for a range and farmland in Sierra Nevada California, using a comparative analysis of 1944 and 1968 aerial photograph to detect changes and assess changes as they related to land management. The study shows that moist Meadows site and Superman regulation had disappeared from 1968 photographs while encroachment of Sage bush shrub had occurred. It is good to note that this study does not make use of ground truth to verify condition especially in the 1944 photographs. Beside the use of only 1963 aerial photograph alone will not be too good for a reliable comparison that is capable of revealing land use change over the period under study.

Henderson (1979) used the westing house k-band Radar Imagery at scale 1:225,000 to map the northeastern part of the United State using the USGS (1976)-classification scheme. It's study when compared with the existing land use region classification of the same area indicate fragmented and complex land scope, thus reducing the level of land scope details visible in the area occupied with that of Mid-West United State. Finally the area consist drainage, relief, transportation and settlement's features. The short coming of this study however was that it failed to delineate the land use region in the area in order to determine the aerial extent of the various land use categories.

Studies for an arid environment was spear Handed by Henderson (1982). He used SEASAT SAR Imagery to map land use for the arid environment in Denver Colorado area of USA using a general electric Imagery 100 interactive processing system to contrast, stretch and enlarge the original Image to the scale. The study shows that the level I land cover of the USGS classification system, could be delineated from (1:500,000) Images and urban built-up area could be accurately defined. Thus introduce a new dimension and the applicability of the SAR Imagery for land use/land cover mapping.

2.5. APPLICATION OF REMOTE SENSING TO LAND USE PLANNING.

Even since one of the earlier space photography of Cairo City (Egypt) was take from the 'GEMINI' Mission in 1966, the use of space images becomes a handy term for urban planner of urban planning and management Satellite remote Sensing data is now available (1972) operationally in the orbit. Satellite Remote Sensing data is available today at 1:1m and 1:1250,00 scale, 1:5000.00 scale convenient for carrying regional and district level planning/studies and 1:25.00 scale useful for metropolitan and city or town planning. At present with the availability of high spatial resolution data from IRS IC and ID. PDN it is possible to generate data in large scale and more useful for even small and medium towns mapping and planning purposes.

This has led to the development of the computer software. Like Geographic information system (GIS) which are belonging essential tools in the data management and plan preparation process. Geographic information system (GIS) is a system for handling spatial and non-spatial data on land and water resources. Land uses and changes pattern; land values, demographic and Socio-economic attributes.

In 1989, Mr.V.B. Prabad has carried out a case study as topic of site suitability analysis for residential development in fridge areas of Jaipur City of India. His attempt was to show how the suitability levels are determined by using a set of criterion, to do land use planning for residential environment and to come with suggestion and comments regarding applicability of aerial photographs and SPOT data for land use planning. In 1982 Mr. Six Nathan and P. Jpthimani had done a study for the urban land use planning. A case Study of Calcutta Metropolitan area based on Satellite Imagery LANDSAT TM 1987, SPOT MLA 1989, IRS LISS II 1990. The main objective of the study was to evaluate the physical parameters responsible for urban land use suitability, to develop a methodology for urban suitability analysis and to evaluate urban land development units for the purpose of urban development.

S.M. Rashid 1992 has analyzed site suitability for urban development and suitability of vacant land. It is objectives war to make inventory of vacant lands using aerial

photography of 1987, to identify land requirement for urban developments to prepare a suitability rating of land quality parameters for urban use of vacant land etc.

1993 S.K Pathan and S.V.S Sastry have analyzed the urban growth trends analysis using GIS. Technique. A case study of Bornbary Metro Politan region. The main objective of the study, was to analyze the physical growth of urban areas in BMR using Multi-date remote sensing data and relate these growth trends to the population growth to estimate the additional requirement of areas for urban development for the year 2001 to identify the areas suitable for urban developments with the help of land suitability analysis to meet the demands for the year 2001.

Dr. Kishori Iai Sharma has carried out his case study as an inventory of vacant lands and suitability for urban development of Saharanpur City in 1983. He has prepared required thematic and land use maps with the aerial photographs and guide map of 1:20,000 scale and topo sheet of 1:50,00 scale. His objective was to identify different types of vacant lands an aerial photograph, preparation of inventory of vacant land and to study change detection of vacant land uses.

In 1995 Babajit Mishra and P.R Mahanty had done a study for the site suitability modeling using remote sensing and GIS for Urban extension in Bhubueswar City. The main objective of the generation of urban spatial information by utilizing remote sensing data particularly large scale aerial data for urban land use pattern study.

In 1997, Ahmedabad urban development authority, Ahmedabad and space application centre, Ahmedabad had made revised development plan of Ahmedabad urban development authority, area for roll, using remote sensing and geographic information system approach based on satellite imagery IRS – IC PAW IRS-KLISS-III< SPOT MLA and LANDSAT MSS/TM. The main objective of the study was to prepare "Development plan of AUDA for the year 2011" to carry out urban land use suitability analysis based on physical – parameters etc.

From the forgoing, it is clear that remote sensing, should play an important role in any land use plan monitoring system plagued with shortages of money and man power, cities should find in a remote sensing a valuable tools for data acquisition. Remote sensing should take the place of present data collection procedure that may be inefficient or as is more likely to be the case provide an important supplement to these methods. However, with few exceptions, urban planning agencies do not appears to be utilizing aerial photographic technique to any great extent. Researchers in the field of remote sensing therefore must work closely with urban planning officials, not only to keep the official abreast of their researches but also to make the result of their researchers more applicable to municipal problems.

CHAPTER THREE

3.0. METHODOLOGY

The methods or procedures used in achieving the aim and objectives of the study includes the followings:

Data from Remote Sensing, Data collection, Development of land use land cover classification, Data interpretation, Data transfer into a final mapping scale to generate static/thematic maps for the bi-temporal periods, ground verification and observation. Measurement of land use and land cover types as well as deviation assessment using the modules in the ILWIS (Intergrated land and water information system) 2.2 computer software.

3.1 DATA FROM REMOTE SENSING.

Formally, land use data have been compiled by census interview or field mapping, major land use are mapped in the field and published on small scale map in some countries (Lunney and bill 1990), generally these methods take a long time.

Today the urgent need for increased food production environmental projection of prime agricultural lands from encroachment have awaken the interest of many in the study of land use and the problem it entails.

Better sensing and interpretations instruments and techniques have facilitated increased applicability of remote sensing to land use. The over whelming advantages

of remote sensing techniques over the tactile methods based on ground survey in at least one stage of data collection. The rapidity of survey and data collection stage" (Lunney and Bill 19700.

Assessing the over all land uses on small – scale imagery first became popular with the advent of Astronauts photography and ERTS image (Rudd 1974). One of the earlier effort employed Gemini and Apollo photograph of the southern California and Texas (Thrower and Senger 1967), wray (1948) used aerial photography to develop an Atlas of Chicago Municipal Airports and acquired basic land use data monitoring urban growth in Lagos.

Odenyo and Pettry (1970) "observed that considerable attention today has shifted from what has become known as conventional aerial photography to small-scale high-altitude and space photography" These have been applied to land use classification in both rural (Vegos 1972, Alexender 1973 b), Urban (Alexender 1973 a), Semi – arid areas (Pilson et'at 1972, Adeniyi 1985) and irrigation pattern (theiruvengada cheri, 1981).

It must be noted, however, that the conventional aerial photographs are integral parts of remote sensing especially in developing countries where the acquisition of space photographs and satellite imagery is difficult.

3.2. DATA SOURCES AND CHARACTERISTICS

Two sets of data were for the study, these are: a four stereopairs (line f, - 12/58 – 59 and line f, - 11/35 – 36) 1982 black and white aerial photographs of Abuja at a scale of 1:40,000 acquired from the federal surveys Lagos and the 1994 SPOT HRV imagery at scale 1:50,000 was obtained from the National Centre for Remote Sensing (NCRS) Jos, Plateau State.

This was enlarged in the scale of 1:25,000 for easy interpretation. The scene has a ground resolution of 10m some buildings could be enumerated with minor stereo magnifier the date of the scene was collected on October 1994.

A copy of Abuja land use plan at a scale of 1:10,000 was obtained produced by the Federal capital development Authority (FCDA). The policy concepts and the design of the city were extracted from its documents. The layout plan of the scene (information plan) produced by yje SF consultants for the phase I of the federal capital city (FCC) was obtained. This gives a detailed design of the impression of the designer, involved in the planning.

During the period of satellite over pass for the scene on hand, the land use plan was not at its middle stage of implementation (i.e. October 1994). However, at the time of carrying out the study the stage is to advance stage of implementation as a matter of facts the phase II has commenced. This called for meticulous ground truthing to up date the satellite image.

Other collateral data used include, the Four quadrants (ABUJA sheet 186 S.W, 186 S.E. sheet 186 N.W and 186 N.E) topographical map of Abuja at the same scale of 1:50,000 photomap, scale 1:25,000 and cadastral map scale 1:10,000. See table 3.1 for the summary of data sources and characteristics.

Two aerial photographs would have cover the entire study area and for the period under study at the stated scale, but for good scale, but for good stereoscopic coverage four (4) aerial photographs were used and for the period 1994 one (1) scene of the SPOT (HRV) Imagery were used).

Basically, the choice of Abuja Federal Capital City (FCC) for the study is a matter of convenience and ready source of data. The dearth of satellite remote Sensing data in developing countries like Nigeria and the exorbitant cost of those available have limited the scope of this research.

The base map for the study area was developed from topographical map (sheet 24, scale3 1:50,000, the four stereopairs aerial photographs of 1982 at a scale of 1:40,000) it was constructed for locational guide for the recording of interpreted land use and land cover to enhance detail analysis of various prominent land features like rivers, roads and rocks were marked on the base map which acted as controls while doing interpretation mapping.

3.3. GROUND OBSERVATION AND VERIFICATION

The researcher proceeded to the ground truthing to identify major land uses, to verify the delineated boundaries, check doubtful features and verify the accuracy of the interpreted data. This was intensively carried out from June 15 to June 28 year 2000. Errors detected were immediately corrected on the preliminary land use maps. Because of the time lag between the period of sensors overpass and field check care was taken so that changes in the land use and land cover will not be taken as interpretation errors.

The ground truthing exercise was limited to those features covered by the satellite scene; no attempt was made for intensive up-date of the plan except in some minor cases.

Fig. 4.8, shows the result of ground truth some level of deviation can be identified. The portion presently utilized for a secondary school. Road bearer names difficult from the names attached to them in the proposal.

The areas that received full implementation in terms of land uses are: three arms zones, the ministry zones, the central business district, the Asokoro district and the Maitama district.

Areas with high degrees of deviation can be identified, these are: Wuse districts and Garki district also experienced some elements of deviation in terms of land uses. For

stance, the Nicon Hilton Hotel located here seems to be out of tune with the vnscape planning adopted in the area.

at the time the satellite scene was acquired few buildings were in place in all the trict Wuse district has about 1970 units of buildings on the site as at October 1994, aitama district 692 units, could be discern, within the three arms zone about 274 ildings could be identified. Garki district had a total of about 1081 units Asokoro strict had about 636 building unit on October 1994. These figures are subject to stortions as a result of limited ability of visual and digital interpretation.

is also note worthy that the type of uses that those units were put could not be educed. This is due to uniform spectral responses that the building roofs possess. It possible that some make shift and temporary structure such as sites offices will be numerated during the exercise.

However, the ground truth revealed a high degree of accuracy in the satellite scenes. The flexible approach used in the design of the land use plans also caused high egree of deviation because some of the layout pattern within the district could equally accommodate office complex as wee as residential units.

The approach resulted to integration of both residential units and commercial, administrative and high industrial uses within districts or zones. While this approach has some advantages, such as increasing the period of active uses in each sector of the city (where there will be 'no ghost town') it will however have great future

nplications. The cityscape as well as functionality of the capital will be ogressively affected adversely. This is evident through the ugly sight that haracterized the residential components of the city centres.

esidential precincts are noted to degenerate faster than other land uses in terms of eauty structure and maintenance. The fact that they are owned by individual mplicate the problems as it becomes difficult to effect general renovations.

.4. CLASSIFICATION SCHEME

A major factor of importance of any survey of land is whether the information ecorded relates to some activity carried out on different places or whether it relates o inherent physical characteristics of those places. Whether the classification is functional or formal will depend partly on the objectives of the study. Activity or specifically principal activity carried on at a site is the main concern of many people in collecting land use data (Cappock and Gebeth 1978; Dickson and Shaw 1978).

There is no ideal classification of land use and land cover as stated by Anderson et at 1976 " There is no ideal classification of land use and land cover and it is unlikely one could ever be developed, there are different perspectives in the classification process and the process itself tends to be subjective even when numerical approve is used, there is infact no logical reason to expect that one detailed inventory should be adequate for more than a short time. Since land use and land cover pattern change in

eeping with demand for natural resources each classification is made to suit the need
the users".

owever, Anderson (1976) advance the criteria which classification for remotely
nsed data should meet thus: -

repeatable results

. Multiple uses of land recognizable

i. Aggregation of categories possible

v. Categorization permitting land cover to be as surrogate for activity

. A minimum level of interpretation accuracy of at least 85 percent.

vi. Equal accuracy for different categories

vii. Possibility of use with remote sensor data acquired at different times.

viii. Applicability over extensive areas

ix. Comparison with future data possible

x. Integration with ground surveyed data of large-scale remote sensor data possible through the use of subcategories.

Smith et at (1987) stated that "the broad category that got in their study were defined in terms of ideal classification" thus substantiating the ideal of no ideal classification for general use while Anderson qt at (1976) scheme emphasized a rather coarse level of mapping levels I, II, III and IV.

ecause land use classification can pre-judice the future (Chive 1983) and constrain
e scope for future development (Rhind and Hudson 1960) what ever classification
ade, must be mutually exclusive, meet the need of the primary users, meet as many
eeds of the secondary users as is possible and must be flexible for new interest and
sk to be met from a modified rather than a completely new classification approach
r land use planning.

.1. SELECTION OF A CLASSIFICATION SCHEME

Although standard land use classification scheme have been developed for general
urpose (Anderson et al 1972) there is no prior land use/land cover scheme for
Nigerian (Adeniyi 1985) for this reason an appropriate classification scheme to suit
he objective of this study with due respite to the available date have been developed
and presented as table 3.2.

A preliminary ground truth was carried out to guide in this classification exercise. Ground verification of doubtful features was marked on the base map. The traverse was planned in such a way that all the themes will be checked on the ground simultaneously. To evaluate the field survey it was conducted successfully and it has been found that this type of field survey can be done easily with the aid of satellite imagery and base maps.

heir description is based entirely on the information obtained from the physical aracteristics of the study area, these land use/land cover classes are: -

Built-up area or urban complex: this comprises of area of intense uses with much of the land covered by man-made structures such as settlements and road networks, included in this broad category are:

Residential lands (planned and unplanned, villages, compact Chester or dwelling units found outside the main urban built-up area. Commercial and storage lands (comprising market, retails, trade, shopping complexes cinema halls, petrol pump stations etc) institutional land, (including government, semi government, public and private sectors officers as well as other research organisation such as parks/garden/nursery areas etc, play grounds and stadium, places of worship/monuments, industrial estates, bricks, kilns and lime kiln, transportation/communications including express roads, Arterial roads, collector/distributor roads and hospitals, post offices, telephone exchange tank, banks etc).

The spatial resolutions of 1982 aerial photographs and 1994 SPOT imagery used do not give credence to individual classification. Thus, it is the considered opinion of the researcher that individual demarcation of these land user will not only be ambiguous but misleading, in view of the apparent differences that will be noted in both 1982 and 1994 situations. Beside the

1982 time frame is deemed too far to be related to any ground verification and area has undergone tremendous changes lately.

Non built-up or non-urban area.

These are lands without any urban function mentioned above. It is an area not under any intense uses and which are not covered by any man-made features. Included here are: water bodies, like rivers, streams cough (used or not used), reservoirs, ponds or wetlands.

Rock out-crop or barren land vacant lands, green belts, Agricultural lands, (cultivated lands and orchards) shrub land, forest lands, dumping ground/waste disposal sites, disused Brick kilns etc. see table 3.2 for the summary of land use/land cover classification system.

ABLE 3.2. LAND USE/LAND COVER CLASSIFICATION SYSTEM.

LAND USE/LAND COVER CATEGORIES		
/NO	A: **BUILT UP LAND OR URBAN COMPLEXES**	
	LEVEL 1	LEVEL II
.	Urban Complex Area	Planned Residential, Unplanned Residential, Commercial, Storage, industrial, Recreational, Villages, Institutional and services.
2.	Transportation	Road networks (express, Arterial, Distributor/collector, minor roads) and communications.
	B: NON-BUILT UP LAND OR NON-URBAN AREAS	
3	Non-built up land	Cultivated land, Fadamas, schrub land, Waste land, Gullied Eroded land, Degraded land, grassland, construction site etc.
4.	Water bodies	Streams, ponds, rivers, canals, etc
5.	Rock outcrop	Bare rocky and stony areas

3.5. ANALYSIS OF LAND USE AND LAND COVER DATA

Land use/land cover mapping can be carried out either by visual image analysis or digital image processing; both the combinations of both were adopted in this study. In visual analysis, minimum area recording unit (MARU) must be determined. MARU refers to the Minimum Aerial extent of land use and land cover type that can be manually delineated and coded on the recording base.

he idea of MARU is to avoid unnecessary waste of interpretation time as well as the duction of moist in the final output map (Adeniyi 1990) carto-graphically it is fficult to delineate and code any map area smaller that 2.5 mm on a side (Anderson at 1976) at a scale of 1:100,000 60kkes (1972) has suggested a MARU of 4mm. he scale of the final map should govern the minimum size to be interpreted (Bather 979) and minimum area should be disregarded for features which are linear.

Unlike the visual approach, which is applied to photographic products of all forms of emote sensing, digital approach is only applied to numerical image data, which are normally recorded on computer tapes. In the study of Odenyo and Pattery (1977) on he land use mapping by machine processing of land in the study of Virginia beach, they produce land use/land cover map with major categories of urban, agriculture, wooded, water, waterland and bareland, twenty four of these classes were specifically separated.

While it is recognized that computer-assisted classification methods could be used in land use and land cover studies visual interpretation methods requires both training and less expensive equipment's than methods using computer assisted techniques for developing countries limited by low budgets, man-power constraints and accessibility of computer technology.

6. DATA INTERPRETATION

he aerial photograph and SPOT imagery used were acquired from the Federal urvey Lagos and National Centre for Remote Sensing, Jos Plateau State spectively. The use of relevant collateral materials such as photo-map, topographic ap, cadastral map, land use plan etc and the guidance of an experienced interpreter s well as a reconnaissance survey before the commencement of the actual nterpretation all helped to a high degree of accuracy in the interpretation.

Materials and facilities used were from the National Centre for Remote Sensing, Jos. A total of four aerial photograph of 1982 of Abuja.

(Line fi – 19/58-59 and line fi – 11/35 – 36) at scale 1:40,000 were interpreted using minor stereoscope with 15 x magnification transparent acetate overlays were place over each photograph interpreted on which the land use and land cover boundaries were delineated, this operation was conducted on a high table.

The satellite imagery (SPOT HRV) was interpreted visually by transparent acetate on the interpreted study area. Visually interpretation procedure was employed first, because there has been a tendency for an over selling of the computer technology, to some extent it can lead to disappointment among the local expertise officials and clients. Visual interpretation of remotely sensed data is a realistic in assessing natural resources, land use plan and environmental change. One great advantage of the visual interpretation method is that the same equipment used for conventional

terpretation of aerial photographs and mapping can also be used for satellite nages, therefore competent staff with a good knowledge of the local conditions ould produce the best result. Visual interpretation make use of low-cost materials nd the technology used for interpretation purposes offer peculiar advantages for nventories in developing countries of the world computer based studies often rely on oreign equipment. There is also the uncertainty of obtaining acceptable and leliverable products from digital analysis.

Both the 1982 and 1994 interpreted scene was scanned by windows 98 computer package and subjected to the geographic information system (GIS) of database design (conceptual design, logical design and physical design) database creation (spatial and non spatial) through the process of master template creation manuscript, preparation coverage editions, appending of map-sheets thematic features etc. To generate the various thematic maps and calculate the respective areas as km2, percentages, and km which was tabulated and discussed in chapter four.

3.6.1. CRITERIA FOR INTERPRETATION AERIAL PHOTOGRAPH

The detection stage naturally leads on to the recognition and identification stage in which image interpreter has to exercise general, local as well as specific levels of reference to allocate objects into known categories. The general level is the interpreter's general knowledge of the phenomenon and the procedures to be

terpreted. The local level is the interpreter's intimacy with his own local vironment and specific level is the interpreters deep understanding of the process d the phenomenon he wants to interpret.

erial photographic interpretations formally defined as "the art of examining hotographic image for the purpose of identifying objects and judging their gnificance (Cowell 1960). During the process of interpretation aerial photographic nterpreters usually undertook at least some of the seven task of Detection, ecognition, and identification analysis and deduction classification, idealization and ccuracy determination.

Detection involves selectively picking out objects that are directly visible for example, rock faces or areas of wet soils on the aerial photographs recognition and identification involved trying to detect the spatial order of the objects or areas.

Deduction is rather more complex and involves the principles of convergence of evidence to predict the occurrence of certain relationship on the aerial photographs.

Classification comes in to arrange the objects and elements identified into an overlay system before the photographic interpretation is idealized using lines which are draw to summarize the spatial distributions of objects or areas. The final stage is accuracy determination where random points are visited in the field to confirm or refute the interpretation.

cognition and identification of objects or areas is the most important links in the ain of events (Walker; 1964); Stanley, 1982) An interpreter uses seven aracteristics of the aerial photograph to help with this stage these are: Tone, xture, pattern, place, shape shadow and size.

one: Tone is the single most important characteristics of the aerial photographs. It presents a record of radiation that has been reflected from the earth surface onto hotographic film light tones represent areas with a low radiance and dark tones epresents areas with a low radiance. The nature of the materials on the earth surface ffects the amount of light reflected.

Texture: this is the frequency of tonal changes within an aerial photograph that arises when a number of features are viewed together, this is dependent upon the scale of the photographs.

Pattern: pattern is the spatial arrangement of the objects.

Place: is a statement of an object positions in relation to others in its vicinity and thus is usually an aid in its identification. For instance, streams may not be seen but its likely location may be along a line if trees give a due to its course.

Shape: it is a quantitative statement of the general form configuration or outline of an object. It is easier to determine the shape of an object it if is viewed stereoscopically.

Shadow: the shadows of an object aid in their identification. It gives valuable lines to shape and sizes of objects. It is very useful in object classification and recognition.

ze: The size of an object is a function of photo scale, the size of objects can be timated by comparing them with objects for which the size is known.

rtunately, there are very few areas of the world for which aerial photographic terpretation has to be undertaken only on the basic of their seven image haracteristic as the interpreters will usually visit the field area and use collateral aterials. For example, in developed countries the aerial photographic interpreter ill have access to at least topographic geological, soil and land use maps and in eveloping countries topographic maps and reports are sometimes available (Esters nd Simoneth 1975)

3.7. MINIMUM MAPPING UNIT.

A decision on the minimum mapping unit was taken before the commencement of the interpretation for clarity. It was put at any $2mm^2$. This unit defines the minimum of any land use/land cover depending on the scale of the photographs, the spatial characteristics of the objects, the desired data handling techniques and the relevance of the research. Therefore, land use and land cover covering an area less than the stated dimensions were classified with the surrounding dominant use.

3.8 DATABASE DESIGN

The design of the GIS database will include three major elements (NCCIA, 1990)

Conceptual Design: basically laying down the major application system requirement and specifying the utilization of the database. Some of the king issues that merit consideration for the conceptual design are: specifying the ultimate use of the GIS database, level or details of GIS database, special elements of GIS database, non-spatial elements of GIS database, sources of spatial and non-spatial data, age of data, spatial data domain, element, impact of study area extent, spatial registration framework, non-spatial data domain. The conceptual design is independent of hardware and software.

b. **Logical Design:** which is the specification of the database vis – a – vis a particular GIS package. This design sets out the logical structure of the database elements determined by the GIS package. Some of the key issues involved are Coordinate system for database, the spatial tile design, Defining attribute data dictionary, and spatial data normalization and tolerance definitions.

c. **Physical Design:** which pertains to the hardware and software characteristics and requires consideration of file structure, memory and disk space and speed. Other issues addressed here are loads of database, access and peed requirements, file and data organization in GIS etc.

ch stage is inter-related to the next stage of the design and impacts the organization a major way. For example, if the concepts are clearly defined, the logical design is sier done and if the logical design is clear the physical design is also easy.

g. 3.1. Shows a framework of the design elements and their relationship.

ifferent types of GIS package are available and the GIS database organization epends on the GIS package that is to be utilized. Apart from the basic functionality f the GIS package, some of the crucial aspects that impact the GIS database rganization are as follows: Data structure of the GIS package, attribute data anagement, title concept of spatial data handling.

3.9. DATABASE CREATION

The procedure for the spatial database creation is described below:

a. **Master Template Creation:** a master template is created as a reference layer and consisting of the district boundary, rivers, roads etc. The template is then used for the component theme digitalization.

b. **Thematic Map Manuscript Preparation**: Based on the spatial domain, the different theme oriented information is transferred from the base map to a Myles/transparent sheet, spatial data manuscript are Myles consisting features that are to be digitized. These manuscripts are prepared on a sheet – by – sheet

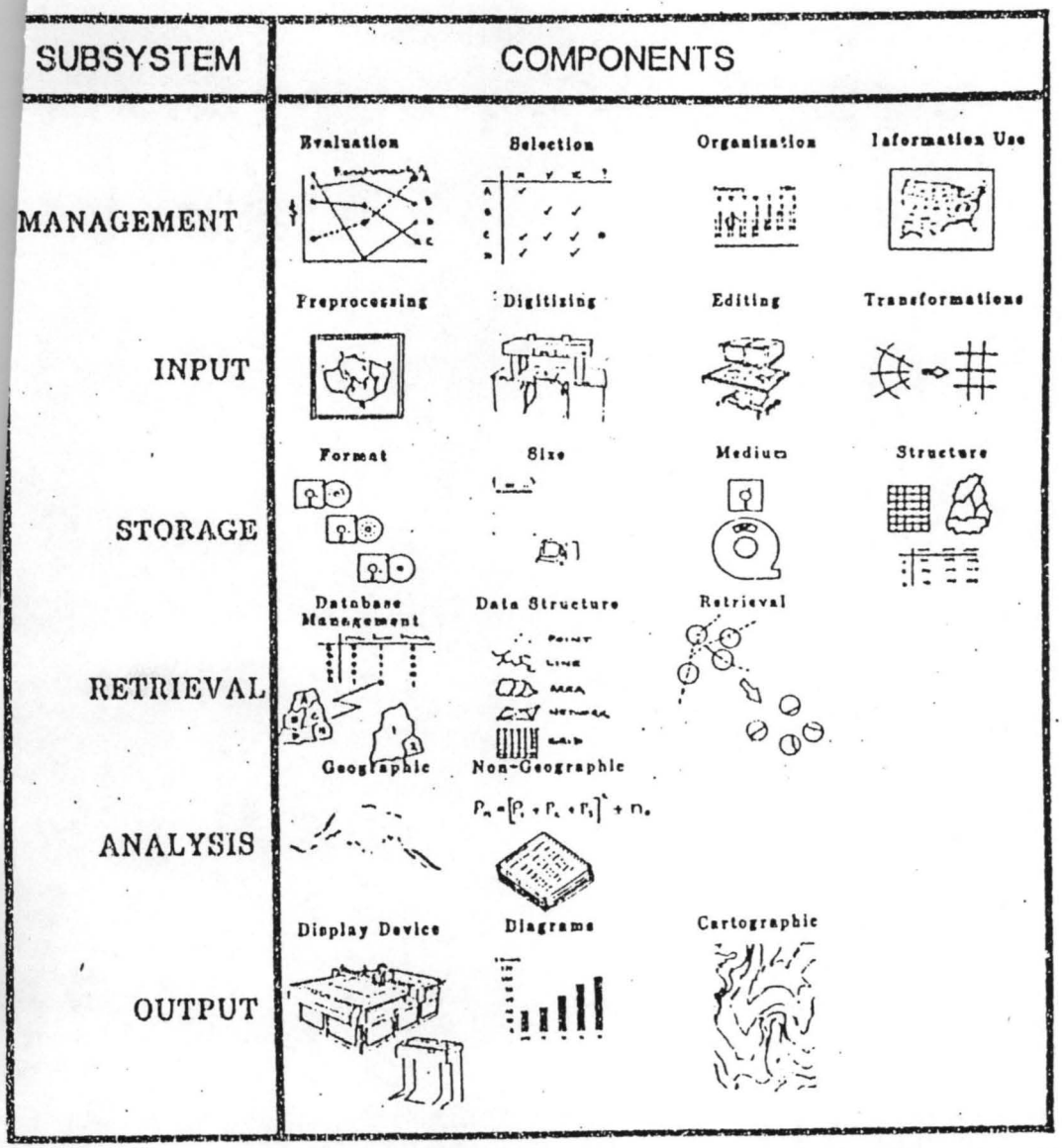


FIGURE 3 : COMPONENTS OF A GIS [4]

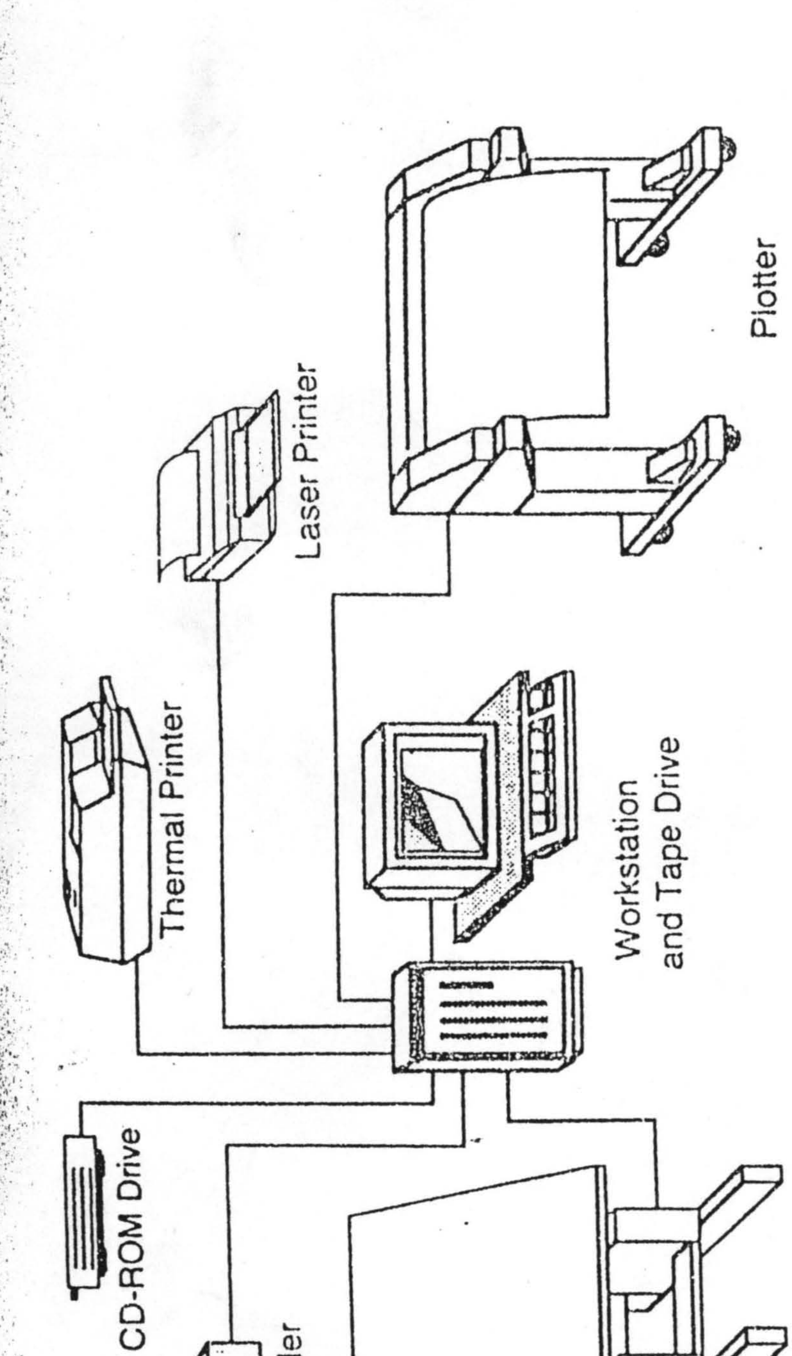


FIGURE 4 : A SIMPLE GIS SYSTEM

FIGURE 4.1 DESIGN STAGES AND THEIR RELATIONSHIP

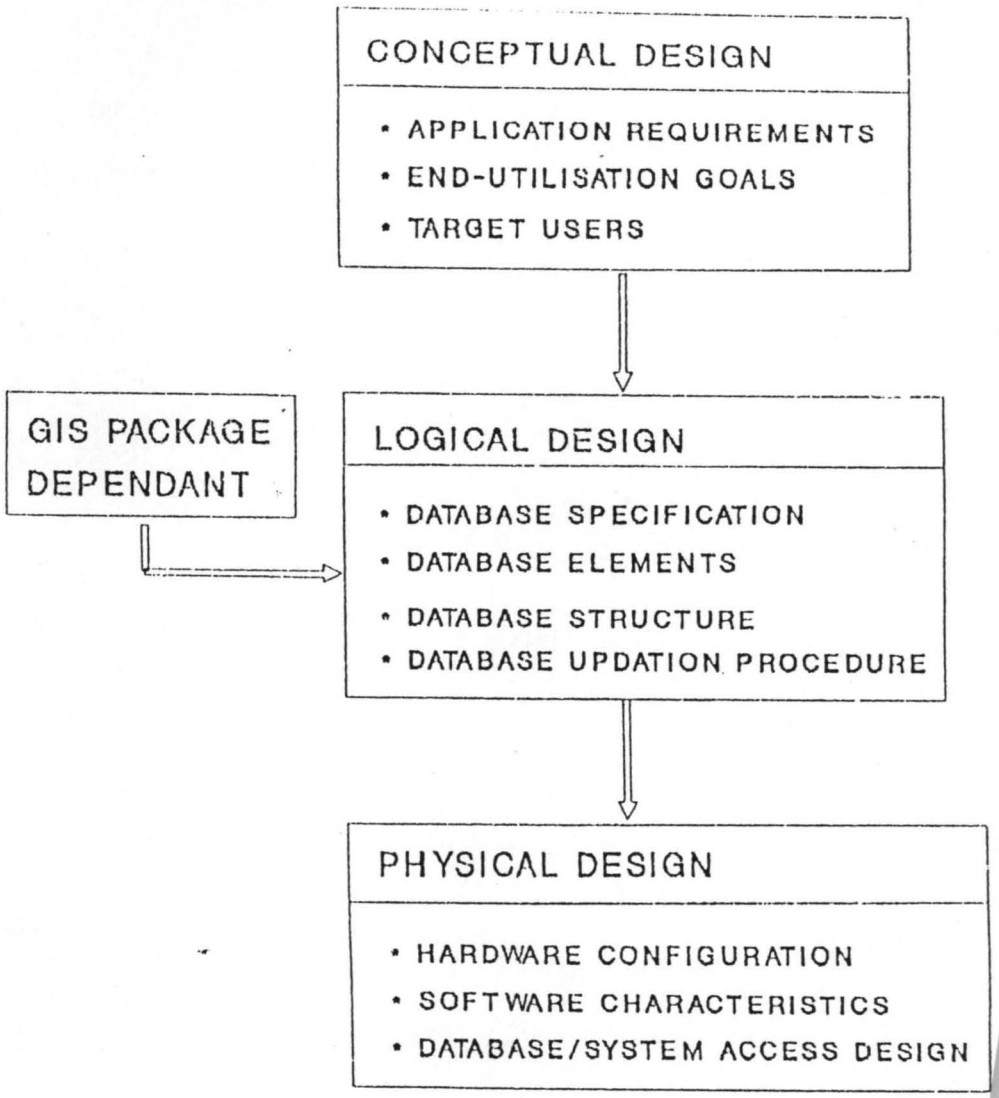
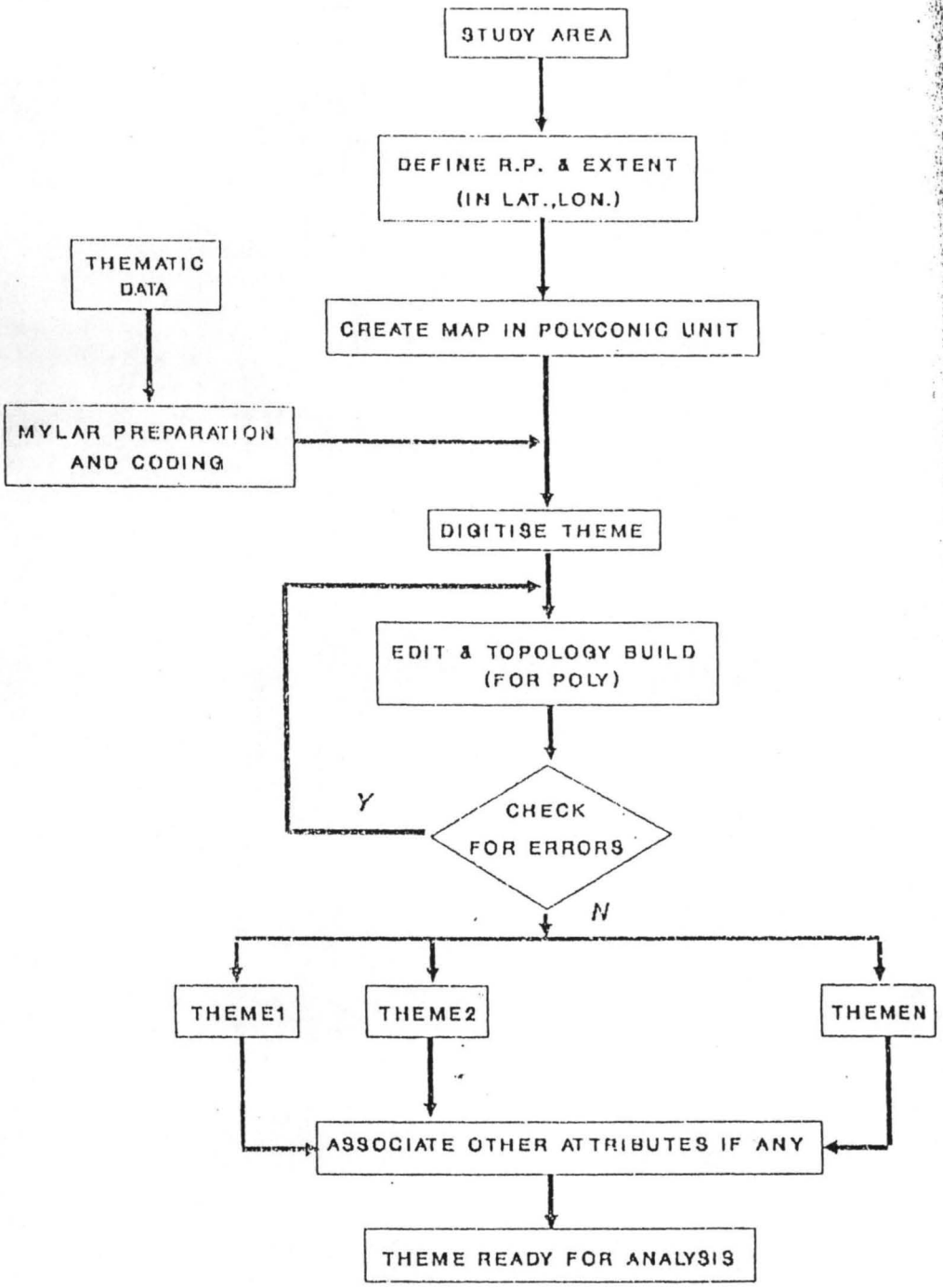


FIGURE4-5: PROCEDURE FOR SPATIAL DATABSE CREATION



basic for digitization. These manuscripts consists "instructions" for digitization or scanning which include:

- Registration points location
- Features codes as per the dictionary defined
- Features boundary
- Tolerance specification
- Any other digitization/scanning instructions

c. **Digitization of Features:** The theme features of the spatial database are then digitized scanned using the GIS package. The digitization is done for each map- sheet of the spatial reference. The master registration point reference is used for the digitization. The theme digitization is done as components into a copy of the master template layer.

d. **Coverage Editing:** the digitized coverage is processed for digitization errors such as dangles, constituting the overshoot or undershoots, and labels for polygons. This constitutes obtaining a report of these errors and then manual editing of these features. Finally the coverage is processed for topology creation. As in the case digitization, the editing is done on a map sheet basic. In the case of raster GIS packages, the topology construction may not be relevant. However a chumping process to identify the chump rasters having similar characteristics is essential and is provided for.

e. **Appending Of Map-Sheets Thematic Features:** the next step in the procedure is the appending or mossaicking of the different map sheets into a single theme map for the whole extent, and the area is estimated. The trammels of registration points are used for this purpose.

f. **Attribute Coding Verification:** the attribute codes for the different categories need to be then verifies and additional attributes – features – name description etc are added into the feature database.

It is only after this procedure that the theme coverage is ready for analysis presented in chapter four. Fig. 5 shows the procedure for spatial database creation.

3.10. AERIAL ESTIMATION AND ANALYSIS

Following the accomplishment of the operations under section 3, (database design and creation) performed by the modules in ILWIS 2.2 GIS computer system, the computer automatically estimate the:

- land use and land cover situation for 1982

  land use and land cover situation for 1994

  land use and land cover changes pattern for 1981 and 1994 (absolute and percentage change)

- percentage distribution of land use and land cover changes with estimated annual changes rates (Decrease/increase)
- Estimated areas of existing built-up areas and open lands areas for 1982 and 1994.
- Percentage change for each class and estimates of the rate of change.
- The3 lengths of raid (express, Arterial and minor roads) in kilometers.
- Proximity analysis for the different kinds of roads fir the two time epoch (1982 and 1994)

The results were shown and discussed in chapter four. The final cartographic map preparation and reproduction were pre-designed specifications and cartographic symbolizations, this was also attached.

3.11. PROCEDURES FOR DEVIATION ASSESSMENT

The process of analysis for the objectives commenced with critical evaluations of the Federal Capital City Abuja land use plan. This allowed a critical appreciation of the content of the land use – plan, the concept of the land use plan was digitized and adjusted for reduction for necessary comparison. However, it was discovered that the conceptual plan is not congruent the affixed scale hence it was not possible to ascertained the scale of this map.

Subsequently, the satellite imagery was converted to line map through visual interpretation with the aid of simple instrument as hand lens and mirror stereoscopes. Sequel to the acquisition of this data the researcher restricted the ground thruthing to roads and major land marks with other relevant land uses.

The layout plan i.e conformation plan produced by S.F. consultants was obtained from the development control unit of the FCDA this was photo reduced and converted to scale 1:25,000 to allow comparison with other plan.

The next step was to identify areas of recent implementation in the plan judging from the time of satellite data covering the conceptual plan and the information plan were compared visually without over – laying due to marked variations that is visually without overlaying due to marked variations that is visually discernable. The parameters of comparison are: Circulation, major land uses and cover design.

Consequently, the information plan and the satellite scene were compared by manual overlay of one on the other, or to determine the types and magnitude of deviations was intuitively ascertained. It is worthy that the ground truthing revealed that some of the deviations come as a result of natural and man-made obstacles, which were not considered properly at the construction stage of the plan.

CHAPTER FOUR

4.0. DATA ANALYSIS AND DISCUSS

Information of land use types, growth, changes as well as deviations from the original land use – plan is fundamental to land use planning as they helps in formulating policies and programmes for urban development.

For easy understanding, this chapter has been divided into three segments as follows.

i. Analysis of the static land use and land cover pattern for 1982 and 1994.

ii. Analysis of the changes in the land use and land cover between 1982 and 1994.

iii. Analyses of the deviation in the land use plan of phase I Development area of Abuja Capital City.

4.1. STATIC LAND USE AND LAND COVER ANALYSIS

As stated earlier, an attempt was made to device a suitable land use and land cover system for used with remote sensor database on the objective of this study. A minimum level of accuracy of about 90% or better has been attained in the nterpretation for the several categories in the classification system. To satisfy the irst objectives of the study i.e. to map out the various land use types in Abuja FCT sing remote sensing data for 1982 and 1994. Fine land use and land cover classes as generated for the entire city Phase I development area, they are;-

i. *The built up areas or urban complexes:* meaning areas of intensive use, with much of the land covered by man-made structure such as planned and unplanned residential areas, villages, commercial and storage, recreational, cultural and religion land uses, industrial communication utilities and service land uses.

ii. *Road Network or transportation land user.* The vast areas of land allocated to it and it right of way made me to divorce it, little from the built up land. The roads were classified as follows express ways, arterial roads, collector and distributor road as well as minor roads.

iii. *The non-built up land:* Basically it is an area not under any intense uses which are not covered by man-made structures included here are: vacant land, waste land, green built in urban complexes, Agricultural land, dumping grounds, waste disposal site disused brick, kilos etc.

iv. *The water bodies:* This delineate land cover under natural drainage system like rivers, streams as well as linear drainage system like canals, and natural or man-made structures like reservoir or ponds or generally, areas who for significant part of most year the water table is above at the surface or below the land surface.

v. *The rock out crop:* it include bare exposed rock or land limited by its ability to support life and in which lass than one third of the area has vegetation.

4.1. STATIC LAND USE AND LAND COVER ANALYSIS

TABLE 4.1. LAND USE/LAND COVER SITUATIONS IN 1982

Land use/land cover Classes	**Aerial extent In hectares**	**Percentage**
Built-up Area/urban land	422.03	5.80
Road Network	992.41	13.65
Non-built up Area	5151.54	70.83
Rock out crop	690.57	9.49
Water bodies	16.41	0.24
TOTAL	7272.98	100

SOURCE: Author's Laboratory Analysis.

As shown in table 4.1. Above, non-built up land dominated the study area as at 1982 with 5151.54 hectares (20.83%) followed by road networks with 992.41 hectares (13.65%) the next is rock outcrop 690.57 hectares (9.49%) while built up land or urban areas covers 422.03 hectares (5.80%) and the least, water bodies, cover 16.41 hectares or (0.24%) of the total study area as at 1982.

The built up structures are scattered all over the study area but with construction in the Wuse and Garki axis, this is depicted as fig. 4.1. Abuja as at this period is still at its formative stage, physical development commitment tossed in Lagos. Generally, the population of the entire territory is low too, only 138241 (projected estimate from the 1963 census) the sparse population is culminated with low economic activities and the available roads are minor and rudimentary constructed to open-up land in increase and speedy physical development.

Summarily, the non-built up lands (rock outcrop and water bodies inclusive recounted for 5859.52 hectares (80.55%) of the entire city in the 1982 time period leaving just 1414.46 hectares (19.49%) to the built – up land and road network.

The situation in 1994 is not the same. There has been a tremendous lateral expansion of the built – up land or urban centres at the expense of the non-built-up land. Has shown in table 4.2, the built –up land covers a total of 2441.81 hectares (33.57%) this time widely spread around the Wuse district, Maitama, Garki and Asokoro district. The resolution of the SPOT image use does not permits specific differentiation of residential, commercial, or industrial classes of land use because of this they were jointly regarded as built-up land. Apparently, due to the increase in the built up land, the road network that serves as the connecting links increased appreciably to about 748.69 hectares (24.04%).

The non-built-up land that covers 3065.57 hectares (42.75%) dominated the three-arm zone, which was originally designed as a low-density residential and institutional structure with adequate provision for green area within the layout.

The rock out crop mostly harbored in Maitama district accounted for 3.3 hectares (0.045%) and water bodies occupied 13.48 hectares (0.19%) as presented in table 4.2 and fig. 4.2. on how these hectares and percentages were obtained, please refer to section 3.8 to 3.11.

Table 4.2. Land use and land cover situation in 1994

Land use/land cover Classes	**Aerial extent In hectares**	**Percentage**
Built-up land	2441.81	33.57
Road Network	1748.69	24.04
Non-built up land	3065.57	42.15
Rock out crop	3.3	0.045
Water bodies	13.48	0.19
TOTAL	7272.98	100

OURCE: Author's Laboratory Analysis

4.2. ANALYSIS OF LAND USE/LAND COVER CHANGES (1982-1994)

The land use change from the period between 1982 and 1994 time period is shown in table 4.3. from the analysis, it can be readily seen that two land use classes (built-up land and road network recorded an increase while three land uses (non-built up land, water bodies and rock out crop) recorded a decrease.

The built-up land recorded the highest rate of increase i.e. 422.-05 hectares in 1982 to 2441.81 hectares in 1994 in order words, 2019.76 hectares of land were urbanized between the 12 years period. Thus representing an increase of 36.8% over the period. Statistics to justify this marked increase are not available in the relevant authorities or agencies. But this can be attributed to population explosion that are rising from the relocation of the seat of government to Abuja which invariably culminated in the various milestone construction targets in 1984, 1986 and 1988 as enunciated in the land use plan as well as the physical planning for the city each year.

The non built-up land in the study area recorded the highest rate of reduction as it falls from 5151.54 hectares in 1982 to 3062.57 hectares in 1994. This is because most of the gains in term of land hectarage recorded by the urban or built-up land as well as all categories of road network is at the expensed of the non-built-up land, in essence, every unit of land converted to urban structures or transportation routes in the study area and during the period under study leads to a proportionate reduction in the extent of the non-built-up land. *Takuma 2000 (a)*

TABLE 4.2. LAND USE AND LAND COVER CHANGES 1982 - 1994

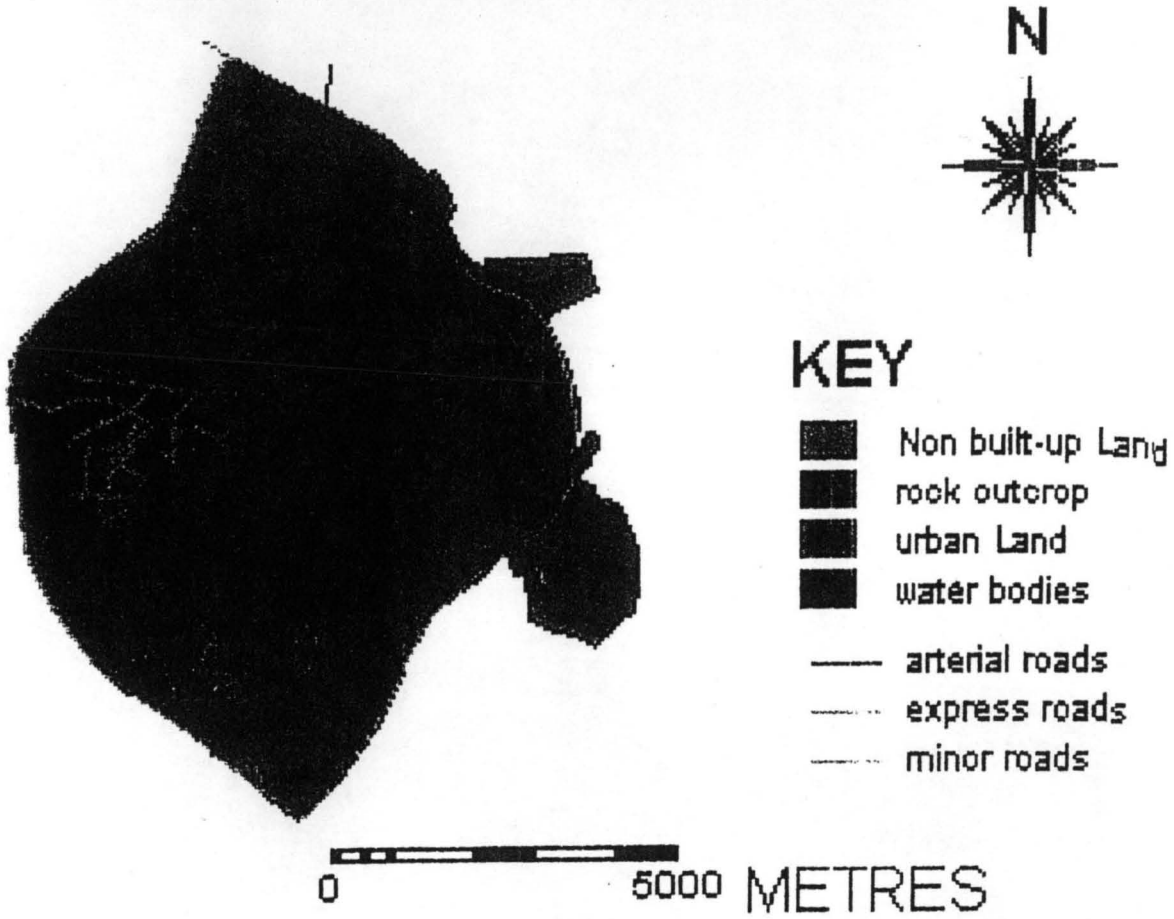
Land use/land cover classes	A 1982 (Ha)	B 1994 (Ha)	Magnitute of Change B-A=x	Percentage of change
Built-up land	422.05	2441.81	2019.76	36.38
Road Network	992.41	1748.69	756.28	13.62
Non-built up land	5151.54	3065.57	-2075.97	37.57
Rock out crop	690.57	3.3	-687.27	12.38
Water bodies	16.4	13.48	-2.92	0.05
TOTAL	7272.98	7272.98		

SOURCE: Author's Laboratory Analysis

The proportion of the rock out crop in the study area also reduce between the period, what used to be 690.57 hectares in 1982 changes to 3.3 hectares in 1994. This is a direct reflection of the quarrying activities that have taken place along side with construction of buildings and roads in light of does land classes which are hitherto water bodies or wet lands are reclaim for building and road construction or having here channel redirected, thus leading to a significant reduction in its area span from 6.4 hectares in 1982 to 13.48 hectares in 1994.

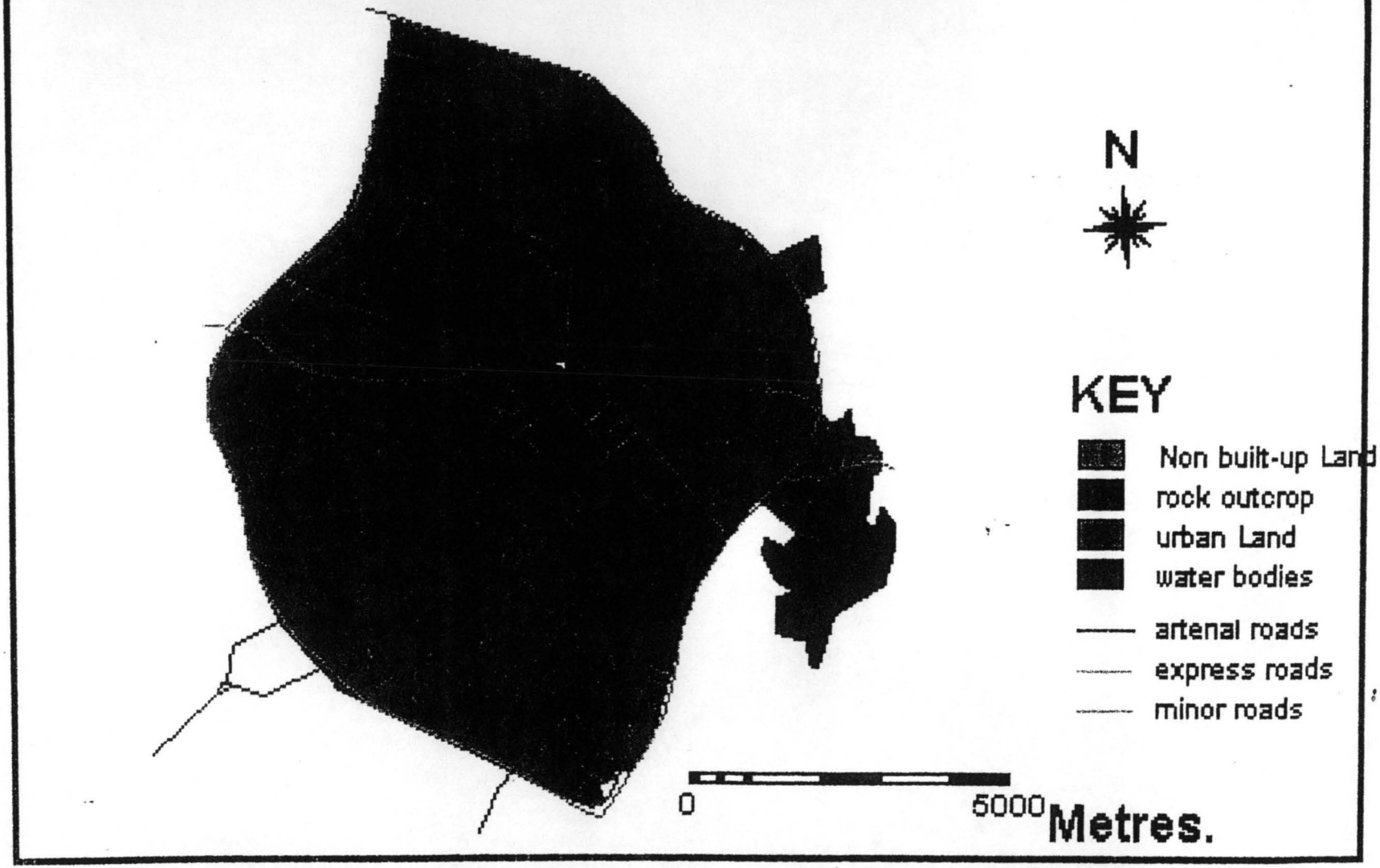
During the period under study, the road network area extend increase drastically with over 756.52 hectares over what it used to be in 1982. This of course made it to

Fig. 4.1 Landuse/Landcover Map of Abuja, 1982.



Source: Laboratary Analysis of 1982 Aerial Photograph

FIG.4.2 LANDUSE/LANDCOVER MAP OF ABUJA 1994



LABORATORY ANALYSIS OF 1994 SPOT IMAGE

change from minor and rudimentary to a wide and dual carriage all seasoned express and arterial roads. Talking about increase in length (km) the categories of road as classified (express, arterial, and minor) increase from 73.69 km in 1982 to 157.01 km in 1994 and increment of about 113% as presented in table 4.4.

Since Abuja is the new capital city of the country, it is only reasonable to expect that once the transportation lines are provided, the interaction with other regions will automatically flow. These indeed seems to be what is happening now, as many private interest are participating in the provision of the mobile facilities needed to properly link the area with other regions. The accessibility of the city to the region especially in terms of the cost involve is slow.

TABLE 4.4 ANALYSIS OF CHANGES IN ROAD NETWORK

Categories of road	**Length in km 1982**	**Percentage 1982**	**Length in km 1994**	**Percentage 1994**
Express roads	11.32	15.64	65.16	41.40
Arterial roads	26.88	36.48	82.99	52.86
Minor roads	35.29	47.39	8.86	5.43
TOTAL	73.69	100	157.01	100

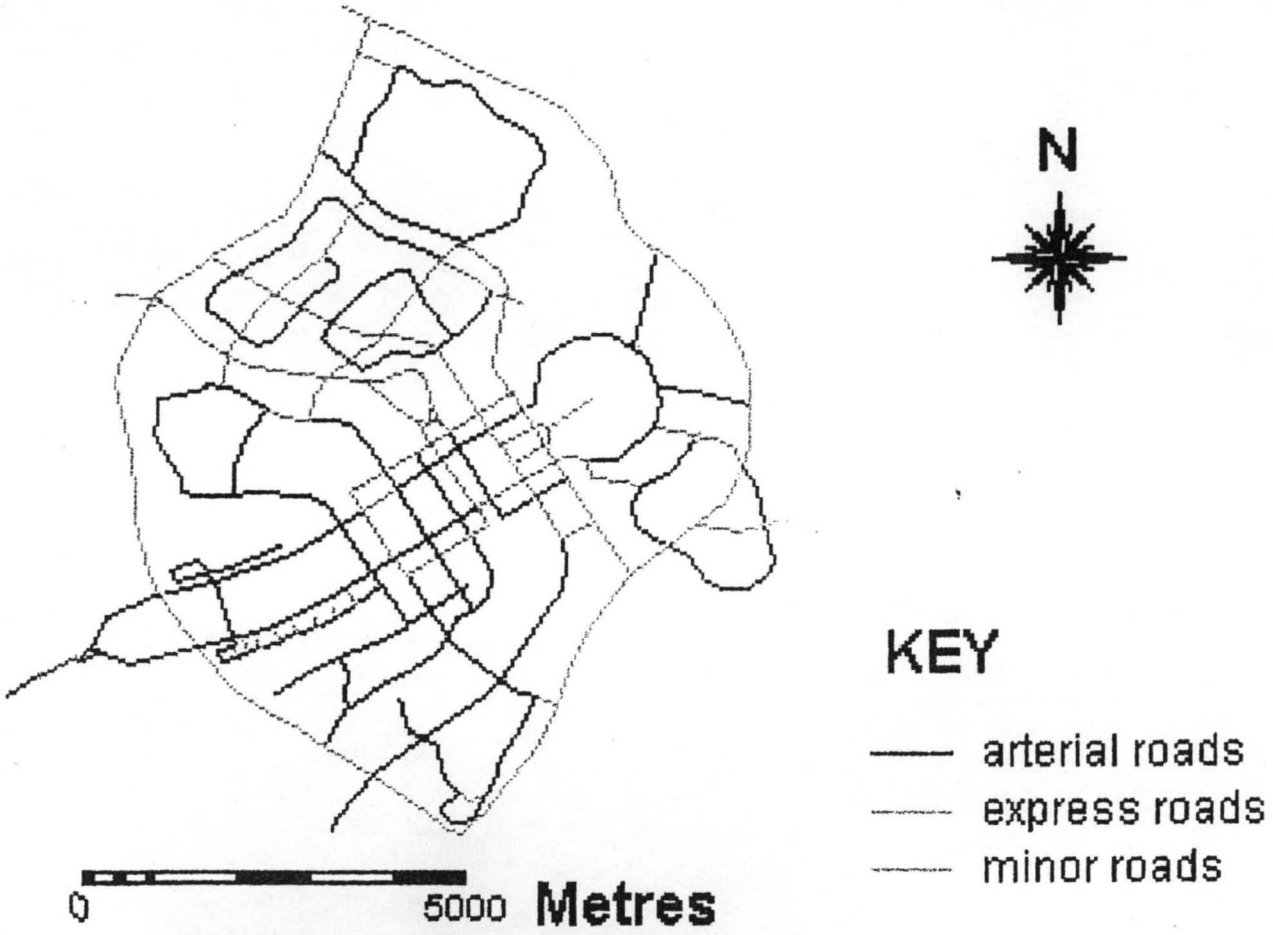
SOURCE: Author's Laboratory Analysis

Whether or not Abuja will develop into a "problem city" such as Lagos will depend on how effective the transportation system will be. There is no doubt that the

Fig. 4.3 Road Network of Abuja, 1982.

Source: Laboratory Analysis of 1982 Aerial Photograph

Fig. 4.4 Road Network of Abuja, 1994.

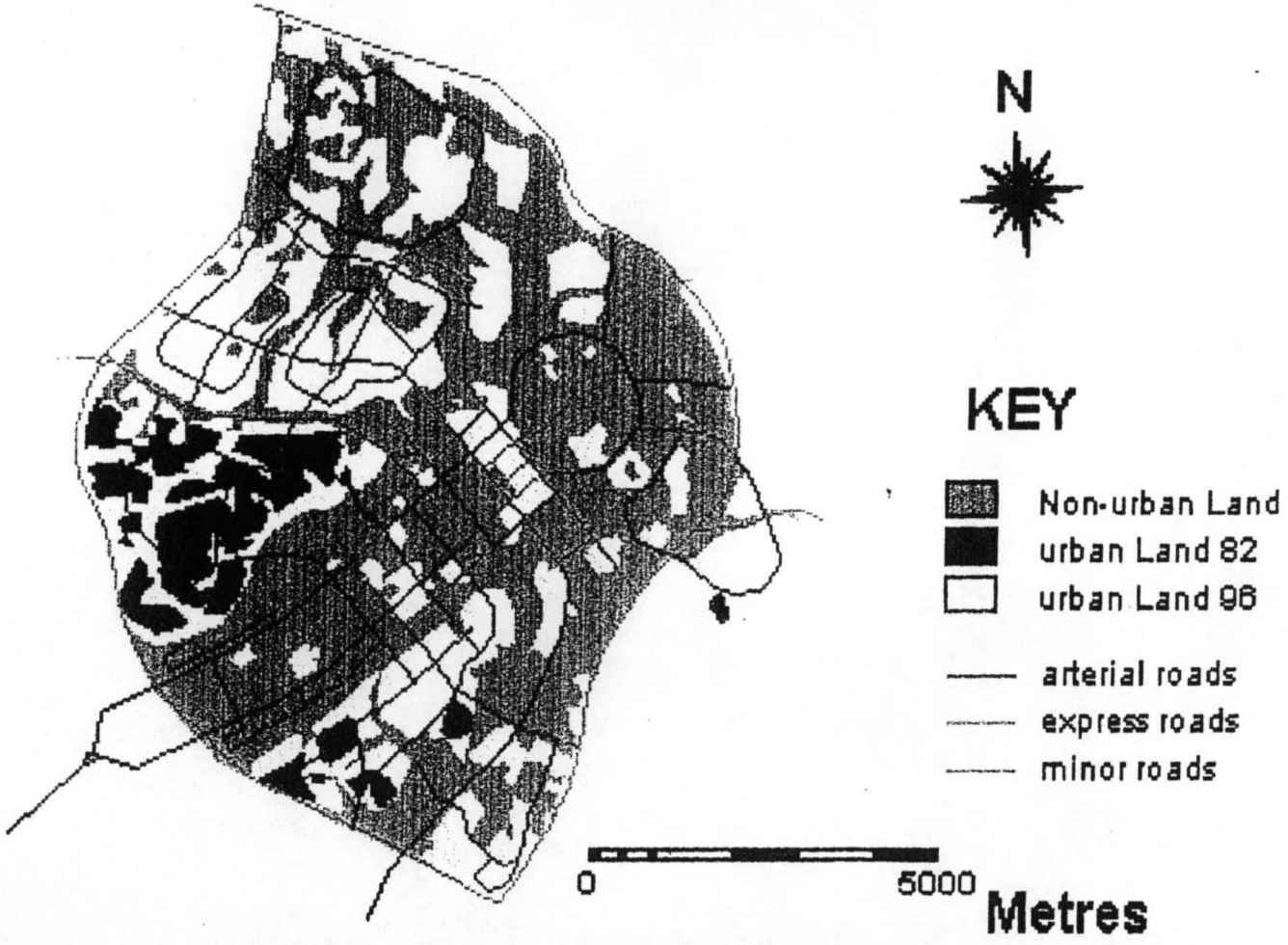


Source: Laboratory Analysis of 1994 SPOT IMAGE.

provision of an effective immobile transportation infrastructures has been planned for and its been executed steadily. Nevertheless, their seems to be an emerging crisis in the provision and used of the mobile transport facilities not only is the city, its fast developing a tradition which emphasizes private car used, but also the public transportation system both in the city and between the region is hardly satisfactory.

From the foregoing analysis, it has been shown clearly that there is a resounding increase in the nature, pattern and extent of physical development as regard road network and built-up land in Abuja city phase I. In the light of the planning implication of this, the land use plan for the administrative capital of Nigeria may not have envisaged this growth. It is upon these note that the Ministry of the Federal capital territory through the assistance of the federal government have initiated relevant policies and trends in terms of socio-economic development of the town in particular and the federal capital territory in general. Such policies that were carried out through the effort of the Federal Capital Development Authority (FCDA) were mainly the provision of reasonable infrastructures and basic amenities to meet the needs of the resident. However, population is not only inhabiting factors in socio-economic development, but also a potential obstacle to the achievement of the set goals in the development plan.

FIG. 4.5 LANDUSE/LANDCOVER CHANGE MAP OF ABUJA



Source: Laboratory Analysis of 1982 Aerial Photograph & 1994 SPOT IMAGE.

4.3. COMPARISON OF INFORMATION PLAN WITH THE SATELLITE SCENE

The satellite scene was obtained by October 1994, phase I of the land use plan was in advance state of implementation while the phase II has began in Ernest. Some of the roads were still un-tarred as at this period but the reflectance properties of the graded roads allow the roads to be specifically discerned. The scale of the plan also allows the observation and enumeration of buildings. The buildings in each neighbourhood were counted visually (subject to human errors) the total number of these buildings were estimated in the ground truth exercise and the results presented here.

For easy estimates, the deviation was categorized into three types namely: -

i. Duration by displacement:- this refers to all deviations in the implementation that were not positional accurate, compound with what was proposed in the information plan.

ii. Deviation by substitution and omission:- this refers to all deviations that were originally in the information plan (proposal) but were not detected by the satellite. This types of deviation ranges from land uses that are yet to be implemented to those that have been dropped from implementation, and to those that are too difficult to be detected by the visual interpretation of the SPOT satellite scene.

FIG 4.6 THE SATELLITE SCENE OF ABUJA (FCC) AS AT OCT. 1994.

Arm with these three methods of categorization, the researcher proceeded to assess the implementation of the land use circulation and the civil design.

4.3.1. **DEVIATION BY OMISSION**

a. *Circulation*

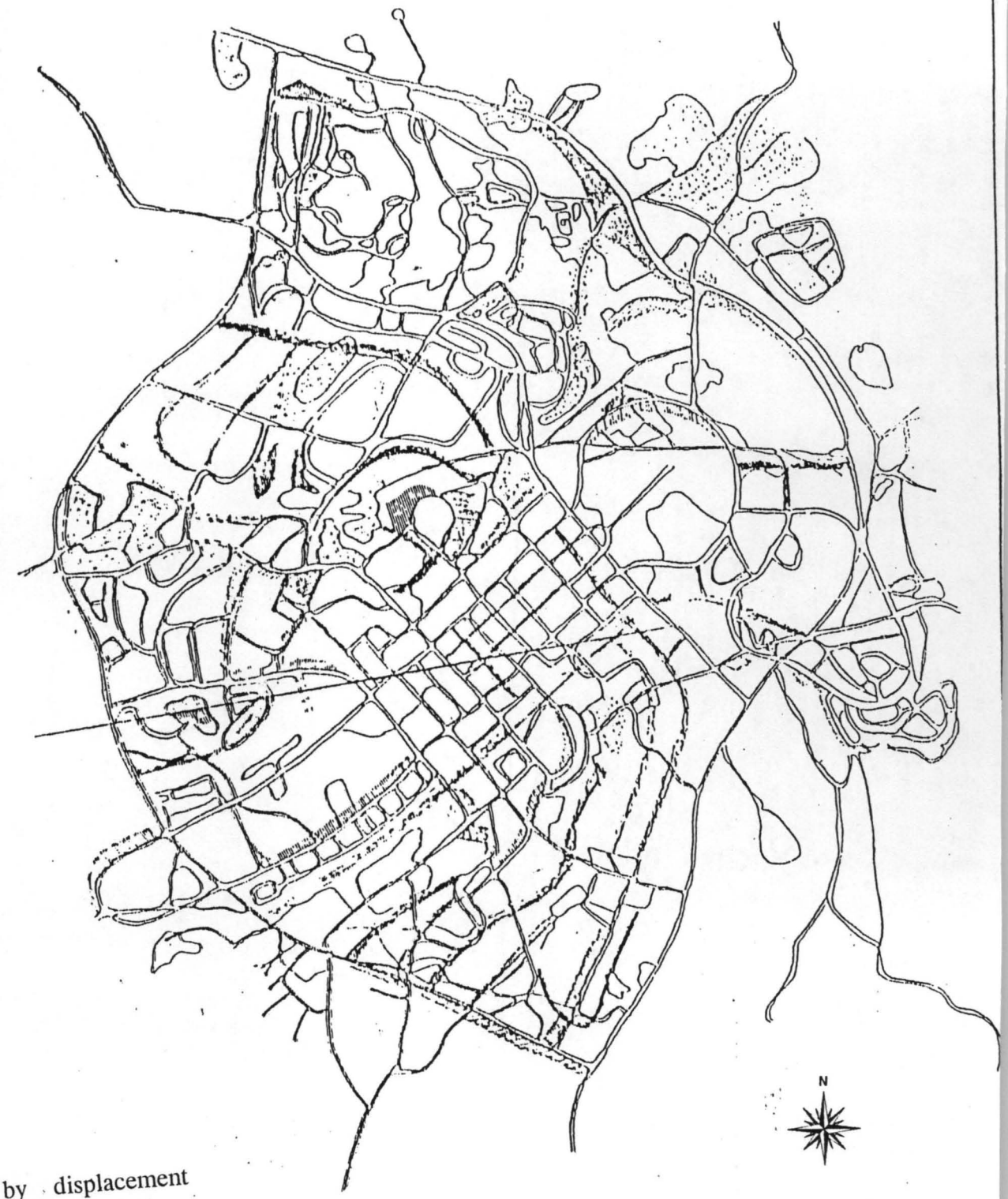
About 40% of the circulation network falls in this category, the two linear express way both the linear southern and the linear northern express way were yet to be implemented the evidence from literature all reflected that as at 1995 these two roads are yet to be constructed.

The transit ways are use not yet implemented. These are outer northern transit ways on the left side of the northern express way the inner southern transit way on the right side of the inner southern express way.

The parkways are also involved in this categorization. The outer roads are not left out in this category. The roads omitted can be found in the ministries zone, cultural zone, Wuse district, Garki district and Maitama district, some arterial roads are also left unimplemented such as arterial 314, arterial 41, arterial N11, arterial N14 civil designs.

Son a general analysis, the beauty of the federal capital city is nothing compared with the proposed aesthetic comfort of the plan, this gross deviation in the circulation was in inevitably affected the overall internal organization of the city hence it is pattern

FIG 4.7 EXISTING CONDITION OF FEDERAL CAPITAL CITY ABUJA (DEVIATION MAP).



from a visual comparison of fig. 4.6 (the information plan) and fig. 4.7 (the satellite scene) the difference in the general pattern is easily discernable. It is estimated that aesthetically about 30% of the aesthetic component of the city were dropped from implementation or yet to be implemented. The buffer zones along the arterial right roads, transit roads and express ways were not yet implemented fully.

b. Land use/land cover

This types of assessment was a little difficult due to the following reasons:-

i. Most of the land uses that were not implemented have been reflected by other land uses, thus they cannot be categorized as deviation by omission.

ii. Some land covers are not detectable from the space due to limited capabilities of the sensors on board in terms of ground resolution.

iii. Some authors categorized circulation as part of land uses hence the omission identified above can also are regarded as deviation in land implementation.

4.3.2. DEVIATION BY SUBSTITUTION

These categories of deviation are very ubiquitous outside the ring road when new layout of residential plots can be detected in fig. 4.7. It can be found in the left side of the outer northern express way and the southern part of the city close to the Nnamdi

Azikiwe road (ring road) the residential layout in this section is completely re-arranged contrary to the original layout proposal. This set up can also be found as pocket of deviation in various parts of the city.

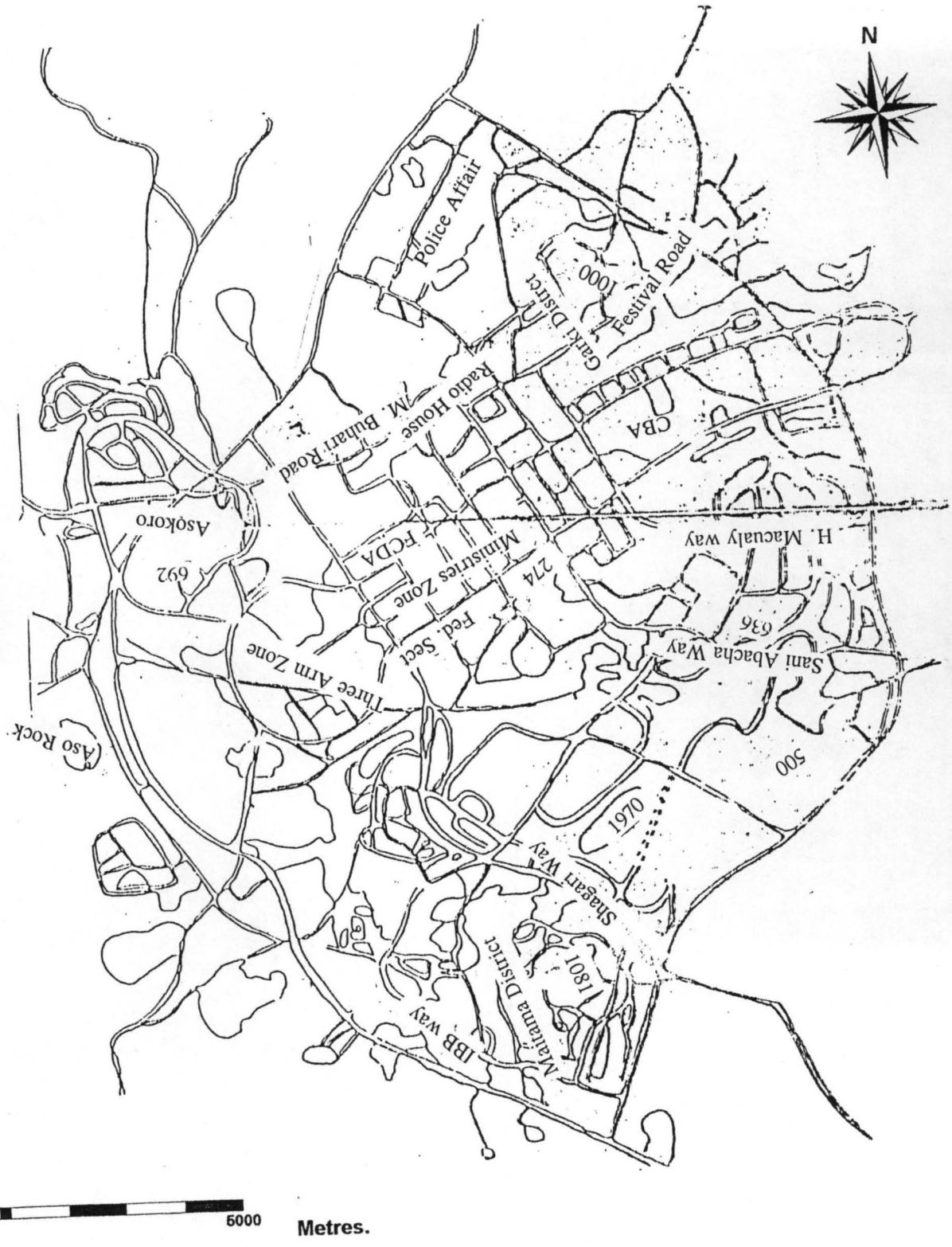
Deviation by substitution are the lowest in the overall deviation discernable from the satellite scene in this category of deviation identified during the ground truth, this type of deviation about 15% of the total phase I development area of Abuja site.

4.3.2. DEVIATION BY DISPLACEMENT.

This type of displacement is discernable for about 35% as shown in fig. 4.7, the three arm zones, the ministries zones, the National Art Theatre zone, the northern outer expressway, the central arterial loop among others shows certain degree of deviation by displacement.

The displacement ranges from little extension to complete displacement from the original position. It is likely that the displacement is a resultant effect of some natural features that must be taken into consideration during the specific site planning and engineering design. It is note worthy that this deviation by displacement affected the technicality of the city in a major way especially the cityscape was changed from what is on the plan. The place occupied by the National Art Theater is far smaller that the proposed space while the locations of some projects were changed.

FIG 4.8 . ADJUSTED SATELLITE SCENCE FROM GROUND TRUTH OF FCC ABUJA.



SOURCE: Laboratory analysis of 1994 spot image of Abuja.

4.4. CAUSES OF DEVIATION

The major causes of deviation in the land use plan are noted below:-

i. Natural and Man-made features. It was noted that some of these features were not properly referenced during the conceptional plan preparation. The layout plan was based on the survey work where the actual positions of the features were shown.

ii. Cost construction: the engineering design for road networks was contracted out. The contractors place more emphases on cost implication of the road construction, therefore the cause of road changes.

iii. Political decision and influences: Abuja being the capital city of the nation has been subjected to various changes of leadership both at the national and Federal Capital Development Authority (FCDA) levels.

iv. Inadequate equipment and data to monitor the levels of deviation and to test the likely future consequence of deviations. This encourages contradictions of private land uses.

v. Inactivity of the development control unit officials in educating the consultants on the need to strictly follow the land use plan and proposals during detailed engineering designs.

vi. Logistic problems, which range from lack of vehicles to adequate competent staff to properly monitor the growth development through out the Federal Capital City.

CHAPTER FIVE

5.0.0 SUMMARY RECOMMENDATION AND CONCLUSION

The main objectives of the study were to determine the rate of land use and land cover changes and location with a view of providing maps, statistic and reports for land use planning purposes. To compare the pattern of land use dynamics with the Abuja master plan so as to identify deviations in land use.

5.1.0. SUMMARY OF MAJOR FINDINGS

From the analysis, one can see that there has been a significant reduction in the area of non-built up land between 1982 and 1994. Such a major reduction was also experiences in area covered by rock out crop as well as water bodies. However, areas under built-up or urban land and road network increased greatly during the period under study from the studies conducted in the area, the rapid increase in the population of Abuja, arising from the relocation of the Federal Capital in 1982 as well as the construction targets of the government in 1984, 1986 and 1988 with various degrees of success to meet the accommodation and offices structures needs of the resident may have been strongly responsible for this lateral expansion in the physical development of Abuja between 1982 and 1994.

Beside, during the period under study, the length of roads within the study area increased and because of that increment the proximity analysis of Abuja in 1994 indicate better connectivity between the existing roads and residential apartment than what was obtainable in 1982, the implication is that greater area are accessible with ease in 1994 than in 1982.

The analysis further shows that, the areas covered by water bodies decrease during the period under study, these reduction could be ascribed to climatic variations and physical construction, whereby a naturally active channels have been rendered in active. This reduction potent a prove implication because there is a reduction in the rate of albedo on the rivers.

This is possibly linked to the fact that the rate of reduction in water body is not commensurate with the rate at which river replenish itself. Most importantly, anthropogenic factors through construction activities, dumping of refuse and debris on the river channels or reclaiming wet lands for buildings and road construction, all these put together here reduced the level of water bodies in the area between 1982 and 1994.

On the objective (C) deviations identification, the study reveals massive deviation in the implementation of the Federal Capital City Abuja land use plan, these deviations were grouped into three i.e. deviation by displacement deviation by omission and deviation by substitution.

It was gathered from the study that deviation by omission covered the highest percentage, this can be attributed to the factors that implementation was still going on as at the time, that the SPOT image was obtained. However, it was identified that some roads were not implemented, such as arterial, transit spines and collector roads etc.

The second rank in deviation is the deviation by substitution, which is more in terms of specific land use that fall into this category, they cannot be identified from space due to the limited satellite sensors ground resolution.

The third in rank is the deviation by displacement, were land uses were observed to have been shifted a little or greatly from the original position earmarked for them in the proposal. This category of deviation was observed more on the road layout.

A visit to ALM consultant, the company involved in the design of the road revealed that the aerial photographs rather than the proposal served as the basis of their design. Reference was only made to land use plan to know original destination and transit zones. The possibilities of using satellite images to assess the level of implementation of land use plan were proven. It is thus possible to track the development on timely basis using this device. There is no strict guidance from the Federal capital Development Authority (FCDA) to ensure total compliance with the

original proposal. Therefore subsequent consultant resulted to easy way approach to design.

Political influence in the implementation was enormous and resulted in many deviations. The elastic nature of the land use plan also gave room for deviation. It is unfortunate that this weakness of the plan was over-played to the detriment of the over all functionality of the city and the beauty of the cityscape. The natural features and landscape obstacles were not properly considered in the layout design. The survey was either inaccurate or not competently interpreted before the initial proposal. The cause of the deviation has been noted under section 4.4.

5.0.2. **RECOMMENDATION**

The relationship between perceptions of land as physical resources and as an aspect of the physical environment is complex. This is because the agencies concerned with urban development were distinct from those charged with the responsibilities for conservation. Nevertheless, it should be noted that there is need for space to be used economically, the land is a natural resource, which will be depleted if not used properly. There is therefore an urgent need for an effective control of future development, which can prove positive for nature reserves.

Since pressure on land may lead to irreversible trend in the environment the increase in population and consequent increase in pressure on land, however, the in advent and immediate counter measures if the drive towards sustainable environmental development is to be accelerated.

Furthermore, while short term decisions may be satisfactorily made by subjective means, in the long term, it would appear necessary to have complex models where evaluation of the land use policies can be fully tested, for this continued data collection and research into the relationship between land use and environment is an urgent need. If the impending environmental problem is to be averted, the use of satellite data provide the perspective viewing of various regional problem and the repetitive courage for forecasting seasonal changes, both are renewable natural resources and when planning major public work projects.

In view of the facts revealed in the summary there is the need to employ a multi-disciplinary approach to land use plan preparation right from the on set. This will guide against extensive deviation. Nigerians being peculiar in the history of contraventions should be encouraged that land use plan be made rigid rather than been flexible. The implementing agency (ies) may not be able to properly present the idea of the planner involved in the sophisticated approach of monitoring, the development should be adopted to our cities. Siting satellite-receiving station will help in these directions. It is time for Nigeria to computerize her development

control system so as to properly tract the development as well as provides a laboratory atmosphere for the consequence of deviations computerizing plan monitoring will ensure compliance and make development control very cheap to undertake by the government.

This approach can be done in three categories; it is recommended that the country involved herself in the space experiment. As temporary measure these proposal for introducing satellite data to urban and rural administration should be introduced, and this is group into three basic categories thus: -

i. *Satellite Tricking Station*

The effectiveness of satellite remote sensing in producing real time, up-to-date-data of the earth resources render into the earth related discipline. SPOT has southern receiving station all over the world where the information can be down linked from the satellite over pass within the radius of 4000km to the station.

Uptill-date there is no receiving station close to Nigeria infact there are only two stations in Africa. The installation of ground receiving station is thus recommended. This station can be installed in Federal Capital City Abuja with the hope that a complete coverage of the country, being 32,000km^2, can be obtained. The ground receiving station will also geo-reference the data and

other image deformation can be corrected before the information is transmitted.

ii. *The information dissemination station,*

This station can be separated or combined with the above, it will be charged with the responsibility of processing the digital image and convert the data to the specific mode before disseminating the data to the corresponding agency (ies). It is expected that all the Parastatals that deals with the land and natural resources will have representatives in the station in order to adopt the processing of data for their specific uses. The information obtained can be transmitted to land survey, Federal Ministries of works and Housing, Urban Development Boards, State Town Planning Authorities, Ministry of transport and Aviation, Media Department etc.

Each Ministry and Parastatal is expected to have microcomputers installed in their offices, loaded with appropriate softwares for project specific analysis of the cities in their jurisdiction.

iv. *Development control units.*

In Nigeria, states have ministries of town planning which are saddled with the responsibilities of monitoring and controlling development within their

jurisdiction among others, in a few states a specific board of Urban development is charged with the responsibilities of town planning.

It is recommended that computer hardware's be installed in the states ministry of town planning or urban development boards where the computer compatible tapes (CCT) source from the national information dissemination centre can proceed into mosaic form for onward transfer to each local planning units.

Two levels of control will be effected on development with the use of this approach. The first tier of controls will be at the state level, where the land use planning will take place for the individual local planning authorities. Each development control unit in both state and local will receive satellite data from the information dissemination station or state ministry of town planning as the case may be either inform of computer compatible or hard copy image maps.

Other recommendations include: provision of grants and funds by the government to research institute for carrying out research into the application of remote sensing technology to the Nigeria environment, concerted effort should also be made to strengthened the National Centre For Remote Sensing (NCRS) Jos in terms of equipment's to be able to handle remote sensing class interpretation approaches.

Government should be entirely involved in the Development of Information System which give support to land Management by providing information about the land resource in it and the improvement made in it.

Raising public awareness about the risk of environmental degradation and strict enforcement and adherence to environmental edict will be a right step in the right direction.

There should be regular seminar and workshops to deal with the various application of remote sensing technology to environmental studies in our day-to-day life.

There should be co-operation between the National Center for Remote sensing and other advance foreign Remote Sensing Agencies such as European Space Agency (ESA) Earth Observation Satellite, American Society of Photogrametry and Remote Sensing and others. This is to enhance adequate and uninterrupted flow of knowledge.

Associations like the Nigeria Society of Remote Sensing should harness the available Remote Sensing opportunities and capabilities in the Nigeria environment for the benefit of the country.

The Federal and State Government Scholarship should be made available to the students of Remote Sensing Applications as a way of incentives and motivations to indigenes of less privilege resources. It is obvious that remote

sensing is cost intensive in nature but the economic and scientific gains in the long run supercede the initial cost. Hence, government must be responsive to this clarion call.

It is also recommended that this type of study and research be carried out periodically for every other states capital major urban centre in Nigeria. In order to accelerate or and further planning, development and growth of the various cities as well as their levels of compliance to the respective comprehensive land use plan.

5.2.0. CONCLUSION

From the various findings of this study, the evaluation of land use and land cover changes as well as land use plan implementation and monitoring, in urban and rural areas is considered as a very important and serious issue for monitoring and controlling o f development which otherwise would be haphazard.

It is pertinent to note that remote sensing which has been under – utilized over the years especially in areas of urban/rural planning studies would tremendously benefit urban/rural planners, managers and of course other municipal officials. Remote sensing technology has a number of peculiar advantages as a tool of monitoring the environment. The study of environmental structure by remote sensing technology cannot be over emphasis in a situation where a large structure or phenomenon as in

the research needed be assessed. Studied and managed periodically with the advantage of speed convenience and cost at heart, satellite remote sensing provides the best alternative in the present dispensation of technological advancement.

From the research, it is now more obvious that the tool of remote sensing has been justified especially for this fact that millimetric or recurrent one metric position accuracy are not required considering the theme of the study if the point accuracy of SPOT satellite is of interest to some environmental scientific and engineers the present 10m spatial resolution is very much adequate for most environmental mapping and management considering the synoptic coverage and this altitude of the satellite platform. The only exception in the above claim or assertion is the case of topographic mapping operations with contour interpretation of Sony 2-5m or 5-9m or as the case may be.

None the less for other application we do not need to kill mosquito with a sledgehammer. However, a research on digital elevation modeling (DEM) by SPOT data is a good avenue of testing the viability of satellite remote sensing in topographic surveying and mapping.

The study has also succeeded in examining the tremendous capability of satellite data in monitoring the process of development of the Federal Capital City Abuja. The degree of deviation was assessed and proposals for ameliorating the problem of deviations were proposed. Effort was made to propound a proposal of reform in the

prevailing approach to development control. The integration of satellite remote sensing into urban management in Nigeria was successfully addressed. It is hoped that further research on the introduction of image processing and cartographic information system into Nigeria urban planning and management system will take a leap from the result of this study.

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