CHANGE DETECTION ANALYSIS ON THE PHYSICAL DEVELOPMENT OF ABUJA (F. C. C.) USING REMOTELY SENSED DATA.

BY

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MARCH, 2000

CERTIFICATION.

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DEDICATION

This work is dedicated to the Glory of God almighty the fountain of knowledge and unto my dearly beloved Sister JANET B. MATTHEW, without whose blessings and continuous support this would not have been possible.

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"In this dynamic situation accurate meaningful current data on landuse are essential if public agencies and private organisations are to know what is happening and to make sound plans for their own future action then reliable information is critical."

The varieties of landuse and land cover data needed is exceedingly broad, current landuse and landcover data are needed for equalization of tax assessments, in many states of the Federation. Landuse and landcover data are also needed by federal, state and local agencies for water resources inventory, flood control, water supply planning and waste water treatment.

Many federal agencies need current comprehensive inventories of existing activities on public lands, combined with the existing and changing uses of adjacent private lands to improved the management of public lands. Federal agencies also need landuse data to assess the environmental impact resulting from the development of energy resources, to manage wildlife resources and minimize man-wildlife ecosystem conflicts to make national summaries of landuse patterns and changes for national policy formulation and to prepare environmental quality.

Remote sensing information is of great help for planners to prepare for either natural or man-induce hazard in both rural and urban land areas and as an efficient methods of discovering the physical development trends of a region. However an essential pre-requisite for any development effort is the appraisal of the existing landuse and how the situation has been changing over time (Adeniyi 1986). To know how a particular parcel of land come to have its present use demand at a minimum a longitudinal profile of changes in use

Some activities of man however, cannot be directly related to the type of landcover, one concept that has much advantage is that: Landuse refers to "Man's activities, which are directly related to the land" (Clawson and Stewart 1965).

According to Adeniyi (1990), landuse represents the imprints of people, activities on and in relation to the land. It is to a large extent an abstraction which according to Cambell (1987) is not always directly observable by even the closest inspection. It is largely for this reason that the term landcover is often used together with landuse even when the objective of the mapping concerns the later.

Land cover on the other hand, "described the vegetation and artificial constructions covering the land surface (Burley 1961). These are all directly visible from the remotely sensed imagery. Three general classes of data are included in the landcover:

- Physical structures built by human beings:
- Biotic phenomena such as natural vegetation, agricultural crops and animal life:
- Any type of development, (Townshend 1981) it includes all the features present on the surface of the earth. For instance, urban buildings, road networks, lakes, trees, and so on.

1.2 Statement of Problem:

Developing countries are faced with too little practical research, too few scientist and insufficient funds for technological development (IPTRID 1991).

This work therefore is set to tackle the questions what was the landuse/landcover of Abuja Federal Capital City (In terms of physical development) before and how have these been changing over time? How have these changes affected the urban system and the physical environment?

1.3 Aim of the Study:

The broad aim of this study is to investigate the possibility of employing bi-temporal remote sensing approach in monitoring changes in the physical development of Abuja Federal Capital City of Nigeria.

1.4 Objectives of the Study:

The specific objectives to achieve this aim include:

(i) To determine the rate of landuse/landcover changes in Abuja between 1982 and 1996.

(ii) To analyze network and accessibility pattern for the two time epoch (1982 and 1996).

(iii) To assess the effect of the landuse and landcover changes on the physical environment and the urban area.

(iv) To use the results, obtained to propose possible amendment(s) to the pattern of urban development.

1.5 Scope of the Study.

The main scope of the study lies in generating a strong information base and future management plan. The survey tries to find out the results by integrating various techniques and methods mainly related to image 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 cannot be overemphasized.

The knowledge of spatial distribution of the physical development in an area is of great importance to regional planners and administrators. The lack of basic resource information has been identified as one of the problems hindering development process in Nigeria (FAO 1966, Mabogunje 1978, Areola 1982)

A pre–requisite to monitoring change in over all use of land or developing plan for improved landuse is the knowledge of the current pattern, there fore, a modern nation as a modern business must have adequate knowledge and information on many complex interrelated aspect of it's activities in order to make decisions (Anderson et al 1976). In Nigeria it is an undeniable fact that for good decisions on landuse/landcover to be made, adequate information about it is paramount. It is believed that this study will help in guiding not only the state government but also the federal government in making far reaching decisions on landuse in the Country. For although remote sensing is not a panacea for resources development and management problems. It can provide the basic tools for sound resource inventory, monitoring and management (Bale el al 1974).

1.7 Justification of the study:

As postulated by Adeniyi (1972). The economic status of any nation is always a direct formulation of the use it make of the available natural resources and poor decisions regarding resources allocation and use can lead to decline in resource quantity, quality and economic productivity. This statement is true, especially as it applies to land as a natural resource. The knowledge of the current landuse pattern is a pre-requisite to monitoring changes in the over all use of land or developing plans for improved landuse, therefore the administrator and the planner must have comprehensive and current information if they are to have any hope of promoting orderly use of land.

Furthermore, since a particular landuse generally have 'unnatural' expression in the landscape, landuse is especially susceptible to study by remote sensing techniques (Nunnally 1974). In different situations the study of man-environment interaction as a cultural theme of geography received it's unity through landuse investigation (Lintz and Simoneth 1976). Physical development inventories provides basic data for the development of landuse plans and remote sensing technology provides a vehicle for the rapid collection of current detailed physical development inventories for a varieties of planning and management purposes.

1.8 Limitation to the Study:

Lintz and Simonett (1976) Summaries the problems of landuse studies in remote sensing as three fold in nature.

(i) Problems of mapping landuse triats
(ii) Problem of classification and categorization.
(iii) Problem of classifying landuse from various types of remote sensor imagery.

Most common problem associated with interpretation of landuse from remote sensing imagery and other sources are as follows.

(i) To reconcile incompatible and inconsistent terminologies and,

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

Thus an agreement was reached to the effect that there were not only a wide diversities and discrepancies among landuse and landcover classification but

also a great number of different types of landuse classes and definition each fitted or created to suit every possible seasonality and geographically distributed landuse types.

To this end, the researcher succinctly, submit to the opinion of Nunnally and Witner (OP cit), that it is not practicable to create landuse classification system which can be applied to all the various types and scales of remote sensor imagery, in fact Clawson (1966) recommended that, a single or pure line concept should be used in a single classification scheme and an inductive approach must be adopted. This implies that the use of smallest recognizable parcel of land for interpretation in as much detail as possible so that the use can be grouped into categories most appropriate to the needs of the researchers and planners.

It is also important to note that reliable identification of cultural features, such as roads and building, that are usually shown on topographical map at any scale require a ground resolution of 2 – 3 meters per line – pain (m/p). It thus become clear that a great many cultural features cannot be obtained from present – day electro – optical sensors including SPOT (Krishna 1990). Another limitation is the existence of time lag between the data s (1982 and 1996) and the period of ground trukting. This time lag is not too wide to obscure any meaningful comparison. Above all the study is limited to the study area – Abuja Federal Capital City.

1.9 Rationale For The Use Of Remote Sensing:

Remote sensing has been variously defined by authors these definitions differs with authors background. However the most comprehensive definition was drawn by Short (1982). According to him "Remote Sensing is the acquisition of data and derivative information about an objects or materials (targets) , located on the earth surface or in its atmospheres by using sensors mounted on a platform, located at a distance from the target to make measurement usually (Multispectral) of interaction. Between the targets and electromagnetic radiations" from the above it is noted that the analysis of data and derivative information obtained through remote sensing activities determine the useability of the information and the art of deriving information about the earth's land and water areas from images acquired at a distance. It relies upon measurement of features of interest.

The derivation of geographic information through the use of remote sensing devices contribute immensely to the advancement of the understanding of physical development changes and their impact on the environment.

Geographic information system (GIS), according to Chorley (1987) "is the system for capturing, storing, checking, integrating, manipulating and analyzing data which are spatially referenced to the earth. This is normally considered to involved spatially referenced computer data base and appropriate application software" in essence GIS is a computer software package for management and analysis, display, storage of earth phenomenon. This spatial information covers a large range which include the distribution of national resources (Soil, water vegetation), the location of infrastructures (Roads, buildings, utilities, political, administrative and ownership boundaries)"

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, he further noted is to detect changes occurring in the environment. The temporal resolution of remote sensors, especially the space borne one's, will permit them to perform this activity better than any systems. Satellite data is a major input into any natural resource information system. It provides the perspective for viewing the regional problems and the repetitive coverage for forecasting seasonal changes.

Traditionally, physical development change detection monitoring and 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 risks and hazards involved.

One of the modern most powerful techniques for resource investigation is remote sensing. Its overriding merits are that it provides a permanent synoptic, spatial and temporal records of an environment (Adeniyi 1988). Thus the possibility of obtaining synoptic, spatial and temporal information by remote sensing techniques permits rapid in – house assessment of resources with reduced fieldwork and highly veritable and more consistent results. Even changes occurring in a region can be monitored by comparing sequential coverage.

It is not the aim of this research however to compare the traditional methods of landuse and landcover mapping with the modern method, but rather to exploit the characteristics of the modern methods as a way of complimenting the information derivable from the traditional method of mapping landuse and landcover information for change detection and resource management.

1.10.0 THE STUDY AREA:

1.10.1 <u>The Making of a Capital.</u>

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 in 1914,. With time the increased tempo of economic activities and the influx of people into Lagos were not matched with corresponding increase in the level of infrastructural 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 Lugard, who himself had recommended Kaduna to the British Government upon the amalgamation, because of its central location invigorating climate and its accessibility by rail to the East, West the far North and the middle belt. This recommendation shows, however that Lugard did not understand the economic interest underlying Imperial expansion. He had based his 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 announced a seven man committee headed 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 sq km landmass carved out from the former Kwara State (part of which is now Kogi), Plateau State (part of which is now Nasarawa) and Niger state was marked out 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 in 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.

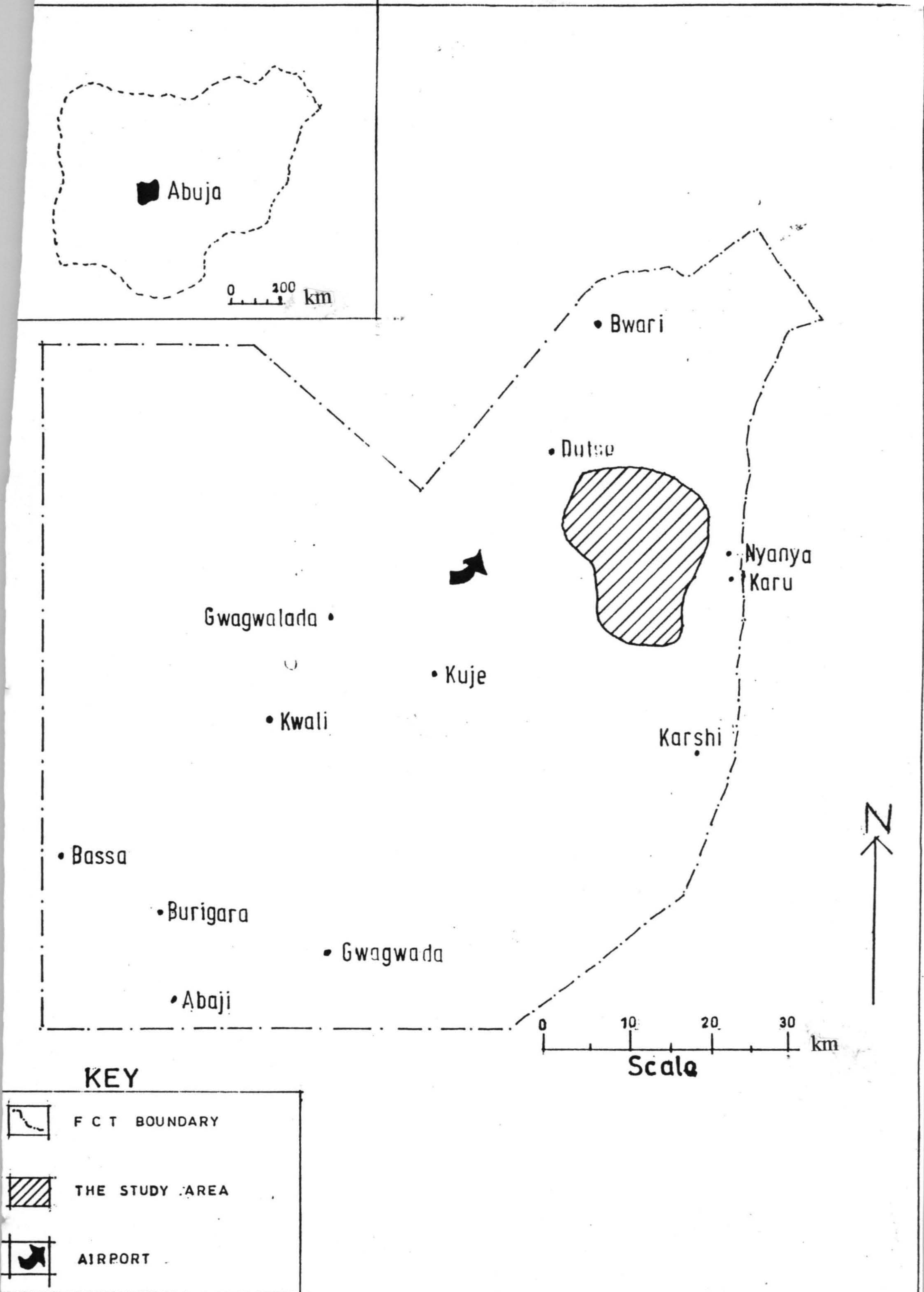
In his broadcast of February 3, 1976, proclaiming Abuja as the new Federal Capital Territory, late General Murtala Mohammed said "The site recommended satisfied the panel criteria of centrality, good and tolerable climate, land availability and use, adequate water supply, low population density, physical planning convenience, Security and Multi-access possibility. The area is not within the control of any major ethnic groups in the county.

We believe that the new capital created on such a virgin land will be for all Nigerians a symbol of their oneness and unity.

December 12, 1991, was a water shed in the history of Abuja, In that on this day the seat of government of the Federation finally moved to Abuja.

1.10.2 Location.

Abuja is located in the Guinea Savanna region of the middle belt of Nigeria, between latitude 6° 45' and 9° 20' East of the green which meridian. It is bounded to the North by Kaduna State, Nasarawa State to the East and South – East, Kogi to the South West and Niger to the West. The total land mass is an area spanning 8,000 square kilometers, greater than twice the landmass of Lagos State (3,535 sq km). 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, or 3 percent of the total land area. The remaining 7, 744 square kilometers constitutes the city's regional components. The highest points in the F.C,.T located in Bwari has 750 metres above sea level. See fig 1.1.



Map of the study area

1.10.3 Climate

The temperature regime is warm to hot through out the year, even though there is a slightly cold period between November and February. The average sunshine is 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 temperature of as much as 17°C is recorded. The mean annual temperature is between 20°C, but the mean monthly values ranges between 21°C in the coldest month (December) and 31°C in the hotest months (April – May). This is greatly influence by the humidity condition in the air. Relative humidity falls in the afternoon to as low as 20% in the city site zone, this relative humidity coupled with the high afternoon temperature account 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 and 190 days in the South with an annual measurement of 1632ml. The predominant vegetation is Guinea Savannah with catchments of woods, Savannah rain forest e.t.c

There are two major air masses predominant in the Federal Capital Territory (F.C.T). These are the tropical maritime airmass and the tropical continental airmass. The former air which is warm and moist, emanates from the Atlantic ocean and moves inland . In a South – West to north – east direction. The other airmass has its origin from the Sahara desert, it is warm and dry blowing from the north – East to South – West direction. The later is a dust laden wind, which gives the site its characteristics climate. The dust laden particles, which reduces visibility to a few hundred metres during some seasons.

1.10.4: <u>Population Trend.</u>

The projected estimated (from the 1963 census) by Dioxides (Nigeria) limited (1983, P, 270) put the population of the entire territory at 124.678 people in 1977; and rising to about 132, 816 at the onset of physical development in 1980. This give an overall positive change of 6.5% over the 3 years period, about 2.2% per annum. Projections for those early permanent losses or gains of population through migration processes.

On the order hand data from the Department of planning research and statistics of the F.C.D.A. recognising the new element of migration in the demography of the F.C.T suggest that the overall population had risen to 492,2300 in 1980 then 516,900 in 1987 and 555,668 in 1988 (FCDA 1988b). These indicate an overall growth rate of 5.0% per annum between 1988 and 1987 and 7.5% between 1987 and 1988 (see table 1.1): 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 212,854 for the municipal area council. See table 1.1.

Table 1.1 Estimated Population of the F.C.T by LGA 1986 – 88.

LGA	Estimated Population			percentage changes	
	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.

1.10.5 Peoples and Culture.

Among the indigenous population of the Abuja Capital City, the GBAGYI constitutes a majority their main settlement include: Bwari, Karu, Durumi, Garki, Ketti, Kabusa, Maitama, Kukuaba, Mabushi, Jabi, Lugbe, Ido, Toge and Hulumi others are Pyakassa, Jikwoyi, Kurudu and Orozo. They are hospital 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, folklores, and arts and crafts.

Another set of the city's indigenous population was the GWANDARAS. They are commonly found in Nyanya, Karshi, Shrertti etc. Like the Gbagyis they are also peaceful and hospitable, the people are mainly farmers unlike the Gbagyis the Gwandaras women are more commercially oriented, but however shares the common character of strong willed, hard working and industrious. Another ethnic group in the city include the Koros which have a separate language but shares similar characteristics with their neighbors 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 Nigerians into the city, the result of which is a beautiful blend of the national 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.

CHAPTER TWO

2.0 LITERATURE REVIEW

The review of related literature will be carried out under the following sub-topics.

(i) Urban landuse theories.
(ii) Landuse and landcover studies
(iii) Landuse change
(iv) Specific application of remote sensing to landuse change detection studies
(v) Landuse/land cover classification
(vi) Data from remote sensing.
(vii) Analysis of landuse and landcover data
(viii) Conclusion.

2.1 Urban Landuse Theories.

Various factors help to explain the distribution of activities in the urban centers. The central business district (CBD) is taken as the center of urban settlements from which landuse varies. This concept helps in explaining the distribution of activities in the urban centers.

Generally two factors can be used to explain why there is a concentration of activities in the urban centers. These forces in operation is responsible for the internal structuring and re-structuring of the urban centers they are:

(i) The centrifugal forces otherwise called the push factors i.e forces that discourages the concentration of population and inward movement of people into the core of the town, examples are traffic congestion, delays, shortages of parking spaces, noise, environmental pollution and accidents. Other are, the decrease of land value from the CBD towards urban fringes high cost of rent and poor housing condition.

(ii) The centripetal forces otherwise call the pull factors i.e factors that encourages the inward movement and consequently the concentration of population activities in the core of urban centers. Examples are: Site attraction, accessibility, functional magnetism and linkage, locational prestige and human/ cultural attraction.

Three basic structure of intra-urban landuse pattern can be identified. These are: The concentric landuse theory, sectorial landuse landuse theory and the multi-nucleic landuse pattern.

2.1.1 Concentric Landuse Theory.

This landuse pattern was first identified by Burgess in 1933 after his study of Chicago. Burgess argued that activities taken place in the urban center are in a circular form all surrounding the central business district as shown in Fig 2.1.

The CBD is the core of the town. It is the center of socio-economic, political and recreational center of the city. It is the heart of the city that contains shop, offices, banks, theatres and hotels. If the urban center is large, there is the tendency for the CBD to be divided into several sub-centralizations.

It is very congested during the day and traffic during the peak hours but may be nearly deserted late in the night.

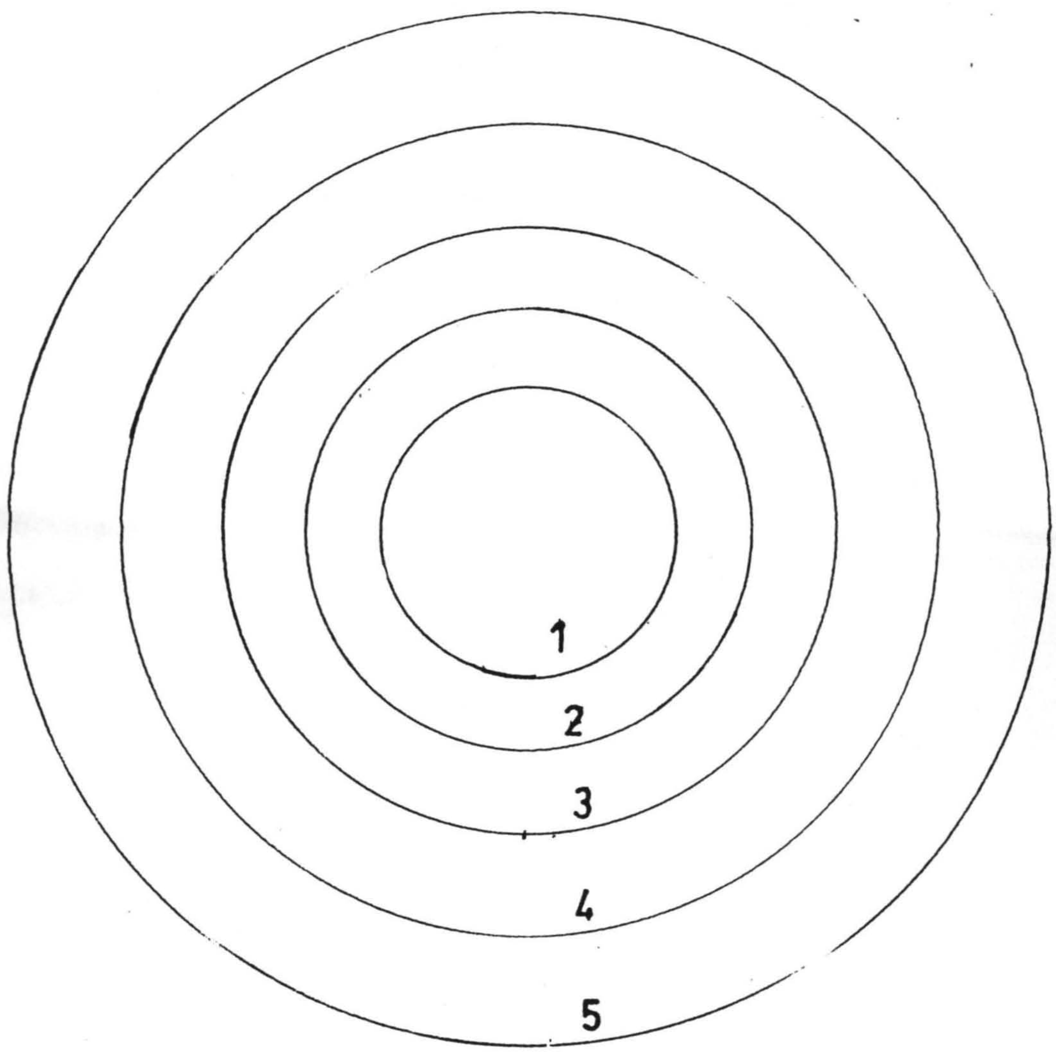
Next to the CBD is the transitional zone, which is an area, characterized by deterioration and the scene of urban renewal programmes. It is the center of encroachment of business and light manufacturing. It is as well a zone of persistent urban blight in this day of tenement and share inadequacies of services.

The independent workers zone are zone which have little numbers of houses that are at least superior to those in the transitional zone, they are occupied by single family with clean environment and fewer incidence of crime, social mobility is possible in this zone and people live there so that they can be as close as possible to their places of work.

The improved workers zone consists of middle class residence otherwise referred to as the improved residential zone. It is a zone occupied by middle class people and it is generally characterised by greater affluence and speciousness. It is noted for high-class apartment hotels and business suburbs, banks and departmental stores.

The commuters zone is also referred to as the urban fringe. It is exclusively characterized by high-class residential buildings and it consists of communities that are in effect dormitories to the CBD. Where most of the economically active residence goes to work on a daily basis. The zone habours some of the highest christened residential areas in the urban centers. The zone equally marks the inter-digitations between urban and rural areas this is the zone where the effect of urban sprawl are found.

Fig 2.1 Concentric landuse theory as concieved by Burgess 1933



Key

1 The central district
2 The transitional zone
3 Zone of independent worker
4 Improved industrial zone
5 Commuters zone

2.1.2 Sectoral Landuse Theory.

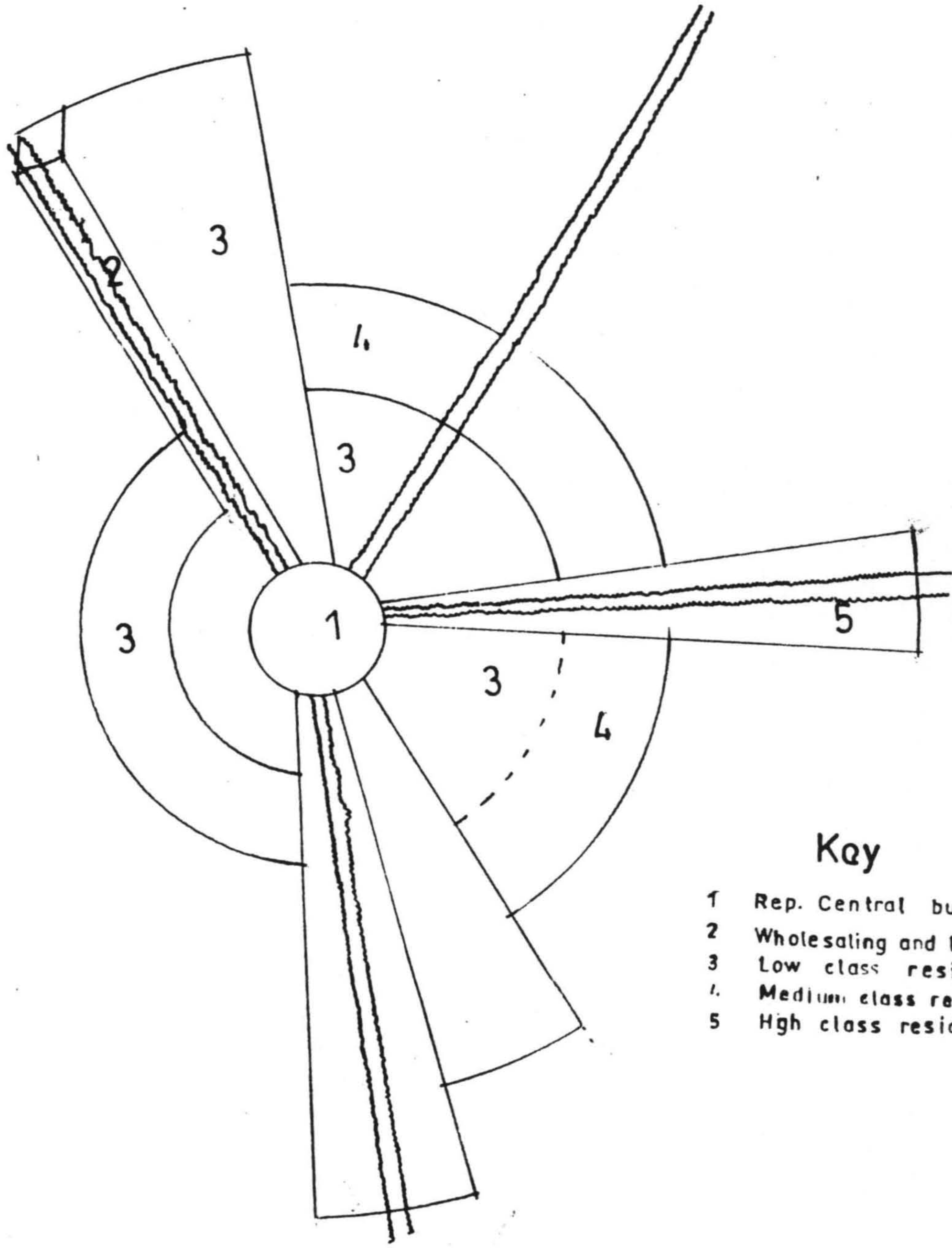
Sectoral landuse theory was propounded by Homer Hoyt (1939) and it is also based on the study of Chicago. Hoyt opined that Burgess concentric model will not be readily applicable, because development may take place along specific arteries and the perpetration of developing according to him will result in sectoral form. In urban landuse development. Hoyt argued that certain landuse type radiate from the CBD with a greater tendency towards dominating a particular sector. His model confirmed Von Tunnel and Williams Hord models that "there is always an increasing tendency for urban development to take place along a specific sector where movement is effective where transport is effective and where land value is not high.

In his wisdom the development that will occurs in space along major sector is depicted as a ream with spokes linking the ream with the hub in the center of the ream. As show in Fig 2.2.

2.1.3 The Multi-Nuclei Landuse Theory.

The multi-nuclei landuse theory as propounded by C. D Harrie and E. L. Ulman (1946), considered what was obtainable in the Von Tunnel, Concentric and Sectorial theory of Hoyt as been peculiar to the traditional cities, but where not relevant interms of what is obtainable in the cities of today. While the concentric theory may be relevant to the small urban or traditional town, in the large urban center the multi-nuclei theory is applicable which is a multiple center (nuclei). This theory gives us the vague idea of urban landuse that is: usually CBD and other sub-centers called the outline business district i.e the district that will serve the large and small center.

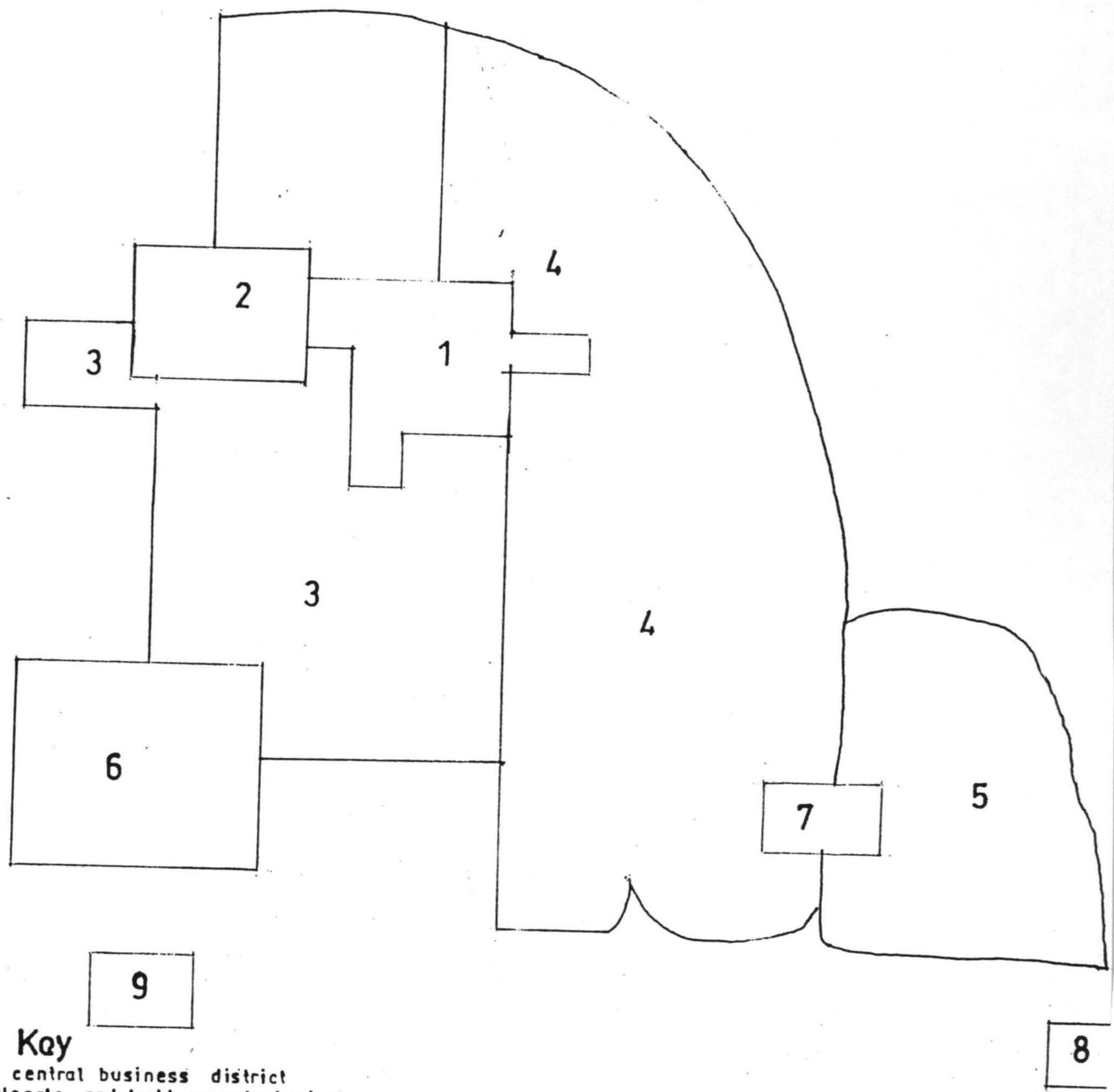
Fig 2:2 Sectoral theory of urban landuse after Homer Hoyt and M.R. Davie (1939)



Key

1 Rep. Central business district
2 Wholesaling and light manufacturing
3 Low class residence
4 Medium class residence
5 High class residence

Fig 2.3 Multi-nuclei landuse theory after C D Harie and E L Ulman (1946)



Key
1 The central business district
2 Wholesale and light manufacturing
3 Low class residence
4 Mediun class residence
5 High class residence

There are four basic reasons for the this development these are:

(i) Some activity requires specialized activities that may be naturally provided.

(ii) Activities tend to grow together for cost minimization.

(iii) Because some activities are detrimental to one another and has to be separated from residential buildings in view of their high rate of industrial pollution.

(iv) Some land area or activities cannot afford the high cost in some areas and therefore have to more away.

The overall effect of this combined with transportation leads to wider differences in activities or urban areas and thus leading to several core areas other than having single core area within a single area.

2.2 Landuse and Landcover Studies.

One of the major task confronting planners and other municipal officials is the acquisition and analysis of information upon which the administration of the cities and towns depend. Today most cities are attempting to establish some type of information system. Efforts on this direction have been largely unsuccessful. Present methods of data acquisition and analysis continue to be time consuming, costly and extremely inefficient. In an attempt to improve the effectiveness of urban information system researches is 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 landuse maps, this categories of maps which is basically an inventory of land is presently being utilized, it illustrate the spatial relationship of various landuses, if accompanied by quantitative summation. It also illustrates how much land is devoted to each use. Furthermore, the landuse map shows the extent of the transportation network and most importantly the relationship of transportation network to landuse (David Hiegreen 1979).

Research has demonstrated that urban landuse survey's now can be conducted from aerial photograph; furthermore, employing sequential photography, changes in the use of urban space can be detected and analysed.

Landuse and to some extent landcover 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 receives its unity through landuse investigations (Linz and Simonett 1970). One of the most important type of resources information requires for comprehensive planning is a current data base of landuse and landcover. According to Rudd (1974), a number of studies have shown that landuse mapping for various purpose and at widely varying degree of detail is possible through remote sensing techniques.

Interaction occurs between everyday behaviour and the future landuse pattern. Existing landuse arrangement in part determine where people live where they work and when and how they travel, where they stop, in turn help to shape future landuse pattern. Indeed the central position of land in economic and social life quite apart from the political heat generated by the use of land, has generally lead to considerable state intervention both direct and indirect in the landuse 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 to produce effective state control of land for development process (landuse decree 1978; No 6 F. G. N. official Gazatte 65 (14)).

There can be no doubt of the significance of landuse studies, on the one hand, we all require land on which to live and on other hand, the use of any given parcel of land affects not those who reside there or have use of that land- for what ever purpose- but also those who live on or have use of adjacent and surrounding areas (Rhind and Hudson 1980). Man had constantly been at the center of struggle over its 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 landuse for Military ends (Lacoste 1973)

As noted earlier, the past present and future arrangements and juxta position of landuse have occupied academic drawn from a number of disciplines including; Agriculturists, Economist, 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 landuse and landcover mapping above any other interest.

A 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 researcher and planner in their professional activities to understudy the process and formulate operational models, they also provide the Federal, State and Local Government officials is basis for up to date decision making as well as a means of motoring the out come of past decisions.

2.3 Landuse Change.

The subject of urban change may be partitioned into changes in the physical social and economic subsystems 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 overall 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 a particular parcel of land come to have it present use through time (Rhind and Hudson op.cit). In order to understand why landuse changes as well as how the changes occur, it is necessary to have information on the landuse and landcover over different time. Thus it is necessary to understand the past and the present landuse to be able to predict the future role of the land.

In the past the, processing of overlay to produce changes has often been carried out by photographic means when 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 coincidence which can be measured using a planimeter (Rhind and Hudson Op Cit). However the use of computers have greatly eased such comparism.

2.4. Specific Application of Remote Sensing to Landuse/LandCover Change Detection Studies.

Landuse change detection using aerial photography and other remote sensing data has been applied to both rural and urban areas and found to be an efficient methods of discovering the development trend of a region, change detection involves the use of sequential remotely sensed data over a specific region from which the landuse map for each data was mapped and compared.

Anderson (1975) evaluated the usefulness of side-looking air borne radar (SLAR) for general landuse mapping at 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 1:80,000 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 landuse region at level one and two classes respectively. His study reveals that much of his landuse region conformed with the existing classification scheme indicating the applicability of Radar imagery to landuse change detection studies. But it should be reminded here that, work of this nature could lead to double counting of landuse category if not reviewed against the existing ones.

In the study of Welch et al (1975) LANDSAT . I MSS data of scale 1.100.000 was used to produce a colour landuse map. A false colour composite of each scene of the study area at a scale of 1.500,000 projected onto a viewing screen. A transparent overlay of 5 x 5mm grid was then place on top of the colour composite image for cell by cell interpretation of the landuse/landcover, as a result of the restriction by low spatial resolution of LANDSAT data, eight categories of Anderson et ' al (1976) "USGS classification scheme was used. Their conclusion was that for a knowledge of the insight of the urban structure in the cities a methodology that permit mapping areas was developed where accurate up to date spatial data are difficult to obtain.

Collins and El – Belk (1971) studied the urban landuse in the city of leads, using three sequential aerial photographs in a transparent overlay from the photographs in which details were then transferred. This work reveals a high degree of accuracy and greater details within the Level 1, 11, and 111 classification scheme.

In the study conducted by Poulton et al, (1977) for a range and forestland environment in Sierria Nevada, California, using a comparative analysis of 1944 and 1968 aerial photograph to detect change and assess changes as they relate to land management. The study shows that moist meadow site and separian vegetation had disappeared from 1968 photographs while encroachment of sage bush shrub had occurred. It is good to note here that this study does not make use of ground truth to verify condition, especially in the 1944 photographs. Beside the use of only 1968 aerial photograph alone will not be too good for a reliable comparism, that is capable of revealing landuse change over the period under study.

Henderson (1979) used the Westing house K-band Radar imagery at scale 1:225,00 to map the North-Easting part of the United State using the USGS(1976) Classification Scheme. His result, when compared with the existing landuse region classification of the same area indicates fragmented and complex landscales, thus reducing the, the level of landuse details visible in the area. Compared to that of the Mid-west United State, finally the area consist drainage, relief, transportation, and settlement features. The shortcoming of this study however was that it failed to delineate the landuse region in the area in order to determine the aerial extent of the various landuse categories.

Byrne et al (1980), used the transformation enhancement of multi-temporal data to study landuse change of Atlanta United State by Super Imposing two LAND SAT data different dates and treat them as a single eight dimension data array. A principal component analysis was carried out to determine:

(i) Changes that would extent over, substantial part of the scene such as change in atmospheric transmission and Soil, water state.

(ii) Changes that was restricted to parts of the scene such as clearing forest, construction of roads and erection of buildings. It should be noted here that, while this approach sound interesting. Its application is too technical and quite unpopular.

Better still, Synder (1981), used LANDSAT MSS Imagery and other collateral materials to study landuse in some parts of former U. S. S. R. with black and white positive prints of landscape schemes to delineate regions of uniform landscape elements. This study delineate 30 Categories and Sub-categories of landuse and landcover associations, with much of the USSR dominated by a single element such as woodland or cropland. Thus, the study implies that it has a very large extent that could hardly allow for an effective co-ordination of landuse and landcover mapping.

The principle of computer assisted approach was employed by C. P. LO(1981) in the landuse/landcover mapping of Hong Kong using LANDSAT MSS imagery the band in analogue form and then delineate the study area in band 5 of the Image with reference to the Scan-line number. The delineated study area extracted from the original data tape and stored in a disc file. Landuse classification of the Hong Kong is determined with reference to existing landuse map and aerial photograph. From this study, eight landuse and landcover classes were found appropriate. Then statistical programmes was run to compute the mean and standard deviation of the pixel values for each band in each training data set, finally, change class progreamme was run to classify the image of the study area with this a line printer map of the classification is produced by computer, This was then transferred to the base of the map by direct training. The study concludes that digital approach to landuse /landcover mapping using LANDSAT can surely produce reasonable and accurate result. An important note here is that the study does not reflect the aerial extent covered has been able to effectively delineate landuse/landcover for the study area.

Studies for an arid environment was spear headed by Henderson (1982). He used SEASAT SAR Imagery to map landuse for the arid environment in Denver, Colorado area of U. S. A. using a general electric Imagery 100 interactive processing system to contrast, stretch and enlarge the original Image to three scales: Smaller (1:500,000), medium (1:131,000), and large (1:40,000). The study shows that the level landcover classes of the USGS classification System, could be delineated from (1:500,000) images and the urban/built up area could be accurately defined, resulting in a very coarse landuse maps. Thus the study introduce a new dimension and the applicability of the SAR Imagery for landuse/landuse mapping.

Roger et al (1985), conducted a study to assess quantitative change in the land surface as a result of mans activities, series analysis of LANDSAT MSS of 1970, 1976 and 1979, covering St. Lawrence valley in Quebec Canada, were used to monitor seasonal and long term variation in the landuse and vegetation cover. Three types of landcovers were distinguished with the result showing that deforestation had occurred and there is a Significant decrease in farmland and a marked process of urbanization. This study fails to show the method used in their classification, before comprehensive analysis of landuse and vegetational cover as seem on LANDSAT Imagery has not be made. Hong and Lasaka (1982), use a post classification change detection to study the coastal changes in Tokyo Bay of Japan using three different LANDSAT Imagery of 1982, 1976, and 1980. Upon registering three sets of the imageries using ground control points read from 1:500,000. Scale to Topographical map, the approach was to classify independently each LANDSAT scene by applying standard procedure of classification. The result were overlaid and compared so that areas and types of changes could be identified.

The LARSY Software package was used for the landuse classification and the resultants landuse maps were displayed on colour screen and were later super imposed 'two by two' to detect changes, which were indicated by a distinctive colour. Thus the percentage change in the area between the three years of study beside it has shown what the changes have been for a specific class from year one to the next. From this finding it can be deduced that no observation has been made with regards to factors that give rise to the changes noted. However, the study is simple to adopt.

Here in Nigeria, Remote sensing techniques have been variously applied in monitoring changes in landuse and landcover studies (Odewumi 1972, Adeniyi 1982, Areola 1986, Akinsanmi 1986 and Adefolalu 1986).

Ademola and Soneye (1993), used remote sensing and Geographic information system (GIS) technique to map landuse and landcover in the middle of Sokoto river, North-western Nigeria, with a land SAT Imagery acquired in 1986 with a scale of 1:125,000. Using the PRO-COMZ optical image transparency analysis equipment to interpret the image, 13 landuse/landcover classification categories was delineated and they concluded that the visual interpretation of the enhanced LANDSAT MSS data can provide adequate spectral information required for mapping of landuse and landcover.

Adeniyi (1980), Applied a modern approach to landuse change detection and it involves the use of computer . two sets of Aerial photography of 1962 and 1974 with a scale of 1:40,000and 1:20,000 respectively covering the urban and non urban area of Lagos was used. Nine major landuse/landcover categories were identified with a minimum mapping unit of one hectare as a basis of interpretation and subsequent storage into the computer. With the interpretation and the fieldwork data were transferred into a base with the aid of a 300m transfer scope. A clear acetate sheet with 100m x 100m was placed on the map and the data manually encoded and key punched into a digit before they were transferred into a Computer tape for processing. A spectral Computer programme was written.

The landuse change detection revealed the rapid increase of residential landuse and a strong lateral expansion of the urban areas of Lagos. Thus Computer approach is certainly more desirable for landuse change detection with the recent advances in computer technology laborious encoding and digitizing of the landuse data for computer input can be done much more quickly and easily.

2.5 **Landuse Classification.**

A fundamental under pinning of any survey of land is whether the information recorded relates to some activity carried on a different places, or whether it relates to inherent physical characteristics of those places. Whether the classification is functional or formal will depend, partly on the objective of the study. Activity or specifically 'Principal' activity carried on at a site is the main concern of many people in collecting landuse data (Cappock and Gebbett 1978, Dickson and Shaw 1978).

Clawson and Steward gives a succinct definition of landuse as "Man's activities on land, which are directly related to the land "land-cover according to Burley (1961) refers to the vegetational and artificial construction covering the land surface."

There is no ideal classification of landuse and landcover as stated by Anderson et al 1976.

> "There is no one ideal classification of landuse and landcover and it is unlikely that one could ever be developed. There are different perspectives in the classification process and the process it Self tend to

be subjective even when numerical approach is used, there is in fact no logically reason to expect that one detailed inventory should be adequate for more than a short time, Since landuse and landcover pattern change in keeping with the demand for natural resources each classification is made to suit the need of the users".

However, Anderson (1976), advances the criteria which classification for remotely sensed data should meet thus.

(i) A minimum level of interpretation accuracy of at least 85 percent;

(ii) Equal accuracy for different categories.

(iii) Repeatable results

(iv) Applicability over extensive areas.

(v) Categorization permitting landcover to be used as surrogate for activity.

(vi) Possibility for use with remote sensor data acquired at different times.

(vii) Intergrating with ground surveyed data or large-scale remote sensor data possible through the use of sub-categories.

(viii) Aggregation of categories possible.

(ix) Comparism with future data possible.

(x) Multiple uses of land recognizable.

Smith et al (1977) stated " That the broad landuse groups they got in their study, were defined in terms of ideal classification, thus substantiating the ideal of no ideal classification for general use.

Anderson et al (1976), scheme emphasized a rather coarse level of mapping – (Levels I, II, III and IV). The levels I and II which were appropriate for maps at the scale of 1:250,000 and 1:100,000 used in the USGS programme. The more discrete higher landuse was developed on the assumption that different sensors will provide information for different levels of classification. The success of the USGS landuse and landcover classification system is proved by the fact it has been used not only within the U. S. but also in other countries of the developed and developing world with slight modification (Allan 1980)

Because landuse classification can pre-judice the future (Clive 1963) and constrain the scope for future development (Rhind and Hudson 1980), whatever classification made used must be mutually exclusively, meet the detailed need of the primary users. Meet as many of the needs of the secondary users, as is possible and must be flexible for new interest and task to be met from a modified, rather than a completely new classification approach for change detection.

Classification techniques have been applied in both urban and rural environment. (Rubec and Thie 1978, Stom et al, 1977). Results using classification approaches are frequently unsatisfactory, because they tend to compound and misclassification and misregistration errors that may be present in individual classification. (Piton et al 1988). Methods which incorporate both enhancement and classification techniques have been suggested (Tod 1977, Wilson et al, 1976, Adeniyi 1990). It is important to add here that there is no prior landuse/landcover classification scheme for Nigeria (Adeniyi 1985).

2. 6 Data From Remote Sensing.

Formerly, landuse data have been compiled by census interview or field mapping. Major landuse are mapped in the field and published on small-scale map in some Countries (Lunney & Dill 1990). Generally, these methods take a long time.

Today the urgent need for increased food production environmental protections of prime agricultural land from encroachment have awaken the interest of many. In the study of landuse and the problems it entails. Better sensing and interpretation instruments and techniques have facilitated increased applicability of remote sensing to landuse. The over whelming advantages of remote sensing techniques over the tactile methods based on ground survey are the consistency which "Can be ensured in at least one stage of data collection, the rapidity of survey and data collection stages (Lunney and Dill 1970).

Assessing, the overall landuse on small-scale imagery first became popular with the advent of astronauts photography and ERTs Image (Rudd 1974), one of the earlier efforts employed Germini and Apollo Photography of the South-west from southern California to Texas (Thromer and Senger 1969), Wray (1948) used aerial photography to develop an atlas of Chicago municipal airports and acquire basic landuse data for 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 landuse classification in both rural (Vegos 1972, Alexander 1973b) urban (Alexander 1973a), Semi-arid areas (Pilson et al 1972, Adeniyi 1985) and irrigation patterns (Theiruvengadachari, 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.

2.7 Analysis of Landuse and Landcover Data.

Landuse landcover mapping can be carried out either by visual image analysis or digital image processing or through the combination of both (Adeniyi 1990). In visual analysis, minimum area recording unit (MARU) must be determined. MARU refers to the minimum aerial extent of landuse /landcover type that can be manually delineated and coded on the recording base.

The idea of MARU is to avoid unnecessary waste of interpretation time as well as the reduction of noise in the final output map (Adeniyi 1990). Cartographically it is difficult to delineate and code any map area smaller than 2.5m mm on a side (Anderson et al 1976), at a scale of 1:100,000. leokkes (1977) has suggested a MARU of 4mm . The scale of the final map should govern the minimum size to be interpreted (Baker 1979) 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 remote sensing, digital approach is only applied to numerical image data, which are normally recorded on Computer tapes. In the study of Odenyo and Pettery (1977) on landuse mapping by machine processing of land in the city of Virginia Beach, they produce landuse/landcover map with major categories of urban, Agriculture, wooded, water, wetland and bare land. Twenty-four of these classes were spectrally seperated.

While it is recognized that Computer-assisted classification methods could be use in landuse and landcover studies visual interpretation methods requires both less training and less expensive equipments than methods using Computer assisted techniques. For developing countries limited by low budgets, manpower constraints and accessibility of computer technology.

2.8 Conclusion.

On the basis of the review, it is clear that remote sensing should play an important role in any urban expansion monitoring system plagued with shortages of money and manpower. Cities should find in a remote-sensing a valuable tool for data acquisition. Remote sensing can take the place of present day data collection procedure which may be inefficient or as in more likely to be the case provide an important supplement to these methods. However with few exceptions, urban planning agencies do not appear to be utilizing aerial photographic technique to any great extent. Researches in the field of remote sensing therefore must work closely with urban planning officials, not only to keep the officials abreast of their researches but also to make the result of their researches more applicable to municipal problems.

However, there are numbers of technologies for example based on infrared and microwave technique and aerial data collection can be utilized in the study. To achieve the Objectives of the research methodology, through correct data analysis and interpretation as well as good methods of data presentation. These among others are essentially what shall constitute the concern of chapter three.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

To adequately extract information on landuse and landcover changes in the study area (Abuja federal Capital City) the procedure adopted were as follows; Data collection, development of landuse/landcover classification creation of base map, decision on the minimum mapping unit, data interpretation. Data transfer into a final mapping scale to general statistics maps for the bi-temporal periods, ground truthing, measurement of landuse/landcover classes using ILWIS 2.2 computer software packages and compilation of results as well as discussions as represented on Fig 3.1

TABLE 3.1 SUMMARY OF DATA SOURCES AND CHARACTERISTICS

Data Sources	Date	Scale	Type of data	Acquisition Source
Aerial Photo	Mar. 82	1:25,000	Panchromatic	Fed. Survey Lagos
Spot(HRV) Image	Oct. 96	1: 50,000	M. S. S	N. C. R. S. Jos
Comp. Landuse Plan	1982	1:10,000	Map Sheet 12	F. C. D. A. Abuja
Photo Map	Sept. 88	1:2500	Panchromatic	F. C. D. A. Abuja.
Topo. Map	Mar. 88	1:2500	Map Sheet 24	F. C. D. A. Abuja

3.1. Data Sources And Characteristics

Two sets of data were used for the study a black and white aerial photography covering the study area within the period of 1982 (at a scale of 1:25,000) and two the 1996 SPOT HRV imagery (at a scale 1:50,000) other collateral data sources used were Topographical map (1:25,000), Photo map (1:2500) and comprehensive landuse plan (1:10,000).

Normally, two aerial photograph covers the study area for the period of study and at the stated scale but for good stereoscopic coverage four (4) aerial photographs were used and for the period 1996 one (1) SPOT HRV Image were used. See table 3.1 for the summary of data sources and characteristics.

SPOT HRV (High Resolution in the visible) is a Satellite instrument launched by France on February 1986, the techniques of operation is the push-broom scanning (along –track method) the image repeat capability is 2.5 days (off nadir). It frequently imaged a scene using the wavelength frequency of visible and near infrared, with the type of data generated been panchromatic. The spatial resolution is 10metres –20 meters thereby making it possible for identification and delineation of physical characteristics of the environment. The swath width is usually 60km and the main area of application are landuse/landcover studies, Agriculture, Cartography and exploration.

3.2 Selection of a Classification Scheme

There is no ideal classification for landuse and landcover and it is unlikely that one could ever be developed. There are different perspectives in the classification process. And the process itself tends to be subjective. Even when an objective numerical approach is used there is infact no logical reason to expect that one detailed inventory should be adequate for more than a short time. Since landuse and landcover patterns change in keeping with demands for natural resources each classification scheme is required to organize the needed information into a structure that satisfy the resources problem and objectives. The types of resource data being sought and the physical nature of the terrain.

Although standardized landuse and landcover classification schemes have been developed for general purpose(Anderson et al 1972) There is no prior landuse/land cover scheme for Nigeria (Adeniyi 1985). Therefore for this reason an appropriate classification scheme to suit the objective of this study will be developed and presented as table 3.2. A preliminary ground truth was carried and 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 imaginary and base maps.

The landuse and landcover classification scheme is made explicit as much as possible and carefully presented as table 3.2.

TABLE 3.2 LANDUSE/LANDCOVER CLASSIFICATION SYSTEM

LANDUSE/LANDCOVER CATEGORIES.		
SL.No	**A-Built up land or Urban Complexes.**	
	LEVEL I	**LEVEL II**
1.	Urban Complex area	Planned Residential, Unplanned Residential, Commercial, storage, Villages, Institutional, Utilities and Services.
2.	Transportation	Road Network (Express, Arterial and Minor Roads), Communication.
	B-Non Built-up Land or non Urban Areas	
3.	Non Built up Land	Cultivated land, Fadama, Schrubland, Wasteland, Gullied Erodedland, Degradedland or Dense forest etc.
4.	Water Bodies	Streams, Ponds, Rivers, Canals, etc.
5.	Rock Outcrop	Bare Rocky/Stony Area.

3.3 Description of Landuse and Landcover Classes

This description is used entirely on the information obtained from the physical characteristics of the study area.

Built-up area or urban complex area this comprises of area of intense uses with much of the land covered by man- made structures such as settlements and road networks. Landuse/landcover types under this classification include.

Residential: - This includes lands, which provides living spaces around buildings or houses to meet the daily needs, Of the families of different types . This area is predominantly identified for the purpose of living accommodation these are developed according to some plan or devoid of any plan. These are mainly covered under planned and unplanned residential etc.

- Planned residential. These are homogenous residential units mainly used for housing purposes with a regular layout as well as regular network or road pattern where the plot size is more of less uniform, though the plot is the same the house type or size may vary and is governed by the prevailing building law.

- Unplanned residential. These are homogenous residential units developed without any proper planning or devoid of any regular road pattern. These generally include the old settlement or town developed without any planning taking place with respect to time. This also includes areas characterized by irregular layout, varying plot size and dwelling unit.

- Villages, compact cluster or dwelling units found outside the main urban built-up area surrounded by Agricultural land. These residential areas are generally unplanned and characterised by irregular layout.

- Commercial and storage: Commercial areas are those built-up land essentially with a non-residential used and broadly classified into some kind of business transactions. This includes: market, retails, trade, shopping complexes cinema halls, petrol pump and other commercial activities not relating to manufacturing.

- Institutional: This classes generally includes built-up land use, and constructed purposely as working places for government, semi-government public and private sector offices. Institutional and other research organizations.

- Recreation, cultural and religious landuses, This class can be further subdivided into the following parks/Garden/Nursery areas, they are mainly used for passive recreational practice only.

- Playgrounds/Stadium, are used mainly for active recreation purpose.

- Places of worship/Monuments: religious places community centers are covered under this category.

- Industries: This main classes also includes industrial estates and other industrial activities based on agricultural and animal husbandry.

- Brick, Kilns and Lime Kilm; oval rectangular shaped area with chimneys surrounded by excavated land or depression primarily engaged in brick/lime from the mud is classified in this category.

- Transportation/communication. This class includes the land utilized for providing transportation and communication facilities. They include: Express roads Arterial roads, collector/distributor and other minor roads.

- Utilities and services. It includes basic amenities, which is a requirement for urban environment, like hospital, post-office, telephone exchange tank etc.

- The totality of all the landuse/landcover described above are jointly classified as Built-up or urban complex area because they are under one form of urban function or the other. More so, that spatial resolution of the 1982 aerial photograph and the 1996 SPOT Imagery used do not permit individual classification. Most importantly the researcher consider it ambiguous in trying to separate these landuse/landcover type because of the apparent difference that will be notable in the 1982 and 1996 situation. Beside the 1982 time period is considered too far to be related to any ground truth conducted this year. Because the area has undergone drastic changes in recent time.

Non-Built Up Land On Non-Urban Area

These are land without any urban function mentioned above. It is an area not under any intense uses and which are not covered by an man-made features. This classes includes.

- Water Bodies : This are landcover under natural drainage system like rivers, streams as well as linear drainage system like canals (used or unused) and natural or man-made structure like reservoir or ponds. Water bodies or wetland area are land area whose water table for most part of the year is above, at the surface or below the land surface.

- Rock out crop or barren land: This are land so limited by its ability to support like and in which less than one third of the area has vegetation or other covered.
- Vacant land: These are plots or small areas on which no activities are done due to several reasons.

- Wasteland: Mismanaged unutilized or partially utilized degraded land. It is a land not used for human activities as well as forestland. It could result from inherent, imposed constraints such as by environmental chemical and physical properties of the soil or management constraints. It includes barren rocky land, River sand/sand cast areas.

- Green belt in urban complex: Clothing vegetation around urban or built-up area.

- Agricultural Land: Areas which are used for cultivation and raising crops. Generally found near the villages and in the outskirts of the main city areas, But within the city areas also one can find out agricultural patches and are included in this category. It can be subdivided into: Cultivated land and orchards.

- Shrubland: Vegetation consisting of dwarf or stunted trees and shrubs often very thick is considered under the category.

- Forest: Predominantly is of forest trees, which are in areas included under natural vegetation.

- OTHERS: These include the land, which are not classified by the above classes: They include.

- Dumping ground/waste disposal sites i.e. Land used for industrial dumping and city waste disposal.

- Disused Brick Kilns: Areas covered under abundant brick Kilns, which are not in use, are classified in the category.

3.4 Creation Of Base Map.

The base map for the study was developed from topographical map (sheet 24,scale1: 25000) and the base map was constructed for locations guide for the recording of interpreted landuse and landcover to enhance detail comparative analysis various prominent land features like rivers, roads and rocks were marked on the base maps which acted as controls while doing interpretation mapping

3.5 Minimum Mapping Unit

A decision on the minimum mapping unit was taken before the commencement of the interpretation for clarity; it was put at 2 mm^2. This unit define the minimum of any landuse /landcover 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 landuse/landcover covering an area less than the stated dimension was classified with the surrounding dominant use.

3.6.0 Data Interpretation

The use of relevant collateral materials such as the photo map, topographical map, landuse plan, the guidance of an experienced interpreter as well as a reconnaissance survey before the commencement of the actual interpretation all helped to a high degree of accuracy in the interpretation.

A total of four aerial photographs were interpreted using mirror stereoscope with 3* magnification and zoom stereoscope with 15* magnification. Transparent acetate overlays were placed over each photograph interpreted on which the landuse and landcover boundaries were delineated, this process was carried out on a light table .

The satellite imagery (SPOT HRV) was interpreted visually by placing transparent acetate on the interpreted study area to the imagery . The1982 and 1996 interpreted scene were later scanned by Windows 95 computer software. The necessary computer operation such as Geo-referencing, checking overlaps dead-ends and intersection were performed to generate the various thematic maps using the ILWIS 2.2 (Integrated land water information system) software package.

3.6.1 Criteria For Data Interpretation

The detection stage naturally leads on to the recognition and identification stage in which the 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 interpreters' general knowledge of the phenomenon and the process to be interpreted. The local level is the interpreter's intimacy with his own local environment and specific level is the interpreters' deep understanding of the process and the phenomenon he wants to interpret. In recognition and identification the non-geometric image characteristics of tone or color, shape, size, shadow, pattern, texture and association normally give clue Visual interpretatıon technique have also been used to study digitally enhanced products on the basis of the image characteristics. These elements of interpretation helped in delineating various types of textures present in the urban environment and judge their significance in delineating thematic information related, to urban landuse/landcover.

Shape: shape refers to the general form configuration or outline of individual objects. Shape of an object as seen above is different from what one is accustomed to see or ground. However each object has its shape and this characteristic helps in identifying the objects.

Size: it helps in determining the size of an unknown in relation to the size of a known objects, it is the dimension of an object and essential clue to the identification of objects of similar shape and can be used as standard for comparison.

Shadows: shadows give valuable clue to shape and sizes of objects and it is very useful in object classification and recognition. Long shadows tend to emphasize linear features.

Site association and location: it is a skill developed by the interpreter who involves a reasoning process which uses all the principle of interpretation to relate an object to the surroundings, where other characteristics fails to give clue. Topographical location and relative elevation are helpful in identifying the objects.

Tone or color: it is a record of energy reflectance or emittance which has different meaning according to the spectral sensitivity of the detector or film employed. Tone is a combination of hues, chrome and saturation in color image or relative brightness or objects in black and white image. Tone differences are most important of the element as they attract most of attention. Without the natural tonal, differences, the shape and pattern could not be discerned.

Texture: is related to the frequency of the tonal changes, which gives an impression of the roughness or smoothness of the image features. It is caused by objects, which are too small to be clearly distinguished individually texture ranges from small or fine to coarse depending upon the scale of the image.

Pattern: it is the spatial arrangement of the object, pattern can be man-made caused by farming practices, the development of cities, industrial complexes or they may be natural caused by erosion and the general geology of the area. Pattern is a valuable tool in assessing landuse type, helped by shadows, see table 3.3.

TABLE 3.3 CRITERIA FOR IMAGE INTERPRETATION

PHOTO ELEMENTS						
Major Landuse Landcover classes	Shape	Size	Site Association	Tone	Texture	Pattern
Built-up Land	+	+	+	+	+	+
Agric Land	+	-	-	+	+	-
Vegetal Cover	-	-	-	+	+	+
Water Bodies	+	-	-	+	-	-
Wet Lands	+	-	-	+	-	-
Bare Surfaces	-	-	+	+	+	-

Remark (-) Non effective identification elements
(+) Effective identification elements.

The result of identification and recognition is a list of objects and features in the area. This forms the basis for the delineation of areas having homogenous observable pattern and characteristics. In the analysis stage, such area so delineated has to be classified through a process of induction (general inference from a particular case) and deduction (particular inferences from general observation) and then the area is calculated and tabulated for necessary discussion and comparison.

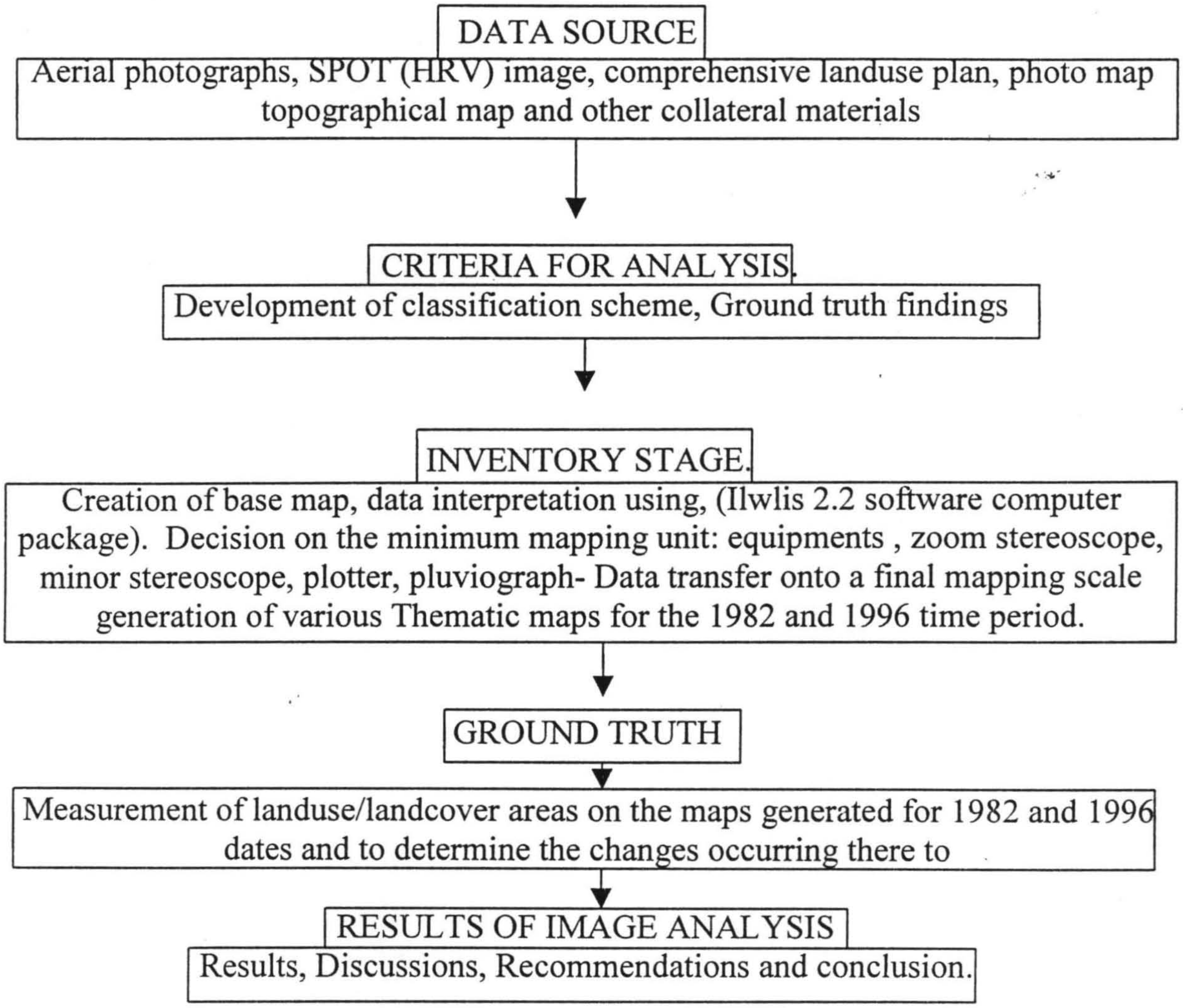
3.7 Data Transfer.

Because the satellite imagery was not in the desired scale of mapping (1:2500) only the aerial photography was. There is the need to bring the satellite imagery at scale (1:50,000) to the same scale of the aerial photographs (1:25,000) to do this, the pluviograph in the national center for remote sensing, Jos, Plateau state, was used. In doing this two points were identified and marked on the transparent over lay interpreted from the aerial photograph (which is on the desired scale of mapping) and then placed on top of the pluviograph. These same points are as well marked on the transparent over lay interpreted from the SPOT (HRV) images the overlay is then placed before the focal length of the pluviograph. The equipment then image the map on the light table on which the interpreted aerial photographs overlays is place. The equipment is then adjusted to reduce the map until the point's marked overlap and when it overlapped, it means they are now in the same scale. A transparent acetate paper is again placed on the reduced map image on the table and it is then mapped at that scale. Thus, this differences in scales were resolved by reducing the scale of the satellite imagery by the use of pluviograph.

3.8 Ground Truthing.

The researcher proceeded to the ground truthing to identify major landuses, to verify the delineated boundaries, check doubtful features and verify the accuracy of the interpreted data. This was intensively carried out on January 2000 to check doubtful features. Errors detected were immediately corrected on the preliminary landuse maps. Because of the time lag between the period of sensors overpass and field check care was taken so that changes in the landuse and landcover will not be taken as interpretation errors. See fig 3·1for methodological framework.

Fig: 3.1 METHODOLOGICAL FRAMEWORK.



CHAPTER FOUR

4.0 DATA ANALYSIS AND DISCUSSION:

Information on urban growth detection and analysis especially the extent, spatial distribution and changes is a pre-requisite for the site suitability analysis for development. The landuse and landcover information helps in formulating policies and programmes for urban development.

For the purpose of clarity, these chapters have been divided into three segments thus:

(i) Analysis of the static landuse and landcover pattern for 1982 and 1996.

(ii) Analysis of the network and accessibility pattern for the two-time epoch (1982 and 1996).

(iii) Analysis of the changes in the landuse and landcover, between 1982 – 1996.

4.1.0 Static Landuse And Landcover Analysis

An attempt has been made here to adopt a suitable landuse and landcover system for use with remote sensor data. A minimum level of accuracy of about 90% or better has been attained in the interpretation for the several categories included in the classification system.

For easy understanding and because of the focus of the study – change detection analysis in the physical development of Abuja F.C.C – five landuse and landcover classes was prepared for the entire federal capital city phase 1 development area and they are:

(i) The built – up areas or urban complexes. This composed of areas of intensive use with much of the land covered by man made structures such as planned and unplanned residential areas, villages, commercial and storage, recreational, cultural and religious landuses, other are , industrial communication utilities and service landuses these have been designed appropriately under Section 3.3.

(ii) Road Network or Transportational landuses, because of importance attached to this in the study area and the vast areas of land allotted to it including it right of way, it will be wise to divorce it a bit from the build-up area so that proper analysis of it can be made. Generally road network comprises of transportation routes which are in the categories of Express ways, Arterial roads, collector and distributor road as well as minor roads depending on the ability of each to be discern on the respective images.

(iii) The non-built up land. These are land without any urban function mentioned above. It is an area not under any intense uses, which are not covered by any man-made features and whose much of the land are covered by grasses, shrubs, sand, forest, bare surfaces etc. Landuses included in this category are vacant land, waste land, Green belt in urban complexes, Agricultural lands, shrubland, forest land, dumping grounds, waste disposal site, disused brick, kilns etc.

(iv) The water bodies. This delineate landcovers under natural drainage system like rivers, streams as well as linear drainage system like canals (used or unused) and natural or man-made structures like reservoir or ponds. Generally it is an area who for significant part of most years the water table is above, at the surface or below the land surface.

(v) The rock-outcrop: This include bare exposed rock or land limited by its ability to support life and in which less than one-third of the area has vegetation.

4.1.1 Landuse/Landcover Situation In 1982.

As shown in table 4.1 the non-built up area dominated the landcover of Abuja as at 1982. It covers about 5151.54 hectares or 57.41% of the landuse/landcover for the whole area. While this landcover types spread round the study area. It has full concentration in the central area, Maitama district and Asokoro district. This was followed by the road network which has about 892.41 hectare of land or 12.92% percentage of the total area this road network were found running between and around the built up land. The rock out crop can only be found in the Asokoro district, the three arms zone and Maitama district, it accounted for about 690.57 hectares of land or 9.85% of the distribution. The water bodies which is the least classes of landuse/landcover for the or 1982 occupies just 16.41 hectares of land or 0.24%

The built-up land or the urban complexes about this time is still very small, only 266.05 hectares of land or 3.81% of the entire city phase 1 were build upon.

These early noticed developments are most concentrated in the Wuse 1 and 11 axis with slight extension toward the Garki district as can be seen in Fig 4.1. The above distribution is so because, Abuja the new Federal Capital is still at its formative stage the rate of physical development is still low the seat of government of the federation is still operating in Lagos. General population too is low, only 138241 (projected estimate from the 1963 census) people reside in Abuja, thus culminating in low economic activities and then low physical development. Most of the roads available are minor and rudimentary constructed to open up the lands in order to facilitate speedy physical development.

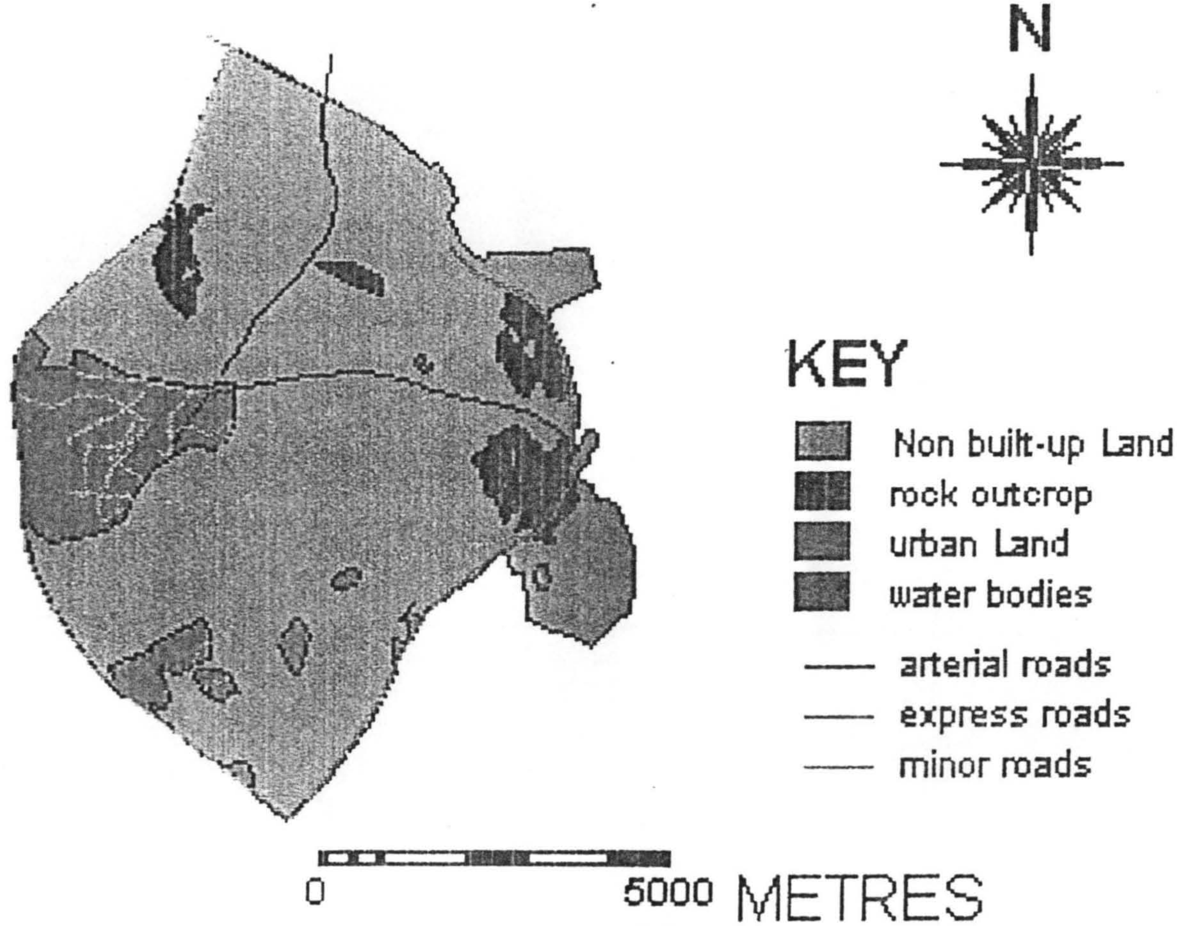
From the forgoing analysis it could be summarily stated that the non-urban area or the non built up lands (rock outcrop and water bodies inclusive) accounted for 5858.52 hectares or 83.49% of the entire study area for the period 1982 while the built –up land or urban area (road network inclusive) accounted for the remaining 1248.46 hectares of land or 16.51% of the study area, see table 4.1

TABLE 4.1 LANDUSE/LANDCOVER SITUATION IN 1982.

Landuse/Lancover Classes.	Arial Extent In hectares	Percentages
Built-up Area urban	266.05	3.81
Road Network	892.41	12.72
Non-built up Area	5151.54	73.41
Rock out crop	690.57	9.25
Water bodies	16.41	0.24
TOTAL	**7016.98**	**100**

SOURCE: Extracted from the analysis of 1982 Aerial photograph of Abuja.

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



Source: Laboratory Analysis of 1982 Aerial Photograph

4.1.2 Landuse/Landcover Situation In 1996

Table 4.2 present the landuse/landcovers situation in 1996. It is shown that the non-built upland covers about 3005.57 hectares of land or 42.84% of the total distribution it dominated the city's landuse/ landcover classes. With much concentration in the central area and the three arm zone. This is because this areas are originally meant to be low density residential and institutional structures with provision for green areas or buffer zones within the layout.

The built-up land or the urban complexes covers a total of 2345.93 hectares (33.44%) Bulk of this structures are found in the Wuse district, Maitama district, Garki and Asokoro district the resolution of the Spot image and the photograph does not permit the ability to differentiate between, residential, institutional, commercial or industrial structures and so they are taken jointly as a built – up land. Because of these observed increase in the urban or built –up land. The road network that serves as the connecting links between the various landuses also increase appreciably to about 1648.69 hectares in aerial extent with good linkages between the expressways, Arterial and minor roads in all parts of the study area.

The rock out crop found only in Maitama district accounted for 3.3 hectares (0.05%) and water bodies occupied 13.48 hectares or 0.20% of the total land mass of the study area. See fig 4.2 and table 4.2.

TABLE: 4.2 <u>LANDUSE/LANDCOVER SITUATION IN 1996.</u>

Landuse/landcover Classes	Arial extent in hectares	Percentages
Non-built up area (non-urban)	3065.57	42.84
Rock out crop	3.3	0.05
Water bodies	13.48	0.20
Built up land (urban)	2345.93	33.44
Road Network	1648.69	23.50
Total	**7016.98**	**100**

Source: Derived from the analysis of 1996 SPOT image.

Bargraph showing landuse/landcover situation in 1982 and 1996

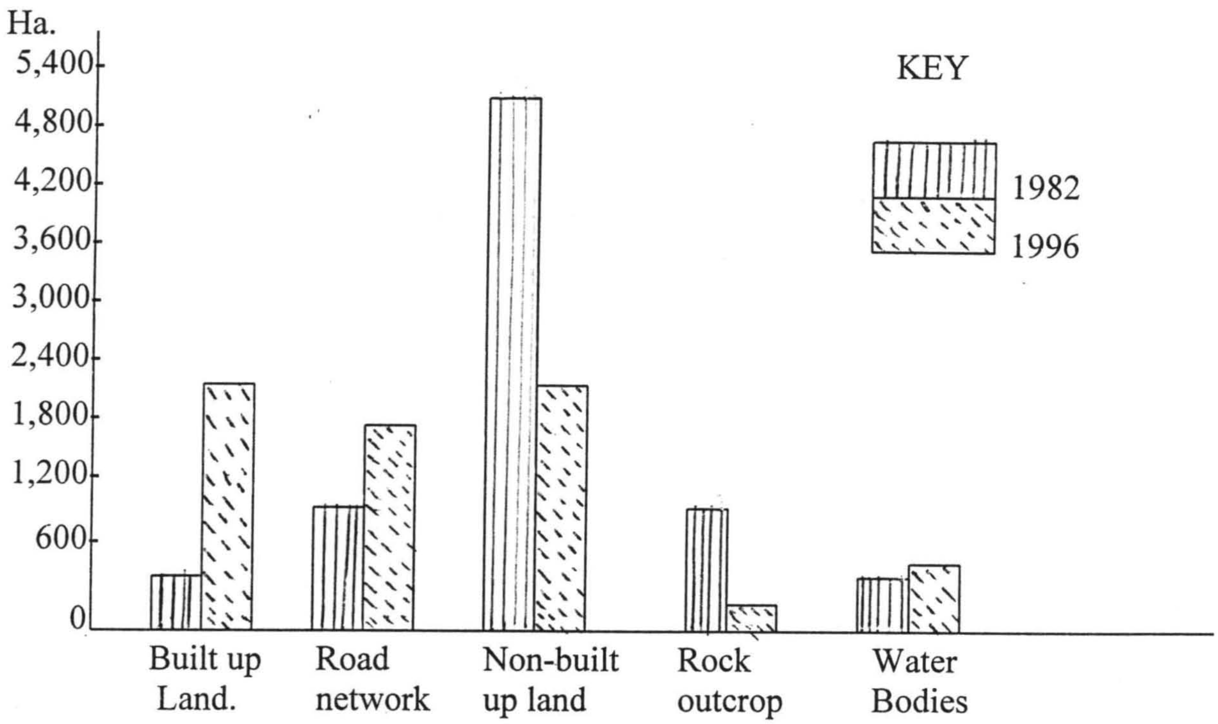
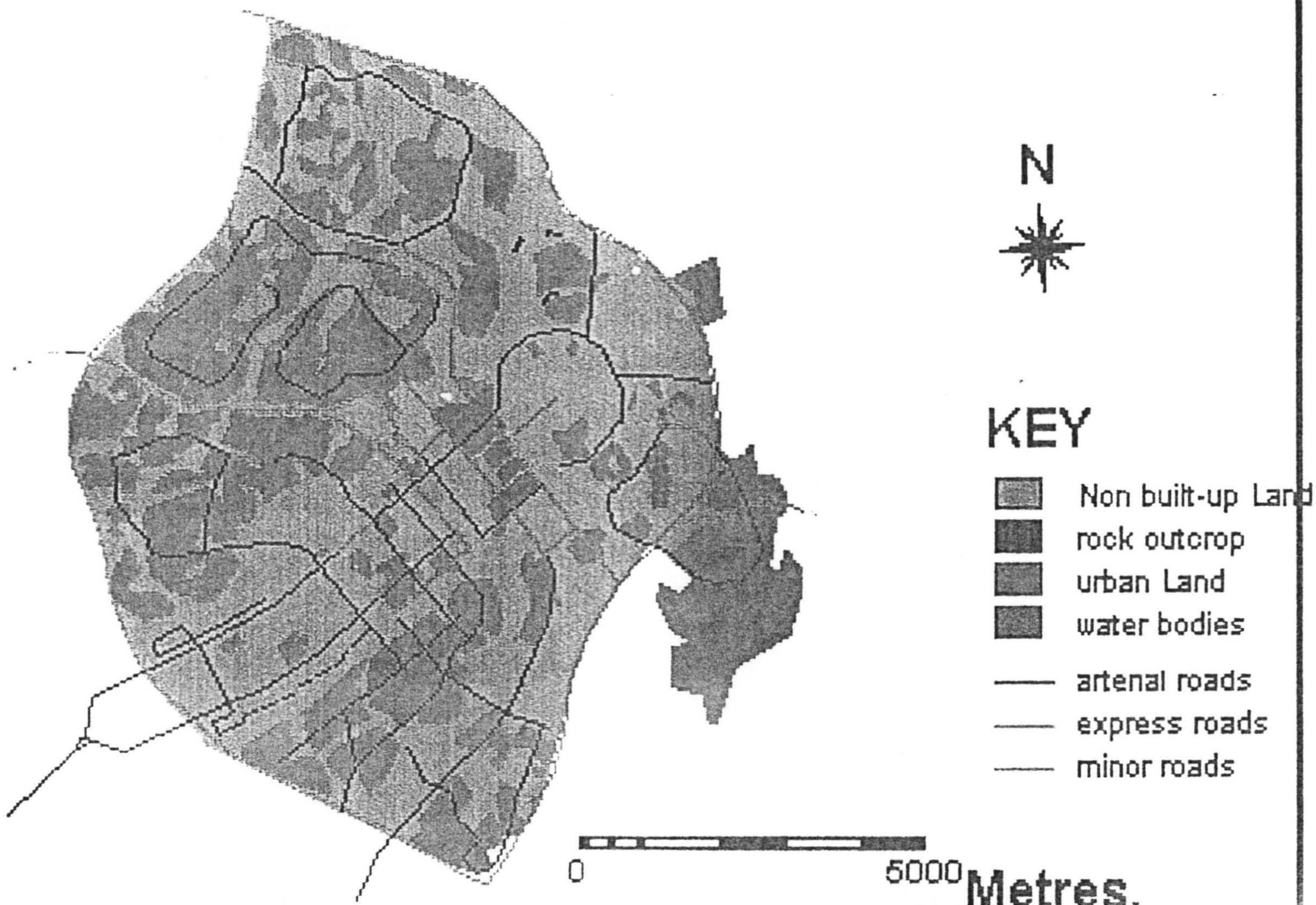


FIG.4.2 LANDUSE/LANDCOVER MAP OF ABUJA 1996



LABORATORY ANALYSIS OF 1996 SPOT IMAGE

4.2.0. Analysis Of Network Pattern.

Transportation systems integrate the various components of a city and facilitate interaction between the city and other locations. A city is so much dependent on the transportation systems that where the system is only rudimentary, landuse may of necessity aggregate around a point in space. In order words, cities expand or shrink depending on how efficient the transportation system is.

It is not only the physical size of a city that is dependent on transportation but, also how efficiently the economic systems operate. This is because it is the ease of contact between the producer and the consumers that gives meaning to any economic system. Thus, other things been equal where the transportation system is efficient and hence interaction facilitated, the economic system will operate effectively while the reverse is the situation where transportation facilities are lacking, since any given city has a more or less reciprocal relationship with other settlements, especially nearby ones, for it to survive and grow, there has to be an efficient transportation linkages between it and other locations. In other words, the planning for an efficient transportation system has increasingly been an important aspect of the design and development objectives of cities.

The road network is one of the important parameters in identifying the areas for urban development as it provides linkages between the settlement, entire road network in the study area has been classified under three types such as, the express ways the arterial roads and the minor roads.

The express way system are designed to have an initial cross section of three lane, in each direction for the inner part and two in each direction for the outer portion, in addition there is a right-of-ways reservation of four lanes for future expansion. The road links the various sector routes for inter city traffic and as bye pass for traffic. Designed for speeds of 100 km/hour, it is expected to accommodate all motorized vehicle types see Fig 4.3 and 4.4. The arterial system connects each sector with the expressway system and serves as a major traffic channel within each sector. While the minor roads (collector and local roads) links the neighborhood units and the arterial street system while at the same time providing access to minor travel within the sector and as a means to the dwelling units.

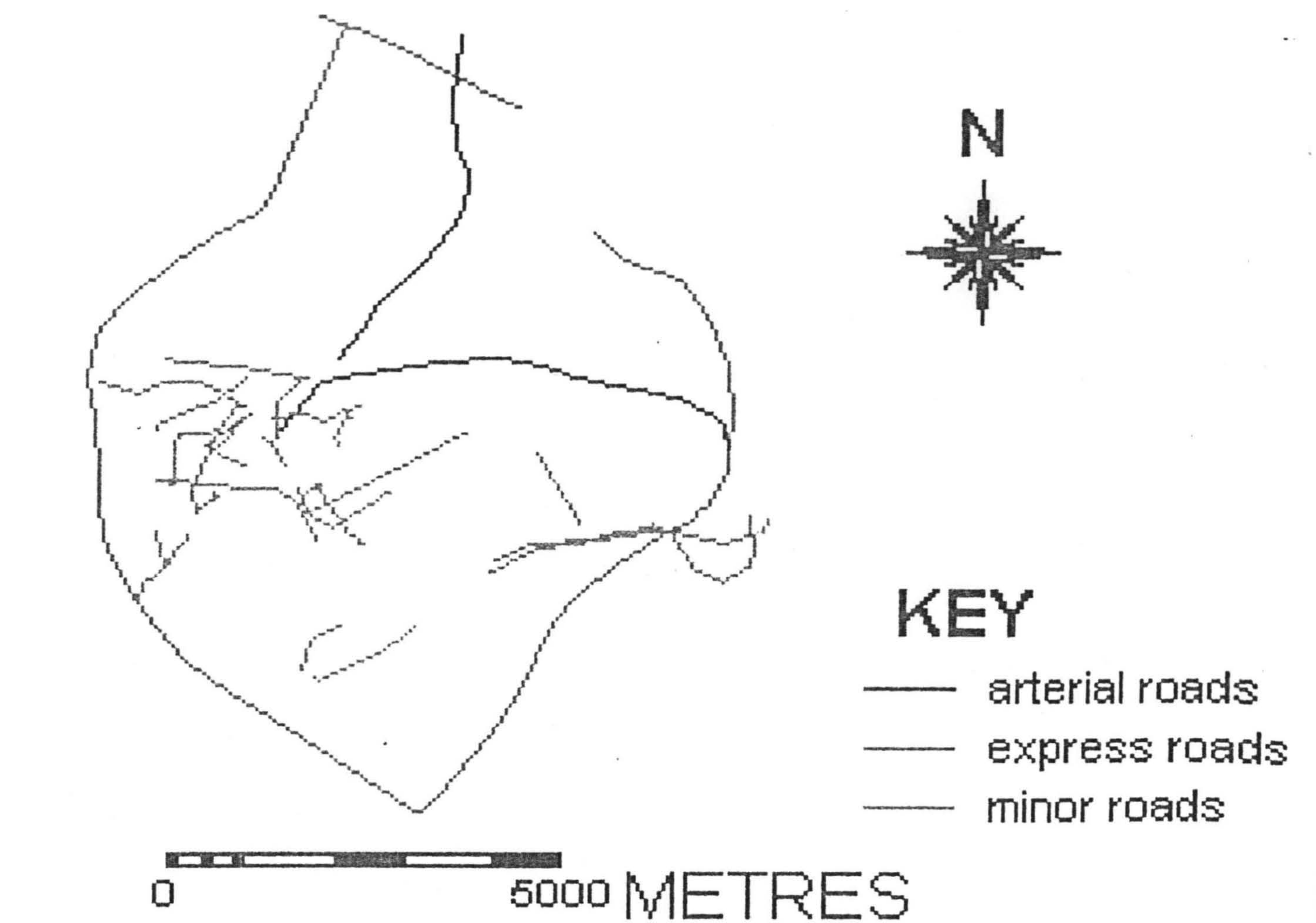
Based on the analysis from the 1982 aerial photograph of Abuja and presented in table 4.3 the total length of express roads stood at 11.52 km or 15.64 % of the distribution, while the arterial road was 26.88 km or 36.48% and the minor roads which top the list stood at 35.29 km or 47.39%. The reasons for this distribution is because the process of construction then is still at its developmental stage.

TABLE 4.3 CATEGORIES OF ROADS IN ABUJA AS AT 1982

Categories of road	length in km	percentage
Express roads	11.52	15.64%
Arterial roads	26.88	36.48%
Minor roads	35.29	47.39%
Total	**73.69**	**100.00**

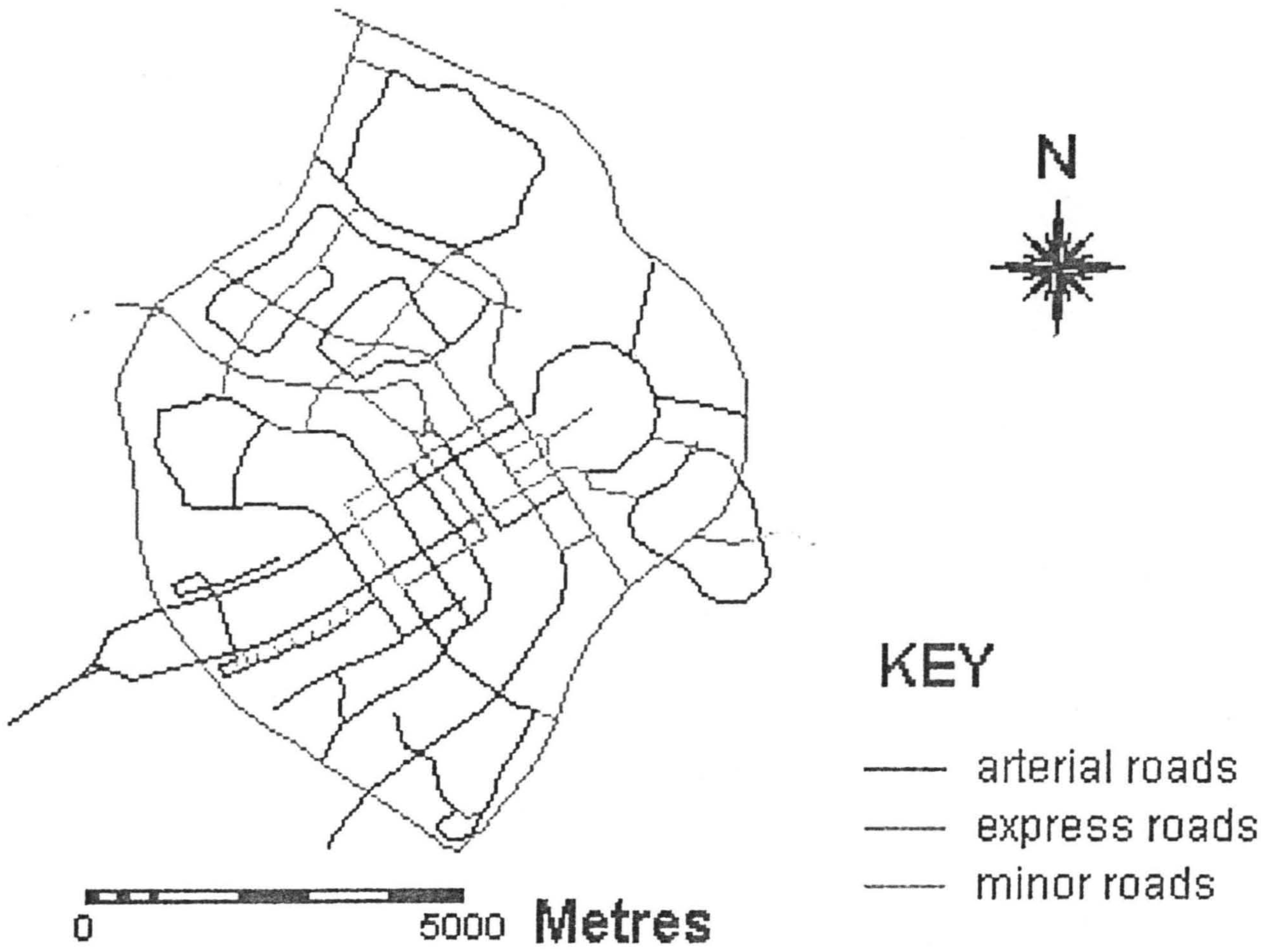
Sources: derived from 1982 Aerial photograph.

Fig. 4.3 Road Network of Abuja, 1982.



Source: Laboratory Analysis of 1982 Aerial Photograph

Fig. 4.4 Road Network of Abuja, 1996.



Source: Laboratory Analysis of 1996 SPOT IMAGE.

In 1996 out of the total 157.01 km of roads obtained from the analysis, the arterial road dominates the scene taken about 82.99 km (52.86 %) followed by the express road with 65.16 km (41.40 %) while the minor roads was 8.86 km (5.43%), there were however, significant changes first in the total length of roads between 1982 and 1996, first, it increases from 73.69 km in 1982 to about 157.01 in 1996, an increasing of 79.68 km. Secondly the general network pattern which were initially dominated by minor roads in 1982 was overtaken by arterial and express roads in 1996, the reason is simply obvious, in between this periods there were series of expansion of urban development and opening up of virgin land for physical construction an exercise which culminated in the construction of roads.

In order to fulfill the objective of the study, i.e to analyses the accessibility pattern for the two time epoch (1982 and 1996) – the proximity analyses of road network within the study area was conducted using the Modules in the Ilwis 2.2 (integrated land and water information system) computer software package and the resultant map is shown as fig 4.5 and 4.6.

Proximity analysis as it is used here refers to the process of determining the accessibility of the built-up area to the existing main road. The United Nations standard reference for residential building i.e. 300 meters buffer were used here.

For the purpose of landuse suitability analysis for further development, the express road, arterial roads and minor roads that are resolvable in the 1982 aerial photograph and 1996 SPOT image were analysed using the modules in the Ilwis 2.2 computer software package and three buffers were categories, thus: areas under 300m buffers were delineated in red, 500m buffers in yellow colour and areas under 700 buffered were shown in blue color.

These map have been generated for both 1982 and 1996 as shown in fig 4.5 and 4.6.

In 1982, 25.5 % of the built up area lies within 300 meters buffer indicating good connecting links between the built up land while 39.9% fall under 500 meters buffer and 34.6% were under 700 meters buffer. The situation in 1996 changed a bit as more areas 35.5% of the study area built-up land fall under 300 meters buffer with 42.1% and 25.4% under 500 meters and 700 meters respectively. Area under 300 meters buffer are considered best and good for residential purposes hence referred to as good proximity, while farther away indicate less and lesser proximity. In essence it is safe to say that the attendant urban expansion is match with good network connectivity.

TABLE 4.4 CATEGORIES OF ROADS IN ABUJA AS AT 1996.

Categories of road	length in km	percentage
Express road	65.16	41.40
Arterial roads	82.99	52.86
Minor roads	8. 86	5.43
Total	**157.01**	**100**

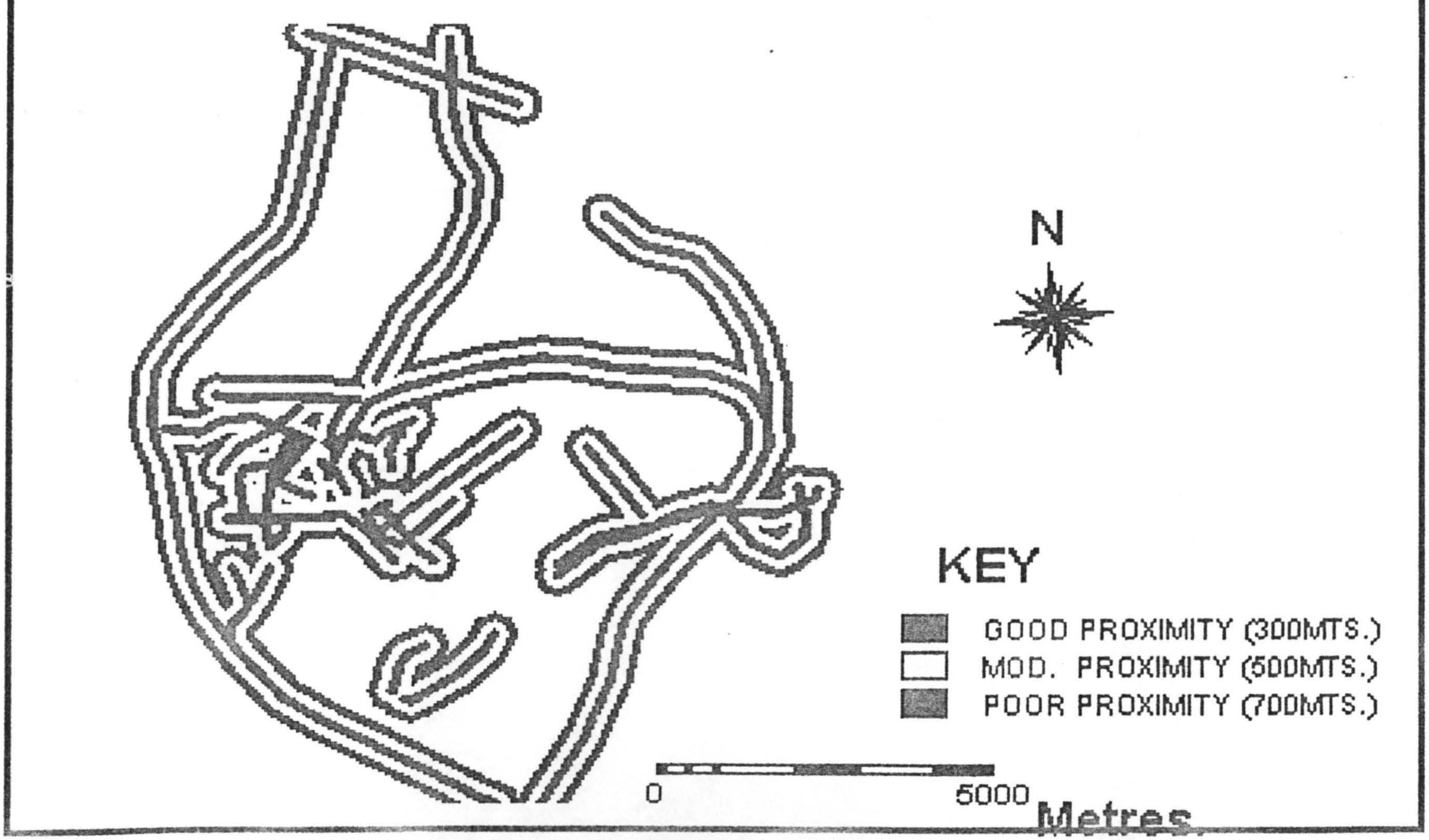
Source: Derived from the analysis of 1996 SPOT Image.

Since Abuja is the new capital city of the country. It is reasonable to expect that once the transportation lines are provided, the expected interaction with other regions will automatically flow. This indeed seems to be what is happening now as many private interests are participating in the provision of the mobile facilities needed to properly link the area and other regions. The accessibility of the city to the regions especially in terms of the cost involved is low.

The use of staff bus system as is done by some organizations, is not really a solution. This is particularly so because given the economic cost to the operators it may be difficult to sustain such system for long. The taxi system is not the solution either because of the cost to the user. This is why the need to encourage private bus stops operators whose routes could change depending on the spatial pattern of demand over the day. In a long run, however, what is necessary is a train service between the satellite towns and the city. If well operated this will be cheaper to the user and may cope better with the demand.

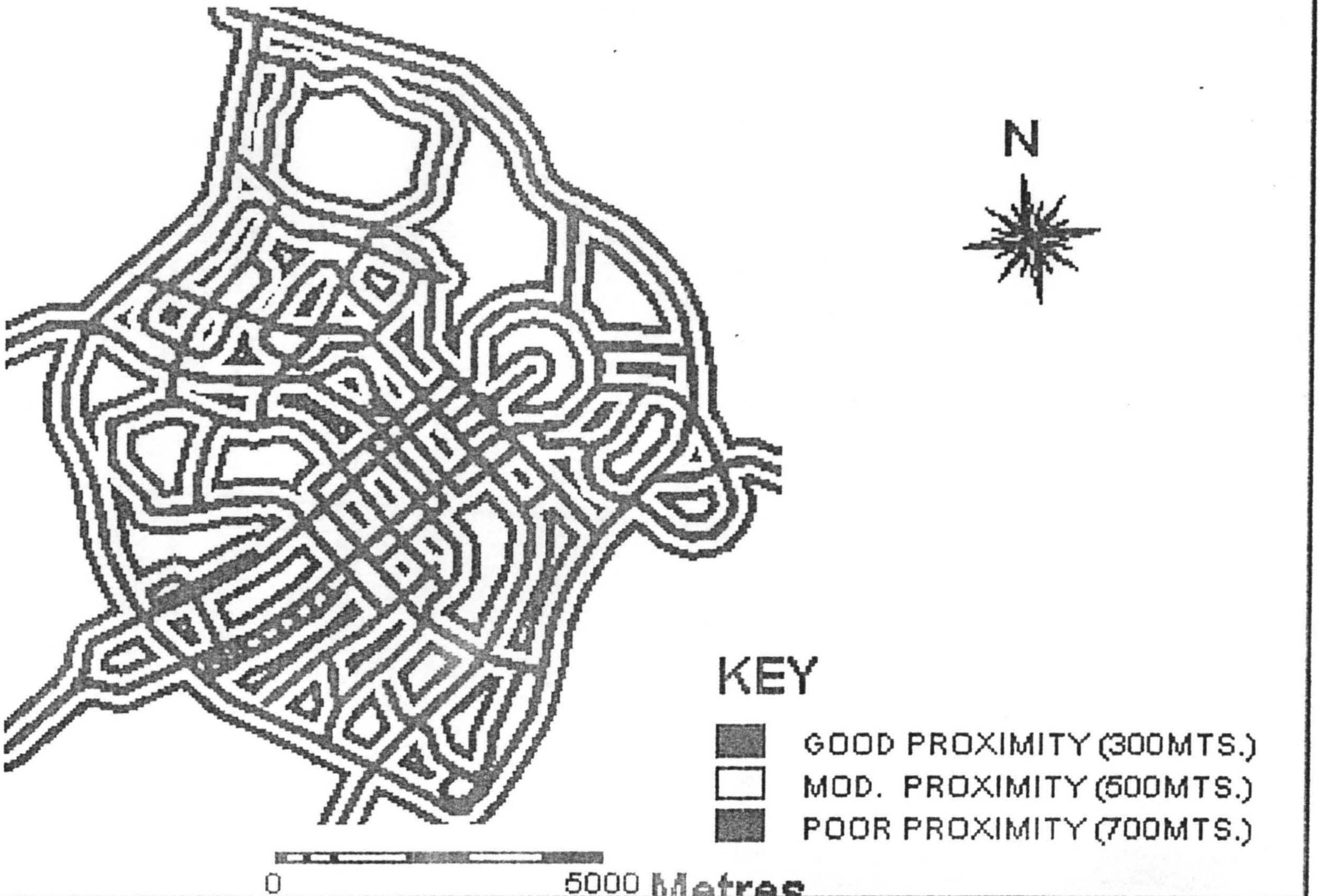
Whether or not Abuja will develop into a "problem city" such as Lagos will depend on how effective the transport system will be. There is no doubt that the provision of an efficient immobile transportation infrastructures has been planned for and is being executed steadily, never the less, there seems to be an emerging crisis in the provision and use of the mobile transport facilities. Not only is the city is fast developing a tradition which emphasizes private car use, but also the public transportation system, both in the city and between the region and the city is hardly satisfactory.

FIG. 4.5 ROAD ACCESSIBILITY MAP OF ABUJA 1982



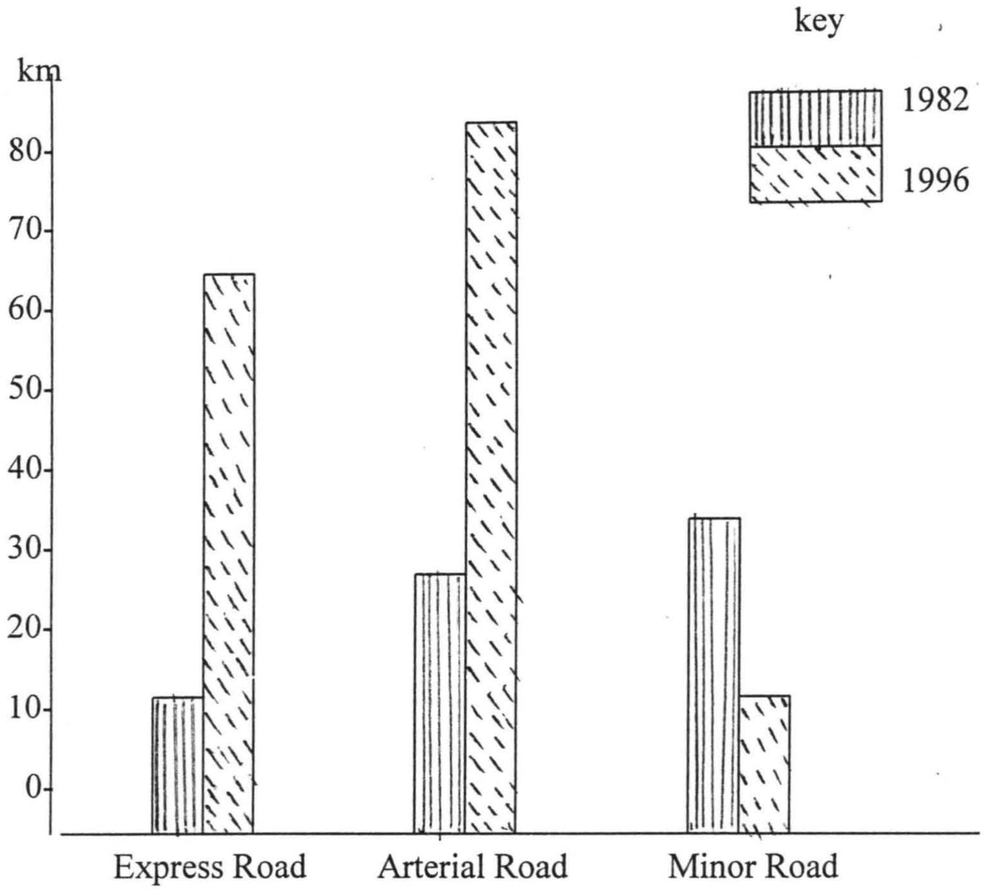
SOURCE: LABORATORY ANALYSIS OF 1982 AERIAL PHOTOGRAPH

FIG. 4.6 ROAD ACCESSIBILITY MAP OF ABUJA 1996



SOURCE: LABORATORY ANALYSIS OF 1996 SPOT IMAGE

Bargraph Showing Categories of roads in Abuja as at 1982 and 1996.



4.3 Analysis Of Landuse/Landcover Changes (1982 – 1996)

The landuse changes for the period between 1982 and 1996 is shown in table 4.5 from the analysis it was revealed that three classes of landuse/landcover classes recorded a decrease while the remaining two classes recorded an increases.

The built-up area or the urban land recorded the highest rate of increases i.e. from 266.05 hectares in 1982 to 2345.93 hectares in 1996 an increase of 2079.88 hectares that is to say much physical development occurred between 1982 and 1996. While it is relatively difficult to lay hold on statistics justifying this increase, the various milestone construction targets in 1984, 1986 and 1988 as enunciated in the master plan and the various physical planning for the city each year may have accounted for this growth.

For instance various units of detached houses, flats, multi-family house, institutional and recreational facilities were completed under the 1984 construction target, greater figures were completed in Garki, Asokoro, Wuse and Maitama in the 1986 construction target with the construction of, 35 km of express roads, 40 km of arterial roads and 78km of local roads the same scenario also occur in the housing construction of 1988 (Usman Sabo Ago 1988).

The eventual relocation of the federal capital to Abuja in 1992 and the attendant movement of people to Abuja from all over the country necessitate the need to erect more structures by both the government and the private stakeholders to meet the need of the teaming population. The road network also witnessed a tremendous increase of additional 806.26 hectares of land over and above what it used to be in 1982. This also revealed that this physical development Is not limited to building construction alone most of the road networks in 1996 had changed from minor and rudimentary to a wide dual carriage and all season express and arterial roads.

Talking about increase in lengths the development is also enormous. All categories of road increase from 73.69km in 1982 to 157.01 km in 1996 an increment of about 113%.

The Non-built up or non-urban land in the study area recorded the highest rate of reduction, it fallen from 5151.54 hectares in 1982 to 3005.57 hectares in 1996 i.e. a reduction of 2145-97 hectares between 14 years time period. This is because most of the gains recorded by the urban or built – up land as well as all categories of road network is at the expense of the non-built up land, in essence every unit of land converted to either built –up land or transportation routes in the study area leads to a proportionate reduction in the extend of non-built up land.

The proportion of the rock out crop in the study area also reduced between this time period what used to be 670.57 hectares in 1982 has reduce to 3.3 hectares in 1996. This is because physical construction in the form of buildings and roads had taken them up. Also within this period,

TABLE 4.5 <u>CHANGE DETECTION AMONG LANDUSE/LANDCOVER CLASSES1982 – 1996.</u>

Landuse /landcover Classes	1982 Arial extent in Ha	1996 Arial extent in Ha	Increase in Ha	Decrease in Ha
Non built up land	5151.54	3005.57	-	2145.97
Rock outcrop	690.57	3.3	-	687.27
Water bodies	16.41	13.49	-	2.94
Built up (urban)land	266.05	2345.93	2079.88	-
Road Network	842.41	1649.49	806.28	-
TOTAL	**7016.98**	**7016.98**		

Source: Derived from the analysis of 1982 Aerial photograph and 1996 SPOT Image of Abuja.

Parts of the water bodies and wetlands in the study area has been reclaimed with buildings and roads on them or their channels have been redirected, thus leading to the reduction in the total aerial extent of water bodies from 16.41 hectares in 1982 to 13.49 hectares in 1996.

In an attempt to relate the proportion of change of each landuse/landcover class to the over all change so as to determine which of this landuse/landcover recorded the highest changes, table 4.6 was generated from table, it can be seen that the highest percentage of decrease was experienced on the non-built up land to the urban category during period 1982 to 1996 it shows a decrease of 12.02% . While the built up land or urban category and the road network recorded in increases of about 30.35% and 14.10% respectively, see table 4.6. below.

TABLE 4.6. THE PROPORTION OF CHANGE OF EACH CLASS CATEGORY TO THE OVERAL CHANGE.

Landuse/landcover Classes	1982 Area Extent in Ha a	1996 Arial Extent in Ha b	Magnitude of Change in Ha (b-a=c)	Percentage
Non – built up land	5151.54	3005.57	-2145.97	-37-52
Rock outcrop	690.57	3.3	-687.27	-12.02
Water bodies	16.41	13.49	-2.94	-0.05
Built up (urban) land	266.65	2345.93	2079.88	36.35
Road network	842.41	1648.69	806.28	14.10
TOTAL	7016.98	7016.98	5722.34	100

Source: Derived from the analysis of 1982 aerial photograph and 1996 SPOT image of Abuja.

In order to address the policy thrust of this study, an attempt was made to visualized changed analysis in the study area clearly. That was done by re-grouping the various landuse/landcover classes into two, i.e. the build -up or the urban land and the non-built up or the non urban land.In this reclassification the urban land i.e landuse/land cover classes under any intensive uses or covered by man- made features included here is the built up land and road network. Secondly the non-urban land comprising all landuse/landcover classes not covered by man-made features in this group are non-built up land, rock outcrops and water bodies. Thus we now have two main classes as shown in table 4.7 below.

TABLE 4.7 <u>URBAN/NON URBAN CLASSIFICATION</u>

Landuse/landcover Classes	Arial 1982 Extent in Ha	1996 Arial Extent in Ha	Increase in Ha	Decrease in Ha
Non urban land Urban land	5858.32 1158.46	3022.37 3994.65	- 2836.16	2836.16 -
TOTAL	**7016.98**	**7016.98**	**572.35**	

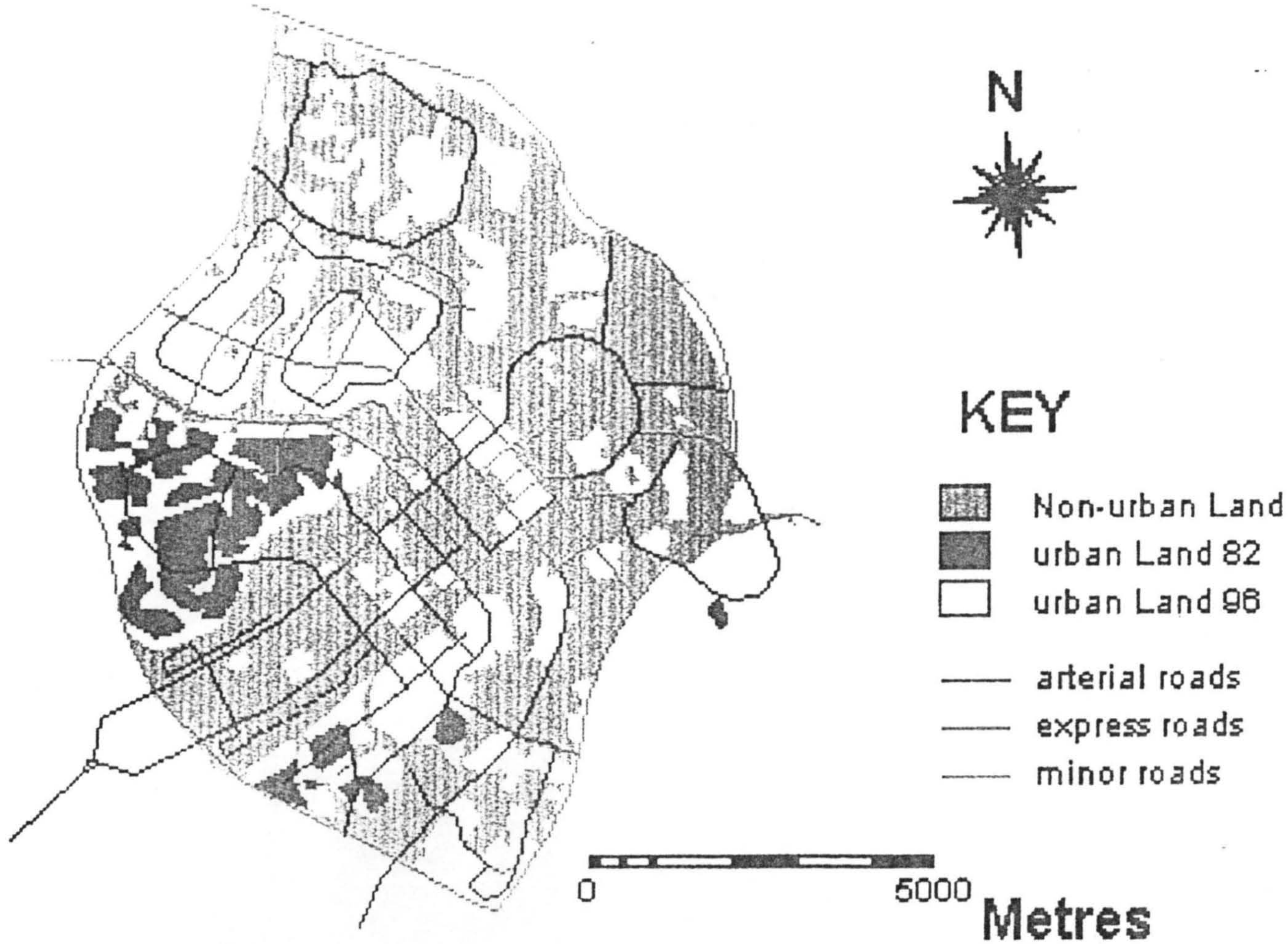
Source: Obtained from the analysis of 1982 Aerial photograph and 1996 SPOT Image or Abuja.

From table 4.7 5859.52 hectares of land are unurbanised in 1982, that figure has drastically reduced to 3022.27 hectares of land in 1996 while the built-up land rose from 1158.46 hectares in 1982 to 3994.98 hectares in 1996. Specifically if a Total of 2836.16 hectares of land were urbanized between 1982 and 1996 (14 years) in the phase 1 development. It then means that on the average 202.585 hectares of land was taken over by urbanization each year. If the same figure is projected to the year 2010 then about 6020.5 hecters of Abuja land will be urbanized during the year 2010.

One of the major objectives of this study is to determine the physical development trends of the study area from 1982 aerial photography and the 1996 SPOT Image. Form the analysis conducted it has been revealed that there was a resounding increase in the natures, pattern and extent of physical structures especially in the built up land and road network. Following this finding and considering the planning implication. The master plan for the administrative capital of Nigeria may not have envisaged this rapid growth.

Be that as it may, the physical development has grown tremendously between 1982 and 1996, even up till now. Following this growth rate the ministry of the federal capital territory through the assistance of the federal government have initiated relevant policies and trends in term of socio-economic development of the city in particular and the F.C.T 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 growing needs of the residents. However, population is not only an inhibiting factor in socio-economic development but also a potential obstacles to the achievement of these set goals and targets in the development plan.

FIG. 4.7 LANDUSE/LANDCOVER CHANGE MAP OF ABUJA



Source: Laboratory Analysis of 1982 Aerial Photograph & 1996 SPOT IMAGE.

CHAPTER FIVE

5.0 SUMMARY RECOMMENDATIONS AND CONCLUSION

The analysis of the data presented in chapter four naturally leads to certain recommendations and conclusion, relating to the objectives of this research.

5.1 Summary Of Major Findings

From the analysis, one can readily see that there has been a significant reduction in the area of non- built up land between 1982 and 1996 . Such a reduction was also experience in area covered by rock out crop as well as water bodies. However area under built-up or urban land and road network increase greatly during the period under study. From other studies conducted in the area, the rapid increase in the population of Abuja, arising from the relocation of the federal capital in 1992, as well as the construction targets of the government in 1984, 1986 and 1988 with various degree s 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 1996.

Beside during the period under study, the length of roads within the study area also increase and because of that increment the proximity analysis of Abuja in 1996 indicate better connectivity between the existing roads and residential apartment than what is obtainable in 1982, the implication is that greater areas are accessible with ease in 1996 than in 1982.

It must be noted, however that some of the structures are so small that they cannot be resolved by the aerial photograph and Spot image, in addition to the fact that they are roofed with materials which made their spectral signature not to differ from the surrounding non-built up land

It will be expected that there will be construction of access road under residential and institutional layout, but because some of this roads cannot be resolved by the spot image, also the possibility of distortion the mapping of such roads will create, they were left out the express road, arterial and some minor roads were mapped.

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 or physical construction, whereby a naturally active channels have been rendered inactive. This reduction potent a grave implication because there is a reduction in the rate of albedo on the rivers. This is probably 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 building and road construction, all these put together have reduced the level of water bodies in the area between 1982 and 1996

5.2 Recommendations.

The relationship between perceptions of land as physical resources and as an aspect of the physical environment is complex. This is so because the agencies concerned with urban development are quite distinct from those charged with the responsibilities for conservation. Nevertheless, it should be noted that though there is a 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 inadvertent and undesirable effects of such human pressure requires 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 neccesary to have complex models where evaluation of the landuse policies can be fully tested for this, continued data collection and research into the relationship between landuse and environment is an urgent need, if the impending environmental problem is to be averted. The use of satellite data provide the perspective for viewing regional problems and the repetitive coverage for forecasting seasonal changes, both are imperative when making decisions about the use of renewable natural resources and when planning major public work projects.

It will be extremely useful for Nigeria to invest on the provision of facilities to receive satellite data for monitoring our environment. The establishment of a National Center for Remote Sensing in Jos Plateau State by the government of Nigeria is a right step in the right direction; such center should be fully equipped with up-to-date data especially for research work. Acquisition of this imagery should be able to classify the study area appropriately, thus, making sequential time series analysis possible in order to understand the dynamics of environmental processes.

Although, it is noted that computer assisted classification methods could be used to study landuse/ landcover changes visual interpretation methods requires less training and expensive equipment than using computer assisted techniques. Also, it is a simple method that is more practical for developing countries with limited low budgets, manpower constraints and inaccessibility of computer technology.

More sophisticated approach of monitoring the development should be adopted for our cities. It is time for Nigeria to computerise her development control system so as to properly track down development as well as providing a laboratory atmosphere for the consequence of deviations. Computerising plan monitoring will ensure compliance and make physical development control cheap to be under taken by the government and lastly a vigorous campaign exercise should be carried out to demonstrate the use, importance and capabilities of remote sensing techniques to various authorities in the federal state and local government levels.

5.3 Conclusion

The basic objectives of the study, were to determine the capability of integrated remote sensing in analyzing changes in the physical development of Abuja within two time epoch (1982-1996) with a view to providing maps statistics and report for planning purposes. The magnitude and the location of such changes have been assessed and recommendation passed for management such a rapidly urbanizing town.

The analysis shows that there has been a tremendous lateral expansion of the built-up land or urban centers at the expense of the non-built up land or non-urban area. To be specific an average of 202.59 hectares of land are being urbanised yearly. Such a rapid physical development if not properly managed can lead to a damaging effect on the environment since urban growth leads to the extinction of the natural vegetation to be replaced with paved surfaces, the more obvious effect can lead to soil erosion and increase in Albedo, a major factor in desertification, thus in an attempt to increase physical development by way of rapid urbanization a major risk of environmental hazard is at state. Whether or not this lateral expansion conforms with the master plan for the phase 1 development scheme is a subject for further enquiry therefore it is expected that further research on the application of remote sensing to master plan implementation and monitoring will take a leap from the result of this study.

BIBLIOGRAPHY.

Ademola O. and Seneye A. (1993), Land use map accuracy criteria: photogrametric Engineering and Remote Sensing 42 95) pp 671 – 677

Adeniyi .o.p(1980). Landuse and change analysis using sequential aerial photography and computer techniques. Photogrammetric engineering remote sensing vol. 40 no.11 pp1447-1464.

AdeniyI 0 .P. (1985): Digital Analysis of multi temporal landsat and data for landuse/landcover classification in a semi-arid area of Nigeria. Photogrammetric engineering and remote sensing vol. 52 No11 pp 1761-1774).

Adeniyi o.p.(1986): Role of remote sensing in landuse planning in Mkambue .M.(ed).Application of remote sensing techniques in Nigeria.

Adeniyi O. P. (1987) The Presidential address presented at the Nigerian society of Remote Sensing (NISORS) Tenth National Conference at Bayero University Kano vol. 4 – 7

Adeniyi O.P (1990) "Remote Sensing Application in Agricultural Development and Management" invited paper presented at Sweden.

Adepoju Onibokun (1990) "the implementation of master plan for a Federal Capital territory-Abuja-an appraisal" workshop paper-4.

Alexander R. H.(1973) land classification and analysis using E. R. T. S.-1. Imagery in CAPETS, SYMP, on significant results of remote sensing obtained from ERTS-1 section 3,923-930.

Anderson J. R.; Hardy E. E., Rouch .J .I (1972). A Landuse classification system for use with Remote sensor data: U. S. Geological survey circ 671 Washington D. C.

Anderson,James, Ernest E. H. ,Rouch J. T. Witer R. E. (1976) A Landuse and Landcover classification system for use with Remote sensor Data U. S Geological Survey professional paper 964.

Areola O.(1962) Changing resources system and problems of development planning in Nigeria, resources management and optimization vol.2(1) pp 41-71.

Areola O.(1986) Introducing remote sensing techniques Routines Surveys in Nigeria, in application of remote sensing and techniques in Nigeria.

Baba J. M. "the regional impact of Abuja"(1990) Abuja past present and future workshop paper 20.

Bale J. B. Conte O. Geolicy, and Simonet D.S.(1974).Remote sensing application to resource management problem in the Sahel,U.S.Agency for international development department of state Washigton D.C.

Burley T. M (1961) Land use or land utilization professional geographers 13 (6) pp 18 – 20

Cambel M.G (Ed) 1987 Land use and environment. An antropology of reading Chicago iii A. M Six planing officials for environmental studies div.

Cappock J.T. and Gebbert L.F.(1978), Landuse, landform and country planning. In Munder N .F.(ed) review of U .K statistical sources vol 8 Oxford pergamon.

Clawson M. and Steward C.L (1965) Land use information: A critical survey of US statistics including possibilities for greater uniformity Baltimore the John hopkins press for resource for the future Inc.

Curtis,Virginia(ed)(1973,) Landuse and environment. An anthropology of reading: Chicago 3. An six planning 0fficial for environmental studies Dir.

Curran P.J. (1985) principles of remote sensing Longman scientific and technical England.

F.G.N. "official gazette"No.65(14) 1978:Landuse decree.

Haggets P. (1965) Locational analysis in human geography. New York st. Martins press hall oxford pergamon press.

Harris R. (1987) Satellite remote sensing (An introduction) T.J.press (padson)ltd. 1987, padstow cornivall.

Henderson F.M (1982) Land use analysis of Radar Imagery photogratric Engineering and remote Sensing vol. 41 pp 307 – 319.

Hiegreen D.S (1979) Urban/suburban landuse analysis in cowell R.N (Ed) mannual of Remote Sensing second edition vol. Ii American society of photogramentry vieginia 571 – 666

Hoffee R.M. and staff (1975): Natural resources mapping in mountains. Terrain by computer analysis of ERTS-Satellite Data. West latyette,indiiana, purdue university. Agricultural experiment station and laboratory for application of remote sensing research bulleting off 19, 124 p.

James O Whealer and Peter O. Muller (1981) Urban land use theories in economic geography pp 142 – 146 John Willey and Sons Inc.

.Krishna K. M. (1990) "can satellite Replaces Arial photograph?" A photogramentry view I..C.journal 1990 – 1991

Lacoste Y.(1973):An illustration of Geographical warfare bombing of the dykes on the red river, north vietrian antipode 5(2) 1-13.

Leokes G .L jr.(1977).Specification for landuse and landcover associated maps U.S Geological survey open file no 77-55, 103 p.

Lintz and Simonett D.S. 1976(eds) Remote sensing of environment. Addison-Westly publishing company inc U.S.A.

Lillesand T.M and Kieffer R.W.(1979) Remote sensing and Image interpretation (2nd edition) John Wiley and sons USA.

Lo, C. P. (1985) Applied Remote Sensing, Longman Scientific and technical Longman House Burnit Mill Harlow Essen

Lunney P.R and Dil H.W Jr. (1971) uses potentials and needs in Agriculture and forestry National Academic sciences washington D.C

Mabogunje A. L.(1977) cited in Federal Capital development Authority, Abuja master plan.

Mabogunje A. L.(1978): Geographic perspectives on Nigeria development in Oguntoyinbo et al ed. A geography of Nigeria development: Heinemann education book Nigeria ltd. Pp 1-13.

Odenyo V.A.O and Pettry P.E. (1977): Landuse mapping by machine processing of landsat 1 Data In photogrametric Engineering and remote sensing vol XL LLS, No4 PP515-524

Onokerhoraye A.G and Omuta G.E.D.(1986) Urban systems and planning: Editorial committee Geography and Planning series, University of Benin- Benin city, Nigeria.

Odewumi S.G (1972) Change Detection on the physical Development of the University of Lagos using sequential. Aerial photographs paper presented at the Nigeria society of remote sensing conferences, Ibadan (1972) .

Pilon P.G Howarth P.J. Bullock, R.A and Adeniyi P.O (1988) An enhanced classification approach to change detection in semi-arid environments. Photogrammetric Engineering and remote sensing vol 54 NO 12 PP 1706-1716.

Price L. C. (1990): Remote sensing of the sahelian environment. A review of current state and future prospect . London George Allen and Unanis.

Pahl R.E (1971) : "Planning and the quality of urban life" paper to the town and country planning summer school southampton 1971.

Robert D and Barker et al (1979) :Landuse and landcover mapping from aerial photographs. Photogrametric Engineering and Remote sensing vol. 45, PP 661-668.

Rubee D.S and Thie J. (1998): Landuse monitoring with lands at Digital data in Southwestern Manitoba, proceeding of the fifth Canadian symposium on remote sensing Victoria British Columbia PP 136-150.

Rudd (1974) Remote Sensing – A better view Wadsworth publishing company Inc. Belmouth Carlifonia. 45 Sabins F.F Jr 1978 remote sensing principles and interpretation W.H feeman and company san-Franscisco

Smith T.f, Vingenderen, J.I. and Holland E.W (19 77) : A landuse survey of developed Areas in England and Wales, Cartographic Journal 14 (1) 23-29.

Stow D.A.L.R. Tinney and J.E. Esters (1980) Deriving landuse/landcover change statistics from landsat: A study of prime Agricultural land proceeding of the fourteenth international symposium on remote sensing of environment, Ann Arbor, Michigan, PP 1227-1237.

Short N (1982) "The landsat Tutorial Workshops", National Aeronautics and space Administration Washington D.C. NASA preference publication 1078.

Thromer, N.J, Wand, Senger L, (1969): landuses mapping of Southen-Western United state from Satellite images AA89-579. American Astronautic society Nat I meeting New Mexico state university Lascruses.

Townshend J.R.G (1981) Terrain analysis and remote sensing London George Allens Unuis

Todd W.J. (1977) urban and regional landuse change detection in semi-arid environments Photogrammetric Engineering and Remote sensing Vol. 54 No 12 PP 1709-1716.

Weils (1994) "spot Development", A seminar paper presented at National seminar on Remote sensing for planners and decision makers.

Wuredu, Y.K.S (1989):Development plans in planning in Nigeria, Wuredu Y. K. S. and Wannop M.A. (eds) Gower Aider shot, England 1989.

Vegos P.L. (1972): A procedure for the use of small scale photography in landuse mapping NASA forth resource laboratory manned-space-craft center.

Wilson J.R. jnr, C. Blackman and G.W. spum (1976): landuse change Detection using landsat data proceeding of the fifth annual remote sensing of earth resources conference. Tullahamm, Tennessee, PP, 79-91.

U.S department of Agriculture (1972) Conservation needs Inventory committee 1971 Inventory of soil and water resources special publication no 86 pp 116.