ASSESSMENT OF URBAN GROWTH USING AERIAL PHOTOGRAPH AND SATELLITE IMAGE
(A CASE STUDY OF MINNA TOWN)

BY

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DECLARATION

I hereby declare that this thesis was carried out by me under the supervision of Dr A.S. Halilu of the Department of Geography, Federal University of Technology, Minna. Niger State.

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CERTIFICATION

This is to certify that this thesis has been accepted and approved by the Department of Geography, Federal University of Technology, Minna as meeting the requirements for the award of Masters degree in remote Sensing Applications.

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DEDICATION

This project work is dedicated to the Glory of Almighty God and also to the entire Raji family.

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ABSTRACT

This study explores the possibility of using image interpretation technique to assess the rate of growth and spatial pattern of urban built-up land use in Minna town between 1982 and 1994. Land cover maps of 1982 and 1994 were produced by visual interpretation of aerial photographs and SPOT satellite image respectively. The two maps were brought to the same scale and land use map of 1982 was superimposed on land use map of 1994. The result revealed the change that occurred in land use between over the years which was the developed into map of increase in urban built-up land use between 1982 and 1994. The area covered by each of the classified categories of land use was computed for 1982 and 1994 and the areas of increase in built-up portion between the periods were computed.

The estimation of area of each categories of land use for 1982 revealed that urban built-up land use, farmland, forest, water and rock occupied 336.0, 400.0, 3600.9, 55.1 and 88.0 hectares respectively and the percentage coverage by each categories of land use to the total area were 7.5, 8.9, 80.38, 1.23, and 1.96 percent respectively. The 1993 land use area estimate shows that the urban built-up portion, farmland, water and rock category were 664.0, 1000, 2672.9, 55.1 and 88.0 respectively while the percentage of area coverage by each category of land use were 14.82, 22.32, 59.66, 1.23 and 1.96 percent respectively. The estimation revealed that the built-up area land increased by 328 hectares in 1994, the vegetal cover (farmland and forest) produced a decrease in area coverage by the same 328 hectares, the expansion of the built-up area led to reduction in vegetal cover only. Rock and water did not change during the study period. The estimation of the rate of change per year revealed that the built-up portion, farmland, and forest changes by +27.33, +50.00,

water did not change during the study period. The estimation of the rate of change per year revealed that the built-up portion, farmland, and forest changes by +27.33, 50.00 - 77.33 hectares every year over the period of study but rock and water did not change.

The emerging spatial pattern of Minna was irregular which is seem to conform with the multiple nuclei theory of urban growth.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Remote sensing is the act and science of obtaining information about object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation (Lillesand and Kelfer, 1983). It is also classified as a branch of photogrammetry (Wolf, 1983) where photogrammetry was defined as the art, science and technology of obtaining reliable information about physical object, environment through process of recording and interpreting electromagnetic energy and other phenomenon (American Society of Photogrametry, 1983).

The techniques of Remote Sensing has a very wide range of applications due to large volume of data acquired. Most of the land use and land cover survey make use of Aircraft and Satellites and Interpretations of photos produced from aerial photograph.

Photo interpretation for map making is made possible with aerial photo mosaics. This could be used to produce township map, topographic maps and other maps. The application through the use of photo interpretation can also be extended to the study of urban growth and urban land use, estimation of population of urban centre, residential patterns (e.g. types, size, form of building), spatial arrangements of building as well as pattern of road network.

The use of aerial photographs and satellite imagery in making population estimation is being canvassed as a way of overcoming the difficulty in obtaining up-to-date and reliable information on population (Areola, 1986).

Urban planners and city managers attribute the inefficiencies of planning and management efforts to lack of reliable and up-to-date information on the growth of cities.

Okigbo (1985) noted that our planning will continue to be scrappy, tenuous and unreliable until some probity is restored in compilation, collection and free publications of statistical data. When these are done. the problem of slum. traffic congestion, pollution, flooding etc. will become a thing of the past because adequate provision might have been put in place to guide against them.

The most important and reliable information, the population figure, that forms major criterion used in planning cities had not been adequate. Only the 1953 and 1991 population census were accepted due to some percentage eligibility, but those of 1963 and 1973 were subjected to dispute due to inflation of figures in some parts of the country and were not accepted.

The possibility of employing Remote Sensing data to assist in the study of urban qualities have been suggested by Moore (1990). Moore suggested the use of Remote Sensing data as an alternative means of effectively measuring housing qualities, when he noted the growing concern on the inadequacies in urban data.

Therefore, this study attempts to use Remote Sensing techniques to assess the growth or expansion of Minna town between the period of 1982 and 1994 using aerial photograph, stereoscope, satellite image (SPOT, 1994) and urban map of the area.

1.2 STATEMENT OF THE PROBLEM

Minna is the capital of Niger State. It is seen to be growing faster with increasing demand for land either by government or private individuals. With this development, there is increase in built up area which call for effective planning of the town, hence the need to study the rate of expansion of the town. It is therefore necessary to ask the following questions:

a) Is it possible to use Remote sensing techniques (aerial photographs and satellite imagery) to estimate the increase in the built up areas in Minna Town between 1982 and 1994?

b) Is it possible to know or study the rate of growth as well as the percentage changes of the built-up area between the periods under study?

c) Can Remote Sensing techniques through the use of Aerial photographs and satellite images be used for future planning?

d) What is the pattern of growth? Does it conform with the existing theories of pattern of urban growth?

1.3 AIM AND OBJECTIVES OF THE STUDY

The study aimed at assessing the percentage rate of change or expansion of Minna Town during the period of 1982 to 1994, using remote sensing application through aerial photographs and satellite image interpretation.

This aim could be achieved through the following objectives:

a) To examine and produce the land use maps of Minna Town between the period under study.

b) To use land use map produced to estimate the built-up area and its increament for 1982 and 1994.

c) To study the rate of expansion of the Town based on increase in the size of built-up area for the period under study.

d) To estimate the percentage changes in the size of the built up area.

e) To examine whether the pattern of growth is in conformity with the existing theories of urban growth and patterns.

1.4 JUSTIFICATION/RELEVANCE OF THE STUDY

The study would aid the planners in future to care for the problems of slum, traffic congestion, flooding etc. can be adequately catered for.

It would also help the government in resource allocation and distribution of social amenities in the Town.

It would also assist researchers investigating on other issues to relate the findings of this thesis to their work.

1.5 SCOPE AND LIMITATION OF THE STUDY

This research work is limited to Minna Township covering Minna Local Government and part of Chanchaga and Bosso Local Government Councils where the expansion is noted.

The focus is to produce the land use map and to estimate the built-up area in order to determine or assess the percentage of expansion over the period under study.

The built-up area under study includes residential, commercial and services, industries, transports, communications and utilities, play ground, all of which can be interpreted from aerial photograph and satellite imagery (Lillesand and Kiefer, 1989).

One major factor limiting this research work is the inability of the researcher to acquire set of aerial photographs of Minna taken at different years. This limit the research work to the use of only one aerial photograph of the research area in conjunction with the satellite image and base map.

If series of aerial photographs covering the area taken at different periods were available to the researcher, it would have been possible to study the rate of expansion not only over the long period under study but also between the period when the photographs were taken.

Another factor limiting this research is in the area of satellite image to be used for the study. The satellite image available did not cover the entire study area and this will necessitate the use of anxillary data in producing the land cover map.

1.6 THE STUDY AREA

Minna is the capital of Niger State and is located in the middle belt of Nigeria. It is located on Latitude 09°37′ North and Longitude 06°33′ East. Niger State shares boundary with Kebbi State in the northern part, Kwara State in the West, the Federal Capital Territory in the South-East and Kogi State in the South. Figure 1.1 shows the position of Niger State and Minna in the map of Nigeria.

1.6.1 CLIMATE

The mean annual rainfall taken for a long period of years is 1334mm and experiences highest rainfall in the month of September. The mean temperature of the area is highest in March rising to about 30.5°C and the lowest is about 25.1°C in the month of August.

1.6.2 EDUCATIONAL FACILITIES

There are many primary and secondary institutions distributed within the study area. So also are the institutions of higher learning which contribute to the rapid growth of Minna Town apart from being the seat of Niger State Government.

Some of the institutions of higher learning located in the Town include:

The Federal University of Technology

Niger State College of Education

Niger State School of Nursing and Midwifery

Nigerian Police College

Raw materials Research Institute

College of Advance Legal Studies etc.

1.6.3 VEGETATION

Minna is located in the middle belt between the northern and southern part of Nigeria. Therefore, the vegetation is transition between the forest in the south and the grassland in the north. It can thus be said that Minna shared both the Forest vegetation towards the southern ends and diminishes to savannah region towards the northern part of the city.

1.6.4 WATER SUPPLY

The major source of water supply for the people of Minna is Tagwai reservoir. There is also Bosso reservoir, which supplies water to Bosso community although the reservoir is being augmented by the Tagwai reservoir. The same Tagwai reservoir also augments the reservoir that supplies water to Bida Town.

1.6.5 MEDICAL FACILITIES

There are many medical facilities of different grades located within Minna Town and the environ. Among them is the state owned General Hospital and many standard private hospitals like the I.B.B. specialist hospital and Bay Clinic. Other categories of health facilities are health centres, maternity centres and dispensaries owned by the local governments.

1.6.6 TRANSPORTATION FACILITIES

Minna has a very good road network. There are major roads connecting the Town to other major Towns e.g. Minna-Zungeru road, Minna-Bida road, Minna-Suleja road and Minna-Kaduna road. It is connected to other parts of the country by railway and major roads. The railway line that runs from Lagos to the northern part of the country traverses through Minna.

The major means of transportation within the city are taxi cabs, buses operating on commercial basis and private cars, government intra-city buses as well as the motor-bikes popularly known as Okada.

Figure 1.2 is a map of Niger State showing Minna Town, the study area.

1.6.7 ATMOSPHERIC POLLUTION

The major pollutants identified in the city are dusts, carbon monoxide (CO) and Suphurdioxide (SO_2).

The level of atmospheric dust particles is high in the dry season, particularly during harmattan period between December and March. The harmattan wind brings a lot of dust particles from the sahara desert.

The Carbon monoxide (CO) is the result of smokes from vehicles and industries. This is on the increase everyday with the increase in the number of traffic and industries in the area.

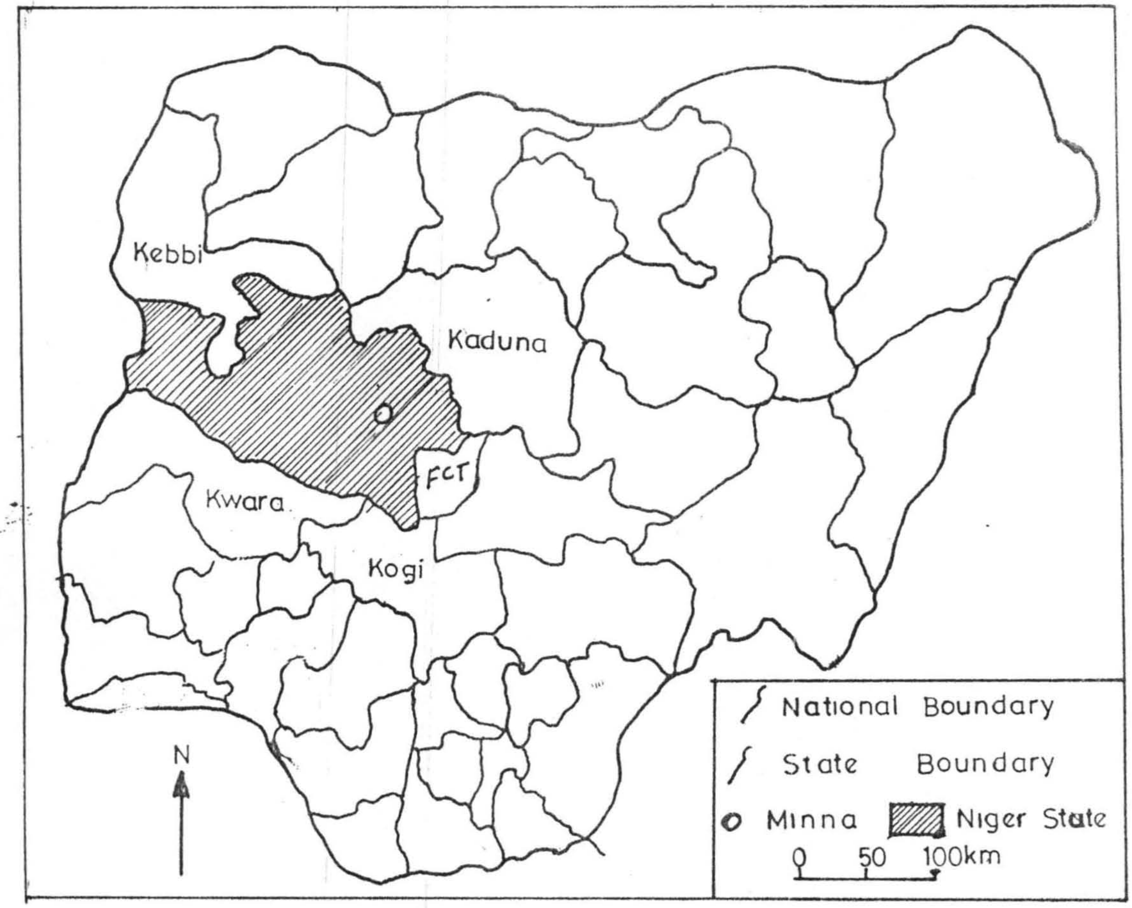


Figure 1.1 Map of Nigeria Showing Location of Niger State & Minna The National Setting

Source : Niger State Ministry of Land and Survey

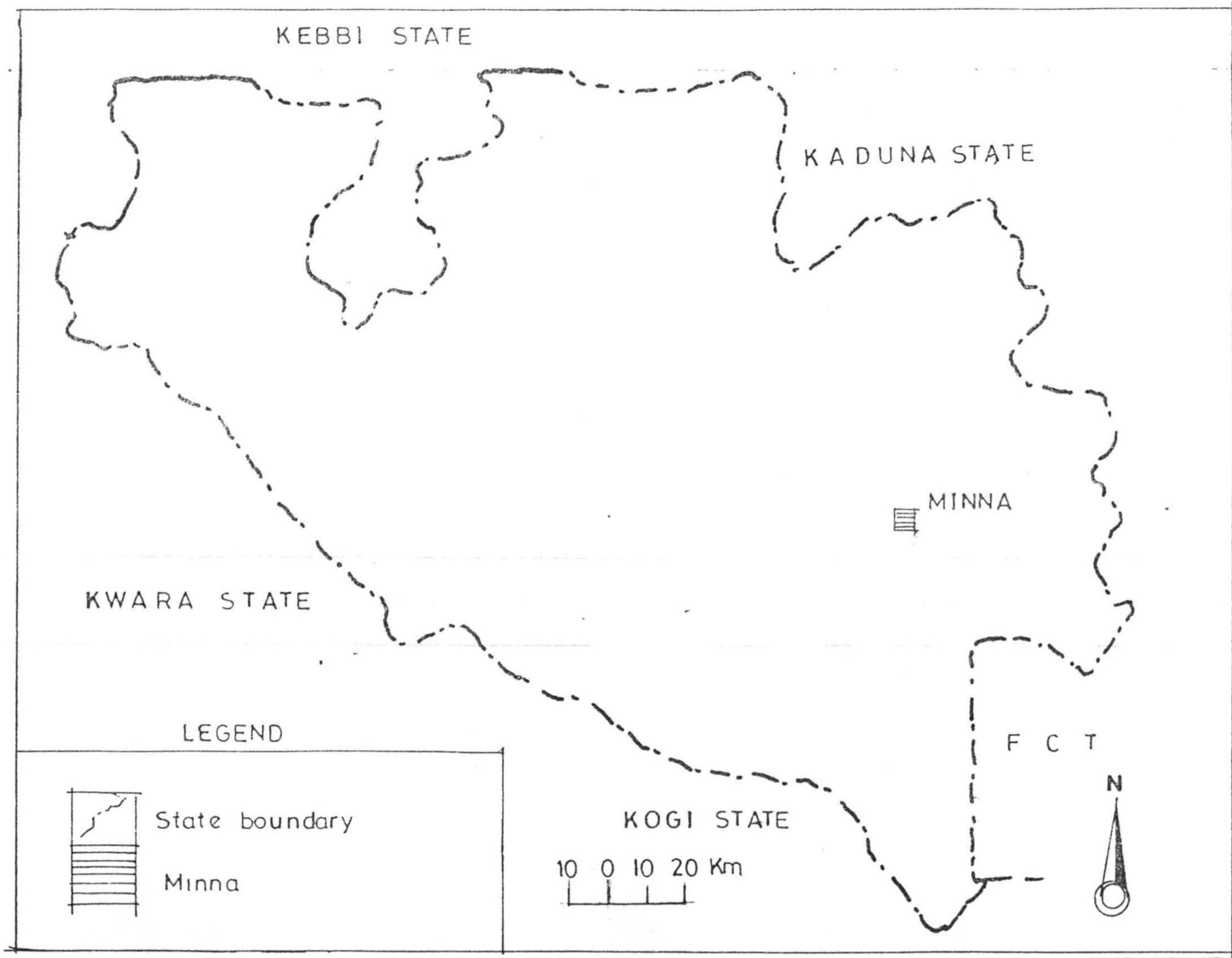

KEBBI STATE
KADUNA STATE
MINNA
KWARA STATE
F C T
LEGEND
State boundary
Minna
KOGI STATE
10 0 10 20 Km
N

Fig 1.2 NIGER

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 APPLICATION OF REMOTE SENSING IN URBAN GROWTH STUDIES

Numerous research works had been undertaken in the application of Aerial Photograph and Satellite Imagery to urban studies and other related problems. These include population growth, residential estimations, inventory and road mapping as well as urban expansion rate.

Aerial photograph is used in urban studies not merely to present static pictures of urban land use but also to analyse temporal changes in land use and the spatial growth in the city (Areola, 1986).

Vinay (1980) used Remote Sensing and Geographic Information System (GIS) techniques in monitoring the urban sprawl in and around Jharia Coalfields (Dhanbad). He studied the urban sprawl between 1974 to 1990 around Jharia Coalfields where coal is being exploited for the last hundred years using Landsat-TM acquired in August 1990 which was processed for radiometric and Geometric correction by image processing software. He also made use of the survey of India topographic sheet of 1974 drawn at a scale of 1:50000. After the classification and delineation, he superimposed the topographic sheet on the map of 1990 prepared by remote sensing techniques.

The result of his research made it possible to delineate macro level changes in urban areas in the regional scale and to find that the urban growth which is around 4% per year has been haphazard and follows irregular patterns during the year under study.

Another researcher, Olayonwa (1999) monitored the expansion of Ibadan municipality from 1972 to 1993 with the use of aerial photographs, SPOT satellite imagery and the base map of Ibadan. After classification, he was able to study the rate of expansion of Ibadan municipality and the pattern of expansion within the year under study based on the United States Geological Survey classification scheme. The result of the study provides the techniques of obtaining information on the growth of cities as well as a reliable alternative method of obtaining and updating information on city growth.

The study of residential land use in order to be able to estimate and predict population growth in the cities as well as devising a classification scheme for Lagos using aerial photographs was carried out by Adeniyi (1978, 1980 and 1981). Also the use of sequential aerial photographs was adopted to study the growth of metropolitan Lagos by Greenzebeth (1978). The two authors were able to determine changes in land use in metropolitan Lagos between 1962 and 1974 using aerial photographs of the city taken in those two years.

The evidence of vision 2010 committee report (1997) also revealed that Township mapping, Topo-map series, Boundary maps and administrative maps had been produced from aerial photography through photo interpretation from 1950s to 1970s and satellite image for some years, generally at a scale of 1:20000 to 1:400000. The aerial photographs and satellite imagery of Abuja have been used for Topomapping. map interpretation and physical planning.

Nwadialor (2001) studied the status of Afaka Forest reserve in Kaduna State from 1962 to 1994, using aerial photograph (B-W) of 1962, Landsat MSS of 1970 aimed at detecting, mapping and modeling forest disturbances responsible for depleting the natural forest. The researcher was able to generate separate composite maps and concluded that the forest reserve under study was under the stress of threats with the overall rate of deforestation at 1.06 percent per annum.

Yusuf (2000) and Akanji (2000) respectively carried out the monitoring of urban growth of Kaduna Township using aerial photographs and the assessment of spatial urban growth of part of Jos metropolis using the techniques of remote sensing. Their studies revealed that the techniques of Remote Sensing could be used to monitor and assess the urban growth for proper planning of cities.

Having studied the methods of assessment of the rate of growth of urban areas as well as the results obtained by different researchers on different cities. Their methods was considered very useful in this research for the study of the rate of the expansion of Minna Town by remote sensing technology using Aerial photograph, satellite image and the map zone (base map) of Minna.

2.2 SOME BASIC THEORIES OF URBAN GROWTH AND PATERN OF GROWTH.

Four basic theories of urban growth and pattern of land use relevant to this study are:

- The concentric zone model
- The Axial model
- Sector model
- Multiple nuclei model.

2.2.1 CONCENTRIC ZONE MODEL

This was developed by Burgess (1927) on his empirical study of Chicago. It was postulated that the process of urban growth is by a series of concentric circle expanding rapidly from the central business district.

Four zones were identified.

(i) A zone of transition marked by deterioration of old residential structures containing high density, low income slums, roomy houses and ethic gethos.

(ii) A zone of "independent working people's home" occupied by industrial workers.

(iii) A zone of better residences, single family homes, or high rent apartment occupied by those wealthy enough to exercise choice in housing location and to afford the longer, more costly journey to central business district (CBD) employment.

(iv) A commuter's zone of low density, isolated residential suburbs.

2.2.2 AXIAL DEVELOPMENT MODEL

This development type takes influence of transportation facilities in modifying the direction of growth of a city. Instead of a concentric pattern of growth, a star-shaped pattern of growth emerges.

2.2.3 MULTIPLE NUCLEI MODEL

Large cities developed by peripheral spread from several nodes of growth. Each node usually has a special function – commercial, industrial, port, residential etc.

Harris and Ullman (1965) observed that many urban areas do not expand from one focal point, but from many focal points known as nuclei. Nuclei could be subsidiary settlement, which through the process of expansion might have been absorbed into a large settlement to form a combination.

2.2.4 SECTOR THEORY

High rent residential areas are dominant in the city expansion and grow outward from centre of the city along major arterials. This theory was developed by Hoyt (1939) and suggests that the growth along a particular axis of transport routes usually takes a form of similar land use type. The sector of each homogenous land use expands outward in a particular direction from the central business district. The resulting shape is a sector or wedge-shaped urban area.

All the four theories of urban growth reviewed had the assumption of uniform terrain and topography in which case urban areas can expand towards the intended direction. Daniel and Hopkinson (1993) observed that "the pattern of growth was frequently influenced and sometimes constrained by natural barriers and both existing and new lines of communication".

2.3 AERIAL PHOTOGRAPHS AND SATELLITE IMAGE INTERPRETATION TECHNIQUES

The aerial photograph is an image or picture of the earth's surface as seen from above. Although the image appears more real than presented on maps. It is nevertheless still a representation of the earth surface. The photographs image needs to be interpreted so that the information it provides can be communicated to others.

Photo and satellite images interpretation therefore is the identification of the earth surface features and conditions imaged, the analysis of their character and evolution of their significance (Areola, 1986).

There are two major approaches to image interpretation. There are manual or visual approach and also computer assisted approach.

2.3.1 MANUAL APPROACH TO IMAGE INTERPRETATION

In the manual or visual approach to image interpretation, the interpreter is engaged in three major operations, which are as follows:

(i) Photo or image reading which is ***detection and identification*** of objects and surface condition on the aerial photographs and satellite image by their special characteristics and signatures. Morain (1974) and Lo (1986) noted that the detection of an image is aided by spatial, spectra and radiometric resolution of sensor used in imagery.

Detection is the ability to make sure that object had been imaged on aerial photograph or satellite image. Spatial resolution has to do with the ability of the imaging system to distinguish closely spaced objects.

Spectra resolution has to do with the ability of the sensors to record objects by several wave bands while radiometric resolution has to do with the level of brightness of which the image can be displayed to provide varying level of contrast.

In identification, the image interpreter has to associate himself with different features detected on the image to known categories. The knowledge of the interpreter from the ground survey or reference data is of important at this stage.

(ii) ***Delineation and classification***

Delineation involves marking the boundary around areas that have homogenous characteristics and patterns on this image. This can be achieved by placing or overlay a tracing paper on the aerial photograph or satellite image.

Classification involve categorizing or classifying each of the homogenous areas delineated into where they belong according to the classification scheme designed for the area.

(iii) ***Classification Output***:- This is the stage where the overlay in which the boundaries of features on image is delineated and classified will be developed into a thematic map of this area.

2.4 APPLICATION OF IMAGE INTERPRETATION TO LAND USE LAND COVER MAPPING

Many researches have been carried out on the application of image interpretation to land use/land cover mapping. The Land Resources Division (LRD) of the British Ministry of Overseas Development introduced some refinement into land use mapping by using aerial photographs interpretations to provide some indications of the intensity of Agricultural Land Use (Hutcheon et al, 1978). After the classification, they were able to define land under cultivation to include fallow lands adjoining the farmlands, which from photo evidence appear to be in cultivated cycle.

Oyelese (1968) classifies the land use into such broad units as tree crop land, bush fallows, grass fallows, regenerated forest mixed with tree crops, all these were done through the help of image interpretation. Wicken (1966) used the image interpretation to study and map the extent of past and present settlement and cultivation of lands. He was able to identify areas which had been settled and extensively cultivated in the past and gave reasons for abandoning such land for future planning.

The knowledge of land use land cover is very important for many planning and management activities concerned with the surface of he earth.

The term land cover relate to the type of features present on the surface of the earth such as artificial feature like buildings and natural features like lakes, forest etc. (Lillesand and Kiefer, 1985). The term land use relates to human activities associated with a specific piece of land, which may or may not necessarily be interpreted directly on aerial photographs.

When using aerial photograph, there is need for mosaic compilation i.e. joining several frames of aerial photographs together to form a mosaic of the area under study, as only one photograph cannot cover the area.

When satellite image is to be used, corrections has to be made for radiometric and geometric errors. In geometric correction, raw data contains geometric distortions which are so significant that they cannot be used as maps. The sources of these distortions range from variations in altitude, and velocity of the sensor platform to factors such as panoramic distortion, earth curvature etc. The importance of geometric correction is to compensate for the distortions introduced by these factors so that the corrected image will have the geometric integrity of the map.

The type of radiometric correction applied to any given digital image data set varies widely among the sensors (Lillesand and Kiefer, 1985).

After the initial steps, classification scheme follows. This is a way of assigning features on the images into classes. The United State Geological Survey (USGS) devised a land use land cover classification system for use with remotely sensed data, this need some modification in order to classify others that do not appear in USGS classification.

The United States Geological Survey has form levels in respect of land cover and land use with varying degrees of details. Levels I and II were designed for use with small scale imagery and contains the least details. Level III was designed for use with small scale aerial photographs. The level I has the following categories:

Urban built up area, Agricultural land, Range land, forest land, water, wet land, barren land, Tundra, perennial storms (Lillesand and Kiefer, 1986).

The USGS land use land cover classification was designed according to the following criteria.

a) The minimum level of interpretation accuracy using remotely sensed data should be at least 85%.
b) The accuracy of interpretation for the several categories should be about equal.
c) Repeatable or repetitive results should be obtainable from one interpretation to another and from one type of sensing to another.
d) The classifications system should be applicable over an extensive area.
e) The categorization should permit land use to be inferred from land cover types.

f) The classification system should be suitable for use with remote sensor data obtained at different times of the year.

g) The categories should be divisible into more detailed sub categories that can be obtained from large-scale imagery or ground survey.

h) Aggregate of the categories must be possible.

i) Comparison with future land use should be possible.

j) Multiple uses of land should be recognized when possible.

After the development of the classification scheme, the general procedures of image interpretation as detailed in 2.2 will follow.

Olayonwa (1999) used the USGS classification criteria above to study the built-up areas and settlement shape of Ibadan metropolis. The present study aims at using the same USGS classification to study the growth and settlement patterns of Minna Town and also to determine the increase in the built-up areas over the period under study.

CHAPTER THREE

3.0 METHODOLOGY

3.1 INTRODUCTION

This chapter explains the method used in carrying out the assessment process, the method of data collection, production of land use maps between the periods under study, estimation of areas occupied by land use between such period and the increase in the built-up areas.

The chapter also deals with method used in calculation of growth rate between 1982 and 1994 and lastly the determination of the emerging pattern of growth.

Post classification comparison method was used to determine the increase in the area of built-up portion of Minna town between 1982 and 1994. Land cover maps of Minna for 1982 and 1994 were produced and compared. The percentage growth was determined by dividing the increase in the area of built-up portion of the town in 1994 by the total area of built-up portion in 1982. The result was then computed in percentage.

3.2 DATA COLLECTION AND INSTRUMENT

The following data were used during the court of the research for successful execution of the work.

a) The aerial photographs of Minna consisting of about eighteen frames at a scale of 1:25000. The aerial photographs were in four lines and are acquired in 1982.

b) The satellite image was SPOT XS panchromatic digital image which was acquired in 1994. The satellite image was shot at an altitude of 832.6km with an angle of 49.7°. The satellite computer print out was produced at a scale of 1:80000.

c) Anxillary data used was the built-up area map of Minna obtained from the Ministry of Land and Survey produced in 1982 and is constantly been updated.

These three data sets made it possible for the researcher to achieve his aim and objectives.

The major instrument (personal) used in this study are microcomputer with printer used for satellite image enhancement and image print out, photocopying machine, pocket stereoscope, planimeter, drawing board and T-square, light table as well as drawing instruments such as scale rule, set square, tracing paper, compasses, divider, protractors, pencil, drawing pens and colour marker.

3.3 PRE-INTERPRETATION STAGE

Prior to the classification of images, two major steps were followed which enhanced an accurate classification and production of land cover maps.

a) Moving round the entire study area to get familiar with the existing featurés.

b) Studying both the aerial photographs and the satellite image.

c) Developing the classification scheme.

Familiarizing oneself with the study area is an important aspect in this research work. It was done by initially moving round the whole town (the study area) to note the major features on the site and on the map data. This was followed by familiarization of the researcher with the features on the images both the aerial photographs and the satellite imagery. This aided the development of the classification scheme.

The classification scheme was categorized into four as seen in Table 3.1. Each category of land use is further classified into first and second level classification.

TABLE 3.1 **LAND USE/LAND COVER CLASSIFICATION SYSTEM**

	LEVEL I	LEVEL II
1.	Urban built-up Area	1.1 Residential 1.2 Commercial and Services 1.3 Industrial 1.4 Transport, Communication and Utilities 1.5 Industrial and Commercial Complexes.
2.	Vegetation	2.1 Extensive Farmland 2.2 Intensive Farmland 2.3 Forest Land 2.4 Crop land and Orchard 2.5 Grass land etc.
3.	Water	3.1 Streams and Canals 3.2 Lakes 3.3 Reservoirs
4.	Rocks	4.1 Rock Outcrops.

SOURCE: Lillesand and Kiefer (1975).

3.4 CLASSIFICATION, MAPPING AND CHECKING FOR ACCURACY OF CLASSIFICATION

The following processes were involved in the classification and mapping.

a) Preparation of Imagery and Overlay.

b) Delineation and assignment of numbers to homogenous image areas e.g. built-up area assigned the same number after delineation.

c) Reduction of the Overlay to map scale.

d) Classification of images.

e) Checking the accuracy of classification through ground truthing

f) Production of land use maps for 1982 and 1994.

g) Final production of the map of increase in land built-up portion.

Eighteen frames of aerial photographs were used to produce the mosaic to cover the study area micro-analysis. Computer and image interpretative analysis were used to print out the digital SPOT XS satellite image at a scale of 1:80000 and the image was enhanced before printing for easy classification.

The boundary of the study area was defined from the base map of Minna, which was transferred unto the images. The mosaic was first produced for 1982 aerial photograph and an overlay of tracing paper was made on it after which the boundary of the study area was traced out.

An overlay of tracing paper was also made on the satellite image and the boundary traced out as well. Delineation of homogenous areas on the imageries on the overlay of tracing paper prepared was done by putting the overlay on the mosaic and satellite image respectively on light table. With the aid of the mirror stereoscope which is an instrument used for easy interpretation of features on the aerial photographs, boundaries were drawn round the identifiable homogenous areas on the mosaic and satellite images. These homogenous areas were assigned the same number for easy identification. The delineated areas were assigned to classes based on image elements such as tone, size, texture, pattern, association etc. (Wolf, 1985).

The accuracy of the classification was checked by taking 40 points at random from urban built-up and vegetation categories respectively. This was verified from existing maps and ground survey using Global Positioning System (G. P.S.) instrument. Table 3.2 below shows the summary of the land cover map classification accuracy.

TABLE 3.2: **LAND COVER MAP CLASSIFICATION ACCURACY**

Land Cover Type	No of Sample Points	Preparation of correct sample	Accuracy in percentage
Urban built-up	40	38/40	95
Vegetation	40	35/40	87.5
Water	10	10/10	100
Rock	5	5/5	100
Total	95	88/95	92.6

SOURCE: Measurements from random selection of points.

The few classification categories used made it possible for the researcher to achieve high accuracy in classification. Dimyati et al (1996) suggested that fewer numbers of classification categories give a high level of classification accuracy. This reflected in his study of land use and land cover map of Yokyakanta, Indonesia.

Map of increase in built-up areas of Minna between 1982 and 1994 was then produced by matching the land cover map of 1982 over that of 1994. This was made possible by bringing the land cover map of 1982 and 1994 to the same scale with the aid of photocopier. The result of the overlapped formed the pattern of growth where part of the vegetal cover in 1982 had been replaced by urban built-up portion in 1994.

3.5 ESTIMATION OF AREAS OCCUPIED BY LAND COVER CATEGORIES OF 1982, 1994 AND INCREASE IN THE BUILT-UP PORTION BETWEEN 1982 AND 1994

A planimeter, which is an instrument capable of quick determination of areas of irregular figure mechanically (Ramsey, 1975), was used to estimate the total area enclosed in the study area and areas occupied by each category of land cover i.e. built-up area, vegetation, water body and rock outcrops. The planimeter was used to trace out the boundary of the study area and by applying the scale factor, the total area covered was obtained.

The same planimeter was used to trace out the boundaries of each category after the classification. These were added together to give total coverage by each category in 1982 and 1994 respectively. Areas of increase in built-up land cover between 1982 and 1994 was also estimated. This was done by subtracting the area of built-up portion of 1982 from the area of the same category in 1994.

The mechanical method of area calculation by planimeter proves to be more accurate and faster compared to the graph-square method because it does not give room for estimation and approximation of irregular boundary. The tracing arm of the instrument traced out exactly the required portion.

The estimation of growth rate over the period under study was expressed in percentage. The growth rate was determined by dividing the increase in the area of built-up portion between 1982 and 1994 by the total area of built-up portion of 1982, the result of which is multiplied by 100. The formula for percentage is expressed as follows:

$$GR = \frac{\text{Increase in area of built - up portion}}{\text{Total built - up portion in 1982}} \times 100$$

The same was done for all other categories of classification. While some categories produced a tremendous increase between the period under study. Some recorded a decline while other produced no effect.

The rate of change over the period was calculated per year using the formula

$$R.C = \frac{\textit{Increase in built - up area between 1982 and 1994}}{12}$$

3.6 DETERMINATION OF EMERGING SPATIAL PATTERN

One of the objectives of this study is to determine whether or not, the pattern of growth of Minna town conformed with any of the existing theories of urban growth pattern i.e. whether it is concentric, sectoral or an irregular pattern of growth. The pattern which the 1994 land cover map represented was then verified after the production of map of increasing built-up area.

CHAPTER FOUR

4.0 PRESENTATION AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

The aim of this study is to estimate the growth of built-up area in Minna between 1982 and 1994. The classification comparison of Land cover maps for 1982 and 1994 was produced through interpretation of aerial photographs and satellite image respectively. The extent of growth rate of growth and the emerging pattern of growth are determined. The results are presented and discussed in this chapter.

4.2 AREA COVERAGE BETWEEN 1982 AND 1994 LAND USE MAPS

Table 4.1 shows the area coverage by land use map in 1982 and 1994 as well as the percentage changes as obtained from classification of land use maps between 1982 and 1994.

TABLE 4.1 **AREA COVERAGE BY LAND USE MAP IN 1982 AND 1994**

Land Cover Type	Area Coverage in 1982 (Hectares)	Percentage Covered (%)	Area Coverage in 1994 (Hectares)	Percentage Covered (%)	Magnitude of change (Hectares)	Percentage Change (%)	Rate of Change per year	% rate of change per year
Urban built-up	336.0	7.50	664.0	14.82	+328	97.60	27.33	8.13
Forest	3600.9	80.38	2672.9	59.66	-928	25.77	-77.33	2.15
Farmland	400.0	8.92	1000	22.32	+600	150	50.00	12.50
Rocks	88.0	1.96	88.0	1.96	00	00	0.00	0.00
Water	55.1	1.23	55.1	1.23	00	00	0.00	0.00
Total	4480	100	4480	100				

SOURCE: Measurement from land cover maps of 1982 and 1994.

4.2.1 ASSESSMENT OF LAND USE MAP OF 1982

Figure 4.1 shows the land use map of Minna and its environs in 1982. It was revealed that the major areas that constitute the built-up areas are Mobil, which is the centre of the town, Keteren Gwari, Maitumbi, Bosso, Tunga area. All these amounted to 336 hectares of the total study area.

The vegetation which was classified into farmland and forest was seen to dominate the major part of the study area. The entire western parts of the study area constitute farmland (intensive farming, agricultural area) while the eastern and northern parts are mainly forest with sparse built-up portion. The major dam as revealed by the 1982 land cover map was located at the north central part of the study area with some rivers most of which flows from the north to the south as seen from their tributaries as well as the topography of the town. The rock outcrops are mainly found around Maitumbi and Bosso area.

The pattern of growth as at that time was irregular and the explanation for the irregular pattern of growth can be traced to the history of the earlier settlers in the area apart from the commercial activities. The Gwari people settled at Bosso, Nupes settled around Keteren Gwari, the Hausas and Gwari settled at Chanchaga and later the Yoruba and Nupes settled at the then outskirts of the town, Kpakungu, which has now became developed. Mobil area is the major commercial centre for trading. People converged at this place which eventually became the site of the two major markets in the town i.e. the modern market and Kasuwan Gwari market.

Road network also influenced the growth of the town as the built–up area also extended along Abuja road from Mobil toward Tunga to Chanchaga area. This is due to the ease with which traders transport their goods. The table shows that the urban built up portion occupies 336.0 hectares (or 7.50%), the forest and farmlands occupies 3600.9 and 400.0 hectares (or 80.38% and 8.92%) respectively while rocks and water occupies 88.0 and 55.1 hectares (1.96% and 1.23%).

Finally, the 1982 land cover map revealed a multiple nuclei pattern because those places aforementioned form the nucli from which development sprang up.

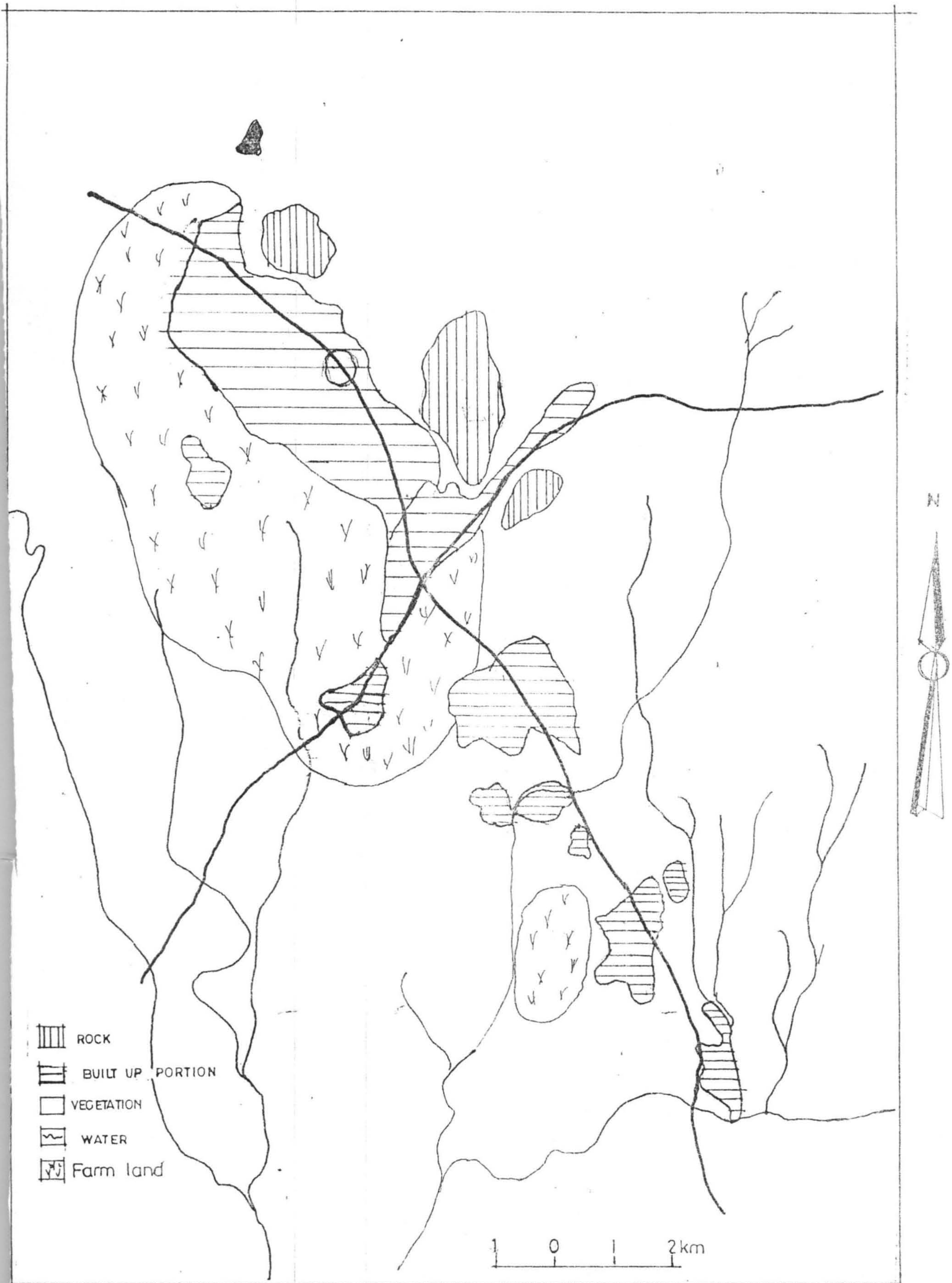


FIG 4.1 LAND USE MAP OF 1982
Source: Photo Interpretation

4.2.2 ANALYSIS OF LAND USE MAP OF 1994.

Figure 4.2 presents the land use map of Minna as at 1994. The classification revealed that the dominant category noticeable for expansion is the built-up portion. Vegetal cover gradually diminished from what it was in 1982. Rock outcrops and water body remained unchanged. The analysis of Table 4.1 reveals that the urban built-up area occupies a total of 664.0 hectares (or 14.82%), forest and farmlands occupies 2672.9 and 1000.0 hectares (59.66% and 22.32%) while rocks and water occupy 88.0 and 55.1 hectares (1.96% and 1.23%) respectively.

The possible explanation for the increase in the built-up area in this period can be attributed to the increase in population of the town since it became the capital of Niger State. There is increase in the commercial activities, establishment of ministries and parastatals, institutions of higher learning as well as increase in the number of industries. All these attracted people from different parts of the country.

The shift of the Federal Capital of Nigeria from Lagos to Abuja, which is closer to Minna, was also noted to have contributed to its growth in 1994. The Federal capital later became congested; accommodation and cost of living became very high and unbearable. Therefore, people preferred to reside in neighbouring areas where they can still enjoy all the social amenities as in the Federal Capital Territory.

4.3 COMPARISON OF LAND USE MAPS OF 1982 AND 1994.

Table 4.1 shows that in 1994, although vegetation category is occupying the largest area coverage, it has greatly reduced in size compared to that of 1982. The forest category has reduced from 3600.9 hectares to 2672.9 hectares which is 59.66 percent of the total area.

The farmland increased from 400 to 1000 hectares representing 22.32 percent of the total area in 1994. The increase in size is due to increasing population, more land is being cleared for family activities.

The rock outcrops remain the same in 1994 as in 1982 occupying 88 hectares which is 1.96 percent of the total study area so also is the water body which occupied 55.1 hectares amounting to 1.23 percent of the total coverage.

The table also reveals the magnitude of change that occurred between the period under study. The vegetal cover (farmland and forest combined) produced the lowest magnitude of -328. The simple explanation for this is that the area of vegetal cover especially area of intensive agriculture are used for development, this tends to increase the built-up portion by +328. Only the rocks and water body neither expands nor reduced and therefore has zero magnitude respectively.

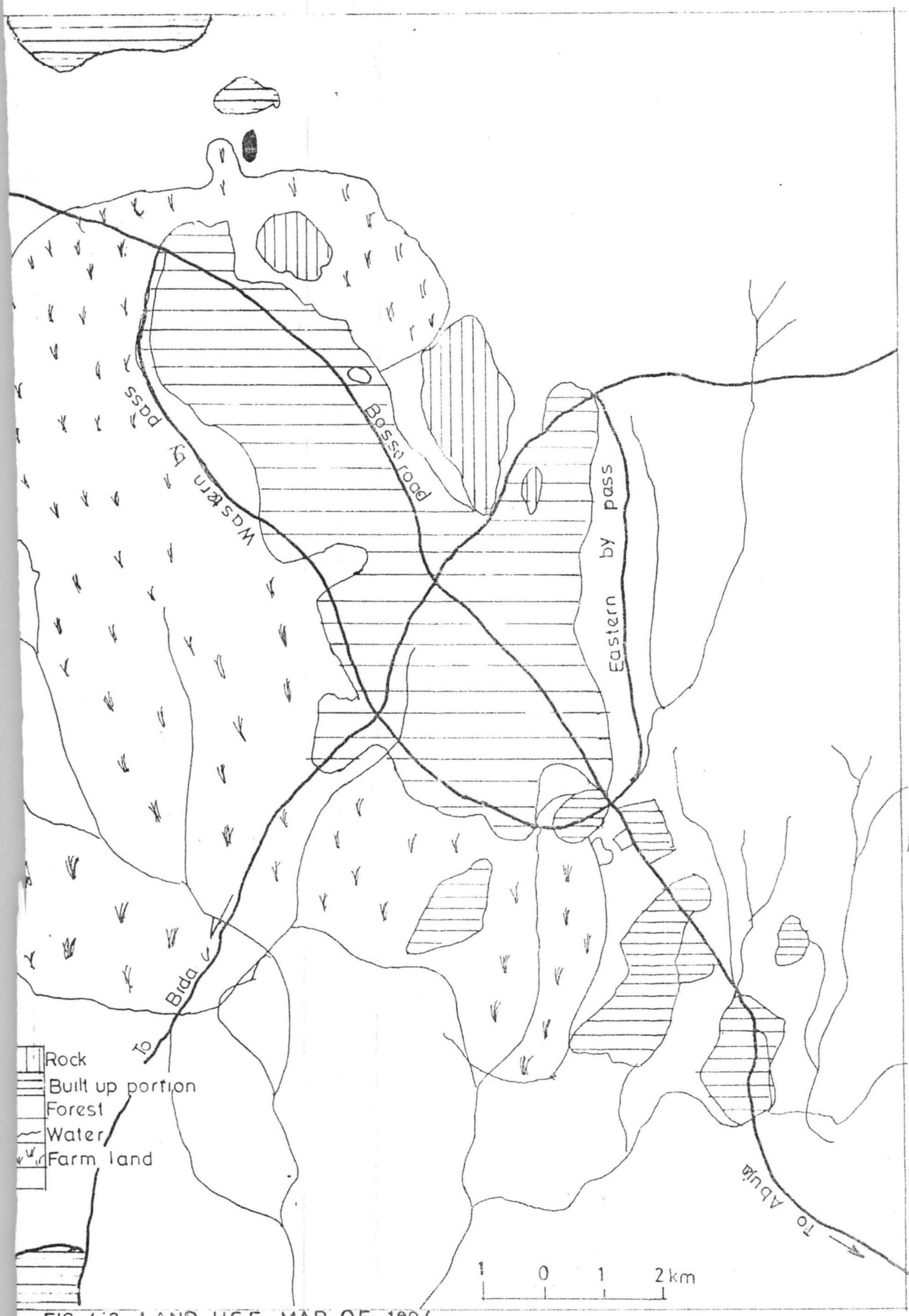


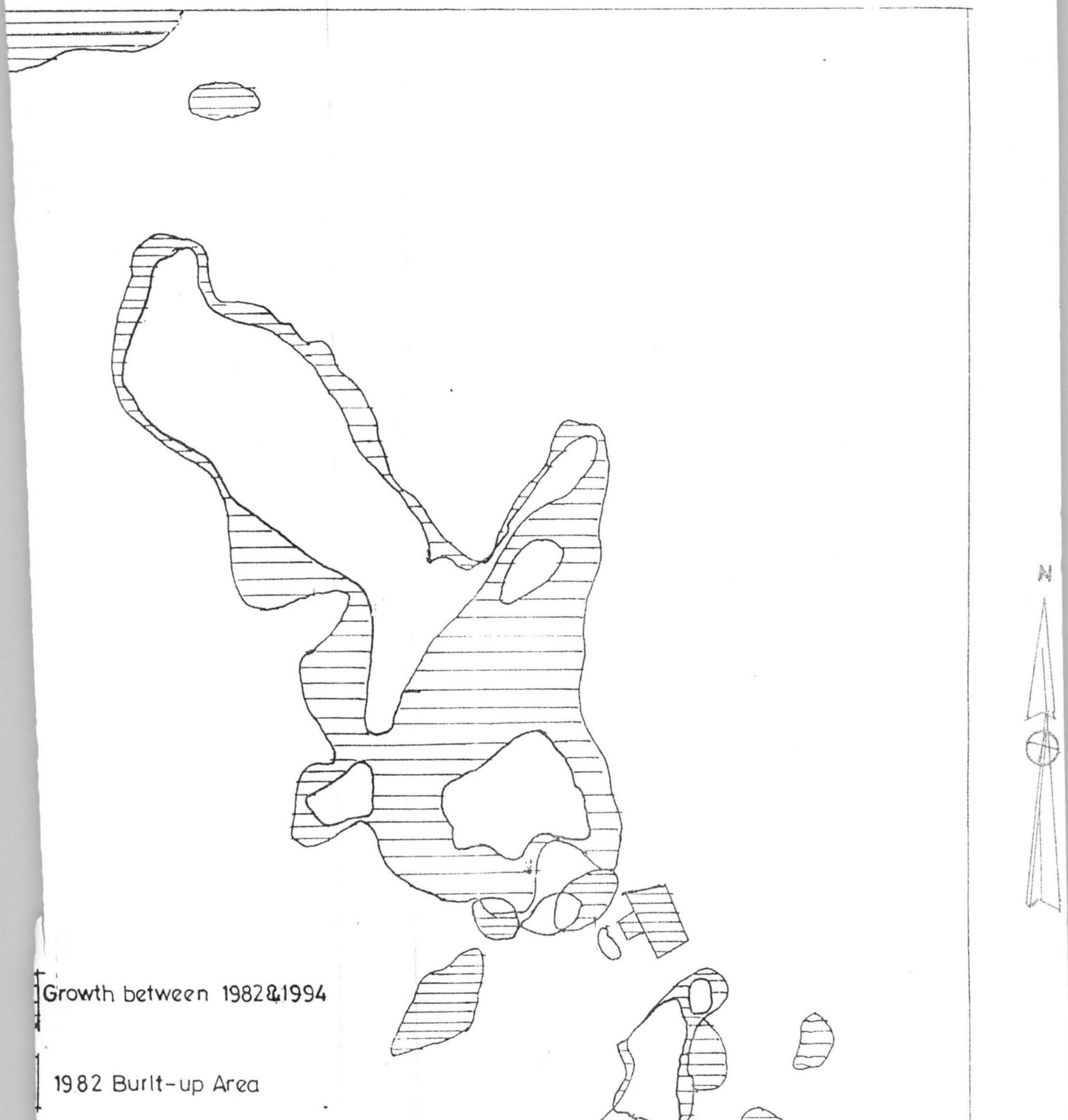
FIG 4.2 LAND USE MAP OF 1994
Source: Photo Interpretation

4.4 BUILT-UP AREA ESTIMATION AND THE RATE OF CHANGE.

Figure 4.3 illustrates the increase in the built-up area between 1982 and that of 1994 respectively. The percentage increase in the built-up area is shown in Table 4.1.

The map reveals that the change or expansion occurred in almost all the built-up areas of 1982 and some other new areas. The expansion was noted to be pronounced in the centre of the town and Bosso area as well as along Chanchaga road. Only the places after the rocks have sparse built-up area.

One possible explanation may be found in the influence of town as a state capital and local government headquarters for many years, which might have made it possible to attract much investment in real estate and urban infrastructural development.



4.3 INCREASE IN BUILT UP AREA BETWEEN 1982 & 1994
urce: Map Interpolation

4.5 ANALYSIS OF THE RATE OF CHANGE BETWEEN 1982 AND 1994 USING BAR CHART

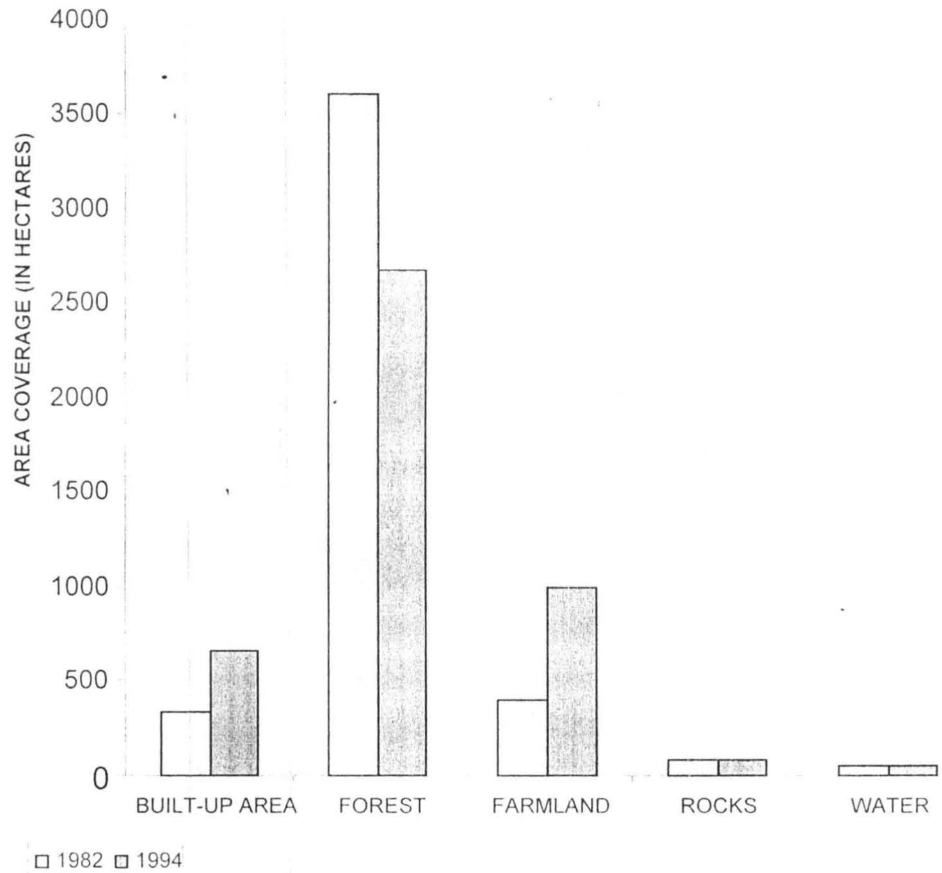


Figure 4.4 **BAR CHART SHOWING THE RATE OF CHANGE BETWEEN 1982 AND 1994**
Source: Table of Area Coverage in 1982 and 1994.

The figure 4.4 shows the plot of the area coverage of each land use in 1982 compared with the area coverage in 1994. The changes can then be seen to be positive in both the built-up area and farmland, forest has a negative change while rock and water has zero change.

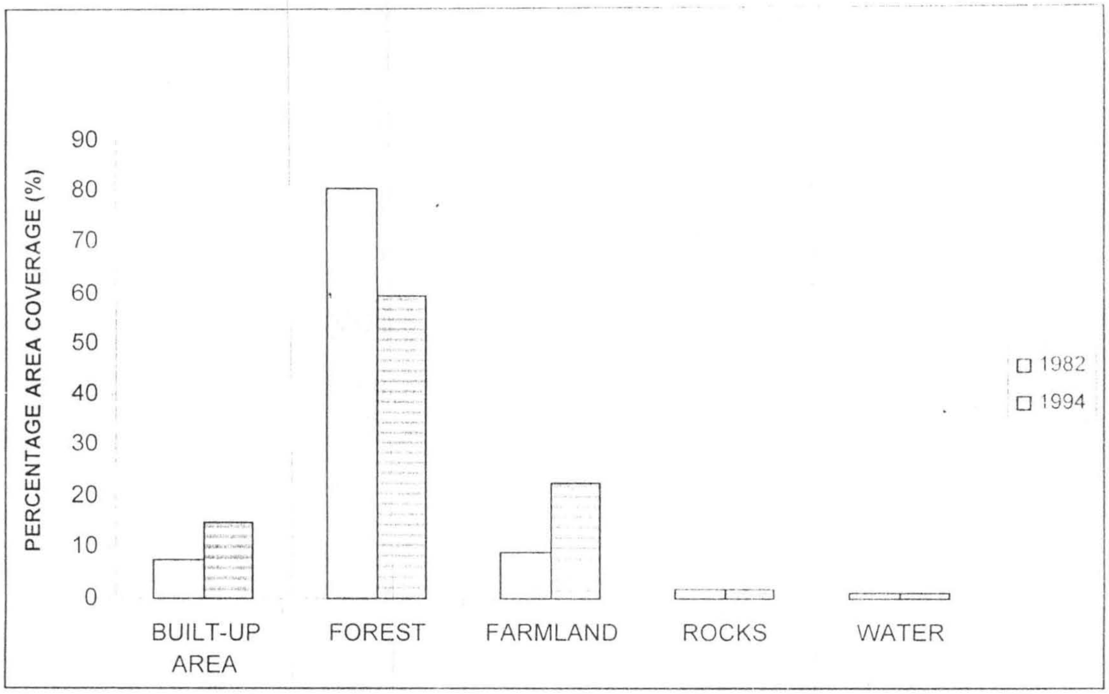


Figure 4.5 **BAR CHART SHOWING THE PERCENTAGE RATE OF CHANGE BETWEEN 1982 AND 1994**

Source: Table of Percentage Area Coverage in 1982 and 1994.

Figure 4.5 shows the plot of the percentage area coverage by each land cover category between 1982 and 1994 in bar chart. It was a plot of percentage coverage against the years under study.

4.6 PRESENTATION OF THE EMERGING SPATIAL PATTERN

The spatial pattern of urban built-up area, presented in Figure 4.2, is irregular. This is in conformity with multiple nuclei theory of urban growth.

One possible explanation for this emerging spatial pattern is that public and private estates, institutions and roads alignment constituted the nuclei from which the development radiated. For instance, The Federal University of Technology, Minna has been identified as one of the nuclei, which stimulated development in some part of Bosso area. For example, one development that might have been stimulated by the University is residential area, which might have been developed to cater for housing need of the University staff and students.

Places like Mobil, Keteren Gwari, Bosso, Kpakungu etc. also formed the nucli from which development sprang up. Most of the residential and industrial estates located in the north and southern part of Minna also constituted nucli from which development radiated.

4.7 COMMENTS ON THE RESULTS.

The results of this study have demonstrated the potentialities of image interpretation techniques in assessing the expansion of Minna.

However, better results could have been achieved if more interpretation data like LANDSAT- TM and other frames of aerial photographs taken at interval between the study periods were available. This could have improved the study of the emerging pattern of growth, as the duration of observable change would have been shorter than twelve years used in this study. Shorter periods would explore subtle growth rate and intervening factors over the years.

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY OF FINDINGS

The study has used image interpretation technique to assess the rate of growth as well as the emerging pattern of Minna town over the period of twelve years between 1982 and 1994. The summary of findings is presented below.

Visual examination of 1982 land cover map revealed that the major built-up land cover concentrated around the central part of the town towards the south and south-eastern parts of the study area. Vegetal cover dominated the west, south and eastern parts. Rock outcrops were found in the north and north-east which hinder development around this zone.

1994 land use map indicated that the urban built-up land has increased. The vegetal cover was found to have reduced since much of the vegetal cover in 1982 has given way to urban built-up land cover. The major water body was located in the northern part of the study area with rivers flowing from the north to south. The rock outcrops did not change in size.

The map of increase in built-up area indicates that the major change that occurred between 1982 and 1994 is the replacement of vegetation by urban built-up land cover. These changes were noticeable and pronounced in the core of the town.

The 1982 estimate of the areas occupied by each category of land use revealed that urban built-up land cover occupied a total of 336 hectares (or 7.50%) of the study area, vegetal cover i.e. farmland and forest occupied 400 hectares (or 8.92%) and 3600.9 hectares (or 80.38%) respectively while water body occupied 55.1 hectares (1.23%) of the study area.

The 1994 estimate of the area occupied by each category of land cover revealed that urban built-up land cover area has increased to 664 hectares (or 14.82%), farmland has increased to 1000 hectares (22.32%), and forest cover was reduced to 2672.9 hectares (or 59.66%). The area occupied by rocks and water bodies recorded no change as they maintained the total area of 88 and 55.1 hectares (or 1.96% and 1.23%) of the study area respectively.

The emerging spatial pattern of urban built-up land cover in 1994 was irregular shaped pattern which is in conformity with multiple nuclei theory of urban expansion.

5.2 CONCLUSION

This study has been able to produce the percentage rate of growth and the emerging pattern of growth of Minna Town over a period of 1982 and 1994 using aerial photograph and SPOT-XS satellite image. The result obtained indicated that image interpretation technique could provide a reliable method for the assessment of urban growth of cities.

It is important that those involved in city planning and management will take from the result of this study to adopt the technique of information acquisition for meaningful urban planning and management.

The study of this nature will go a long way in improving the life of the people in the town in terms of better planning and good living.

5.3 RECOMMENDATIONS

The following recommendations, arising from the findings, are directed to the relevant authority.

(i) The study of urban growth and pattern of growth of Town should be done on regular basis and within short periods. This will enable the planners to have adequate planning information as well as efficient distribution of social amenities.

(ii) Aerial photograph and recent satellite images of high resolution should be made available and at an affordable price so that periodic checks on the rate and pattern of growth can be carried out.

(iii) Periodic training or course should be organized for city planners on image interpretation techniques by institutions of higher learning offering Remote Sensing application as a course e.g. Federal University of Technology Minna, Regional Centre for Training Aerospace Services (RECTAS) at Obafemi Awolowo University, Ile-Ife and National Centre for Remote Sensing at Jos.

(iv) Public enlightenment on the advantages of Image Interpretation techniques as a way of acquiring information over the traditional approach is of paramount importance for all the professionals involved in city planning.

(v) Government should make it compulsory for any land developer to produce the survey plan as well as building plan prior to any development. This will eliminate/reduce the problem of slum in the city.

(vi) Further study of urban growth can be done by using Multi-Spectral image data, other urban centres and shorter periods in order to validate the results and to explore subtle growth rate and intervening factors over the years.

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APPENDIX A

SAMPLE FRAME OF AERIAL PHOTOGRAPH AT REDUCED SCALE

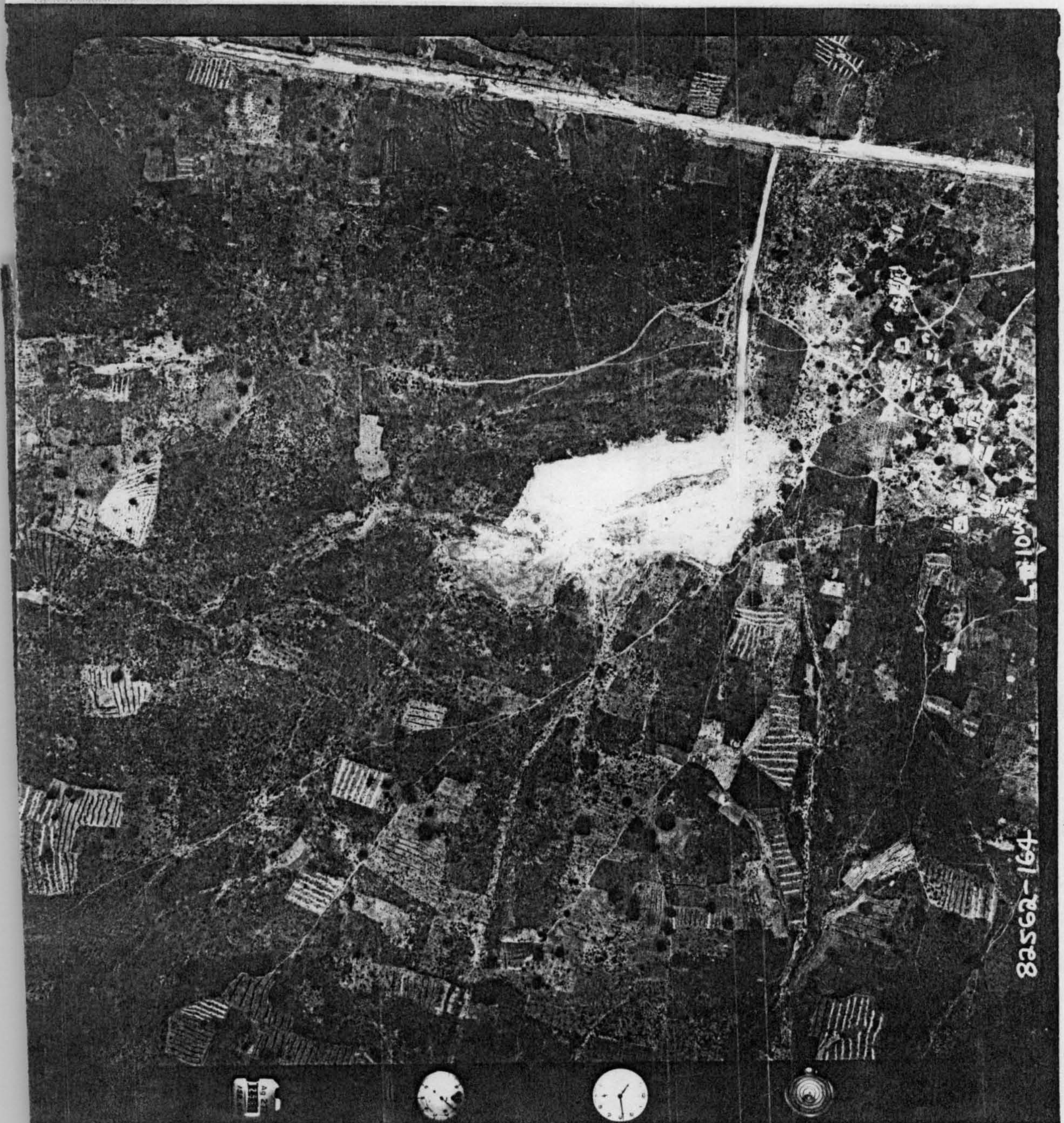
APPENDIX B

SAMPLE FRAME OF AERIAL PHOTOGRAPH AT REDUCED SCALE

APPENDIX C

SAMPLE FRAME OF AERIAL PHOTOGRAPH AT REDUCED SCALE

APPENDIX D



SAMPLE FRAME OF AERIAL PHOTOGRAPH AT REDUCED SCALE