APPLICATION OF REMOTE SENSING TO THE ASSESSMENT OF DEFORESTATION IN THE MAIDUGURI AREA

BY

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CERTIFICATION

I certify that this study was carried out by Mohammed Kabir Aliyu of the Department of Geography, of the Federal University of Technology Minna under the supervision of Professor D. O. Adefolalu of the Department of Geography, School of Science and Science Education.

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DEDICATION

This study is dedicated to my family and to my beloved parents in persons of Mallama Hafsat Garba, Late Mallam Mohammadu Yamalladan, Late Mallam Mustapha Yanda, Late Ya'ai'sa and Late hajiya Hafsat Chamalwa.

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ABSTRACT

The environment is a system and a resource. Deforestation, resulting from the effect of human-induced activities on the natural resource has now become a Global problem, with the ever-increasing pressure on Land occasioned by population growth.

The main aim of this study is to determine the extent deforestation in Maiduguri. It is in this way, argued that detection and analysis of Land cover changes is a necessary requirement for evaluating both influence and effect of changes in Land cover in a fragile vegetation area of Maiduguri and its environs.

To effectively relate satellite observation to land cover changes, a quantitative link necessarily must be established. To get factual information for the study, statistical data were obtained based on the satellite data (1976-1993), analysis of deforestation in Maiduguri, has been carried out.

Statistical presentation in tabular format shows changes in different cluster. Therefore, there is need for Land cover data collection process to be technical, so that satellite-aided Land cover change analyses conducted in different areas can effectively be related. The only way to do this is for every study to employ different approach of ground data collection processes into baseline process.

The result obtained revealed that between 1976 to1993, the various land cover types have undergone the following changes in their spatial extent ; build- up area (1. 3 %) , forest area (1 5%) and agricultural area(4.3%) . Possible underlying reasons for the observed changes , and their implication have been discussed.

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CHAPTER ONE

1.0 INTRODUCTION

Many literatures have highlighted the dramatic weather events and Anthropogenic activities to deforestation taking place in the Sahelian region. The term Sahel, from the Arabic language mean coast or plain. It was first used for areas south of the Sahara as a photo geographical concept. It describes the belt of vegetation that stretches from the Atlantic sea and separates the Sahara from the deciduous savanna woodlands in the south. The present deforestation in the study area has developed long ago and one of the most important events was the increase in its extent through desert encroachment. With the felling of the trees in the environment, deforestation can be defined as the artificial conversation of forestland to non-forestland that is accompanied by clear cutting of the plant in an area for use by the people living in the area. In Nigeria (particularly in the north) due to poverty, increase in population etc, people often depend more on the little forest resources around them for fossil fuel and other domestic uses, (especially in Maiduguri). They also use it as source of supplementing and diversifying their income by selling it.

Destroying the little vegetation around this area has great impact on the environment. It helps to increase net greenhouse gas emission to the atmosphere in the study area and the globe in general. The rate of deforestation varies from region to region. Recent research result showed that in the Brazilian Amazon, the rate of deforestation was around 6200 square miles per year from 1976—1986, but fell to 4,800 square miles per year from 1986—1993 (sources: NASA, 2000). However, in the Maiduguri environment the rate of deforestation increases the amount of carbon dioxide ($C0_2$) and other trace gases in the atmosphere. The plants and soil of tropical forest hold 460-575 billion metric tons of carbon of the world, each area of tropical forest storing

about 180 metric tons of carbon. Vegetation is one of the fundamental components of Biosphere and plays some vital role in the substance ecosystem. Besides, it's well known function of being a major source of food and fodder for man and for Livestock. It serves as a major catalyst in a number of physical and Biochemical processes, that act separately in combination to shape the earth to what it is at a particular time. The advent of the satellite and high power computer has paved the way for better resolution. One advantage of remote sensing techniques over almost all the tools for environmental monitoring is that satellite data are gathered in digital format, which makes computer-assisted analysis a relatively easy task. This became glaring as a result of the findings of a number of research workers who demonstrated the efficiency of Landsat MSS ,TM and SPOT in detecting vegetation change and monitoring in different parts of Nigeria.

However, the challenges of inaccessible areas and very wide region of study, present to same limitations in the generalization of available data . That is why it is necessary to exploit potentials of Landsats, which provides a low-cost imagery and analysis of available data . Also Landsat make such a wide region vegetation data information of 1976 and 1993 extremely possible and cheaper.

The study area is of particular relevance not just because of the intensive human activities it has traditionally been supporting but also because of the natural climatic changes such as drought, low-rainfall, high temperature and desert encroachment, which are known to be causing both positive and negative environmental changes. In order to address these problems of deforestation in the area of study, this study will present the results of satellite data imageries available.

1.1 DEFORESTATION: A PREVIEW

Anthropogenic activities, either direct or indirect, have positive and negative effect on the study area. Deforestation in Maiduguri is rampant; due to the fact that 75% of the people living in the area use firewood, clear the little trees around for farmland, human settlement etc, thereby exposing the surface bare to climatic activities. It was observed to that the rate of disforestation has increased to about 74km^2 (+12%) between 1980 and 1987 in the northern part of Borno state (MAFR 1983). The land cover was confirmed to be a cultivated field on which some tree species and shrubs were scattered, ostensibly to promote interaction between the trees/shrubs and non-trees/shrubs components of the land. This practice, sometimes called parkland Agro forest: has been shown to be a major one in Nigeria's semi-arid and savanna region (Gadzama, 1991). Tropical deforestation has been noted as a serious ecological problem, especially under low rainfall areas (Salau, 1992; IGBP, 1993), as noted in the study area. This has negative influence on the vegetation growth in the area, but due to high demand for fuel wood, the few trees/shrubs are cut down. Deforestation results not only in the loss of trees, but also on the partial break down of the surrounding vegetation where moisted areas are drained and the organic matter (e.g. humus) bound in the soil becomes easily decomposed. All these processes release carbon dioxide ($C0_2$) and Methane (CH_4) into the Atmosphere. Since 1850, there has been a world—wide release of some 20% (117 thousand million tones) of carbon, which was stored up in vegetation, (Global climate problem, 2000). However, such carbon is lost due to human-activities in the forest.

If the vegetation of the study area and other part of the world continues to change at the current annual rates, most of the forest areas would disappeared (Global Climate Problem, 2000). Such will have adverse effect on the ground surface and surviving organisms that make up the forest. Investigation will be

needed using a remote sensing technique to monitor or confirm the extent of deforestation. Landsat MSS, TM, SPOT and NOAA AVHRR produce imager coverage of the earth. It is necessary to apply them to monitor and detect changes in the forest area in order to save our environment from degradation.

1.2 STATEMENT OF PROBLEM

75% of the people in the study area are poor and they depend on the little forest around Maiduguri for fuel wood and other domestic uses. They use it as source of supplementing and diversifying their income by selling it. Most of the forests in the area, in the last 40 years, are greatly threatened due these activities. The economic factors influencing deforestation in the area have been on the increasing demand for gum Arabic, tannin materials for the leather processing industry and fuel wood demand from 1976-80, the current trends or pressure on the study area vegetation is due to increase in population, poverty etc, which lead to high demand on natural resources and new trends in land-use with linkages between crop production, livestock and human settlement.

Destroying such little vegetation has impact on the environment. It helps to increase net green house gas emission into the atmosphere in several ways. Firstly, it increases carbon stored in standing trees by releasing it into the atmosphere. Secondly, deforestation degrades the forestland and the soil in the area. Such activities have increased desert encroachment in the area. Deforestation also has profound effect on global climate, which endangers the ecosystem, other life support and man.

1.3 OBJECTIVE OF THE STUDY

The aim of the research is to analyse deforestation in the fragile ecological zone of the Sahel region. In carrying out the research the following shall be addressed:

a. To compute the percentage area degraded and the rate of deforestation
b. To determine the factors influencing degradation.
c. To provide land use charges map as it relates to deforestation.

1.4 JUSTIFICATION

The Research will contribute to policy formulation for environmental protection and also will help in the knowledge of the contribution Remote Sensing application to academics.

By careful examination of dynamic nature of the forest condition of the study area, this research will examine the extent of deforestation in the area, the information derived from the study will be of importance to up-dating the data of the area.

Historical information shows that documents, sequential survey notes, aerial photographs and other remotely sensed data can serve as a means of information about the extent of deforestation and related changes. This shows that, direct comparisons of deforestation at different areas using remotely sensed data would be the best for decision in policy making, the coming of satellite raises the possibility of monitoring a large scale of forest area. However, these applications are yet to be known in the study area. The application of remote sensing in the Sahelian region area will be beneficial for monitoring and the planning on deforestation in the area, in order to protect the area from desert encroachment or degradation.

Satellite image have been chosen for this study due to the fact that, when viewed against the content of inaccessible areas and the wide region of study, the use of the present available data appears not to be only prohibitively

expensive, but will be associated with practical complexity and problems that could even compromise the accuracy of change in estimation. That is why it necessary to exploit potentials of landsat, which has a low-cost imagery and analyze the data available. Moreover, the choice of the Maiduguri and environs in Borno state was based on the magnitude of environmental changes taking place in the area and the need to educate the people about the environmental impact of deforestation in the study area and the country at large.

1.5 SCOPE AND LIMITATION

Deforestation serves as environmental degradation, which are as a result of human-induced activities. The interest of this study is to analyse the extent of deforestation, its factors and its effect in the study area. To carry out this set goals, maps produced by FORMECU (1976 and 1993) are to be used. The maps are cartographical representations of the real land used and the vegetation whose shapes and relationships must be understood as the changes in the study area.

However, it was difficult to obtain images of recent times and other related remote sensing material like aerial photographs, due to financial disability.

Another constrain in the study was the inability to go round the study area to collect some data. Hence some selected areas in Maiduguri like Molai, Jere and unimaid have been chosen for the study during the field check in December 2001. Satellite Images data of 1976 and 1993, field check report, and computer facilities at the Javi Solutions Center Suleja was used. Examples were also drawn from a range of recently published books, journals, paper presentation, etc to accomplish the study. This study was restricted mainly to the study area and was derived directly from the available data.

1.6 GEOGRAPHY OF THE STUDY AREA

1.6.1 LOCATION: MAIDUGURI

Maiduguri the capital city of Borno state, is located on latitude $11^0$5N and longitude 13^0, 05N. It is entirely situated within the Chad basin (figure 1.1). It stands on the surface 1160ft (355 metres) above sea level on a relatively undulating plain north west of the Bama ridge. It has an area of about 543 square kilometers. The population of the area is 629, 486 people with a density of 159.1 persons per square kilometer, (census 1991) and (Borno census 1994).

1.6.2 CLIMATE

According to Koppens classification (Koppens 1931), Maiduguri is dry tropical bush type climate. Thus, it is semi- arid (Thambyaphillay 1979). This type of climate represents a transitional climate situated between humid savanna and the desert. In fact, the climate of the study area is generally hot and dry for most of the year. It is marked by two seasons; wet and dry season. The wet season last for three to four (3-4) months, while the dry season is between eight to nine (8-9) months. Temperatures are generally high all year round with a mean of about 34.8^0c (Oguntoyinbo, 1978). The average monthly mean maximum temperature is about 31^0c and the average monthly mean minimum temperature is 15^0c. This results in heavy concentration of dust. During the harmattan, the northeast trade winds obstruct the suns rays from penetrating the atmosphere, which result in extremely cold weather.

Maiduguri is located in Sahel Savanna with an annual rainfall of about 650mm and has relative humidity under 40 percent throughout the dry season and 60 percent during the wet season.

The rainy season begins with intermittent trickles and heavy wind around the end of March or early April but does not get established until the middle of

June or July. The range here is influenced by the seasonal migration North-South of the inter-tropical Discontinuity (ITD). The beginning of the season is characterized by heavy storm especially between the rains. However, with the progress of the rainy season, the strength of the wind calms down, only to be strengthened in November-February.

The precipitation in Maiduguri is basically of the convectional type of rainfall. July and August are the wettest month with range from 100mm-295mm on the average.100mm per drop is common, at this period for example there were record drops of 11.3mm on 6th August, 1953, 103.4mm on 2nd July 1958 and 126.5mm on 6th August 1967. The last was the maximum rainfall value ever recorded in Maiduguri (1964-1993). Generally, single drops are between 25.0mm and 66mm. The Rainfall pattern is a single maximum type. It is usually recorded during the afternoon and associated with thunder storm (Max lock, 1976).

1.6.3 RELIEF AND DRAINAGE

Maiduguri has a relatively flat terrain of the Chad basin formation, which is made up of clay and sandy soils of a large undulating plain and slopes gradually toward lake Chad in the North-East. This plain is recognized as Borno plian.

Maiduguri area is drained by River Alo and its tributary River Ngaddabul, which are ephemeral in nature. The main River Alo, divides the town into two geographical units; to the west lies the largest urban area while to the East is gwange and other newly developing area. Presently, four (4) bridges have been constructed to link the various sectors of the metropolis.

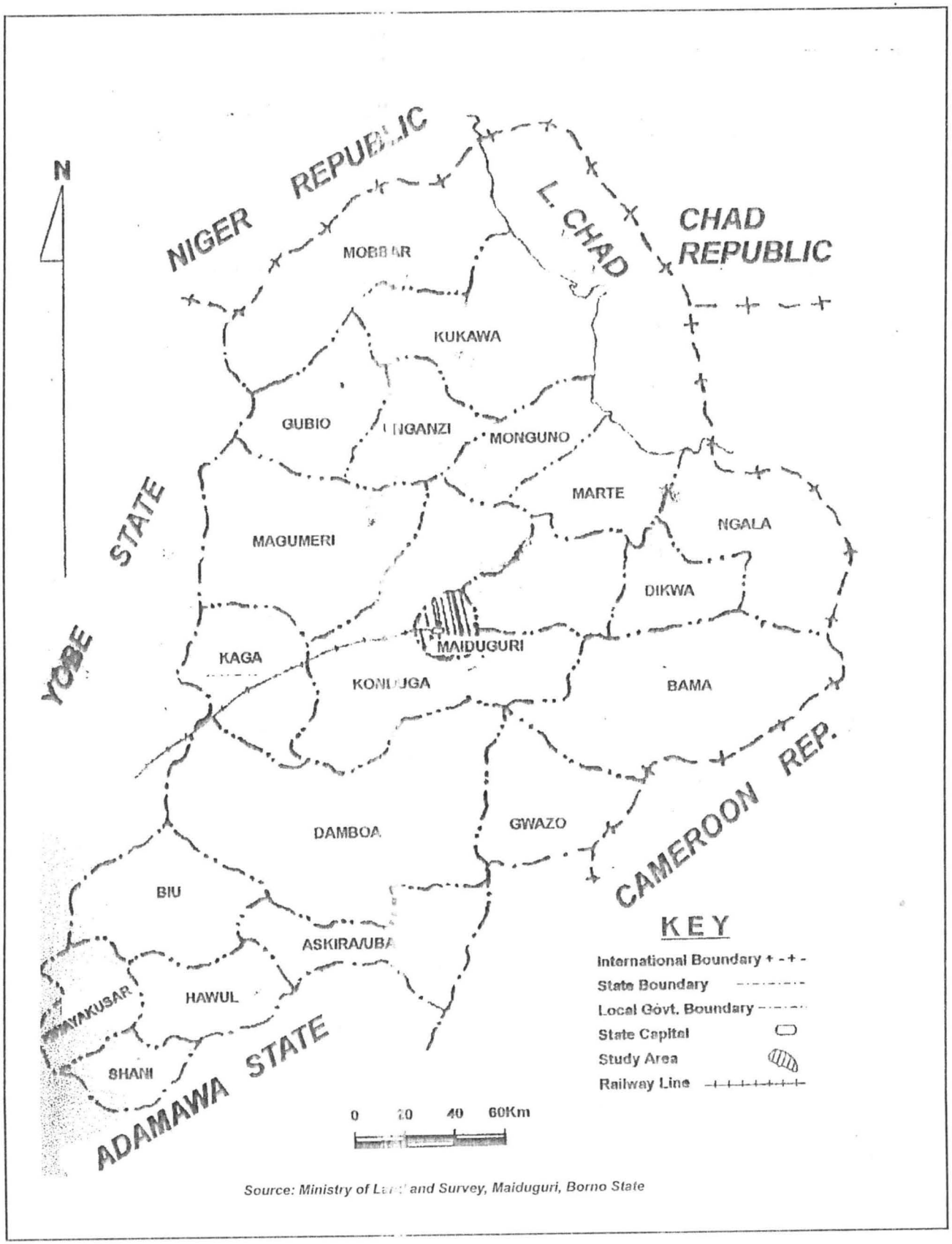

Figure 1.1 Map of Borno State Showing the Study Area

Other topographical structures include large ponds, depression, basis, pits and hollows, which originated either from tectonic or human activities through digging of sand and clay for the construction of mud and cement houses.

1.6.4 SOILS AND VEGETATION

The soils are mainly clay formation overlaid by sandy, which may be up to three hundred feet (300ft) thick. Sand dunes are also common features in Maiduguri. This sandy nature of the soil may not be unconnected with the fact that the origin of the material is Aeolian (Grove, 1968)..

Maiduguri is generally covered with great variety of unconsolidated deposit. The prominent sand ridge which passes through Maiduguri and goes beyond Bama, popularly known as Bama ridge, is thought to mark the south shore of Lake Chad in the Pleistocene times (Thambyaphllay, 1979). However, the soils are fertile and encourage plants growth, but the area is deficient in moisture vegetation.

The vegetation of the area is sparsely distributed with some short grass here and there with few shrubs and thorny trees. The trees around here are Neam, Acacia, thorny bushes, baobao and dump palms, Which are xerophytes.

1.6.5 HUMAN ACTIVITIES

Maiduguri with its environ is densely populated. The people in the city are engaged in different activities with the majority of them engaged in tertiary activities, that is government jobs and trading. However, some engaged in primary activities such as farming. These farmers produce crops; fruits and vegetables. Such as millet, guinea corn, groundnut, beans and maize, fruits like

mangos, paw-paw, water melon, guavas, and cashew nut, and vegetables like onions, carrots etc. Some of the crops are produced during the dry season, with irrigation on a small scale basis at the back of their houses, behind offices and on the bank of lake Alo along Bama Road, some 16 kilometers away from the city. Others, though little, engage in secondary activities, such as metal work, leatherwork, local soft drink and other production of consumable goods.

Due to economic hardship, people living in Maiduguri now engage in more than one activity. For example, they farm in the dry season, work as unskilled labour in manufacturing industries or building and construction companies. In addition, government workers are also husbandmen /rear animal or farmers or petty traders.

1.7 STRUCTURE OF THE REPORT

This research is based on chapters. Chapter one is the introductory part of the study. Which comprises; deforestation preview, statement of problem, objective of the study, justification, Geography of the study area, structure of the report as well as scope and limitation.

Chapter two, contain the review of related literatures,. Chapter three deals with methodology, instrumentation and data analysis procedure.

Chapter four is the main body of the work, which deals with data analysis and interpretation of two different maps acquired in 1976 and 1993, factors influencing deforestation, result of findings, scanning and summary of the findings. Chapter five deals with conclusion recommendation, and summary. Finally references and appendix were also documented.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

The environment is a system and a resource, while deforestation, desertification and biodiversity loss are resultant effects of over exploitation of the natural resources in the environment The environment is a life support system, a resource with wide array of use, values and a waste, assimilator. Today the issue of our environment is high on the global agenda. This is because many dimension of environment degradation such as deforestation, desertification, ozone layer depletion, global warming and loss of biodiversity and many more, transcend national boundaries. Environmental degradation is an umbrella term that includes physical, demographic and socio-economic processes contributing either directly or indirectly to the deterioration of the environment. (Sanusi and Sarah 1999). The over bearing element in desertification control is man.

The improper management of land use in Nigeria influenced by the traditional tenure system is a problem in itself. It encourages fuel wood gathering, over grazing of vegetation area and crop production, to the detriment of the environment. Hence the rural population is forced to degrade the environment in the absence of ineffective legislative policies. Thus in the study area (Maiduguri) and areas like Kano, Sokoto, Katsina and some part of Yobe with high concentration of human population with unequal land tenure system within the framework of subsistence living, communities utilize the natural environment beyond its capacities thereby encouraging desertification .

However, let us look at the primary cause, how they introduce deforestation in the area and other part of the country. It is generally known that, the vast inhabitants of Nigeria's sudan sahel zone depend on fire wood for cooking and

heating for both domestic and non- domestic uses.

Studies in Kano found that the estimated consumption of firewood per person in urban households was 360kg or 0.52m every year.. Satellite remote sensing is considered as perhaps the only viable option in this regard (Prince, at al 1990 Alwashe and Bokhari, 1993). One added advantage of this tool over almost all the other tools for vegetation monitoring is that satellite data are gathered in digital format which makes computers – assisted analysis a relatively easy task, the data volume involved notwithstanding (Campbell,1987). Being in digital format also makes it possible for satellite derived vegetation data to be integrated with other ground –collected vegetation within a GIS framework and such a data integration is considered as being very fundamental in, especially, land cover change detection . Thus presently , satellite remote sensing and its associated technologies of geographical information system(GIS) and GPS (Global Positioning System) , provide a good basis for us to comprehensively examine and monitor land cover changes, especially vegetation (Thenkabail and Noite 1995; Jensen,1996). A number of research workers have demonstrated the efficacy of finer resolution satellite data (Landsat MSS ,TM, and SPOT) for use in vegetation change monitoring in different parts of Nigeria's semi-arid region (Pilon,1986 ;Pilon andAdeniyi, 1976 Pilon et al 1988 ; Brown, 1987 Sule 1990 ;Omojola and Ezigbalike, 1993 Abdallah , 1994 Omojola 1997) .

Infact, lack of spectral confusion as a result of land cover heterogeneity in the Sahelian semi- arid area in considered as one Justifiable reason of utilizing satellite remote sensing in the land cover types (Prince et al 1990) .

Observation by Arnoni 1981, indicated that as a result of rapid increase in population since 1970's, demand for land in order to provide enough food for

the growing population has increased. Simultaneously, there has been increase in livestock with increased -intensified use of forest to meet rising demand for fodder, fuel wood, poles and other forest products. When population pressure was not excessive, traditional agriculture produce sufficient food and maintain an acceptable level of supply.

Forestry plays a significant role in Nigeria's economy. In the past, in addition to the exports of cocoa, groundnut, cotton and palm product, forestry products played a significant role in Nigeria's favourable balance of payment. It also provides raw materials which satisfy consumer's demand and investment needs. The estimated demand and supply of fuel wood and projections for the year 2000, 2005 and 2010 are presented in table 1. The structure of demand and supply was accessed according to ecological zones. The thirty-six states of the Federation and the Federal Capital Territory were group into three fairly homogeneous regions on the basis of resources availability under the following: - High forest, guinea savanna, Sudan savanna.

Table 1: Estimated supply (sustainable production) of fuel wood. According to Ecological region of Nigeria (in 000m3)

Ecological region		1997	2000	2005	2010
High forest	1	65,79	63,518	60,046	56,575
Guinea Savanna	2	7,068	6,508	6,146	5,797
Suda Savanna	2	3,008	2,749	2,554	2,359
Total		**79,728**	**75,759**	**68,749**	**64,731**

Source :(a) Estimate was derived from Ojo (1994).

The communiqué of the 28th annual conference of forestry association of Nigeria held in Maiduguri, Borno State 1999 holds that the major source of

fuel wood supply in Nigeria is from the high forest ecological zone.

If also maintained s that there has been a decline in the estimated supply (sustainable production) of fuel wood in Nigeria. The sustainable supply is estimated to decrease from 79.7 million m3 in 1997 to 64,731m3 in the year 2010 respectively, [see table1]. This shows that the greatest effect of the various changes in the estimated years [2005 and 2010] follows increase in the number of cultivating unit and amount of land under cultivation in the exploitation pressure, which has in some cases exceeded the production capacity of the land resource.

It was projected by Ojo 1994 that in the years 2000 and 2010 respectively the total area of forest suitable for sustainable production of fuel wood and other wood products in Nigeria has declined from 7.71 million hater. All these are as a result of human induced activities on the forest area of the country. Fuel wood is the dominant of domestic energy accounting for over 90% of total wood requirements (Biliya 1987). The use of wood as a major source of fuel has led to serious supply demand imbalances, which is more severe in the sudan and guinea savanna zone of Nigeria.

Another exponent observed that, (Silviconsult 1991), with a declining sustainable fuel wood production a huge supply deficit of about 31,5million m3 in 1997, for the guinea savanna and sudan savanna region combined and a projected national negative balance of about 2.2 million m3 in the same year have been recorded. Fuel wood supply deficits of about 4.5 and 4.4 million m3 have been reported for Kano and Lagos respectively for the year 1990. In such cities, the impacts of rapidly depleting forest (deforestation) have made fuel wood supplies very expansive as a result of high transport costs.

Moreover, National programme and desertification control reported that, the causes of desertification in Nigerian environment is mainly caused by the anthropogenic factors as the disruption of the ecological system, caused by poor land use and even increasing pressure put upon the available resources by the expanding population. More specifically, there are fine primary causes, notably overgrazing, over exploitation, deforestation, wood extraction and poor irrigation purposes. These are influenced by factors such as changes in population, climate and socio-economic conditions. It is obviously a complex inter-relationship, which includes:

- Poor physical condition in terms of soil, vegetation topography and inherent extreme variability climate as manifested in frequent drought.
- Disruption in ecological balance caused by poor land use and ever increasing demand being made on the available resource by the expanding population and socio-economic systems of the affected area.
- Improper land use practices and poor land management. the United Nations Sudano-sahelian office (UNSO) has identified forest depletion as major agent of desertification in Nigeria. As a result of the demand for wood for construction, for domestic use and grass cover from the fragile land of the sahel will continue to accelerate degradation of the soil to desert like conditions. In the country side people find the sale of firewood to the town people a useful supplement to their meager cash/ incomes. For construction purposes, 350,000 haters of land is under the thread of disforestation annually; while the rate of reforestation is estimated at about 30,000haters . (CAZS MAIDUGURI) 2001.

Bush burning is another agent in the process of deforestation in the study area. Owing to the low relative humidity of the semi-arid zone coupled with very dry hamattan, wind, there is always a high incidence of bush fires every dry season. The occurrence of fire within the zone can be attributed to:

1. Bush burning by villages when clearing land for Agriculture.
2. Hunters who is in such of game, set bushes on fire.
3. Cattle herd man who set fire to dry grass to stimulate growth of dominant grass buds.

According to an organization knows as the southern African development coordination conference (SADCC), more than 60 million people live in the nine member countries of SADCC region. The vast majority rely upon biomass in the form of wood, charcoal and crop or annual residues for their basic household fuel, which account for 50 percent (Zimbabwe) and 90 percent (Tanzania) of natural energy consumption. As the below table 2 reflected energy flow (1985) final energy consumption.

	Pj(10 15 joules)	percent
Wood fuel	1100	79.0
Oil products	143	10.3
Coal	87	6.2
Electricity	63	4.5

SOURCE: SADCC Energy Sector Angola 1985

The current demographic growth patterns, shows that demand for fuel wood continue to grow by the year 2000, with estimated 100 million people. The growing people will continued to increase pressure on the woody plant by more deforestation on the forest area either through human settlement which reduce the areas where woody plant can grow or crop lands.

However, afforestation would claim to have complete answer to desertification. This problems is best explained by more finding or research and educating people about the damage or the impact of deforestation which has halved, the

area of the forest and savannah wood lands in the developing nations since the turn of the century. Despite all the efforts of natural governments and life natural and community the rate of deforestation is increase. 11 million lectures a year are being cost (common wealth forestry review 1985).

Another school of thought looks at deforestation as contributory factor in desertification process and lowered crop yields in sahel-sudanian zone mainly as sequence of accelerated wind erosion of top soil and reduced moisture availability in the soil (Spears 1985).

The long history of human occupation of the sahel region of the study area has meant that human use of the plants has been both spatially extensive and locally intensive. This use has, over large areas, been destructive, as we shall see in the image produce in 1976/78 and 1993/95, during that time most of the forest have greatly reduced environmental vital through afforestation. However, it was then motivated by economic influencing afforestation in the sahel zone have increasing demand for gum Arabic, tanning materials for the leather processing industry and fuel wood demand from 1976-80, 618, hectares of Acacia Senegal (Gum Arabic) and 755 hectares of fuel wood plantation were established.

The most important plant species are Acacia Senegal, Acacia nilotica and Azadirachta indica. Other includes eucalyptus SSP and cassia Siamea (Papka 1984). Most of the school of thought agued that; global warming is not being driven solely by energy production. It is caused also by the changes in land use (deforestation and increase in grazing lands and rice paddies). The primary man made sources of the most important green house gas carbondioxide (co_2) include the burning of fossil fuels, deforestation, co_2 is estimated to account for

half of that heat trapping potential of the green house. (World resources institute 1990). The loss of forest has a profound effect on the global carbon cycle. From 1850 to 1990, deforestation world-wide (including the United States) released 122 billion metric tons of carbon into the atmosphere, with the current rate being approximately 1.6 billion metric tones per year (NASA, 2000).

It was further observed that, the rate of deforestation varies from region to region. Recent research results showed that in the Brazilian Amazon, the rate of deforestation was ground for about 6200 square miles per years from 1978 – 1986, but fell to 48000 square miles an area the size of new England). However, due to the isolation of fragment and the increase in forest / clearing boundaries, a total of 16.5% of the forest (230,000 square miles, an area nearly the size of texas) was affected by deforestation. Scientist are currently analyzing rates of deforestation for the current decade, as well as study how deforestation change from year to year. Tropical deforestation is responsible for approximately 20% of total human – caused carbondioxide emissions, figure comparable to fossil fuel emission from the united states. (Intergovernmental panel on climate change 2000).

However, some has the ideas that, deforestation results not only in the loss of trees, but may also cause the entire remaining vegetation to partially break down most areas are drained and organic matter (e.g humus) bound with soil becomes easier to decompose. All these processes release 20% (117 thousand million tones C) of Co_2 and CH_2 locked up in vegetation since 1850 into atmosphere. (Climate problem 2000).

Another view on deforestation according to (FAO/UNEP in 1980) the arboreal and shrubby tropical formations plus the forest follow, cover about 2.9.7

million km^2 Their distribution by categories and regions is given below in Table 3. the world's closed and open tropical forests being deforested at the annual rates of 0.62% and 0.52%, respectively. The striking similarity of the rates of deforestation by regions shown in Table 4 should not hide the marked difference that exist between individual countries and between sub-region, for example, the annual deforestation rate for the closed forest of west Africa is 6% or six times higher than the comparable rate for east Africa (including Madagascar) and 30 times higher than that for central African. These results are mostly through logging operations, intensely or carelessly, which can irreparably degrade the environment particular on steep slopes or fragile ecosystem such as the mangroves or sahilian like the study area. Nearly half of the forest area goes to shifting cultivation and for the most part accrue the crusting forest fallows without irreparable ecological damage if not cleared again.

Today, however, many shifting cultivation shorten the follow periods because of land scarcity or because of change in their needs and perceptions.

Table 3. Tropical forest resources assessment

Tropical Regions	**Forest**			**Forest follow**	**Shrub Land**	**Total**
	Open	**Close**	**All**			
African 37 countries America	2.2	4.8	7.0	1.7	4.4	13.1
23 Countries Asia	6.8	2.2	9.0	1.7	1.4	12.1
16 Countries	3.0	0.3	3.3	0.8	0.4	4.5
Total 76 countries	12.0	7.3	19.3	4.2	6.2	29.7
Sources	FAD/UNEP Tropical forest resources assessment.					

Table 4 Tropical Deforestation in thousand km$_2$ and in % of surface per

year

	Closed Forest		*Open Forest*		*Total*	
Tropical Regions	Areas	%	Area	%	Area	%
African 37 countries America	13.3	0.61	23.5	0.48	36.8	0.52
23 Countries Asia	43.4	0.64	12.7	0.59	56.1	0.63
16 Countries	18.2	0.60	1.9	0.61	20.1	0.60
Total 19 countries	74.9	0.62	38.1	0.52	113.0	0.58
Sources	**FAD/UNEP Tropical forest resources Assessment.**					

Base on the observations made on the environmental factor and human induced activities leading to degradation of the forest the study area and the world in general, there is need to relieve the pressure on natural forest and reverse the rate of the deforestation and arid zone desertification through conservation and monitoring. A question aroused that "The Environment is degradation as a result of human induced activities, how can such be monitor and control.

In an attempt to answer the above question, researchers, in the field of geography and technology have come up with studies about the anthropogenic activities that lead to deforestation, how deforestation can be monitored and controlled. The first step in assessing the impact of forest conversion to deforestation or degradation, is to determine the aerial extent of the degradation and subsequently the rate of change in the environment and the techniques involved in monitoring environmental satellite data for the changes.

Widely scattered and largely uncoordinated and uncontrolled development in the study area dictated that remote sensing offers the only practical and forest solution for a large area assessment of forest conservation. To data, most remote sensing monitoring techniques have been based in the contrast between the reflective channels of the multi-spectral scanner on LANDSAT-1, -2 ….., -5 and of later thematic mapper was used by (Tardin et al 1982) to estimate the tropical forest conversation of the Brazillian Amazon. Similar approach on the kainji National park of Nigeria to estimate the conservation of the environmental resource (Appolonia 1999).

Matson et al 1984 and Murhead and Cracknel 1985 demonstrated that the 3.8mm channel on board the AVHRR effeetively detected sub-pixel resolution forest fires, tundra fires, peat fires straw fires, and controlled burning (Matson and Dozer 1981) presented a theoretical approach to determine the area and temperature of any sub-pixel fire detected by the 3.8mm channel that does not saturate the sensor. Other investigator shame used the 3.8mm channel estimate the aerial extent of fires in forested areas. Most notable, Malingreau et al (1985).

Land degradation is widely regarded as a serious problem yet it has proved difficult to identify and map. Ground based assessment techniques (e.g. UNFAO/UNEP 1984, GRAPHA 1988) are difficult and expensive to implement on an extensive scale. Remotely sensed data often frequent complete spatial coverage of vegetation cover change, but the must successful degradation assessment techniques require data with a relatively high spatial resolution from landsat-MSS, landsat-TM or SPOT HRV, for example, federal department of forestry coordinating unit (FCDMECU) 1976/78 – 1993/95 attempted using SPOT

xs, LandSat Tm,ERS – 1 SAR and JERS 1 SAR and JERS-1 to map land use and changes analysis in Nigeria. It results that, whole country is seriously undergoing changes in its climate and vegetation as result of anthropogenic activities, on other hand human induce activities.

As the area are been affected with the impact of the deforestation, which effect the climate, give raised to climatic change and inflection is noticed in different part of the state and Nigeria in general, with enhanced intensity as observed by Thambyahpillay (1979).

> *" The problem of climate change has once*
> *Again surfaced, this time with even greater vigour*
> *Than in the past...*
> *In circumstance of extreme weather*
> *Anomalies during the present decade"*

With the recent condition or situation of changes in the climate, show extreme anomalies, for example Maiduguri the study area recorded a total mean rainfall of 234.00mm in 1982; resulted as the lowest rainfall received, also the rain fall of 1983 and1984 had a mean precipitation of 283mm and 328 respectively showing the second and the their lowest values source FMV Maiduguri 1995.

My investigation presents a case study of assessment of deforestation of Maiduguri and its environs. In spite of the above views, it make us to understand that deforestation in Maiduguri, the study area, is as a result of pressure on the natural resource (vegetation) around, due to increase in human population, crop land, and human settlement, in number of grazing animals, as well as climatic change in the area and the world in general. This work is limited to study area.

2.1 FACTORS INFLUENCING DEFORESTATION

There are many causes associated with deforestation in the study area. Anthropogenic factors are mainly the disruption of the fragile zone of the forest in the area, caused poor land use (farming), increasing pressure upon the available resource by the expanding population. More specifically, there are some primary causes notably over exploitation, over-grazing poverty and bush burning.

Similar studies was reported by Sani M.A. 1998 that; ground vegetation data revealed that these GCPS happen to be ones where evidences of wood exploitations, grazing intensity and bush fires are moderate to very high. Thus, this suggests that among the selected 35 GCPS they are the ones that maintain generally low vegetation cover throughout the study period, most probably because of the combined influences of the above named agent of vegetation degradation .Since these GCPS represent about 30 % of the sampled GCPS, it is thus arguable that some moderate to high pressures of grazing intensity , bush fires and wood exploitation . Over these same GCPS also, the vegetation indices depicts generally decreasing trends over the 1988 –1997 period, suggesting a general decrease in vegetation over the period.

Tropical deforestation has well known been noted as a serious ecological problem, especially under low rainfall areas . (Salau, 1992, IGBP, 1993). In low rainfall areas, such as the study area, beside the negative influences of declining rainfall amounts on few vegetation development, excessive pressures are placed on the vegetation resources through grazing, wood collection and clearance for cultivation. In 1980, this cover represents the highest of the observed cover classed in the area about 870km2 but within seven years, it dropped to the second. (Abudakar et al 1998).

However, let us look at the primary causes, how they introduce deforestation in the area and other part of the country. It is generally known that, the vast inhabitants of Nigeria's sudden sahel zone depend on firewood for cooking and heating for both domestic and non- domestic uses. The northeast arid zone development programme (NEAZDP) household surveys has confirmed, this dependence on firewood, while only about 10% of the household has kerosene stove. However, studies in kano found that the estimated consumption of firewood per person in urban wood using households was 360kg or 0.52m every year. For example in Kano metropolitan it was found to be 273kg/person /yr ($0.39m^3$). While in the study area the demand is twice that of the Kano study, due to the fact that, about 75% of the people living in Maiduguri and environs depend more on fuel wood for cooking and other domestic uses. During field checking, it was observed that many trucks enter into Maiduguri metropolitan daily with tons of firewood to their depots in Gwange area.

2.2 EFFECT OF DEFORESTATION

Deforestation results not only in the loss of trees, but also cause the entire remaining vegetation to partially break down. Moist areas are drained and the organic matters (e.g. humus) bound in the soil becomes easily decomposed. All these processes release carbon dioxide ($C0_2$) into the atmosphere since 1850 there has been a world –wide release of some 20%(117,000 tones c) of carbon, which was locked up in vegetation. However, such carbon has been lost due to human induced activities on the forest. (Climate problem, 2000).

Global warming is not being driven solely by energy production. It is also caused by change in land use (Deforestation, over grazing etc). Deforestation may have profound effects on global climate of the area by reducing the

evaporating, cooling that takes place from both soil and plant life. As trees and plant are cleared away, the moist canopy of the tropical rain forest quickly diminishes. Such has greater effect on the ground and the living organisms that make up a rain forest.

However, in the study area, the map of 1976/78 – 1993/95 presents an analysis of changes in every land cover around the area. This is due to more demand on fuel wood supplies, which result in indiscriminately cutting of plants. These practices lead to deforestation and facilitate desertification in the area which study hopes to proffer solutions to.

Desertification is the out come of the deforested area, the study area serves as a good example of it. FORMECU (1994) in their studies sees deforestation as a trend to promote soil erosion. As soils are eroded, there will be reduction of soil nutrients available to adjacent crops.

Fuel wood shortage is also an economic issue . Fuel wood scarcity and the increasing distance over which fuel wood must be transported, for example from kundiga area along Damboa-Biu Road and along Damaturu road, have caused prices to rise sharply in recent years.

Mohammed (1985) found out that, fuel wood scarcity impairs agricultural productivity. Farmers where forced to up root crop residue after harvesting for use as fuel which traditionally should be left to enrich the soil. In certain situations, people resorted to the use of cow dung as fuel. These practices tend to reduce crop productivity and incomes where dung and crops residues could otherwise be used to fertilize the soil and as livestock feeds.
This result is lower fertility for agricultural land. The lower fertility of land

leads to lower productivity, giving a lower income, which prevents purchase of other substitute fuels. This phenomenon in turn leads to a greater dependence on fuel wood.

The economic effects of fuel wood scarcity are felt beyond the home. Agro-based industries such as fish smoking are equally affected.

However, social impact of deforestation is in the rural community around the study area. As fuel wood supplies become scare increasingly, people are walking long distance in search of new supplies as far as 40 –80km along Damboa-Biu Road. In must rural communities of Nigeria women are assigned the task of gathering firewood e.g. in Biu local government area (Babur Women), in Niger State (Gwari women) etc. This affects the family as it reduces the time available for alternative activities such as tending crops, preparing food and carrying out other domestic activities.

With the above views and thought, it shows that deforestation has a greater effect on the fragile ecological zone of the sahel savanna area and it result to detraction or degradation of the forest in the study area.

CHAPTER THREE

3.0 MATERIALS AND METHODOLGY

3.1 MATERIALS

The instruments used for the research are satellite imageries, and topographic maps of the study area. The imagery was acquired within the period of 23/01/93 Landsat TM on path 185km/Row52. The analysed topomaps were processed by FORMECU in 1995.

The selected areas of study were surveyed over five days (13^{th}-17^{th} December 2001). During the research ground truthing (field checks 2001), identification of ground location of every selected area was made using a hand-held binocular. Though photographs were not taken during the ground truthing but it was clearly observed that the area visited show a progressive decline in vegetation cover due to construction of residential buildings and road. Also observed was less biological diversity through the loss of species, and insufficient in old G.R.A housing area. This was as a result of depletion of the top layer of humus from the soil and an increase in surface run-of which is as a result of deforestation.

Also , some of the research instrument were presented to the supervisor who examined them and content validity before they were administered.

3.2 METHODOLOGY

In analyzing the data obtained, for this research work, reference map of the area, of the same scale with landsat TM and MSS data, was obtained and digtised into ILWIS (integrated land and water information system) GIS data file. The two satellite images were then registered to this map using image- to – map registration algorithm. Landsat MSS band 1,2 and3 were single out, from the four band data set for each date, for detail land cover classification based

upon the understanding that they are the main ones that depict land cover quality and quality adequately (Curran, 1985). The acquired data were first preprocessed to correct for radiometric and geometric distortions, using ILWIS software.

The based map, in the GIS data file was then used to locate reliable and easily identifiable ground to collect information that will aid in defining cluster into a specific land cover class it fits best. When the clusters were defined into land cover classes, appropriate ILWIS GIS routines were used to calculate the arial extent of every land cover class at both 1976 and 1993 dates, and the magnitude of change in every land cover between the two dates. The field checking was conducted during the month of December for collection of ground truth data.

The percentage were also found for the extent of the changes, showing the distribution trend of each of the identified nine forests reserved and different land cover classed of 1976- 1993 of the study area.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.0 INTRODUCTION

This chapter deals with the statistical analysis of vegetation and land use changes in the study area, using image interpretation. There are many cost associated with deforestation in the study area. Anthropogenic factors are the main cause of disruption of the fragile zone of the forest in the area. More specifically, there are some primary causes, notably over exploitation, over-grazing, poverty and bush burning.

About 75% of the people living in Maiduguri and environs depend more on fuel wood for cooking and other domestic uses. During field check, it was observed that about 10-15 trucks enter into Maiduguri metropolitan daily with tons of firewood to their depots in Gwange area.

This is evidently observed during field check that, the vegetative destruction in the study areas in often less systematic as it does not always involve larger-scale, whole tree harvesting, but rather it was observed that there is systematic lopping and chopping up of tree branches. This means that trees in such areas are not as much felled as they are being degraded and consequently the areal extent of a vegetation community is not necessarily reduced, but its quality being systematically altered.

4.1 RESULT OF THE FINDING

It is clear from the results obtained here that Land cover changes in the study area between 1976 and 1993 involved transformation of forest-like covers into non-forest covers, such as accelerated land degradation process like erosion , desert encroachment and deforestation .

This means reduction in both the density and amount of the higher vegetation community.

Table 4.1 Shows the distributional trend of each of the identified four Land cover classes of the study area and the present changes in the four identified Land cover classes.

Table 4.2 presents the analysis of nine forest reserve, degradated extent and changes in every forest reserves between 1976-1993. Figure 4.2 and 4. 3 also show the Land use changes in the study area (1976-1993).

4.1.1 BUILT UP AREA

The build up area was about 11km^2 in 1976 which had increased to 21.3km in 1993 at an annual growth rate of 1.3%. It is not difficult to blame the changes on population growth and migration towards the Maiduguri town from different part of the state. It is worth noting here that the growth of Nigerian population used to be less than 2% per annum in the 1950s and 1960s, but increased due to progressive up-surge in population during the 1970s and 1980s.

4.1.2 FOREST AREA

Naturally, this area suppose is to be dominated by thick vegetation cover. Due to increase in demand of fuel wood, this area has undergone a decrease in spatial extent of about 116.55km^2 between 1976- 1993 which represents a decrease of about 11.5%. Tropical deforestation has well been noted as a serious ecological problem, especially under low rainfall area (Salau, 1992, IGBP, 1993). In low rainfall areas, such as the study area, beside the negative influence of declining rainfall amounts on vegetation development, excessive

pressures are placed on the few vegetation resources through grazing, wood collection and clearance for cultivation. In 1976, this cover represent the second highest of all the observed cover classes in the study area (41.3 km^2) but within seventeen years, it dropped to about 27.5 km^2 in 1993. During ground truthing, it was observed that the forest Land cover is actually encroached by farmlands, while the remaining little forested area is under increasing threats of wood collection.

4.1.3 AGRICULTURAL AREA

This cover represents the highest of all the observed cover classes in the study area having about 156.9km^2 in 1976 (intensive small holder Rainfed Agriculture), and 122km^2 in 1993 (extensive small holder Rainfed Agriculture). The farmlands was introduced to livestock farming, plantation, Rainfed Arable crop farming and Agriculture with Denuded area. This means that the little forest like and non-forest trees in the study area are much felled and cleared for farmland as they are being degraded and consequently the areal extent of Land cover has changed, such resulted to the highest degradation rate of 4.3% per annum in the study area.

4.1.4 WATER BODY AREA: -

Lake Alo, (fresh water, marsh/ swamp area) in the study area occupied about 0.25km2 in 1976 and 10.25km2 in 1993 of fresh water body . This represent a total increase of 1.2 per annum in seventeen years. While the marsh / swamp area decreased from 0.75km2 in 1976 to 0.25km2 in 1993 .

While there is increase in the size of the water body of about 10.% in seventeen years. Various reasons, including construction of Dam, sand and gravel collection. During the field check it was observed that the cover in actually under increase threats of sand collection , which also contributed to the

increased in the size of the water body area .

TABLE 4.1 SESTIMATED AREAL EXTENT AND CHANGES IN THE CLUSTER LAND USE COVERS BETWEEN 1976-1993.

Classes	*Total extent Areal 1976 km2*	*Total extent areal 1993 km2*	*Total areal change km2*	*%*	*% P.A*
Built up area	*11*	*21.3*	*10.3*	*15.2*	*1.3*
Forest area	*40*	*27.5*	*12.5*	*18.4*	*1.5*
Agric area	*157*	*122*	*35.0*	*51.6*	*4.3*
Water body area	*0.25*	*10.25*	*10.0*	*14.8*	*1.2*
Total	***208.3***	***181.1***	***67.8***	***100***	

Table 4.2: Estimated areal extent, differences of degradated area and changes in the forest Reserves 1976/1978 –1993/1995.

Classes	Degradated extent 1976 km^2	Degradated extent 1993 km^2	Land use changes km^2	Percentage %
Jaori	0.25	2.5	2.25	12.5
Molai A	0	0	0	0
Molai B	0	4.75	4.75	26.4
Getlur	1.25	2.5	1.25	9.6
Femari	5.75	6	1.75	9.7
L/Alo reserve	0	0	0	0
Limati	2.25	0	2.25	12.5
Azaya	2.75	2.75	15.3	
Part Jaori	3	0	3	16.7
TOTAL	**12.5**	**18.5**	**18**	**100**

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMANDATION.

5.1 SUMMARY OF FINDINGS

It is clear from the results obtained (table 4.1) that there is reduction in both density and amount of higher vegetation community .Analysis of the result show that; from 1976 to 1993, the build up area has increased from 11km^2 to 21.3km^2 due to explosion in population growth.

This gave annual recent increase of 1.3%. During the ssame period, lake Alo with spatial extent of 0.25km as of 1976 has by 1993 increased in spatial extent to 10.25km^2, which gives an annual increase of1.23% . This is a pointer to the rapid rate of construction of Dam, sand and gravel collection.

On the other hand, some decrease were observed in other cover types in the area during the same period. The forest cover has declined from 40km2 to 27. 5km^2 which indicated an annual rate of change of about 1.53%.

This pattern of land cover transformation in the study area will contribute significantly towards accelerating land degradation process such as accelerated desert encroachment in the area.

5.2 CONCLUSION.

Remote sensing techniques as employed to investigate land cover changes in Maiduguri and its environs, Form 1976 to 1993.

The area was stratified into four different land cover types (Built –up area , forest area, Agricultural area and water body), through GIS-based Landsat TM and MSS images classification .

extent of each Chester land cover for the two analysed topographic maps (1976 and 1993), and how it has changed between the dates (figure 4.2and 4.3.) .

As this study advances to the stage of satellite data analysis and ground truth collection. It is envisaged that more questions are likely to emerge, waiting to be answered . This is most especially because satellite data is not in anyway an end in itself, for its value is greatly enhanced only when it is integrated with other spatial data sets, especially ground truth (Bradbwiy and Rollin,1986) . However, lack of Aerial photograph for 1993 prevented carrying out changes detection accuracy evaluation of the technique employed here to be made.

Some previous studies using multitemporal landsat data (single, 1986, Omojola and Ezigbalike, 1993, Jusoff and Abdulmary, 1995) have however shown that, conversion can be identified fairly accurately, leading some credence to the change in figures identified in the study. The assessment of deforestation in the study area by using remote sensing data would lead to generation of comprehensive result or out come of deforestation in the area and Nigeria at large.

5.3 RECOMMANDATIONS.

Therefore from the above result of the study, it is considered desirable to make the following recommendations, which could go a long way in reducing the rate of deforestation in the study area and Nigeria at large.

While sustaining the ongoing unarticulated and uncoordinated efforts of government programmes, the government should center on formulation and designing of a comprehensive long-term intervention package. Such an intervention package must be functional in structure, specific in objectives and time frame, and sustainable in methodology and above all backup by a coherent and efficient environmental policy and agencies.

Government should enact enabling laws and policy aim at in encouraging tree planting/afforestation programmmes.

Improve the livelihood of the people, by reducing the price of the other source of energy for domestic used, such as kerosene , cooking gas and coal . Establishment of geographic information system (GIS) to study the ecological problem in magnitude of deforestation.

There is need for the creation of a strong Non-government organization (NGO), which should composed of professionals as it is done in other countries face similar problems. This NGO should work hand in hand with other government agencies to educate the people of about deforestation and its related problems on the environment.

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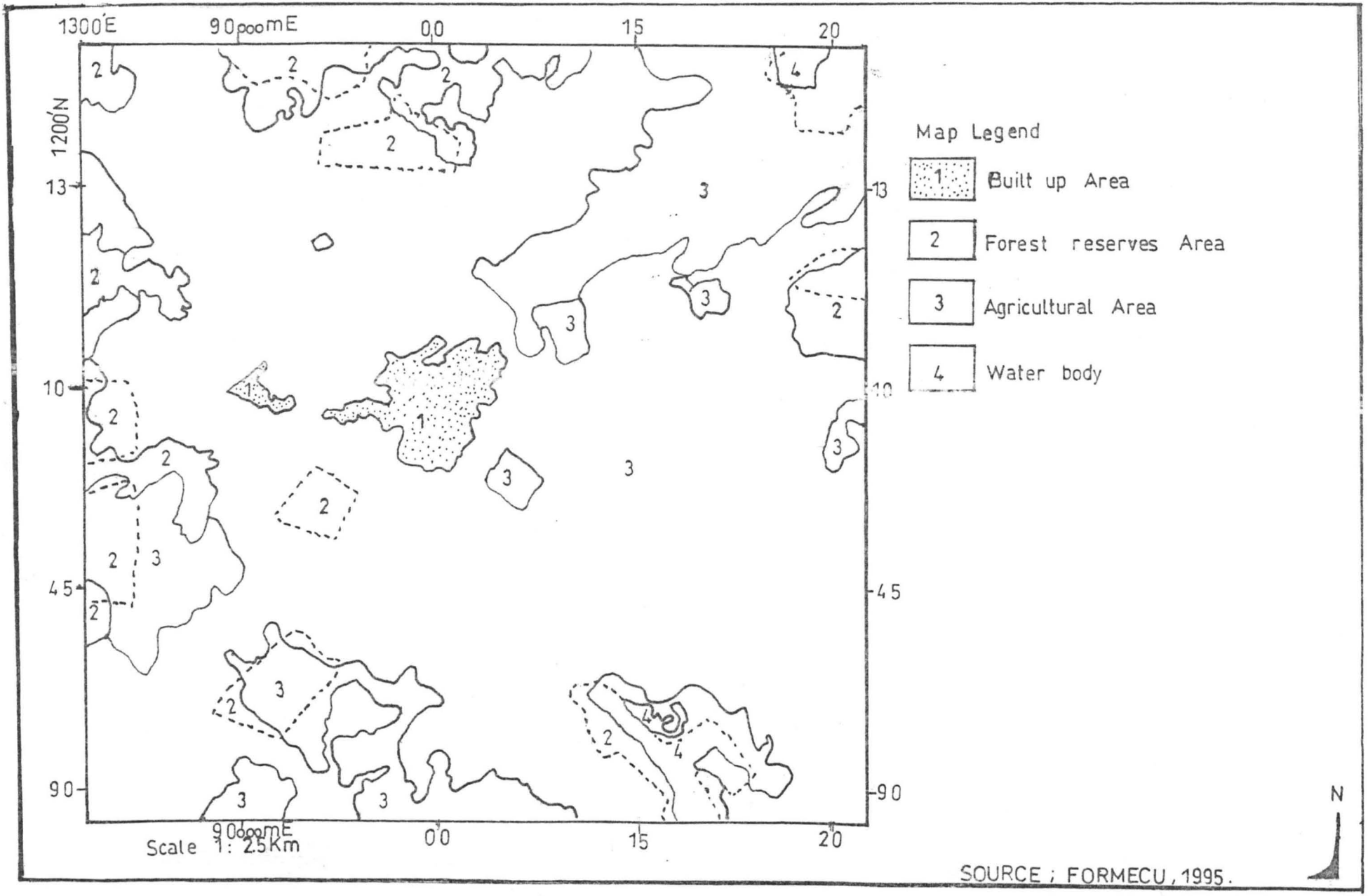

1300'E
900mE
00
15
20
1200'N
13
10
45
90
Map Legend
1 Built up Area
2 Forest reserves Area
3 Agricultural Area
4 Water body
Scale 1: 25Km
N
SOURCE ; FORMECU, 1995.

42

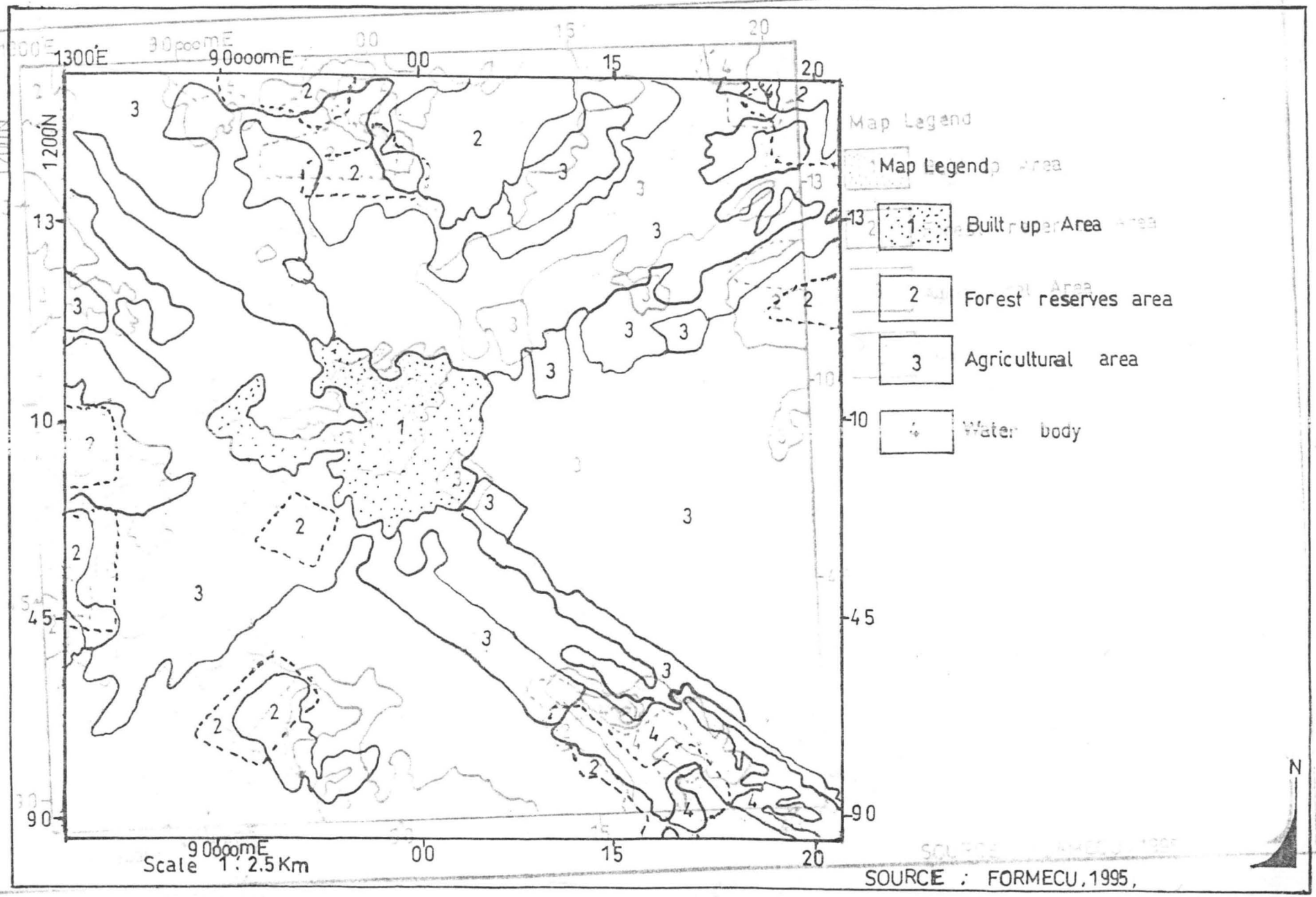
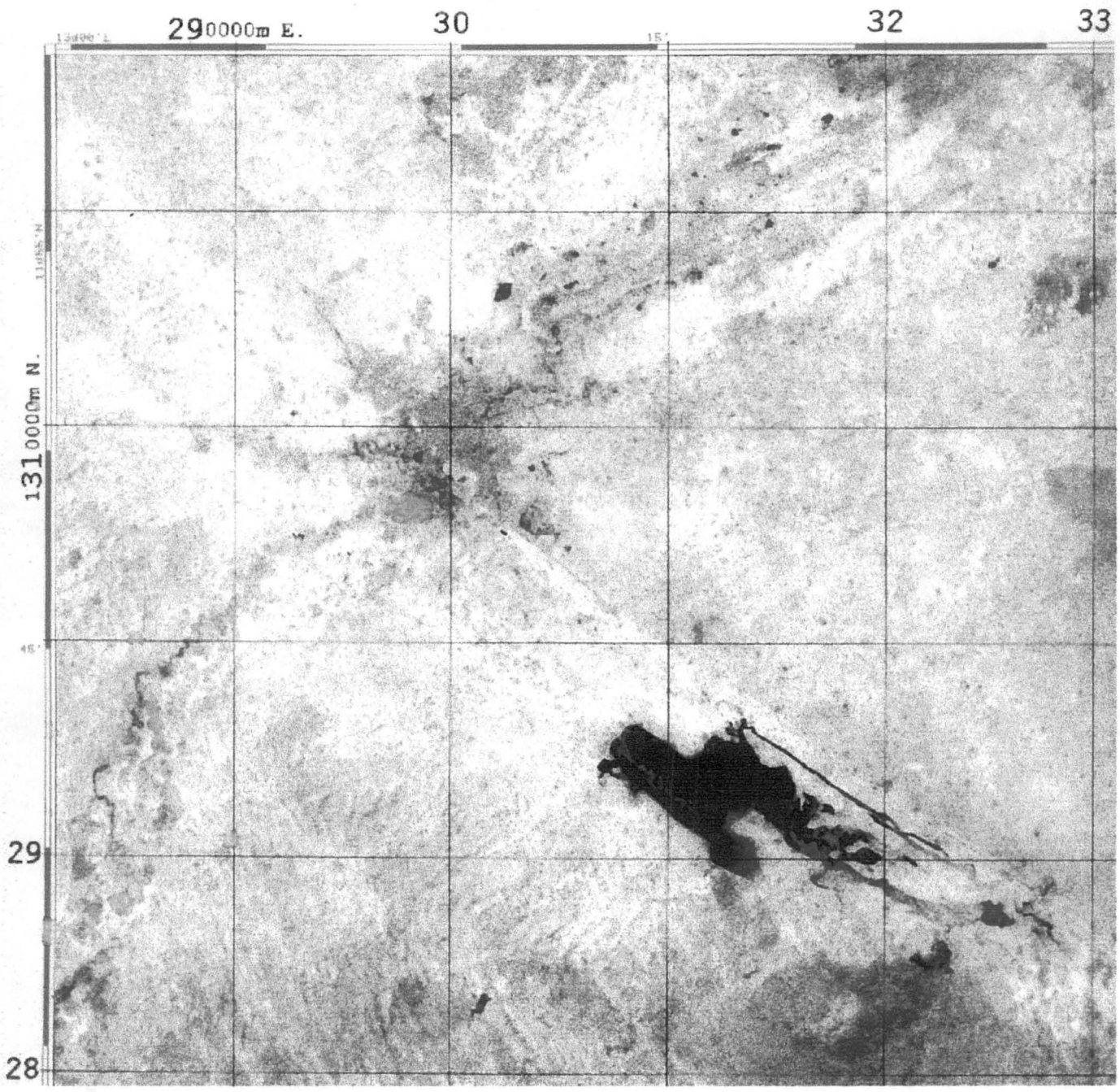


Fig 4.3 MAP OF THE STUDY AREA SHOWING LAND USE 1993/95

APPENDIX 1

Satellite Image of Maiduguri



Source: FORMECU 1995

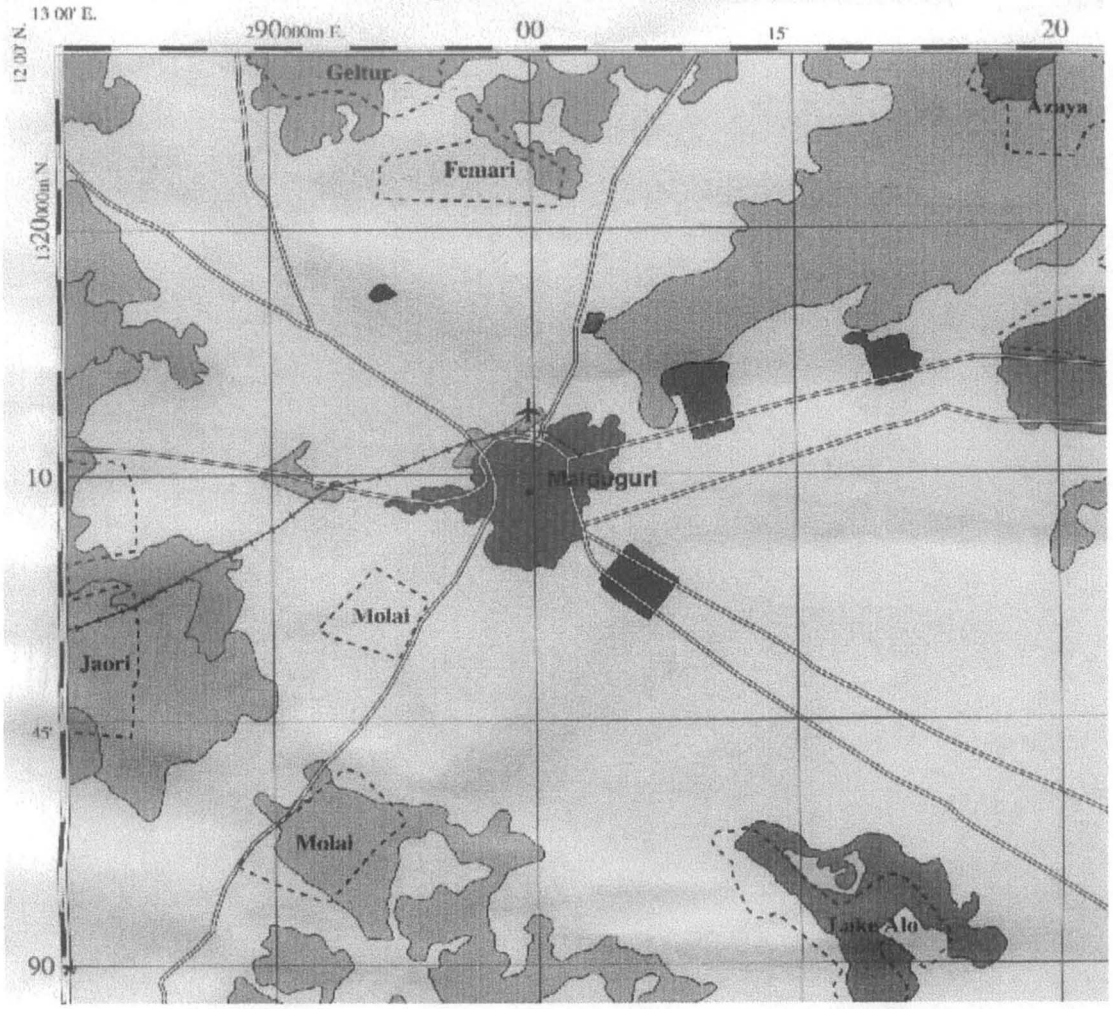
N

Scale 1 : 250 000 or 1 centimetre to 2.5 kilometres

Scene	Satellite	Path/Row	Date (mm/dd/yy)
A	Landsat TM	P185/R52	01/23/93

Maiduguri
Sheet 27

APPENDIX 2 Nigeria Vegetation and Land Use 1976/1978



Derived from Landsat MSS Imagery - (1976-1978)

Map Legend

- Major Urban
- Minor Urban
- Intensive (rowcrops, minor grazing) - Small Holder Rainfed Agriculture
- Rainfed Arable Crop
- Live Project
- Agricultural Tree Crop Plantation
- Dominantly trees/woodlands/shrubs with a subdominant grass component
- Dominantly Shrubs and dense grasses with minor tree component
- Teak/Gmelina Plantation
- Shrubs/Sedge/Graminiod Freshwater Marsh/Swamp
- Natural Waterbodies: Ocean, River, Lake

Infrastructure and Other Map Elements

- Main Roads
- Railways
- Forest Reserves (FR)
- Airport
- Town

Maiduguri

Sheet 27

N

Source: FORMECU 1995

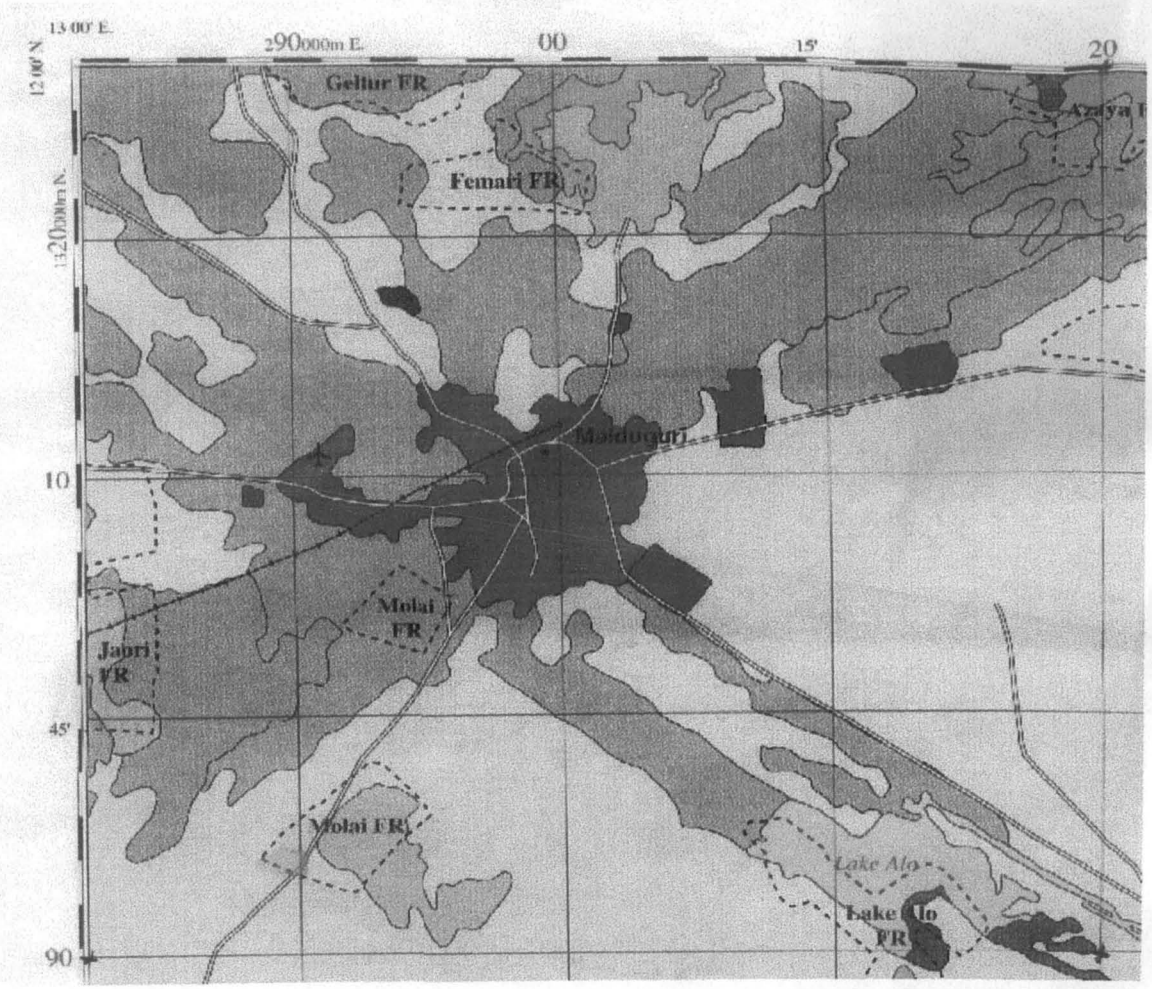
Satellite Image Data Used for Interpretation.

Scene	Satellite	Path/Row	Date (mm/dd/yy)
A	Landsat MSS	199/52	01/25/76

Scale 1 : 250 000 or 1 centimetre to 2.5 kilometres

10km 0km 10km 20km 30km 40km

APPENDIX 3 Nigeria Vegetation and Land Use 1993/1995



Derived from SPOT XS, Landsat TM, ERS-1 SAR and JERS-1 SAR Imagery - (1993-1995)

Map Legend

- Major Urban
- Intensive (rowcrops, minor grazing) - Small Holder Rainfed Agriculture
- Extensive (grazing, minor row crops) - Small Holder Rainfed Agriculture
- Extensive Small Holder Rainfed - Agriculture with Denuded Areas
- Rainfed Arable Crops
- Live Project
- Dominantly Shrubs and dense grasses with minor tree component
- Dominatly Trees/Woodland/Shrubswith Sub Dominant Grass Components
- Forest Plantation
- Shrubs/Sedge/Graminiod Freshwater Marsh/Swamp
- Natural Waterbodies: Ocean, River, Lake
- Teak/Gmelina Plantation

Infrastructure and Other Map Elements

- Main Roads
- Railways
- Forest Reserves (FR)
- Airport
- Town

Source: FORMECU 1995

Satellite Image Data Used for Interpretation.

Scene	Satellite	Path/Row	Date (mm/dd/yy)
A	Landsat TM	P185/R52	01/23/93

Maiduguri

Sheet 27

N

Scale 1 : 250 000 or 1 centimetre to 2.5 kilometres

10km 0km 10km 20km 30km 40km