THE USE OF REMOTE SENSING TECHNIQUES IN ASSESSING WATERSHED MANAGEMENT IN MINNA, NIGER STATE, NIGERIA

BY

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M.TECH/SSSE/2005/1384

DEPARTMENT OF GEOGRAPHY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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A THESIS SUBMITTED TO POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY (M.TECH) IN GEOGRAPHY (REMOTE SENSING APPLICATIONS)

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DECLARATION

I, Sidikatu Salahu, hereby declare that this research work has been carried out by me under the guidance of Dr. A. S. Abubakar of the Department of Geography, Federal University of Technology, Minna, and have neither copied some one's work nor have someone else do it for me. The information is derived from personal field investigation, published and unpublished work of others which have been acknowledged.

______________	2/3/2011
SALAHU, Sidikatu	**Date**

CERTIFICATION

This thesis titled: The Use of Remote Sensing Techniques in Assessing Watershed Management in Minna, Niger State, Nigeria by: SALAHU, Sidikatu (M.Tech/SSSE/2005/1384) meets the regulations governing the award of the degree of Master of Technology (M.Tech) of the Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to Almighty Allah for his Devine protection and favour upon me and my family.

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ABSTRACT

Land and Water are the two most valuable essential resources which form the basis of all life and are the key resource in all economic activities ranging from agriculture to industry. With ever increasing pressure of human population, there is severe stress on water resources. Watershed degradation has potentially enormous environmental and socio economic costs. Yet efforts to develop and use goods and services provided by watershed have not been well integrated with efforts to protect and manage watersheds sustainably in Minna. This thesis aimed at using remote sensing technique to assess the watershed resources of Minna metropolis, to create landuse changes map of Minna in order to analyse the change in landuse and land cover based on resources monitoring and finally to determine the trends damages on water land. MSS and Landsat satellite imagery of three decade (1973, 1995 and 2007) were used. Digitally image processing was carried out using three different software's (ArcGIS, ArcView and Idirisi). Landuse variances classification table was generated and represented with a graph. It was clearly observed from the analyses carried out that water shed was seriously reduced from 22.18% in 1995 to 12.12% in 2007. It was also discovered that one of the major problems of management of Nigeria's resources today is the general lack of information or data on the available resources. Water being one of the resources should be adequately catered for. Therefore, an urgent need for updating and regular monitoring is needed.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Land and Water are the two most valuable essential resources which form the basis of all life and are keys in all economic activities, ranging from agriculture to industry. With ever increasing pressure of human population; there is severe stress on water resources, and so there is need for rational and sustainable use and management of the scale water resources

The utilization of a watershed area and its carrying capacity to provide food and shelter for the exploding population has resulted in its deterioration in most parts of the world (FAO, 1985). However, such deterioration is more severe in developing countries, including Nigeria.

A watershed is an area from which runoff, resulting from precipitation, flows past a single point into a large stream, a river, lake or an ocean. Watershed or sub watershed is an independent hydrological unit, any modification of the land used in the watershed or sub watershed will reflect on the water as well as sediment yield of the watershed. A watershed may be only a few hectares as in the case of small ponds or hundreds or square kilometres as in the case of rivers. Watershed management or protection implies the proper usage of all land and water resources of a watershed for optimum production with minimum hazard to natural resources. Watershed management harmonizes the use of soil, water, and vegetation in watershed area in order to increase agricultural productivity and conserve natural resources. Conservation measure include revegetating barren land to assist in the control of runoff; introducing sustainable agricultural practices for hilly area to improve soil and watershed management; and constructing water reservoirs for irrigation purposes. Watershed management often requires collective action among diverse stakeholders, among whom the costs and benefits may be unevenly distributed. Accordingly, watershed investment must rely on people with the experience, incentives, and skills needed to organise stakeholders.

The development of remote sensing technology has afforded an opportunity for many and diverse research efforts to be conducted in a variety of disciplines and along interdisciplinary lines. It is envisaged as a data source for inventory, monitoring and gaining new insights into the complexity of the natural environment.

Remote sensing is concerned with the use of electromagnetic radiation to yield useful information. The major objective of remote sensing is to detect and record energy in a selected portion of the electromagnetic (EM) spectrum. Remote sensors acquire imagery by detecting or sensing level of emitted and/or reflected radiation energy that moves with the constant velocity of light in a harmonic wave pattern. Our eyes acquire data on variations in electromagnetic energy distributions. In this study, however, emphasis is placed on data from electromagnetic remote sensing of the earth resources. That is remote sensing that have earth resource observation as their primary operating objectives e.g. the Land sat and SPOT series of Satellite.

Usually, remote sensing data can be either analogue or digital. When an image has a continuous grey tone or colour e.g. photograph, it is referred to as analogue image. A digital image data on the other hand is a group of small cells with integer value of average intensity at the centre, representing the cells value. Often, these types of image are arranged in squares-256 samples. Example of digital data is a multispectral scanner data.

Reference data are utilized in remote sensing. These are often referred to as term ground truth. It means more than collecting information on the ground since many forms of reference data are not collected on the ground, but may be collected in the air in the form of detailed aerial photograph used as reference data when analyzing less detailed or satellite imagery.

Photograph as stated by Wiesnet,(1976) is the only example of remote sensing, which senses in the optical portion of the electromagnetic spectrum used in remote sensing are solar infrared, ultraviolet, near-infrared and microwave.

Space photo has the advantage of a synoptic view of a big areas. For example, the American satellite "Landsat" circles the Earth every 103 minutes or roughly 14 times a day. The same area is photographed every 18days. The soviet satellite M-18 uses the four spectral band viz: green (10.5-0.6 micrometres and 0.8-1.1 mircometres), to obtain images of the Earth. Such satellite allows the study of some natural phenomena of global and regional for example drought and floods.

By and large, Harris (1987) has many things to say about the significance of remote sensing detecting and monitoring activities.

These among others include:

i. Data coverage is greatly improved over the traditional sensors. Remote sensing allows data collection in remote places, ocean and ice which otherwise might be data void or have a limited data supply for reasons of accessibility for political reasons.

ii. Homogeneity of data: - Information collected by any remote system is uniform. For example, the Landsat thematic mapper uses one sensor and so provides spatial consistence data.

iii. Remote sensors allow spatially continuous compared to the point or small-area data commonly found in conventional method.

iv. The data form is suitable for computer processing.

v. The frequency of data collection is greatly improved using satellite remote sensors. Geostationary weather satellite scan a disc of the Earth every thirty minutes, polar orbit weather satellite collect data twice per day. For each part of the Earth on successive days by off-nadir viewing.

vi. The time base of a single pass of a satellite is very restricted; so that spatial changes in environmental variables are minimized.

vii. Measurement from remote sensors is complimentary to conventional observations of an improvement of the latter.

viii. Remote sensors provide a low cost of environmental data collection, although the cost of Earth resources satellite data has increased steeply. The computer compatibility of remote sensors data allows reduction in the time and manpower required to produce environmental survey information.

Nevertheless, it must be conceived that remote sensing is not a panacea; however, it's simply an additional but very powerful tool to be added to those which already are in use. It provides not the solution to problems but it only provides the basic information necessary for arriving at solution.

1.2 Statement of the Problem

In an awareness publication of Federal Ministry of Environment it was stated that Nigeria watersheds are faced with many problems. Generally, these environmental problems which include:

- population pressure and the continuous exploitation of marginal lands, aggravating the process of drought and desertification in areas above latitude 11^{o}N parallel;
- serve gully erosion in the south-east and the central states in the north;
- coastal and marine erosion/ and land subsidence in coastal and marine areas;

- flooding of in low-lying belts of mangrove and fresh water swamps along the coast, the plains of large rivers and short-lived flash floods in the inland rivers;
- inappropriate land –use and agricultural practices;
- soil crust formation caused by loss of water in the semi arid ecological zone;
- destruction of vast agricultural lands;
- creation of borrows pits associated with bad mining practise and road work;
- oil pollution from spillage and gas flaring-related problems in the oil producing states;
- industrial pollution, municipal waste generation and urban decay;
- extensive deforestation, contamination of surface and ground water, etc.

Nigeria therefore needs a coherent strategy and action plan to address the depletion of its natural resources as well as the growing environmental problems as a result of the mismanagement of the watersheds.

Socio economic conditions of most of the rural areas in Niger State are below average level of development. Major development activities have been taken up for the upliftment of these conditions. Given the ecological importance of watershed and the extent of human dependence on the services provided by them. Watershed degradation has potentially enormous environmental and socio economic costs. Yet efforts to develop and use goods and services provided by watershed have not been well integrated with efforts to protect and manage them sustainably. The result is to put watersheds at increasing risk to degradation and hence to jeopardise water supplies and other vital ecosystem services that can be extremely costly to replace. Integrated watershed management especially replying on remote sensing, is a newly established procedure in developing countries. It is proving to be a major component in river- basin management. The problem to be investigated here is to see whether remote sensing technique can provide an efficient tool for assessing watershed management.

1.3 Aim and Objectives

The main aim of this research is the use of remote sensing technique in assessing watershed management in Minna, Niger State, Nigeria

Under the general aim, the following objectives shall be achieved:

1. To assess the extent of landuse changes of the study area using three different years (1973, 1995 and 2007) satellite imagery.
2. To analyze changes in land uses and land cover based on resources monitoring.
3. To determine the level of the watershed shrinkage
4. To recommend appropriate remote sensing technique for the sustainable management of watershed.

1.4 The Significance of Study

With the intensification of the pressure by man upon his resources and the environment, there is a rapidly growing need for more and better information for multidisciplinary decision and action programmes. The complexity of man's impact on the environment in relation to watershed resources and land-use planning and management demand more efficient and rapid method to acquire and analyze resource information (Poulton, 1985)

Recent advances in science and technology, fortunately, continue to create hope and produce new technologies, which helps to collect data on land degradation. These include the application of remote sensing in the area of mapping resources monitoring and modelling land degradation and hazards. In fact, many dynamic geo-physical processes occurring in very different locations are difficult to reach and it is therefore hoped that this study will not only help for a watershed management and also in environmental resources monitoring

The importance of water resources to national and human development cannot be over emphasis; and thus this research work is of great importance to the nation in general as it will provide a frame work upon which individual community and government can build and expand to in solving the problems of watershed degradation. It will also serve as a reference material for further study in future.

1.5 The Study Area

The study is located between latitude 9^0 36'22"N of the equator and longitude 6^0 33'15E East on a geographical base of undifferentiated basement complex of many gneiss and magnetic the town enjoys a climatic typical of middle belt zone.

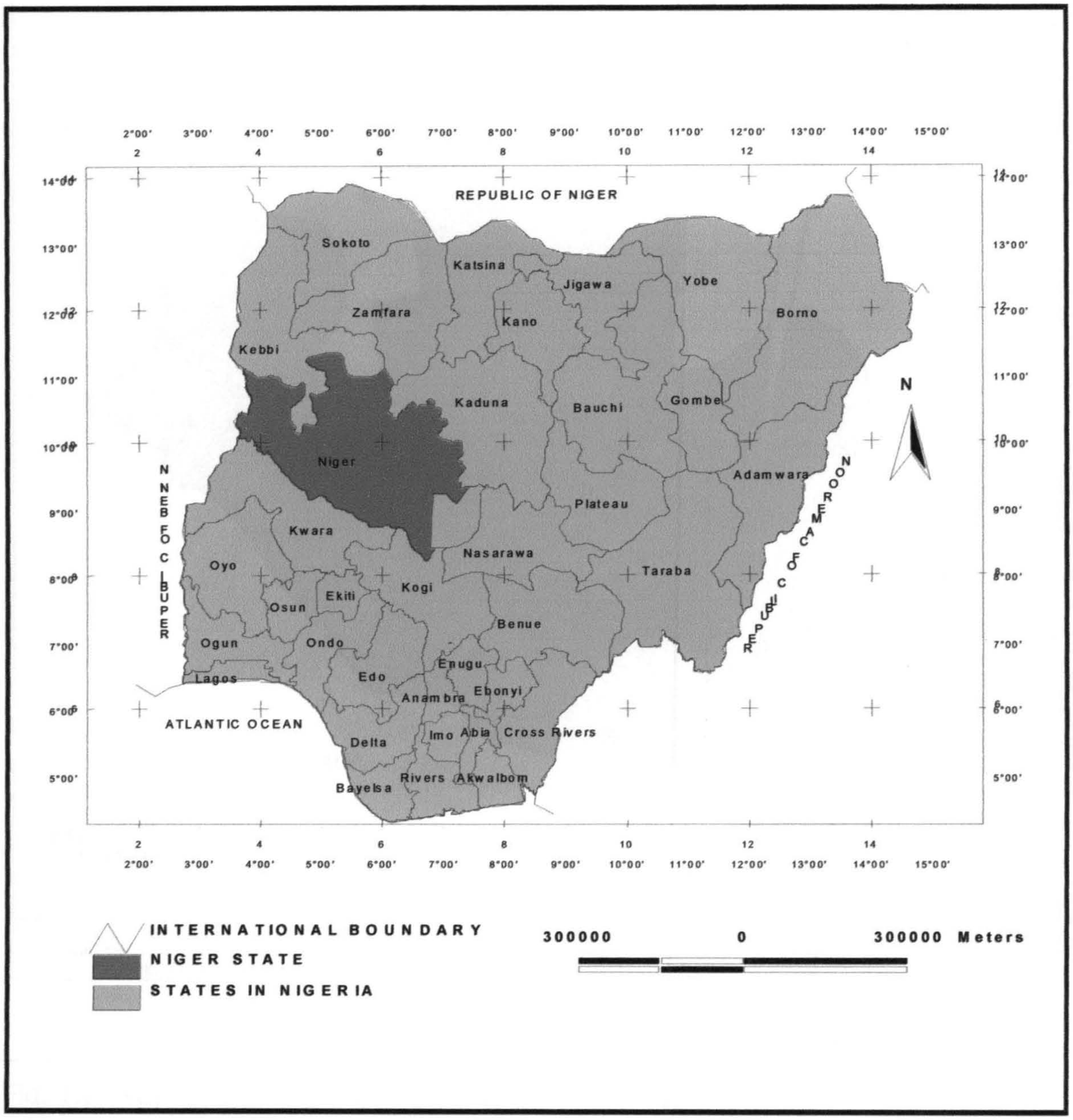

Fig. 1.1: Map of Nigeria showing the location of Niger State

1.5.2 Climate

The study area is located in a tropical climate which is characterized by two seasons in a year. The wet seasons and dry seasons. The annual rainfall received within the region is less than 1000mm in the wet season and it last between April and September with a maximum downpour between months of July and August. The dry season lasts between the month of October and March. Temperature varies within the region annually with the seasons. During the dry season, temperatures are low because the sun is in the southern hemisphere. Minimum temperatures below 20^0 C are recorded during the harmattan period, which is late December and January in the following year. And maximum temperature are not above 26 ^{0}C. During the wet season the sun moves northwards from the equator to the tropics of cancer. This results to high temperatures because the sun overheads at noon. Minimum temperatures average above 26 ^{0}C and Maximum temperatures average about 30 ^{0}C particularly at mid-day between May and July.

1.5.3 Vegetation

The vegetation of Minna is the Tropical savannah type, which changes in nature with the seasons annually. During the wet season the vegetation is evergreen while in the dry season it dries up with trees losing their leaves and the grasses are fed upon by the extensive grazing cattle within the region. The vegetation tends to be thick and greenish no matter the season along the river course, because along the river course the soil is wet frequently and this result to the occurrence of dark green vegetation normally called the "fringing forest" within the area.

1.5.4 Physiography

The study area is situated on a fairly high topography which decreases from the surrounding highland towards the main wide valley. The area can be regarded as the net valley between the north central highland and the western highlands of Nigeria that is the western part of Niger-Benue Trough, comprising younger sediment rocks and basement complex rock. The relief is estimated at a height of 900 feet above sea level.

1.6 The Scope and Limitation

The study area will is a watershed located in Minna, it will limited to the degree at which urbanization process alter with the natural waters. Remote sensing technique especially digital image processing of satellite data had gained recognition throughout the world. Its application in various fields of human endeavour especially in environmental study has established a clear break-through. However, it must be understood that technology is expensive. This will limit the number of years of satellite data to be used to just three years.

Also the study was faced with the problem of availability of a wide range and up to date aerial photographs that covered the whole study area for comparison

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Several studies have been conducted using different types of remote sensing techniques. Globally, this technique has gained popularity because it is efficient and provides high enough precision than the traditional method of study. The evolution of satellite data (earth observation), satellite have proven to be of significant value, particularly when general information needs to be acquired over a large area. Satellite offer several advantages by providing a wide synoptic coverage as well as fairly fine detail and systematic coverage (Campbell 1996).

GIS and remote sensing techniques are widely used for studying Earth's resources at various levels (Deekshatulu 1991). In one study, Shaban et al (2005) notes how the use of integrated watershed assessment, especially relying on remote sensing and GIS has become a newly established procedure in river basin environmental management in developing countries.

2.2 The Use of Remote Sensing Technique in Resource Monitoring

According to Kumar (2006), remote sensing has shown its superiority in data collection for natural resources management. It has been recognised that the value of data which is collected by known conventional means is considerably enhanced by the use of remote sensing and satellite image interpretation technique, which in turn calls for data affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame et al, 1994).

Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development. There are also incidental impacts on land cover from other human activities such as forest and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by tropospheric ozone resulting from automobile exhaust (Meyer, 1995).

Hence, in order to use land optimally, it is not only necessary to have the information on existing land and development but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape.

Conventional ground methods of land use mapping are labour intensive, time consuming and are done relatively infrequently. These maps soon become outdated with the passage of time, particularly in a rapid changing environment. In fact according to Olorunfemi (1983), monitoring changes and time series analysis is quite difficult with traditional method of surveying. In recent years, satellite remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use and development control and monitoring changes at regular intervals of time. In case of inaccessible region, this technique is perhaps the only method of obtaining the required data on a cost and time – effective basis.

A remote sensing device records response which is based on many characteristics of the land surface, including natural and artificial cover. An interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about land cover.

The generation of remotely sensed data/images by various types of sensor flown aboard different platforms at varying heights above the terrain and at different times of the day and the year does not lead to a simple classification system. It is often believed that no single classification could be used with all types of imagery and all scales. To date, the most successful attempt in developing a general purpose classification scheme compatible with remote sensing data has been by Anderson et al(1976) which are also referred to as United State Geological Survey (USGS) classification scheme. Other classification schemes available for use with remotely sensed data are basically modification of the above classification scheme.

Ever since the launch of the first remote sensing satellite (Landsat-1) in 1972, land use studies were carried out on different scales for different users. For instance, waste land mapping of India was carried out on 1:1 million scales by NRSA using 1980 – 82 landsat multi spectral scanner data. About 16.2% of waste lands were estimated based on the study.

Xiaomei and Rong (1999) noted that information about change is necessary for updating land cover maps and the management of natural resources. The information may be obtained by visiting sites on the ground and or extracting it from remotely sensed data.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Development control is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest.

Macleod and Congation (1998) list four aspects of development which are important when monitoring natural resources:

i. Detecting the changes that have occurred
ii. Identifying the nature of the change
iii. Measuring the area extent of the change
iv. Assessing the spatial pattern of the change

The basis of using remote sensing data for development changes is that changes in land cover result in changes in radiance values which can be remotely sensed.

Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computer power.

A wide variety of digital change detection techniques have been developed over the last two decades. Singh (1989) and Coppin & Bauer (1996) summarize eleven different change detection algorithms that were found to be documented in the literature by 1995. These include:

1. Mono-temporal change delineation.
2. Delta or post classification comparisons.
3. Multidimensional temporal feature space analysis.
4. Composite analysis.
5. Image differencing.
6. Multitemporal linear data transformation.
7. Change vector analysis.
8. Image regression.
9. Multitemporal biomass index
10. Background subtraction.
11. Image ratioing

In some instances, land use land cover change may result in environmental, social and economic impacts of greater damage than benefit to the area (Moshen, 1999).

Therefore data on land use change are of great importance to planners in monitoring the consequences of land use change on the area. Such data are of value to resources management and agencies that plan and assess land use patterns and in modeling and predicting future changes.

Shosheng and Kutiel (1994) investigated the advantages of remote sensing techniques in relation to field surveys in providing a regional description of vegetation cover. The results of their research were used to produce four vegetation cover maps that provided new information on spatial and temporal distributions of vegetation in this area and allowed regional quantitative assessment of the vegetation cover.

Arvind et al, (2006) carried out a study on land use land cover mapping of Panchkula, Ambala and Yamunanger districts, Hangana State in India. They observed that the heterogeneous climate and physiographic conditions in these districts has resulted in the development of different land use land cover in these districts, an evaluation by digital analysis of satellite data indicates that majority of areas in these districts are used for agricultural purpose. The hilly regions exhibit fair development of reserved forests. It is inferred that land use land cover pattern in the area are generally controlled by agro – climatic conditions, ground water potential and a host of other factors.

It has been noted over time through series of studies that Landsat Thematic Mapper is adequate for general extensive synoptic coverage of large areas. As a result, this reduces the need for expensive and time consuming ground surveys conducted for validation of data. Generally, satellite imagery is able to provide more frequent data collection on a regular basis unlike aerial photographs which although may provide more geometrically accurate maps, is limited in respect to its extent of coverage and expensive; which means, it is not often used.

In 1985, the United States Geological Survey carried out a research program to produce 1:250,000 scale land cover maps for Alaska using Landsat MSS data (Fitz Patrick et al, 1987).The State of Maryland Health Resources Planning Commission also used Landsat TM data to create a land cover data set for inclusion in their Maryland Geographic Information (MAGI) database. All seven TM bands were used to produce a 21 – class land cover map (EOSAT 1992). Also, in 1992, the Georgia Department of Natural Resources completed mapping the entire State of Georgia to identify and quantify wetlands and other land cover types using Landsat Thematic Mapper ™ data (ERDAS, 1992). The State of southern Carolina Lands Resources Conservation Commission developed a detailed land cover map composed of 19 classes from TM data (EOSAT, 1994). This mapping effort employed multi-temporal imagery as well as multi-spectral data during classification.

An analysis of land use and land cover changes using the combination of MSS Landsat and land use map of Indonesia (Dimyati, 1995) reveals that land use land cover change were evaluated by using remote sensing to calculate the index of changes which was done by the superimposition of land use land cover images of 1972, 1984 and land use maps of 1990. This was done to analyze the pattern of change in the area, which was rather difficult with the traditional method of surveying as noted by Olorunfemi in 1983 when he was using aerial photographic approach to monitor urban land use in developing countries with Ilorin in Nigeria as a case study.

Daniel et al, (2002) in their comparison of land used and development control over change detection methods, made use of 5 methods namely; traditional post – classification cross tabulation, cross correlation analysis, neural networks, knowledge – based expert systems, and image segmentation and object – oriented classification. A combination of direct T1 and T2 change detection as well as post classification analysis was employed. Nine land use land cover classes were selected for analysis. They observed that there are merits to each of the five methods examined, and that, at the point of their research, no single approach can solve the land use change detection problem.

2.3 The Use of Remote Sensing Technique in Watershed Management

Remote sensing data/images have been used in water management in citing various recharge structures through the preparations of thematic maps on land use/land cover, geomorphology, surface water bodies, and so on; it is possible to prioritise areas in watersheds where theirs need for immediate afforestation or other treatment to conserve the soil.

Also remote sensing data can be used for the preparation of a set of resource maps such as surface water bodies, ground water potential zones, ground water recharge sites, types of soils, existing land use patterns among others, and the combination of these data with other information meteorological data, socioeconomic factors, and so on can be used to identify the priority areas of various land uses to meet the needs of people disturbing the ecology. (Kumar, 2006)

Shaban et al, (2005) stated that advanced geoinformation tools such as remote sensing and Geographic Information Systems (GIS), prove to be a valuable asset in securing data on the fabric of the Akkar El Kabeer watershed in relation to it's and anthropic interference. Remote sensing captures the watershed a characteristic and landuse without constraints. The natural fabric includes geology, drainage, forests and soils. The anthropic fabric includes settlements utilities, roads, agriculture and land use. The technique also shows the impact of malpractices from excessive human interference that result in degradation of land and water quality changes, in watersheds such environmental degradations were observed as water pollution, soil erosion forest decline and socio economic unbalance.

Assessment of resources degradation, and finding out the socio-economics conditions in a water shed, are essential factor for proper understanding and planning for watershed conservation and development purpose, (Sah et al, 1996). They found that remote sensing and GIS in combination with Universal Soil Loss Equation (USLE) model were appropriate tools for resource monitoring, while house questionnaire surveys yield better result for socio-economic status. They conclude that highly sensitive areas suffered from sped resources degradation which resulted from poor socio-economic status. Again, poor socio-economic status resulted into speedy resource degradation which may be irrespective sensitivity. They developed a multiple linear regressive model from these parameters which can be used to simulate the resource degradation speed under various socio-economic conditions. It was recommended that, development activity should be concentrated in valley while conservation activities should be focused to the hills, by considering and formulating land use plan.

In another research on watershed management, user participation was recognised as critical for success in watershed development and management projects. Local residents were often not considered in the formulation of top – down watershed projects, resulting in plans and technologies that were inconsistent with peoples need and ignorant of local people's vast and detail knowledge of land and land use practices. They conclude that giving users a role in managing their own watershed resources can lead to projects that more efficient and effective that their top down predecessors.

User participation also has implication for watershed management research. In addition to the changing the way technologies and practices are developed and disseminated, participation broaden the research agenda, bringing new topics like organizational behaviour, collective action and conflict resolution. There is a great need for further research on these topics as they relate to land and watershed management. (Johnson et al, 2001)

The growing incidence of environmental degradation in southern part of Nigeria as Okoko (1999) points out can be buttressed with the frequency of oil spills between 1979 and 1980 which devastated communities along the Niger Delta watershed. Under this setting, human activities inland have exerted a lot of pressure through intense use of land surrounding the watershed for oil and gas drilling, agriculture, logging, and fuel wood extraction and increasing reliance on the river for electricity consumption to satisfy both domestic and foreign exchange needs. Compounding the problems are the lack of efficient, inventorying and mapping of precise data to sustainably manage the watershed. Notwithstanding the gravity of these trends, there has not been any major effort by resource managers aimed at examining these issues in watershed management within the Niger Delta Region of Southern Nigeria. This calls for the need to find appropriate tools to aid the management of the river. Perhaps the most important element in the efforts to manage the Niger Delta is the need to provide a baseline data based on integrated GIS and remote sensing approach about the ecology and forest cover to form the basis of future management (Merem et al 2005). This approach is quite effective in monitoring the impacts of human activities on watershed environments in international development (Shultz et al 1998). In light of this, many authors view the widespread applications of GIS and remote sensing techniques in watershed management as a major step towards sustainability and resource conservation (Malczewski 2003).

The drainage basin (watershed area) of the River Chanchaga is an area of interest as it has a high economic value for the Niger State people. It provides a wide range of opportunities for various activities in the area, which in turn produced a conflict of interests between different stakeholders. An integrated water resource management plan in River Chanchaga is needed to widen the picture and helps in addressing and solving the real problems in the area.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Data Collection

Three moderate resolution Landsat imageries were acquired for this study from Global Land Cover Facility (GLCF) website. This includes Multispectral Scanner (MSS) Imagery of 1973, Land TM of 1995, and Landsat ETM 2007 covering the study area (Minna). Each image was imported into the IMAGINE (.img) file type from tiff format for further processing. Population figure was collected from National Population Commission.

3.2 Description of Data

The three sets of data used are MSS, and Landsat Imageries of the Study area. Landsat imagery data have been used by government, commercial, industrial, civilian and educational communities in the United States and worldwide. These data are being used to support a wide range of applications in such areas as global change research, agriculture, forestry, geology, resource management, geography, mapping, water quality, and oceanography. Landsat Image data have potential applications for monitoring the conditions of the Earth's land surface. The images can be used to map anthropogenic and natural changes on the Earth over periods of several months to several years. Examples of changes that can be identified include agricultural development, deforestation, natural disasters, urbanization and the development and degradation of water resources. The Landsat ETM satellite has seven (7) bands like the land sat TM but carries an additional panchromatic band making eight (8) bands.

Table 3.1: The Wavebands of Land sat ETM

BANDS	WAVELENGTH (UM)	SPECTRAL LOCATION
1	0.45 0.52	Blue
2	0.52 0.60	Green
3	0.63 0.69	Red
4	0.76 0.90	NR
5	1.55 1.25	MR
6	10.4 12.5	Far
7	2.08 2.35	IR
8	0.52 0.90	Panchromatic

Source Harris 1987

Landsat ETM has a spatial resolution of 30m and the panchromatic band has a 15m spatial resolution while ETM has a temporal resolution of 16 days.

3.2.1 Description of Landsat TM Imageries that were Utilized

Scale: 1:2500

Spatial Resolution: 30m

Number of Bands: 7

Swath Width: 185km

3.3 Geo-Referencing

Handling spatial information requires the establishment of a *spatial reference system* to which all spatial measurements must relate. The primary function of the map is to portray accurately real-world features that occur on the curved surface of the earth. Geographic referencing, which is sometimes simply called *geo-referencing*, is defined as the representation of the location of real world features within the spatial framework by which the positions of real-world features are measured, computed, recorded and analyzed. In practice, geo-referencing can be seen as a series of concepts and techniques that progressively transform measurements carried out on the irregular surface of the earth to the flat surface of a map, and make it easily and readily measurable on this flat surface by means of a coordinate system. Map data are different from all other forms of data by this characteristic of geo-referencing and, the ability to manipulate and analyze geo-referenced spatial data is what distinguishes GIS from CAD and other types of computer graphics systems. The concept of representing the physical shape of the earth by means of a mathematical surface and the realization of these concepts by the definitions of the 'geoids' and the *ellipsoid* are fun Reservoirental to geo-referencing.

The geo-referencing properties of both images are the same while image thinning was applied to the 1973 imagery which has a resolution of 80m using a factor of two to modify its properties and resolution to conform to the other two has given below;

Data type: rgb8

File type: binary

Referencing system: utm-31

Reference units: m

Unit distance: 1

Minimum X: 214505.25

Maximum X: 236706.75

Minimum Y: 1053602.25

Maximum Y: 1073552.25

Min Value: 0

Max Value: 215

Display Minimum: 0

Display Maximum: 215

Image thinning was carried out through contract which generalizes an image by reducing the number of rows and columns while simultaneously decreasing the cell resolution. Contraction may take place by pixel thinning or pixel aggregation with the contracting factors in X and Y being independently defined. With pixel thinning, every n^{th} pixel is kept while the remaining is thrown away.

3.4 Image Enhancement

Regardless of the extent of digital intervention, visual analysis invariably plays a very strong role in all aspects of remote sensing. While the range of image enhancement is broad; as earlier mentioned, filtering and contrast stretch where the major image enhancement techniques performed on the image in other to remove haze and cloud.

Digital sensors have a range of output value to accommodate the strongly varying reflectance values that can be found in different environments, it is often the case that only a narrow range of values will occur over most areas. Grey level distributions thus tend to be much skewed. The goal of contrast enhancement is to improve the visual interpretability of an image, by increasing the apparent distinction between the features in the scene. Although the human mind is excellent in distinguishing and interpreting spatial features in an image, the eye i s rather poor at discriminating the subtle differences in reflectance that characterize such features. By using contrast enhancement techniques these slight differences are amplified to make them readily observable.

Contrast stretch is also used to minimize the effect of haze. Haze results in overall higher DN values and this additive effect results in a reduction of the contrast in an image. The haze effect is different for the spectral ranges recorded; highest in the blue, and lowest in the infra red range of the electromagnetic spectrum.

One of the most intriguing capabilities of digital analysis is the ability to apply filters. Filters can be used to provide edge enhancement (sometimes called christening), to remove image blur, and to isolate lineaments and additional trends, to mention just a few.

The satellite images covering the study area were processed using ArcView GIS Software for the linear stretch and contrast enhancement were also performed on the images to optimize visual interpretation especially during the training set phase. See Appendix i, ii and iii.

3.5 Image Classification

Image classification refers to computer-assisted interpretation of remotely sensed images. Classification is the process of developing interpreted maps from remotely sensed images. As a consequence, classification is the most important aspect of image processing to GIS. Traditionally, classification was achieved by visual interpretation of features and the manual delineation of their boundaries. However with the advent of computers and digital imageries, imagery attention has focused on the use of computer-assisted interpretation. Although the human eye still brings a superior set of capabilities to the classification process, the speed and consistency of digital procedures make them very attractive. As a consequence, the majority of classification projects today make use of digital classification procedures, guided by human interpretation.

There are two basic approaches to the classification process: supervised and unsupervised classification. They differ in how the classification is performed. In the case of supervised classification, the software system delineates specific land cover types based on statistical characterization data drawn from known examples in the image (known as training sites). With unsupervised classification, however, clustering software is used to uncover the commonly occurring land cover types, with the analyst providing interpretations of those cover types at a later stage.

The distinguishing characteristic of hard classifiers is that they all make a distinctive decision about the land cover class to which any pixel belongs. Three very popular supervised classifiers in this group are Parallelepiped, Minimum Distance to Means, and Maximum Likelihood. They differ only in the manner in which they develop and use a statistical characterization of the training site data. Of the three, the Maximum Likelihood procedure is the most sophisticated, and is unquestionably the most widely used classifier in the classification of remotely sensed imagery. This explains why the Maximum likelihood classification has been employed in this project.

On the contrary, soft classifiers do not make a distinctive decision about the land cover class to which each pixel belongs. Rather they develop statements of the degree to which each pixel belong to each of the land cover classes being considered.

One of the most powerful classifier in common use is that of Maximum Likelihood. Based on statistics (mean; variance/covariance), a (Bayesian) Probability Function is calculated from the inputs for classes established from training sites. Each pixel is then judged as to the class to which it most probably belongs.

A description of each land use category is given below, for a better understanding of what each category represents.

a. **Intensive Built-up Area:** This comprises of all types of buildings close together and the study area was a clustered area, this is identified by appearance of rooftops. The ground features in this mapping unit consisted of individual homes and commercial buildings such as big and small enterprises such as market, bank, hair salons, tailoring shops etc were found here.

b. **Farm Land:** Smaller areas occupied by scattered tree crowns with medium texture and medium toned, but the area was predominantly grass and shrubs.

c. **Water Bodies:** Downstream of the lake, Smaller water bodies flowing into the major river. Appearing very thin and more curvilinear than the Major River and dark toned in some areas where vegetation is dense along the course of the river.

3.6 Software Used

Basically, five softwares were used for this project viz;

a) ArcView 3.2a – this was used for displaying and subsequent processing and enhancement of the image. It was also used for the carving out of Minna region from the whole Niger State imagery using both the admin and local government maps.

b) ArcGIS – This was also used to compliment the display and processing of the data

c) Idrisi32 – This was used for the development of land use /land cover classes and subsequently for change detection analysis of the study area.

d) Microsoft word – was used basically for the presentation of the research.

e) Microsoft Excel was used in producing the bar graph.

METHOD OF ANALYSIS

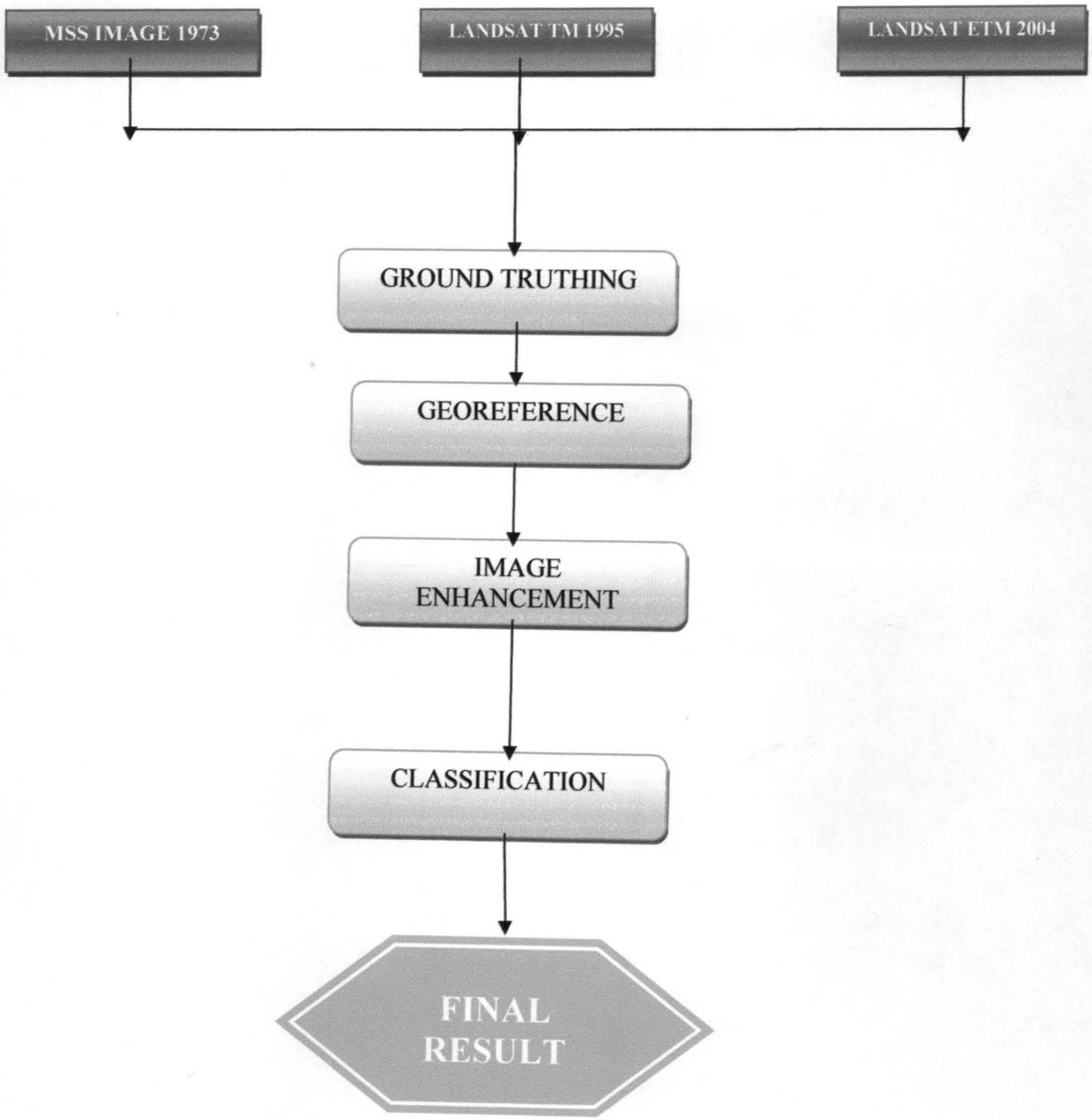

Fig 3.1: Flow chart of Analysis

CHAPTER FOUR

4.0 RESULTS

4.1 Landuse Category for 1973 MSS Image

The 1973 MSS imagery classification used for these analysis is shown in Fig. 4.1, the area comprises of Minna and its environs.

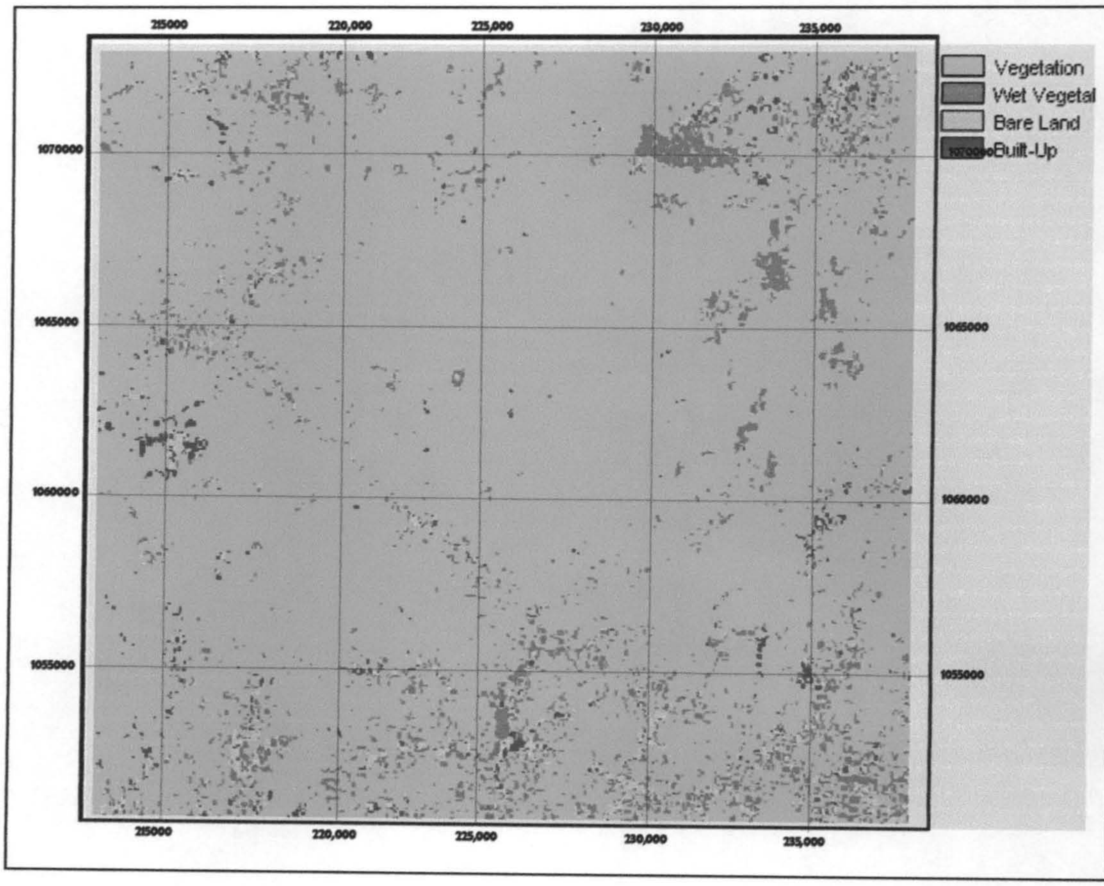

Fig. 4.1: Classification of MSS Imagery in 1973

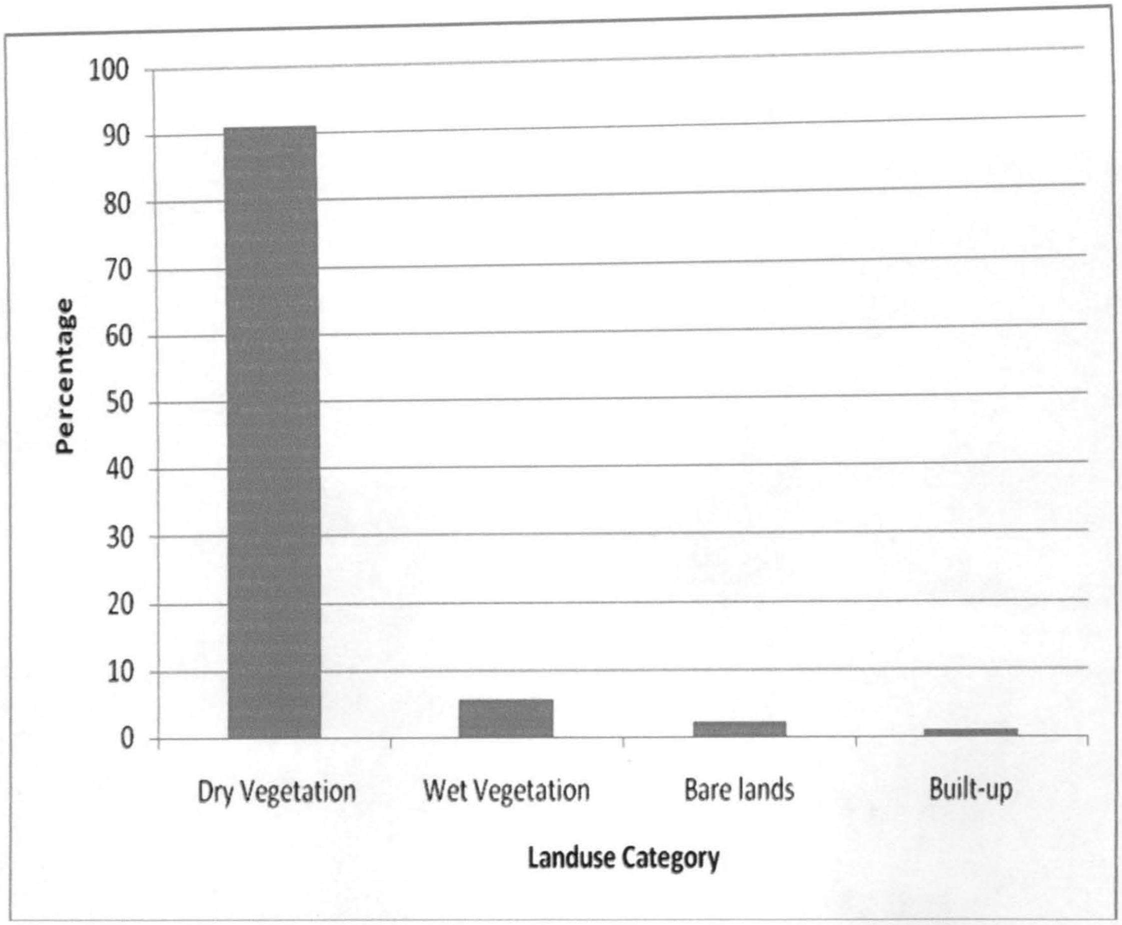

Fig. 4.2: Percentage of Landuse Category as at 1973

Fig. 4.2 shows that dry vegetation covers about 403.13 Km square (km^2) which is 91% of the total land area, wet-vegetated land occupied about 5.67% (25.11 km^2). Bare land covers about 9.86 km^2 (2.22%). The built-up-up land covers 0.96% (4.24 km^2).

4.2 Landuse Category of Landsat TM Imagery, 1995

The Landsat TM imagery for 1995 used for the interpretation of landuse category covering the study area is shown in Fig 4.3.

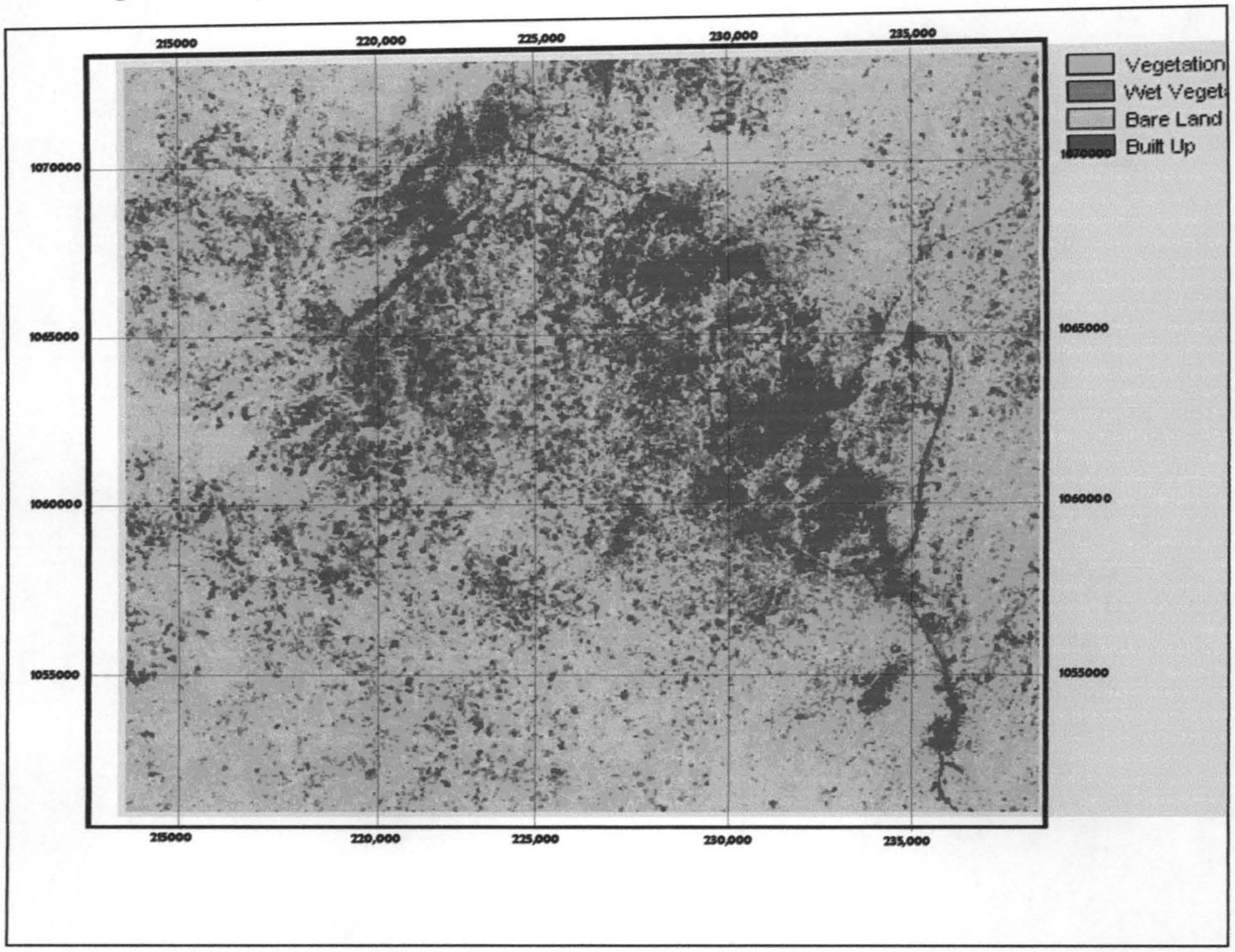

Fig. 4.3: Landsat TM Classification of Minna 1995

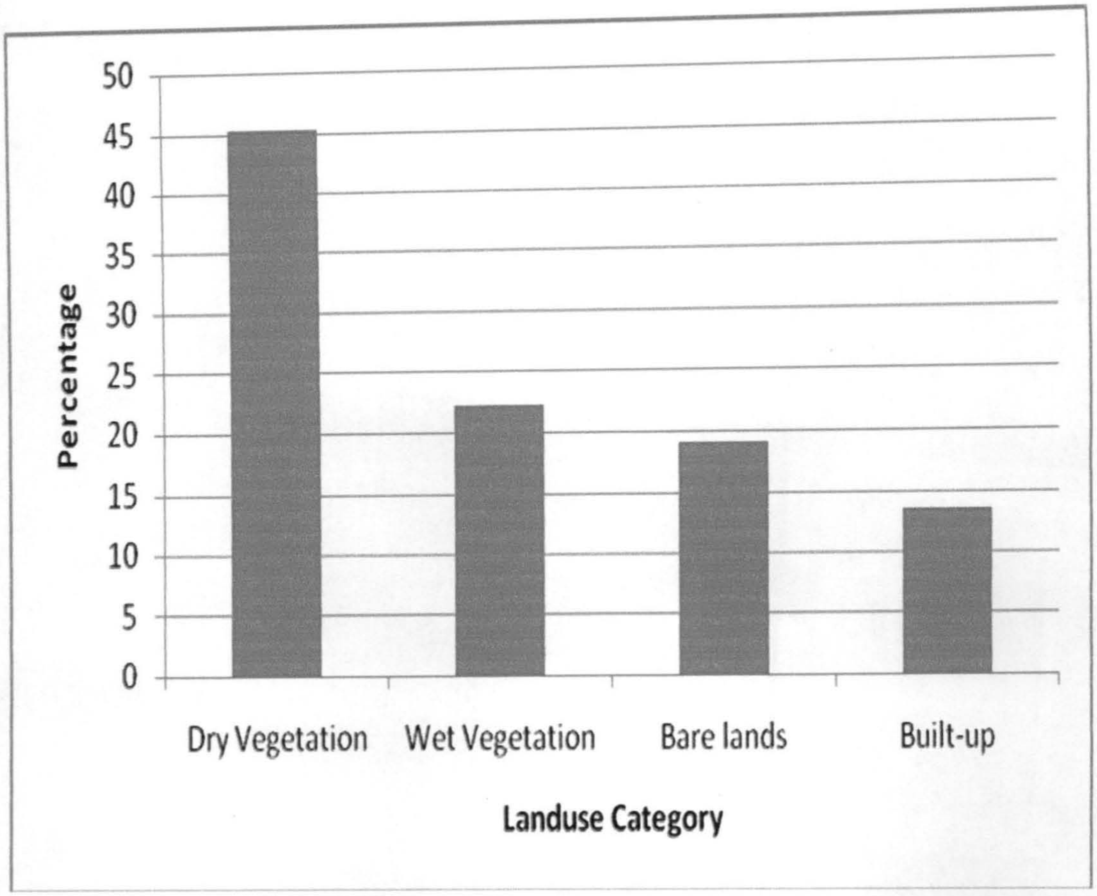

Fig. 4.4: Landuse Variances in 1995

The built-up lands which include residential and industrial land occupied about 13.57% (60.09km^2). Similarly, the classification showed that Bare lands and wet vegetation covers 98.24km^2 (22.18%) and 84.17km2 (19.01%) respectively. Dry vegetated/ Farm land covers about (200.42km^2). This compared to the 1973 landuse map, shows that dry vegetation has reduced tremendously from 91% to 45.26% as shown in figure 4.4

4.3 Landuse Category of 2007 Landsat ETM

The interpretation of landuse classification map covering the study area for 2007 is shown in Fig 4.5. The Landsat ETM Image of 2007 shows serious changes in the landuse.

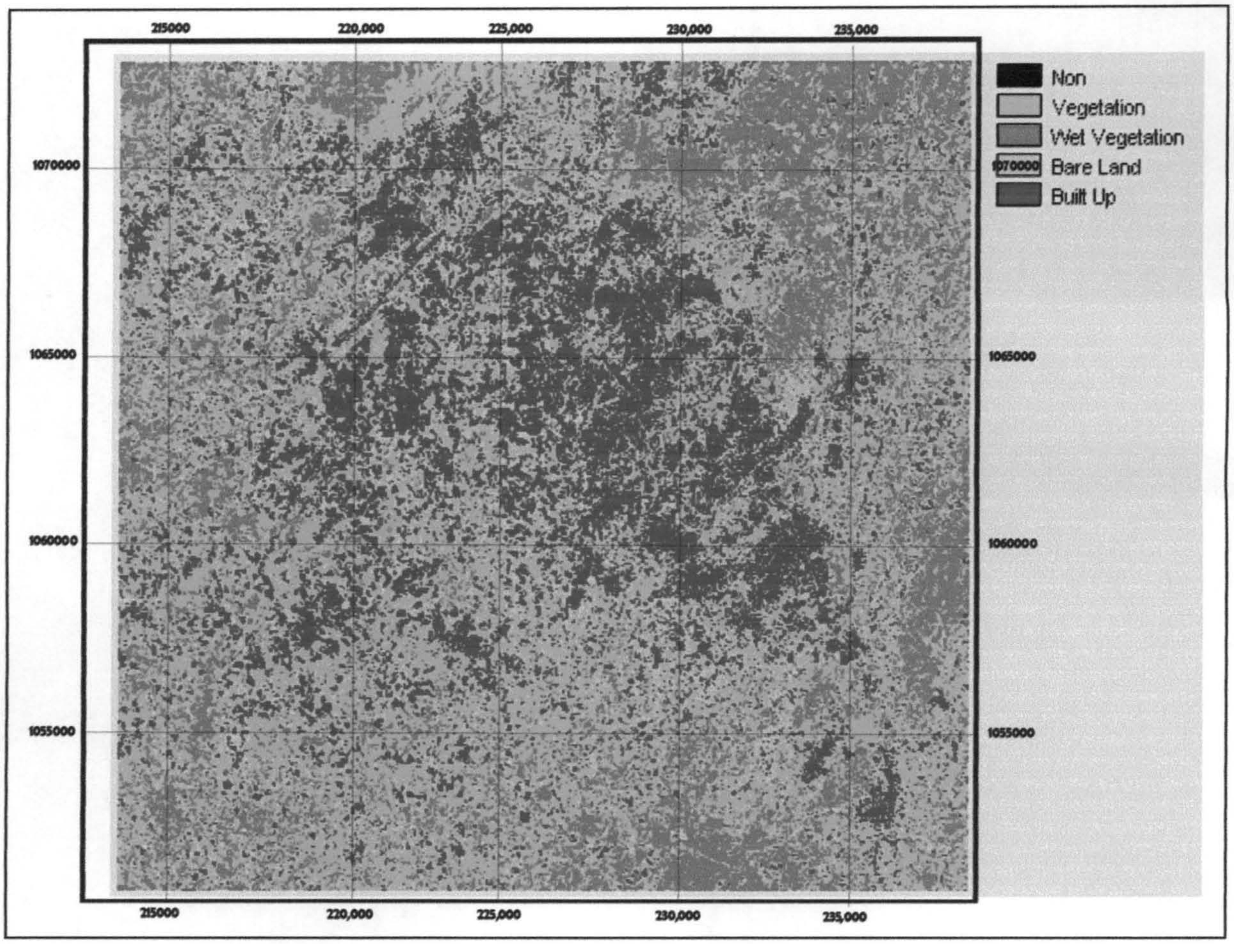

Fig. 4.5: Classified Landsat ETM, 2007

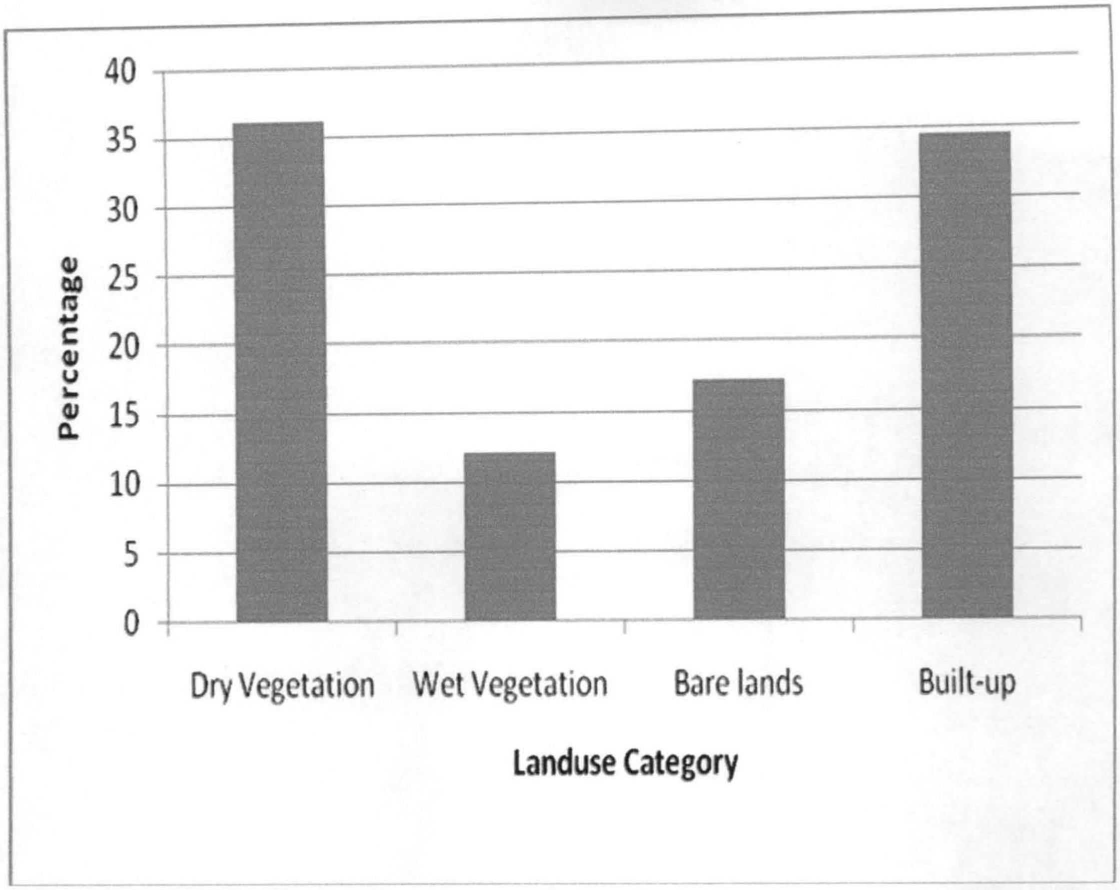

Fig. 4.6: Percentage of Landuse Variances in 2007

This classification (figure 4.6) shows that dry vegetation and wet-vegetation which includes scattered cultivation, farm land and water body has reduced to 160.85 km^2 (36.27%) and 54.19 km^2 (12.22 %) respectively. Built-up areas have increased from 60.09 km^2 to 148.78 km^2.

4.4 Changes in Landuse

Change in this study refers to the expansion and contraction of the various land use types. Figures 4.2, 4.4 and 4.6 show the percentage land distribution in years. Figure 4.7 shows the percentage difference in each land variances category changes within the period under study.

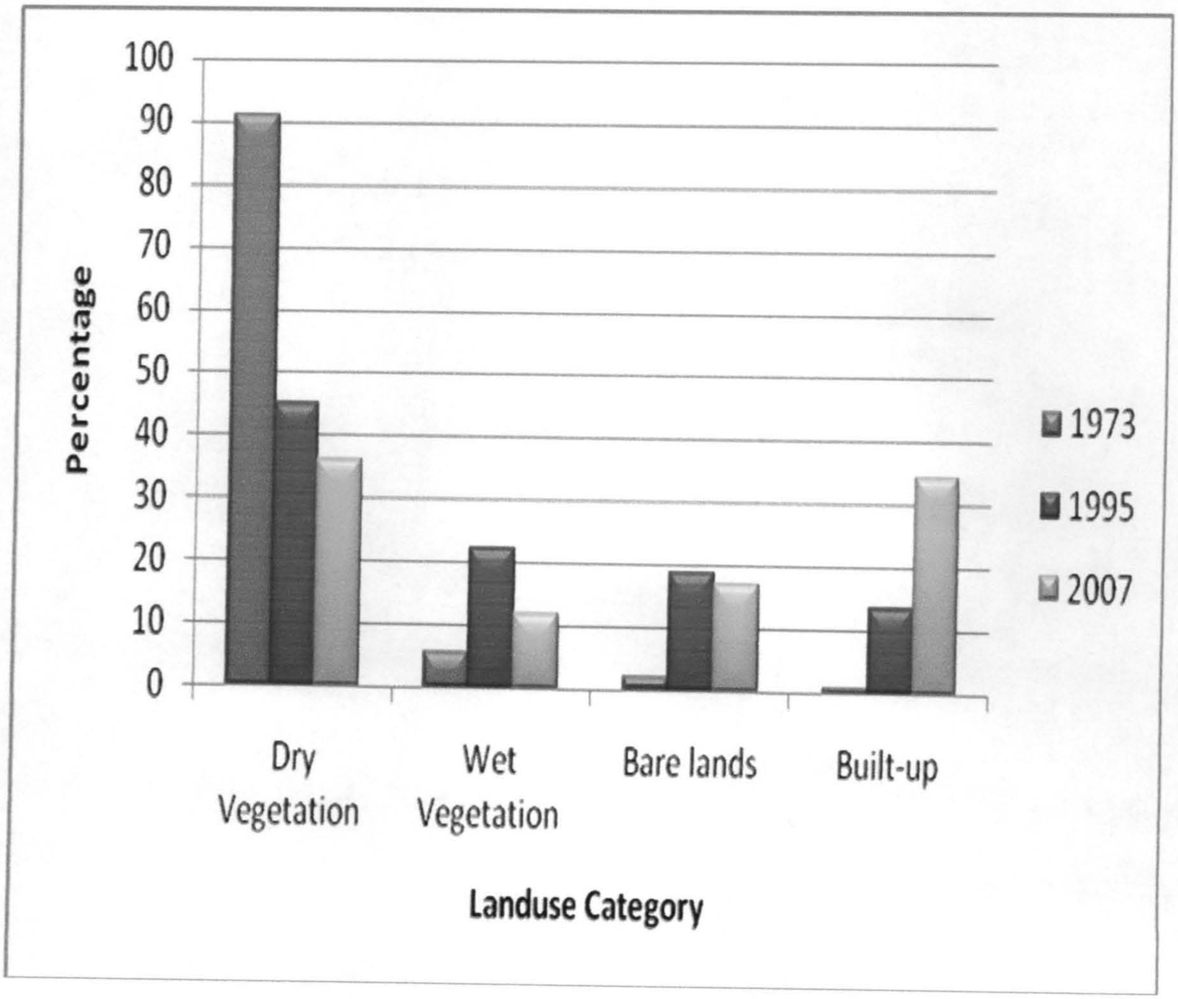

Fig. 4.7: Changes in Landuse from 1973 – 2007

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion of Results

This work attempts to discuss the use of remote sensing techniques to assess the watershed resources of the study area with a view to create the landuse changes map of the study area and to analyze the change in land use and land cover based on resources monitoring. During the field survey carried out in some selected areas in Minna, it was discovered that urbanization has serious effect on watershed. The analysis of data was based on the objective of the study.

5.1.1 Landuse Variance in 1973

The interpreted image of 1973 MSS shown in fig 4.1 showed that Vegetations covers about 403.13km^2 which made up the largest landuse category, wet-vegetation occupied about 25.11 km^2 made up mainly of Bosso dam, and river Chanchaga, which flows from the Northern part through the southern part and passes through the study area with streams flowing into it. Bareland covers about 9.8km$^{2.}$ The built-up-up land comprises of commercial land which covers about 4.24km^2, clustered and scattered residential lands.

5.1.2 Distribution of Landuse Variance in 1995

This period witnessed a great change in landuse category, most especially the built-up land. Fig 4.3 Similarly, the classification showed that dry vegetation was about 200.41

km^2, wet vegetated land which includes water bodies covered about 98.24 km^2, Bare lands cover 84.16 km^2, while built-up increase up as a result of urbanization to about 60.09 km^2.

5.1.3 Distribution of Landuse Type for 2007

The Landsat ETM Image of 2007, shows serious changes in the landuse as a result of urbanization, watershed has reduce, wet vegetated land has reduce due to human activities, development has taken over part of vegetated land and wet lands has vanished as a result of human activities. In fig 4.5 the classification showed that dry vegetation and wet-vegetation which includes scattered cultivation and plantation has drastically reduced to 160.85 km^2 and 54.19 km^2 respectively. Built-up areas has increased from 60.09 km^2 to 148.78 km^2, this shows evidence of urbanization changes in terms of built-up areas.

Minna, which was once very sparsely populated and considered as rural, has changed significantly. As mentioned earlier, this is basically due to the general increase in population.

Poor sanitary conditions, poor water supply, improper disposal of waste and poor living standard are associated with some area in the study area. This is as a result of improper planning. Evidence of improper planning can be seen in the haphazard arrangement of buildings. Commercial areas are mixed up with residential. Also roads are not properly lay.

5.1.4 Determine the Trends on Water Land

The amount of change was calculated and represented by a histogram. From figure 4.7 Built-up areas has recorded the highest amount of change from 1973 to 2007. Dry vegetations and wet vegetated land decrease. This indicates that urban development in terms of increase in the built up areas has seriously affect natural resource, Natural vegetation and wet vegetated land decreases as a result of human activities. A lot of new buildings had been constructed as a result of this development. Considerable area of farm land was cleared. These changes are shown on the map.

The growth of Minna has been tremendous and rapid over the last two decades; this is reflected not only in population but also in built up area development, which affect water body over the years.

There is likely going to be crowdedness brought by compactness in Minna come 2015. This situation will have negative implications in the area because of the associated problems of crowdedness like crime and easy spread of diseases. It is therefore suggested that encouragement should be given to people to build towards the outskirts through the provision of incentives and forces of attraction that are available at the city center in these areas.

Indeed, between the period of 1973 and 1995, there has been a reduction in the spatial expansion of Minna compared to the period between1995 and 2007. There is a possibility of continual reduction in this state over the next 14years. This may therefore suggest that the city has reduced in producing functions that attracted migration into the area. Indeed, there have been many defunct industries within this period. It is therefore suggested here that Niger State government should encourage investors both local and foreign and more importantly.

After the initial reduction in farm land between 1973 and 2007, the city has witnessed a steady growth in this class and indeed, may continue in this trend in 2007/2015. For this projection to be realistic, it suggested here that a deliberate attempt should be made by the State government to achieve this since this will lead to food security and more importantly, it will be a source of revenue to the State.

Farm land has been steady in reduction between 1973 and 2007 and in deed; this may likely be the trend 2007/2015. It will be in the good of the State and in deed, the Nation as a whole if the moderate reduction in farm land observed in-between 1995 and 2007 which is also projected by 2015 is upheld.

Also, land absorption coefficient being a measure of consumption of new possible changes by each unit increase in urban population which was high between 1973 and 1995, reduced between 1995 and 2007. This therefore suggests that the rate at which new lands are acquired for development is low. This may also be the trend in 2001/2015 as there seems to be concentration of development at the city center rather than expanding towards the outskirts. This may be as a result of people's reluctance to move away from the center of activities to the outskirts of the city.

5.2 Conclusion

This research work demonstrates the ability of GIS and Remote Sensing in capturing spatio-temporal data. Attempt was made to capture as accurate as possible three land use land cover classes as they change through time. Except for the inability to accurately map out water body in 1973 due to the aforementioned limitation, the three classes were distinctly produced for each study year but with more emphasis on settlement as it is a combination of anthropogenic activities that make up this class; and indeed, it is one that affects the other classes. In achieving this, Land Consumption Rate and Land Absorption Coefficient were introduced into the research work.

However, the result of the work shows a rapid growth in built-up land between 1973 and 2007 while the periods between 1995 and 2007 witnessed a reduction in this class. It was also observed that change by 2015 may likely follow the trend in 1995/2007 all things being equal.

With the limited facilities and some obvious constraints due to the under development of the science of remote sensing in Nigeria, environmental changes of Minna, in Niger

State of Nigeria was successfully undertaken to establish the current condition of the study area using remote sensing techniques. Complemented with extensive ground truth survey. The study has shown clearly the extent to which the MSS and Landsat imagery interaction techniques with extensive ground truthing can be of help in providing biophysical information necessary for monitoring and assessing the environmental impact of development in the area.

The study further exposed the various constraints mitigation against effective satellite imagery interpretation processes, prominent among which is: lack of adequate and up-to-date database and problem of experience interpretation of data set. In other word due to the difference in scale, errors are likely to arise on environmental change map. Errors may have also come from the technique used in calculating the area coverage for each landuse categories. However, the change map produced provides adequate information of the general environment of the area as well as gives an idea of the rate of Changes.

Environmental change maps could provide baseline information for resource planner and manager and would also assess the changes and effect created by development project.

5.3 Recommendations

One of the major problems of management of Nigeria's resources today is the general lack of information or data on the available resources. Environment being one of the resources should be adequately catered for. Therefore, an urgent need for updating and regular monitoring is needed. Remote sensing is providing the potentials for meeting these needs. To this end, it is recommended that;

1. The major draw-backs to the development of remote sensing technology in Nigeria are lack of enough funds and trained manpower. The government should initiate, through the Federal Ministry of Environment, the active participation of Nigeria in the United Nations Environment Programmes, and Global Environmental Monitoring System (GEMS). Government should also seek Technical Corporation with the European space Agency (ESA), United State National Aeronautical and Space Administration (NASA) and the World Bank for the establishment of ground receiving Land Sat imagery of the entire country. This will enhance data for environmental changes and monitoring in the country.
2. The acquisition of remote sensing data particularly the MSS and Landsat imageries so as to make a multi-temporal study of Minna and its neighbouring towns. With this, any negative changes can be easily detected, early enough so that appropriate measures can be taken.

3. It is also recommended that environmental management curriculum be developed at the primary, secondary and tertiary levels so that students appreciate the need to conserve our natural environment especially watersheds.

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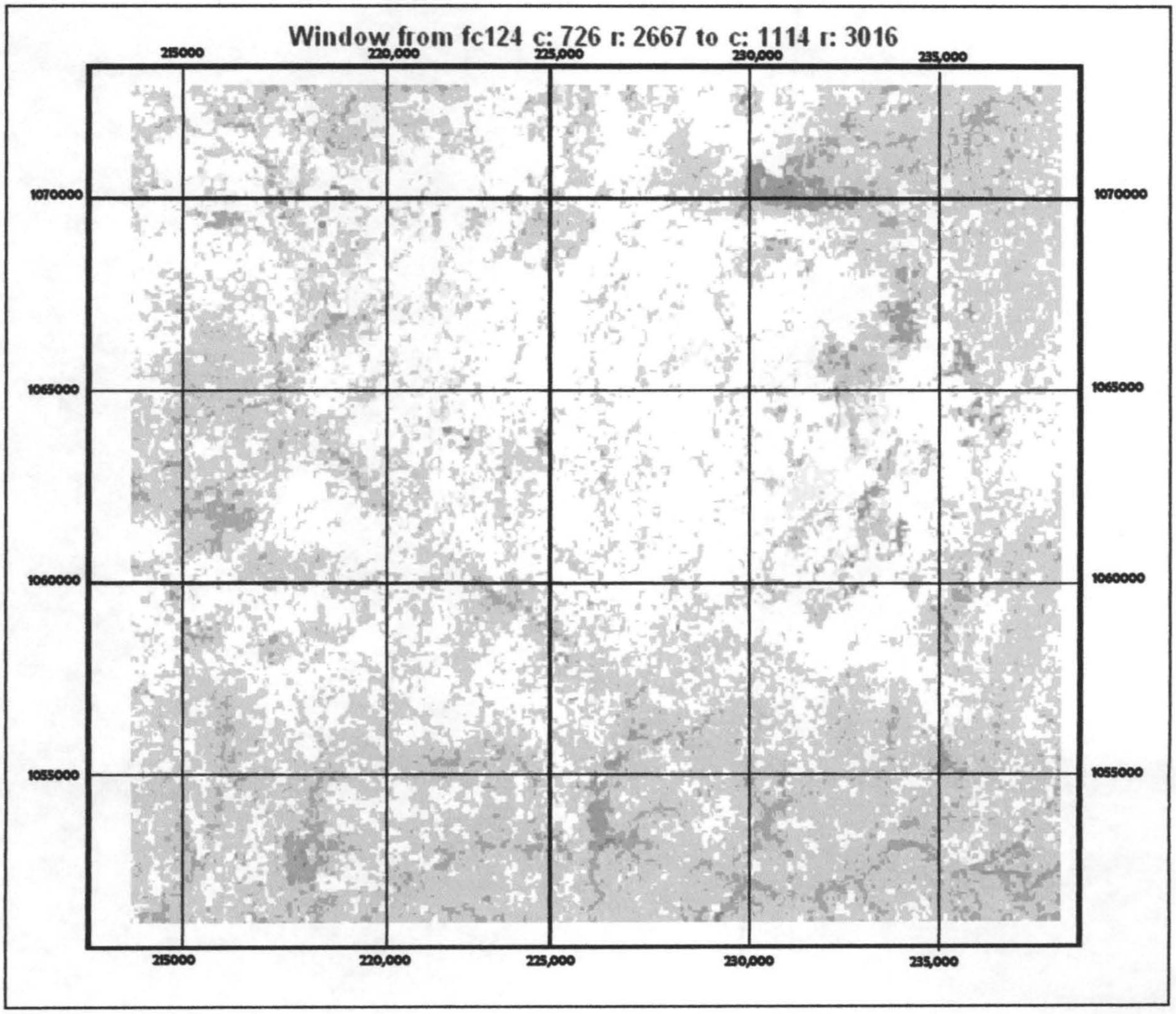
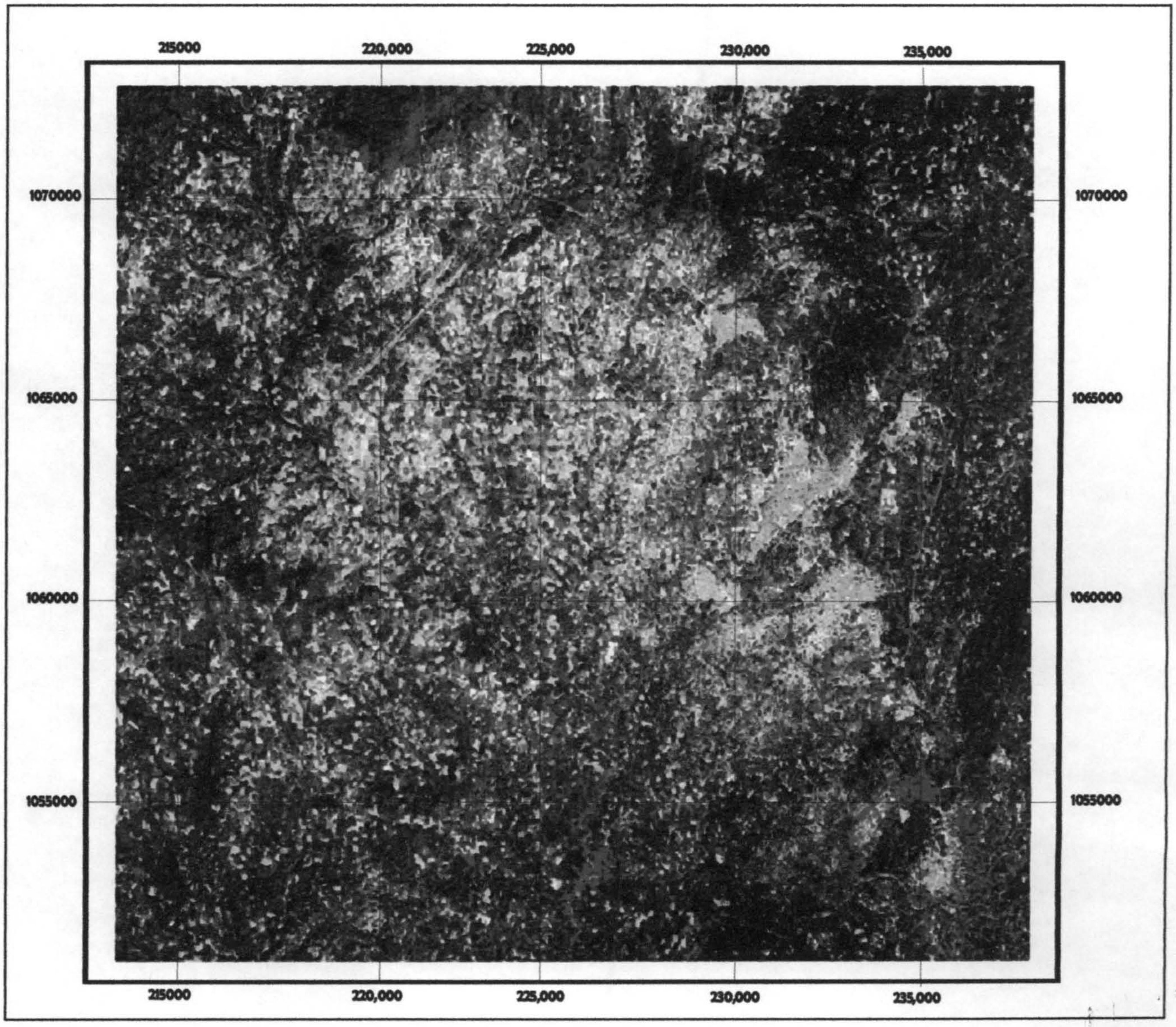
APPENDICES

Appendix I: Minna MSS Imagery 1973



Appendix II: Minna TM Imagery 1995



Appendix III: Minna ETM Imagery 2007