

REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM
APPLICATION IN LANDUSE MAPPING
CASE STUDY OF KADUNA AND EVIRONS

BY

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IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF
POSTGRADUATE DIPLOMA ENVIRONMENTAL MANAGEMENT OF THE
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

DECLARATION

I hereby declare that this research was conducted by me under the guidance of Dr. Okhimamhe A.A. of the Department of Geography, School of Science and Science Education, Federal University of Technology, Minna Nigeria.

Credit has been given to writers whose work was referred to in the project.

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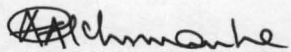
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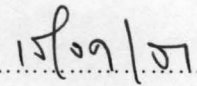
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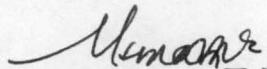
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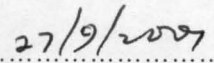

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DEDICATION

Dedicated to my late parents (Mr. and Mrs. Usman Sarki) and my family.

ACKNOWLEDGEMENT

I most specially thank the almighty God for his guidance and protection throughout the programme. Many thanks to my supervisor Dr Okhimamhe A. A. for her advice.

My gratitude also goes to the Head of Department, Course Coordinator, lecturers, Course mates and friends for the happy period we stayed together during the programme. Thanks to my loving wife and the children for their understanding and prayers. God bless you all.

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ABSTRACT

As an option to a more traditional approach for different kinds of planning work and studies, computer assisted Geographic Information System (GIS) and Remote Sensing has been applied more frequently. This is due to the increasing capacity of modern computer and the development of specialized and user-friendly software.

The need for an assessment of extent of environmental degradation in Kaduna and environs through the use of Remote Sensing and GIS is crucial.

This study examined the use of Remote Sensing and GIS in land use mapping. From data acquisition or collection to data input and analysis using the appropriate hardware and software, which include arcinfo, ERDAS Imagine, and arcview.

Although we still do not have an accurate assessment of land use and no systematic monitoring is yet in place, these innovative studies have provided us with a sound basis for future work or study

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

The use of Remote Sensing and Geographical Information System (G.I.S) techniques is increasing rapidly finding new fields of application as technology advances in developing the remote Sensing and GIS. One of such application is the topic of this project “Application of Remote Sensing and GIS technique in land use mapping: A case study of Kaduna and environs.

As an operational earth resources system, Remote Sensing means the acquisition of useful information about ecosystems and earth phenomenon with high efficiency, within a very short time, at an optimal low cost, with minimal groundwork. Emphasis is placed on one such tool used in acquiring the information which is referred to as REMOTE SENSING; a technique that enables us to use eyes in the sky” to record information on our environment (Okhimamhe A.A. 1999).

A more traditional approach for processing of the acquired information for different kind of planning work and studies especially as regards to environmental resources, computer assisted Geographical Information System has become more frequently applied. A tool capable of capturing, store, edit,

retrieve and update all forms of geographic information with the necessary hard and software components. GIS also handles the non-spatial characteristics referred to as attribute of an area

1.1.1 Satellite Image Processing

The atmosphere influences the incoming radiation by atmospheric scattering and atmospheric absorption. Scattering is a process of diffusion, caused by redirecting of the radiation by particles of different sizes that are present in the atmosphere. Absorption consumes part of the incoming energy, and some of it will eventually be re-emitted from the atmosphere as heat. Both processes are governed mainly by the sizes of the present atmospheric particles, that is the prevailing atmospheric conditions and the nature of the incoming radiation, mainly its wavelength. The scattering is of three types:

Rayleigh scattering, Mie scattering and Non-selective scattering.

Absorption is when different gases in the atmosphere absorb the radiation energy. Absorption is also wavelength selective; depending on what atoms the gases are built of. The most important absorbers of the incoming solar radiation in atmosphere are water vapour, Carbon dioxide and Ozone.

The raw remote sensing data would have to be processed further. Therefore, image processing involves the use of computers to manipulate and interpret digital data because of the tremendous amount of data involved. This process is not only extremely broad but also involves complex mathematical procedures.

1.1.2 Image Correction

Before using the satellite images, it is necessary to compensate for different inherent errors. The common name for techniques applied to compensate and correct errors and distortions in the image is pre-processing. Corrections are divided into two categories; Geometric correction aiming to correct geometric errors in the data acquisition system and to register the satellite image to a map projection and Radiometric correction is the correction of radiometric errors due to sensor specific errors and to the atmospheric condition during recording. For many applications the corrected image is also treated by different image enhancement techniques to improve the quality and facilitate the analysis.

1.1.2.1 Geometric Correction

Geometric distortions in the raw satellite image are so apparent that the images may not be used without applying some correction algorithms. Errors in the geometry of the image originates from many different sources, variation in altitude, ground speed of the satellite, attitude, variation in the scan speed of a scanning mirror, rotation of the earth during the registration of an image, earth curvature, and relief displacement all needs to be compensated for.

Many distortions are systematic which means that they follow a known pattern and can thus be corrected easily. Other distortions are random, or unique for each image and needs supplementary information to be corrected. The satellite ground speed, attitude, altitude etc are monitored during flight, and corrections

for variations are normally applied before commercialization of the images. Registration of the satellite image to a map project is carried out only on request or can be done by the advanced user having access to necessary hard and software, and possessing enough knowledge of the study area.

1.1.2.2 Radiometric Correction

Corrects sensor-specific errors and errors due to atmospheric distortion during image acquisition. Further image enhancement are applied to improve the interpretability of the images, or to emphasize certain qualities that will make the identification of required features easier and to facilitate analysis. Corrections for prevailing atmospheric conditions during recording is necessary when dealing with more than one image in a study or project, otherwise adjacent areas may appear different in colour, brightness or texture. Haze is a common phenomenon, the effect of which must be eliminated. This is carried out by reference to a feature like water, which is expected to have a zero reflectance in the near infrared (NIR) band. Any reflectance values for water in this band is taken to be due to atmospheric scattering, and can be safely subtracted from all pixels in that band. Topography, angle of incidence of the sun rays and aspect have definite effects on how an object looks in the imageries, and therefore, normalization of the radiance measurements to a pre-determined incident and reflection angle is usually necessary in accurate work. Noise is unwanted signals caused by limitation in the sensing process, either during recording, transmitting or storing the data. This can be due to malfunction of the sensor, electronic interference between different

components in the sensor, or similar problems during transmitting or storing the data.

1.1.3 Image Enhancement and Rationing

The human eye can detect small differences in spatial arrangements of features, but is less adept at resolving differences in colour shades or intensity or tone. In order to improve the interpretability of the imagery, it is usual to 'Stretch' the range of reflectance values in an image to enable little differences to be accentuated in order to make them more noticeable. The radiometric resolution of an 8-bit image is 256, with zero representing "black" and 255 representing 'white'. Displaying an image, for example containing pixels with a dynamic range of say 50 – 120 only, this image will look rather dull and without contrast, making it difficult to interpret. Contrast stretching this image to map the range 50 – 120 to the full range of 0-255 will make the 50 values coincide with 0 and the 120 with 255. It is easy to see that small differences in the reflectance values in the image will then be represented by large values in the output. There are other enhancement techniques designed to achieve special effects, e.g. rationing, Principal Components Transformation, Normalized Difference Vegetation Index (NDVI), etc.

Computers are very efficient in tasks like pre-processing involving pixel-by-pixel manipulation of digital images, geometric reprojecting, radiometric corrections, etc. Recent advances in computer technology have made options of computerized image processing more viable for many users. It is now possible

to perform image enhancements to improve images for specific purposes. It is also now possible to combine data from various sources e.g. aerial photographs, radar, satellite data to improve interpretation results.

When working with multi-spectral data, many objects have different reflection properties in different bands, so that by processing different band combinations these objects can be identified and separated. For example, the mapping of vegetation proved to be quite difficult. The reflectance from vegetation resembled the reflection from many other surface features. By using digital data permitting virtually all kinds of manipulations of the pixel values the recorded reflection from the NIR-band and the red-band was used to create a ratio forming a new image that emphasizes the vegetation and decreases the influence of other objects. This ratio is called the Normalized Density Vegetation Index (NDVI) and has become a standard in the mapping of living green biomass.

1.1.4 Satellite Image Maps (SIMS)

The implementation of remote sensing was focused on the use of satellite imagery for mapping and evaluation of physical features. In the process of selecting imagery, it is of vital importance to consider, not only the sensor but also the image quality, date of recording, atmospheric conditions, cloud cover, season, climate, vegetation etc. SPOT and Landsat were the earth resource satellites used for this project and also were the main input for the production of SIMS.

A technique of image mosaic was applied, merging the satellite scenes with each other. Using this material, Satellite Image Maps (SIMS) were produced in suitable map scales and formats. The scale of 1:250,000 was chosen as the main interpretation scale. The satellite data was geometrically processed to fit the national map projection, specially enhanced for highlighting physical features. The produced SIMS covers an area equal to 125 by 125 kilometers each, except for some map sheets near border areas, which were extended to include border areas.

1.2 Statement of the Problem

In the southern part of the study area and some parts of the north, severe population pressures have resulted in degradation of the environment with north and south of Kaduna being a prime example. Largely, the degradation is due to tree and shrub removal for fuel wood and the clearing of land for agriculture. Many of these areas have shallow soils that do not resist erosion well.

In the far northern areas, there seems to be a process of desertification occurring as the land are now exposed due to deforestation. Large areas of gully erosion are clearly visible and denuded areas can be seen in many agricultural areas. This may be a relatively short term occurrence due to climate changes however factors such as damming large water bodies, and

increasing intensity of agriculture due to population growth may also be influencing these observations.

As population pressure increase in Kaduna and environs, as a result of migration from far north of the country, agriculture is expanding along the floodplains and the open areas. As a result also land is cleared for settlement and agriculture and trees and shrubs cover removed for fuel wood. In this area, there has been increase in the number of reservoirs over time period. While the source of water has been beneficial to the local populace, its long-term effects on the environment are of concern.

The technique used in this project will clearly show the extent of the land use and thus give idea of solving this complex problem.

1.3 Aim and Objectives

The main aim and objective of this project is to extract some environmental resource information from remotely sensed satellite imageries by way of interpretation and the use of G.I.S. Techniques in order.

- a. To produce an up to date land use map of Kaduna and environs.
- b. To serve as future reference in the application of the techniques on similar project or other fields.
- c. To provide detail information for trend analysis, i.e. identifying extends and intensity of changes in land use over certain period.

1.4 Justification of Study

The look the environment around us wears today is the result of gradual modifications by man since the beginning of life. Man has continuously modifies his habitat either unconsciously or on purpose. Globally, it is now understood that the environment exists only in relation to man problems emerge.

Peasant farmers destroy their own future livelihood by indiscriminate tree felling, but do so only because they have no immediate alternative. Improper land utilization is exacerbating problems environmentally, such as deforestation, desertification, soil erosion and water pollution, which, in turn, are causing further immiserisation. The degradation is widespread and alarming in the state. The excessive depletion of environmental resources due to improper land use attracts justified concern for the future. Hence producing a land use map will show the extend and effect of the land use to the environment.

1.5 Scope and limitation

This project emphasizes on the use of Remote Sensing and Geographic Information System (GIS) technique to produce land use map of Kaduna and environs. This technique involves the extraction of useful information about the earth surface with high efficiency, within a very short time, at an optimal low cost, with minimal groundwork.

The extracted information by way of interpretation is now processed by applying a tool known as Computer assisted Geographic Information System which is capable of capturing, storing, edit, retrieve and update all forms of geographic information with the necessary hardware and software components.

The study is limited within the scope as mentioned above and the research did not go beyond the application of this technique.

1.6 Description of Study Area

1.6.1 Location and Physical Environment of Kaduna State

1.6.1.1 Location

The study area (kaduna and environs) is located in the central part of kaduna state and covers approximately 672.04 Km Square of land lies between Latitude $10^{\circ} 20'$ and $10^{\circ} 40'$ north of the equator and Longitude $7^{\circ}15'$ and $7^{\circ}35'$ east of the prime meridian. The state is bounded in the north by Katsina State, south by Federal Capital Territory, in the west by Zamfara and Niger State, in the east by Plateau, Bauchi and Kano States respectively. (Fig.1).

The kaduna and environs has a population of about 1.0 million people (census 91), and serves as the state capital as well as a major industrial center.

1.6.1.2 Topography

The physiography of kaduna is dominated by gently undulating plains with slope of 0-20% covering about 75% of the land area. Steeper terrain occurs in the southern half of the state where slopes greater than 16% are prevalent.

The contribution of topography to overall erosion hazard seems therefore to be a minor one. Steep slopes greater than 20% in Kaduna are rock outcrops with shallow patches of soils over bedrock.

1.6.1.3 Soil

Kaduna is underlain mainly by undifferentiated complex igneous and Metamorphic rocks. With the soils developed from the above parent materials, most topsoils in the kaduna are therefore of medium to coarse texture. (Sandy Loam and Loamy Sand). The sub soils are usually finer textured (SMNP – FDALR, 1985, 1991). The contrast in the top –soil and sub-soil textural classes reduce the ability of the soil to resist erosion, especially under heavy storm conditions.

Four major soils grounds were mapped in Kaduna State (FDALR) 1985, 1991), with their percentages of occurrence as:

Ferric Acrisols 50%

Dystric Cambisols 30%

Haplic Luvisols 10%

Gleyio Luvisols 10%

1.6.1.4 Vegetation and land Use

Roughly 70% of Kaduna State was covered by un-cleared vegetation dominated by wooded shrub grassland and woodland physiognomic types (NIRAD Project 1978).

Most cropped lands in Kaduna and environs are concentrated around Kaduna and its immediate surrounding. Cultivation practices include crop rotations cultivated on flat and ridged land. Mixed cropping is widely practiced, with Sorghum, Maize and Millet in the northern part of the study area, Sorghum, Maize and Yam to the south, and Sorghum/Yam to the southeast. Other important crops are Groundnut, Cowpeas, Soya beans and Ginger; Maize is increasingly replacing, in some areas, Sorghum as the dominant crop. Cattle rearing are on the increase with only about 18% of farmers reporting ownership (FAO, 1991).

There has been marked migration from the rural areas to the major cities, notably Kaduna, with a concomitant increased pressure on the land resulting in increased and extensive areas now solely used for continuous cropping. The shortened fallow has reduced the fertility status of the soil and has given rise to heavy dependent on in organic fertilizer with continuous decreasing organic manure input to ameliorate declining soil fertility.

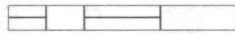
1.6.1.5 Climate

Kaduna experiences two distinct seasons, rainy and dry seasons. The annual average rainfall is about 34509mm. The wet season last for six months on the average and the dry season commence from the tail end of October to April. The harmattan cold accompanied with dusty wind occurs between November and February, while March to September is associated with heat.

STUDY AREA



20 0 20 40 Kilometers



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Background

With the easy availability of satellite digital data, the implementation of G.I.S. for many applications has been enhanced. It is nowadays possible to integrate the Remote sensing data and image analysis results with a GIS so that data can be stored and manipulated in a way that will facilitate monitoring and modeling of spatial events as well as mapping and management of resources. Satellite Remote Sensing offers a way to examine large tracks of the earth's surface quickly and in an efficient manner.

Hard copies of digital imageries can be used as the basis of the mapping of the state of the land through the interpretation of the imageries. Remote Sensing data has wide ground coverage, allowing observation of large tracts of land at the same time e.g. Mapping of vegetation cover or identification of the eroded parts of a landscape. Regional studies are possible because of the large extent of simultaneous coverage of satellite imagery.

2.1.1 Remote Sensing

In 1972, the USA sent the first land-sat remote sensing satellite into space using charge-coupled devices (CCD) based sensors to record reflected radiation. In 1986, the SPOT satellite was launched, having higher resolution sensors giving the capability of pointing the field of view sideways to obtain stereoscopic coverage of the ground.

With the arrival of Land-sat – 1 in 1972, the first Earth Resources Satellite, it became possible to view large areas of ground at the same time. It also made it possible relatively cheaply to obtain updated views of the same portion of the earth's surface every 16 days. Because of the low resolution of the early Land-sat digital data (7m), the accuracy obtainable from the classification of the earth's surface was low. However, today, modern Remote Sensing Satellites have resolutions of 10 and 20 metres (SPOT, launched in 1982) etc. The Landsat TM, with a pixel resolution of 30m, is superior to MSS in terms of accuracy, number of bands (seven instead of four in MSS) and the quantization levels (256 instead of 128). It has been proved to be better than MSS for detailed interpretation in inventorying Land-use and Land Cover (Williams et al, 1984).

2.1.2 Geographic Information System (GIS)

During the 1960s and 1970s, new trends arose in the way maps were being used to assess resources and to plan Land-use. Realizing that different aspects of the earth's surface did not function independently of each other, people began to want to evaluate them in an integrated, multidisciplinary way. One way of doing this was to simply overlay transparent copies of resource maps on light tables and look for places where the various attributes on the maps coincided.

This technique was adapted to emerging computer technology by making simple maps by printing statistical values on a grid of plain paper, overlaying these grids values and using the overprinting of line-printer character to produce suitable gray scales representing the statistical values, in what was known as a grid-cell or raster system. The results of these early methods, however, were not refined enough to final acceptance among professionals.

By the late 1970s, the technology of computer map making had advanced rapidly, with literally hundreds of computer systems and programs being developed for various cartographic applications. At the same time advances were being made in a number of related fields, including, surveying, photogrammetry and remote sensing. As systems multiplied and experience was gained, the potential for linking different kinds of spatial data processing together into truly general-purpose geographic information systems emerged. By the early 1980s GIS had come into its own as computer technology became more sophisticated, less expensive and more widely adopted. Public agencies, research laboratories, academic institution private industry, the military and public utilities are rapidly establishing systems.

In essence, GIS is a system of computer hardware, software and procedures design to support capture, management, manipulation, analysis, edit and display of spatially referenced data for solving complex planning and management problems.

For appropriate decision-making for land-use planning and management, data must be transformed by formalized interpretations and evaluation procedures into usable information for specific purposes (Antoine J 1991). The processes of land resources assessment and land-use planning and management are thus particularly complex in these environmental conditions, as they are dependent on a wide variety of factors and characteristics which are very variable in both space and time.

Therefore, the resources planners need a tool to manage the large amount of basic data and information, statistical, spatial and temporal, needed to deal effectively with the various problems associated with decision-making. GIS takes advantage of these tasks. Because of the advantages of GIS in speed and flexibility; speed in data processing and information generation, flexibility in the use of data, GIS now makes it possible for the resource planner to rapidly produce a combination of maps and tables that show together “where” (location of resources). “What” (Kind of resources) and “how much” (quantity/limitation) of resources.

Okhimamhe A.A. (1999) stated that images could serve as input especially in the identification mapping and monitoring of soil erosion sites. In combination with GIS possible erosion sites can be identified.

Forestry Monitoring, evaluation and coordinating Unit in a World Bank project undertook an assessment of land use and vegetation changes in Nigeria between 1978 to 1993/95 using Remote Sensing and GIS. A historic statistical record on the status of vegetation and land use in 1976/78 was used as baseline information for 1993/95 studies. (FORMECU Preliminary report 1996).

In another World Bank project tagged Environmental Management Project (EMP) by Federal Department of Agricultural Land Resource, undertook an Assessment of Soil Degradation in Nigeria using Remote Sensing and GIS techniques to build up the Department's capacity and capability to set up a framework to mitigate Nigeria's erosion problems. (Swedish Space Corporation Final Report 1998).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Collection of Data

3.1.1 Data for Base Map

Although the method of assembling the map details is basically the same, there are differences in practice depending on whether the map being produced is basic or special purpose map.

A base map is a map containing topographic information and on which the thematic information hangs. Basic topographic maps are usually derived from original survey and likely to be at large or medium scale.

Special purpose maps or thematic maps are maps that portray themes while the basic features like roads, rivers, contours etc are subdued.

The data collected for the base map were topographic maps at different scales most ranging from scales 1:50,000, 1:100,000 and 1:250,000 covering the entire Kaduna State. Small scale maps like 1:2,000,000 were also acquired from different sources, most of them from the state's land and survey department.

3.1.2 Satellite Data

Two types of satellite data were used for the project and include:

- a. SPOT Multi-spectral (1993/95).
- b. Land-sat Thematic Mapper (TM) (1993).

3.1.2.1 Spot XS

The SPOT – Satellite family was launched in 1986 and is based on the push-broom sensor technology. The sensor is called High Resolution visible (HRV) and the satellite actually carries two parallel sensors capable of recording radiation either in panchromatic mode or in a three band multi-spectral mode (See figure 14). In the construction of the satellite sensors special attention was made to ground resolution. The pixel size in panchromatic mode is 10 by 10m and 20 by 20m in multi-spectral mode. The HRV sensors are movable, having the ability of recording data both vertically under the satellite and oblique.

The oblique option of the sensor makes it possible to get very frequent recordings from the same area and to assemble stereopairs. Using photographic prints of the satellite images makes it possible to make topographic maps with the same instruments that are used in aerial photography photogrammetry.

3.1.2.2 Landsat TM

The LAND-SAT-Satellite family uses a scanning mirror system for data acquisition. The LAND-SAT, Launched by the USA in 1972, was the first satellite having generally available high-resolution data. Geometric resolution of the first generation of multi-spectral scanning (MSS) data was 80 by 80m and the sensors on board was recording radiation in four wavelength bands (Fig.12). A second generation of LAND-SAT Satellites that become operational in 1984 contains two sensors; the MSS and the Thematic Mapper (TM) that records the radiation in seven bands (Fig. 13) being an improvement of the radiometric resolution derived from experiences gained

- with the MSS-data. The spatial resolution of the TM-data is also higher the pixel size is 30 by 30m. The coverage of one LAND-SAT scene is 185 by 185km on the ground for both sensors. LAND-SAT Satellite data has a much higher radiometric resolution, which often is more important than spatial resolution in remote sensing applications.

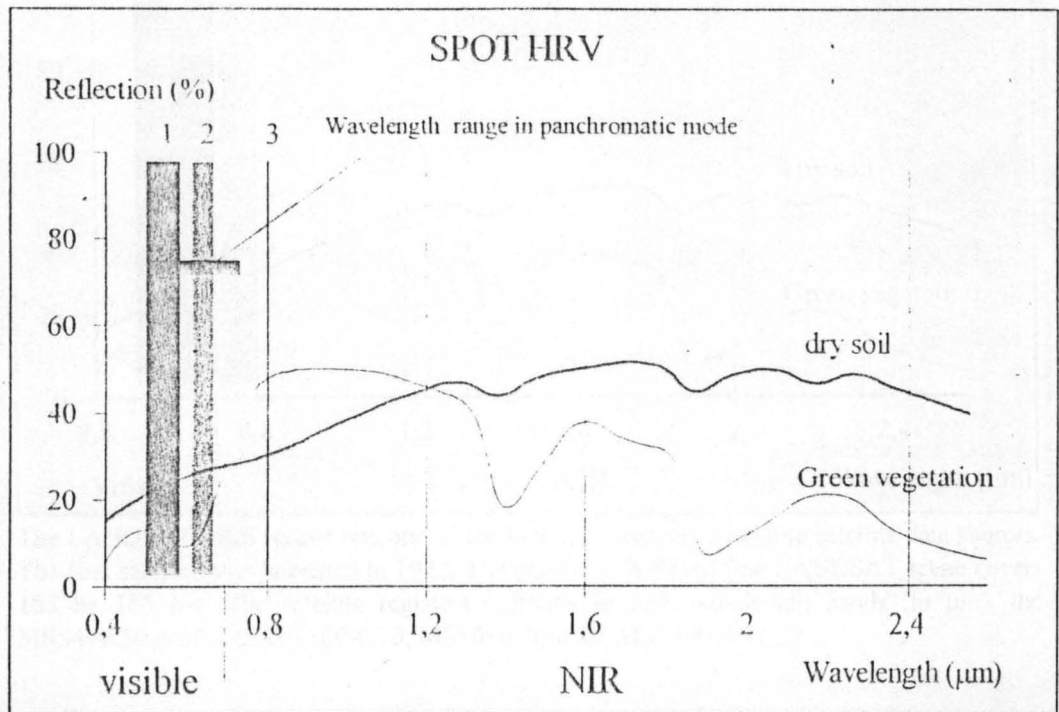


Figure The HRV sensor onboard the SPOT satellites has two recording modes, panchromatic (P), recording from 0.51 to 0.73 μm and multispectral (XS) mode recording in three bands, 0.50-0.59, 0.61-0.68 and 0.79-0.89 μm . Ground resolution is 10 m in P-mode and 20 m in XS-mode.

3.2 CLASSIFICATION OF DATA

3.2.1 Land use Classification

A summary of dominant Land-use classes as at 1993/95, Kaduna and environs.

Land-use Classes

Agriculture

Intensive Agriculture

Extensive Agriculture

Floodplain Agriculture

Forest Plantation

Trees/Wodland/Shrubs

Urban

Major Urban

Minor Urban

Towns and Village

Roads

Major Roads

Minor Roads

Railway

Hydrology

River

Water body

Reservoir

Based on the above classification a legend description and interpretation key was developed. See Table 1 on pg. 30.

3.2.2 Legend Description

Each of the legend classes are defined by differences in their physical attributes and characteristics which can be discriminated in a false colour composite satellite image Land-use classes are identified through pattern, colour, tone and texture recognition, size, shape and class relationships, and location.

The legend adheres to international mapping standards and provides the necessary information required to adequately assess and evaluate Land-use change. Land-use is defined primarily on the basis of degree of change from natural to human-manipulated environments. All legend classes are described below both by their physical and image characteristics.

Urban

Major Urban

Densely populated city core, residential, industrial, commercial, government reservation administrative and educational areas of both traditional and modern major cities.

Identified mostly by the large size of the city. In the colour composite satellite image major urban areas appear as a bright cyan blue. Example of major urban is found on the satellite image map sheet 32 Kaduna.

Minor Urban

Smaller urban centers and the outskirts of large cities, which are less densely populated than the core. Also includes larger rural, nucleated settlements, villages and small towns.

Minor urban areas are recognized by their smaller size and a mottled cyan blue color. Mottling is in tones of red, orange and pink indicating the presence of sporadic vegetation.

Agriculture

Intensive Agriculture

Intensive smallholder agriculture is characterized by small plot farms (0.5 To 2 ha) growing mostly millet and sorghum. Cattle, goats, sheep and donkeys are common. Small farms are usually combined with minor grazing.

On the satellite images intensive agriculture is discriminated as a patchwork of yellow to white. Pinkish tones may also be present if imagery was collected towards the end of the wet season.

Extensive Agriculture

This is a complex class indicative of extensive smallholder agriculture activity, scattered throughout an area that has been denuded. Small farms are interspersed with small areas of bare exposed soil, which has become unsuitable for agricultural activity. Small-vegetated areas are used mostly for grazing activity and subsistence farming.

Grazing lands appear as grasses with scattered trees and shrubs. Recognized as mottled Grey tones (grasses) with scattered, discontinuous reddish areas (trees and shrubs). Denuded bare sandy soils in the northern part show up as white on the imagery. There areas contain scattered, yellowish patches representing smallholder agriculture.

Gully Erosion

Areas of gully erosion formed from runoff following removal of natural vegetation. In northern portions of Kaduna, some gullies are actually headwater channels being actively mined for soil for the production of bricks.

Recognized from the satellite imagery by the whitish (with blue, Grey or green tones) feathery dendritic patterns along rivers.

Floodplain Agriculture

Agricultural activity confined within the floodplains of a river. Fadama type agriculture (walled fields) is common within floodplains. This class may include minor irrigation activity, however, it is mostly maintained through high water tables and over bank flooding.

Recognized by proximity to a major river such as Kaduna River. Floodplains cropping patterns as well as the limits of flooding are easily discriminated through changes in colour and pattern bordering a river.

Trees/woodland/Shrubs

Trees/woodland/shrubs swamp occurs in poorly drained parts of streams, usually within floodplains, and in depressions that form the source of small streams.

They show up in the satellite imagery as a combination of a rough textured, dark red shrubs and vibrant red to pink sedge grasses. This class is also recognized by its association with streams, floodplains and large dams.

Reservoir.

Lakes created by the damming of rivers and streams. Identified as lakes, in varying shades of blue, occurring on rivers and streams. The straight nature of the dam is discernable on the satellite imagery. Tone may be lighter if influenced by turbidity or if very shallow.

Water body

Mature river with well developed floodplains. Is more than 2mm wide on the SIMS and mapped as a polygon.

Identified as meandering watercourse. Whitish sand depositions may be present due to sand banks emerging at low water conditions. Dark tones if water is not affected by sediment transport or pollution.

Water Course

River with less pronounced floodplains. Less than 2mm wide on the SIM. May be dry during dry season. Identified on the satellite image with vegetation along river courses. Stays fairly reddish even if recording is made during dry season.

Table 1

**INTERPRETATION KEY
KADUNA AND ENVIRONS**

Land use	Code	Description	Identification
Gully erosion	1a	Areas of gully formed from runoff following removal of natural vegetation.	Whitish (with blue, gray or green tones) feathery dendritic pattern along a watercourse.
Trees/woodland/shrubs	2c	Occurs in poorly drained part of streams, usually within floodplains.	A combination of rough textured dark red shrubs and vibrant red to pink sedge grasses. Also associates with streams, floodplain and large dams.
Intensive agriculture	3d	It is characterized by small plot farms growing mostly millet, sorghum and usually combined with minor grazing.	Identified as a patchwork of yellow to white pinkish tone.
Extensive agriculture	4e	Small farms are interspersed with small areas of bare exposed soil, which has become unsuitable for agricultural activity.	Recognized as mottled gray tones (grasses) with scattered discontinuous reddish areas (trees/shrubs). Shows as white on the imagery in the northern part as a result of bare sandy soil
Major Urban	5g	Densely populated city core, residential, industrial, commercial etc.	Identified mostly by the large size of the city and appears as a bright cyan blue.
Minor Urban	7e	Smaller urban centers and the outskirts of large cities, which are less densely populated.	Recognized by the smaller size and a mottled cyan blue color. Mottling is in tones of red, orange and pink indicating the presence of sporadic vegetation.
Forest plantation	6a	Large plantation of exotic and indigenous tree species.	Identified by their shape (polygons with some straight edges) and homogenous color (red) and textured.
Reservoir	9b	Lakes created by damming of rivers and streams.	Identified as lakes in varying shades of blue. The straight nature of the dam is discernable on the satellite. Tone may be lighter if very shallow.

Water body	10a	Matured river with well developed flood plains.	Identified as meandering watercourse. Whitish sand deposition may be present due to sand banks emerging at low water condition. Could have dark tone at peak periods.
Floodplain agriculture.	8f	Agricultural activity confined within the floodplains of a river. Fadama type of agriculture are common	Identified by proximity to major river and can be discriminated by reddish to pink color pattern bordering a river.

3.3 IMAGE INTERPRETATION

As in conventional aerial photo interpretation, the study of satellite imageries is an indirect method of collecting information concerning surface and sub-surface features of the earth. Conclusions on character as well as details of soils, geology, topography, drainage conditions, vegetation and Land-use can be drawn from interpretation of physical elements in the images.

These physical elements may be of various types depending on the objective of the study. The colour tones, distribution, pattern and texture of vegetated areas, can be used as indicators in a study of the vegetation and/or Land-use. The fundamental part of satellite image interpretation is the understanding of the

significance of such indicators as the Keys to the landscape and its physical properties.

Interpretation of satellite imagery can be done either automatically using computers, or visually, using the eyes and brain. For some applications automated methods can be less time-consuming than visual methods, still yielding acceptable results. However, for most applications it is difficult for a computer to beat a human being knowledgeable in her subject area and environment, perhaps stemming from many years of fieldwork, is applied to the interpretation.

3.3.1 SATELLITE MAPPING PROCEDURE

Mapping was performed on SPOT XS satellite image maps on a scale 1:250,000 the highest possible precision was observed in the tracing procedure to guarantee the quality of the final result. Interpretation key is very important in this regard serve as guide in the mapping procedure (see Table 1).

During the satellite image mapping it was important to follow a working procedure to avoid confusion and unnecessary problems during this step of the production.

- i. Ink drawing pens (0.25mm) and clear drawing film was used for the Satellite Image Interpretation. The drawing fill was cut to a suitable size leaving approximately 2 – 4cm margins around the image. The film was firmly attached to the image with scotch tape in all four corners. Tic

marks (Lat., Long.) was drawn in the corners to assure that the film can be readjusted to fit at exactly the same position over the images even if it was accidentally removed. The tic marks was drawn using intersections in the grid on the image maps as referenced. Tic marks were drawn with a ruler.

- ii. When the image and drawing film were attached securely, Satellite Image map number, date and name of the layer being interpreted were noted at the upper right corner of the drawing film.
- iii. Then interpretation began. Fingerprints on the drawing film was avoided, otherwise it will render drawing more difficult. Large polygon features were interpreted first and then continued with finer polygon features. A magnifying glass was used for smaller features. All features, which will be shown as points and lines on the final map, were interpreted on a separate plastic sheet. Each layer was marked with its respective feature (Polygon, line or point)
- iv. During the interpretation relevant maps like the topographic maps, vegetation maps, soil maps etc were consulted and used as complimentary information for increasing mapping accuracy. These maps were very important sources from which additional information were obtained.
- v. After the interpretation, it was necessary to check for error and correction effected. Once the interpretation was certified correct, it was marked as finished on the index map.

A total of six layers were interpreted on the Satellite Image Map (SIM). The layers include Land-use coverage, stream coverage, Gully erosion areas, Flood-plain coverage, Towns/Villages coverage and Stream polygon coverage. All adjacent coverages were edge matched to ascertain continuity of interpreted features

3.4 GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS is a system of computer hardware, software and procedures design to support capture, management, manipulation, analysis, edit and display of spatially referenced data for solving complex planning and management problems.

For appropriate decision-making for land-use planning and management, data must be transformed by formalized interpretations and evaluation procedures into usable information for specific purposes (Antoine J 1991). The processes of land resources assessment and land-use planning and management are thus particularly complex in these environmental conditions, as they are dependent on a wide variety of factors and characteristics which are very variable in both space and time.

Therefore, the resources planners need a tool to manage the large amount of basic data and information, statistical, spatial and temporal, needed to deal effectively with the various problems associated with decision-making. GIS

takes advantage of these tasks. Because of the advantages of GIS in speed and flexibility; speed in data processing and information generation, flexibility in the use of data, GIS now makes it possible for the resource planner to rapidly produce a combination of maps and tables that show together “where” (location of resources). “What” (Kind of resources) and “how much” (quantity/limitation) of resources.

3.4.1 GIS COMPONENTS

A modern GIS may be viewed as an integrated system composed of five main components: Hardware, Software, Data, Methods and Human resources

3.4.1.1 Hardware

The hardware components of a GIS include several which are common to any computerized data base management system, such as a central processing unit (CPU), a disk drive storage unit for storing data and programs, a tape drive used to store additional data, and a visual display unit, as well as other general-purpose computer peripherals.

The GIS has, in addition, several specialized hardware components including: a digitizer or scanner, which is used to convert the geographical information from maps into digital form and send it to the computer plotter, which prints out the maps and other graphic outputs of the system; and a visual colour graphics display unit (work station) on which spatial data editing and display can be performed by the user.

3.4.1.2 Software

The main GIS software components are designed to perform the following functions

- Data input
- Data storage and data base management
- Interaction with the user (graphic/map editing)
- Data output and presentation (Plotting).

Some of the GIS software's include: Arc/info, ELWIS, ERDAS, ARVIEW, AUTO CAD, IDRISI etc.

Arc/info

This software is made up of several subsystems; each handles a different group of functions. Listed below are different ARE/INFO subsystems written by ESRI.

ARC – Is the overall GIS manager. Use Arc to:

- Generate and manage coverages in the database.
- Convert data from other digital formats.
- Manipulate spatial and attribute data in one or more coverages.
- Create new data relationships between coverages.

Arctools – Is a collection of Arc micro language (AML) – based tools, implemented through an easy-to-use graphical user interface, for common ARC/INFO operations and functions.

TABLES – Tables software is a tabular management system that uses INFO files to create, store, edit, and query tabular data.

ARC PLOT – Is a graphic module for map display and query use it to:

- Display spatial and attribute data for one or more coverages.
- Query spatial and attribute characteristics.
- Create screen displays and maps, and generate plot files.

ARCEDIT –Is an interactive graphic editor. Use it to:

- Digitize and edit one coverage at a time.

3.4.1.3 Data

A detailed database design is a critical component of any GIS system design.

The database design depends on the hardware and software configuration and function, and vice versa.

The database is normally composed of data generated by means of satellite remote sensing (including radar), aerial photography and radar, field studies and use of existing data. Experience shows that use of images from satellites can only compliment aerial photography and field studies such as ground survey and questionnaire. For example, while remote sensing techniques have dramatically increased our ability to map trends in land use patterns and natural resource depletion, they leave undressed the socio-economic and political forces underlying these trends.

3.4.1.4 Methods

The tools (hardware and software) and procedures used in data acquisition, data input, data processing, which includes database manipulations and other analytical functions. By defining these functions, the character of the system takes form.

3.4.1.5 Human Resources

Perhaps the most underrated step in GIS development implementation is that of organization and human resource development. Approaches to human resource development vary from project to project, but well-trained and organized staff, with a clearly defined mandate, is the key element of success in any GIS application.

3.5 DATA INPUT

There are two main classes of elements in the data entered into GIS:

- a. Spatial elements or map features such as points, lines and areas or polygons (for example towns/villages, roads/rail, land use boundary, state/local govt. boundaries, rivers etc).
- b. Thematic elements which are the attributes to the spatial elements (Land use components of mapping units, names of towns/villages for instance)

Data entered into a GIS are stored in digital format spatial elements were entered into the GIS manually through digitization and automatically using scanning techniques. Thematic elements were entered using the traditional input media, such a computer keyboard.

The software used to perform these functions is the ESRI ARC/INFO; developed by Environmental Systems Research Institute (ESRI) in United States of America (USA).

3.5.1 Digitizing

Digitization is a common method for capturing and converting analog spatial data from a map to digital format thereby creating coverages. The coverages are a digital representation of any information taken from the source map.

The digitizer or digitizing tablet contains a mesh of wires that define its coordinate system. The density (resolution) of these wires is an indication of how close together digitized points may be captured from the manuscript.

The digitizing cursor is used to locate features from a map manuscript that is mounted to a digitizing board. The coordinates, defining the location and shape of features are recorded each time the user presses a key on the digitizing cursor.

Digitizing in DOS ARC/info.

Step 1 Preparation

Before digitizing started the, some preparations were made such as specifying different parameters, defining the setting and configuring the digitizing table.

The first and one of the most important things was ensure that the 4 tics on the transparent film exactly match those of the corresponding satellite image maps.

The accuracy of the whole database depends on this first step. The interpreted

sheet (the transparent film) stocked on the digitizer table with masking or white scotch tape.

Thereafter, computer and digitizer were started. At the dos prompt (C;) start the arcinfo arc environment by typing.

C:arc

The Arc command processor is the environment within which Arc commands are executed eg. Creating coverages with command createcov.

Step 2 starting Arcedit.

Then open the Arcedit environment by typing at the arc-prompt:

Arc: arcedit

It was within the Arcedit environment that all digitizing and editing works were all performed. Arcedit was also used for assigning feature attributes and feature edge matching.

The next step was the monitor or screen for graphic display was set to number 4, which is the graphic device for Arcedit session.

: Display 4

Step 3 set mode of coordinate entry

During digitizing work, coordinate entry was generated from the digitizer. The cursor (mouse) and the screen were also used, which is another common coordinate entry mode.

: Coordinate digitizer

Step 4 setting edits tolerances

The following settings were defined for the digitizing to be as accurate as possible.

Snap distance defines the maximum distance that a node will snap to another node. For this project, the snap distance was stated to be 250m in reality, which means 1mm on a 1:250,000-scale map sheet.

: Snap distance 250

Weed distance is the minimum distance between two vertices in a line. This command is used to avoid too much storage space to be occupied. This is especially important when using the track mode (See step 5). Define weed to be 100m in reality (equal to 0.4mm on a 1:250,000 scale map sheet) by typing.

: Weed 100

Edit distance is used for feature selection, where it specifies the maximum distance the programme will search for a selected feature. Set edit distance to 1000m (equal to 2.5mm on a 1:250,000 scale map sheet)

: Edit distance 1000

Step 5 configuration of digitizer

For the digitizer, it is possible to choose between different data entry modes, point mode and track mode. The following modes were used for different feature digitized:

For tics and labels – use point mode.

For arcs – use track mode and occasionally point mode.

Step 6 Entering tics

Arcedit will ask for tics to be defined to be able to orient the cover. To define the tics it is important to:

- Set coordinate entry mode to digitizer.
- Set data entry mode from the digitizer to point mode.
- To digitize the latitude – longitude tic coordinates in the sheet corners.
- To look up the tic numbers specified on the map.

Choose the tic-number 1 from the digitizer, press (A) to end the number and then one more time (A) having the marked tic located in the middle of the cross hair on the digitizing cursor. The first tic is now positioned. Continue to the next one; choose the next tic number, then press A and then A again having the next tic in the middle of the cross hair. Continue with the same procedure as above for all four tics. To stop tic entry just press O followed by the A key.

When defining the tics, accuracy was maintained, as the entire session will rely on the precision. The software showed the calculated tic error called RMS (Random Mean Square). The RMS should not be larger than 0.005. If the RMS is less or equal to 005 you may answer “yes” to the question, if not, answer ‘no’ and re-enter the tics. The RMS was 003, just accurate enough for digitizing.

Step 7 Digitizing

Now everything is prepared and digitizing started. “Add” is the command used whenever you want to add new features or start digitizing. Type.

: Add

A menu will appear explaining the digitizer key functions. It is advisable to mark every new digitized feature. It is also recommended to make it a habit to always start the digitizing work in the upper left corner. Make a habit to save every 10 minute otherwise all newly digitized features may be lost if a power break occur.

: Save

An arc always starts with a node and end with a node. After digitizing save and quit. Type:

: Save

: Quit

3.5.2 Scanning

Scanner is a device using an optical laser or other electronic device to scan graphic information and convert its image to digital raster data. Scanning is generally faster than digitizing for raw data input but requires considerable post-data input processing.

Arcscan contains a set of software tools that allows you to impart, correct, edit, vectorize, plot or export scanned raster documents.

If the scanned data are stored in an image format supported by ARC/INFO, the image can be used as graphic component in a map or displayed as a background image in Arcedit.

3.5.3 Keyboard

The user interface unit, where commands, data etc. are manually entered as letters or numbers. All attribute data of the spatial data were inputted through the keyboard by manually typing the texts into the database. The attribute information was stored in the feature attribute file, the PAT file for point or polygon coverage and the AAT file for arc coverage.

3.6 Editing of digitized data

The data had to be edited for errors during data input and topology had to be built in order to make the database useful. Some of the digitizing errors were corrected automatically while other had to be manually corrected.

There were two types of node errors; Dangles and pseudo node errors. Pseudo nodes are displayed where two lines intersect, and generally are not necessary to edit. Dangle node errors in contrary are products of overshoots or undershoots during digitizing. These errors need to be manually corrected.

There were a number of ways the errors were corrected manually in arc/info-arc edit:

I. Polygons that were not closed during digitizing. The following commands were used:

Arcedit: editfeature node or ef node

Arcedit: move

II. For undershoot errors:

Arccedit: ef arc

Arccedit: select

Point at the arc to extend and press 1 from the menu.

Arccedit: extend

III. For overshoot errors:

Arccedit: ef arc

Arccedit: select

Point at the overshoot arc and select

Arccedit: delete

When editing was completed, the changes were saved using the 'save' command.

3.6.1 Building Topology

Topology is the spatial relationship between connecting or adjacent coverage features e.g. arcs, polygons and points. The following commands were used to create or build topology.

Clean

The clean command performs automatic coordinate editing and creates feature attribute table for polygons and line coverages. It also creates intersections wherever lines cross one another. If arcs are shorter than the dangle length specified, it eliminates overshoot and snaps node that are shorter than the specified fuzzy tolerance.

Build

The build command is used for generating topology for polygons, lines and points. This command does not change the coordinates such as clean. Therefore all overshoots and undershoots should be edited before a build command.

3.7 MAP PREPERATION AND PRODUCTION

3.7.1 Map Transformation

The coordinate units after digitizing were in digitizer inches. Transformation applies an equation to the coordinates of the original coverage to create a new coverage, identical topology, close to identical shape, but usually contrasting in scale and orientation compared with the original coverage. Rotation and rescaling are the most obvious result of transformation.

3.7.2 Map Projection

Mapping of any area inevitably introduces the problem of representing a spherical surface onto a flat one. The method of transforming three-dimensional space onto a two-dimensional map called projection. It is controlled by a set of mathematical expressions. Map projection is suitable at particular locations on the earth and can serve different purposes.

The projection used for this project is the Universal Transverse Mercator (UTM). The UTM projection is a global system that divides the earth into sixty zones, each spanning six degrees in width.

3.7.3 Map Creation

Arcview software was used to create the final map because of its compatibility with arc/info.

The steps for creating maps in arcview are as follows:

- 1 Open arcview window by clicking on icon
- 2 Open a view by double clicking the view icon from the project window
- 3 Adding themes i.e. the thematic layers by clicking view/add theme or click the + button
- 4 Go to the directory where the data is located. All the layers for the project are found in the directory.
- 5 Open all the layers one after the other by clicking the arcs, polygon or points holding down the shift key and clicking on each of them in left window.

If all is done click ok.

All the layers will be arranged vertically on view window. Each of the layers is made active by clicking one after the other. The layers will fall on each other to form a map project from which a layout is created

Other map elements like the scale, north arrow, legend, and borderline etc.

were added on the layout by clicking the appropriate icon on the view window.

The final map after all editing and adjustments was sent the plotter for printing.

CHAPTER FOUR

4.0 FINAL MAP OUTPUT ANALYSIS

Map output deals with the way the information is displayed to the user. This can either be as a visual display (soft copy) or printed copy (hard copy) drawn by plotter. The plotter or printer produces a copy of the information including basic colors.

The final map now reveals all the classes of land use in kaduna and environs and the extend of the land use in terms of area, perimeter and descriptive code as shown in table 2.

4.1 PROBLEMS ENCOUNTERED

4.1.1 Problems in data collection and acquisition.

With regards to data collection, getting satellite data of the study area was problematic. This goes to show that satellite Remote sensing techniques in environmental management has not been widely applied. Even where it is used, institutions or government agencies finds it difficult to part with the data.

Where the data is available, the price for them is extremely exorbitant. That almost made this study impossible.

The other problem was that of collecting base map information. Most of the base maps for the study were out of stock. The few ones collected, especially topographical maps had most of the base information outdated; although that was not too much of a problem.

5.2 Problems in data processing

Delineation of land use boundaries during interpretation was a little problematic because of differences in colour continuity between adjacent satellite scenes.

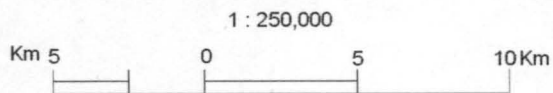
Importing digital imagery from CD-ROM into the system proved difficult at a stage because it needed a large storage space in the hard disk due to many number of scenes involved. To cover the study area, about ten satellite scenes were used; that was quite big for the system to handle.

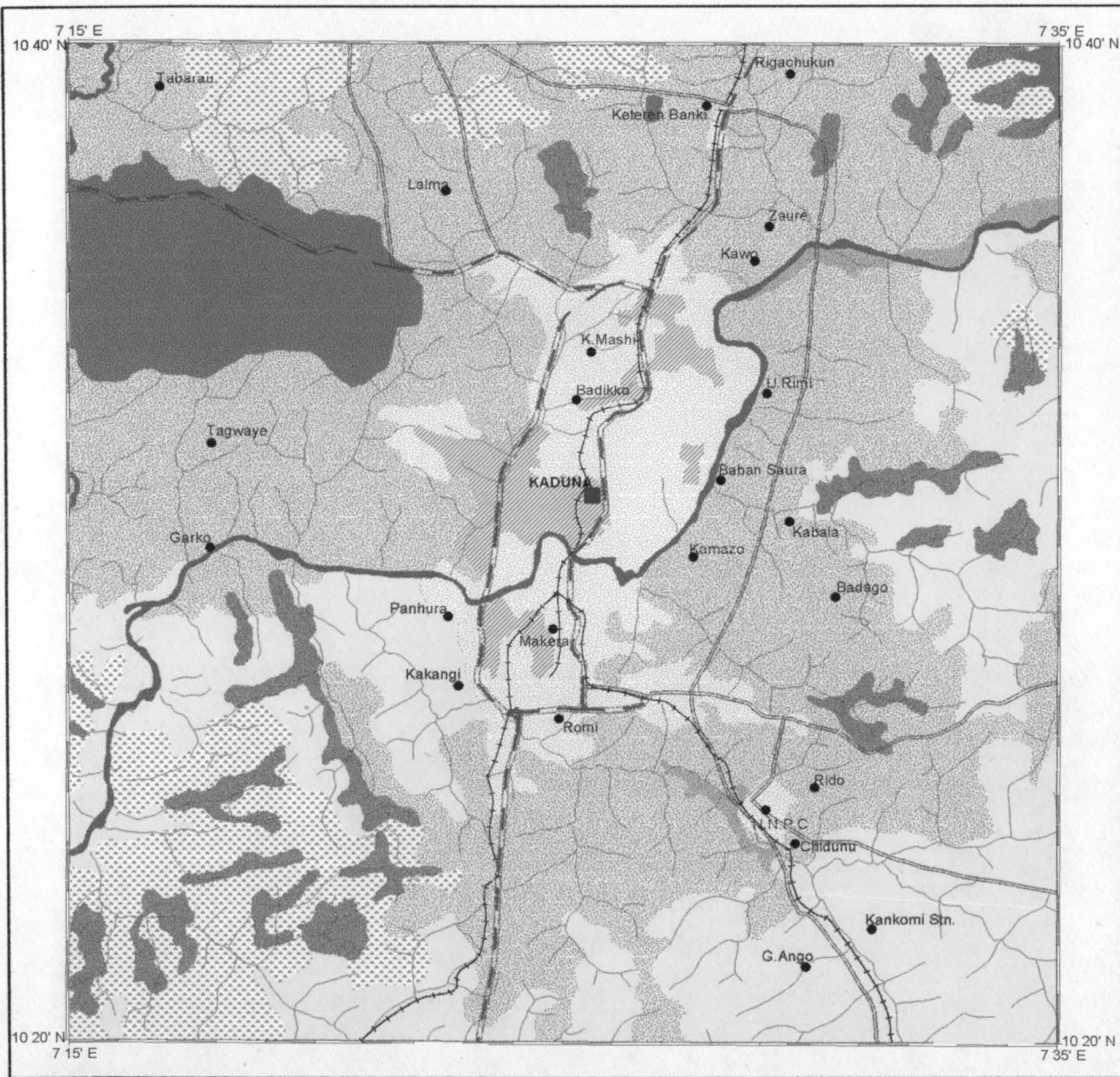
Continuous power failure made data processing difficult because of repetition of processes that had been completed.

SATELLITE IMAGE INTERPRETATION KADUNA AND ENVIRONS



- | | |
|--------------------------|---------------------------|
| 1a Gully erosion | 6a Forest plantation |
| 2c Trees/woodland/shrubs | 7e Minor urban |
| 3d Intensive agriculture | 8f Floodplain agriculture |
| 4e Extensive agriculture | 9b Reservoir |
| 5g Major urban | 10a Waterbody |



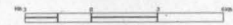


LAND USE MAP
KADUNA AND ITS ENVIRONS
 DERIVED FROM SPOT XS AND LANDSAT TM

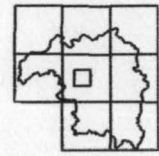
LEGEND

- Extensive Agriculture
 - Floodplain Agriculture
 - Forest Plantation
 - Gully Erosion
 - Intensive Agriculture
 - Major Urban
 - Minor Urban
 - Reservoir
 - Trees/Woodland/Shrubs
 - Waterbody
- OTHER MAP ELEMENTS**
- Town/Village
 - Major roads
 - Minor roads
 - Railway
 - Stream

Scale 1:250,000



MAP INDEX



Produced by CI IRISTOPI ICR GIDCON UGMAN
 PGD/GEO/99/2000/047

CHAPTER FIVE

5.0 SUMMARY

The final map (see fig.4.0) reveals all the classes and extent of land use in Kaduna and environs. Out of the total area of 672 sq km of the land use classes, Intensive agriculture takes the highest area cover of 597.24sq km. this goes to show that a lot of land clearing has taken place for agricultural purposes. This is as result of population explosion as one of the factors. Extensive agriculture covers 28.69 sq. km, Urbanization covers 15.22 sq km., tree/woodland/shrubs covers 13.42 sq km, gully erosion covers 6.78 sq km, forest plantation covers 8.08 sq km. water bodies and reservoirs covers 1.46 sq km and 0.22 sq km respectively.

5.1 CONCLUSION

Resource planners, policy makers and administrators are increasingly charged with the responsibility of providing answers to several problems to the onerous tasks of maximizing outputs from the limited resource base, while at the same time minimizing risk and any wastage of the resource base.

This requires the collection, analysis and dissemination of large amount of varying information in the form of attribute data and maps. The planner therefore requires a tool to manage the large amount of data, spatial and temporal necessary to deal effectively with various problems associated with decision-making; and GIS is it.

Therefore, the techniques (Remote Sensing and GIS) through its processes has shown the extend and how land is put to use by man. That in effect can spur resource planners to provide answers to the environmental problems like erosion, deforestation, continuous expansion of agricultural land etc. due to population explosion. The technique can also be used in revealing and finding answers to most environmental problems by undertaking studies in trends of land use over a period of time.

5.3 RECOMMENDATION

The increasing use of Remote Sensing and Geographic Information System is providing greater opportunities for analysis, manipulations and storage of data. Therefore resource planner, policy makers and administrators should greatly facilitate future work in this field by creating awareness through continuous training. This is only likely to be overcome when properly equipped and well-trained human resources are established all over government institutions with a central coordinating unit.

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