LAND USE CHANGE DETECTION ANALYSIS OF KADUNA SOUTH USING REMOTE SENSING APPROACH

BY

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CERTIFICATION PAGE

I certify that this work was carried out by ADEGBOLA MAKANJUOLA STEPHEN as part of the requirements for Masters of Technology (M.Tech) Degree in Remote Sensing Applications, School of Science and Science Education, Federal University of Technology, Minna.

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PROF. J. M. BABA ***DATE***

APPROVAL PAGE

This Thesis has been read and approved as meeting the requirements of the School of Science and Science Education (Geography Department)

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EXTERNAL EXAMINER ***DATE***

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HEAD OF DEPARTMENT ***DATE***

DEDICATION

This thesis is dedicated to the following people:

My Late father, MR S. A. ADEGBOLA

My sweet mother, MRS M. B. ADEGBOLA

My lovely Brother, MR. R. O. ADEGBOLA who is always there whenever I need him.

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ABSTRACT

This research on Land-Use Change Detection Analysis of Kaduna South, is a clear demonstration of the use of Remote Sensing Data to detect land use change over a specific period of time. These changes occur as a result of human activities on the land. The emphasis of this study is mainly on determining the trend of physical development in the area of study.

Black and White panchromatic aerial photographs of 1962 and 1972 of scales: 1:40,000 and 1:25,000 respectively acquired from the Geological survey Department, Kaduna, were used to detect the changes within the study area over a period of 10 years (1962 - 1972). The land use classification scheme used was the modified USGS land use classification scheme. The 1962 land use map was enlarged to the same scale with that of 1972 to make the change detection easier. However, this could introduce a degree of *error.*

Be that as it may, image interpretation elements such as size, association, pattern etc. were imployed in the manual interpretation and classification of the two aerial photographs. The classification and interpretation were done using mirror stereoscope at the Laboratory Department of Geological Survey, Kaduna.

However, the change dynamics for the two periods were calculated from the statistical data generated from the technicques for the 10 years period. A landuse change map was also produced on which eight categories of land were delineated.

From the study, the result revealed that of 675 hectares of total land, 332 hectares were recorded as having undergone some change representing about 49% of

the total area. A magnitude of about 95.6 hectares of land was recorded as a decrease in agricultural land. While shrubland category has increased by about 14.8%. Built-up area, transportation, wet land, open space have also increased by 11.69%, 13.80%, 7.30% and 3.80% respectively. All these trends have planning implications and these are critically discussed.

It is further specifically proposed that the Local Government should try to provide as much as possible, more recent and sophisticated data (Imagery) with high resolution to enable quick monitoring of environmental changes.

This research has clearly shown that Remote Sensing Techniques are cost effective and time saving for the purpose of monitoring the dynamics of Human activities in our environment.

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only some relict forms of the old order remains. Changing geographic settings also affect often severally, the fortunes of cities, countries and even larger parts of the earth.

Land is a basic resource of a city. Land is a complex system composed of many sub-systems or elements which include the topography, climate, soils, vegetation, plants and animals etc. The successful administration and control of the rights to occupy it and its use or misuse are basic to the well being of all its inhabitants. Land use is a primary indicator of the extent and degree to which man has made an impression on the landscapes. It reflects political, economical and social aspects of human cultures and provides an index of the intensity of human life styles. Since particular land uses generally have "unnatural expressions" in the landscapes (Esther and Senger, 1974).

A contemporary society as a modern business must have adequate information on several complex interrelated aspects of its activities in order to make sound decisions. Land use is only one such aspects, but knowledge about land use/land cover has become imperative as the nation plans to over-come the problems of haphazard, uncontrolled development, environmental deterioration loss of prime agricultural lands, distruction of important wet lands and loss of aquatic life and wild habitats. However, Campbell (1983) simply put land use as mans activities on land in relation to the land and he went further to say that landuse has been studied from many diverse viewpoints so that no one *single definition is really appropriate in all different contexts.*

The term landuse relates to the human activity associated with a specific piece of land. As an example, a tract of land on the fringe of an urban area may be used for a single family housing. Depending on the level of mapping details, its landuse could be described as urban use, residential use or a single family residential use. It is also possible to look at landuse in terms of the land capability point of view evaluating the land in relation to the various natural characteristics. Aldrich (1981), views land as a raw material of a site which is defined in terms of a number of natural characteristics, namely climate, geology, soil topography, hydrology and biology. Landuse is also viewed as the use of land by people usually with emphases upon the functional role of land in economic activities, while land cover often designates only the vegetation, either man made or natural, on the earth's surface. On a broader sense, land cover desginates the visible evidence of landuse to include both vegetative and non-vegetative features and is subject to direct observation (Campbell, 1987). Adefolalu (1985), conducted a study in Nigeria and his study reveals that human activities such as intensive agriculture account for over 80% of the total land in Kano State, which has led to desertification; that as as result these activities on the land, it only requires a long spell of drought to turn the entire arable land into shrubland of the sahel proper.

Landuse, unlike geology is seasonally dynamic, and most requirements are not only for mapping of the existing landuse but also for a system to monitor regualrly changes that had occured. These changes could be urban expansion and the loss of agricultural land, changes in River regimes, the effects of erosion and desertification and so on. However, the significance of a planned approach to changes in landuse has recently become widely recognised. This recognition is especially important for that sector of agricultural land which is influenced by urban development as this is where the most rapid changes are likely to occur. It is important to predict natural and uncontrolled changes to evaluate their importance and the possibility of avoiding the unnecessary and harmful changes. The most obvious and visible indicators of existing landuse patterns and their forthcoming changes are strongly connected with the physical and socio-economic features charactrised by the nature of the land.

Landuse change detection of both rural and urban areas is found to be very important as a means of discovering the development trends of a region. The mapping of landuse is closely related to the study of vegetation crops and soils or the biosphere. The process of landuse monitoring involves change detection. This refers to the activity of observing, recording or measuring changes between components of the resource base and analysing the significance of such changes.

Change detection refers to the general problem of monitoring a *system and discerning changes that are occuring within the system, thus providing information that is useful for formal planning by the environmental scientists. This could be addressed by intergrating Remote Sensing data with conventional data in a system that describes and reports these changes. Remote Sensing Applications provide a means of monitoring changes in the distribution of activities which in turn, are related to socio-economic changes.*

Remote Sensing is only an input to over all change detection sytem. Other data from surveys are necessary sources which relate to change, identifying those indicators that describe the change in a useful way, and to construct systems and monitor variables for useful data output.

1.2 ***PROBLEM STATEMENT***

Change is the only permanent process in life. Kaduna as a metropolitant town is growing at a rapid rate. As the former capital of Northern Region and Premier settlement in Northern Nigeria in terms of developments, Kaduna has been expanding and engulfing its suburbs. In fact, the area called Kaduna today cannot specifically be referred to as one settlement but an Urban Sprawl. The study area, Kaduna South, was not mostly in the original Kaduna settlement but came to be as a result of expansion of Kaduna metropolitant area. Changes have taken place in the lanscape in the area and there is the problem of landuse as Kaduna South is fastly feeling the impact of rapid expansion of Kaduna *metropolis with the location of most industries, especially the Refinery in the area. Does this rapid development have any impact on the landuse? Does it conform to the plans of the area? There is also the problem of determining the particular use the area is put into with the aim of advising future planning of the area. This study is to use Remote Sensing Approach to detect landuse changes in Kaduna South in order to determine the development trends of the region.*

1.3 <u>AIM AND OBJECTIVES</u>

This study aim to use Remote Sensing technique to analyse landuse changes with a view to fulfilling the following objectives:

1. *Determine the landuse changes that occurred in the area between 1962 and 1972.*
2. *Determine the spatial extent of each of the landuse changes over the ten year period.*
3. *Analyse the physical development trends in the area.*
4. *Make suggestions on future physical planning in the area.*

1.4 <u>JUSTIFICATION FOR THE USE OF REMOTE SENSING</u>

Remote sensing of the earth is the science and art of deriving information about the earth's land and water areas from images acquired at a distance. It relies upon measurements of electromagnetic energy reflected or emitted from the features of interest.

One of the most powerful modern techniques for land use change detection is Remote sensing. This is because it detects changes that

Nigeria, ready accessibility through transportation network and constant water supply, were important considerations in the decision to build the capital city at the point where the Lagos-Kano railway crosses the Kaduna River. (see fig. 1)

Although, Kaduna was originally built as an administrative capital, it was also to become an important industrial town and a major military training centre. These functions have combined to make for the rapid growth of the population of the city. The growing importance of Kaduna as industrial centre had attracted migrants particularly since the end of the civil war, thereby ensuring a steady increase in population. The River Kaduna is one of the most dominant physical feasture of the site of Kaduna which is built on a rolling Plateau of about 600 metre above sea level.

GEOLOGY

Kaduna district is underlain by decomposed granite rocks of the basement complex. Over most of the area, these rocks have weathered to form deep layers of fine textured soil, which become waterlogged when it rains and dryout and crack during the dry season. It is the alternation of wet and dry conditions that have given rise to the formation of lateritic crusts in most part of the districts.

VEGETATION

Much of the natural vegetation of Nigeria particularly the Kaduna area, has been altered or even obliterated by cultivation, grazing and fire *over along period of time. The vegetation cover of Kaduna is the mixed leguminous wooded savanna type. This is defined as a mixed formation of trees, shrubs and grasses. The grasses are at least 1.2 metre tall, perennial, forming a continous layer dominating a cover stratum, these are usually burnt annually. The leaves are usually flat and basal. Woody plant or trees are intermitently found at variable density, and dominantly decidous.*

<u>CLIMATE, RAINFALL AND WIND</u>

During the dry season, from November to March, the dust laden Harmattan wind, cold, dry and often very harsh and strong, blows from the North-East straight off the sahara regions. By the time the first rains arrive in April, the prevailing wind changes to South-West and continues up to October.

But the rainstorms that are usually characterised by violent thunder and lighting usually preceded by a driving wind, come from the North East.

In the wet season Kaduna has some 1,016mm to 1,524mm of rain which usually rises to a peak from late July and into September. Of course, there are usually variations from year to year and can occur both monthly and annual totals. This can be adduced to the high intensity of many storms and the narrow front with which they sweep across the country side. Generally, this storms are interspersed by clear skies although there can be consecutive days of dull and overcast especially *during August and September. However, it is rare for any rain to occur between November and February and more than a total of 25.4mm to fall from the month of October to March. This seasonal invariability regime of dry and wet seasons exerts a major and permanent influence on agriculture and man's habitation, the tradition of which it would be dangerous to ignor.*

TEMPERATURE

Kaduna temperature are highest in April and range between 35.28° census and the lowest are in January between 7.28° and 12.88°C. The mean range is greater than that found in temperate climates and the extremes of hot and cold in a single day places a strain upon the inhabitants aggravated by considerable changes in humidity which in the dry season may well be below 10 per cent in the afternoon and 30 per cent at dawn. Skin and lips do crack at this time and the fine dust blown by the harmattan irritates the nasal passage. Whereas in August, a relatively cooler month because of the rains, the humidity at mid-day can be over 70 per cent and at dawn 95 per cent.

1.6 ***EXPECTED FINDINGS AND IMPLICATIONS***

This is supposed to be the initial assumption as to what would be the outcome of the research. It is expected to reveal that there would be changes in the various categories of landuse either positively or negatively. More specifically, it is expected that the built-up area and transportation network would change positively, implying a lateral urban *expansion. It is also suspected that there will be a decrease in agricultural land implying a loss of agricultural land and hence a reduction in agricultural activity. Again, it is expected that there will be an increase in the wet land especially in the riverine area and a reduction or a decrease in the water body. This implies that either part of the river is filled with sand or debris thereby reducing the water body and increasing the wet land. Furthermore, it is expected that there will be an increase in the shrubland.*

1.7 ***<u>LIMITATION AND SCOPE OF THE STUDY</u>***

This research is limited by the inability of the researcher to obtain more recent aerial photographs which would have presented a tool for change detection between 1972 and now. This also made the collation of data difficult. With this lack of recent aerial photographs, it is apparently clear that systematic field work could not be performed due to 24 years lapse between the date of the last (1972) aerial photograph acquired and now. This study is limited by the ~~inavailability~~ nonavailability of aerial photographs of the same scale. Hence, the landuse map of 1962 had to be brought to the same as that of 1972 using the usual manual method of grid referencing, which is more prone to error.

The researher was also financially constrained and could not acquire a recent innovative data such as LANDSAT and the SPOT DATA that would have enabled a direct and systematic analysis of the topic in question.

LOCATION OF STUDY AREA

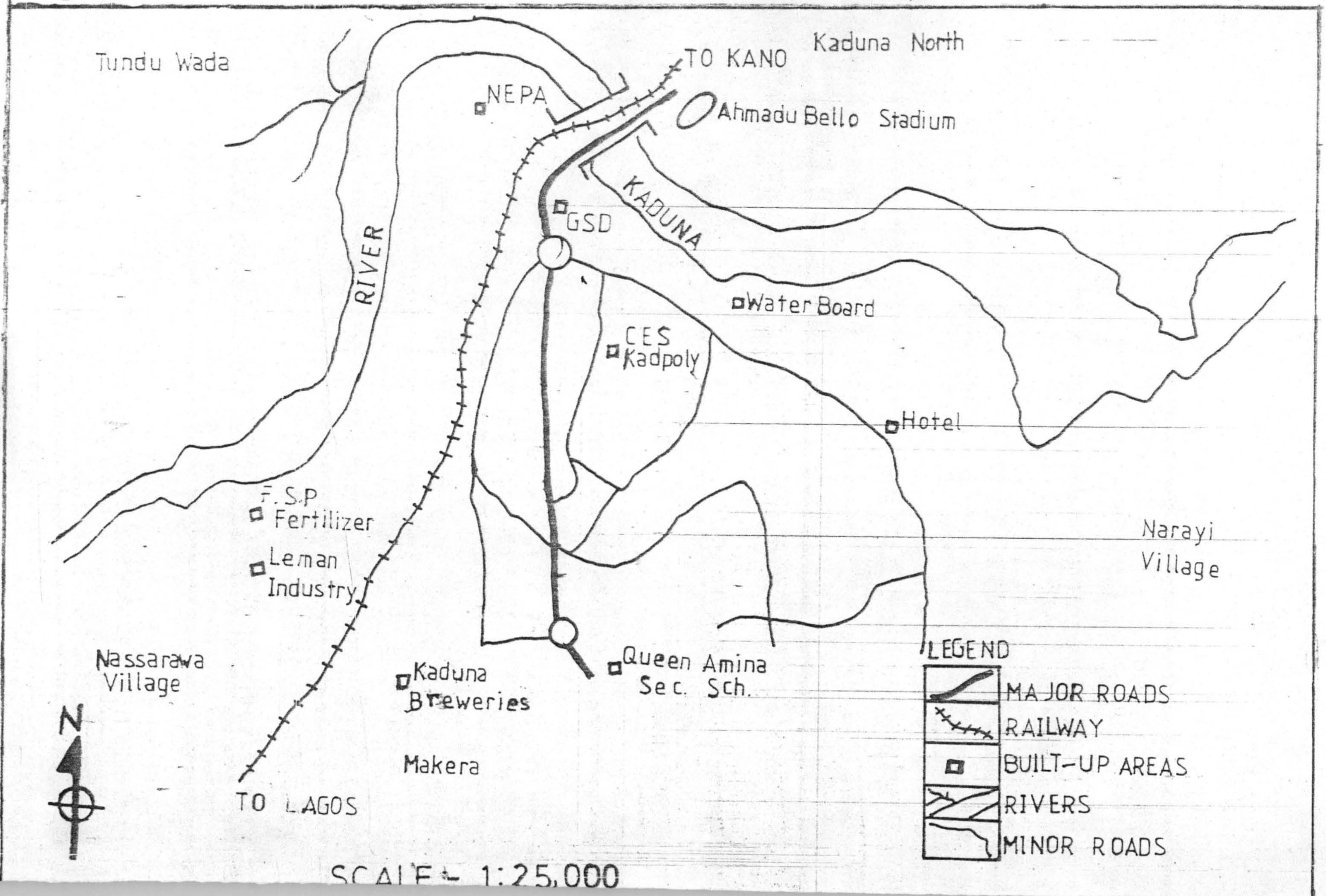
The study area lies south of River Kaduna, the Eastern part by Narayi Village while in the Western part it is bounded by the SSP Fertilizer Company and Leman Industry. Finally, to the South is the Kaduna Textiles and Queen Amina Secondary School (see Fig.2).

1.8 ORGANISATION

Chapter One provides an introduction to the research work. This is followed by Literature Review in Chapter Two. Chapter Three discusses the research materials and methodology, while Chapter Four is devoted to analyses and discussion of results.

Finally, Chapter Five presents recommendations and cnclusion.

Fig. 2 MAP OF THE STUDY AREA (KADUNA SOUTH).



CHAPTER TWO

LITERATURE REVIEW

Several studies have been conducted on Landuse/Landcover mapping and landuse change detection using different types of remote sensing data. The use of Remote Sensing Techniques has achieved or attained a high level of sophistication especially on the international scene which is yet to be attained at the local level.

Collins and El-Beik (1971), studied the urban landuse in the city of Leeds, UK using three sets of aerial photographs of scale 1:10,000. These photographs covered an extensive area with a dominant landuse of commercial, industrial or residential. Also, a key of urban landuse was compiled by carrying out a field survey of the landuse covered by these three aerial photographs. A building unit was used as the unit of interpretation for the built-up area, the function of which had to be inferred. The three photographs were then carefully examined under the stereoscope in order to become more familiar with the photo images of the various items in the key of urban landuse. They then delineated the landuse categories on a transparent overlay from the photographs.

Details were then transferred directly from the overlays to the *map. The photo interpreted urban landuse maps was checked against one compiled from field work. Their work revealed an accuracy of 88.5% achievement for the overall map with eight major categories of landuse. This research used the level II classification scheme. Had they gone down further to level III classification, this would have brought out details of their study.*

Henderson (1975), evaluted the usefulness of side-looking Airborne Radar (SLAR) for general landuse mapping at a scale of 1:250,000 covering part of midwest of United States. What he did was to first of all regionalize the area using physical and cultural features of the environment interpreted from a continuous film trip Radar imagery of scale 1:80,000 which facilitated the description of the area and to detect changes. The criterion used for the regionalization was that a landuse region should be one within which the physical and cultural charcteristics are similar. With this, he was able to detect five major and fourteen sub-components of a landuse region at level one class and two class respectively. The level one class composed:

1. *Surface configuration*
2. *Naturaal Vegetation*
3. *Field Pattern and Size*
4. *Settlement Pattern and*
5. *Transportation and Communication network.*

Each of these regions was delineated on a separate transparent overlay and finally composited to determine the boundaries of the level of the landuse region. His study revealed that much of his landuse region conformed with existing classification indicating that Radar imagery better than using traditional approach, and finally it should be possible to revise existing landuse map with Radar imagery. From this work, it is possible that the transparent overlay will not give actual areal extent of each landuse category due to double counting.

In another study conducted in Northeast China, Welch et al (1975), made use of LANDSAT 1 MSS data of scale 1:600,000 to produce a colour landuse map. They used a false colour composite of each scene of the study area at a scale of 1:500,000 projected onto a viewing screen. A transparent overlay of 5 x 5mm grids was then placed on top of the colour composite image for cell by cell interpretation of the landuse/landcover. An eight category landuse/landcover was employed as a result of the restrictions by low spatial resolution of LANDSAT data. These categories which were equivalent to level one of the United States Geological Survey (USGS) scheme were -

1. *Extensive field cropland*
2. *Intensive markets garden*
3. *New agricultural land*
4. *Steppe shrubland and grassland*
5. *Mixed decidous and evergreen forest*

6. Urban or built-up land

7. Bog and Marsh land, and

8. Rivers, stream and lake and playa.

it was then concluded that one could obtain some insight into the urbn structure of these cities. A mothodology that permits mapping areaas was developed where accurate up to date special data are unavilable or difficult to obtain.

Brown and Holz (1976) applied the thermal scanning imagery to study the landuse classification in Texas using the USGS classification system. The scanner was an An/AAS-18 line scan infrared detecting set in wavelength range of 8-14mm, using the thermal infrred imagery of a cale of 1:24,000 and a photographic map of the study area, with a scale of 1:25,840, the landuse categories on the thermal infrared was delineated.

Aeronuatic charts and USGS topographic maps of scales 1:24,000 respectively were also consulted. Ten landuse categories were delineaated. The study concludes that the interpretation of thermal infarred imagery require an understanding of the intensity of infrared energy emitted by an object according to its absolute temperature, thermal capacity, texture background and emissivity. From this study, it clearly means that the entraction of landuse information from thermal infarred imagery requires more inference or deduction than or compared to the use of aerial photographs. This is to say that aerial photographs *are better used for landuse information than are of thermal infarred imagery.*

Todd (1977), used LANDSAT data to conduct a study on Landuse change detection in Atlanta Georgia, United States, using band ratio. What he did was to accurately register images from two different dates. This study involves the use of ground control points and the solution of a series of linear equation. A colour composite was then produced by combining the data from the two ratios to facilitate visual detection of changes. Only band 5 data of the two dates was employed and from this a change map was produced. The study revealed that 91.4% of the category of landuse/landcover change were correctly identified as change.

Poulton C E et al (1977), made a comparative analysis of 1944 and 1968 aerial photogrphs to detect change and assess causes of change as they relate to land management in a range and forest land environment in Sieria Nevada, Califonia. Ground data were not available to verify conditions in 1944 photographs, so only that of 1968 was used.

Some changes detected were the moist meadow site, and separian vegetation had disappeared from 1968 photographs while encroachment of sage bush shrub had occured. This study was restricted to only two classification schems instead of extending to other classificaation system of USGS. That is to say that they had narrowed *down their research to just two classification schemes.*

Henderson (1979), also tried to use Radar imagery to map a more developed and urbanised northeast United States. In this study, the radar imagery used was the westing house K-band imagery at scale 1:225,000. He used the levels I and II landuse categories of USGS system to delineate the study. A transparent grid of one kilometre cells overlay was then placed on top of the image and the lanuse of each cell was interpreted with the aid of Bausch and lomb 2407 stereoscope. Based on this interpretation, the landuse regions for the study area were delineated, though the interpretation was found more difficult and complete because of longer history of development of the study area. his findings include -

1. *Level 1 category of USGS system was delineated but the analysis of level II was difficult.*
2. *When his result was compared with the existing landuse region classification of the same area, the agreement was poor, indicating that the more fragmented and complex landscapes of the Northeast united States contributed highly to environmental modulation. This reduced the level of landuse detail visible in the study area compared to that of the midwest united States. Finally, the forest stands found everywhere in the area concealed drainage relief, transportation and settlement features. In this study, he did not try to delineate the landuse region in the area in*

order to determine the areal extent of the various landuse categories, this has to be adequately addressed.

Byrne et al (1980), used the transformation enhancement of multitemporal data to study landuse change detection of Atlanta united States. What they did was to superimpose two LANDSAT data of different dates and treat them as a single-eight-dimension data array. A principal component analysis was carried out. By this method, a new set of co-ordinate axes were fitted to the imagery, choosing as the first new axis or components as an orientation which would minimize the variance accounted for by that axis. Subsequent ones would account for successive smaller portions of the remaining variance. In this study, the principal component analysis decomposed the four plus four channels of correlated MSS data into eight orthogonal axes. The first and second order component images resulted which were believed to represent unchange landcover while the third and later component axes exhibit changes. Changes to be anticipated were of two types (1) those that would extend over a substantial part of the scene such as changes in atmosphere transmission and soil water states and (2) those that were restricted to parts of the scene such as clearing forests, construction of roads and erection of buildings. Their conclusion or findings were rather too complex to be understood due to the computer application used. They should have simplify their results for the ordinary man to understand.

Synder (1981), used LANDSAT MSS imagery and other collateral materials to study landuse in parts of Union of Soviet Socialist Republic (USSR). Black and White positive prints of LANDSAT imagers at scale 1:500,000 was used. He adopted the landscape approach in this study. In order to device a landscape scheme, a study area of 41 scenes located in USSR giving a combined surface area of about 1:4 million square kilomettre. From this study area, a landscape classification scheme consisting of 30 categories and sub-categories of landuse and landcover associations was deviced. The landscape approach delineated regions of uniform landscape element. From the study, it was found that much of the USSR was dominated by a single element such as woodland or cropland that is in the uniform landscape category. From this classification scheme, a landuse map at 1:1,200,00 scale was produced. This study has a very large areal extent and this made it very difficult for proper co-ordination and registring of the landuse/landcover of the area.

LO (1981), mapped the landuse/landcover of Hong Kong using LANDSAT digital data computer assisted approach. What he did was to first examine the LANDSAT MSS imagery of the study area separately for each band analogue form. The study area was delineated on band 5 of the image with reference to the scanline number. The LANDSAT computer compatible Tape (CCT) digital data acquired from EROS Data centre in united States are radiometrically corrected. The delimited study area was extracted from the original data tape and stored in a disc file.

To check that the study area is properly delimited, a programme called NMAP is run to show the overall pattern of the data at the desired number of bands. This providess the basis for the training data selected for a supervised classification. Landuse classification scheme of Hong Kong is determined with reference to existing landuse map and aerial photograph. From the study, eight landuse and landcover classes were found appropriate and these are -

1. *Residential*
2. *Residential - commercial mixed*
3. *Reclaimed land*
4. *Cropland*
5. *Woodland*
6. *Grassland and Shrub*
7. *margrove, and*
8. *Water Features*

After this classification, a STAT program computes the mean and standard deviations of the pixels values for each band in each training date set or landuse. Finally D CLASS programme was run to classify the image of the study area, with this a line printer map of the classification is produced by the computer.

This was then transferred to the base map by direct tracing. The study concludes that digital approach of landuse and landcover mapping using LANDSAT can surely produce reasonably accurate results. This *occured during the period. In their study, they did not indicate if they used the USGS classification scheme or the modified scheme, and they did not compare their result if it agreed with existing landuse of the region.*

On the local level, Remote sensing has been used to study landuse changes by different Nigerian researchers. Adeniyi (1980), applied a modern approach to landuse change detection and it involves the use of computer. Two sets of aerial photographs of 1962 and 1974 with a scale of 1;40,000 and 1:20,000 respectively covering urban builtup areas, urban vacant plant and non urban in Lagos were used. A landuse classification scheme of nine major landuse/landcover categories were residential, commercial, industrial, institutional and utilities, recreational and open space, vacant land, non-urban land and water. A minimum mapping unit of one hectre was used as a basis for interpretation and for subsequent storage into computer. On each model the built-up areas were identified and delineated first and followed by vacant and non-urban landuses. The interpreation was done using mirror stereoscope. The interpretation and field check data were transferred into a base with the aid of a 300m transfer scope. A clear acefate sheet with 100m x 100m width was placed on this map and the data manually encoded and key punched into a digit before they were transferred to a computer tape for processing. Special computer programm was written to a (a) compare each major landuse categories for the two periods on a cell by *cell basis (b) provide information about the locations, types and amount of changes (c) produce a landuse and change map with the drawn plotter. A data bank was finally created in which the landuse data could be easily updated and intergrated with other types of data. His findings include:*

1. *the landuse change revealed a rapid increase of the residential landuse and a strong lateral expansion of the urban area of Lagos; and*
2. *that the computer pproach was adjudged to be more flexible and desirable for landuse change detection.*

In this study, the he did not indicate how he reconciled the scale difference between the two aerial photos acquired in 1962 and 1974.

Adefolalu (1986) in his study used a combination of SLAR and LANDSAT data with ground truth observations to study both West Africa and Nigeria landuse (vegetation) situation. His study revealed five major vegetal covers - woodland, grassland, shrubland, farmland and forests. He agues that two states in the Sahel Savannah (Borno and Sokoto States) as of 1986 were experiencing harsh effects of desertification of arable land which had been reduced to 19.29% and 41.89% respectively, while grasslands/shrubs were 59.97% and 38.36% respectively. He argued further that human activities made situations in Kano and Kaduna States equally pathetic. Both States had between 68% and 82% respectively of the total land under intensive *agriculture. He concludes that arable land in the two states would be turned into shrub land vegetation and the sahel proper at the early part of 1991 - 2000.*

Ademola O and Soneye A S (1993), used Remote sensing and geographic information system (GIS) techniques to map the landuse and landcover in the middle Sokoto River, North Western Nigeria. A LANDSAT MSS imagery acquired in 1986 with a scale of 1:125,000 was used. Other collateral materials like the topographic map of the study area was also consulted. The LANDSAT MSS positive image transparency was interpreted using the PRO-COM2 optional Image transparency analysis equipment. 13 landuse/landcover classification category was delineated, of these the study reveals that the grass shrub land occupied about 37.70% or 13,230.6 hectares of land which was the highest or largest, while the forest wetland accounted for about 0.01% or 2.7 hectares of land which was the lowest. The study concludes that the visual interpretation of the enhanced LANDSAT MSS data can provide adequate spectral information required for the mapping of landuse and landcover, while the AIS sub system can provide easy analysis and presentation of the maps generated through Remote Sensing Techniques.

Okhimamhe (1993), studied landuse and landcover changes in Burunburun/Tiga area in Kano State. A combination of aerial photographs of 1974 and SPOT HRV1 of 1986 were used to detect the *changes. Image element was employed in the manual interpretation and classification of the aerial photos. This was transferred into a base map created from topographic map sheets used to classify the SPOT Image. The changes for the period between 1974-1986 were calculated from the statistics generated from techniques. An attempt was made to produce a synthesised landuse change map over the 12 year period. The changes were graphically represented to show distribution and changes in the stipulated landuse classes. The study reveals that 38.587 hectares of change had taken place. Crop/pasture and wooded shrubland/thicket had decreased in large magnitude while grassland/shrubland has increased by 104%. There was also a 12% increase in sandy areas.*

CHAPTER THREE

3.0 <u>*RESEARCH MATERIALS AND METHODOLOGY*</u>

3.1 *MATERIALS*

Aerial photographs of the study area dated 1962 and 1972 and of scale *1:40,000 and 1:25,000 respectively, acquired from Geological Survey Department, Kaduna, formed the main source of the data used. In additin, topographic maps reproduced in 1967 of scale 1:50,000 and with identification sheet number 18, Kaduna South, obtained from Federal Surveys Department, Kaduna, were also consulted. Mirror Stereoscope and a transparent film was used to delineate the aerial photographs at the Geological Survey Department Laboratory, Kaduna.*

3.2 <u>*IMAGE INTERPRETATION PRINCIPLES*</u>

The principles of Image Interpretation simply consist of four basic premises:

(1) *A Remote Sensor Image is a pictorial representation of the landscapes.*

(2) *The Image is composed of patterns, indicators of things and events which reflects the physical, sociological and cultural components of the landscapes.*

(3) *Similar patterns in similar environments reflects similar conditions and unlike patterns reflects unlike conditions.*

4. *The type and amount of information obtained from image is proportional to the knowledge, experience, skill and motivation of the analyst, interpreter, the efficiency of the method used, and an awareness of the limitations imposed on the analysis by the Remote Sensor System, data format and analytical method.*

3.3 **PRINCIPLES OF AERIAL PHOTOGRAPHY**

The most commonly implored sensor for aerial photography is the conventional photographic camera designed to detect energy in the visible 0.4 - 07 μm and near infrared (0.7-0.9μm) portions of the electromagnetic spectrum. This is made possible by the use of suitable black and white or colour films sensitized to these spectral regions. In order to enhance the contrast between the object and the background of interest in the resultant photograph a minus blue filter (i.e. yellow) is normally employed at the time of photograph to eliminate the rayleigh scatter in the atmosphere.

An important component of the photographic camera is the lens system which should be relatively free of lens apparation or distortion to avoid causing the images of points to be displaced on the photograph.

Photographs are taken onboard aircraft which serve as the platform, with a metrically accurate camera for photogrametric purposes. This usually involves vertical aerial photographs terrains with 60% forward overlap between successive frames of photographs along the flight strips and 15% to 20% lateral side lap between two adjacent flight strips. These flight configuration permits aerial photographs to be viewed telescopically to give an impression of three dimensions, thus facilitating the interpretation of the terrain feature.

Electromagneic energy is reflected from tthe terrain to pass through the lens and its regarded as a bondle of light rays travel in straight line points.

The normal scale of the vertical photograph is given as:

$$S \; \frac{F}{H}$$

Where F = Focal lenght of Camera
H = Flying height for assumed flat terrain

Where relief of the terrain is taken into account the scale at point 'A' is given as:

$$S = \frac{H}{H\text{-}ha}$$

ha = height at point 'A' from the datum.

On the whole, the average scale (Sav) should take into account the average terrain so that is:

$$Sav = \frac{F}{H=hav}$$

hav = Average terrain height.

The standard film type for aerial photograph is the panchromatic Black/White film which is sensitivity ranging from 0.35 - 0.7um. A minus blue (yellow) filter is normally used to absorb the atmospheric haze found in the blue portion of the spectrum.

Another film type is the infrared Black/White film which has spectral sensitivity range from about 0.7 - 0.9um leaf mesophyl of vegetation is highly reflective and water bodies are highly absorbtive of infrared radiation. These functions coupled with its ability to absorb haze make infrared black and white film ideal for rural landuse and land cover map.

The focal lens used for 1962 aerial photographs was 6mm and the height was 6,000 metre above sea level, while the focal lens used to acquire the 1972 aerial photographs was 152.07mm and the height is 4,500 metre above sea level. Of course, the normal photographic camera, black and white panchromatic film was used.

3.4 __ELEMENTS OF INTERPRETATION__

There are some important diagnostic characteristics used in analysing and interpreting Remote Sensing Imagery. They help analyst to recognise, differentiate and quantify objects on the imagery. These characteristics include:

*A. **Size:-** The size of an object is very critical in its identification. The lenght and breadth, area and volume of an object could also be used to differentiate items in the same class.*

B. **Texture:-** *The visual impression of roughness or smoothness also helps identify objects. Texture is created by tonal representation in groups, objects often too small to be discerned as individual objects..*

C. **Pattern:-** *This is the representative arrangement of objects. It can also relate to spatial arrangements of a group of objects.*

D. **Site:-** *The location of an object with respects to the other features. This is useful in manipulating and identifying an object.*

E. **Association:-** *Certain objects or features are commonly associated with others so that one tends to indicate or confirm the presence of the others.*

F. **Shape:-** *This refers to the general form or configuration or outline of individual objects.*

3.5 METHODOLOGY

The system used for the classification of the landuse in this study was the modified level 1 Anderson et al (1976) USGS classification scheme. And with this in mind, 8 - classification scheme was designed comprising:

1. *Urban or built up land or area:- These are area of intensive use with much of the area covered by structures such as cities, towns, villages, streets development along highways, power communication facilities, shopping centres, industrial and commercial complexes, institutional and so on. This category takes precedence over the other criteria if more than one category are met.*

2. *Transportation:- This category include all transportation network the major roads, minor roads, footpath and the railways.*

3. *Agricultural Land:-* *This is landuse is primarily for production of food and fibres e.g. cropland and pasture orchards, vine yard, nuseries etc.*

4. *Shrub Land:-* *This is land where the potential natural vegetation is predominantly grassland such as shrubs where natural grazing was an important influence in the pre-civilization states.*

5. *Forest Land:-* *These are areas that have tree crown area density stock with trees capable of producing timber or other wood products.*

6. *Water:-* *It includes rivers, streams, lakes, canals, reservior etc.*

7. *Wet Land:-* *These designates those areas where the water table is at near or above land surface for a significant part of the year.*

8. *Open Space:-* *This includes areas that are left vacant either awaiting development or are already developed for other open space activities like relaxation centre etc.*

After the classification scheme has been so designed, the base map for change detection was prepared from the topographical map sheets of cultural and natural features onto a clear transparent film at a scale of 1:50,000.

3.6 *MANUAL INTERPRETATION OF 1962 AND 1972 PHOTOGRAPHS*

There are basically two major approaches to image interpretation, the manual approach and the computer assisted approach. The latter approach of image interpretation is basically a classification process which involves a number of steps to be followed. This approach is adjudged by various users to be the best of the approaches because the advantage far outweighed that of the manual. It is fast, it can deal with large volume of data image and it gives the best result to *ones data output. This approach is however, quite expensive and cannot easily be reached.*

The manual approach used in this study as compared to the computer assisted approach is quite cheap and is easily accessible. This was the main reason why the author decided to use the manual approach.

The 1962 aerial photograph which is at the scale of 1:40,000 was enlarged twice to bring the scale to 1:20,000. Similarly, the 1972 aerial photograph with a scale of 1:25,000 was also enlarged to a scale of 1:20,000. By this enlargement, the two aerial photographs were brought to the same scale of 1:20,000. The transfer was done using graph paper which could have introduced a degree of error.

Next, the manual interpretation was done by placing the aerial photographs on a light table and a transparent film was placed on top of the photograph, and a mirror stereoscope was used to delineate the various landuse types or classes at Geological Survey Department, Kaduna.

The same manual system of interpretation was done for 1972 aerial photograph to delineate the landuse classes or types. The minimum mapping unit for delineate area was specified as 2mm^2 on the final map. In situations where a complex pattern of extremely small units were encountered, generalization was done and the predominant category present within each parcel is labelled. The minimum mapping unit was based primarily on what could be satisfactorily interpreted and delineated on the aerial photographs. However, each of these landuse was identified by a single digital symbols indicating the level one *category interpreted from the aerial photographs.*

The landuse classes used for the manual classification are given in Table 1 below:

Table 1

S/NO.	*USGS CLASSIFICATION SCHEME*	*MODIFIED MANUAL CLASSIFICATION SCHEME*
1	*Urban or Built-up Land*	*Built-up Area*
2.	*Agricultural Land*	*Agricultural Land*
3.	*Range Land*	*Shrub Land*
4.	*Forest Land*	*Forest Land*
5.	*Water*	*Water*
6.	*Wet Land*	*Wet Land*
7.	*Barren Land*	*Open Space*
8.	-	*Transportation*

After this each of the landuse classes was calculated by the grid square system in the graph paper to establish the aerial extent of each class. Magnitude of change and the percentage change of each landuse type. After this, it was followed by the superimposition of 1972 landuse map on 1962 landuse map to detect the changes that had occured.

CHAPTER FOUR

4.0 PRESENTATION AND DISCUSSION OF RESULTS

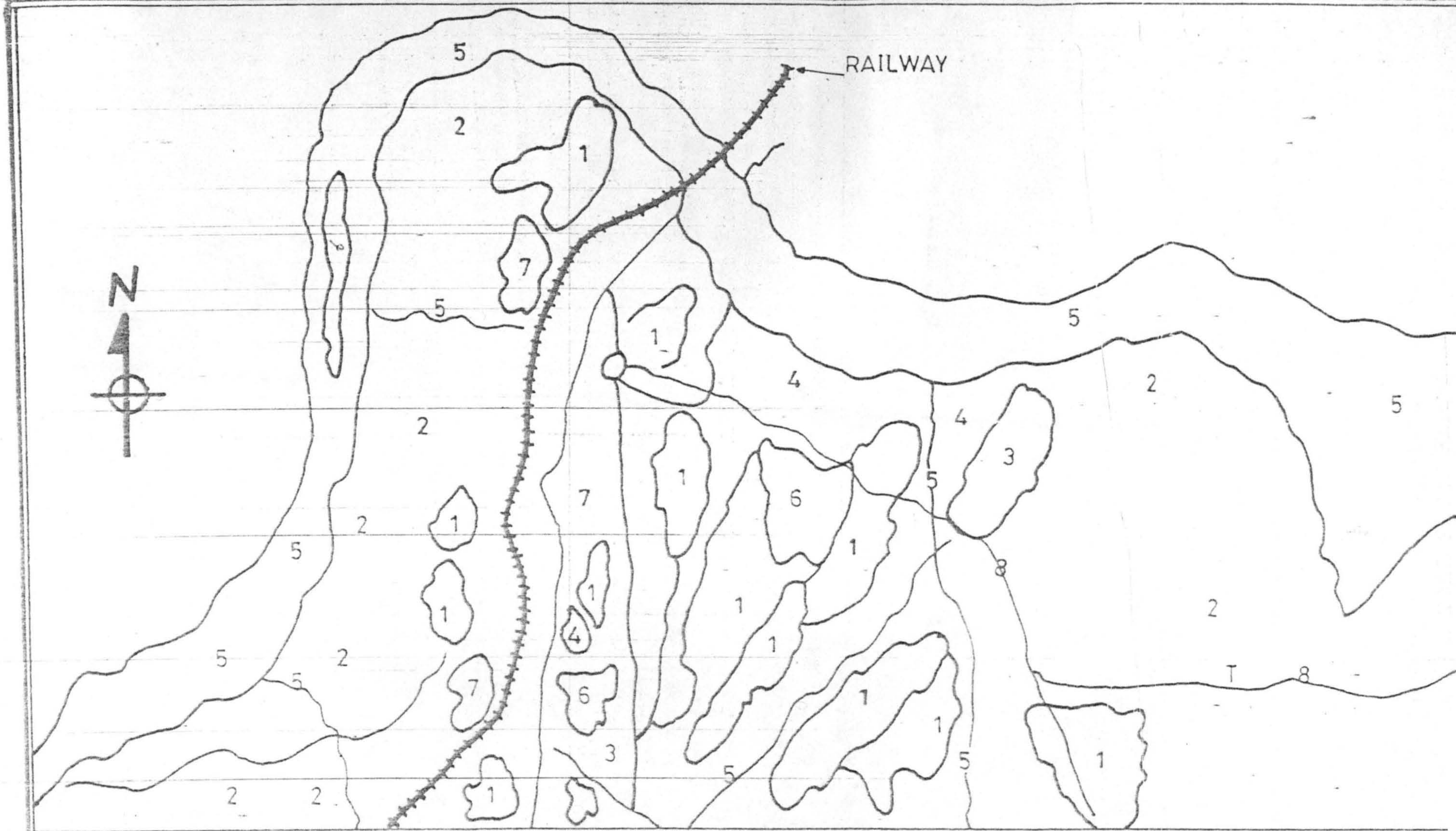
4.1 INTERPRETATION OF 1962 AERIAL PHOTOS

The landuse of Kaduna South interpreted from the aerial photograph of 1962 is shown in figure 3. The interpretation was based entirely on personal interpretation aability since field checking could not be carried out to verify the accuracy of the interpretation due to the time interval between the date of interpretation and the time the photograph was taken. on the whole, the result of the interpretation was no too far from the general landuse classification. This means that it was adjudged to agree wih the general landuse/landcover classification of the united States Geological Survey (USGS) classification scheme.

The aerial photographs showed that 300 hectres (Ha) of the 675 Ha of land under study was made up of agricultural land, which represent about 35.04%. This is mostly found at the extreme Western and Eastern parts of the study area. Water covered the Northern boundary and its tributaries at the central part of the study area. The transportation network which include the railways occupied 24.2Ha or 3.6% of the area mostly located within the Central part of the study area.

Built-up area occupied about 140.2Ha or 20.77% of the total land area which is equally found at the central parts of the area especially where the transportation class was located. Wetland, which occupied 35Ha or 5.19% of the

Fig: 3 KADUNA SOUTH LAND-USE CLASSIFICATION USING AERIAL PHOTOS OF 1962



SCALE 1: 20,000

LEGEND

1. .... Built-up Area
2. .... Agricultural Land
3. .... Shrub Land
5. .... Water
6. .... Wetland
7. .... Open Space

total land is mostly found in River Kaduna and also in the interior part of the land under study. Open space category covers about 15Ha or 2.22% of the total land, this category include parts of the railway station in the study area. 36Ha or 5.33% of the study area is occupied by the forest land category mostly found just south of River kaduna shrub land category occupied about 33Ha or 4.89% of the total land area where the predominant vegetation found is grass.

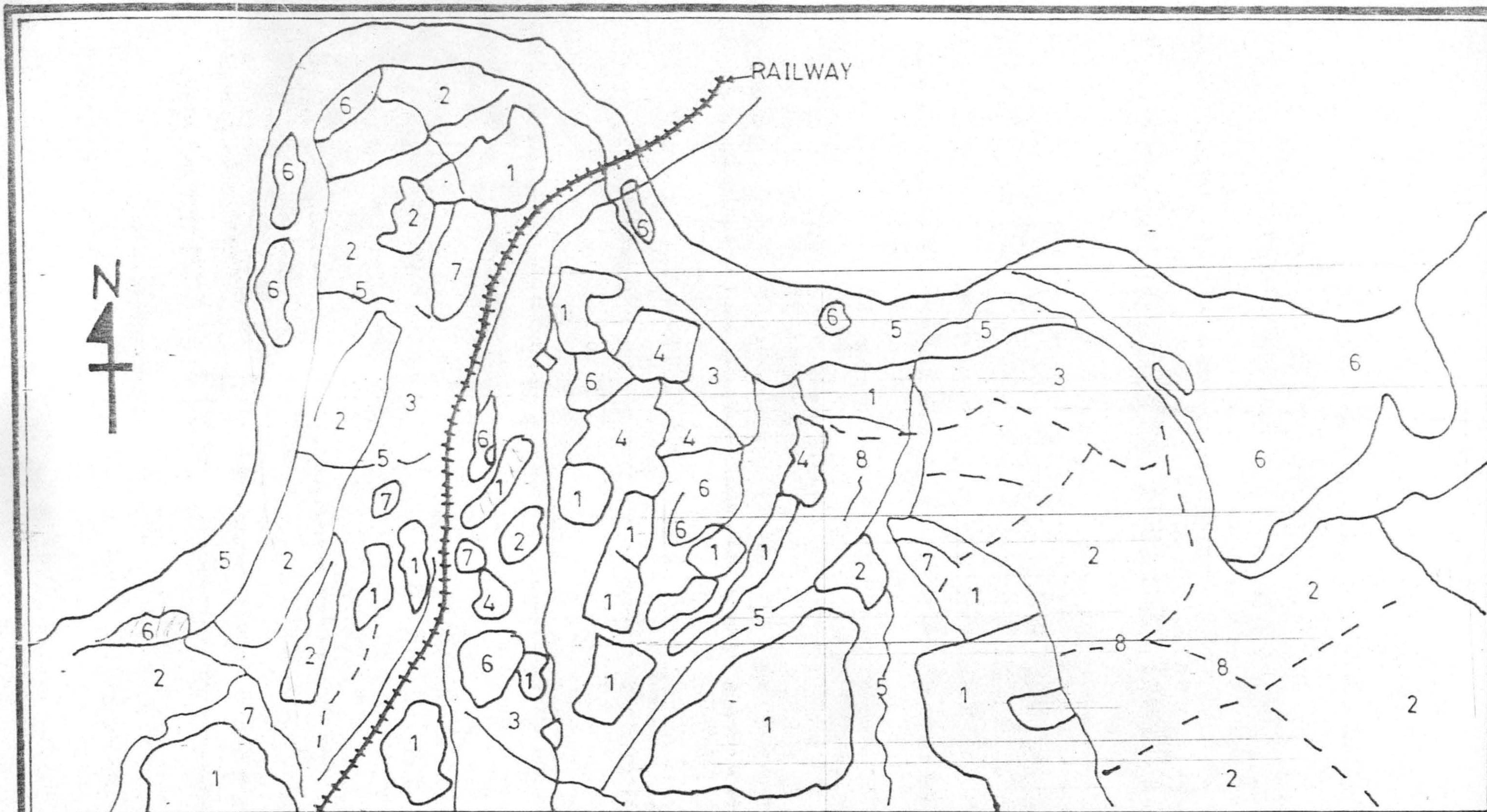
4.2 INTERPRETATION OF 1972 AERIAL PHOTOGRAPH

The landuse of the study area which was manually interpreted from the 1972 aerial photographs is shown in figure 4.

In this landuse classification, the built-up area occupied the highest portion of the land covering about 179Ha or 26.5% of the total land area under investigation. Agricultural land ctegory which occupied over 21% or 144.4Ha of the study area is the second largest category. The next category is the waterbody which occupied about 84.2H or 13% of the total land area.

80Ha of the land under study is occupied by the shrub land ctegory representing 11.90%. This can clearly be seen close to the forest land and the agricultural land categories. Transportation category covering about 67Ha or 10% of the total land area is clearly visible around the built-up areas. Forest land category covered about 33 Ha or 5% of the total land under investigation. 59Ha or 8.7% of the total land is covered by the wetland this are clearly seen inside River kaduna itself. The last which also covers the least land area is open space category which occupied about 27Ha representing about 4% of the total area.

Fig: 4 KADUNA SOUTH LAND-USE CLASSIFICATION USING AERIAL PHOTOS OF 1972



SCALE 1:20,000

LEGEND

1............Built up Area
2............Agricultural Land
3............Shrub Land
5............Water
6............Wetland
7............Open Space

From these interpretation, it is apparent that the landuse changes that occured in 1962 quite differs from that of 1972. The changes were either positive or negative (see table 2 for Hectres and percentages used).

4.3 LANDUSE CHANGES BETWEEN 1962 AND 1972

The landuse changes for the period between 1962 and 1972 is shown in figure 5. From the analysis, it was revealed that three clsses of landuse recorded a decrease while the remaining five classes recorded increases.

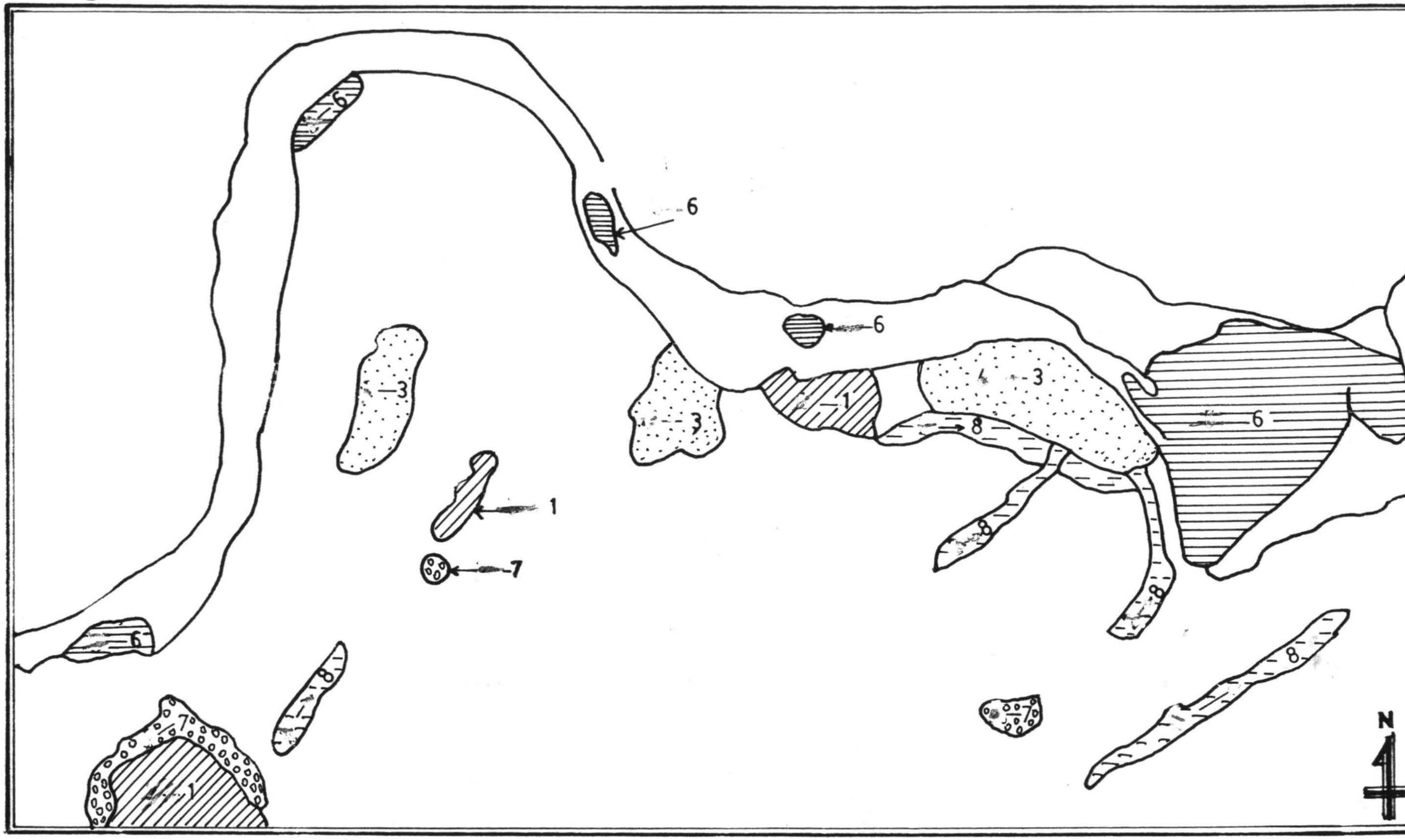
The agricultural land category dcreased by 95Ha or 28.80% of the total land area which recorded the highest change and also the highest decrease between 1962 and 1972. Also, within this periods, the water category recorded a change of about 67.4Ha which represents about 20.30%. The change here was a negative one too meaning a decrease in waterbody.

The forest land category which recorded the least change of 3.00Ha representing 0.90% of the total land area was also a negative one. That is, there was very little decrease in the forestland category.

The transportation network category recorded the highest increase of about 43.4Ha or 13.00% of the total land area. This revealed that there was a rapid deveopment on transportation network in the study area. The built-up area also recorded second highest increase of about 38.8Ha or 11.69% of the land area. This has also shown that there has been a lateral expansion in the built-up area engulfing part of the agricultural land category.

Also, wetland category has increased by about 24.2Ha or 7.30% of the

Fig. 5: KADUNA SOUTH LAND-USE CHANGE MAP



SCALE:- 1 : 20,000

LEGEND

1 Built up Area	4 Forest Land	7 Open Space
2 Agricultural Land	5 Water Body	8 Transportation
3 Shrub Land	6 Wet Land	

total land area signifying a reduction in the waterbody category because most of the wetland are found in the major waterbody in northern end of the study area. open space too has recorded an increase because as the area is expanding it tends to create relaxation centre to meet the growing population. 47Ha or 14.16% of the land was recorded for the shrubland category. Although the aerial photographs were taken at the peak of dry season, so much of the interprettion was based on generalization.

Table 2 shows the areal extent of landuse categories and the magnitude of change in hectres. In the change map, the built-up area, agricultural land and the transportation categories are seen to cover most part of the study area, although figure 3 shows the different categories clearly. Though the water category is mostly seen at the northern most part of the study area which is the River Kaduna itself, while some of the tributaries drained into River kaduna. Forest land category is equally seen at the central part of the southern boundary of kaduna River, while the shrubland category are seen scattered around the study area. The wetland category is not left out as the major change recorded is seen at the eastward portion of Kaduna River and the central portion of the study area. Table 3 shows the percentage distribution of the landuse categories.

The proportion of change within each class to the overall change is shown in Table 4. This reveals clearly that agricultural land recorded the highest change of about 28.80%, while the least change recorded was the forest land category with about 0.93%, both changes are negative change.

The overall total change recorded is 332Ha or 49% of the entire study area. The most prominent change recorded was the transportation network category with about 178.05%. This can be attributed to the fact that since the built-up area has incresed the tendency for the transportation network to increase is high in order to cope with the growing population of the area.
Another appreciable increaase recorded occured in the shrubland category with about 143.35%, this could also be linked to the season (peak of the dry season) the aerial photograph was taken. Meanwhile, an increase is also recorded for an open space category with about 83.33%, this could also be attributed to the fast development of the area, so there is need for more parking space and relaxation centres.

One of the major objectives of this study is to determine the physical development trends of the study area, from the analysis conducted it has clearly indicated that there was an increase in development in terms of its physical structures especially in the build-up areas and the transportation network.

Following these findings and considering the urban sprawl of the region, the master plan for the administrative capital of northern Nigeria did not envisage the rapid growth in the area. The growth rate was higher than what they envisaged. Be that as it may, the physical development has grown tremendously between 1962/1972 and now, and following this growth rate the government of Kaduna State through the assistance of the Federal Government have initiated relevant policies and trends in terms of socio-economic development of the region in particular and Kaduna in general. Such policies that were carried out through *the effort of the Petroleum Trust Fund (PTF) were likely to be, the provision of reasonable infrastructures and basic social amenities to meet the growing needs of the population of the study area. This policies include the provision of potable water through the national water rehabilitation projects, roads constructions and the practicing of mechanised system of farming in the study area. however, population is not only on inhibiting factor in socio-economic development but also a potential obstacle to the achievements of the set goals and target in development plans.*

4.4 *ACTIONS AND IMPLICATIONS*

From the discussions in this study, one can readily see that there has been reduction in agricultural land. The implication is that there would be a reduction in agricultural activities because most of the farm land has been overtaken by other users like the built-up areas. From other studies conducted in the area like the rural-urban migration, some of the farmers has probably moved to other sector of the economy and also there is the likelyhood that some farmers has moved to a more remote area to practice there farming. However, the present situation on the ground now has change because virtually all the agricultural land has been taken over by other categories of land use.

Another implication of this finding is in the reduction of the waterbody. The implication of this is grave because there is a reduction in the rate of albedo in the River. This is probably linked with the fact that the rate of reflection in the water body is not commensurate with the rate at which the river replenishes
More so the rate
itself of anthropogenic faactor through construction activities, dumping of refuse

and debris in the River, all this put together has reduced the level of water in the area between 1962 aand 1972.

The increase in the wetland category found in the eastern portion of River Kaduna is a good implication becaause this could give way for more intensive system of agricultural practices in the area. However, the government of the area could encourage the farmers by given them incentives to grow crops such as vegetables, tomatoes etc, which can be done as an all season farming.

Table 2: AREAL DISTRIBUTION OF LANDUSE CATEGORIES, MAGNITUDE OF CHANGE, OVERALL PERCENTA(

LANDUSE CATEGORY	1962 AREA IN HA(A)	1972 AREA IN HA(A)	MAGNITUDE OF CHANGE IN HA (B-A = C)	PERCEN
BUILT-UP AREA	140.2	179	38.8	116
AGRICULTURAL LAND	240	144.4	-95.6	-28.
SHRUBLAND	33	80	47	14.
FORESTLAND	36	33	-3	-0.
WATER	151.6	84.2	-67.4	-20.
WETLAND	35	59.2	24.2	7.
OPEN SPACE	15	27.6	12.6	3.
TRANSPORTATION	24.2	67.6	43.4	13.
TOTAL	675	675	332	

DATA SOURCE: AERIAL PHOTOGRAPHS OF 1962 AND 1972, KAKURI-KADUNA

Table 3: PERCENTAGE DISTRIBUTION OF LANDUSE CATEGORIES

LANDUSE CATEGORY	1962 PERCENTAGE DISTRIBUTION (%) (A)	1972 PERCENTAGE DISTRIBUTION (%)(B)	PERCENTAGE CHANGE INCR/DECR: 100 $\frac{(B-A)}{A}$	REMAR
BUILT-UP AREA	20.77	26.51	27.63	INCR
AGRICULTURE LAND	35.6	21.39	-39.91	DECR
SHRUBLAND	4.89	11.90	143.35	INCR
FORESTLAND	5.33	4.88	-8.44	DECR
WATER	22.4	22.47	-44.33	DECR
WETLAND	5.19	8.77	68.97	INCR
OPEN SPACE	2.22	4.07	83.33	INCF
TRANSPOTATION	3.6	10.01	178.08	INCI
TOTAL	100	100		

DATA SOURCE: AERIAL PHOTOGRAAPHS OF 1962 AND 1972, KAKURI-KADUNA

Table 4: THE PRORPOTION OF CHANGE OF EACH CLASS CATEGORY TO THE OVERALL CHANGE

LANDUSE CATEGORY	MAGNITUDE OF CHANGE IN HA	CHANGE PERCENTAGE OF EACH CLASS (C/TOTAL X 100)	REMARKS
BUILT-UP AREA	38.8	11.69	INCREASE
AGRICULTURE LAND	95.6	28.80	DECREASE
SHRUB LAND	47	14.80	DECREASE
FOREST LAND	3	0.93	DECREASE
WATER	67.4	20.30	DECREASE
WETLAND	24.2	7.30	INCREASE
OPENSPACE	12.6	3.80	INCREASE
TRANSPORTATION	43.4	13.08	INCREASE
TOTAL	332	1,000	

DATA SOURCE: AERIAL PHOTOGRAPHS OF 1962 AND 1972, KAKURI-KADUNA

1962 Aerial Photograph
Kakuri - Kaduna

1972 Aerial Photograph Kakuri - Kaduna

CHAPTER FIVE

5.0 <u>*CONCLUSIONS AND RECOMMENDATIONS*</u>

5.1 <u>*CONCLUSIONS*</u>

To be able to use land to its full capabilities, it is important that the activities on that land are recorded and any change occurs therein is monitored. The variability in use of land in any one country defers depending on the pressure on land, hence the interval in monitoring will also vary.

This study could provide information for assessing and monitoring landuse change over time. In this dynamic situation accurate, meaningful, current data on landuse are essential, if public agencies and private organisations are to know what is happening, and are to make sound plans for their own future action, then reliable information is critical. However, one of the prime prerequisites for better use of land information on existing landuse patterns and changes in landuse through time is to reguarly provide means of monitoring this within some time interval.

It is necessary to monitor the changes that occur in landuse to optimise land activity and the interval in detecting this change will directly relate to the pressure placed on the land. Because the changes in landuse are strongly connected with physical and socio-economic features characterized by the nature of the land, there is *need for more than a single data base and this will ultimately lead to the production of a Geographical Information System (GIS).*

Thus a GIS should be started where this is possible, the cadastre will provide a base from which to start this activity. Where the cadastre is numerical the start will be much easier.

Be that as it may, the result, discussions and findings of this study will go along way to help the state government take some relevant actions regarding their environment. This research should also serve as a means of enlightening governments and other authroities about the relevance of Remote Sensing techniques as quick and cheap means of providing solutions to our environmental problems.

Unfortunately, lack of adequate information on natural resources and alternative management procedures poses some serious problems in most countries especially the developing nations. Because of this problem of inadequate data, effective control and monitoring of landuse and management practices become even more serious in the light of the unfortunate effects on land quality and environmental sustainability.

5.2 ***RECOMMENDATIONS***

Basically, environmental problems could be reduced or averted if researh efforts are channelled towards provision of adequate information on various aspects of human and bio-physical environment than the achievements made in this research.

However, this research efforts will recommend the following:

1. *A vigorous campaign exercise should be carried out to demonstrate the use, importance and capabilities of Remote Sensing Techniques to various authorities in the Federal, State and Local Government levels.*
2. *It will be extremely useful for Nigeria to invest on the provision of facilities to receive data from satelite for monitoring our environment. This could be possible through the establishment of a National Remote Sensing Centre that will be fully equipped for gathering up-to-date data especially for research work.*
3. *Acquisition of these imageries should be at different seasons of the year in order to be able to classify the study area. This will make sequential timeseries analysis possible in order to understand the dynamics of environmental processes.*
4. *In as much as landuse planners and landuse managers, and government authorities are involved in the decision making of the state in terms of landuse of the area, care must be taken to*

involve the climatologist or meteorologist so that there will be a coherent sound decision that will help reduce our environmental problems.

5. *Finally, there should be further research work on this subject in order to up-date the baseline information established by this study. This will serve as a modest but welcome beginning of Geographic Information System (GIS) for effective planning in the area.*

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