THE USE OF COMPUTER AND MANUAL ANALYSIS IN DETECTION OF LANDUSE CHANGES IN THE BUKURU - JOS REGION

BY

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CERTIFICATION

I certify that this work was carried out by Solomon Ndache Jiya (M. Tech./sss6/97/114) as part of the requirements for Master of Technology (M. Tech.) degree in Remote Sensing Applications, School of Science and Science Education, Federal University of Technology Minna.

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DEDICATION

This thesis is dedicated to the following people: My Late father Baba Isaiah Zhigi Majin Jiya, My Sweet Mother Nna Sarah Woye Jiya, My wife Alice, Baba Majin and Ya – Ninma (Children) Sisters and brother Ya-Rebecca, Ya-Jacob, Ya-Alice, Ya Elizabeth, Ya-Lydia Ya-Grace, Ya-Hannah and Ya-Christiana Fatima.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the problem

The activities of man in the process of fulfilling human needs such as food, shelter, security and amenities, accelerates the pace of change on earth surface (either for a short or long term). For that, man in his inventiveness has determined how to use and manipulate his environment for self satisfaction.

Land is a fundamental necessity of life since it is the very and framework on and within which social political and economic activities of a people function. But even in the absence of people change goes on.

Since all developing countries economies depend largely on agriculture and mining of mineral resources, they are dependent solely on land and its products for subsistance. However, the inventory and control of land and landuse are generally useful through surveying and mapping. Conventionally, the latter, based on data acquired with direct physical measurement, has yielded promising and accurate results.

A tremendous development in data acquisition and computer – aided analysis techniques has become possible to derive subtle and diverse information regarding the physical (i.e size, shape, and area etc) and chemical properties of the features and surfaces of the land. This new approach known as remote sensing has found increasing application in develop countries .

It deals with the science of acquiring information about objects from measurements made without coming into physical contact with the objects concerned.

Indeed, multi – purpose planning, inventory and management of land resources and environmental protection constitute one of the primary issues of economic development. The inventory of land resources calls for current situation mapping while the control and management of these resources and monitoring of environmental change demand repetitive synoptic and comprehensive coverage and mapping. Both temporal and spatial characteristics of environmental changes can be studied through successive mapping at appropriate time intervals, using data from repetitive coverages. To meet these requirements, the data for mapping should be:-

(a) Accurate and reliable

(b) Timely

(c) Cost effective

(d) Comprehensive

(e) Available as and when required.

Aerial photography is the oldest and most universally employed forms of remote sensing. It had been used for accurate, reliable and comprehensive mapping of data. Satellite remote sensing is the most recent source of mapping data capable of meeting comprehensiveness, timeliness, cost effectiveness fully accuracy, reliability and availability as and when required.

In order to make sound decisions one must have adequate information on several complex interrelated aspects of its activities i e landuse of a contemporary society. The search for the knowledge is the duty of man – kind on land use / land cover which has become imperative as the nation plans to over – come the problems of haphazard, uncontrolled development, environmental deterioration, loss of prime agricultural lands, some distractions of important wet lands and loss of aquatic life and wild habitats has been studied from many diverse viewpoints so that no one are single definition is really appropriate in all different contexts . On a broader sense, land cover designates the visible evidence of land use to include both vegetative and non – vegetative features and is subject to direct observation (Campbell 1983)

Land use change is seasonally dynamic and most requirements are not only for mapping of the existing land use but also for a system to monitor regularly changes that are occuring. These changes could be expansion and the loss of agricultural land, changes in river regime the effects of erosion and desertification and so on. A planned approach to changes in land use has recently become wildly recognised. The agricultural land is influenced by urban development as this is where the most rapid changes occur . To understand natural and uncontrolled changes so as to evaluate their importance and the possibility of avoiding the unnecessary and harmful changes where applicable, land must be studied comprehensively.

The development trends of a region is discovered by a means of land use change detection of both rural and urban areas. This refers to the

activity of identification, measuring and recording 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 occurring within the system thus providing information that is useful for formal planning by the environmental science. This can be addressed by integrating computer and manual analysis in a system that describes and reports these changes. This integration has led in Geographic Information System (G I S).

Regions may be conceived as expanding and contrasting entities perhaps even migrating ones where a certain type of economy or cultural trait begins and then spreads from there as far as conditions favour its expansion .

The growing population of an area uses land more intensively than expected. Urban land is used for growth than their rural counterparts land is both a resource and a property. However, unlike most properties, the owners are restricted in its use by regulations. This leads to the notion that much of the value of urban land use can be ascribed to public investments, institutional decisions and economic inter – dependencies of urban activities (Quadeer 1981).

Essentially, a society's land use is a clear manifestation of their priorities and goals. Within each society every social group tries to influence the use of urban land to further its economic interest and improve its way of living .

Urban landuse has its unique nature and plays a crucial role in human settlements. In the light of this, it will not be a wise course of action to treat

land as ordinary asset controlled by individuals and subject to the pressure and inefficiencies of the market system litchfield (1980). It is also a conventional wisdom that land problems lie at the very heart of planning, building and managing human settlements. As a result, severe competition, Co-operation and conflicts for this important resource often prevails. For instance, the protection for agriculture and forest and for the preservation for recreation and tourism pose pressing problems even in urban centres as in rural areas. Land use is so critical to all developments that its role in the urban development package can be seen and tackled as an entity distinct from other components. This comes naturally from recognition that it is a unique feature of life and its development as such has its own peculiar characteristics as the platform for all human activities.

The role of land use in any urban economy is multi – dimensional for example taxes and charges on real estate do not only contribute to the revenue of the manicipal governments but also have the potential to influence the distribution of income. Remote sensing applications provide a means of monitoring changes in the distribution of activities which in return, are related to socio economic changes. Remote sensing is only an input to over all change detection system. Other data from surveys are necessary sources which related to change, identifying those indicators that describe the change change in a useful way, and to construct systems and monitor variables for useful data output . Policy officials at both the local and federal levels must make important decisions affecting landuse. Development efforts based on integrated physical development plan, poverty alleviation programme, transportation, housing programmes,

industrial location and strategy and public social services delivery systems are required.

These are a few of the many areas of public needs which are influenced by and have affects on languse. Because of the great complexity of urban systems, Modelling may have great potentials as an aid to formulating and analyzing public programms in these and other policy areas .The use of remote sensing Application's provide a means of monitoring changes in the distribution of activities for useful data OUTPUT of a given environment.

1.2 PROBLEM STATEMENT

The displaced persons of the Jos Plateau mining region together with the migrant workers who have become job-less as a result of considerable reduction in mining activities have continued to exert pressure on the largely reduced useable lands. For many years past, Jos Plateau has witnessed incessant soil destruction by mining operations. Mine failings , neglected excavations and unfilled sample pits have left an indelible disfiguration of a once rich and beautiful region. The study area, Bukuru was not mostly in the original Jos settlement but now has become an expansion of Jos metropolitant area. Since Bukuru is fast growing due to expansion of Jos, residential and office accommodation are concentrated there.

Lands are mined extensively in the study area, but it takes not less than 15years to be reclaimed. Despite the exiting laws, little or no attention is paid to reclamation of the land. However, in the face of mining ponds and dumps all over the surface of the Jos plateau, the devastating effects of erosion caused by mining activities, coupled with the large number of unrelinguished leases is a large number of migrants who cannot claim ownership over control system. The question is what impact does expansion of Jos has on the land use of Bukuru? What extent of change occurred since 1963 - 1976 – 1991 ? To be able to determine the developmental trend and land use changes of Bukuru, the use of remote sensing application (Retail photograph) will furnish a reliable source of information.

1.3 AIM AND OBJECTIVES OF THE STUDY

The study aims to use computer and manual techniques to analyse landuse changes with a view to fulfilling the following objectives:-

(i) To examine the use of remote sensing technique in landuse change detection of Bukuru – Jos area.

(ii) Interpret through the aerial photographs the landuse changes that occurred between 1963-1976 and between 1976 -1991.

(iii) To measure the percentage growth between the periods of 1963 – 1976 and that between 1976 – 1991.

(iv) To make recommendations on the use of Remote Sensing in modern planning and growth.

1.4 JUSTIFICATION FOR THE USE OF REMOTE SENSING TO THE STUDY

Remote sensing is a new technology that has greatly and rapidly expended in the study of land and monitoring of the environment and human spatial organization. Hundreds of spatial phenomena around the globe are being monitored by remote sensing today. Among them are soil and vegetation changes, crop health (diseased fields having different temperatures than normal ones and can easily be detected locust infestations potential oil and gas deposits, air pollution,land use change, population shift and heat losses by buildings. Also a comprehensive geographic investigations include information on the land scape of the study area called ground truth is largely carried out.

Since remote sensing constitudes a set of techniques that extend the range of human perception beyond the visible spetrum, land use changes can be monitored effectively through the use of remote sensing technique

1.5 DECRIPTION OF THE STUDY AREA

1.5.1 LOCATION AND EXTENT

Jos plateau lies in the central part of Nigeria which covers a total surface area of 9,400km^2 . The plateau is located at latitudes 10^0 11.N and 8^0 55.N and longitudes 8^0 21E and 9^0 30'E.(fig 1.1) The study area (Bukuru – Jos) covers a total land area of 37. 375 km^2 (fig 1.2).

1.5.1.1 GEOLOGY

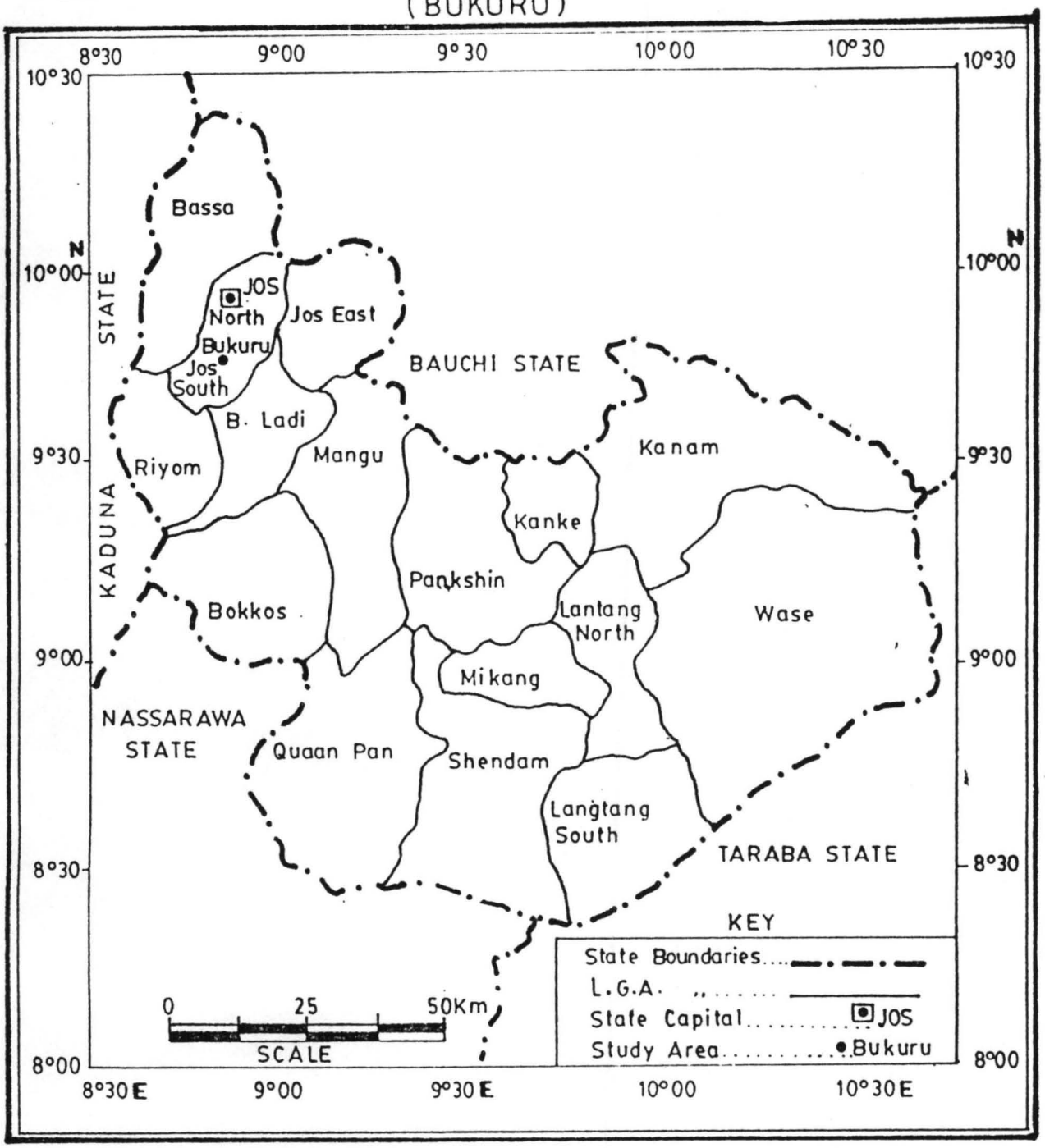
Geologically, the Jos plateau is part of the precambrian to mid cambrian and jurassic Northern Nigerian Crystalline Shield. The crystalline rocks are of two categories: metamorphic and Igneous (John, et al 1977). Geologically there is nothing specific and nothing particular in the study area that cannot be observed in other parts of the Nigerian crystalline complex. In other words, the study area (Bukuru) is not a geological unit because it cannot be demarcated on the basis of any distinct geological criteria. It is purely a morphological or relief unit with elevation above the ground level as the only feature distinguishing it from the rest of the Crystalline Sheld. The elevation is about 600metres above surrounding plains which results from a tectonic uplift.

1.5.1.2 RAINFALL

In the Jos Plateau the rainfall is low, rarely above 100cm. The type of rainfall is orographic and about four month rainfall in the plateau. Extreme concentration of rain occurs in the month of July, August and September. The peak of the rains is always reduced in October. Water budget calculated by the Plateau State Water Board reveals that mean annual base flow Co-efficient is 0.19; the mean annual evapotranspiration Co-efficient is 0.28.

Rivers are effluent some of them are perennial and dries up towards the end of the dry season. Evaporation from the surface of the impounded

Fig 1.2 PLATEAU STATE MAP SHOWING THE STUDY AREA (BUKURU)



Source : After Appolonia O (2000).

reservoirs of the study area is on the average 2 metres per year (Particularly during dry season). (Source federal department meteorology Jos)

1.5.2 CLIMATE

The Jos plateau is one of the coolest region in Nigeria. The region is characterised by four to five months of dry season and seven to eight months of wet season. The dry and wet seasons in this area as in other parts of the country are greatly controlled by the annual migration of intertropical zone of convergence (ITZC). In the Jos Platueau the influence of the northeast wind is strong particularly during the months of November and March when the hamattan, a strong, dry dusty wind prevails

The dry tropical continental air mass arrives the country from the north till October and by January it's effect is felt in almost every part of the country as the dry and cold hammattan season. It retreats in March and by July it is completely out of the country .

The dry season is characterised by the dust laden harmmattan wind coming across the sahara desert. This occurs between November to March to area where relative humidity is low, night temperature is cool, vegetation growth decreases to minimum, the soil dries out .

The wet season set in by the month of may and lasts till September. It is characterised by frequent storms which coincides with the planting season. During this period the moist southwesterly winds brings rains and

1.5.3 TEMPERATURE

Temperatures especially maximum and diurnal temperature ranges are greatly influenced by the altitude and the cloud cover. This is associated with the dry and wet seasons. The highest temperatures and maximum diurnal ranges are experienced during the months of the dry season (November – April). The maximum temperature is high during the months of March and April with diurnal range which is high in December.

The minimum temperature, particularly during December and January may be as low as 10^0 c, From the months of may to October which is raining season, maximum temperatures ranges from 15^0 c to 25^0 c but the diurnal range is reduced without exceeding 2^0 c .

1.5.4 LANDUSE

The study area is characterised by mining dumps, built up of clayey sand or sandy clay, excavated in the process of mining of tin Ore up to 20^M high and almost without vegetation. In the study area erosion is on the increase leading to the rejuvenation of stream valleys probably due to deforestation, overgrazing and bush fire and possibly also to isostatic uplift.

The mining ponds are also used intensively for both water supply and irrigation. The mining industry also provided employment opportunities and most importantly the mineral exploitation provided a good source of revenue. But inspite of these enumerated advantages, mining activities on the Jos plateau/ the study area (Bukuru) have left a terrible eye sour of landuse.

The study area had been dug by aggressive tin miners who had one goal – dig out tin no matter what happens to land in the process. Quite obviously, within a short time, the initial green vegetation of the region had given way to red mounds of sand. Today, the study area has a pathetic and deplorable condition of landuse. The surface soil is dangerously replaced with red brown soils which lack fertility. Evidence of numerous land degradation also exists in the form of bad land type features left on old, previously mined and abandoned river courses. There are erosional processes and gully which are diverse and intensive in the region. These manifest in the transport of loose sands from the mining dumps to the small plains agricultural fields and the fadamas.

The above scenerio of the mined lands suggest that such lands of the study area today are unsuitable for agricultural practices, construction, grazing and forestry among others. It is against this background of land use changes of Bukuru Jos that this study has been conceived and written.

1.6 STRUCTURE OF THE PROJECT

The project work is divided into five parts, from chapter one to five. The chapters are outlined as follows:-

Chapter one, titled "introduction" presents introduction of the project topic, statement of research problem, aim and objectives, Justification for the use of remote sensing to the study, description of the study area, land use as well as the structure of the thesis itself.

Chapter two titled "literature review". It deals extensively with the relevant and related literature of the studies .

Chapter three titled "Research materials and methodology" comprises research materials used, principels of interpretation, types of interpretations, Aerial photographs interpretation, Ground truth and Computer assisted interpretations.

Chapter four titled "Discussion of Results" presents analysis discussion and results Interpretation of 1963 Aerial photograph.
Interpretation of 1976 Aerial photograph
Interpretation of 1991 Aerial photograph
Land use changes between 1963 and 1976
Land use changes between 1976 and 1991

Chapter five titled include summary, recommendations and conclusions

CHAPTER TWO

2.0 LITERATURE REVIEW

A modern approach to land use changes in a more complex and rapidly changing environment like Bukuru – Jos involves the use of the computer Landuse Change detection using aerial photography has been applied to both rural and urban areas and found to be an efficient method of discovering the developmental trends of a region or area. Change detection involves the use of sequential aerial photography over a specific region from which the land use map for each date is mapped and compared.

2.1 LAND USE CHANGES

One of the most common uses of remote sensing techniques is in land use identification, classification and land use changes (Adeniyi 1985) verstappen (1977) observed that land system mapping from small scale imageries such as landsat and radar may prove more useful than contour maps for general planning purposes, particularly a very large region at a time. This is a bit contrary to Jeje's (1986) assertion that band 5 of landsat imageries appears to be very useful for land use mapping purposes, but radar is less suitable for land use mapping .

Data from both Spot and Landsat Satellites are available in either photographic or digital form. In photographic form , images are available either as prints or transparencies and in various scales. An advantage of photographic imagery is the simplicity and very low cost of interpretation

tools required (simple light table or projection device). With digital information, users require computer based image analysis system to manipulate and interpret the information. However these digital systems offer great power and flexibility and can aid in image enhancement, multidate image registration, registration with digital maps, and digital image classification.

A view to the future and providing a competitive adge, the need for highest quality information will routinely use the data from satellite and airborne sensors to perfect their activities. Digital analysis system now exist for personal computer systems, augmented with colour monitors and suitable software. More interactive devices using computer – based geographical information systems will facilitate the use of combined data sets, such as soils or cadastral maps (Static sets) and remote sensing data as a source of up – to date information on changing elements, such as landuse and agricultural practices. Such systems will clearly facilitate planning and decision making for those working in agricultural field.

Campbell (1983) made a comprehensive approach to landuse studies and discovered map between two time periods is usually produced to understand the changes. Adeniyi (1980) presented a good example of how change detection using sequential aerial photography was carried out in Lagos, Nigeria. Adefolalu (1986) used a combination of SLAR and LANDSAT data with ground truth observations to study west Africa and Nigeria landuse vegetation situation.

Remote sensing has been applied to various management issues to minimize erosion and soil degradation Howard (1977). This is because

remote sensing can provide classification of landscape which identify exerts susceptible to erosion and can also be used to map stream and river courses Qian et al (1990). Ademola and soneye (1993) used remote sensing and geographic information system (G I S) techniques to map the land use and land cover in the Sokoto river north western Nigeria. In the studies of some effect of Tiga dam in Kano State, on the environment down stream, Olofin (1980) identify erosion and flood plain formations that resulted in landuse changes from aerial photographs.

Also Osterlund (1992) in chiang Rai Northern Thailand province study, using enhanced landsat colour, calculated rate of deforestation at 2% per annum between 1977 and 1984, 4% between 1984 to 1990 and by 64% within thirteen (13) years. A V H R R was used by Tucker et al 1984 and Nelson et al (1986) for assessing detorestation over 100km x 400km area of Rhondonia,Brazil and Richardson (1984), while Wacharachiti (1985) used sequential landsat MSS imageries of 1973, 1978 and 1982 in this study of mum chi phong and phen watershed in northern Thailand to classify and map deforestation.

Paul, et al (1988) used enhanced classification approach from landsat MSS data sets (1975 – 1984) in assessing natural and man induced changes in land use / land cover in the semi arid environment of north western Nigeria after construction of Bakolori Dam and reserviour. It was evident that these results of an overlay enhancement of band 5 images (as described in Banner and Lynham 1981) provided the most accurate identification or spectral changes.

Avery (1965) used U.S. Department of Agriculture aerial photograph at 1:200,00 scale in 1944 and also 1960 to evaluate landuse changes in clarke county, Georgia. Okhnimamhe (1993) studies landuse and landcover changes in Burunburun / Tiga area in Kano State using aerial photographs of 1974 and spot HRV1 of 1986 to detect the changes. Poutton at al (1977) also made a comparative analysis of 1944 and 1968 aerial photographs to detect change and assess causes of change as they related to land management in a range and forestland environment in Sierial Nevada, Califonia .

2.2 AGRICULTURAL LAND USE

Carter (1958) used aerial photographs to identify agricultural landuse, sheet and gully erosion affecting River Njaba resulting from the nature of slope, run – off and human activities.

Gerald (1982) used panchromatic black and white and infrared photographs to map erosion in some agricultural land in south Africa and observed that high spectral sensitivity of panchromatic photographs are very good for cultivated and uncultivated areas. The satellite carry various sensing systems capable of viewing the earth below. These systems act like cameras, measuring light reflected from the surface of the earth in different colours or spectral regions. Because agricultural crops and landscape features reflect light in different ways they can often be identified and characterized from the satellite images. Some crops are relatively easy to identify such as winter wheat in western canada and corn and potatoes in

the east. Crop identification, however depends in general on the stage of growth and on the crop condition.

NOAA has launched a series of weather satellites that carry an imaging system called the Advanced Very High Resolution Radiometer (AV H RR). This instrument can image every agriculturally significant reion of the globe daily, at a resolution of 1. 1km, to provide information on vegetation condition and density. AVHRR images collected in early August of 1983 and 1984 are presented as false – colour infrared images in which the areas of better vegetation growth are represented by the brighter red tones. Progressing from these bright red to nes, through less reddish shades to blue tones represents a change from areas of lush vegetation to areas of sparser vegetation growth, poorer plant development and lower potential yield. The crop yields in most of saskatchewan in 1984 were considerably less than in 1983, and this is born out by comparing the two images.

The overlays on the images represent crop reporting district boundaries, and the numbers are crop reporting district average yields in kilograms per hectare. These data are being used by the canadian wheat board and other agancies to monitor crop condition over large areas, to make decisions for agricultural marketing and for early warning of food aid requirements. This is in conjunction with other data sources such as meteorological information.

Five LANDSAT satellites, the first of which was launched in 1972 have carried sensors that record dramatic and revealing aimges of earth. Each satellite is designed to travel in an almost perfectly circular near polar

orbit and passes over the sunlit side of the planet several times daily. The orbit shifts progressively westward so that every part of the surface of the earth is imaged every 16days.

Two sensors aboard LANDSAT currently collect agricultural data – the multispectral scanner (MSS) and the Thematic Mapper TM. These camera like devices divide the images into tiny picture elements (pixels)and measure the brightness of each pixel in several portions of the electromagnetic spectrum. Some in the visible range and ot hers at wavelengths not perceptible to the human eye. Large amounts of data about the land and vegetation it carries become available to farmers and agrologists.

Most people are familiar with the weather viewing capabilities of satellites. Now enhanced systems make available many other types of data for farming and crop management. Crop area mapping and crop condition monitoring are just two examples of how satellites can be of value to agriculture.

2.3 VEGETATION

Remote sensing has potential for application to natural and semi natural vegetation as well as for agricultural lands evaluation. Thematic mapper (TM) with increased sensitivity will provide better information for mapping differences in soil types and vegetation conditions. Satellite

sensors are capable of discerning many of the changes in physiognomy characteristics of vegetation through spectral radiance measurement. The visible infrared bands on the satellite multi- spectral sensors allow monitoring the greeness or vigor of the vegetation. The green vegetation is highly absorbing in the visible part of the spetrum (Halilu 1993) and low absorbing in near infrared part (Tucker 1979) due to chilorohyll and water content and scattering caused by the leaf's internal spongy mesophyll layer (Myers 1983)

Landsat band 5 appears to be very useful for mapping and interpretation of vegetation, while radar could be less suitable for same purpose (Jeje 1986).The thematic mapper TM has made moderate to good potential for mapping vegetation (Jones 1986, Mulders et al 1986, Akinyede 1970) due to high spatial spectral resolutions. As vegetation becomes stressed or senescent, its ability to absorb visible light through chlorophyll is decreased, so that the amount of visible light increases, the spongy mesophyll layer also contracts, density of air spaces decreases and thereby decreased the reflectance of near infrared radiation (Harris, 1987)

N. O. A. A. satellite provide high resolution picture transmission (HRPT) local area coverage (LAC) and Global Area Coverage (GAC) data. Scientists have examined the GAC in the last few years to prepare maps and analysis of continental and global scale vegetation and vegetation changes (Yates et al 1986). Justice et al 1986 published global overview of vegetation activity by analyzing the GAC and Global vegetation index

(GVT) of Tarpley et al (1984) to explain vegetation phenology and show global changes in vegetation seasonally.

CHAPTER THREE

3.0 RESEARCH MATERIALS AND METHODOLOGY

3.1 The research material used.

The data used were derived form aerial photographs acquired from the ministry of lands and survey department, of Jos, plateau state. The aerial photographs are for 1963, 1976 and 1991 with a scale of 1: 10,000, 1: 10, 000 and 1: 8, 000 respectively. The topographic and political map of Bukuru were also collected for consultation and delineation of the study area respectively. Mirror stereoscope was used in delineating features on the sequential aerial photographs using the elements of interpretations. Transparent papers were used for tracing of the delineated areas.

The aerial photographs for 1963 1976 and 1991 were scanned into the computer using mustek 600 111 Ep plus. The scanned imageries were coneatunated and analysed to assess the use of computer in related studies.

The aerial photographs for the three periods were adequate and augmenting one another in instances of permanent features such as outcrops and roads that were improved upon. The photographs were drawn into mosaic on tracing sheets.

3.2 PRINCIPLES OF INTERPRETATION

The characteristics used in analysing and interpreting remote sensing data had helped in recognising, differentiating and qualifying objects on the

mosaics. Using such elements as size, tone, texture, locational site, shape and shadows were so useful for the interpretation.

The size of the buildings were used in determining the types of building for example differentiating between schools, warehouses and other utilities.

The texture roughness and smoothness of objects were used to differentiate outcrops from a bare soil and also among other features. Farmlands could easily be visible for it roughness as forest could.

The pattern which refers to the arrangement of structure, were used in differentiating schools from offices, more acurately because of familiarity with the area.

The locations of object in relation to others had also helped to ascertain many relevant features. Associations of elements was very important here because the areas with ponds are never associated with cultivation.

Shades casted by features such as ware houses, churches and mosque due to their sizes had also assisted a lot in the interpretation. The shades casted by the trees helped in differentiating it from grasses.

3.3 TYPES OF INTERPRETATIONS

The two types of approaches to image interpretations are manual interpretation and computer aided interpretations. Computer approach to image interpretation is a classification process involving a number of steps/ procedures to be followed by various uses. Computer approaches are done

when the image is in digital format. This is why a set of photographs (1963) were scanned into digital number and interpreted. Manual interpretations are direct interpretation of images that were printed. It involve identifications and mapping of various objects and calculating the area extents of the various features.

Depending on the availability of any type of data, one can use either approaches. These approaches have their different advantages and disadvantages. In case of the size of data, time frame and accuracy digital images are better. When one looks at expenses, types of classification of buildings, accessibility one would be force to consider aerial photograph.

3.4 AERIAL PHOTOGRAPHS INTERPRETATION METHODOLOGY

The various photographs were laid to overlap each other by 60%. The sixty percent overlap gave the stereoscopic view of the features contained on both the photographs. Using the elements of interpretations features such as built up areas, bare rocks, ponds preservation area, public uses, Roads, open spaces and cultivated land were delineated for 1963 set of photographs. The same procedures were used for 1976 and 1991 set of photographs. The three mosaic of traced interpretation could not overlay because of the flight line that varied. The three mosaic were drawn and reduced to the same scale by first registering the permanent features on all the tracing papers used for the multi date data.

From the overlays of 1963 and 1976 a change image was drawn to signify the changes that have occurred since 1963 – 1976 (period of thirteen years). The 1991 mosaic was overlaid on 1976 and changes that occurred for the period of fifteen years were drawn and traced to the same scale.

Land use interpretation accuracy also depends on the landuse classification scheme which has to be designed with regard to the cultural character of the study area. The USGS scheme designed by Anderson et al (1976) has provided a valuable guide for the design. The concept of different levels of landuse or landcover details are interpretable according to the different scales of the imagery and hence the spatial resolution quality is normally adopted by the researcher.

However, each of these landuses will be identified by a single digital symbols indicating the level one category interpreted from aerial photographs of 1963, 1976 and 1991 respectively . The land use classes used for the manual classification are given in table 3.1

With reference to the modified level I Anderson et al (1976) USGS classification scheme, the researcher designed eight classification scheme of the study area as seen above. The definition of these classification are:-

1. Built up area:- This is where the political, economic social, moral and educational institutions and infrastructures are intensively put into practice. These bring about a developmental trend as the level of Co-operation, integration and competition is highly existing among the people. Built up area is therefore a place of focus for a purpose and is the most interesting scene for mankind.

Table 3.1 **USGS LANDUSE CLASSIFICATION SCHEME**

S/No	USGS Classification Scheme	Modified Classification Scheme
1.	Urban or Built up land	Built up area
2.	Agricultural land	Cultivated land
3.	Range land	Reservation area
4.	Forest land	Public uses
5.	Water	Ponds
6.	Wet land	Bare rocks
7.	Barren land	Open spaces
8.	Transportation	Roads

2. Bare rocks:- These are rocks that appear in scattered form in the study area: They maintain the same size and shape for several years.

3. Ponds:- These are open areas where mining activities have taken place. Ponds have water in them which increases in volume and dept during raining season.

4. Reservation area:- Land primarily used formerly for mining activities and now placed under fallow while reclamation is taking place as well

5. Public uses:- These are places set a parts for public uses like markets, games and sports fields, cenema houses, hospital and so on.

6. Roads:- This is refered to transportation network such as foot paths, minor roads, major roads and railway of the study area

7. Open spaces:- The remaining areas not yet developed for a purpose in the study area.

8. Cultivated land:- This is a land where farming activities takes place such as fish farming, cropland and pasture, orchards and nurseries.

3.4 GROUND TRUTH

During the course of the study, the field, though so familiar, was visited several times for verification of interpretation so as to minimise interpretation errors. As much as the research is concerned there was no error encountered because aerial photographs are highly commendable and reliable in this kind of study. The stereoscope made all the features so vivid and mappable. The scale of the image made it so easy and error – free. Areas doubted were visited for accurate interpretation. This helped in accurate interpretation.

3.6 COMPUTER ASSISTED INTERPRETATIONS

A set (1963, 1976 and 1991 photographs) were scanned using mustek 600 111 Ex plus into Idrisi for windows. The scanned images were concatenated to form a mosaic on the screen. This was the tedious aspects of the interpretations. For each feature chosen, using image processing realm 1 Con, ten training sites were selected for such categories. Signatures were created based on the number of categories chosen. Using maximum likely hood the areas were then classified into eight.

From the analysis realm, the areas covered by each category were calculated in percentages. These data formed a basis for comparism with manual interpretation. The results were also indicating which extent any of the works could be relied upon.

CHAPTER FOUR

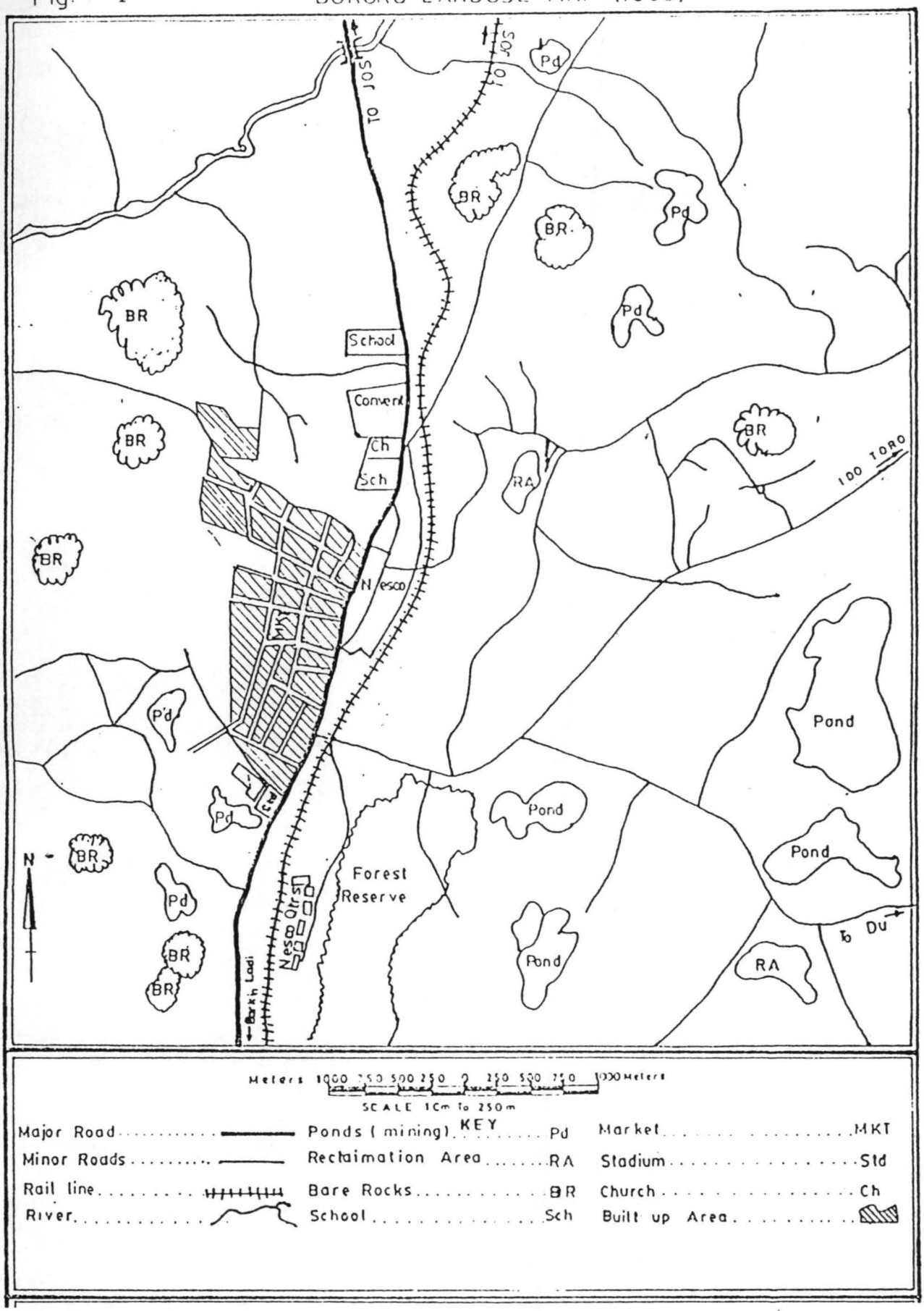
4.0 DISCUSSION OF RESULTS

4.1 INTERPRETATION OF 1963 AERIAL PHOTOGRAPH

From the analysis of 1963 land use, Open Space is the predominant land use class occupying up to 78.19% of the total area of the study (figure 4.1) It is spread towards north east, south east and north western part of the area predominated by short grasses (Shrubs). Open space is followed by road transportation, with marked difference as in fig 4.1. It is 8.70% of the area located in the centre of the study and spreading outwards in a radial direction (Table 4.1). Roads here include footpaths, minor roads, major roads and rail lines. The rail- lines and the major roads run side by side from south to the north while the others (minor roads and footpaths) are scattered (fig. 4.1)

Ponds are scattered over the study area except in north western part and this class of land use is third in size with up to 4. 10% (Table 4.1) size of the total area of the study. The ponds corresponded with areas of the lowest altitude serving as bowl for stagnant water, fishing farm and irrigation, domestic water source. The built up area, dominating the mid – western part of the study is 3. 17% of the total area of the study. It corresponded with area of developed road network and a focal point of the radial spread.

Fig. 1 BUKURU LANDUSE MAP (1963)



Source :- From 1963 Air Photograph

Reservation area is found in the southern part of the study area. It occupied about 2 . 5% of the total study area comprising areas reserved for forestry. Public uses area that is 1. 5% of the total area is situated in the western side of the study area engulfed into the built up area.

The cultivated land scored zero (0%). This can be attributed to lack of time for cultivation since the primary aim of settlers is completely on mining. They set out as early as possible and retired home in the evening time (both male and female) therefore have no time for farming.

Table 4:1 **Landuse Percentage Coverage For The Three Periods**

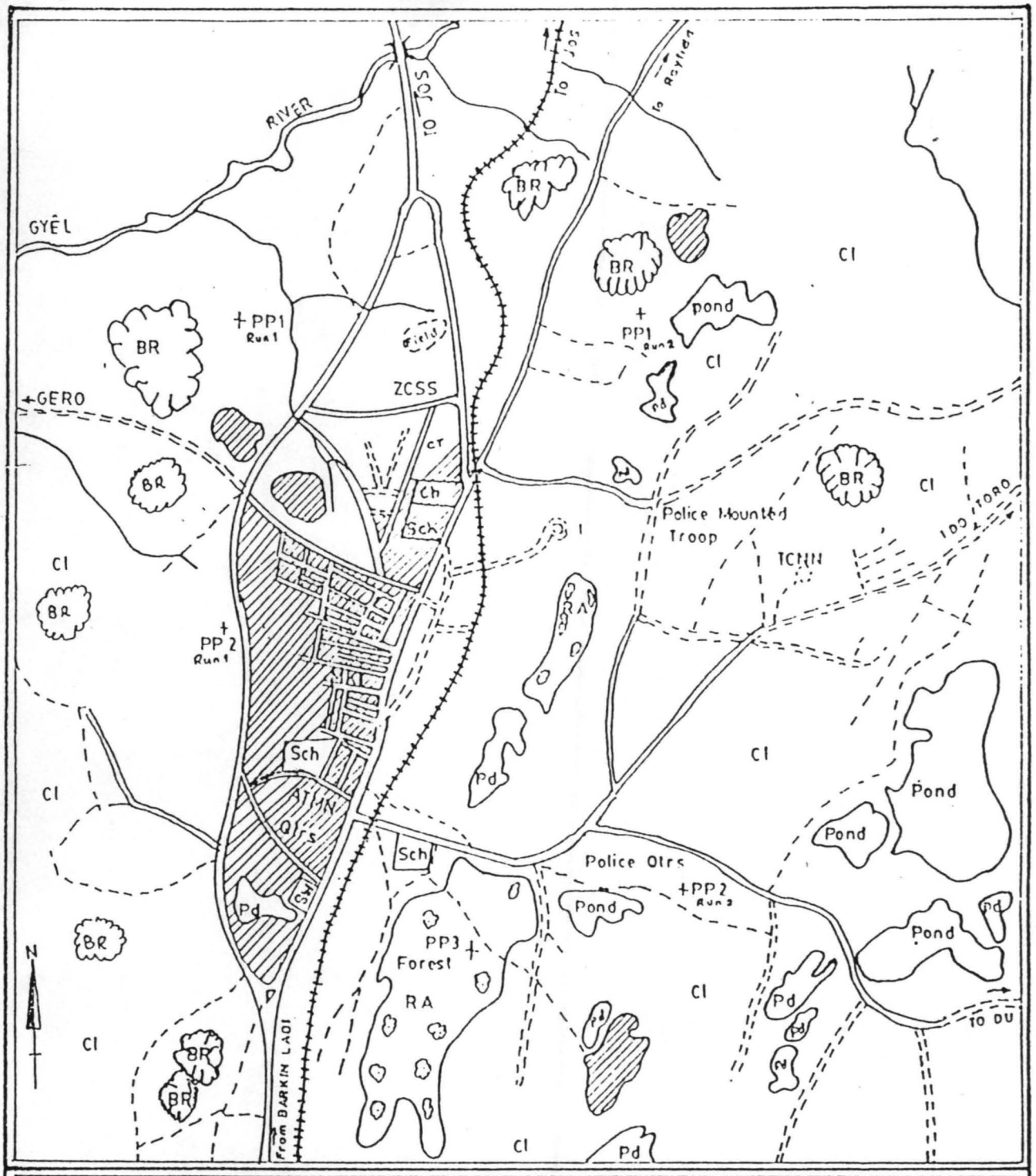
	LAND USE CATEGORY	1963 LAND USE IN %	1976 LAND USE IN %	1991 LAND USE IN %
1.	Built up areas	3.17	5.84	20.06
2.	Bare rocks	1.84	1.84	1.84
3.	Ponds	4.10	3.35	3.35
4.	Reservation area	2.50	2.93	2.93
5.	Public uses	1.50	3.68	4.29
6.	Roads	8.70	16.14	17.12
7.	Open spaces	78.19	37.63	25.67
8.	Cultivated land	2	28.59	24.74

Data source: Author's analysis of Aerial photographs of 1963, 1976 and 1991 Bukuru Jos.

4.2 INTERPRETATION OF 1976 AERIAL PHOTOGRAPH

The 1976 aerial photographs (fig 4.2) shows that the built – up area occupied 5.84% of the study area. The growth tends towards the south western and north western part of the study area from the southern junction to the stadium and main market were developed bringing about much settlement in these places (fig 4.2). The Bare- rocks maintain 1. 84% (Table 4.1) of the area occupied. They are found scattered in all places except in the south and south eastern part of the study area. The ponds scored 3. 35% of the total area occupied which can be found in the north eastern, south and south eastern part of the study area. Ponds are of tremendous assistance to the exiting populace of the study area in terms of domestic uses, fish farming and dry season cultivations. Reservation area occupied 2. 93% tending towards south west of the study area and most places where mining activities have taken place are on reserved grace (fig 4.1). The public uses occupied about 3. 68% of the total land area. The stadium, Government secondary school and market are in the south western part of the study area. Roads including footpaths, seasonal, minor/ major, and railway occupied 16.14% of the study area. Railway and major road runs from south western to the central part where they crossed (fig 4.2). The railway maintain the central run through while major roads passes through the western and the central parts linking places. Other roads foot path, minor and seasonal roads runs all over the study area connecting places of interest. Open spaces occupied the highest land area of 37.63% which can be found in the north western, extreme south western, north eastern and south eastern part of the

Fig. 2 BUKURU LANDUSE MAP (1976)



Meters 1000 750 500 250 0 250 500 750 1000 Meters

SCALE 1Cm To 250m

LEGEND

Major Roads	═══	Bridge	⌓	Cultivated Areas	Cl
Minor Roads	═══	Reclamation Areas	RA	Built up Areas	▨
Seasonal Roads	= = = =	Ponds (Mining)	Pd	Stadium	Std
Foot Paths	— — —	Bare Rocks	BR	School	Sch
Rail line	╫╫╫╫	Principal Point	+PP1		
Rivers	∿∿	Market	MKT		

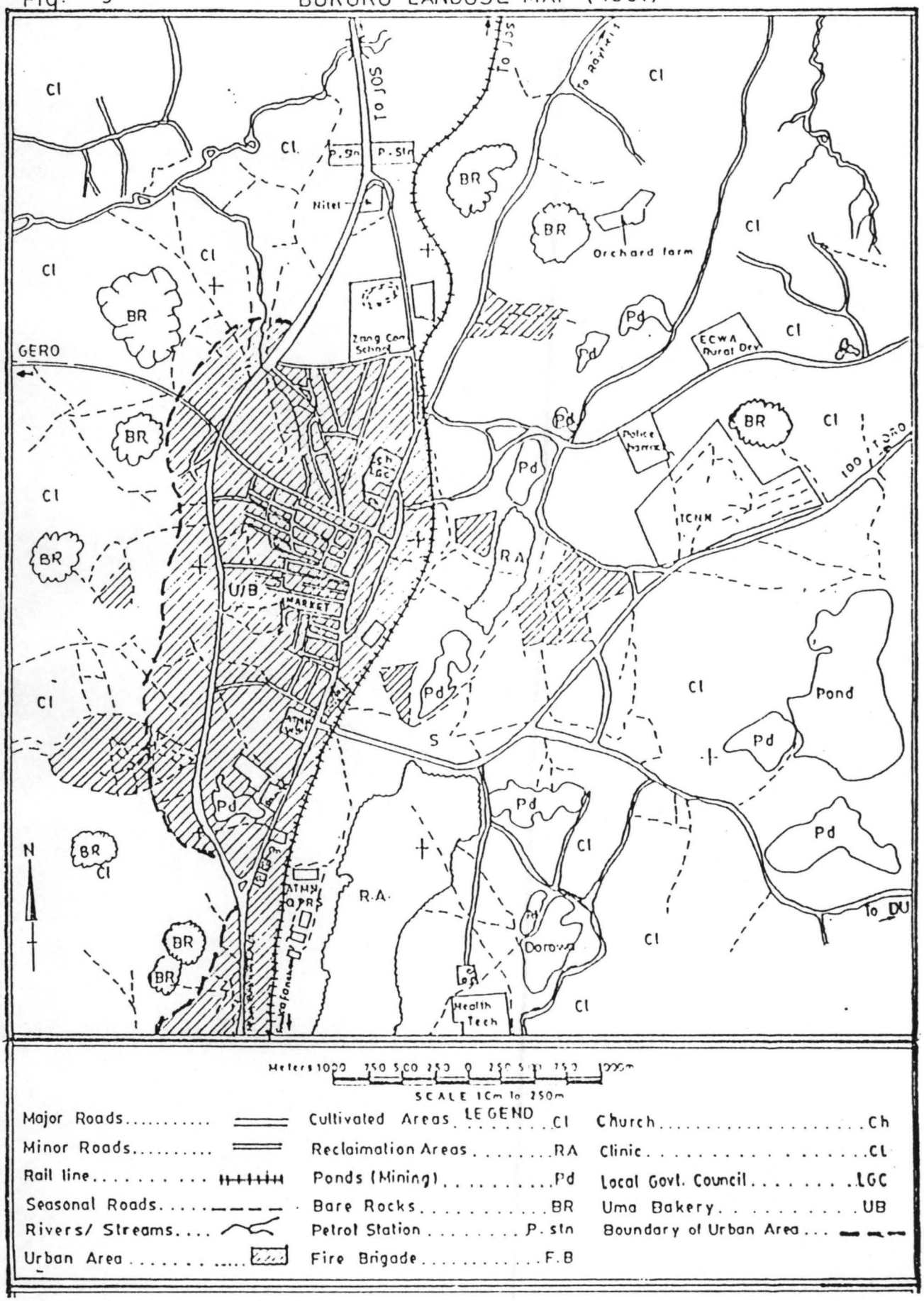
Source:- From 1976 Photograph (Air)

study area. It is dominated by very short grasses as its vegetation. The cultivated land has 28.59% (Table 4.1) of the area landuse which can be found in almost all places except for north western part of the study area.

4.3 INTERPRETATION OF 1991 AERIAL PHOTOGRAPH

Based on USGS design method of classification built – up areas occupied a total of 20.06% (Table 4.1) towards the south west and north western part of the study area. Bare rocks that seemed to be of same size, occupied 1.84% of the area of study. They are scattered in all places except the south eastern part of the study area. Ponds are which are found scattered in the study area except in the north western part occupied a total area of 3. 35%. Reservation area occupied 2. 93% of the study area which are mostly found in the southern and central parts. (fig 4.3) The public uses occupied 4. 29% (Table 4.1) of the total area of the study which are found scattered in the built-up area. Road comprises of major minor rail line seasonal types occupied 17.12% of the study area. It has expanded because of new road such as leading from Barikin ladi to Bukuru and Western bye pass that linked up towards the Northern part of the study area to Jos. Railway line runs from Kafanchan to the Eastern part of built –up area runs through to Jos. Other roads linked –up for easier accessibility. Open spaces leading from North East to South Eastern part and also North Western and South Western part of the study area occupied 25.67%. The highest score is the cultivated land,

Fig. 3 BUKURU LANDUSE MAP (1991)



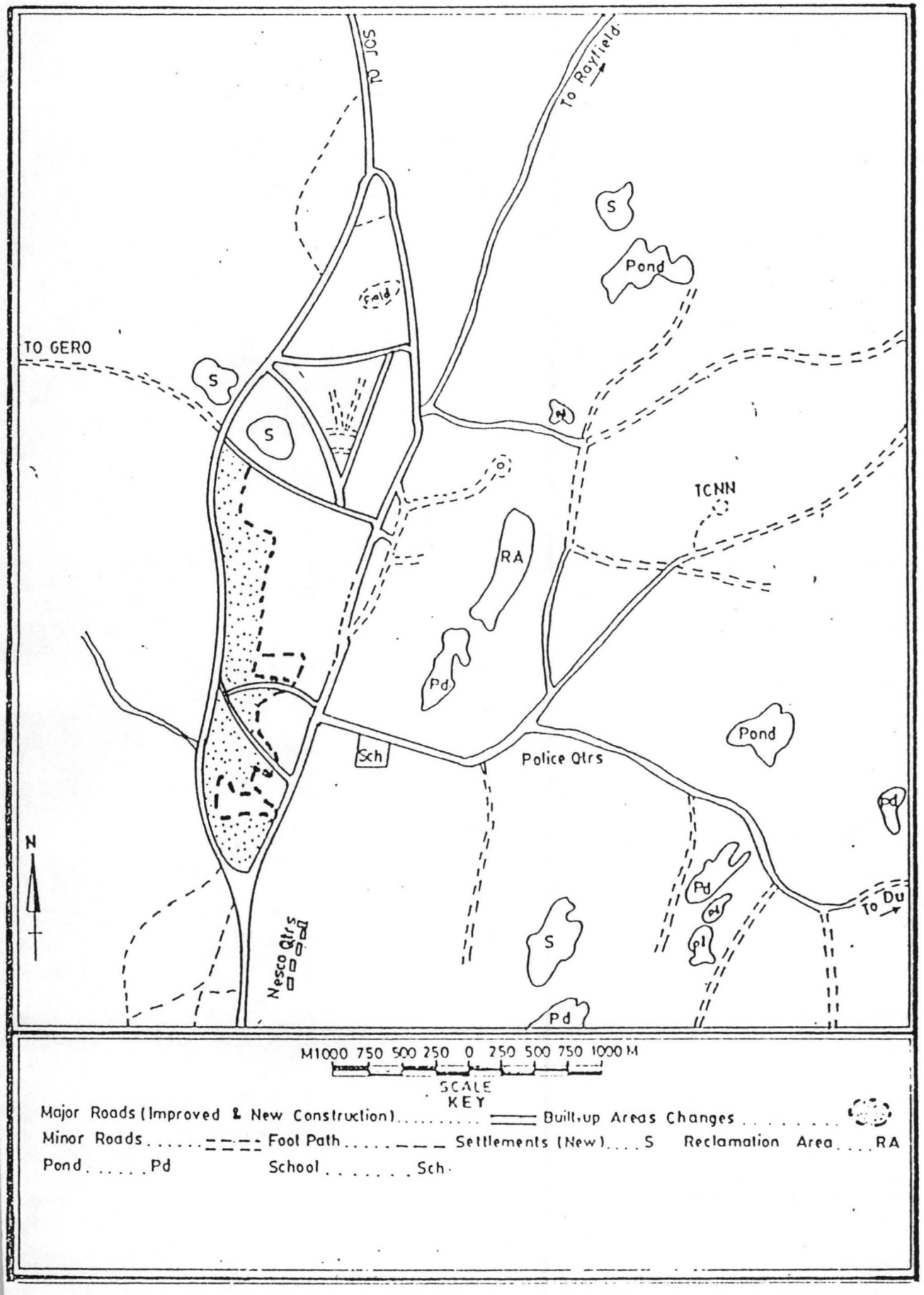
Source:- From 1991 Air Photograph

which occupied 24,74% of the study area. It has grown so suddenly because of the abolition of tin mining in Jos, Plateau region of the study area.

4.4 LANDUSE CHANGES BETWEEN 1963 AND 1976

Landuse changes between the year 1963 and 1967 period were analysed (fig 4.4). The analysis revealed that Bare rocks recorded no change and maintained its percentage of 1.83% of the total area occupied. It also has zero (0%) annual growth since Bare rocks do not easily change unless through heavy erosional process or human activities on it might give it more opening. The expansion of Jos makes a remarkable change (an increase) in built-up area which has a total score of 45.70% and 0.21% (Table 4.2) of the annual growth of the study area. Ponds have a reduction of –22.49% (Table 4.2) which can be attributed to low mining activities in the study area (fig 4.4) The annual percentage growth recorded –0.06 showing a decrease. The cultivated land recovered 100% change. This indicate an increase in reclamation and farming rather than depending fully on mining activities. It record 2.20% (Table 4.3) of the annual growth. The reservation area recorded 14.23% (Table 4.2) which is an increase change of little significance. Public uses has an increase of 59.09% which means that more space is being occupied by the growing population. It also has an annual growth percentage of 0.17 (Table 4.3). Roads score 46.14% increase change as most of the major roads are widen and footpaths gave way for reconstruction. The transportation network in the study area has been increased also. Roads score a total of 0.57% annual growth. The open

Fig. 4.4 BUKURU LANDUSE MAP SHOWING OBSERVED CHANGES BETWEEN 1963 & 1976



Source Aurthor's Analysis of 1963 and 1976 Air Photographs

spaces scored a low percentage of -107.73% which shows that there is a decrease. The reduction can be attributed to high increase change witnessed in built – up area, cultivated land, Roads and so on. Open spaces recorded 3.12% of the annual growth of the study area.

Table 4:2 **Landuse Percentage changes for Thirteen and Fifteen years Respectively**

	LAND USE CATEGORY	1976-63 CHANGES IN %	1991-1976 CHANGES IN %	REMARKS
1.	Built up areas	45.70	70.84	Increased
2.	Bare rocks	0	0	No change
3.	Ponds	22.49	0	No change
4.	Cultivated land	100	-15 .54	Decreased
5.	Reservation area	14.23	0	No change
6.	Public uses	59.09	14.06	Decreased
7.	Roads	46.14	5.77	Decreased
8.	Open spaces	- 107 .73	- 46 - 59	Decreased

Data source: Author's analysis of Aerial photographs of 1963-76 and 1976-91 Bukuru Jos.

Table 4.3 **Percentage Landuse crop for the periods 1963 – 1976 and 1976 - 1991**

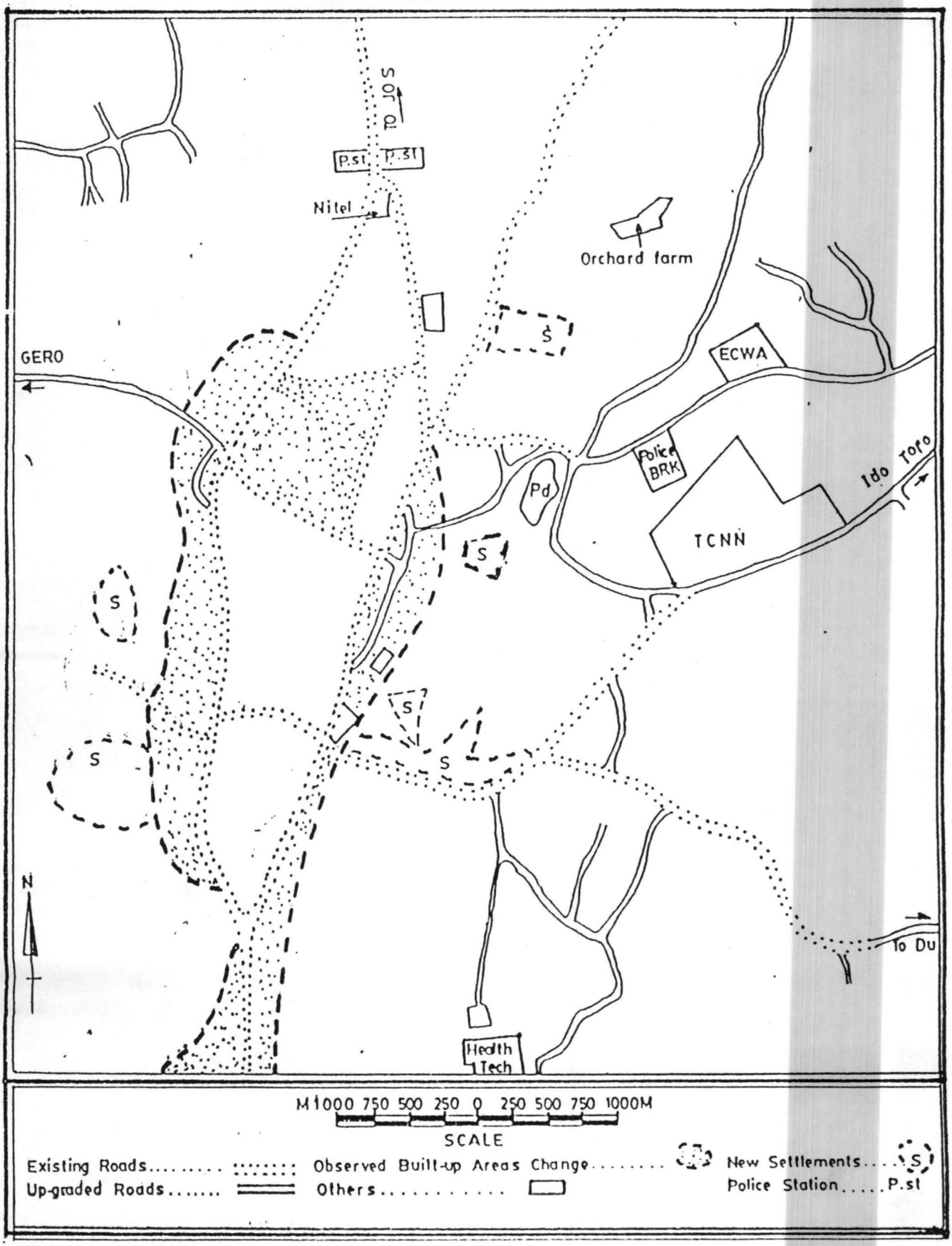
	LAND USE CATEGORY	ANNUAL CHANGE IN % 1963 –1976	ANNUAL CHANGE IN % 1976 - 1991
1.	Built up areas	0.21	0.95
2.	Bare rocks	0	0
3.	Ponds	- 0. 06	0
4.	Reservation area	0. 03	0
5.	Public uses	0. 17	0. 04
6.	Roads	0.57	0.07
7.	Open spaces	- 3.12	- 0. 80
8.	Cultivation land	2.20	- 0. 26

Data source: Author's analysis Aerial photographs of 1963, 1976, 1991

4.5 LAND USE CHAGES BETWEEN 1976 AND 1991

The land use changes for the period between 1976 and 1991, is shown in fig. 4.5 from the analysis, it was revealed that three classes noticed no change. They are ponds, barerocks and reservation areas. While other five categories recorded decreases and increases. (fig 4.5). Built – up area recorded a great change increase of 70.84% than any other category.

Fig 4.5 BUKURU LANDUSE MAP SHOWING OBSERVED CHANGES BETWEEN 1976 & 1991



Source Aurthor's Analysis of 1976 and 1991 Air Photographs

This shows that a lot of growth have taken place in the study area. It has the annual growth percentage of 0.95 in which more buildings of different types now occupy most of the open spaces, cultivated land and so on. The cultivated land recorded a reduction of -15.54% (Table 4.2) change. This could be due to buildings and fast growing and expansion of Jos. Public uses has been recorded to be 14.6% showing a decrease in the area due to growth of Jos city. It also recorded an annual growth of 0.04%. Roads have a record of 5.77% increase with 0.07% (Table 4.3) of its annual growth. The roads linked up all connectivity of the study area. Open spaces has a record of – 46.59% showing a decrease. This is due to increase changes in built – up area, and other categories respectively. The annual growth rate is 0.80% of the study area.

4.6 ACTIONS AND IMPLICATIONS

From the discussion, there are dynamic and static records of results in the categories. Built – up area has witnessed a tremendous increase changes in the study, trend. While a reduction in cultivated land reduced to minimum level. The implication of this action is that many have become subsistent farmers at the expense of fast growing population of the study area. Efforts have been made to reclaim the land which miners have disorganised and agricultural practices made impossible for several years ago. Other categories also have negative effect on cultivated land.

The mining ponds are spread in most part of the study area. The implication is that ponds are stagnant in nature and the large majority of

people use water in these ponds for domestic purposes while animals mostly pigs and cow drink from these ponds. Such development is likely dangerous to life existence. The open nature of the ponds is as well very dangerous to the user as most of the ponds are converted to fish farming – ponds, chemicals of various types may be used for fish catching which could be dangerous to living things that may use the water.

Another good implication is the open spaces of the study area which help reduce tension likely to affect Jos city. Many offices and house accommodation are cited in Bukuru. This is due to rocky nature of Jos where extension have become a big problem. However Bukuru has turned to be a satellite town of Jos which encourage competition and Co-operation among the people.

CHAPTER FIVE

5.0 SUMMARY RECOMMEDATION S AND CONCLUSIONS

5.1 SUMMARY

The landuse changes of Bukuru – Jos with assisted Computer and manual approaches has involved visual examining of the satellite image data which have been preprocessed to remove geometric distortions and radiometric errors.

Land use interpretation accuracy have also depends on the land use classification scheme which designed with regard to the cultural character of individual environments. The USGS scheme designed by Anderson et al (1976) has a valuable guide for the design. The concept of different levels of land use or land cover details interpretable according to the different scales of the imagery and hence the spatial resolution quality is adopted.

Computer utilization involve computer trade offs of time and resources against projected benefits. Computer is designed to minimize the time required for researcher.

Table 4.1 recorded a progressive increase of built – up area from 5.17% to 5.84% and 20.06%. Other categories such as open spaces recorded 78.19%, 37.63% and 25.67% which shows a decrease to. Bare rocks remains consistent with the figure 1. 84% score for the three periods. The rest categories in table 4.1 witnessed some changes either decrease or increase as they engulf each other in the process.

Table 4.2 revealed percentage changes between 1963, 1976, and 1991 of land use changes. Built – up area recorded a very high percentage increase of 45.70 and 70.84 respectively. While other categories like Bare rocks ponds remain unchanged with zero percent (0%) no change. The other category to note is the Roads. To the fact that built – up area has increase, the tendency for roads network to increase was expected. But due to railway and expansion of minor roads and reconstructions of major roads, even to the western bye pass make transport network % sore to be reduce. Open spaces and cultivated land are fast decreasing in the percentage scores. This could be attributed to fast population growth of Buuru where demand for land to build offices and residential accommodati is on the increase. Reservation area recorded a reducing 14.23% and complete zero 0% change. The decrease has great reservation is not giv necessary attention, desert encroachment is likely to be witnessed in the are study.

Table 4.3 gives the annual growth change in per ge to enable the researcher estimate the likely changes that can be pre . For instance built of area which had a percentage score of 0.21 betw 63 and 1976 had grown to 0. 95 for the period 1976 to 1991.The percentage growth let the researcher predict future occurrences.

5.2 RECOMMENDATIONS

The need to understand environmental resources, prob management is the duty of mankind. For that, the use of rem

technique (aerial photograph) is very useful for the study area Bukuru .In view of this, it is pertinent to make the following recommendations:

a. A comprehensive study is carried out so that it could match population growth to growth of the built up area so that modelling could be embark upon.

b. A spot satellite imageries should be studied to see its applicability, reliability and accuracy so as to reduce the cumbersome nature of aerial photo interpretation

c. To reduce the time and the task of interpretation and recommend that satellite imageries should be made available for computer analysis.

d. These satellite imageries should be used in GI S systems to provide a data bank for researchers interested in various aspects of the land use such as soil degradation, vegetation degradation and environmental impact analysis.

e. The periodical aerial photos should be collected and made available for use about 10 years so that a systematic studies of change can accurately be undertaken.

f. The government can use remote sensing to check and monitor direction of growths, types of growth and the proportion.

g. Government should protect forest area to avoid desert encroachment.

h. There should be soil test to anable the pressure on land therefore the fragility of the soil must be study to avoid failure of agricultural practices

i. Policy makers, land use planners and managers, meteorologist and farmers to hold seminars, symposia and workshops so as to reduce the environmental problem.

5.3 CONCLUSIONS

The use of computer and manual analysis have proved to be a viable tool in the study of land use changes. The future of the earth's dwindling resources rests on the ability to analyse data quickly and accurately and in a manner that the general public can understand.

The growing population of the study area uses land more intensively than expected. Infact urban land is used for urban activities than their rural counterparts. Land is both a resource and a property. However unlike most properties, the owners are restricted in its use by regulations. This leads to the notion that much of the value of urban land can be ascribed to public investments, institutional decisions and economic interdependencies of urban activities. Bukuru has its unique nature and plays a crucial role in human settlements of Jos.

It is also conventional wisdow that land use problems lies at the very heart of planning, building and managing human settlements. As such, severe competition, Co – operation and conflicts for land use often prevail in which Bukuru and Jos are not an exception .

Monitoring changes on land use from current data will certainly help to reduce and control much pressure placed on land. The use of aerial photographs with result discussions and finding will certainly help the local state and federal government take good measure to improve living standard by putting some infrastructures inplace. The study enlightens policy officials at all levels about the relevance of remote sensing techniques as a

cheat and quick means of finding solutions to environmental resources and its management.

Further research can be based on integrated physical development plan, upgrading poverty alleviation programmes transportation, housing programmes, and public social services delivery system are a few of the many areas of public needs which are influenced by and have effects on, urban spatial form and location. Because of the great complexity of urban systems like Bukuru, modelling may have great potentials as an aid to formulating and analyzing public programmes in these and other policy areas.

BIBLIOGRAPHICAL REFERENCES

1. Adefolalu, D. O. 1986 Regional studies with satellite data in Africa on desertification of the sudan sahel both in Nigeria in Proc ISLSCP con. Rome italy (Ero Ife. Ed) 430 –439

2. Adeniyi, P. O. 1985 Land use change analysis using sequential aerial photograph and computer techniques photogrametric engineering and remote sensing 46, 47 – 64.

3. Akinyede J. O. 1993 Remote sensing potential for the mapping of Geological, geomorphic soil features for road engineers purpose. Journal

4. Campbell J. B. 1983 Mapping the land aerial imagery for land use information . Resource publications in Geography – Association of American Geographers washington D. C.

. 1958 Erosion and sedimentation from aerial Photographs. Journal of Tropical Geography II 100 – 106

6. Gerald, G. G 1982 Mapping erosion with air photos pandromatic or black and white infrared. I. TC Journal 3, 309 –312.

7. Halilu, A. S. 1993 Identification of potential zones of shallow aquifers Niger State using spot satellite remote sensing. M. Tech, thesis federal university of Technology, Minna, Niger State.

8. Howard, J. A. 1977 "Satellite remote sensing of agricultural resources for developing countries. An international perspective"

9. John, et al 1977 A land use land cover classification system for use with remote sensing survey data, Geological survey professional paper 964

10. Jeje, L. K. 1986 Terrain analysis with special preference to land sat and padar imagery, Nisor publication N. 2 49 – 73

11. Jones, A. R 1986 "The use of thematic mapper imagery for Geomorphological mapping in arid and semi –aid environments: Proc, symp. On remote sensing for Res. Dev. And Enviro management, Enschede. Nether lands, 273 –279

12. Litchfield, N. 1980 Land use data their acquisition kenda ll publishers I owa, U S A and Ontario canada 79 –95

13. Myers, V. I. 1983 "Remote sensing application in Agriculture" Manual of remote sensing (ed.) R. N. colwel 2nd Edition, vol 11, American society of photogrametry, virgina 211 –228

14. Nelson, F. and Holben B. 1986, Identifying deforestation in brazil using multi resolution satellite data; international Journal of remote sensing 7 42 – 48

15. Nichols, J. E 1989 Monitoring the effect of dam construction on fasama cultivation using spot satellite imagery and sequential aerial photography Proc. of the National conference of the Nigerian society of remote sensing, Kano (in preparation) .

16. Okhimemhe, A. A. 1993 Assessment of environmental impacts on dam construction in Nigeria, a case study of Tiga dam in kano state. An unpublished M. Tech thesis F. U. T Minna

17. Olofin, E. A. 1980 Some effects of the Tiga dam on the environment downstream in the kano river basin. Unpublished phd thesis Bayero university kano

18. Omojola, A and Soneye Aso 1993 Application of photographic remote sensing and G I sub – system techniques for land use mapping in the middle sokoto river north western Nigeria –

Journal of Nigerian society of remote sensing vol. 1 No 1.

19. Paul, et al 1988 Environmental Change Analysis Landsat MSS Data Remote Sensing of Environment.

20. Poutton, E. C. et al Use of conventional panchromatic aerial photographs in range monitoring and range resource inventory, evaluation and monitory. Manual of remote sensing 453-455

21. Quadeer, M. A. 1981 Land use classification utilizing infrared scanning imagery, photogrametric engineering and remote sensing 303 – 314

22. Soneye, A and Ademola, M 1993 Applications of remote sensing and G I sub – system techniques for land use and land cover mapping in the middle sokoto river north western Nigeria pp 52. Journal of the Nigerian society of remote sensing maiden edition vol. 1 No1.

23. Verstappen H. T. 1977 Remote sensing in Geomorphology Elserrier.

24. Wacharachiti, 1985 Monitoring Landcover change by Principal

Component analysis of Multi – temporal landsat data Remote sensing of Environment.

25. Welch, R et al 1975 Land in north east china 1973. A view from landsat, map supplements No. 19 Annals of the Association of American Geographers Vol. 65, No. 4