REMOTE SENSING DATA FOR ASSESSING CAUSES OF RIVER FLOODING IN EKITI STATE : A CASE STUDY OF RIVER OSUN IN IKERE-EKITI

BY

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ABSTRACT

Throughout history of the earth, floods have been plaguing mankind and this is of intense interest in many riverine communities especially in Ikere-Ekiti. Most people do not understand why stream cannot manage to stay in their channels when high water comes. To many, it seems that nature is playing "dirty tricks" and in the past, the believe is that flood is usually caused by the wrath of gods. But, instead, this study seeks to understand the natural and human factors that cause river floods in Ekiti State with special reference to river Osun in Ikere-Ekiti. Efforts are also made to prevent deaths and lost of properties through floods in the area.

The remotely sensed data acquired for this study (aerial photograph of 1974 and LANDSAT MSS 1993) were visually interpreted and digitally interpreted respectively. A pragmatic classification cheme based on the classification for use with remote sensing data was employed (USGS anduse/Landcover classification system) for both aerial photograph and LANDSAT imagery. Area overed by each Landuse/Landcover type classified were calculated in hectares and statistically analysed y means of simple percentage. Also, the change dynamics for the period between 1974 and 1993 were alculated and statistically analysed. However, the remotely sensed data on climatic characteristics of e area are not available, hence the use of conventional data, which were equally analysed by statistical ethod. As a compliment to the remote sensing data used in the analysis, ground truthing data were qually employed to ensure that the interpretation of the data were of high precision and accuracy.

Analysis reveals that annual river flooding in the area does not only stem form rainfall but qually from a multivariate factors which include the expansion in the built-up area especially towards e floodplain; the presence of large barren land, orientation of the river basin; the extension of

agricultural practices at the upper course of the river; and deforestation. The implication is that flood occurrences and losses will continue in the study area if no practicable control is urgently effected on both the floodplain and at the upper course of the river.

Finally, the use of aerial photograph and Landsat MSS are found to be appropriate and effective for the understanding of both bio-physical and man-made causes of river flooding. However, much could be achieved than what is achieved here when high resolution sensory imageries like SPOTHRV and LANDSAT TM are used as these would aid clear identification of linear and other minor features owing to their fine resolution.

DEDICATION

Dedicated to the Glory of Almighty God.

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I am indeed grateful to the Almighty God who has in His infinite mercy spared my life and has given me the strength and courage to conduct this study.

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May the Lord in His infinite mercy reward you according to the measure.

A.O. Aladelokun

CERTIFICATION

This is to certify that this work, carried out by Aladelokun Adeniji Olawale has been read and recommended for the award of Master of Technology Degree in the Post Graduate School, Department of Geography, Federal University of Technology, Minna.

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APPROVAL PAGE

This thesis, certified by the candidate's supervisor has been read and approved for the partial fulfilment of the award of Master's Degree of Technology in Remote Sensing Application in the Post Graduate School, Department of Geography, Federal University of Technology, Minna.

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CHAPTER ONE

INTRODUCTION

1.1 <u>**Background to the Study:**</u>

A river may be defined as water moving towards sea level in a natural linear channel. Rivers obtain their water directly or indirectly from rainfall and other forms of precipitation. In other words, rivers are fed by: the immediate run-off of water during rains; sub-surface water issuing through springs and seepages; and the release of water held temporarily in swamps, lakes, snowfields and glaciers.

However, the seasonal variation in the volume of water of a river as stated by Robinson (1977) is determined by two major factors :

(a) Positive factors which are responsible for an increase in the volume such as the amount and nature of the precipitation, the impervious character of the surface over which run-off flows and the size of the drainage basin or catchment area, and

(b) Negative factors which cause a decrease in the run-off and therefore a decrease in the volume such as the amount of evaporation which takes place from the soil, vegetation and water surfaces or as a result of the porosity of the land surface.

There are other conditions often local factors, which may affect the nature of the discharge. For example the nature and character of the vegetation cover has a notable effect on run-off; where the plant cover is scanty, the run-off will be accelerated; where there is a thick forest cover, run-off will tend to be retarded and released gradually. In addition, steep slopes especially if the rocks are impervious, facilitates rapid run-off and so on. However, when the discharge of a river is too much than what the basin can contain, it often leads to flooding.

A flooding commonly is considered to be an unusually high stage of the river. It is sometimes further described as being a stage so high as to overflow the banks and innundate the adjacent lands.

(Wisler and Brater, 1976). In Wesbers New International Dictionary, a 'flood' is defined as

> "A great flow of water; ....especially, a body of
> water, rising, swelling, and overflowing land not usually
> thus recovered; a deluge; a freshet; an innundation". (p. 342)."

During flooding, however, large amount of water or run-off often overtops the banks of water course and flow into the floodplain, which is a desirable plate to locate home and business, these high flow generally cause damage and sometimes; injuries and deaths.

Floods vary greatly in intensity and duration depending on storm patterns, drainage basing characteristics and other factors. A thunderstorm, according to Hoggan (1982) on a small drainage basin may generate a flood with a very high peak flow but of short duration. But on a large basin outlet, storms association with warm fronts on the other hand are likely to be of lesser intensity but of much greater areal extent and larger duration. Other causes of river flooding include: Landuse pattern of the area, and bad planning as well as natural factors such as dam braking and volcanic activities.

However, the nature of floods and their impact depend on both natural and human-made conditions in the flood plain. Economic development and the installation of flood protection measures have political, economic and social dimensions as well as engineering aspects. Emperical analysis of floods must be of great concern and a thing to embrace as this will provide a sound technical basis for facilities design as well as for management decision making that must weight numerous other factors.

Meanwhile, there are many situations in which a better data base would improve our ability to assess our resources, make use of them, understand our environment, and so on. Again, when changes are so rapid, so extensive, and so numerous that their cumulative effort can produce unforeseen results, the kind of monitoring which has served in the past will no longer surface. Therefore, quantities and types of information here are unimagined. To have adequate appraisal of our resources on which to base plans for more ordered use, to be able to foresee incipent problems soon enough to make remedied action worthwhile, and to understand the natural environment well enough to be able to prepare for or modify it's diverse moods, our ability to collect information need to be improved. However, remote sensing offers the way out.

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

Remote sensing defined is

> "The acquisition of data and derivative of information about objects or materials(targets) located at the Earth's surface or in it's atmosphere by using sensors mounted on platform located at a distance from the targets to make measurements (usually multispectral) of interactions between the targets and electromagnetic radiation" (Harris 1987).

Also, from the words of Lillesand and Kiefer (1987).

Remote sensing is conceived as

> "the science and arts of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation" (p.2).

In a nutshell, therefore, remote sensing is concerned with the use of electromagnetic radiation to yield useful information. The major objective of remote sensing is to detect and record energy in a selected portion of the electromagnetic (EM) spectrum. Remote sensors acquire imagery by detecting or sensing levels of emitted and/or reflected radiation in various portions of the electromagnetic spectrum. The term "electromagnetic spectrum" is applied to all radiant energy that moves with the constant velocity of light in a harmonic wave pattern. (See figure 1.1).

However, remote sensed data are the information which are scientifically obtained of an object, area or phenomenon by a devise of electromagnetic energy. Remotely collected data are of different forms. These include variations in force distribution; acoustic wave distribution; or electromagnetic energy distributed e.g. a gravity meter acquires data on variations in the distribution of the force of gravity. Sonar like a but's navigation system obtained data on variations in acoustic wave distribution. Our eyes acquire data on variations in electromagnetic energy distributions. In this study, however, emphasis is placed on data from electromagnetic remote sensing of the earth resources. That is remote sensing that have earth resource observation as their primary operating objectives. e.g. the Landsat and SPOT series of Satellite.

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

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

Photograph as stated by Wiesnet, (1976) is the only one example of remote sensing, which

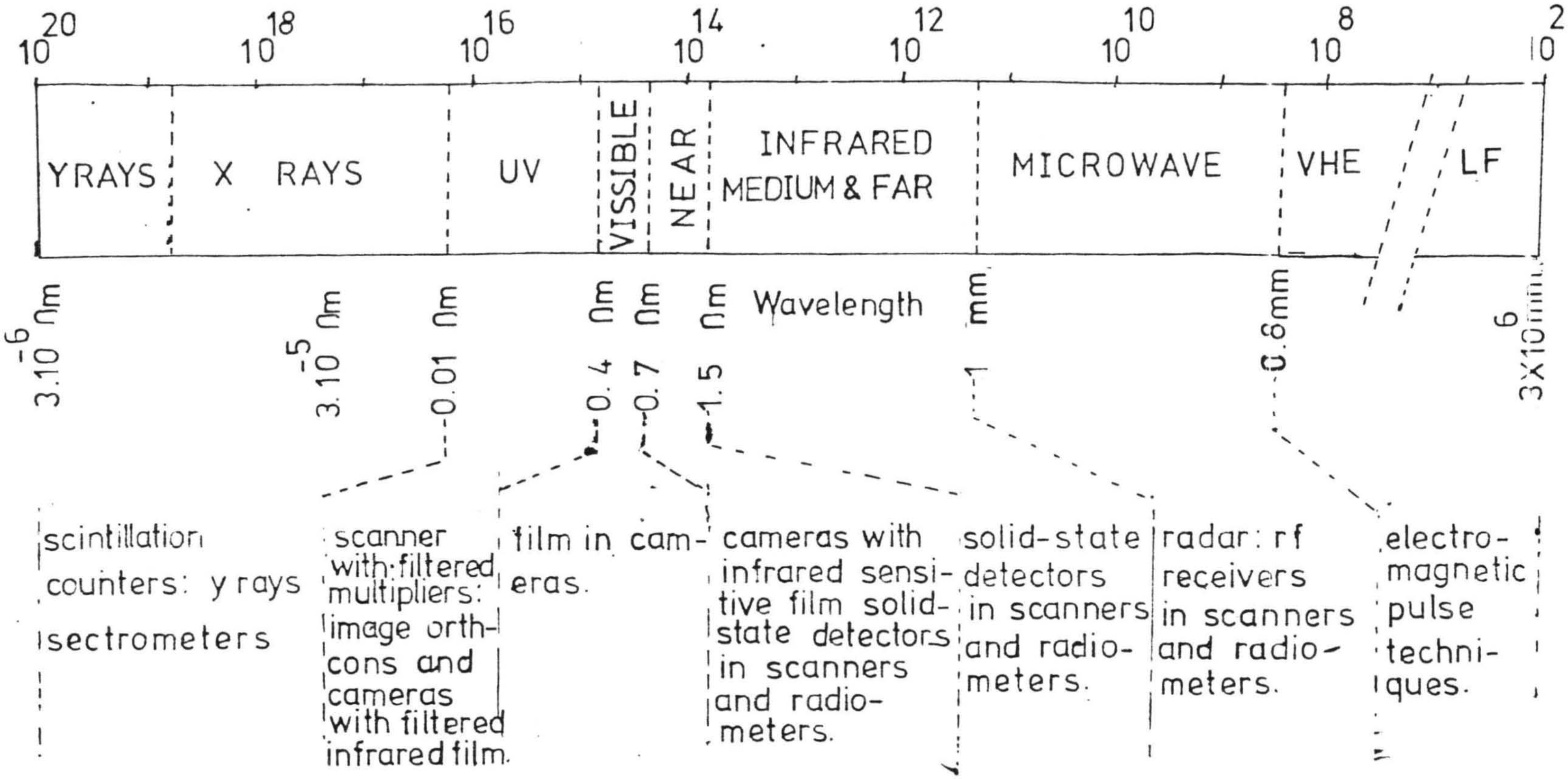


Fig. 1.1 The electromagnetic spectrum and some sensors that image in it (adapted from Ester and Senger, 1974).

senses in the optical portion of the electromagnetic spectrum. Other portions of the electromagnetic spectrum used in remote sensing are solar infrared, ultraviolet, near-infrared and microwave.

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

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

These among others include:

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

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

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

(iv) The data form suitable for computer processing.

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

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

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

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

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

1.2 <u>**Statement of the Problem**</u>:

Inspite of the innumerable value of the rivers (fishing, navigating, industrial and domestic uses etc) in Nigeria in general and Ekiti State in particular, cases of river flooding, have always been a common report yearly. Hence, river flooding is now becoming an endemic problem in many parts of the nation.

Going by the definition given by Olaniran (1983) which state that "flood is any high stream flow which overtops natural or artificial banks of a stream", then Ikere-Ekiti has been experiencing flooding virtually every year". Two people died in a flood incident of 1995 on river Osun in Ikere-Ekiti. Many buildings sited very close to the river banks have been deserted in some areas (field work, 1997), and in many occasions, Ikere - Akure road were rendered impassable at the point where the road cross the bridge on the river.

There are reports of similar unpleasant flood disasters in different parts of the state and neighbouring states. At Ado-Ekiti, about five residential buildings are completely abandoned owing to River Ajilosun annual floods. (Field work, 1997). At Igbemo Ekiti, rice farms were reported washed away in 1996 owing to flood incident on River Efo.

Of the flood events experienced in Nigeria are those of Ibadan which have attracted the greatest attention and have been most documented. In the flood events of October 19th, 1976 in Ilorin, 24 houses submerged under the flood water and about 56 others were evacuated at the third day (Olaniran, 1983). In June 1988, a three days constant rainfall in Lagos caused river Okin near Lagos University Teaching Hospital (LUTH) in surulere over-flowed its banks and rendered Ishaga road at the point impassable. (NEST, 1991). In September 1987 about 130,000 hectares of agricultural land were flooded in some parts of Cross river and Akwa Ibom States resulted from the overflow of Cross River banks.

However, flood incidents are not limited to extreme Southern part of the country. Kano State in the semi-arid sudan savanna environment was affected by floods in August 1988. In Niger State, crops estimated at more than ₦100,000 were washed away by flood in Gawu district of Suleja Local Government Area alone in 1995.

Meanwhile, the financial loss to the individual and corporate bodies directly affected is not only embarrasingly collosal but the psyctrical costs, to the people are uncalculable. Owing to costs, little research, if any, has been done to assess the remote and immediate causes of this unfortunate and avoidable disaster by river floods in the area of study, even where it is done, conventional method is employed. Again, according to Ward (1978)), floods are unique events in the sense that even identical flood generating mechanisms may result in very different floods from one catchment to another or, indeed within a given catchment from time to time. Thus, Ikere-Ekiti floods deserves a separate attention and this has motivated the present study.

1.3 **The study Aims and Objectives:**

In veiw of the stated problems, it is imperative therefore, to assess both natural and man-made incidence of annual river flooding in the area of study with a view to suggesting possible checks to such unwanted incidents of flood menance at present and in the future. The study, therefore sets out to achieve the following objectives:

(i) to evaluate the changes in landuse/landcover of the area;

(ii) to generate the statistics of the landuse/landcover distribution of the area;

(iii) to analyse the stream networks and channel slope; and

(iv) to analyse the rainfall intensity and duration of the area.

1.4 **The significance of the study:**

This work would be of great use to the entire nation as it would provide a frame work upon which individual, community as well as the government can build and expand to solving the problems of flooding.

Also, the work by its orderly and succinct treatment would provide a useful backgroud for further work for whoever desires to carry out similar reserach as an advancement to this study in the future.

1.5 **The Scope / Limitation of the study:**

This study covers river Osun basin in Ikere-Ekiti. Efforts would be made to analyse the following: Landuse/Landcover pattern of the area; the stream network and channel slope; rainfall characteristics such as mean annual rainfall; mean monthly rainfall for wet and dry seasons; and mean rainfall intencities of 0.4hr and 0.7hr. However, the satellite climatic data of the area cannot be procured, therefore, conventional data would be used.

1.6 **The Study Area;**

The study Area is located approximately between latitude 7° 28'N, 7° 32'N and longitude 5° 12'E, 5° 16'E. The town is bothered by Iju/Itaogbolu Local Government Area of Ondo state in the South; on the north by Ado-Ekiti; on the West by Ekiti South/West; and on the East, it adjoins Ise Local Government Area of Ekiti State. (See figure 1.2).

Meanwhile, River Osun takes its source from an upland named Udu located at the South/Western fringe of the town and it has many tributries like river Anaye, river Ikoyi and river Elekun to mention but a few. It flows estward direction and finally joins river Ogbese as one of the latter tributaries and it cut across two major types of vegetation viz: rainforest and derived savanna. The river is characterised by short drift flowing. Although there are several other rivers in the area, such as river Kogun, river Aodu and river Aiha to mention but a few, Osun is the largest and most important of them all. It is a perenial river and is note worthy for its annual flood usually during highest peaks of rainfall which occurs between the month of August and October, although this varies with years. It has a broad flood plain on which Fadama cultivation is practised.(see fig 1.3). It is locally used for domestic purposes and small-scale fishing is carried out on it.

Generally, the area enjoys tropical wet and dry type of climate, dominated by seasonal migration and pulsation of two air massses.The warm and tropical continental (cT) air mass from the Sahara which is associated with dry season; and the warm humid Tropical marine (mT) air mass from Gulf of Guinea influences the area during wet season. The wet season starts from February and ends around mid November with a short brake in July/ August, while the dry season lasts from November till February or March. Recent weather changes seems to have altered this regime.

The temperature, however, is high. It is usually higher just before the rains with an average of about 26°C for each month. The duinal range of temperature is between 4°C and 6°C.

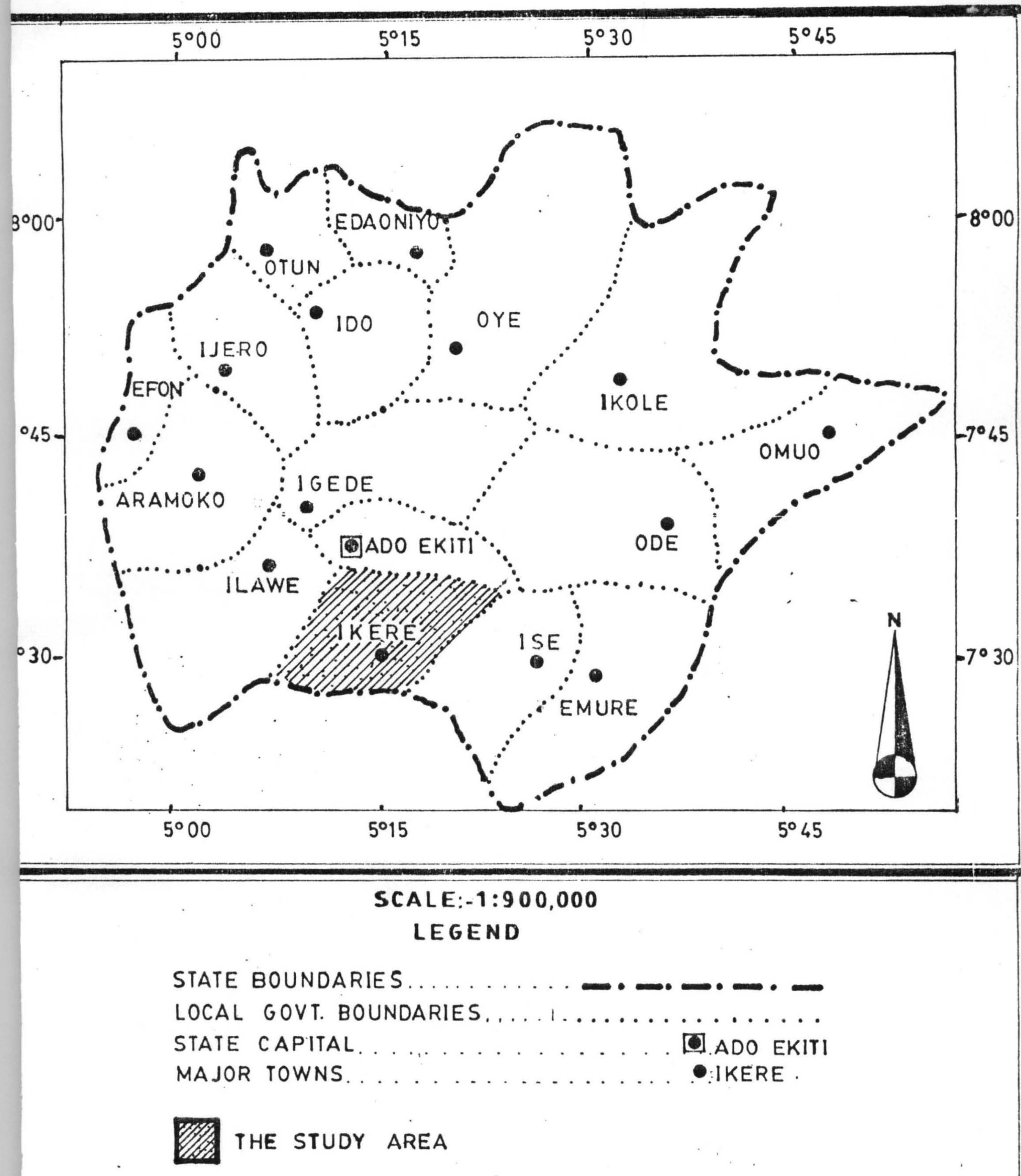


Fig 1.2: MAP OF EKITI STATE SHOWING THE STUDY AREA.

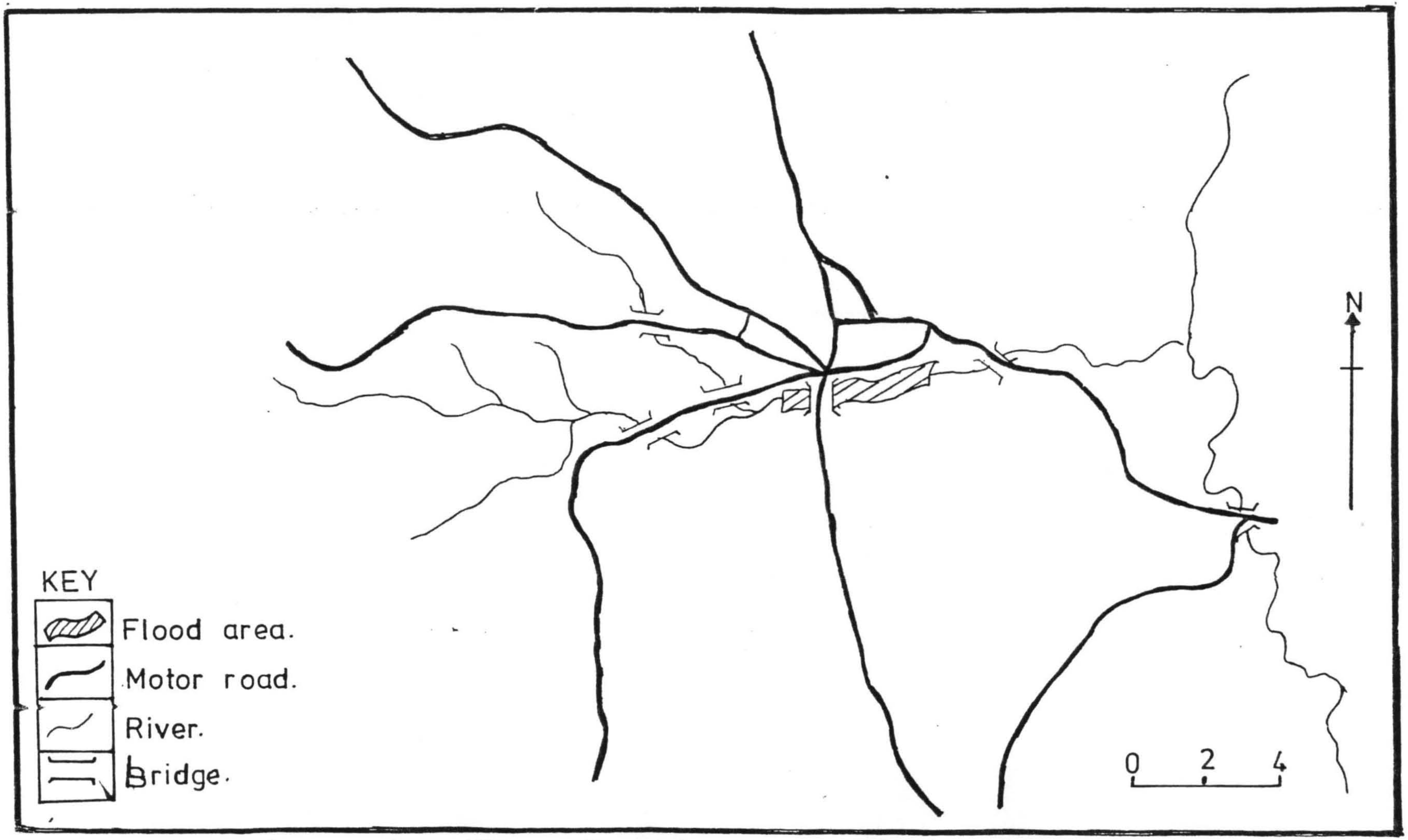


Fig1.3. Flood Areas along River Osun in Ikere-Ekiti.

CHAPTER TWO

LITERATURE REVIEW

2.1 Preamble

The major thrust of this chapter is review of related literature ot the area of study. Authors whose works were reviewed have dealt in one way or the other to assess the various factors responsble for flooding in various part of the world as a whole and Nigeria in particular.Obviously, much has not been done using satellite remote sensing data to assessing the incidence of flooding around the world and satellite remote sensing may be a relatively new term to some hydrology. Meanwhile, the concern of this review centres much on incidents of river floods in Nigeria and remote sensing and its application to river and floods as well as landuse/ landcover.

2.2 Incidence of flooding:

Floods result from a number of basic causes of which the most important are climatological in nature. These causes include:

Rainfall: Floods according to Gregory and Walling (1979) can be the result of high intensity rainfall and some climatic zones. Rainfall is, however,the most unversal causer of floods. That is when rainfall is heavy, execessively prolonged or both. For example a three days constant rainfall in Lagos caused river Okin near Lagos University Teaching Hospital (LUTH) in Surulere to over-flowed its banks in June 1988 (NEST, 1991). On the contrary, a smaller amount of rainfall may also produce flooding on ground that is already saturated with water. This is the situation at Ilorin as revealed by a study carried out by Olaniran (1983) "Flood Generating Mechnisms at Ilorin, Nigeria". According to him, heavy rain greater than 25.4mm / day induce floods when they occur in a month about three or more times during the period of moisture surplus at Ilorin.

Meanwhile, NEST (1991) has identified seven types of flooding in which climatological factors are only partly or indirectly responsible.

These are:

(a) ponding back of streamflow by using much in tides, particulally during spring tide condition;

(a) rivers and tributaries carrying water flows very much in excess of their transporting capacities due to concentration of runoff;

(c) main river barking up the water in their tributaries;

(d) peak floods occuring at the same time in a main river and its tributaries;

(e) heavy rainfall synchronicing with spill of rivers;

(f) inadequate and inefficient drainage of low-lying and flat areas to the outflow; and

(g) flooding of low lying coasts by execessively high tides associated with storm surge effects.

Natrual disasters as causer factors:- Flood may equally result from specific causes including drainage of sub-glacial lakes, volcanic eruptions beneath glacier causing bursts. (Gregory and Walling, 1968). This type is very uncommon in the context of Nigeria floods.

Man interference with balance nature :- The frequency of river floods may have been influended by human activities which can be either direct or indirect.(Gregory and Walling,1968). One major cause of flooding is man's interaction with his enviroment in the form of urbanisation, agricultural activites and deforestation. As urbanization intensifies natural surface are replaced by

buildings, paved roads, and concrete surfaces which do not allow water to percolate readily into grounds. The consequence is that a large proportions of the rainfall which should normally infiltrate into the soil or be intercepted by the vegatation and thus delayed for some time before running off is immediately available for surface run-off into streams and rivers making them flood. Incidents of flooding in Ibadan is a good example. As shown by Akintola (1978), the percentage of the city surface that was impervious to infiltration of water increased from 2.5% in 1949 to 28.4% in 1965. This according to him has in a great deal influenced the floods occurences in the city.

Dam is yet another form of man's activities with the environment to increase the supply of water or for generating of hydroelectricities or for irrigation scheme. More often, the failure of those structure infrequently as they may have resulted in floods. A typical example being the collapse of the Baguada Dam near Kano in August 1988 which had disastrous environmental consequences, (NEST, 1991).

Another human interference which result to flooding in Nigeria is the encroachment of building on the flood plains of stream and rivers flooding through towns and cities and deposition of waste materials in their courses do facilities flooding. According to Oyegun (1982) the growth of Ilorin has encouraged urban development within the floodplain of river Asa and its tributaries as a result of the pressure on land for Urban development. This has in no small measure accelarate river flooding in the area. Also Akintola (1982) declared that the flood incidence at Ibadan is also together with other factors resulted from waste deposition on river Ogunpa channels, which deposition obstruct the free movement of water along the stream channels.

Bad planning also causes floods in addition to the natural rain-induced causes. According to Lt. Col. Tony Asenuga as reporrted by NEST (1991) flooding in most cities in Nigeria is attributed to lack of well articulated concerning the plan and considering various aspects of the plan such as the waste, trafic and population. In the support of this statement, Akintola (1982) opined that the lack of adequate planning as well as inadequate drainage on most of Ilorin roads will probably accentuate flood tendency.

In a nutshell, flooding is not only becoming more frequent in our devastating environment over the past few decades, but the increasing frequency and severity do not stem from increased rainfall. On the contrary, rainfall amount have overall been on the decrease. Rather, flooding is in response to an increasing rate of urbanisation in the absence of well articulated and comprehensive physical planning and planning control. For example Ibadan a non-coastal city has been afflicted by more frequent and more damaging floods than many of our coastal cities as a result of bad planning.

2.3 Experience With Remote Sensing Application In Rivers And Floods:

In Gambia, LANDSAT Imagery showed clearly that the currents from the Gambia River carrying effluents from the city of Banjul for some portion of the year swing past the beach frontage for which a tourist development project was planned. LANDSAT scenes discribed offshore pollution problems also at two coastal tourist development sites inTurkey (NRC, 1974).

Flood mapping with LANDSAT imagery was demonstrated with conspicous success in the case of Mississippi River and Indus River (Pakistan) floods both in 1973. (IBRD, 1973). Also Satellite Imagery (ERST - 1 MSS) was equally used. Coastal flooding caused by hurricanes and typhoons as well as erosion and deposition along the affected coasts were mapped and monitored after the storms. NOAA - 2's scanning radiometer (SR) and very high resolution radiometer (VHRR) are constantly used. The flooded area was mapped precisely at a scale of 1:240,000. (Wiesnet 1976).

Patrick and Abdulhamid (1980) made use of photograph and questionnaire method to assess the impact of dam on agricultural productivity in Kano State. They used aerial photographs to map and predict floods, water locking and erosion risk. Also, Patrick (1987) used aerial photograph and rainfall data to assess the impact of gully erosion in some parts of Gongola and Bauchi States.

Factors that affect slope instability in an area near Sevenoaks (Kent) were monitored by Norman (1975) using Aerial photograph. Changes in catchment characteristics were monitored by Parry et al (1971) using infrared Aerial Photographs. All these studies obviously demonstrated the effectiveness and reliabilities of using photographs to analyse drainage basins.

2.4 **Experience with Remote Sensing Application in Landuse/Landcover Studies**:

Comparative analysis of two sets of - LANDSAT scenes covering the state of Orissa in India (dry season 1973 and Monsoon 1975) has yielded a substantial volume of landuse information of direct value to the status resources managers and agricultural planners. Two sets of scenes highlited the differences between dry and wet season agricultural pattern and identified promising areas for conversion to irrigated two-crop production. The data also indicated areas suitable for dams, showed the extent of forest culting in the highlands and coastal regions, provided a new base for checking the accuracy of crop acreage estimates done by conventional means, and showed the changing course of the Mahandi Rivers and its tributaries as well as major changes in sandbars, spite and Island along the coast (Weismulter, 1976).

In the case of Nigeria, various researchers have used remote sensing data one way or the other to study landuse activities in various parts of the country. Among these scholars is Adefolalu (1986), who have successfully used a combination of SLAR and Landsat data with groundtruth observations to study both the West African and Nigerian Landuse (vegetation) situation. His study recognised five major vegetal cover woodlands, grasslands, shrubland, farmland and forests. He, however, showed that two states in the Sahel Savannah, Borno and Sokoto State, 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. Human activities made situations in Kano and Kaduna State equally pathetic. Both States had between 68% and 82% of the total land under intensive agriculture. He also forecasted that at the early part of 1991 - 2000, arable land in the two states would be turned into shrubland vegetation and the sahel proper.

Okhimamhe (1993) made use of Aerial photograph and SPOT HRV - 1 imagery in landuse classification for change detection in Burumburum/Tiga area of Kano State. The results show that

38,897 hectares of change had taken place. Crop/pasture land, and wooded shrubland/thicket had decreased in magnitude while grassland/shrubland had increase by 104% between 1974 and 1986. There was also an increase in sandy area. The study has shown that the use of satellite imagery and aerial photographs could provide the bio-physical information necessary for monitoring and assessing the environment.

In his own contribution, Okonny (1993) studied the Nigerian Coastline by comparatively analysing Side Looking Airborne Radar (SLAR) imagery and aerial photographic of 1977 and 1964 respectively. This analysis revealed that small scale sand pits and beach ridges had been formed overtime. These coastal features were an indication of a relatively slow depositional rate because the damming of the upper reaches of River Niger had trapped sediment. As a result, longshore depositional currents capacity was greater than the rivers discharge potential.

Employing the capabilities of digital and visual analysis of Landsat MSS for identifying, classifying and monitoring the impact of dam construction in the Sokoto/Rima Basin, North Western Nigeria, Adeniyi (1988) classified landuse and landcover types using maximum likelihood procedure and the standard visual analysis procedure to investigate the changes in the dam site areas. Landsat MSS was found suitable for rapid classification and monitoring of the agricultural resources of the area at a regional scale. Significant changes in Landuse and Landcover were identified especially in the flood plain, and the downstream areas of the dam. Landuse planning, rural and urban growth studies, rural transportation planning and desertification studies could be based on the regional thematic map produced. It was concluded that the combined use of digital and visual analysis of a higher resolution data e.g. SPOT (HRV) would provide baseline data for detailed agricultural resources planning and management. However, these must be acquired at more appropriate dates and intergrated with the local socio-economic system through the application by Geographic Information System (GIS).

CHAPTER THREE

METHODOLOGY

3.1 **Preamble:**

This chapter deals with the methodology employed by the reseacher. The study is a descriptive/exploratory research dealing with Remote Sensing Data for the assessment of causes of annual river flooding in Ekiti State with special reference to River Osun in Ikere-Ekiti. The methodology includes research instrument, data collection procedure and data analysis techniques.

3.2 **Research Instrument**:

To elicit the necessary information on the incidence of annual river flooding on river Osun, the following remote sensing instruments are involved.

(a) Standard satellite Image of LANDSAT(Multispectral sensors) produced for Ondo State Government, Project Management Unit (PMU), ABB - Assisted Agro - Climatological and Ecological Zones Study of Ondo State;

(b) Topographic map sheet;

(c) Aerial Photograph (Black and White);

(d) Computer Hardware and Idrisi Software Algorithm by windows; and

(e) Other instruments including magnifying glass (stercoscope) plastic overlays (transparency and tracing sheets), rotring pens, colour pens, stencils, diskette etc.

3.3 **Data Collection Procedure**:

The data selected for this study consists of Landsat Imagery (Multispectral Sensors) sheet number 264NW, acquired in 1993 from the Climate Change Centre, Federal University of Technology, Minna; Topographic map produced in 1966 by Federal survey in Nigeria with the scale of 1:50,000 sheet number 264 NW, obtained from Ministry of Works, Land and Housing, in Ondo State; and Aerial photograph with the scale of 1:50,000 taken in 1974 which is equally obtained from the Ministry of Works, Land and Housing, Akure. These data are complimented by ground truth data which are obtained during field trip to the area.

It is believed that the available data are sufficient for the study since they effectively cover the area of concern.

3.4 <u>Data Analysis Techniques</u>:

Simple statistical mean and percentage will be used in the analysis. The base map for change detection will be prepared from topographical map sheet onto a clear acetate paper.

The Aerial photograph will be manually interpreted with the aid of mirror stereoscope. Finally, the LANDSAT image will be digitally interpreted and data classified using the supervised maximum likelihood classification. Meanwhile, in the cause of the analysis, the ground truthing exercise serves as check and as well will aid the identification of some features that are not very clear during both visual and digital interpretation of the data.

3.5. <u>Manual Interpretation and Classification of Aerial Photograph:</u>

The analysis and manual intepretation is done using image elements as tone/colour, pattern, texture, shape, size and site/association. The Landuse/Landcover categories will be interpreted using the mirror stereoscope. The interpreted feature will be transferred on the base map created from topographical map sheet.

A pragmatic classification scheme based on the classification for use with Remote Sensor Data will be used. The spatial resolution of LANDSAT (MSS) image and the desired results also will be considered in the classification scheme. In situation where a complex pattern of extremely small units are encountered, generalisation is performed and the predominant category present within each percel labelled. The Landuse/Landcover classes is identified by two-digits symbols or codes indicating that primary categories (Level 1) and secondary categories (Level II) of Landuse/Landcover will be interpreted from both aerial photograph and LANDSAT images. The landuse/landcover classes used for mannual and digital classification is given in table 1.

Table 3.1: The USGS Landuse/Landcover classification System used.

Major Landuse and Landcover classes	**Manual Classification**	**Digital Classificaiton**
1. Urban or built-up Land	11. Residential	Residential
	12. Commercial and Service	Commercial and Service
	13. Transportation and Communication	Transportation and Communication
2. Agricultural Land	21. Cropland	Cropland
	22. Other Agricultural Land	Other Agricultural Land.
3. Rangeland	31. Shrub and brush rangeland	Shrub and brush land.
	32. Mixed rangeland	Mixed rangeland
4. Forestland	41. Decidious forestland	Decidious forestland
	43. Mixed forestland	Mixed forestland
5. Water	51. Streams and canals	Streams and canals
6.. Wetland	62. Non-vegetated land	Wet-Vegetated wet land
7. Barrenland	71. Bare exposed rock	Bare Exposed rock
	72. Transitional areas	Transitional areas.

Proportion of Landuse/Landcover classes obtained will be calculated using the dot grid method. A systematic field checks for accuracy assessment of the map interpreted will be carried out.

3.6 Computer Assisted Classification of Landsat Image:

The LANDSAT imagery will be scanned for computer assisted analysis and interpretation, at Imam Business and Computer Centre, Abuja. Equally an Idrisi Algorithm (Software Programme) at the centre will be used for the image interpretation.

A computer assisted image classificaiton will be done using the classes shown in table 3.1. A description of the spatial and spectral charatistics of these landuse/landcover classes when observed in LANDSAT MSS image will be presented. The classification will be done using maximum likelihood classification system.

The maximum likelihood classification scheme will be quantitatively evaluated both the variance and correlation of the category - response patterns when classifying an unknown pixed. However, prior to the classification, a confussion matrix to measure the statistical separation between category response pattern for all parts of classes will be automatically calculated, so that re-classification either by discharging or by merging of areas below minimum standard of 75% will be done.

The computer will automatically compute areas in hectares. The change dynamics for the period between 1974 - 1993 will be calculated. Meanwhile, field survey to identifying cultural and natural features for the landuse/landcover classificaiton will be undertaken at least to familiarising oneself with the study area.

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF RESULTS

4.1 **Preamble**:

In this chapter, the analysis and discussion of the finding are made. This, however, is based on the objectives of the study as stated in chapter one. Meanwhile, the following sum themes are addressed viz: Interpretation of 1974 Aerial Photograph; Computer - Assisted Classification of Landsat MSS image; changes between the period of 1974 and 1993; River Osun catchment and Streams Network; Climatic characteristics over Osun catchment.

4.2 **Interpretation of Aerial Photograph**:

The interpretation of the Aerial photograph is carried out manually (visually). No ground truthing was carried out as regard the interpretation owing to time lag between the present condition of the area and what were the situations as at that time the photograph was taken. I am quite sure that the interpretation is not too far from ideal landuse/landcover of such area (humid part of Nigeria)

Meanwhile, from the photograph, it is interpreted that about 10.95% of the total area under study was made up built-up area. Agricultural land formed about 25.59% and Rangeland was just 13.16% of the total area.

Along side of the river basin especially the flood plains and in some other places were wetland with vegetation and non-vegetated, which formed about 8.01% and 3.42% respectively. However, the streams and canals sumed up covered a total area of about 23 hectares or 4.33% of the total area.

All together, barenland occupied about 1382 hectares or 18.24%. This is composed of bare exposed rock and transitional zones which formed 13.62% and 4.6% respectively. This is an indication that the area is very rocky.

These all together form the situation of landuse/landcover of the study area in the year 1974

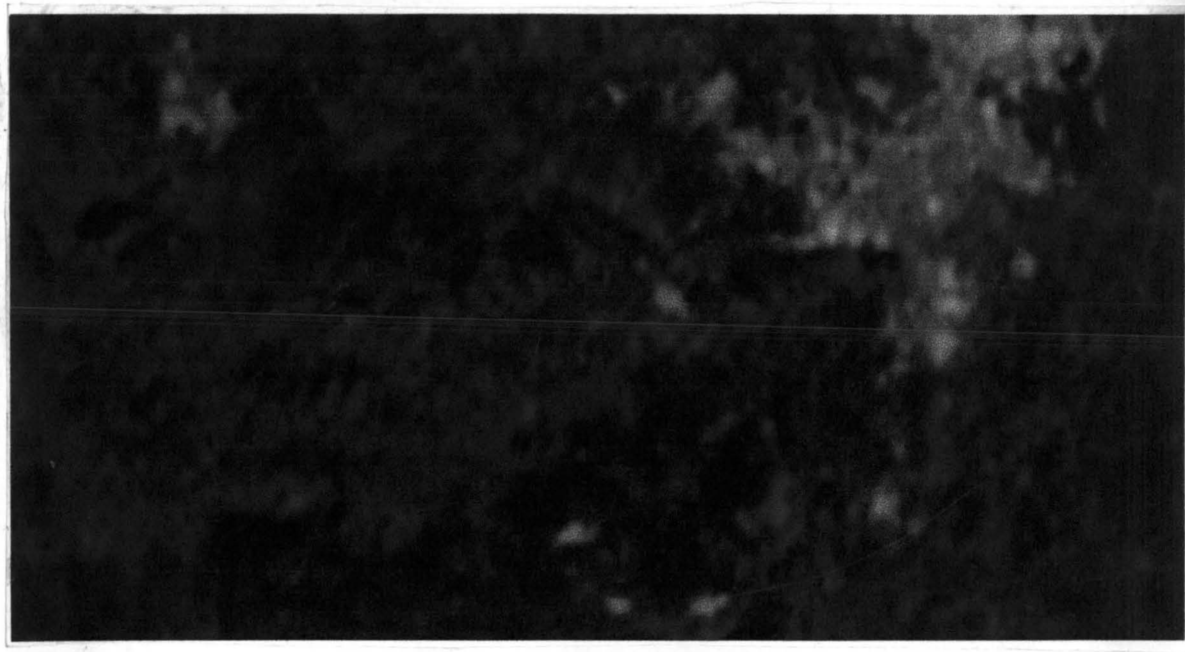


PLATE 1: COLOUR COMPOSITE OF LANDSAT MSS IMAGE OF THE STUDY AREA (1993).

MSS DATA :- Red = MSS 4
Green = MSS 2
Blue = MSS 1.

as interpreted from Aerial photograph taken at that time.

4.3 **Computer-Assisted Classification of Landsat MSS Image:**

The Landsat MSS imagery for the computer assisted Landuse/Landcover classification of the study area is displayed in plate 1. The classification, however is based on maximum likelihood classification and this is believed to be very accurate.

From table 4.1, Agricultural land takes the lead with about 1643 hectares or 22.65% of the total area. This is found scattered over the place. However, this is followed by the build-up area with about 1560 hectares or 21.51% of the study area. Also there is the barren land composed of the exposed rocky area and transitional zones with 14.98% and 5.49% respectivley, but sumed together give about 20.45% as barenland. (See plate 2).

Others include the rangeland which occupied about 7.61% of the total area, the wetland made up of vegetated wetland and non-vegetated wetland which occupied about 8.48% and 4.52% repectively. (See plate 3). Also there is the streams and canals which formed about 4.65% of the study area.

This again describes the situation of the area in 1993 when the satellite photograph was taken. It however shown some changes in the landuse/landcover of the area.

4.4 **Changes between the period of 1974 and 1993:**

From table 4.2, it is clearly shown that lots of changes have occured between the period of twenty years in in the study area. The built-up area has increased by about 96.44% over the years with annual estimate rate of increase of about 4.82%. This somehow indicates that people increases in number and this calls for expansion. Also there is an increase in the area of Agriculture by about 38.87%. This equally stems from the increase in population which calls for expansion of agricultural practices in the area. However, in the forested area as well as in the rangeland,

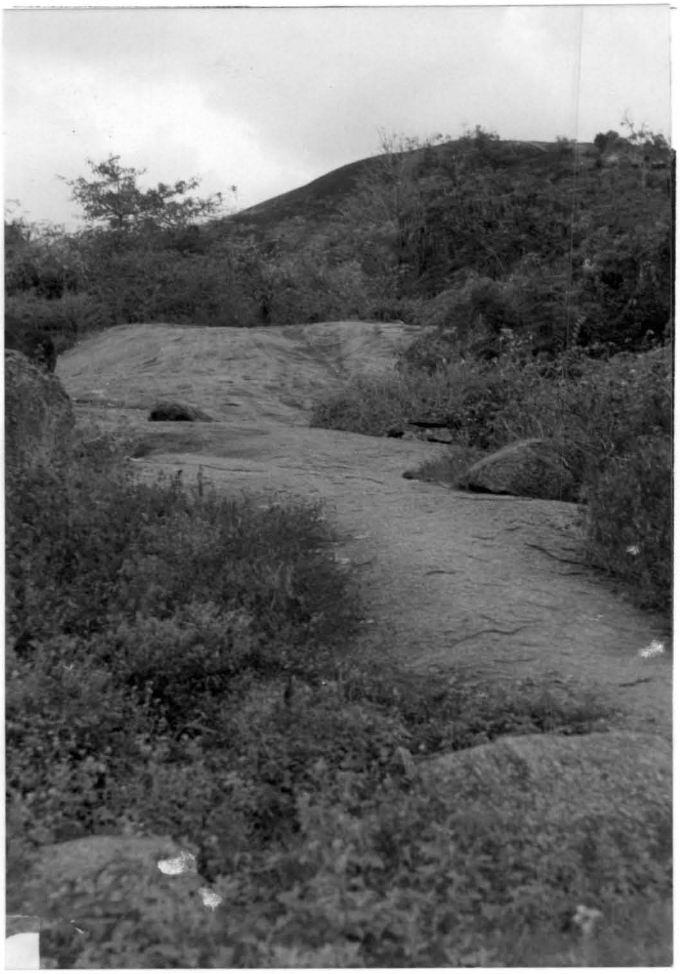


Plate 2. Photograph showing bare exposed rock.(a cross section of the study area).

S/N	Landsuse/Landcover categories	1974 Area in Ha(A)	1993 Area in Ha(B)	Magnitude of change in ha	Remarks
1.	Urban a Built-upland	794	1,560	766	Increase
2.	Agricultural Land	1,182	1,643	461	Increase
3.	Forest Land	1,855	735	-1,120	Decrease
4.	Range land	955	551	-404	Decrease
5.	Streams and canals	314	337	23	Increase
6.	Wetland				
	- Vegetated Wetland	581	615	34	Increase
	- Non-Vegetated Wetland	248	328	80	Increase
7.	Barrenland				
	- Bare exposed rock	988	1,085	97	"
	- Transitional Area	335	398	63	"
		7,252	7,252	3,048	-

Table 4.1: Aerial distribution of landuse categories magnitude of change (Increase or decrease) between 1994 - 1993.

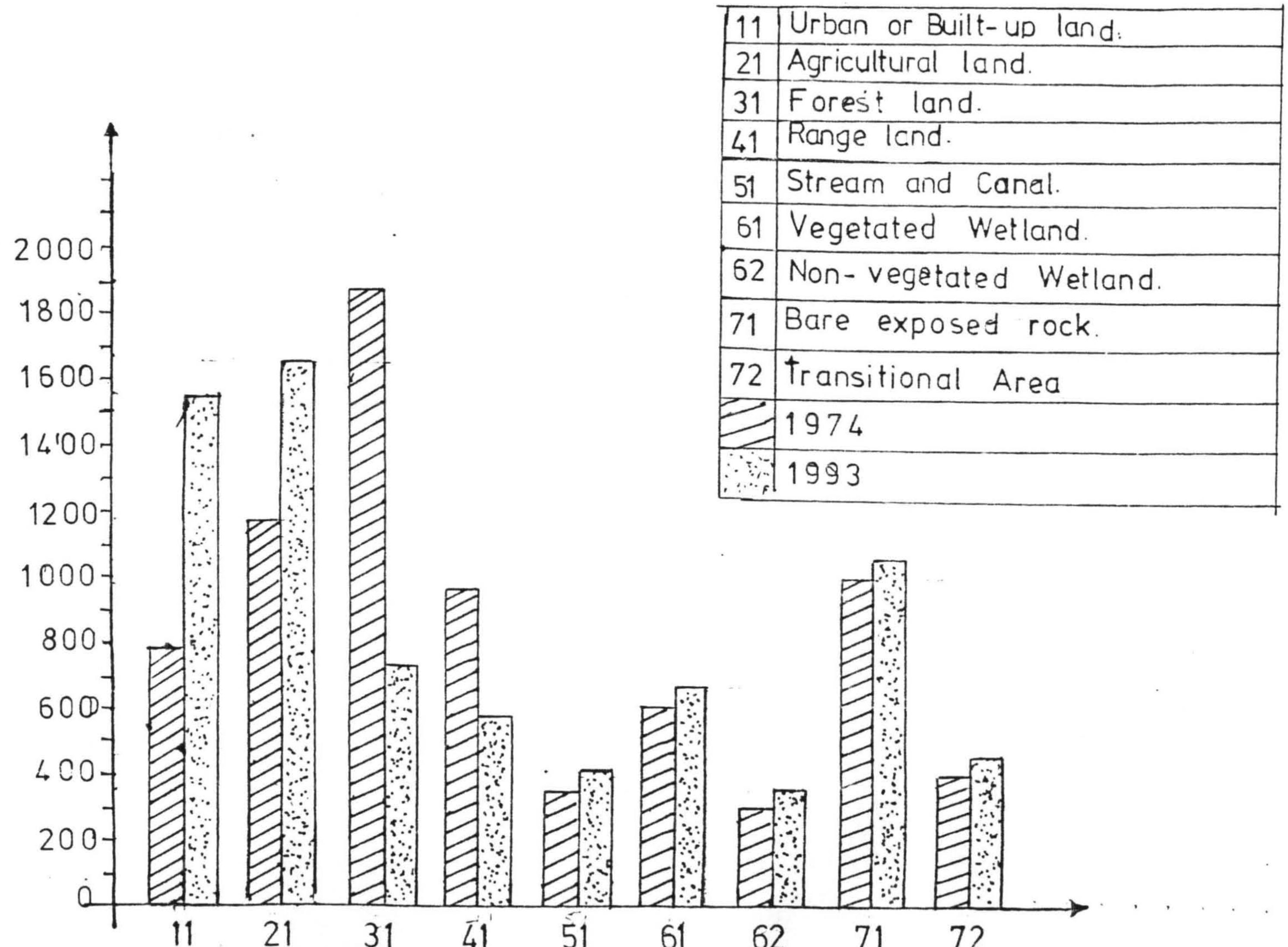


Fig. 4.1 RELATIVE LANDUSE/LANDCOVER IN OSUN RIVER AREA

S/N	Landsuse categories	1974% Distribution (A)	1993% Distribution (B)	% Change B-A x 100 ------ ----- A 1	Estimate Annual Rate of change %
1.	Urban a Built-upland	10.95	21.51	96.44	4.82
2.	Agricultural Land	16.31	22.65	96.44	1.94
3.	Forest Land	25.59	10.13	60.41	-3.02
4.	Range land	13.16	7.16	-42.17	-2.11
5.	Streams and canals	4.33	4.65	7.39	0.37
6.	Wetland				
	- Vegetated Wetland	8.01	8.48	5.87	0.29
	- Non-Vegetated Wetland	3.42	4.52	32.16	1.61
7.	Barrenland				
	- Bare exposed rock	13.62	14.96	9.84	0.49
	- Transitional Area	4.62	5.49	18.83	0.94

Table 4.2: Percentage distribution of landuse categories and the estimates annual rate of change.

a reduction in land area covered was witnessed i.e. the forested land has about 60.41% decrease of the former size while rangeland witnessed a reduction of about 42.17%. This of course has to do with the expansion experienced from build-up area as well as in the field of Agriculture and in other areas. All are as a result of the increasing population.

Streams and canals also witnessed an increase of area covered by about 7.39% with the estimate annual average of about 0.37%. The wetland composed of vegetated wetland and non-vegetated wetland equally witnessed an increase in size of about 5.87% and 32.16% with an estimate annual rate of about 0.29% and 1.61% respectively. Although there may have to be a decrease in size with respect to non-vegetated wetland during dry season as a result of evaporation and some other factors.

The baren land also show increases in the respective categories. From the part of bare exposed rock, about 9.84% increase was recorded with estimate annual rate of about 0.49%. The transitional zone has an increase of just about 18.83% with the estimate annual rate of about 0.94%.

However, the proportion of the change within each class to the overall change is shown by table 4. This clearly shows that the built-up area is about 25.13% of the total change, Agricultural land is 15.12%, wetlands show 1.12% as change in vegetated wetland and 2.62% from non-vegetated wetland. Bare exposed rock and transitional zone have about 1.12% and 2.62% respectivley, while streams and canals show only 0.75% of the total change. Nevertheless, a negative change of about 36.75% and 13.25% were recorded in the forested land and rangeland respectively. Meanwhile, the total change recorded is about 3048 hectares or 42.03% of the entire study area. The highest change recorded whatsoever from the built-up area with 25.13% while the least change is from streams and canals with 0.75%.

S/N	Landuse category	Magnitude of change in Ha (C)	Change (%) of each class C/Total x 100		Remarks
1.	Urban a Built-up area	766	25.13		Increase
2.	Agricultural Land	461	15.12		Increase
3.	Forest Land	-1120	-36.75		Decrease
4.	Range land	-404	-13.25		Decrease
5.	Streams and canals	23	0.75		Increase
6.	Wetland				
	- Vegetated Wetland	34	1.12		Increase
	- Non-Vegetated Wetland	80	2.63		Increase
7.	Barrenland				
	- Bare exposed rock	97	3.18		"
	- Transitional Area	63	2.07		"
		3048	100.00		

Total change (Decrease and increase) amounted to 42.03% of the total area 3048.

Table 4.3: The Proportion (rate) of change of each class to the over all change.

11	Urban or Built-up land.
21	Agricultural land.
31	Forest land.
41	Range land.
51	Stream and Canal.
61	Vegetated Wetland.
62	Non-vegetated Wetland.
71	Bare exposed Rock.
72	Transitional Area.

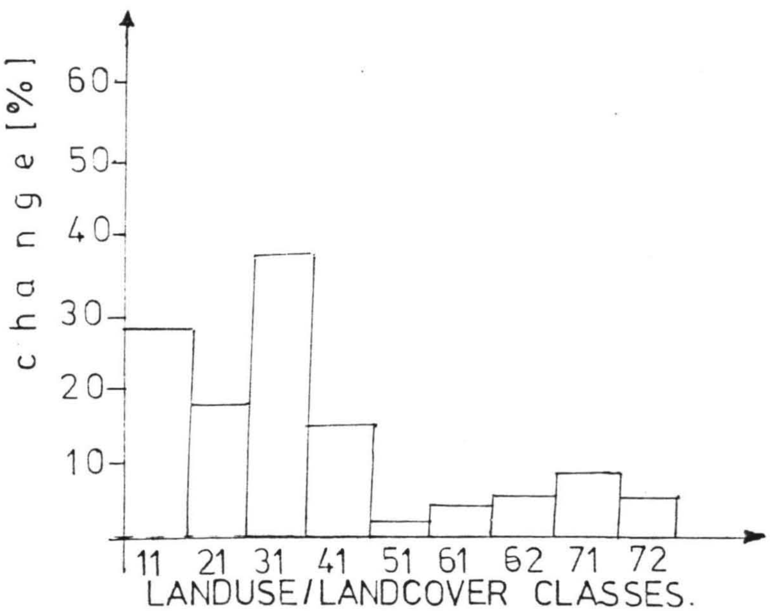


Fig.4.2 Percentage distribution of proportion of each landuse/landcover change to the overall change

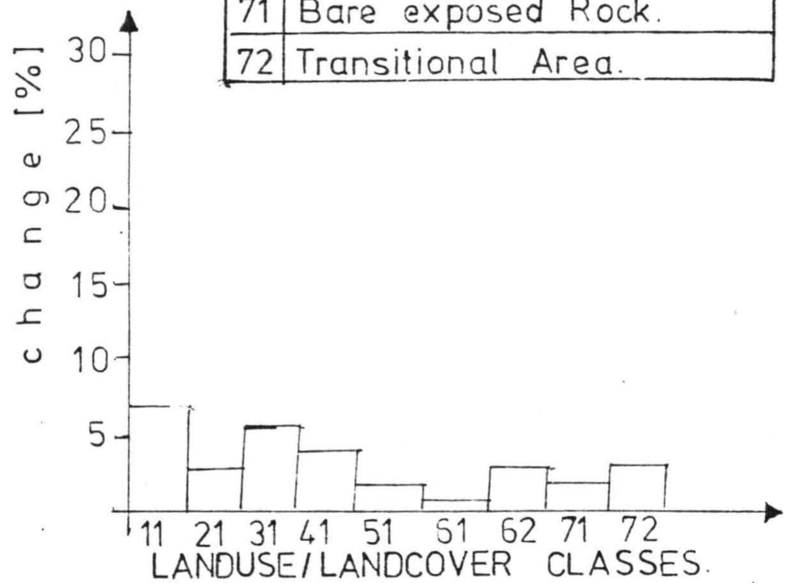


Fig.4.3 Estimated annual rate of land-use/landcover change for 20 years.

Plate 3. Photograph showing vegetated and non-vegetated wetland.(a cross section of the study area).

4.5. **River Osun catchment and streams networks**.

Figure 4.4 shows river Osun catchment with its network of streams. In outline, the basin is elongated and thus less vulnerable to flooding in comparison to a basin with circular shape. However, the location of the built-up area around the floodplain is quite symbolic for peak flow; in prolonged rainfall condition. The coalescence of flood flows from a number of major tribulatries long the drainage basin nay cause sharp high magnitude flood peaks at the basin flood plain.

Analysis of some aspects of the river network and channel slope reveals that the tributary streams of river Osun are comparatively short in length, occupy shallower valleys. It is believed, therefore, that they have a greater flood potential (See table 4.4)

	d Stream lenght (km)	e1-e2 Heigth Descended(m)	e1 -e2 --------- d Mean channel Gradiants
A: Main River	24.00	105.50	1:227
B: Tributaries			
(i)	5.10	53.40	1:96
(ii)	6.70	68.60	1:97
(iii)	3.85	38.10	1:101
(iv)	1.80	38.10	1:47

Table 4.4: Stream length, Valley Dept and Mean channel Gradient of Osun river and some of its tributaries.

4.6 **Climatic Characteristics over Osun River catchment:**

Obviously for a location like Ikere-Ekiti within the tropical region latitude 7°30N and Longitude 5°15E, flood will be rainfall induced.

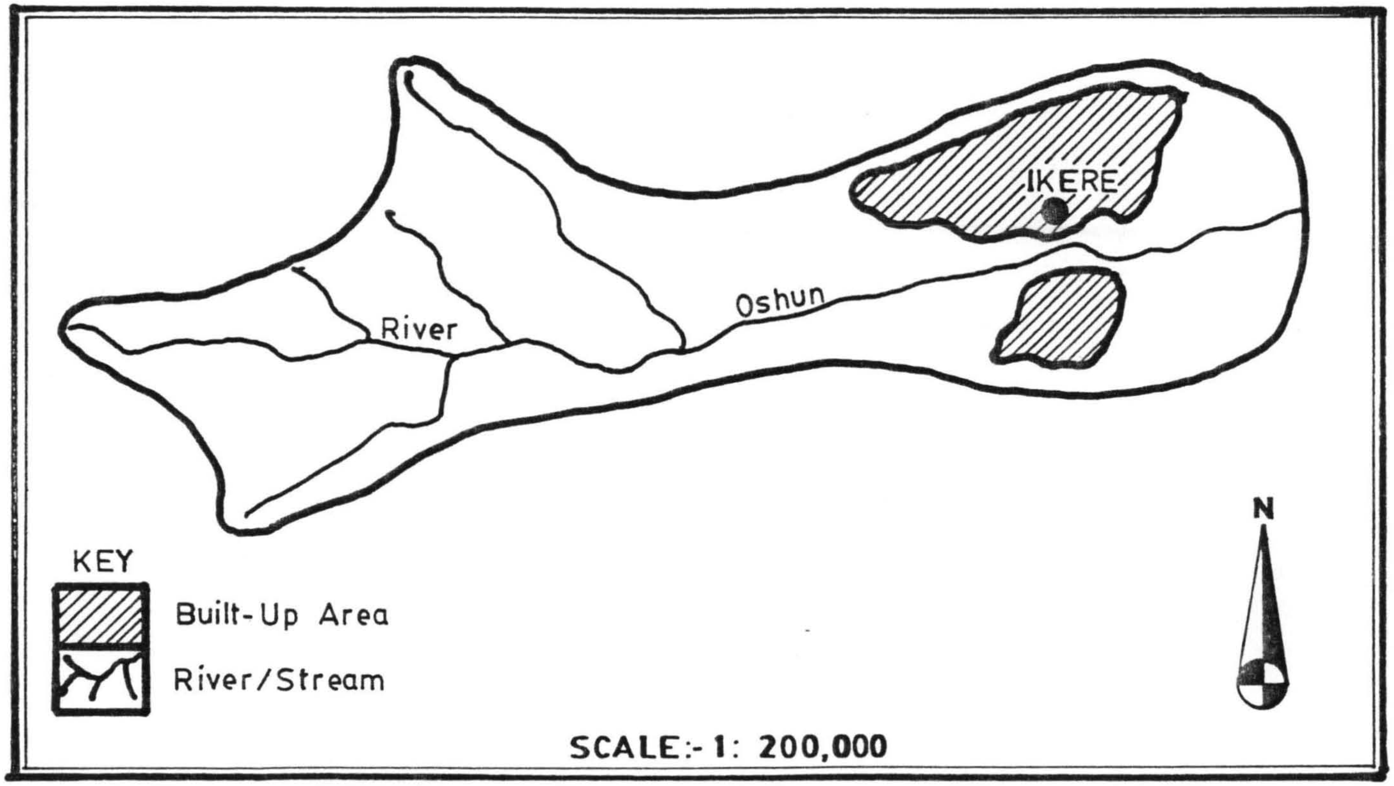
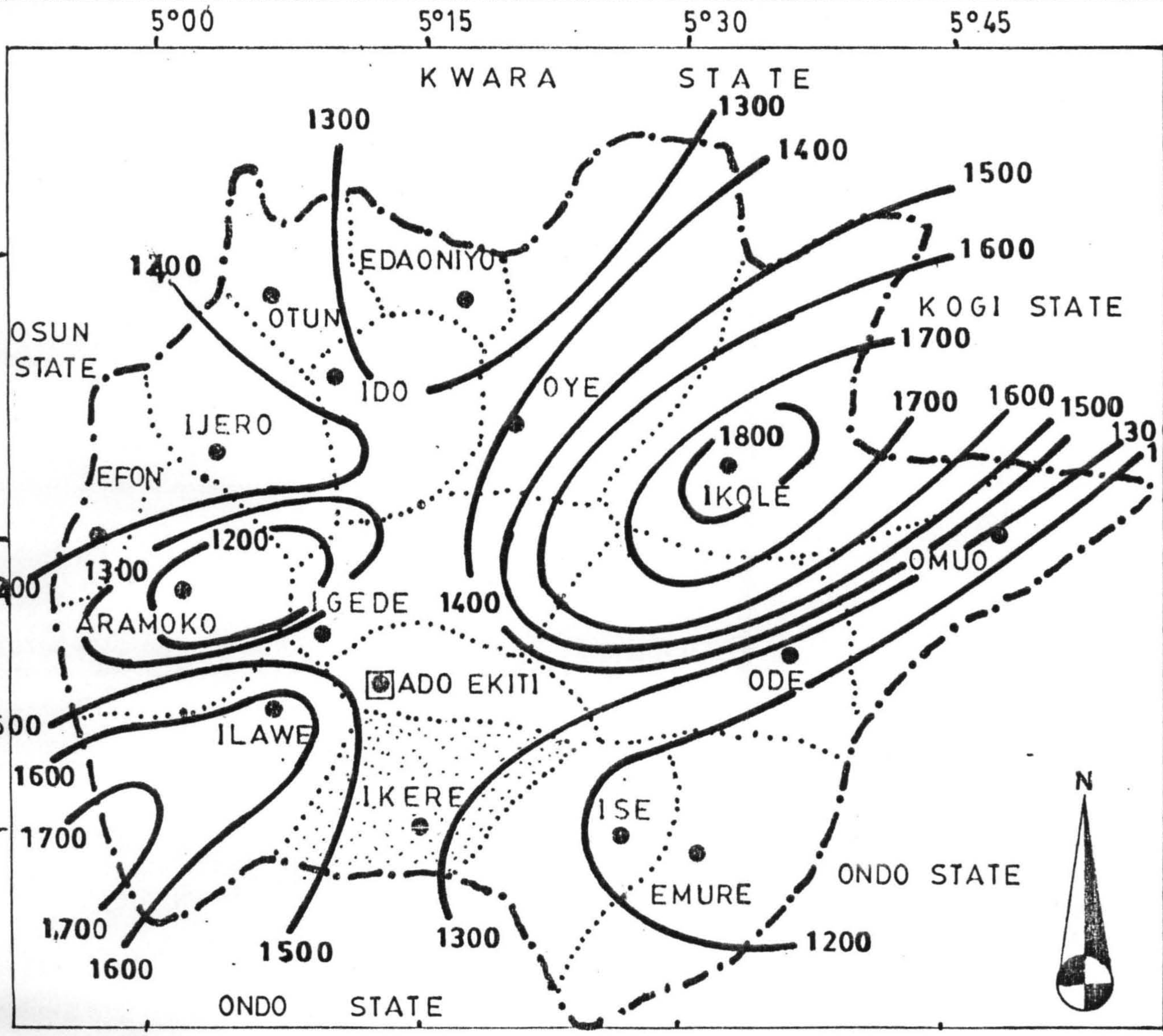


Fig 4.4 CATCHMENT AREA OF RIVER OSHUN

Mean while, the mean annual rainfall in the area is between 1,500mm to 1,700mm. The mean rainfall during wet season (April - October) ranges, between 1,300mm to 1,500mm, while the mean rainfall during dry season (November - March) is just above 200mm. This is an indication that with high magnitude of rainfall during raining season, flash flood is only destined to occur during that period and not during dry season. (see figures 4.5, 4.6 and 4.7).

In addition, averaged rainfall intensity patterns based on 0.4hr records and 0.7hr records are analysed. As may be expected, rainfall intensity (RI) values for 0.7hour are higher than those of 0.4hour with intensities ranging from 70 to 80mm for the former, while in the case of 0.4hour, values are 25 to 70mm. Flash flood is then expected to occur in the area (see figures 4.8 and 4.9). Rainfall intensities are highest about the onset and retreat of the rains. This is probably due to the fact that such rains are accompanied by line squalls and thunderstorms. The heavy rains, however, have high flood potentials.



SCALE:-1:900,000

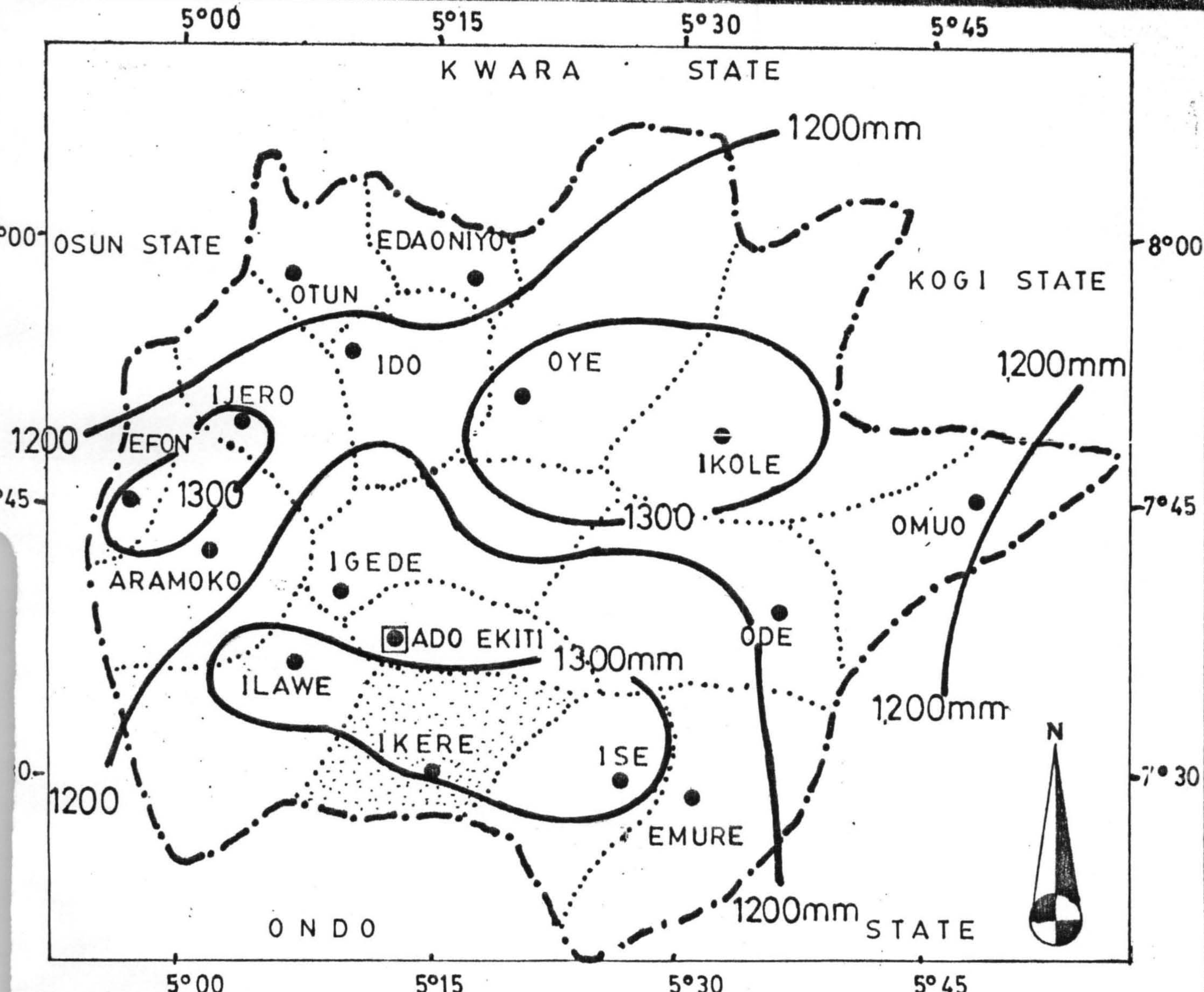
LEGEND

STATE BOUNDARIES
LOCAL GOVT. BOUNDARIES
STATE CAPITAL .... ADO EKITI
MAJOR TOWNS .... IKERE

THE STUDY AREA

Fig.4.5 Mean Annual Rainfall in (mm) in Ekiti State.

Adapted from Adefolalu et al (1995).



SCALE:-1:900,000

LEGEND

STATE BOUNDARIES

LOCAL GOVT. BOUNDARIES

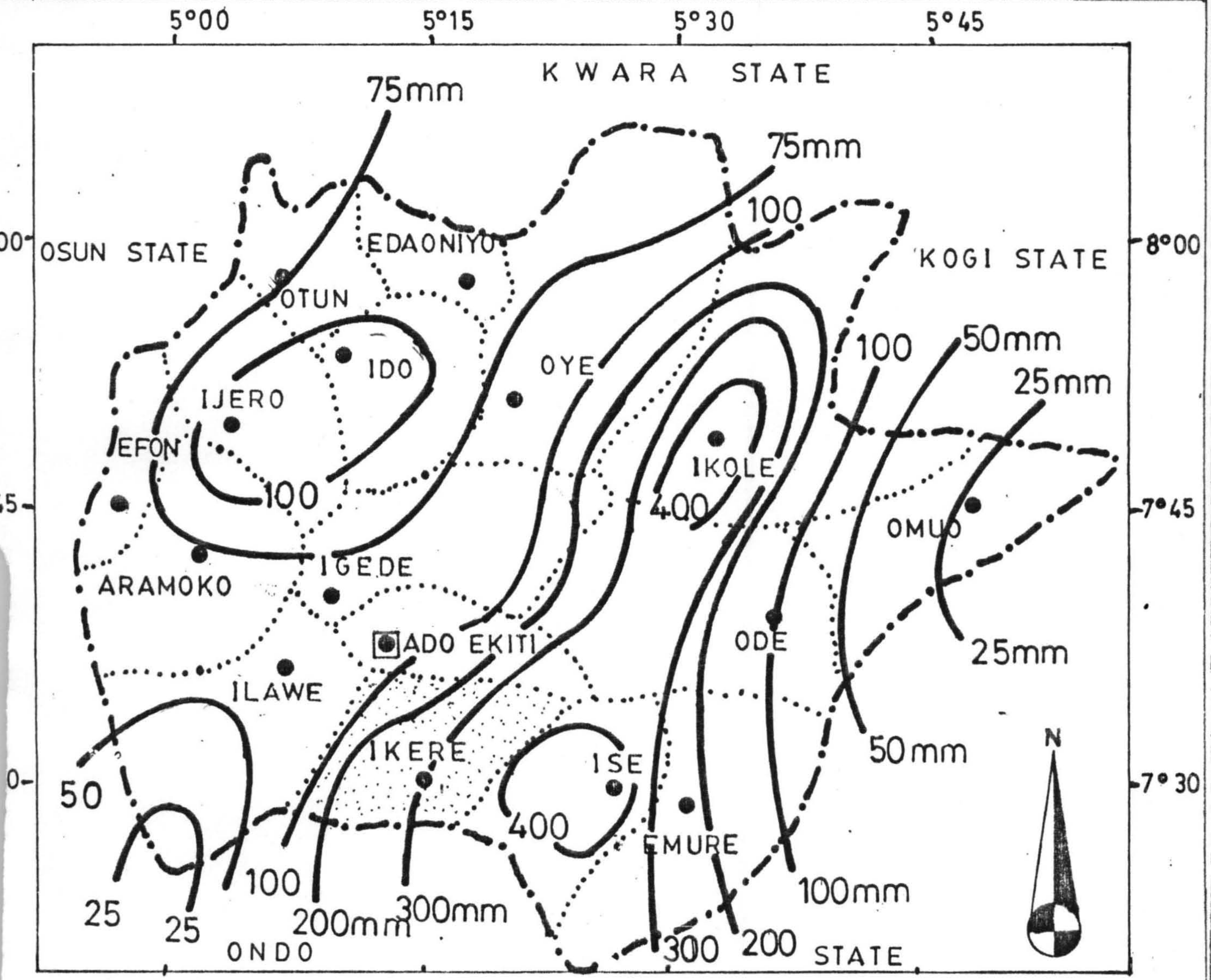
STATE CAPITAL — ADO EKITI

MAJOR TOWNS — IKERE

THE STUDY AREA

Fig.4.6 Mean Rainfall During Wet Season (April- October) in Ekiti State

Adapted from Adefolalu et al (1995).



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LEGEND

STATE BOUNDARIES .... — · — · — · — · —
LOCAL GOVT. BOUNDARIES ....
STATE CAPITAL .... ADO EKITI
MAJOR TOWNS .... IKERE

THE STUDY AREA

Fig.4.7 Mean Rainfall During Dry Season (November–March) in Ekiti State

Adapted from Adefolalu et al (1995)

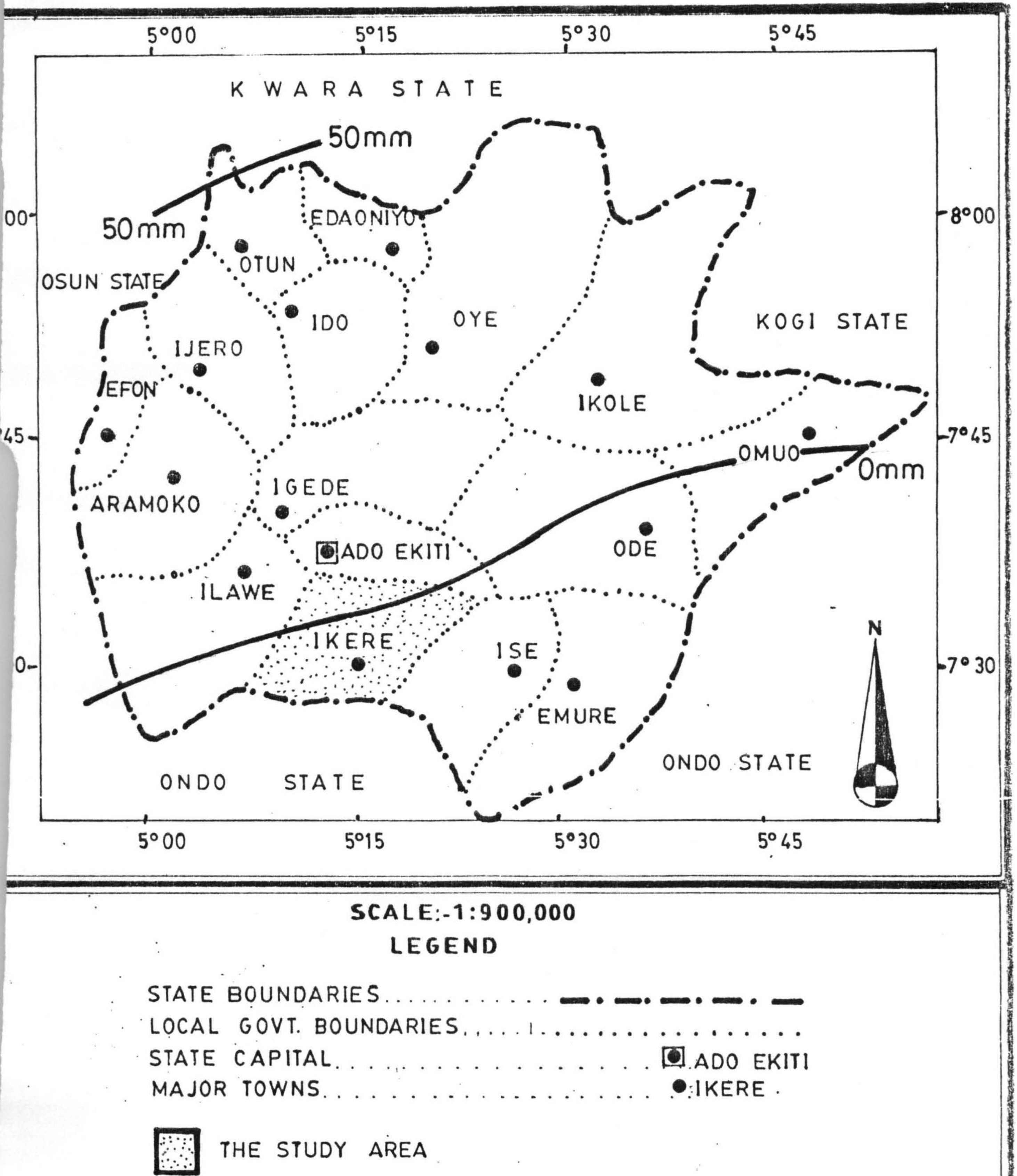

Fig.4.8 Average Rainfall Intensity Patterns Basedon 0.4HR Records in Ekiti State.

Adapted from Adefolalu et al (1995)

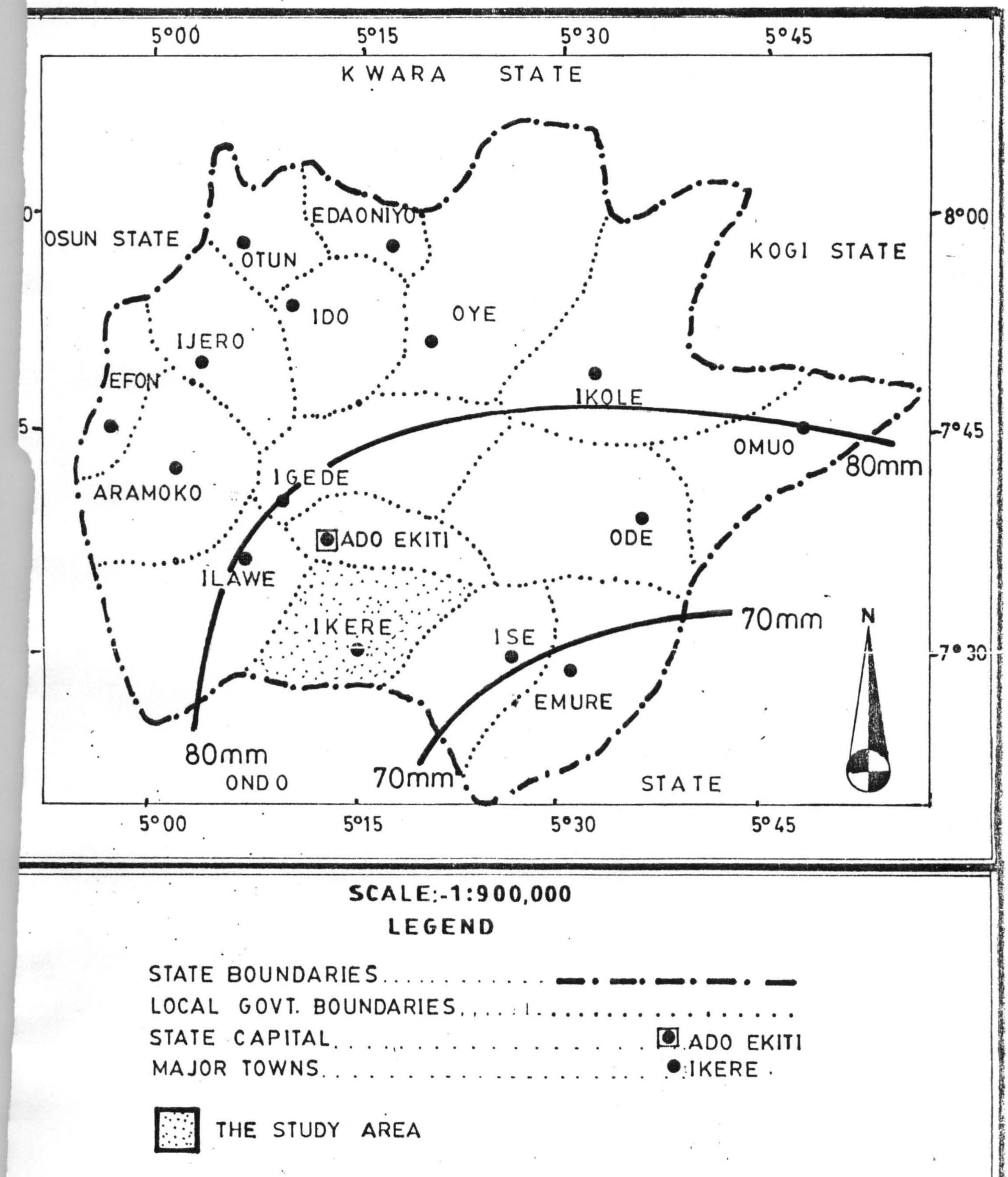

Fig. 4.9 Average Rainfall Intensity Patterns Based on 0.7HR Records in Ekiti State

Adapted from Adefolalu et al (1995).

CHAPTER FIVE

IMPLICATION AND APPLICATION OF THE STUDY

5.1 **<u>Preamble</u>**:

This chapter places emphasis on the implication and application of the findings on chapter four. Meanwhile, if shall be addressed under the following sub-headed issues:causes and effects of flooding; environmental impact assessment; and response of people to the floods.

5.2 **<u>Causes and effects of flooding;</u>**

The subject of floods is of intense interest in many riverine communities especially in Ikere Ekiti. Most people do not understand why stream cannot manage to stay in their channels when high water comes. To many, it seeems that nature is playing "dirty tricks" when floodwaters cover their neighborhood and leave deposites of mud in their houses.

In this study, however, it is revealed that the causes of river flooding in Ikere Ekiti along river Osun banks is as a result of the many other factors apart from the rainfall intensity and duration. These factors include: the ever increasing expansion of the built-up area usually on the floodplain; the extension of agricultural activities at the upper course of the river; deforestation; orintation of the river basin and the presence of large bare exposed rocks.

Settlement beside a river, however, can be mixed blessing, for once in a while the river may overfolw its bank and exact a heavy toll of property losses, income losses, and sometimes losses of life as well. In some cases man has learned to live with such periodic inundations of the floodplain and has turned them to economic advantage. In the case of Osun floods, it is a mixture of blessing and havoc. The flood are a critical input into the economy of the people, for during dry season, the floodplain usually is cultiviated and this yields income to the peasant local farmers. However, the floods are regarded as a burden rather than as an advantage. Often, they cause huge losses of property and income and sometimes losses of life as well. From the interview conducted, during field trip to the area, it was gathered that more than ten lifes have been claimed and property losses are also staggering. The effect of the floods in the area are serious, for recovery is much more difficult. Several times in recent years many people have been left homeless and their sources of food and livelihood have been severely damaged. Meanwhile, the actual cost are not estimated owing to inadequate data. Obviously, if something is not done shortly to abate the flood occurance, more and more losses would be recorded yearly.

5.3 **Environmental Impact Assessment:**

Floods are a consequence of natural water exceeding the capacity of removal by the river channel and can be expected to occur in the area virtually once in every other year. Such floods are important in so far as they provide alluvium to floodplains which in the long trerm maintains their agricultural potentials. Meanwhile, no complete assessment of the environmental impact were made, but it is estimated that about 450 hectares of floodplain results.

Unfortunately, such productive areas are also places where people choose to live and work and so it is desireable to be able to offer some protection against the effects of flooding.

Development on the floodplain must, however, proceed with extreme caution. This is to guide against the staggering annual losses of life and property on the floodplain.

In addition to the danger of floodplain, serious foundation limitations are imposed by the extremely variable soils and high groundwater table. This implies that, if development is to take place on the floodplain, it must be preceeded by a careful study of the soil present, the internal soil drainage and groundwater conditions, and the frequency and severely of flooding that can be expected. Usually, floodplains are better suited to agriculutral or parkland uses that can withstand periodic flooding with comparatively low losses.

5.4 **<u>Responses of People to the Floods:</u>**

Admittedly, few people in the area are begining to restrict landuse on the floodplain and encourge development that would not sustain heavy drainage from flooding. During dry season, of course, dry season farming is practised on the fadama land. Mainly, maize and vegetables are grown.

However, despite the huge losses that have been experinced, floods have not discouraged settlement in the river valley. On the contrary, there is substantial evidence that occupance of floodplain in the area is increasing. It is estimated that between 6% and 8% of the population lives in areas subject to periodic inundation. This implies that flood losses, therefore, seems destained to continue to mount in case settlement on the floodplain is not discouraged.

Beside the channelisation scheme launched in 1996 by the former Ondo State Government and the Local Government, under the unbrella of State Enviornmental Protection Agency (SEPA), no considerable measures have been undertaken to fight river flooding in the area.

Up till today, flood relief is still a matter that is left largely if not wholly to private initiative. Flood victims either draw on their own resources or depended upon assistance from relatives and friends. Adjustment to floods in the area is characerised by the adoption to mainly bearing the loss. Over the years, nothing is done to control occupance of the floodplains.

However, this study will reliably educate individuals, governments, engineers, hydrologists, and many other experts that the flood control measure ever made cannot solely prevent masive damage to property on the floodplain when really big flood occur. A growing body of evidence shows that the flood-control scheme launched there has actually worsened the conditions, causing higher flood level than would have occured without the control structure. For instance the launched flood control scheme of 1996 has failed considerably owing to bad planing and implimentation coupled with inadequate knowledge of flood causer factors in the area, which this study has adequately taken care of.

5.5 **Summary:**

Obviously, river flooding in Ikere-Ekiti is associated with natural and human factors. The effects are not only staggering but the financial loss to the individual and corporate bodies directly affected are uncalculable. However, the alluvium floodplain created are of good economic value to the peasant farmers in the area. No drastic measure has been made to put the flood into control and the one ever tried has not solve the problem. Meanwhile in the subsequent chapter, basic solutions are advanced and if well implimented, flood menace in the area will be a forgetting issue.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 **Summary:**

This study is designed to use remotely sensed data to assess the causes of river flooding on river Osun in Ikere-Ektit. However, throughout history of the earth, floods have been plagueing mankind. No part of the earth except the highestland seems to be entirely safe from floods. In the past, the believe is that floods is usually caused by the wrath of gods. But today, instead we study the natural and human factors that cuases flood (river). Also efforts are made to see what can be done to prevent deaths and protect our properties.

The major thrusts of the study are therofore, set to evalute the changes in Landuse/Landcover of the area; generate the statistics of the Landuse/Landcover distribution of the area; to analyse the steams network and channel slope; and to analyse the rainfall intensity and duration of the area.

Related literature were reviewed based on objectives under three major sub-headigs viz: incidence of river floodings; experience with remote sensing Aplication in rivers and floods; and experience with remote Application in Landuse/Landcover studies. It was gathered, that river floodings results from both natural and human factors. The natural factors are directly and indirectly climatological in nature while the Human factors are concerned with the man interractions with the enviornments in form of urbanisation, dam construction, agricultural activites and deforestation.

Experienced with remotely sensed data in rivers and floods when reviewed shows that they are quite good to monitoring and mapping of flood incidence. For instance, flood mapping with Landsat imagery was demonstrated with conspicous success in the case of Mississippi River and Indus rivers and in some other places.

On Landuse/Landcover monitoring and evaluation, the review equally shown that the use of remotely sensed data are quite adequate. For instance, combination of SLAR and Landsat data with ground truth observations were used by Adefolalu (1986) to study both the West African and Nigerian Landcover (vegetation) situation and this was met with a good success. In all other areas where remotely sensed data have been applied, good success were recorded, therefore, it is generally accepted that the use of remotely sensed data are good for monitoring and assessing the enviornment.

In a nutshell, the Aerial photograph of 1974 of the study area was anually interpretated while the satellite imagery (Landsat MSS 1993) were digitally classified and interpreted. The maximum likelihood classification scheme was claculated in hactares. The evaluation of the Landuse/Landcover of the area was caried out as well as generating the statistics of the Landuse/Landcover distirbution of the area. Increase changes were recorded in the following Landuse/Landcover classes viz: built-up area, agricultural land, baren land; and wetlands, while there are considerable decrease in the area of forestland and rangeland.

6.2 Conclusion:

This study has demonstrated that the use of satellite imagery and aerial photograph could provide the bio-physical environmental information necessary for assessing the causes of river flooding in humid environment. The use of Aerial photograph and Landsat MSS is an improvement over the use of aerial photograph alone, although it has a very low resolution. Meanwhile, the study was embarked upon with the utmost care, having high precision and accuracy on demand.

The esmimated Landuse/Landcover change between the period of study is about 3048 hactares (42.03%). Since, there is increase in the total built-up area, agricultural land, barren lands, and decrease in forested and rangeland, this is an indication that river floods in the area is much more influenced by other factors other than raifall alone. The implication is that inflitration rate is reduced while run-off is accelerated owing to the fact that more impervious land are created resulting from human interference. This was rather confirmed during a field trip to the area. It is evidenced that houses are built quite too close to the river banks even on the flood palins in certain areas. (See plate 4). This of

Plate 5. Photograph showing the river channel.

to parcolate readily to ground. In other words, changes in the landuse pattern as those depicted above will increase the soruce area from which streams collect water directly on account of reduced infiltration capacity of the surface.

6.3 Recommendations:

Efforts could still be made by any researchers to acquire more detailed information on different componets than was achieved by this study. Hence, the following issues should be considered:

i) There is the inadequate record of climatic information of the area, hence the use of meteorological satellite data should be enhanced to provide both temproal and spatial climatic information for the area.

ii) Efforts should be made to employ the combination of high resolution data such as SPOT XS, SPOT HVR and Landsat TM together with ground data. This would provide a more detailed and accurate environmental information for monitoring and planning purposes.

iii) To be able to study in detail as well as to understanding the environmental dynamics of the area, imageries of the area at different seasons should be acquired.

iv) To increase the use of remote sensing system, its awareness as a noble vehicle for data collection should nation-wide be created through media, public lectures, seminars and other viable channels.

v) The need to develop a user capability in remote sensing and so reliable data gathering of retrieval system in Nigeria cannot be overemphasised as the nation suffers a serious problem both in the rural and urban areas owing to inadequate scientific data and sufficient information of the environment. It is therefore recommended that government as well as any interested individual organisation should place serious emphasis than ever done on the use of remote sensing techniques to acquire data in the country.

vi) To encourage as well as facilitating the use of remote sensing data for monitoring, planning and managerial purposes, more and viable receiving stations should be located in the country.

vii) There should be increased education in remote sensing at an introductory level as well as at advanced level. Moreso, since remote sensing is a sensitive technology requiring trained personnel for their effective expectation, training is therefore a prerequiste not only to being using this technology, but also to keep up with rapid advancement in their development.

viii) A data base centre for storing the information derived from processing and analysing satellite data should also be established in each states of the Federation.

ix) Guiding against the menance of river flooding in the area, adequate planning must be embarked upon, regulating the Landuse pattern of the flood plain. The immediate solution might be to keep all development out of the floodplain, but in real sense, an attempt should be made to determine which activities can afford to locate in the flood plain and still pay the price of flood losses.

x) Effort should be made to control flood in the area by adopting flood abatement schemes. This entails modification of cropping practices, teracing, gully control, bank stabilisation, and revegetation.

xi) Finally, flood protection scheme should be launched. The motive behind this would be to minimise the damage it causes by regulating its flow or directing it away from damageable property. In actual fact, it may involve the construction of control works, such as flood walls, or dams and reservior, or the undertaking of channel improvements and dredging.

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APENDIX

CONFUSION MATIRIX FOR MAXIMUM LIKELIHOOD CLASSIFICATION USED FOR COMPUTER ASSISTED CLASSIFICATION

	0	1	2	3	4	5	6	7
1	0.0	99.8	0.2	0.0	0.0	0.0	0.0	0.0
2	0.0	1.7	96.3	0.3	0.3	1.1	0.6	0.0
3	0.0	0.0	1.6	98.4	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	91.6	6.1	0.0	2.3
5	0.0	0.0	0.0	2.8	0.0	91.7	5.6	0.0
6	0.0	0.3	0.0	0.0	0.3	0.0	91.3	8.1
7	0.0	0.0	1.7	0.0	0.6	0.6	0.0	97.6

Plate 4. Photograph showing building on the floodplain.

course is as a result of growth that takes place in the area over the years which encourage development within the floodplain of river Osun because of the pressure on land for urban development coupled with inadequate planning.

The pressure of large barrenland in the area is equally another factors concern which induces flooding in the area. It is quite clear that barren lands or bare exposed rock retain little or no water during rainfall, hence, the increase in the run-off which in turn results to flood. (See Plate 2).

In addition, during the field observation, it was discovered that the river channel is relatively narrow and mostly shocked up by aquatic vegetations. This in turn reduces the speed of the water and can invariably result to flooding incase of heavy rainfall. (See Plate 5).

At this juncture, it is obivous that river floods in the area of study result from many factors which include: the expansion in the built-up areas; the perssure of large baren land (bare exposed rocky lands and transitional zone to barren land); orientation of the river basin; and the large agricultural land. These however, are combined factors together with the high intensity of rainfall in the area. Meanwhile, the satellite climatic data for this area could not be procure but it is the believe that, "there is no smoke without fire". River floods cannot occur in the absence of water in the river channel, which supply is either from the immediate run-off water during rains; sub-surface water during issuing through springs and seepages; and the release of water held temporarily in swamps, lakes snow fields and glaciers. It is quite evidence that the majority of water that leads to flooding comes from run-off during rainfall since no flooding has been recorded at anytime during dry season. And, virtually there is no dam nor reservoure of any kind in the area and being a tropical environment no water is held in ice form.

The expansion in the built-up area as well as the associate factors are, however, confirmed as river flood causer factors by the words of Gregory (1993) as he declared that man's interaction with his enviorment in the form of urbanisation results to flooding. This is to say that, as urbanisation intensifies, natural surface are replace by buildings, paved roads and concrete surfaces which do not allow water