AN ASSESSMENT OF THE FACTORS INFLUENCING BOSSO LAKE SEDIMENTATION USING REMOSE SENSING TECHNIQUES

BY

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DECLARATION

I hereby declare that this thesis titled "Assessment of sediment of the factors influencing Bosso Lake sedimentation using remote sensing techniques" is my own work and have not been submitted at any university or institution. All published and unpublished works of other authors have been duly acknowledged through references.

DEDICATION

Dedicate to my parents and my beloved husband for their encouragement and support. And to all from whom I have learnt.

ACKNOWLEDGEMENT

All my praise is due to Allah, I would like to express my profound gratitude to my project supervisor, Dr. M.T. Usman for his guidance, supervision and full co-operation for the success of this project. To all lecturers especially the members of staff of Geography department the Head of department Dr. (Mrs) A. E. Odafen, Dr. A. S. Halilu, Prof. J.M. Baba, Prof. D.O. Adefolalu, Dr.G.N.Nsofor, Dr.P.S.Akinyeye, Dr.A.S.Abubakar, Dr. (Miss) A.A. Okhimamhe and Mallam Salilu. I say thank you for your contributions.

My sincere appreciation to my husband Mallam Abdulkadir Abdullahi for his understanding and co-operation during the busy time of the study. I also offer much gratitude to my parents, brothers, sisters, colleagues, children and others for their co-operation.

CERTIFICATION

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ABSTRACT

Environmental resources such as land, water and biodiversity are basic needs of human life. Thus the need for acquiring, describing, analyzing, assessing and monitoring of the natural environment using remote sensing technique.

This study used remote sensing technique to investigate the factors influencing Bosso lake sedimentation. Using spot (HRV) multi-spectral data of Minna acquired in 1994 and topographic map of Minna prepared in 1969, five classes of land use were identified. A digital elevation model (DEM) was developed and used to determine potential erosion yield. The NDVI technique was also used to examine the vegetation cover of the study area. Results have shown that the rate of soil erosion, intensive landuse and vegetation degradation of the study area have contributed to siltation and sedimentation of Bosso reservoir, hence its rapid shrinkage. This implies that the shrinkage of Bosso water supply reservoir is a function of its geographic location.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The environment is dynamic, the changes occurring have to be monitored and the impacts of these changes have to be examined. In the course of human history increase demand for food, shelter, either as a result of changes in life style or increase in population has lead to increase encroachment on natural resources. Man's use of the environment has modified it in directions which either enhance or lessen its ability to support or aid sustainable development. In view of this, there is need to measure the impact of human activities on the natural systems. Dam construction has physical modifications on the natural drainage basin which may have some environmental problems such as sedimentation among others.

The component of the environment are not independent, as a result the knowledge of the environment is a pre-requisite for decision making about the utilization and management of natural resources found here in. information regarding lithosphere and hydrosphere are critical for human existence. Remote sensing is a vital tool to extract information of the environment; it increases our knowledge of the earth surface made up of lithosphere, hydrosphere, atmosphere and biosphere. And it allows us to improve on this knowledge for the benefit of mankind as well as a tool for achievement of sustainable development.

In his effort to provide a safe and comfortable environment for development, man then continued to intensify research in areas of flood, migration, erosion, sedimentation, water resource development for irrigation domestic and industrial supply. Specifically the various ways in which man has modified the drainage basin is through the construction of dams and reservoirs. This has been the most desirable means of solving the problem of flooding in the humid areas and of combating water shortage in the sub-humid and arid areas of the world (Olofin, 1980).

Water is one of the basic needs of human life. Globally it is estimated that nearly one billion people in the world are without clean drinking water. In addressing this, there has been a dramatic increase in the numbers of dams in the 20th century, mainly due to rapid growth in population, urbanization and changes in life style. Construction of dams has not been the best solution to water manágement problems. Olofin (1980) pointed out that the construction of dams and their associated reservoirs constitute some problems, not only to socio-economic systems, but to the quality of natural systems as well. In Nigeria, it is observed that the real issue has not been addressed.

Bosso dam was design and constructed for regulating the flow of the river and storage of water to meet the increase in domestic demand for clean water. Man's interaction with his immediate environment has been that of getting what he needs from the earth crust without giving a thought to what happens there after. The construction of Bosso dam in 1947 has upset the steady state of equilibrium already established between the morphological and cascading variables in the Bosso drainage basin. These environmental effects have called for detail assessment of the factors influencing Bosso late sedimentation. If the future must be guaranteed there is therefore an urgent need to protect the fragile environment with its vital strategic resources such as water, soil and biodiversity (Kufonyi, et al, 2003)

Sedimentation processes are natural processes that have been active throughout geologic time scale and have shaped the present landscape of our world. Natural sedimentation processes are caused by external agents like water, wind, gravity and ice. Sediment problems are aggravated by the activities of man and the effects of these activities on the "natural balance" of the sediment formation – denudation process. Geologic information on surface lithology and fracture patterns can be very helpful in exploration. These could be derived from remote sensing. Geomorphologic units can be evaluated with regards to their sedimentation potential to serve as assessment base for dams prospecting.

Information is needed to maintain the quality of environmental resources, since a change in the quality of these resources could affect among others, basic needs of man and, consequently, the survival of man is threatened. New technologies, such as remote sensing and geographic information system, provide opportunities to acquire and process multi-disciplinary, multi-dimensional, multi-temporal and multi-geographic approach with multiple scale perspectives to establish long term monitoring programmes.

Generally remote sensing is an art or science of acquiring, describing, analyzing, accessing, inventorying and monitoring features on the surface. It has an important role in environmental evaluation and management strategy. The information obtain from it will provide the basis for decisions that must be made from time to time. It will enable an evaluation of the effectiveness of decision already made. Remote sensing as an information technology has provide mankind an enhance opportunity to appraise, monitor and model their natural resources (Adeniyi, 2000).

In view of the above, this study attempt to assess the factors influencing Bosso lake sedimentation. Using space derive data, with multi-spectral characteristics and Digital Terrain model developed from topographic map. Remote sensing and GIS remains versatile tool for mapping, monitoring and management of the environmental resources. Based on this view remote sensing technique will be adopted for the study.

1.2 STATEMENT OF RESEARCH PROBLEM

The construction of Bosso Dam is an example of the product of man's interaction with his immediate environment. This has repercussions such as increased erosion, which leads to increased sediment entering the River Bosso and Bosso Lake. Siltations and sedimentation in Bosso reservoirs decreases water storage capacity, reducing the supply of water, power and flood control capabilities.

The rapid shrinkage of Bosso reservoir has increased the need to examine the factors influencing Bosso lake sedimentation and to give attention to potential problem in the lake maintenance's/conservation and steps to be taken in order to make it serve effectively the objectives for which it had been built. These problems raise new complex issues, which would require going beyond conventional approaches, if the problem is to effectively dealt with.

Hence the need to examine the factors influencing Bosso lake sedimentation, using remote sensing technique that is amenable to slight changes.

1.3 AIM AND OBJECTIVES

This study using Satellite Image is aimed at illustrating the importance of factors influencing sedimentation as an aid to sustainable development, management and conservation of environmental resources. Specific Objective of the study is to:

- Identify landuse type around the dam and determine the potential contribution of each to erosion yield.
- Examine soil loss potential of various surfaces.
- Assess on the basis of the above, the factors influencing Bosso lake sedimentation.
- Recommend appropriate conservation strategies for the sustainable use of the dam.

1.4 JUSTIFICATION OF RESEARCH PROBLEM

Man basically belongs to the biosphere, but he is heavily dependent on hydrosphere, atmosphere, lithosphere and even the biosphere. His dependence on these realms of the environment is indicating their interrelationship and the fact that man relies on the resources to survive. However some of these resources are finite, justifying the need for appropriate management and conservation. Man's use of the environment has modified it in a direction which enhances or lessens its ability to support environmental problems such as global warming, depletion of ozone layer, loss of biodiversity, erosion, sedimentation etc. Efficient management is necessary to ensure that human development can be sustained.

Man requires environmental resources for life, health and welfare. Water and land are fundamental resources that remain inevitable for any civilization. Water levels in many parts of the world are low and getting lower, Rivers have retreated from their banks and lakes are shrinking. A specific example is the rapid shrinkage of lake Chad, which is now a mere shadow of its old size at 2000 to 2500 km^2 as compared to its pre – 1963 surface area of about 23,000 to 25,000 sq km. Another is the inability of Kainji dam to perform as designed, while sedimentation down stream is increasing. Land degradation resulting from loss in soil fertility, soil erosion and loss of biodiversity are on the increase. Universally these resources are used as if the flow will never cease, land, fresh water and biodiversity are finite resources. If population and living standard are to rise, demand for these resources will inevitably increase still further.

Bosso dam was constructed to meet domestic demand of fresh and clean water for the growing population of Minna in 1947. This has altered the terrestrial environment. Since it is a natural system which man has manipulated, for social economic reasons. This will upset the equilibrium relationships which pre – existed between the variables of land and those of water in the affected basin. Therefore there is need for detail appraisal of the factors influencing sedimentation of Bosso lake.

However this project on assessment of the factors influencing Bosso lake sedimentation cannot afford to ignore the growing concern about the environment. The extent of the change that has occurred can be used to identify the siltation and sedimentation of the reservoir. It is important to have adequate information on many complex decisions, as such, knowledge of the environment is very important in order to overcome problems of haphazard, uncontrollable development, and deteriorating environmental quality. There is a need for us to understand, develop and apply the best practicable tools possible to tackle the challenge of boosting sustainable development (Adigun, 2000). Thus there is the need to develop the capability to assess quantitatively the factors influencing sedimentation of Bosso lake in order to achieve sustainable development in terms of water supply from that lake.

Application of remote sensing technique in environmental monitoring and assessment has gained tremendous recognition and has been adopted throughout the world. This has established a clear breakthrough in the study of the environment. Remote sensing technology has already been identified as one of the most promising and up-to-date method for studying the factors influencing sedimentation of dams.

According to Akinyede and Buroffice (2003), the solution to sustainable development issues, such as these, lies in the acquisition of reliable and sufficient geospatial data, which can be derived mostly from satellite data and integrated in a GIS environment.

Remote sensing and geographic information systems play a fundamental role in hydrological and terrestrial applications. It provide rapid inventory of natural resources on the earth's surface which can then be extracted, stored and analyzed in various forms with the aid of GIS technologies. However it does not replace the conventional method of data collection, rather it enhance the use of conventional methods of data collection.

In view of the above SPOT (HRV) image and digital terrain model developed from topographic map are used to assess the factors influencing Bosso lake sedimentation. The terrain elevation of any given area is an important tool for the provision of information on the geology, landuse practice, vegetation, soil, hydrology, climate and geomorphic history of the location.

The fact is that many researchers on Bosso dam use photographs and give emphasis to land use mapping in the down stream section. The researchers were not directly engage in assessing qualitatively and quantitatively the factors influencing Bosso lake sedimentation, we must act now if conditions are not to worsen. First to examine the extent of changes using remote sensing techniques and assess qualitatively and quantitatively the factors influencing Bosso lake sedimentation.

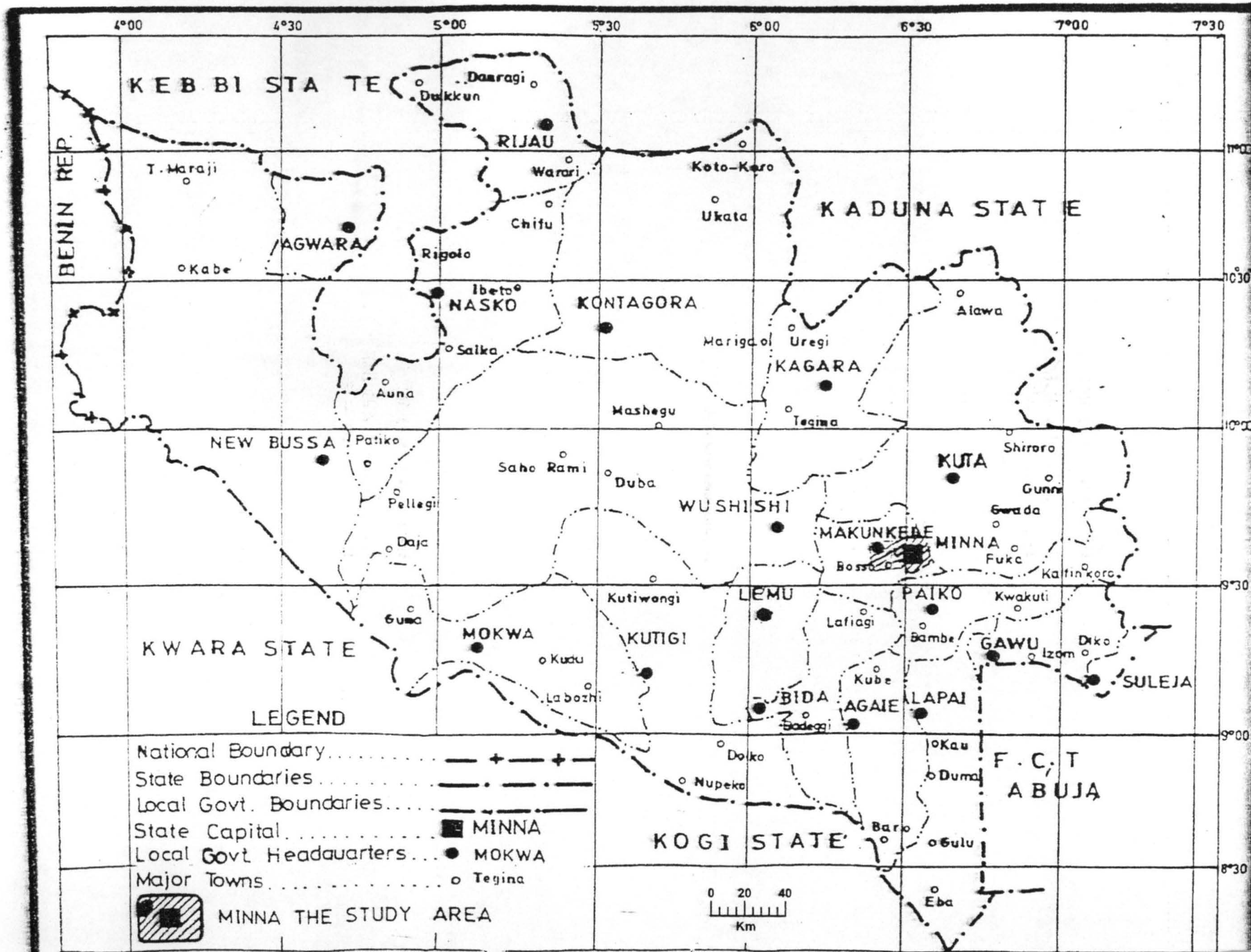
It is for these reasons that the present study is thought to be important in generating empirical data that will assess quantitatively the factors influencing Bosso lake sedimentation and evolves measures for mitigating any problem encountered.

1.5 DESCRIPTION OF THE STUDY AREA

Bosso Dam is located at about longitude $6^0 30^1$E to $6^0 33^1$E and latitude $9^0 40^1$N to $9^0 42^1$N. The study area is located in the North Eastern area of Minna. The dam was constructed in 1947 and the study area occupied an area of about $12km^2$. The reservoir has a depth of about 17.06m and storage capacity of 0.682 billion litres.

The study area has about six months of dry season and six months of rainy season. The annual rainfall amount has been estimated to be between 1200mm and 1300mm. the temperature is generally beyond 27^0 Celsius. The relative humidity is about 80% during rainy season.

The study area is underlain by Basement complex rock of pre – Cambrian age. The volume of water in the river, and consequently the reservoir is controlled



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MINNA THE STUDY AREA

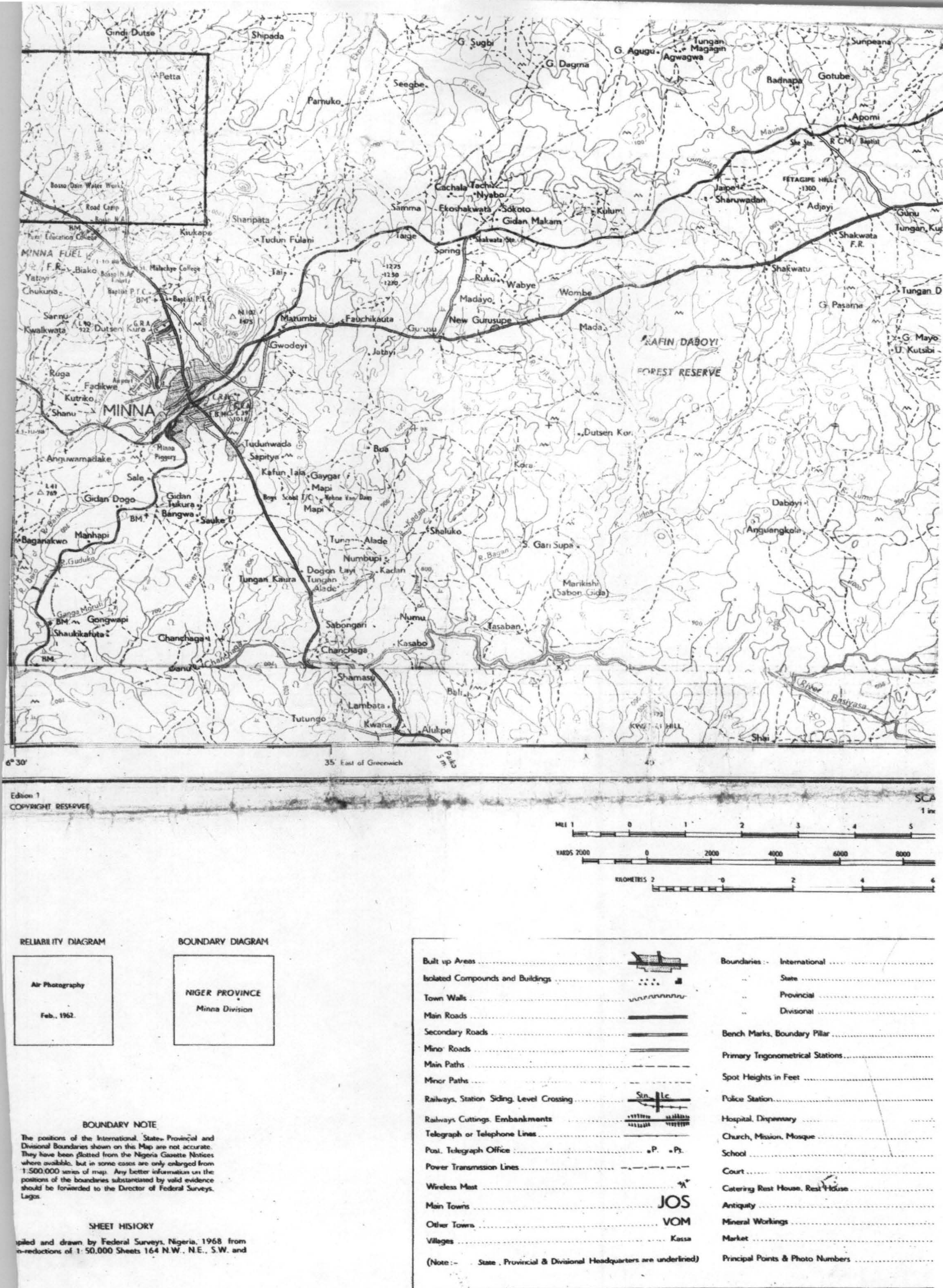


Fig. 2: TOPOGRAPHICAL MAP SHOWING THE STUDY AREA

by the season and the climatic condition, particularly the length of the rainy season. The in flowing rivers include river Suka and river Bosso.

The vegetation is mainly Guinea Savanna type, this is composed of mountainous forest of mainly trees, little shrubs and grasses, riparian and gallery forest, woodland as well bare ground. The ferruginous soil is dominant type of soil. This is developed from pre – Cambrian basement complex rocks under the tropical wet-and-dry conditions.

1.6 SCOPE AND LIMITATION OF THE STUDY

The scope of this study is to assess the factors influencing Bosso lake sedimentation. A SPOT HRV of Minna is acquired from the department of Geography, Federal University of Technology, Minna. The topographical map of Minna 1969 was collected from Ministry of Land and Survey, Minna.

Topographic map of Minna South West was digitize manually due to the absence of a functional digitizer. Fieldwork was undertaken for ground truthing and adjustment are made where there are features that have changed. The accuracy of the study result depends mainly on what could be obtained with remote sensing techniques and ground truthing within the available resources.

CHAPTER TWO

LITERATURE REVIEW

The major task facing geographers is the concept of spatial differentiation. In view of this, most research efforts are devoted to the study of differences between areas and spatial distribution of phenomena. Emphasis of spatial variation has intensified interest in applying the knowledge needed to understand the ever-changing state of our environment as a aid towards achievement of sustainable development. Over the years the use of expert system is another avenue for assessment of the environment, through mapping and quantitative evaluation and establishment of relationship between environmental variables. However, the knowledge of this relationship cannot be considered perfect.

Several studies have been conducted on change detection of the various component of the environment, using different types of remote sensing data and the impact of different developments which results from these changes have also been investigated, both local and international scene. In view of this, it is concluded that the combined use of digital and visual analysis of a higher resolution data such as SPOT (HRV) world provide baseline data for detail environmental resources planning and management.

Peter (1995) conducted a number of comparative studies using change detection techniques, and concluded that there is no universally "optimal" change detection technique, the choice is dependent upon the application. He further stated that digital change detection techniques are useful tools to assist human analysts. This could provide spatial information necessary for assessing the factors influencing Bossso lake sedimentation.

Roger et al (1985) conducted a study to assess quantitatively the changes in the land surface occurring as a result of man's activities or as an impact of climate variability. The series analysis of landsat MSS of 1970, 1976 and 1979, covering St. Lawrence valley in Quebec Canada, were used to monitor seasonal and long-term variation in soil and moisture, land use and vegetation covers. The results show that deforestation occurred and there were significant decrease in farmland and marked process of urbanization. Remote sensing technique is a tool for quantitative assessment of our natural environment.

Schumm (1971) argued that the morphology of stable alluvial channels are largely determined by the nature and quantity of sediments and water moving through them. He accepted discharge of water and sediment as the most independent variables influencing graded channel morphology. He added that the destruction of the natural vegetation in a given basin might increase flood peaks and sediment load. This may convert narrow, sinuous channel with low sediment transport into a very wide and straight bed load channel.

In his contribution Olofin (1980) using comparative analysis confirmed the assertion of Schumm in his study of Tiga dam and concluded that channel incision and the alteration of channel cascade have led to the formation of a new flood plain from the deposition of suspended load to post dam peak discharge. This has formed a silt and clay layer of about 12cm in thickness. Analytical approach are vital tools for environmental modeling.

Most studies using the application of remote sensing techniques for environmental resources, use comparative analysis of two set of data. Weismulter (1976); used two sets of land sat scenes covering the Orissa in India (dry season 1973 and monsoon 1975). Change detection, yielded a substantial volume of land use information of direct value to the status managers and agricultural planners. Two sets of scenes highlighted the differences between dry and wet season agricultural patterns and identify promising areas for conversion to integrated two crop production. The data also indicated areas suitable for dams, showed the extend of forest cutting in the highlands and coastal regions, provided a new base for checking the accuracy of crop average estimates done by conventional means and showed the changing course of Mahandi Rivers and its tributaries as well as major changes in sand bars, Island along the coast.

Wood (1997), with over 20 years of sensitivity studies with Atmosphere General Circulation Models (AGCMS), has clearly demonstrated that land use process affect climate at regional and global scale. He stated that understanding the nature and effects of possible changes on the terrestrial water and energy fluxes as a result of changing climate and land surface characteristics are investigated because of insufficient ground base observations for regional to global monitoring and modeling using remote sensing. This clearly shows that remote sensing offers the potential for environmental modeling.

Olofin (1980) also in his discussion of channel morphological change as a result of dam construction asserted that gully incision occurred on the low terrace, increasing the main depth from a pre-dam 1.4m to a post dam 2.02m. He also observed that channel erosion has occurred in the Kano former storm channel (mean width = 240m) where a much narrower channel (mean width = 34.5m) suitable for the low perennial discharge was formed and incised to a mean depth of 1.07. He also pointed out that there is an increase of organic matter content in channel sediments from pre-dam 0.12% to post dam 1.4% and also increase of silt + clay fraction from about 5.5% to 63% over the same life span.

Okhimamhe (1993) made use of aerial photograph and SPOT HRV – 1 imagery in land use classification using change detection in Burumburum/Tiga area of Kano State. The results show that 38, 897 hectares of change has taken place. Crop/pasture land and wooden shrub has decreased in magnitude, while grass land/shrub land has increased 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 biophysical information necessary for monitoring and assessing the environment.

Rima (1998) used GIS to examine physical ecological and social economic impacts of potential human interactions on aquatic ecosystems across spatial scales. He was able to implement geo-spatial information analysis and integrate landscape features to identify the relationships among the environmental elements. This proved to be a successful analytical tool that allows efficient and scientific sound decision making for conservation of the environment.

In his own contribution, Okonny (1993) studies the Nigeria coastline by comparatively analyzing side looking radar image and aerial photograph of 1977 and 1964 respectively. This analysis reveals that small-scale sand pits and beach ridges had been formed over time. These coastal features were indication of a relatively slow depositional rate because the damming of upper reaches of River Niger had trapped sediments. As a result, long shore depositional currents capacity was greater than the rivers discharge potential. This proved that comparative analysis is central in remote sensing application.

Adefolalu (1986), has successfully used a combination of SLAR and land sat data with ground truth observations to study both the West African and Nigerian land use (vegetation) situation. He studied five major vegetational cover, woodlands, grasslands, shrub land, farmland and forests. He however, showed that two states in the Sahel savanna, Borno and Sokoto state, as of 1986 were experiencing harsh effects of desertification of arable land which had been reduced to 19.29% and 41.8% respectively, while grasslands/shrub were 59.97% and 38.36% respectively. Human activities made situation in Kano and Kaduna state equally pathetic. Both states had been under intensive agriculture. He also forecasted that at the early part of 1991 – 2000, arable land in the two states would be turned shrub land vegetation and the sahel proper.

Jackson (1994) used comparative analysis to captures the impacts of human activities on Kissimme River Basin. He detect physical destruction of the river and floodplain habitat which resulted from canal excavation and deposition of soil. He documented that human action has impact on the ecosystem, primarily through altered hydrologic regimes. Ecological consequences, include diminished floodplain, habitat diversity, reduction of wading bird usage of the floodplain and loss of habitat for forage fish, as well as a longer riverine fish species. He added that the nature and rate of energy exchange between the floodplain also has been disturbed, modification of the river / floodpain interactions has affected the functional integrity of both the river and floodplain and results in the flow of degraded water quality which leads to excessive sedimentation. Comparative analysis provides detailed information essential for spatial differentiation.

Hellden (1985) studied drought impact in Sudan using land use and cultivation information based on aerial photographs, landsat and NOAA AVHRR, Agricultural and Climatic Statistics Cultivated Fields were mapped through the interpretation of 1972 and 1979 landsat MSS imagery. The proportion of cultivated zone, were 21%, 14% and 14% respectively, when these were compared with 1962 aerial photograph, the proportion of cultivated land was 25%, 22%, 24% and 29% respectively. Barren dune complex was found, some, some new non-vegetated dune especially gully between 1962 – 1979 period. He concluded that long lasting desert created during the 1962 – 1979 period was described by some authors. But there was several drought impacts on crop field between 1964 and 1974. This shows that satellite imagery and aerial photographs could provide the biophysical information for mapping the environmental resources.

Patrick and Abdulhamid (1989) made use of photographs and questionnaire methods to assess the impact of dam construction on the down stream morphology and agricultural productivity in Kano State. They use aerial photographs to map and predict floods, water logging and erosion risk. Patrick (1987) use aerial photographs and rainfall data to assess the impact of gully erosion in some parts of Gongola and Bauchi states. He stressed the usefulness of aerial photographs as tools for monitoring erosion hazard and land cover. Factors that affect slope instability in an area near screnoak (Knef) were monitored by Norman et al (1985). Using aerial photograph, changes in catchment characteristics were monitored. The above listed studies demonstrate the effectiveness and reliability of using photographs and satellite images to analyze drainage basin.

Kanyanya (2002) uses remote sensing and GIS for assessment of land use, land cover changes and the environments of land use around with bank dam area of middle – burg Mpumalanga in South Africa. Landsat images for 1994 and 2001 over the area were analyzed using Ilwis 2.1 for windows to assess possible environmental impacts of land use and land covers during the seven years period. Result show that there has been significant changes in the land use and land cover during the period under review. He added, it's evident from the result that there has been an extension in the dam area coverage and resulted in extinction of other land use in the area.

Employing the capabilities of digital and visual analysis of LANDSAT MSS for identifying classifying and monitoring the impact of dams construction in the Sokoto/Rima Basin, North Western Nigeria, Adeniyi (1988), classified land use and land cover types using maximum likehood procedure to investigate the changes in the dam side 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 land use and land cover were identifies especially in the floodplain and the down stream.

Olofin (1980) use comparative analysis to examine some of the effects the Tiga dam has on the natural systems in the immediate channel cascade system. The valley side slope process response system, and the channel process response system were investigated and determined for a period before the construction of dams in the Kano River Basin (time t) and for another period after the Tiga dam came into operation (time t + l). The result of the investigations show that in the Kano River Basin, the Tiga dam, its reservoir and their management by man have modified the channel flow regime, the channel and low terrace gully geometry, and the channel debris storage. The growth of vegetation in the Kano River channel has been encouraged. The flood flow down stream of the dam has been decreased by more than four times, the alteration of cascade system has triggered off a sequence of inter-related morphological and ecological changes in the channel. Comparative analyses are useful tools in assessing human impacts on the environment.

Halilu (1999) integrate remote sensing and GIS technique in studying sediment potential of parts of Usuma River Basin. Surficial indices of sediment yields of the catchment tributaries of lower Usuma dam was used in mapping the potential catchment areas. This was to determine the likely life span of the dam, erosion problems and management of the reservoir, classification of the potential rate of erosion and sedimentation and the two ways relationship between the dam, reservoir and the tributaries was investigated. In view of these remote sensing and GIS technique are vital tool for spatial differentiation.

The use of remote sensing techniques over the last two decades has permitted the monitoring, assessments and evaluation of the environment using change detection, ground truthing and comparative analysis. These are vital tools for spatial differentiation and will be adopted in assessing quantitatively and quantitatively the factors influencing Bosso lake sedimentation and the water storage capacity of the dam.

CHAPTER THREE

3.0 METHODOLOGY

3.1 DESCRIPTION OF DATA

The data assemble for this work include SPOT (HRV), of Minna 1994, multi spectral mode of 20meters by 20meters resolution collected from Remote sensing laboratory Federal University of Technology Minna. This is the main source of data for the research and was utilized for the assessment of the factors influencing Bosso lake sedimentation.

A topographic map produced in 1967 by Federal Survey with scale of 1: 100,000 sheet number 164sw Minna was obtained from the Ministry of Land and Survey Minna. The two sources of data were 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.

3.2 DEVELOPMENT OF DIGITAL TERRAIN MODEL

Digital Terrain Model (DTM) is digital representation of the terrain relief, suitable for computer processing. It gives X, Y, Z, Co-ordinates of any selected surface point. The Topographic map of the study area was digitized manually due to lack of functioning digitizer. The X, Y, Z, co-ordinate of the study area were determined. These (X,Y,Z,) co-ordinates were input into the Idrisi soft ware, which display of the surface in digital form. It automatically interpolates the digital surface into surface image (see plate1). The DTM was used to determine the slope percent.

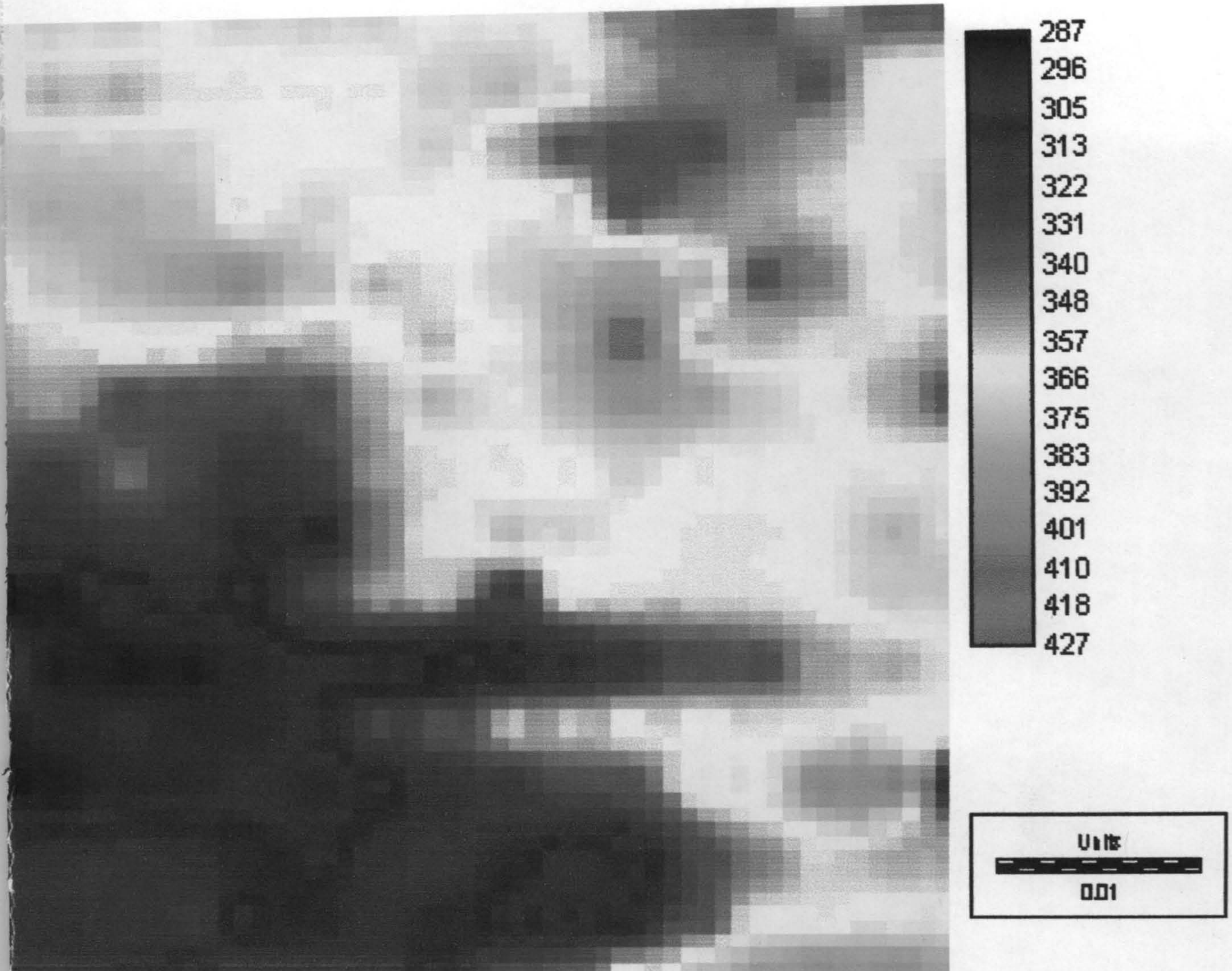


PLATE 1: DIGITAL TERRAIN MODEL (M)

The topographic factor (slope percentage) for the various soil losses is computed using the formula suggested by Wischmeier and Smith (1978). This formula is as follows;-

Where

$$LS = \left[\frac{65.4 \times S^2}{S^2 + 10,000} + \frac{4.56 \times S}{(S^2 + 10,000)^{1/2}} + 0.65 \right] (L/72.5)\ m \ldots\ldots (3.1)$$

Where,

LS = Topographic Factor (slope % and length)

L = slope length, (m x 0.3048)

S = slope percent

M = exponent dependent upon slope steepness (0.2 for slope L1%, 0.3 for slope 1 to 3% 0.4 for slope 3.5 to 4.5% and 0.5 for slope > 5%)

3.3 COMPUTER ASSISTED CLASSIFICATION

The SPOT (HRV) imagery was scanned for computer assisted analysis and interpreted at Remote sensing laboratory Federal University of Technology, Minna. Idrisi for window (soft ware) programme was used for image interpretation which involved the use of quantitative techniques to identify features in a scene of multi-spectral image data. Basically spectral pattern recognition approach was adopted using supervised classification.

In this approach, numerical descriptors of different classes present in the scene were specified to the soft ware. The special attribute of each feature of interest was given a numerical interpretation key. This was then compared with the category that most "resembles" the interpretation key and labeled accordingly using maximum likelihood classifier. Using procedures of classification adopted from remote sensing Notes, JARS fig 3.1

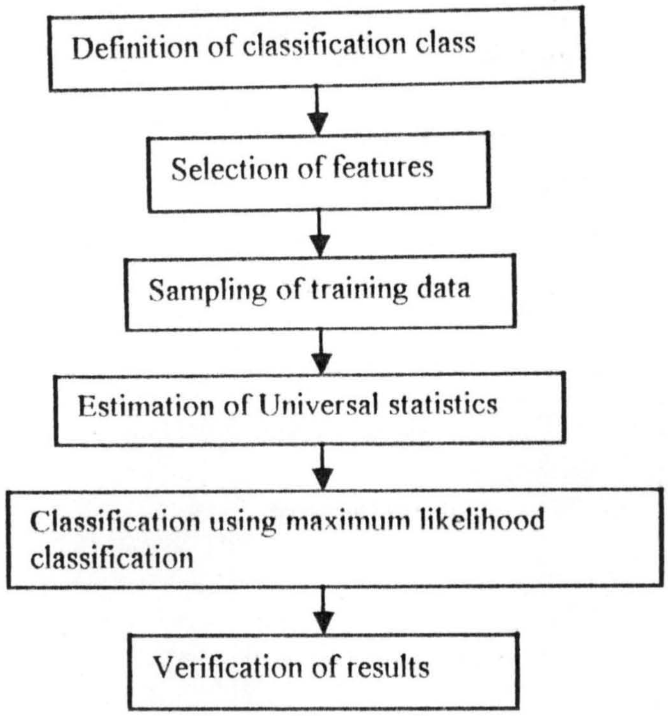


Fig 3.1 procedures of classification. Adopted from remote sensing Notes, JARS.

A computer assisted classification is done using the classes shown in table 3.1. A description of spatial and spectral characteristics of these land use and land cover classes when observed in SPOT(HRV) Images will be presented. The classification will be done using maximum likelihood classification.

TABLE 3.1 NUMERICAL DESCRIPTORS OF THE DIFFERENT CLASSES

CATEGORY	CLASSES
1	Water body
2	Thick vegetation
3	Wet land
4	Bare land
5	Farm land

The maximum likelihood classification scheme was use to quantitatively evaluated both the variance and correlation of the category – response pattern. Field survey to identify cultural and natural features for the landuse were undertaken to verify the classification result.

Idrisi (soft ware) programme was use to determine area of potential erosion yield of three main classes of landuse practice factor and is use to assess factors influencing Bosso Lake sedimentation.

3.4 VEGETATION TYPE

Using normalized vegetation differentiation Index (NDVI) of the infrared and red region of colour composite image, Idrisi for Window Software automatically gave the vegetation types.

$$NDVI = \frac{NIR - R}{NIR + R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Where

NIR = Near Infrared

R = Red reflectance

3.5 TECHNIQUE FOR ASSESSMENT OF THE FACTORS INFLUENCING BOSSO LAKE SEDIMENTATION

The satellite image interpretation and digital Terrain model was verified by ground truthing to assess the factors influencing Bosso lake sedimentation.

The various landuse types around the lake and the contribution of each erosion yield were identified and compared with the soil loss potential of the various surfaces. The area covered by each erosion type was identified and the level of vegetation degradation in the area was determined to assess the impact of man on the natural environment.

These were used to identify the topographical and human factors that change geological erosion to accelerated erosion, thereby increasing sedimentation and hence rapid shrinkage of Bosso lake.

CHAPTER FOUR

4.0 PRESENTATION AND DISCUSSION OF RESULT

4.1 INTRODUCTION

This chapter presents the results, images, figures, tables, and discussion of the analysis of the satellite data of the study area. It assesses the shrinkage of the lake as a function of its geographic location and land use around the lake.

4.2 LAND USE CLASSIFICATION OF THE IMAGE

Computer assisted land use classification of the study area is generally classified into five landuse types on maximum likelihood classification and this is believed to be very accurate (see plate 2).

Half of the study area is dominated by wetland, some vegetated while others are none vegetated. From table 4.1, this cover about 51% of the total study area, these are areas on plains and gentle slopes that are usually tempered with by man for agricultural purposes.

The agricultural land are areas that are facing all year cultivation. The agricultural land was identified from the image, because this farmlands appeared less vegetated with shrub than wetland. This covers 22.1% of the total study area.

The barren land, composed of the exposed rocky area and transitional zones, covers 17.8% of the study area. The upper area around the reservoir is dominated by open outcrop and barren land. The rocky outcrops and barren land

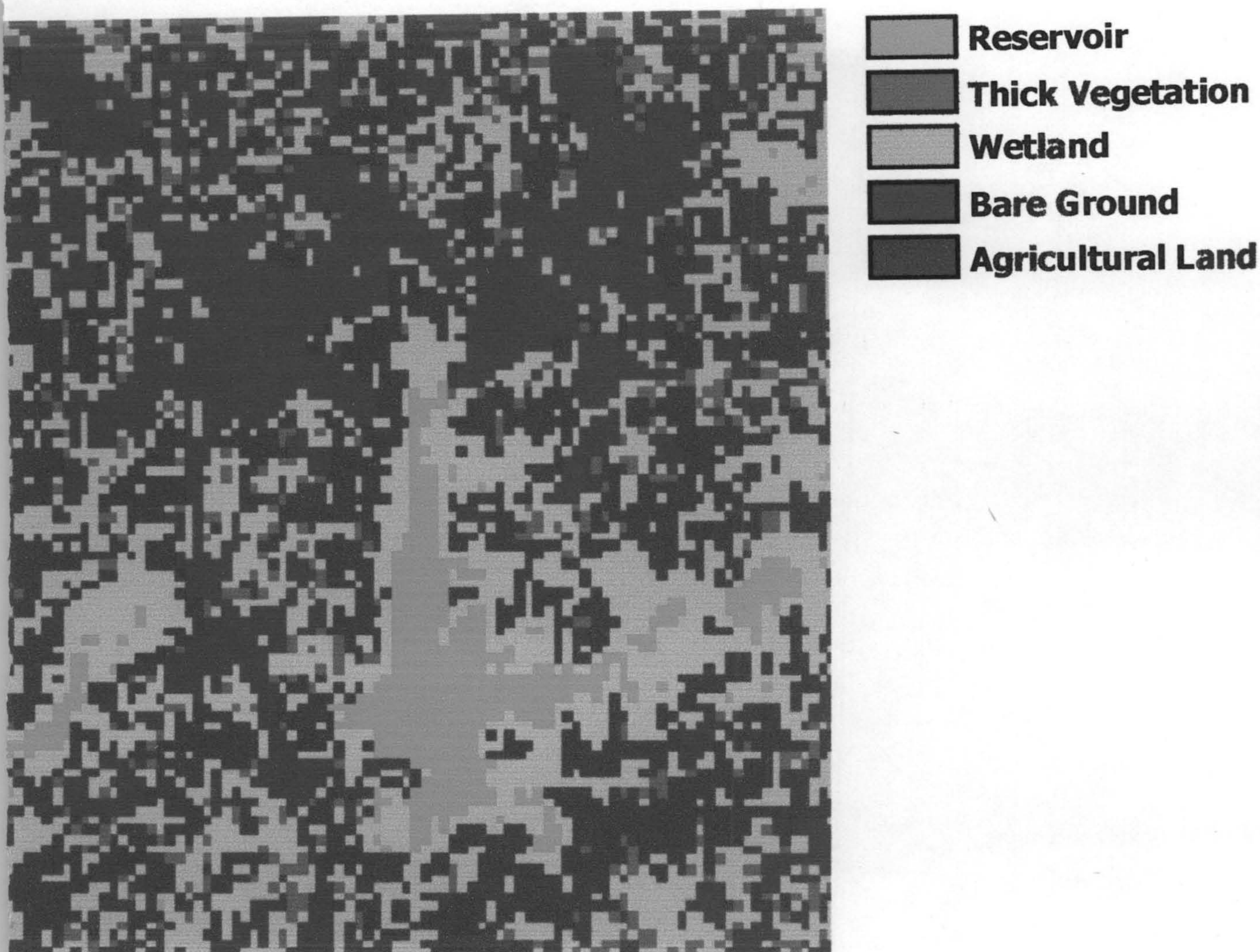


PLATE 2: LANDUSE CLASSIFICATION

coincide very well with highest points in the study area, this area has little soil to be eroded.

The reservoir ranked fourth in the area covered by landuse types. It covers 4.4% of the total area of the image. It is centrally located in the image; it is the deposition zone of most sediment. This land category corresponds with the lowest altitude of the area.

Thick vegetated area covers about 4% of the total area, it is found in areas of gentle slope that are not cultivated. These are areas that looked less disturbed ecologically because of predominant trees, tall grasses and shrubs.

TABLE 4.1: LAND USE CLASSIFICATION

FEATURES	AREA COVERED (km^2)	PERCENTAGE
Reservoir	0.53	4.4
Thick vegetation	0.48	4.0
Wet land	6.20	51.7
Bare ground	2.12	17.8
Agricultural land	2.65	22.1
Total	$12km^2$	100%

4.3 CLASSIFICATION OF EROSION POTENTIAL YIELD

Using Idrisi for window, the surface area, slope percent and gradient were produced automatically. The slope percent was input into equation 3.1

Based on the values for slope percent three classes were identified as potential for erosion yield (see table 4.2)

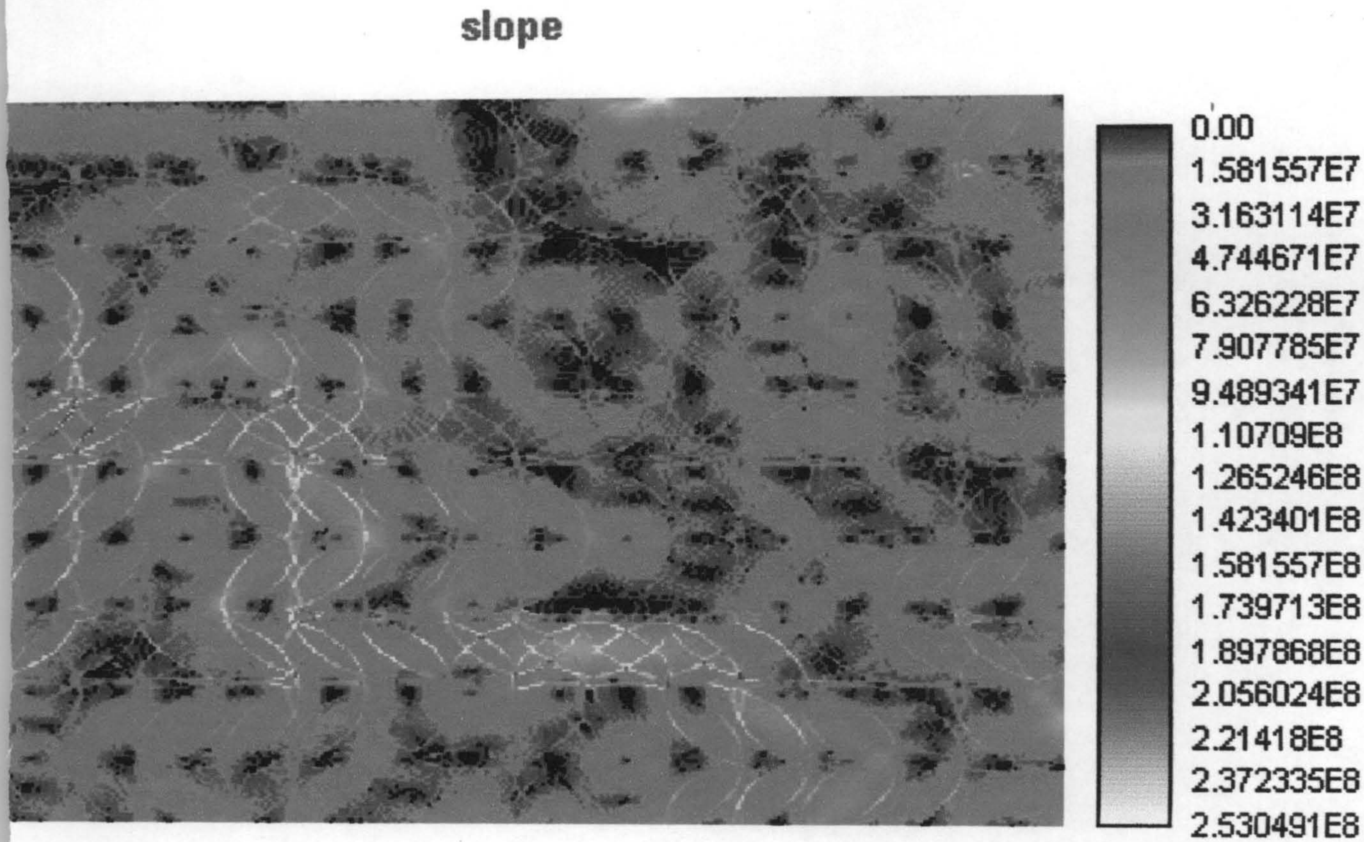
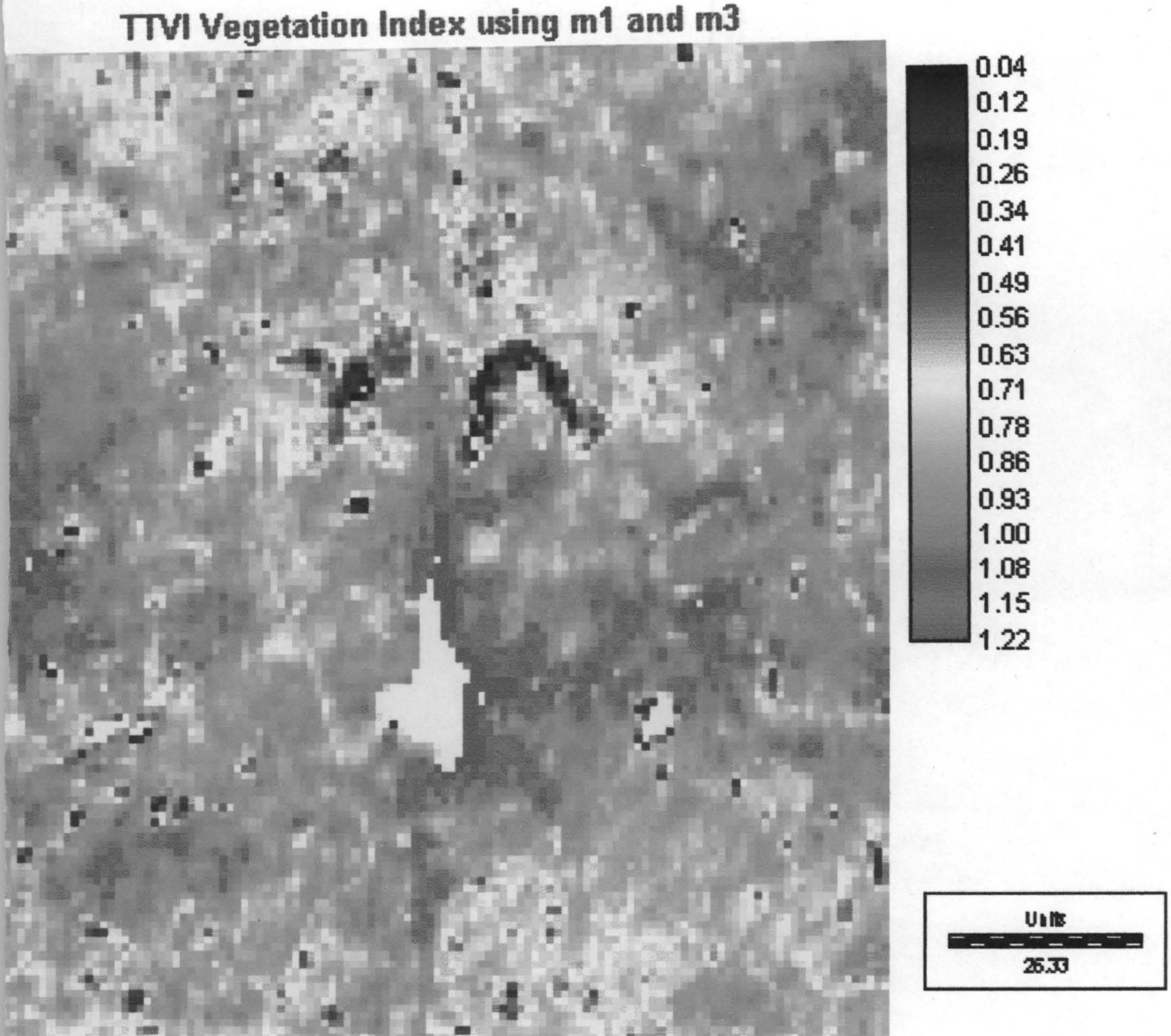


PLATE 3: SLOPE PERCENT



ATE 4: NORMALISED DIFFERENTIAL VEGETATION INDEX IMAGE

TABLE 4.2 SLOPE POTENTIAL FOR EROSION YIELD

FACTOR	LOW	MODERATE	HIGH
Erosion potential yield	0.01 ton/ha/yr	0.32 ton / ha / yr	0.5 ton / ha / yr
Slope %	1%	3%	8%
Hectare covered	90	778	320
Area covered %	7.5%	64.8%	26.7%

From table 4.2, the low altitude area of the reservoir on slope 1% yields 0.1 ton/ha/yr. The moderate slope erosion potential areas are areas with moderate altitude. These areas are on 3% slope and erosion yield is about 0.32ton/ha/yr. The areas of high gradient of about 8% had erosion yield of about 0.5ton/ha/yr. (see plate 3)

4.4 VEGETATION COVER

The areas around the reservoir are largely covered by shrub, which is an indication of vegetation degradation in the study area that is NDVI is less than one. This is confirmed by land use practice in which only about 4% of the study area have thick vegetation. This is close to the size of the reservoir, the thick vegetation areas are on gentle and moderate slopes. These are areas that look less disturbed ecologically because of predominant, tall grasses and shrubs (see plate 4).

4.5 ASSESSMENT OF THE FACTORS INFLUENCING BOSSO LAKE SEDIMENTATION

From slope analysis, there are three potential erosion yield classes and the land use classification also shows that three potential areas of land use contribute to potential erosion yield. The result reveals that the largest area of land use coincides with the largest area of erosion potential yield (see plate 2,3 and table 4). Lack of good vegetation cover on the hill slopes promotes erosion during the rainy seasons. This result to siltation and sedimentation of Bosso Lake (see plate 4).

TABLE 4.3 PERCENTAGE AREA OF EROSION AND LADUSE POTENTIAL YIELD

TYPE/CLASSES	LOW	MEDIUM	HIGH
Land use area	15%	35%	50%
Slope area	7.5%	64.8%	26.7%

From the table there are three potential classes of erosion yield. The landuse classification shows that the largest area of landuse falls under high yield potential with about 50%, these are areas of intensive use of land resources. It is followed by the moderate erosion yield potential areas, which covers 35% and correspond with the reservoir and immediate surroundings. The least in size has about 15% this correspond with outcrop and barren land.

The slope analysis shows that about 64.8% of the area has moderate sediment yield potential and 26.7% has high yield potential. The deposition zone has 7.5% erosion yield potential. This shows that the high erosion potential are from the areas close to the reservoir and reveals that most part of the reservoir

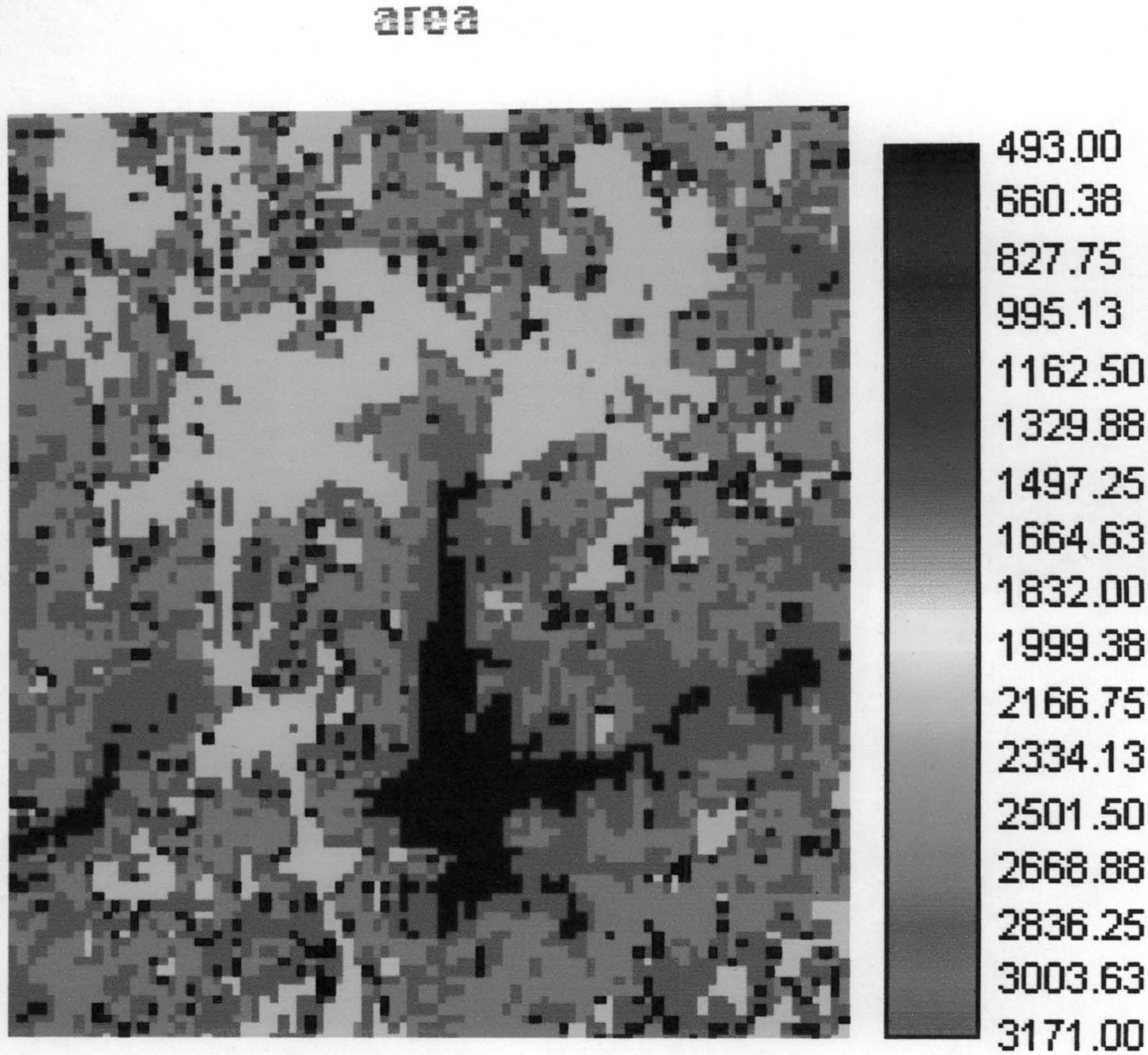


PLATE 5: AREA OF POTENTIAL EROSION YIELD (m^2)

will continue to deteriorate has sedimentation will be increasing since the reservoir is a deposition bowl with the lowest altitude.

The NDVI image confirms vegetation degradation in the study area. The area is ecologically tempered with by human interference and more areas have been open to erosion since land is mostly laid bare by deforestation for agricultural purposes. This promote erosion during the rainy season and increased erosion leads to increase sediment entering the rivers and hence the reservoir, resulting to rapid shrinkage of Bosso lake.

4.6 DISCUSSION

The geographic location and land use classes around the lake has increase the sedimentation potential of the dam. Bosso reservoir is located in the valley with rock out crop on each side of the valley serving as a boundary. The existence of these features have made it impossible for agricultural practice to take place close to the reservoir at the Northern part of the reservoir which has highest erosion potential yield. However, this provides the runoff for potential erosion yield of the moderate altitude surrounding the reservoir. Geographic location of Bosso reservoir has increased sedimentation processes, which is caused by external agents such as water, wind and gravity. These natural processes that have been taken place will continue to take place even in the absence of man. Man is only a major factor in triggering and aggravating sedimentation problems and thus affecting the natural assemblage of processes of denudation. Changing geologic erosion to accelerated erosion.

Sedimentation is a major problem that has affect the storage and capacity of Bosso dam mainly because of its geographic location. Bosso dam is fed by rainfall, small and short flowing streams. This sources carry along sediment load which subsequently enter into the reservoir and trapped by the dam. From the image, it is apparent that areas that are now wetland on the shores of the lake are probably part and parcel of the lake (see plate 2). The rate of siltation and sedimentation of the reservoir is determined by factors such as rate of soil erosion, intensive land use around the reservoir which opens more area to erosion. During the rainy season large proportion of sediment or solid material are carried through the channels into the reservoir. And the dominant bare ground and outcrop around the dam also provide runoff and promote free movement of sediment from the northern part of the reservoir basin into the reservoir.

From the analysis, increase in erosion leads to increase in sediments entering the reservoir, since only small percentage of sediments trapped is release from the reservoir (See Table 4.2). The vegetation degradation, land used by man around the reservoir with large proportion of barren land will frequently increase flooding and magnitude of sediment yield.

Comparing the present surface area of Bosso dam with the surface area of 1950s when the dam was constructed, it is clearly shown that within the first fifty years of construction and operation of the reservoir, it is has reduced to about half of its original size. Generally with increase intensive land use and increase erosion around the lake, there will be increase in sedimentation potential and eventually in the next 50 years Bosso lake will merely be a shadow of its original size. This will result to the inability of the dam to serve the purpose for which it was constructed.

From the analysis more than half of the study area has moderate to high yield erosion potential of about 0.32 ton/ha/yr to about 0.5 ton/ha/yr. These are mainly areas surrounding the dam. The reservoir and flood plain are the receiving regions with lower yield of about 0.1 ton/ha/yr. The high and moderate erosion yield surrounding the lake result in the rapid shrinkage of Bosso dam in recent years.

Specifically the area with moderate slope is of great concern, because it is large in size and it is the area where most of the human activities are concentrated. The vegetation here is sparse and some places are even bare. The areas with least erosion risk potential are mostly within the reservoir and also serving as the receptive areas for soils eroded from upstream and the immediate environment. In view of this, rapid shrinkage of Bosso Lake is a function of its geographic location and land use around the lake which change geologic erosion to accelerated erosion.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Current study using remote sensing technique has confirmed the proof that remote sensing is a viable tool in the study of factors influencing Bosso lake sedimentation and achievement of sustainable development in Nigeria as a whole. The results have been so encouraging and useful when considering it role in rapid inventory of our natural resources on the earth's surface which can then be extracted, processed, stored, analyzed, retrieved and presented in various forms for efficient management of Bosso Lake.

In summary the shrinkage of Bosso Lake was mainly due to siltation and sedimentation of the reservoir, this is a function of its geographic location and land use. The areas of high potential soil loss provide the runoff and aid increased soil loss potential of the moderate slope. This degradation of the study area leads to high erosion risk and thus sedimentation and shrinkage of the reservoir. It is noted too that the degraded areas coincide with areas of concentrated human activities. Thus it does seem that the sedimentation is more the influence of land use practice than the geographic location.

Remote sensing technique provide accurate definition and quantification of soil loss potential, vegetation degradation and land use classification of the study area. This provides the vital information for assessment of factors influencing Bosso lake.

5.2 RECOMMENDATION

The rapid shrinkage of Bosso dam over the years has revealed the inability of the people to take concrete measures or actions to be masters of the environment. The environment is the most endangered "specie" today because recent interaction of man with his environment has been that of "getting what I need-from-the-land attitude without giving thought to what happens thereafter" (Kufoniyi, et al, 2003). In view of this, the following are recommended:

1. There should be introduction of environmental education for the farmers. This will make the people to be environmentally literate and will tend to mitigate the problem of siltation and sedimentation resulting in the rapid shrinkage of the reservoir. Specific awareness programmes should be introduced to raise the level of awareness of decision-makers about the significant and benefit of sustainable development with regards to the reservoir.
2. The environmental impact (EIA) laws in Nigeria cover only large-scale projects. However this has been inadequate. There should be EIA laws for small-scale projects like Bosso lake, this can be used to identify and predict the key impacts of such project. So that the projects can serve the purpose for which they are constructed.
3. There is need to review the utilization and management of natural resources in Nigeria. This occupy a significant place in the survival of man. Thus utilization and conservation of natural resources is important.
4. To protect Bosso dam from sedimentation, the following measures need to be taken:

(a) Erosion can be limited by prohibiting construction and other forms of urban land use outside prescribed limits.

(b) Erosion and land degradation can be mitigated by prohibiting agricultural activities outside prescribed area.

(c) The hill slope sides should be preferably treated by hydro mulching, care being taken that the binder is not toxic or be protected with an excellent growth of trees and cover grasses to help check erosion and subsequent sediment loading into the reservoir.

5. To increase one's understanding of the environmental dynamics of the area, imageries of the area during different seasons should be acquired.

6. It is highly recommended that a detail research be undertaken to further investigate sediment potential of Bosso Lake. The present research has provided an insight into the problem of siltation and sedimentation of Bosso reservoir.

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