AN APPLICATION OF REMOTE SENSING AND GIS TO FLOOD STUDY: THE CASE IN FUFORE LOCAL GOVERNMENT AREA OF ADAMAWA STATE.

BY

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CERTIFICATION

This is to certify that this project was originally carried out by Zinnass Pwakandi Davies and approved as meeting the requirements for the award of a master of Technology degree in the department of Geography, Federal University of Technology Minna, Niger State Nigeria.

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DEDICATION

I specially dedicate this work to my beloved late grand parents Mr. And Mrs. Zinnass and chief and Mrs. Francis Dire. Also my late father Tony and my wonderful Mum Vasty, my sweet aunty Felicia, my Dearest friend Fibayi Makama, and lastly my entire family.

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ABSTRACT

The occurrence of flood events has brought a lot of miseries to man and his environment Fufore has continued to experience yearly loss of lives, properties and farmlands to flood events that are caused by heavy rains and discharge of water from Lagdo dam. This research studies flood in Fufore between 1971 and 1994. For this research, a pre-processed SPOT-XS sub-scene of Fufore taken on 30th November 1994 was enhanced based on its spectral reflectance intensity (Digital number). It was classified into hills and uplands, water, and flood areas. A topographic map of 1971 was digitized using the manual raster grid method and a DEM of the area for 1971 was generated. The DEM was reclassed into uplands and hills, lowlands, and flood areas. The areas that are less than the flood threshold value of 166.5m above mean sea level are reclassed as the flood areas on the DEM. When the flood areas of 1994 and 1971 were compared, the results revealed that the floodable areas had tripled from an estimated is coverage of 16.28% in 1971 as against 50.40% in 1994. And also the NDVI index is high between 0.50-1 on the hills and uplands compared to very low index of less then 0.25 on the floodable areas, thus signifying sparse and dry vegetation in the floodable areas. These results show that floodable areas are on the increase, and unless government takes measures to mitigate it, Fufore will continue to be endangered to flood every year.

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LIST OF ANCRONYMS

ANCRONYMS	MEANING
DEM	Digital Elevation Model
GIS	Geographical Information System
FAO	Food and Agriculture organization
SADC	Southern African development community
BBC	British Broadcasting Corporation
BMP	Bitmap
BIP	Band interleavened by Pixel
DN	Digital Number
TIFF	Tagged Image File Format

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CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND

The increase in the occurrence of flood events of late in the world has become a major source of concern due to its destruction tendencies to human existence. Various religions and cultures have aligned the causes to the anger and wrath of their gods as a measure to reduce the world of evil from the beginning of time.

This can be seen from the mythical tales of Lord Shiva, the god of the Hindus they believed to have cleansed the wickedness of the world through floods to save the righteous with a magical ship, as well as the Biblical story of Noah and the similar Konanic tale of the ark which speak of deluge and destruction cause by the evil in the world.

However, despite these tales, scientists have established that flood events are largely dependent on certain factors. Akintola (1978) attributes rainfall to be the major cause of flood, but this is greatly influenced by other factors such as human activities, global rise in sea level due to the melting of ice caps, irregular weather patterns such as El-NINO and LA-NINA phenomenon, to mention but a few.

The area of study, Fufore local government, has experienced increased developments, farming activities and deforestation in recent years. This has increased the rate of ecological imbalance, and land degradation. This increased level of land-use activities jointly with the yearly discharge of water from Lagdo dam from the Cameroons and the annual rains in the area have continuously endangered the lives and property of the populace due to flood events.

Unfortunately, government and her agencies have continued to work towards providing relief materials to flood victims rather than taking preventive measures against flood occurrences. In 2000, the Federal Ministry of Environment in conjunction with the State Ministry of Environment of Adamawa State carried out a survey to determine the floodable zones within the area. The final report of this survey was received with so much criticism because of the method used and the composition of experts used to conduct the work. Thus there is need to determine more accurately the floodable zones in the area through the use of remote sensing and geographic information system to give a more reliable and accurate flood information for effective flood management. In view of this, this research will attempt to use remote sensing to study flood in Fufore for the period of 1971 and 1994.

1.1 PROBLEM STATEMENT

The problem of disasters due to flood has brought so much sorrow to families, communities and the world. This is because of lack of proper flood management policies in some areas, poor implementation of flow management policies in others, inadequate technical know how in some, or the use of purely conventional structured measures in most part of the world.

Fufore lies within the flood plains formed by river Benue and its tributaries (Gongola,Song,and Kilangi on the north banks , with Ini, Belwa, and Faro tributatries on the southern banks) according to Adebayo and Tukur (1999).Unfortunately, river Benue overflows the lowlands plains annually, as a result of the annual release of water from Lagdo dam and excessive down poor that is experienced at the peak of rains, causing annual flooding of the area.

It is quite worrisome that the Adamawa state government and the Fufore local government council has continued to deliver relief materials to flood victims' year in year out without taking proper measures to mitigate and study the flood situation in Fufore. The closet attempt to study flood of recent was done by the Federal Ministry of Environment together with the state ministry of environment in 2000 of which the quality of study was marred by the constitution of the research team and the methods used.

Apparently, it has become important to carry out a proper flood study of Fufore using remote sensing and Geographic Information System (GIS) technologies to produce flood information that will help the government, policy makers, and environmentalist to draw out a proper flood management policy that can be used to prevent and mitigate flood events.

1.2 AIMS AND OBJECTIVES

The aim of this research is to ascertain floodable areas in Fufore LGA of Adamawa State ~~in Flood~~ using remote sensing and geographic information system technology. This is to be achieved through the following objectives

(1) To generate a Digital Elevation Model (DEM) of the study area as at 1971.

(2) To determine the flood areas in 1971 and 1994, and compare them.

(3) To determine the vegetation index of the study area and compare it with the flood zone.

1.3 JUSTIFICATION OF STUDY

Flood has remained a major environmental problem in our society today. And this is because of the level of destruction that results from it.

There has been series of flood events in recent years that testified to this. The British Broadcasting Co-operation (BBC) on 25th September 2000 reported that over 400 people were feared dead, and 15 million people left homeless due to flood attack in west Bengal, India. In East Africa, according to Rashid (1998, indicated that there was extensive loss of crops and livestock both on the field and store throughout that year in that region.

Back home in Nigeria, the preliminary report on the inventory of the impact of rainfall-related disasters during the 1999 raining season states, that there were at least 65 deaths, over 12 million hectare of farmlands washed away resulting in estimated farm produce loss of over 100 million tons. Infrastructure facilities (houses, schools, roads, etc.) destroyed will cost over ₦50 billion to rehabilitate or replace. And Fufore, had about 13 villages submerged by flood (Adefolalu, 1999).

Invariably, measures must be put in place to study flood and identify areas liable to flooding, through the use of remote sensing and geographic information system technologies.

1.4 SCOPE AND LIMITATIONS

The scope of the study is limited to about 219.375sq km of the study area. And also a topographical map of 1971 on scale 1:250,000 (48A), a sub-scene of SPOT-XS 1994 covering the area, and the annual gauge height data of river Benue taken from Dasin water gauge station from 1985 to 2001 were used.

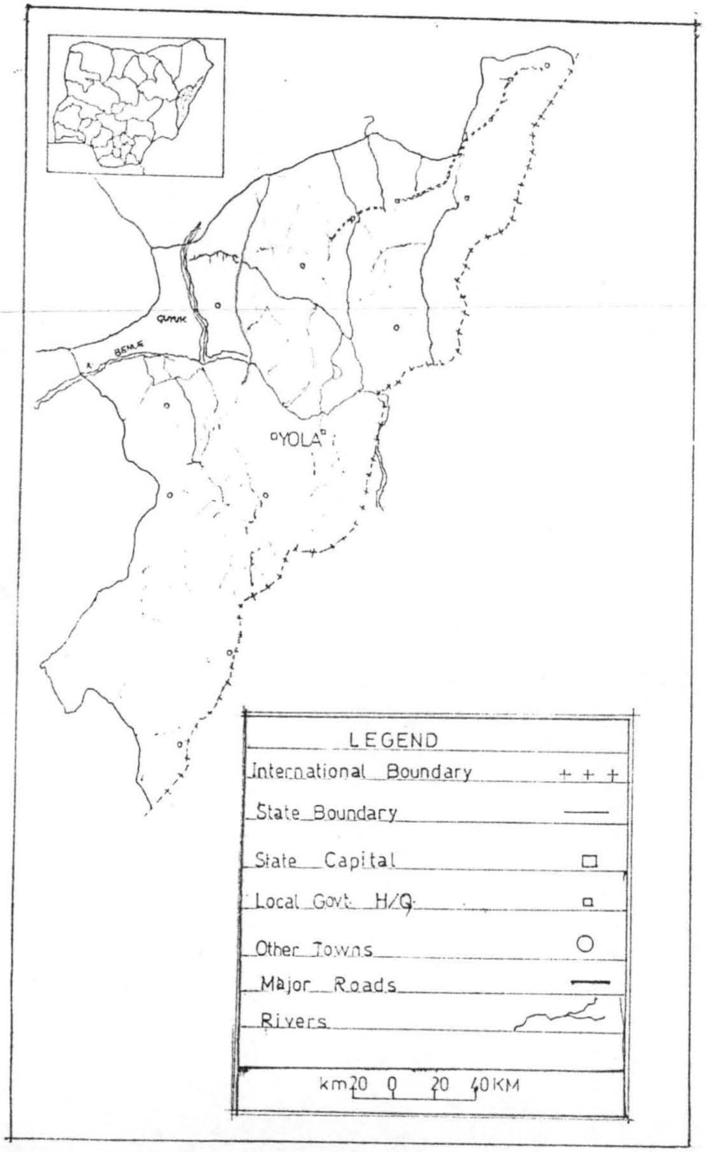
1.5 STUDY AREA

The area of study is between latitudes 9.13N and 9.23N, and longitude 12.35E and 12.51E. It has a mean annual rainfall between 900mm – 1100mm, with onset and cessation dates of 10th may and 6th October respectively. The rains usually last between 4 to 5 months. (Adebayo and Tukur, 1999).

This area occupies the northern guinea Savanna vegetation of Adamawa State and is characterized by plants such as *Afzelia Africana, Viterllaria paradoxa, Terminalia Laxiflora, Annona senegalensis*, wood species with

Anadropogan, Pennisetum, and *Klyparrhenia* as the grass under growth (Usman, 2002). While the soil type of this area is a combination of *Eutric pelluster* (USDA) *pellic vertisol* (FAO). The former are deep, poorly drained soil on nearly flat topographic with a varying colour of grey to grayish brown. And the later are deep and poorly drained heavy clays with a varying colour of dark grayish brown clay loam to black (Usman, 2002).

The hydrology of this area is characterized by the Benue system. River Benue, which is the major river that flows in the state, flows from the Cameroonian highlands and passes through Fufore to most parts of Nigeria. The people of Fufore are predominantly farmers who in the production of groundnuts, rice and maize as their major agricultural produce.


YOLA
LEGEND
International Boundary + + +
State Boundary
State Capital
Local Govt. H/Q
Other Towns
Major Roads
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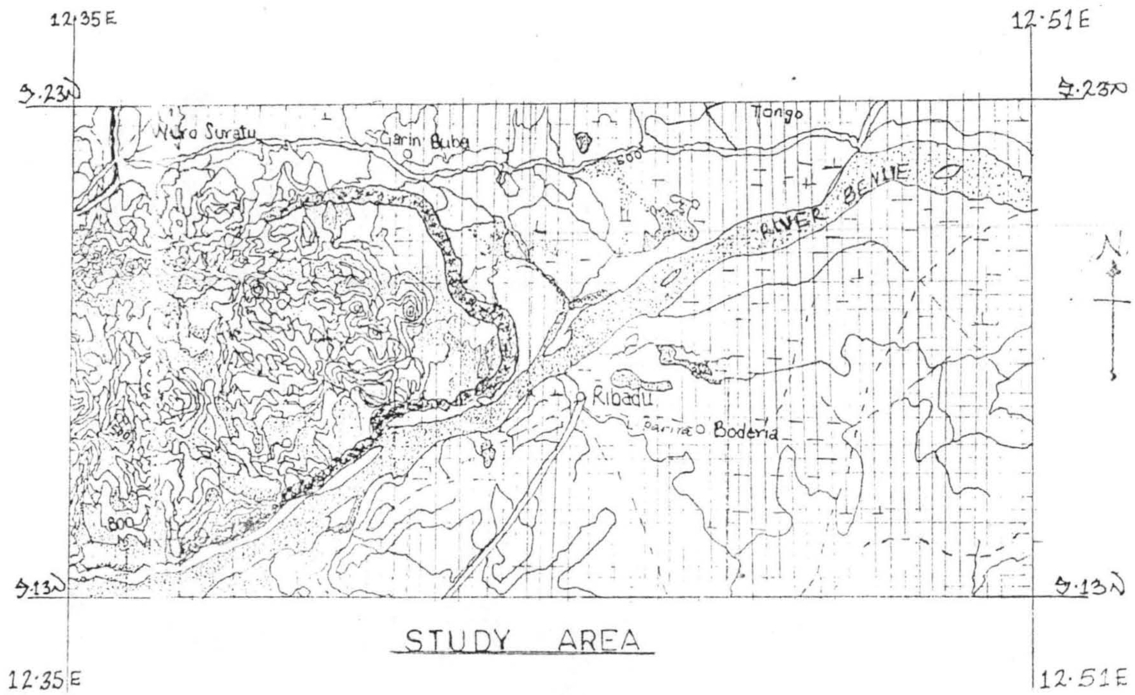
12·35E
12·51E
7·23N
7·13N
Garin Buba
Tongo
RIVER BENUE
Ribadu
Boderia
800

STUDY AREA

1.6 EXPECTED OUTPUT/RESULTS OF THE STUDY

The expected products or output/results of this study include:

1. A Digital Elevation Model of the study area for 1971.
2. A flood map of the study area for 1971 and 1994.
3. The areas cover by flood in 1971 and 1994.

However, the expected results listed above will be incomplete and baseless without a review of the various concepts, tools and literature related to the study on ground. Hence, the next chapter takes a thorough look at several related literature and applications.

CHAPTER TWO

LITERATURE REVIEW

2.0 CAUSES OF FLOODS

Flood is one of the world's greatest environmental problems and this is because of the devastating effects it has on lives and properties. According to Ghose (2003), this disaster does permeate every corner of the society.

Floods are caused by heavy rains or the melting of ice or snow, the bursting of dams, water in land, earthquakes, volcanic eruptions and the bursting of sea banks (Dare, 1990). But then rainfall is the most universal cause of floods most especially when it is heavy, prolonged or both (Aladelokun, 1998).

There are six types of flooding in which climatological factors are partly or indirectly responsible as identified by NEST (1991). These include:

(1) Ponding back of stream flow particularly during spring tide condition;

(2) Rivers and tributaries carrying water flows very much in excess of their transporting capacities due to concentration or run-offs;

(3) Heavy rainfall synchronizing with spills of rivers;

(4) Main river barking up the water in their tributaries;

(5) Inadequate and inefficient drainage of low-lying and flat areas to the outflows; and

(6) Flooding of low-lying coast by excessively high tides associated with storm surge effects.

Akintola (1978) explains that despite the universality of rainfall as a major cause of flood, there are other joint causative factors categorized as human interference. Aladelokun (1998) refers to them as man's interaction with his environment in the form of urbanization, agricultural activities, and deforestation.

According to Aladelokun (1998), when urbanization intensifies natural surface is replaced by buildings, paved roads, and concrete surfaces which do not allow water to percolate readily into grounds. The consequence is that a large proportion of rainfall which should normally infiltrate into the soil or be intercepted by the vegetation and thus delayed for sometime before running off is immediately available for surface runoff into streams and rivers making them flood . The incident 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.

The constructions of dams for increase in water supply and hydroelectric power is part of man's activities that can lead to flood events, through its collapse. A typical example is the collapse of Bagauda dam of Kano in August 1988 (NEST, 1991) caused by sedimentation which reduced the capacity of the dam and so led to its collapse. This led to the destruction of farmlands, properties and lives. (Aladelokun, 1998).

In most Nigerian cities, flooding is attributed to lack of well-attributed plan and consideration of various aspect of the plan such as the waste, traffic and population as reported by Lt.col Tony Asenuga in NEST (1991). And Akintola (1982) supports this assertion and further adds that inadequate drainage is one of the peculiar planning problems that causes flood.

2.1 INCIDENCE OF FLOODING

New Nigerian newspaper (24 July, 2003) reported that heavy rains aggravated flooding in northwest India leaving 100,000 people homeless on the 8^{th} of July 2003. And that in 2002, about 100 people were killed by it while 2.5million were left homeless in Assam district. This was worsened because of the fact that the district was ill equipped. Release of water from reservoirs, and heavy rains left at least 400 people dead, more than 15 million people homeless and 200 people missing in Bengal, India. In Bangladesh, rains washed out embankments, swamped 50 villages, and marooned up to 250,000 people in the north according to relief officials in the country (British broadcasting corporation news, 25th September 2000).

A report of the Southern African Development Community (SADC) regional early warning unit, stated that the Mozambican killer floods left 62 people dead, forced 80,000 people from their homes and affected as many as 460,000 people in 2001 (Mail and Guardian, 2001).

According to Johnson (2001), Kano state in August 2001, experienced torrential rains that caused rivers to overflow and dams to collapse. Sixty villages were submerged, while destroyed farmlands, livestock and agricultural produce estimated to be worth millions of Naira .He further reported that Niger State had more than 250,000 people dislodged by floods in 1999, and 2000. Nigeria as a whole suffered one of her greatest episodes of flood in 1999 where virtually all the geo-political zones were affected. In the preliminary report of the impact of rainfall related disasters of Nigeria during the 1999 rainy season carried out by the climatic change center of the Federal University Of Technology Minna, it was recorded that at least 65 people were left dead, and over 12 million ha of farmlands was washed away resulting in an estimated farm produce loss of 100 million tonnes and infrastructures (houses, schools, roads, etc) destroyed worth ₦50 billion. The report highlighted that Fufore, had 13 villages submerged and hundreds of hectares of farmlands were washed away by floods.

2.2 INTEGRATION OF REMOTE SENSING AND GIS

2.2.1 DEFINITION OF REMOTE SENSING AND GIS

Remote sensing is described as a powerful technique in the collection of multi temporal datasets but there exits a gap between the data collection and utilization (Curran, 1985). Lillesand and Kiefer (1979) refers to it as a science and art 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 objects, area or phenomenon under investigation. Okhimamhe (1999) defines it as a set of techniques used for obtaining information about the environment at some distance from them, usually by means of sensors which detect and record electromagnetic energy.

Thus, remote sensing makes observation of objects easier from a distance without coming in contact with it through the use of sensors. Geographic information systems (GIS) according to Apfl and Baugartner (1996), is a system which is designed to collect, store, update, manage, manipulate, analyze and represent graphical and non –graphical spatial data .GIS is a tool for effective and efficient storage and manipulation of remotely sensed data and other spatial and non-spatial data types for scientific management and oriented information (www.gisdevelopment, 2003). From the FAO report of 1990, GIS was defined as the computerized information, storage, processing, and retrievals systems that have hardware and software specifically designed to cope with geographical reference spatial data and corresponding attributes information.

Thus, GIS is a system that deals with the collection, collation, storage, manipulation and analysis of spatial and attribute data to produce desired results that will help in decision making for a sustainable development.

2.2.2 INTEGRATING REMOTE SENSING AND GIS IN FLOOD STUDIES

The integrating of remote sensing and GIS provides a broad range of tools, for determining areas affected by flood or for forecasting areas likely to be flooded, (De Brouder, 1994). That is why they are increasingly being used as operational tools for studying environmental problems most especially floods (Seth, 2003).

It is in view of this that Mekong Basin commission in 2001, developed and applied techniques using remote sensing and GIS to improve flood preparedness in the four riparian countries in the lower Mekong Basin by using some RadarSat images of 2000, Topographic data and hydrological data of the Basin. The Topographical data was used to generate a Digital Elevation Model (DEM) and in conjunction with the hydraulic model the depth of flooding was derived, while possible flood areas were estimated from the data.

The RadarSat imagery collected was used to extract inundated areas and detect open water.

Thus, flood depth maps were derived by subtracting the DEM from the daily simulated water surface. Inundation depth grids were produced and flood duration was derived from those grids. These data sets were compiled and combined into integrated data sets. The two components of the integrated databases are specific floods and the flood hazard maps of the main flood zones in Cambodia, Laos, Thailand, and Vietnam (Mahaxay, 2002).

The flood study of Megha – Dhouagoda Polda, Bangladesh, was carried out using Remote Sensing and GIS and this proved to be useful and efficient instruments for managing flood – prone areas in Bangladesh (De Brouder, 1994). According to him, a SPOT multispectral CCT image, hydrological data, and Topographic maps of the areas were used. A digital elevation model (DEM) was created by digitizing the existing contour lines on the topographic maps. This was used in showing the extent of the area that is inundated, and two flood maps were created, one for a water level of 3.50m and the other 3.00m above sea level. Using the simple techniques of density slicing on the flood SPOT imagery of the area, as such it was possible to differentiate flooded and non – flooded areas.

Raford (1999) in his report for the city of Warwick and project impact, on the analysis of flood hazard using GIS, showed that the digital photography of the area, contour data, and flood insurance maps of tax plots, zones and road locations were integrated into the project. These were digitized and overlayed. Using the flood height elevations from the original hard copy of the flood insurance maps, contour arc were extracted at these elevations to determine were flood levels would rise, given floods of 100 years and 500 years intensity.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.0 DATA.

The primary data used for this research is a sub-scene of SPOT – XS (System Probatorie d'Observaiton de la Terre, Multispectral) imagery of Fufore taken on 30th November, 1994. This image had already been pre-processed before being put into use, thus had undergone image reconstruction.

The secondary data comprises of a topographical map of the area at a scale of 1:250,000 (48A) of 1971 and gauge height data of River Benue taken from Dasin Water gauge station of Upper Benue River Basin Development Authority from 1985 to 2001.

3.1 MATERIALS.

The following materials were used for this research work:

a) Computer Hardware

b) Computer software, IDRISI 32 GIS and image processing software.

3.2 METHODOLOGY.

3.2.1 DATA FORMAT CONVERSION OF SPOT XS IMAGERY

A file format of a data is the organisation of the data matrix for recording, storing, and distribution of remotely sensed data. The SPOT -XS imagery used for this work was initially stored in TIFF format. However, to use the image in

IDRISI 32 Software, it had to under go some form of format conversion, because the software cannot carryout processing of a 24-bit image

Thus, the image was first imported into IDRISI 32 through the IMPORT function, using the DESKTOP PUBLISHING FORMATS sub-function into BMP IDIRIS FORMATS (Bitmap format). Converting it from a TIFF image to a BITMAP Image.

This image was then separated from a 24- bit BMP composite image into 3 input bands of 8 bit BIP composite image. These bands were stretched to 6 levels (6 x 6 x 6 = 216) and the 256 colour composite palette colours correspond to the mix of blue, green, and red in the stretched images. This was done by importing the SPOT – XS BMP format into IDRISI 32 again through the IMPORT function, using the GENERAL CONVERSION TOOLS into the BIP IDRISI FORMATS.

3.3 IMAGE PROCESSING.

Image processing is the use of computer to manipulate and interpret digital data. This involves 3 basic operations, map reconstruction, image enhancements and image classification (Okhimamhe, 1999).

However, in this study the pre-processed SOPT-xs imagery under went image enhancements and image classification.

3.3.1 IMAGE ENHANCEMENT.

The 8 bit decomposed SPOT-XS imagery of Band 1 was enhanced using the Histogram Equalization stretching technique. The essence of this enhancement is to improve the interpretability of the image; as such the image had to stretch to smoothen the surface. And the option of histogram equalization stretching technique tends to give a better and broader range of brightness level of an image and so it was the most suitable for the enhancement.

3.3.2 IMAGE CLASSIFICATION.

The enhanced image was then reclassed into a Boolean layer to show the flood map of SPOT-XS clearly using the level of reflectance or the digital number of the image. This was done through the GIS ANALYSIS function using the RECLASS sub function of the DATA QUERY module in IDRISI 32. The flood zone was encoded 4, lowlands were encoded 3 Hills and uplands 2 and water was encoded 1.

The reclassed image was the classified using the maximum likelihood classification technique, which is based on the probability density function, associated with, particular training site signature. The option of "use equal prior probabilities for each signature" was used in the maximum likelihood classification. This was done using the MAXLIKE operation of the HARD CLASSIFIERS function in the IMAGE PROCESSING module of IDRISI 32.

3.4 FLOOD THRESHOLD LEVEL.

The flood threshold level is the mean water level of the river between the periods of rains in the study area. This is used to determine the occurrence of flood of the River. The flood threshold level was determined using the formula below:

$$MG = \frac{\sum MWL}{\sum Y}$$

$$FL = MG + GZ$$

Where MG = Mean gauge level

GZ = Gauge zero level

$\sum$MWL = Summation of mean water level between April – Oct.

$\sum$Y = Summation of years

FL = Flood threshold level

3.5 ANALYTICAL OPERATIONS

3.5.1 DERIVATIVE MAPPING

This is one of the GIS analyses and it involves the combination of selected components of the database to yield new derivative layers. In this research, the x, y, and z values of the topographic map of the study area were extracted and combined to produce the digital elevation model (DEM). Using the following procedures.

a. **Digitizing Topographic Map.**

Digitizing is the process of converting hard copy data in the form of a map, orthophoto, aerial photographs or satellite image into vector data. This can be done using a digitizing tablet, scanner, and standard mouse in the case of on-screen or heads up digitizing, and finally using grids as in the case of manual digitizing.

In the case of this research, the topographic map of the study area was manually digitized using the raster grid method with a space interval of one minute between the grid lines on both the x and y axis. The point of intersection of the grid lines was used to extract the x, y, z, values. Where the x values represents the longitudinal locations, y values represents the latitudinal locations, are the z values represents the elevation above mean sea level.

b. **Creation of an IDRISI Vector Point File.**

The IDRISI vector point file is the vector file that contains geodetic co-ordinates and elevation that are used to create surface maps and digital elevation models (DEM).

The x, y, and z values are inputted into an ASCII file using the EDIT module in the DATA ENTRY function of IDRISI 32. The x, y, and z IDIRIS module was then used to import the ASCII file to IDRISI 32 as an IDRISI vector point file.

c. Surface Interpolation.

The digital elevation model of Fufore was generated using the INTERPOL sub-function of the SURFACE ANALYSIS in the GIS ANALYSIS module of IDRIS 32. The INTERPOL operation has two options; to calculate the potential surface model and interpolate digital elevation model (DEM) using weighted average. And for this research work, the second option of interpolating DEM using weighted average was used because it best gives you the surface view of the DEM, moreover the generation of a DEM of Fufore is one of objectives of this research and not calculation of the potential surface of the study area.

3.5.2 RECLASSIFICATION OF DIGITAL ELEVATION MODEL (DEM).

The process of reclassification creates a new layer of each individual condition of interest, which is also known as a Boolean layer. This as because the layer contains areas that meet the condition (1) and areas that don't (0). Such layer is also called a logical layer, since it shows only a true or false relationship. And atimes referred to as a Binary layer for the fact that it contains one's and zero's.

This DEM was reclassed based on this principle and converted to a Boolean layer using the Flood Threshold level to determine flood zones and non-flood zones of the study area for 1971.

3.8 VEGETATION INDEX OF THE STUDY AREA.

The vegetation index of Fufore was determined using the Normalized differential vegetation index (NDVI) model. This was done to assess the vegetal cover of the area, using the IMAGE PROCESSING module of the TRANSFORM OPERATION through the VEGINDEX sub-function which calculates the green vegetation indices through the combination of the visible red and infrared bands of the SPOT-XS image of Fufore

CHAPTER FOUR

ANALYSIS OF DATA AND DISCUSSION OF RESULTS.

4.0 ANALYSIS OF SATELLITE IMAGES.

The SPOT-XS Image of Fufore was taken on November 1994 just immediately after the rainy season. That's why observations from plate 4.1 show that the area of study is almost red. This red colour signifies green vegetation because the near infrared portion of the spectrum reflects green vegetation as red. While the river and water bodies are reflected black. Thus, River Benue and Lake Pariya appear distinctively black. The rocky out crops are reflected brown while the bare ground and sparse vegetation are reflected white. The Band 1 stretched image (Fig. 4.2) is smoothened and clearly brings out the surface features of the study area. The water bodies (Lake Pariya) and the River Benue shows a low spectral reflectance (black). This is because water absorbs energy in the near infrared portion of the spectrum. The Rocky out crops that consist of Bagale hills located at the southwestern part of the area and other surrounding uplands have a moderate spectral reflectance (dark gray) due to the green vegetation cover. The lowlands have a moderate high reflectance (light gray) due to the less dense vegetated while the flood areas have a high spectral reflectance (white). This is so because of the coarseness of the surface, and the dry alluvial deposit that spreads over the trough of the area of study that is shown in the image.

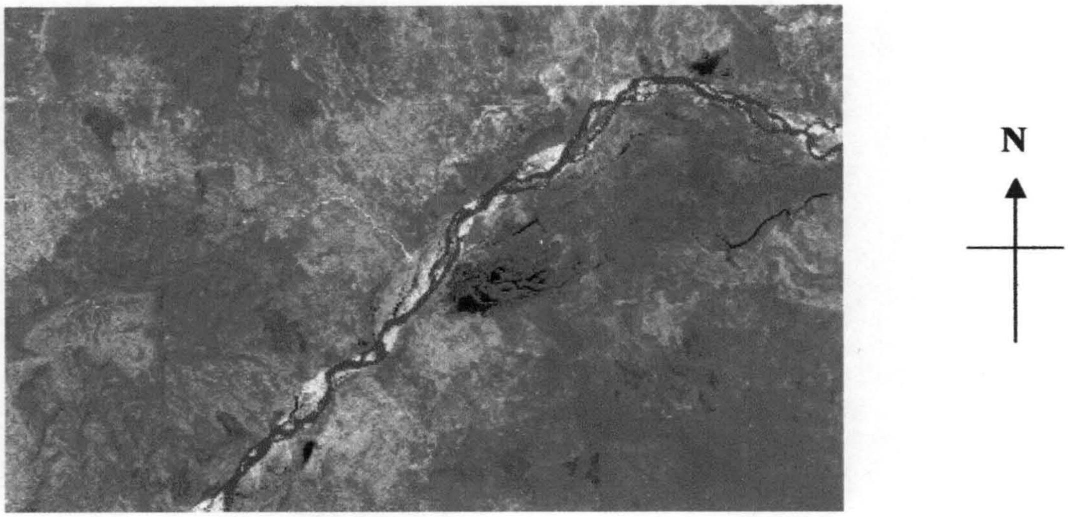

PLATE 4.1: SPOT-XS IMAGE OF FUFORE

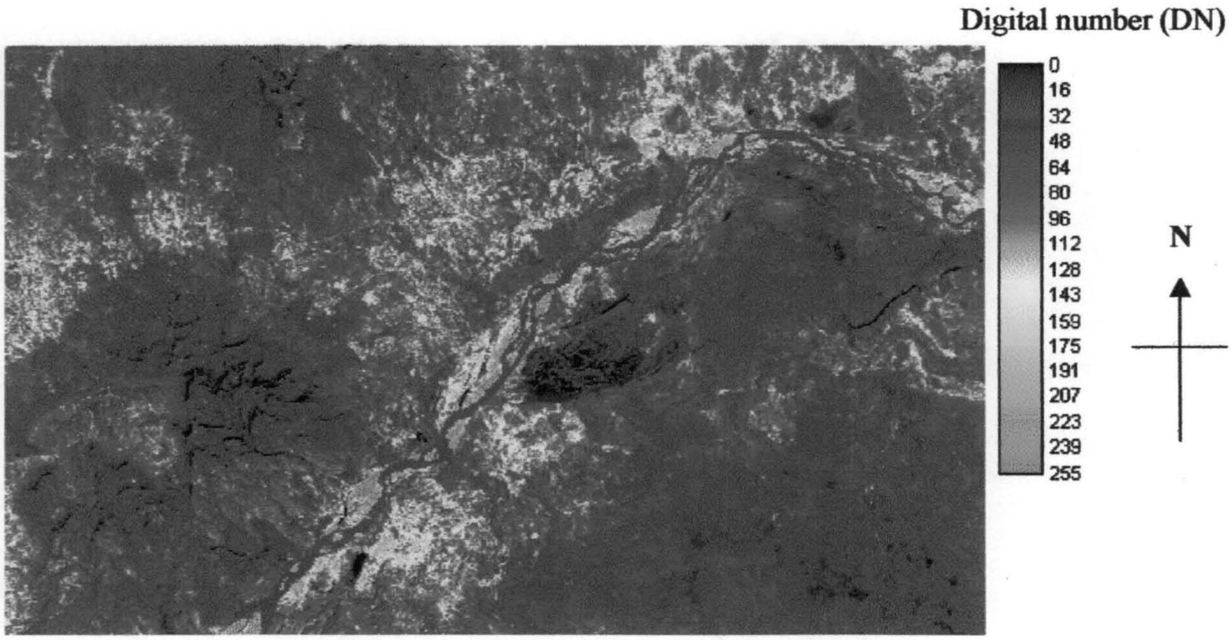

FIG.4.1: THE DECOMPOSED SPOT-XS IMAGE

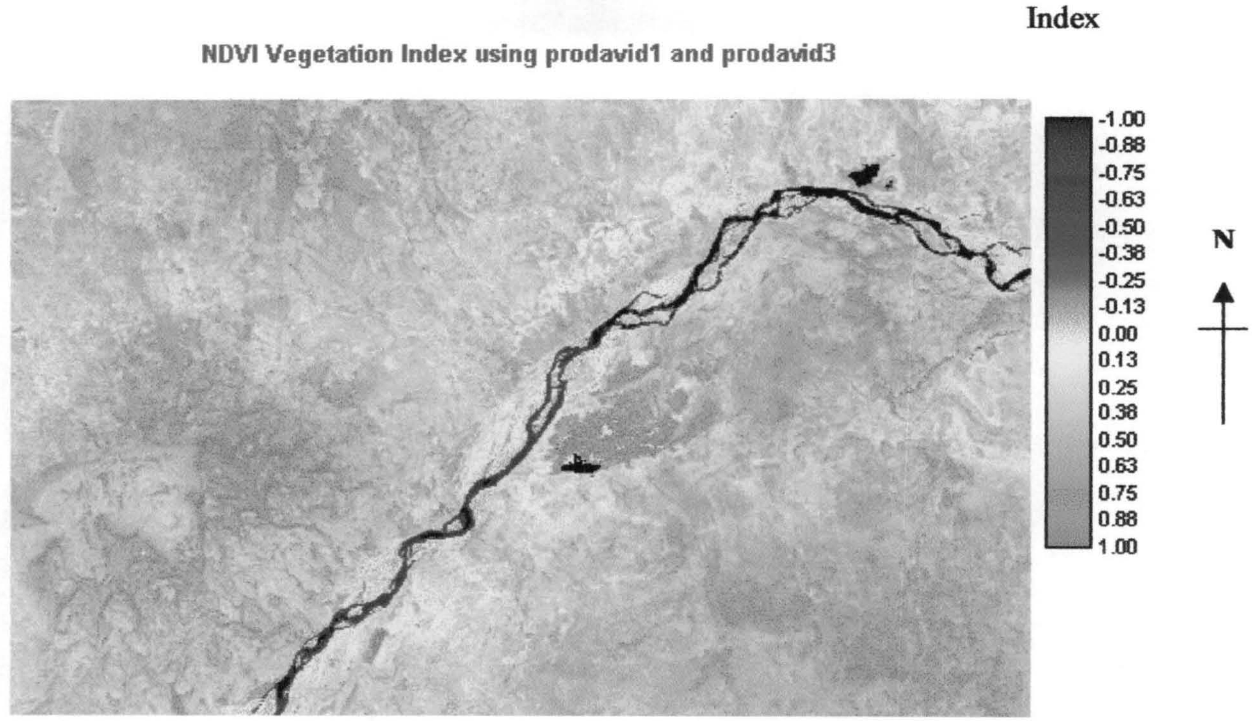

FIG.4.4: NDVI OF SPOT-XS IMAGE

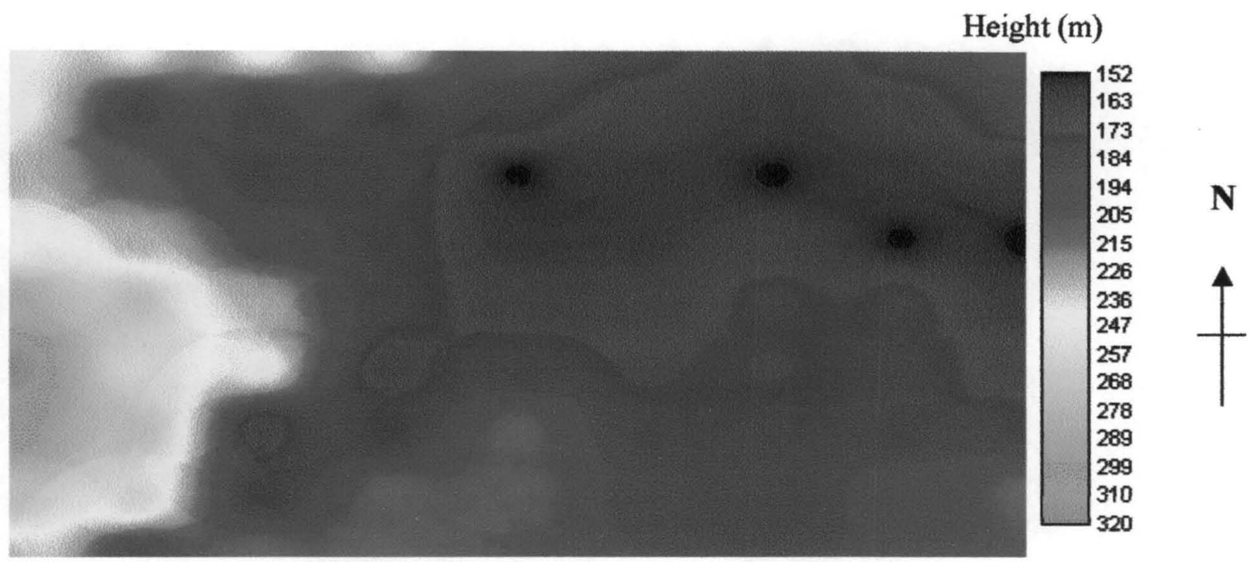

FIG.4.5: DEM OF FUFORE FOR 1971

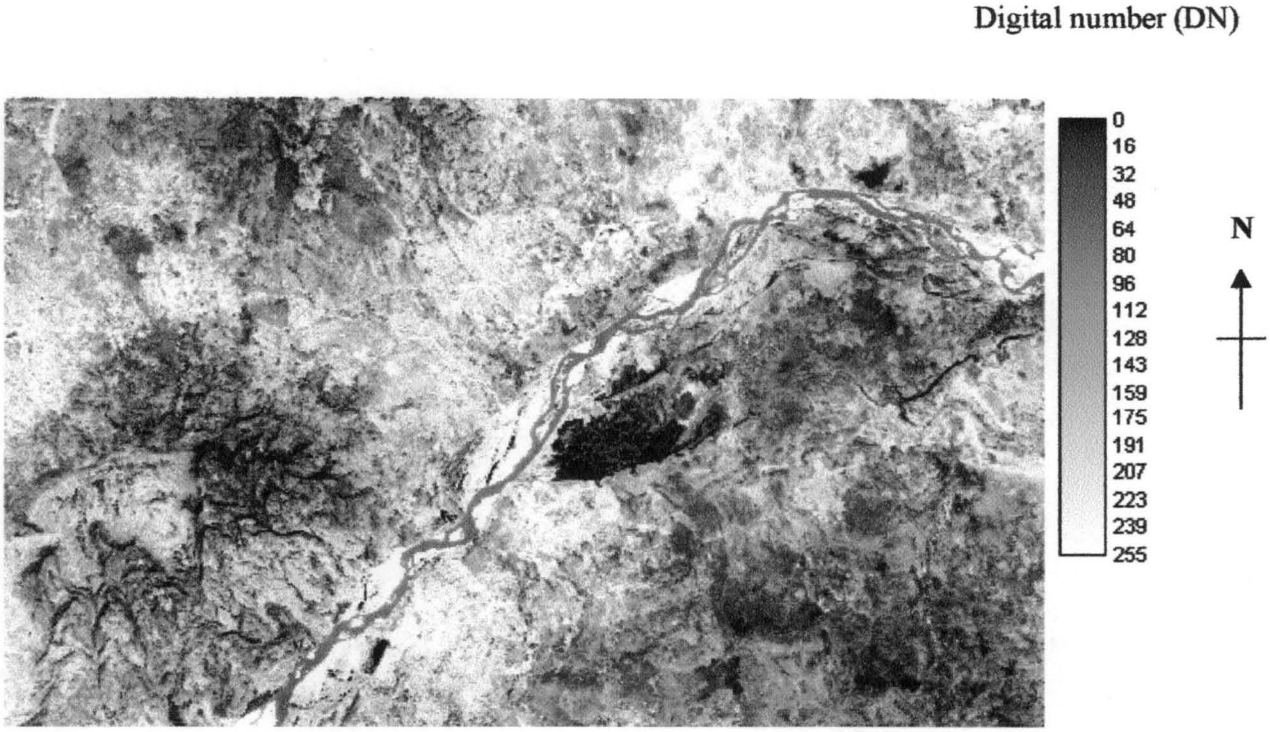

FIG.4.2: ENHANCED (STRETCHED) SPOT -XS IMAGE

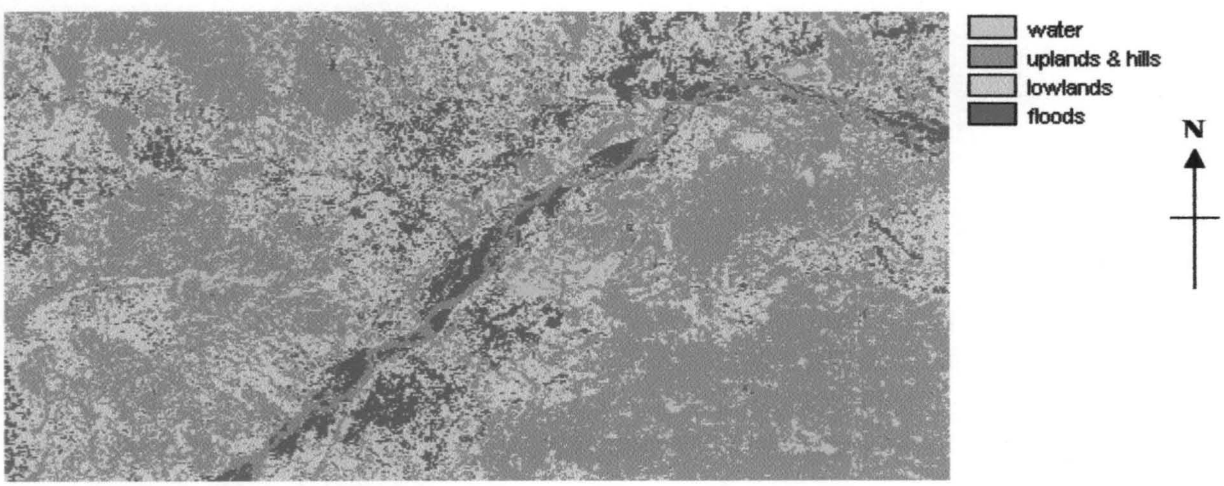

FIG.4.3: IMAGE CLASSIFICATION OF SPOT -XS

The image classification (Fig. 4.3) show the flood area covering almost the entire lowlands and more prominently along the River Banks. This is displayed in Red, the uplands and hills are blue in colour, the lowlands yellow and while the water bodies are coloured light green. And from the NDVI of SPOT-XS, it is observed that the Bagale hills and other surrounding uplands have a high vegetation with an index of 0.5 –1, while the lowlands have a medium vegetation with an index of 0.25 –0.49.

The floodable areas have a vegetation index of less than 0.25, which signifies bare ground and dry sparse vegetation. And this coincides with the features in fig 4.2 and 4.3 respectively.

4.1 ANALYSIS OF THE DIGITAL ELEVATION MODEL (DEM)

From the DEM of Fufore for 1971, in fig 4.5 the numerical representation of the relief of the area is displayed in the image .The topographic surface in terms of a set of elevations measure at finite number of points displays that the study area as a trough with hills and uplands surrounding it. The hills and upland have heights within the range of 191 – 320 above mean sea level, and the trough with a range of 0 – 191m above mean sea level.

Figure 4.6 shows the flood areas of the study area as at 1971, using the calculated threshold value of 166.5m above mean sea level, areas less than

166.5m are classified as floodable areas, and are coloured black, the lowlands are coloured yellow and the hills and uplands and displayed green.

TABLE 4.1: ESTIMATION OF FLOOD AREAS AND NON-FLOOD AREAS FOR 1971 AND 1994.

DESCRIPTION	FLOODABLE AREAS		NON-FLOODABLE AREAS	
	PERCENTAGE	AREA	PERCENTAGE	AREA
1994	50.40%	110.56KM	49.60%	108.81KM
1971	16.28%	35.71KM	83.72%	183.66KM

4.2 COMPARISM OF FLOOD BETWEEN 1971 AND 1994.

Observations from fig 4.3, shows that the flood areas of Fufore for 1994 spread over the entire lowlands on the satellite imaged however the overlay image of the DEM in fig 4.7, shows that the flood areas spread over a small portion of the lowlands and banks of River Benue in the case of 1971.

In table 4.1 above, it could very much be observed that the flood areas in 1994 has tripled that of 1971 with an estimated area coverage of about 50.40%, as against 16.28% in 1971. This spread can be attributed to the damming of River Benue by Lagdo dam in Cameroon, which when it fills up during the rain season is discharged and leads to the overflow of River-Benue, thus destroying the settlements and farmlands located on the lowlands yearly.

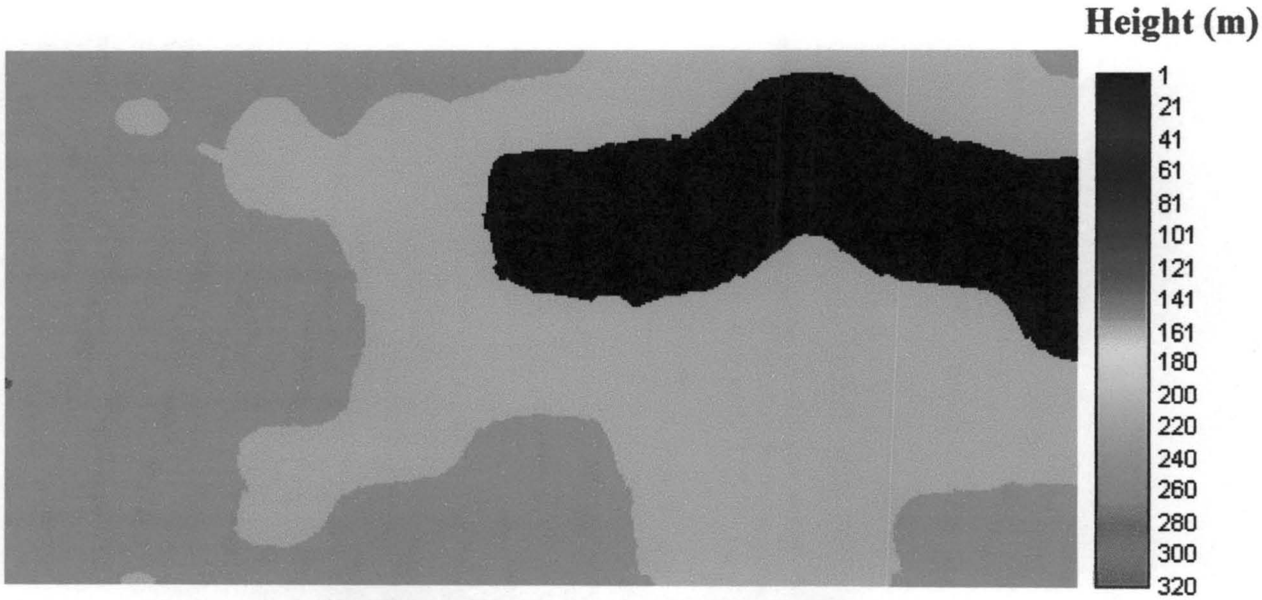

FIG: 4.6: RECLASSIFICATION OF DEM

FIG. 4.7: OVERLAY IMAGE OF FUFORE

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION.

5.0 INTRODUCTION.

This research was basically carried out using Remote Sensing and GIS Technique to study the flood in Fufore Local Government of Adamawa State for 1971 and 1994. This chapter concludes this research by presenting a summary, conclusion, and recommendation of the work.

5.1 SUMMARY

Flood is one of the major Environmental disasters affecting the world. And Fufore has suffered an annual flood event due to the overflow of River Benue when water is discharged form Logdo dam and whenever a heavy down pour is experienced in the rainy season.

This research attempts to study difference in areas covered by flood in Fufore for 1971 an 1994. Thus, to carry out this research, a sub-scene of SPOT-XS satellite image of 30th November, 1994 of Fufore, a 1971 topographic map of the study area was used, as well as the gauge height data between 1985 to 2001 was put to use and these were analyzed.

Results from the analysis of the satellite image of Fufore reveals that almost the entire lowlands are floodable areas. The Bagale hills and the surrounding uplands are covered with green vegetation while the floodable areas have a sparse and dry vegetation cover. The reclassed DEM of the study area for 1971, indicate that only a small portion of the study area is floodable. From the estimated area of is floodable areas, the floodable areas had tripled from an estimated area of 16.28% in 1971 as against 50.40% in 1994.

5.2 CONCLUSION.

From the results of the analysis, it has shown that remote sensing and GIS Techniques have very well shown that the floodable areas have increased in 1994 as against what it was in 1971.

And this is because of the fact that the annual release of water from lagdo dam, and the heavy down pour experienced rises the water level of river Benue an eventually resulting to the flooding of lowlands and destruction of lives, properties and farmlands.

5.3 RECOMMENDATION.

In future, further research on the study of flood can be employed using remote sensing and GIS Techniques. As such, these techniques can be used to develop a dynamic flood warning system, determine flood zones through flood risk mapping, and carry out flood hazard analysis of flood prone areas. Remote sensing and GIS techniques can be used also to assess the extent of flood damage in flood-affected areas.

However from the findings I recommend the following:

1) The Federal Government of Nigeria and the Cameroonian Government. Should through a policy or memorandum of understanding agree on when there will be discharge of water from Lagdo dam and how much water will be released at the time of discharge. This will help them both in planning on what to do with the water and how to guide against its destructive tendencies.

2) The Federal Government and Adamawa State government should build flood embankments, channels, and drainages in the flood prone areas to mitigate the flood events in that area.

3) In the absence of structural flood measures the inhabitants of the flood prone areas should be relocated to areas that are less prone to flood.

4) The Federal and Adamawa State Government should encourage the construction of flood-proof housing structures in flood prone areas.

5) There is need for the creation of a green belt in flood prone areas of Fufore.

6) The Federal and Adamawa State Government should prepare at least a 50 - 100 years flood plain zone control management policy to help mitigate and prevent flood events.

7) The Federal and Adamawa State Government should set up a data bank that will be responsible for the collection and storage of data that can be used for the prediction of flood, advance warning, and information dissemination.

8) The 3-tiers of government needs to be more enlightened on the importance of remote sensing and GIS techniques for Environmental Management.

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APPENDIX: 1

WATER STAGE MONTHLY MEAN VALUES OF RIVER BENUE

STATION: Dasin Hausa from Upper Benue River Basin Authority STATE: Adamawa

Gauge Zero level: 161.574 m (msl)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	
1985	1.43	1.35	1.36	1.39	1.50	2.34	3.18	3.69	4.38	2.94	2.02	1.81		
1986	1.69	1.67	1.69	1.77	1.78	2.12	2.76	3.80	4.29	3.39	2.22	1.77		
1987	1.65	1.69	1.66	1.37	1.67	2.04	2.81	4.26	4.98	5.42	2.27	1.66		
1988	1.65	1.69	1.66	1.37	.167	2.04	2.81	4.26	4.98	5.42	2.27	1.66		
1989	1.48	1.46	1.42	1.48	1.63	2.05	2.85	4.49	5.05	3.53	2.36	1.64		
1990	1.54	1.41	1.47	1.60	1.59	2.02	3.08	4.92	4.46	3.12	2.26	1.69		
1991	1.51	1.46	1.47	2.53	3.01	3.71	4.35	5.91	6.19	4.59	3.45	2.89		
1992	2.70	2.60	2.59	2.66	2.88	3.35	4.36	5.40	6.71	5.03	3.74	-		
1993	-	-	-	-	2.51	2.84	4.19	5.40	5.51	3.92	3.35	-		
1994	-	-	2.31	2.31	2.45	3.03	3.86	5.18	7.25	5.63	3.74	2.88		

APPENDIX: 2

WATER STAGE MONTHLY MEAN VALUES OF RIVER BENUE

STATION: Dasin Hausa from Upper Benue River Basin Authority STATE: Adamawa

Gauge Zero level: 161.574 m (msl)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	
1995	2.58	2.46	2.54	2.57	2.82	3.48	4.78	6.83	7.29	4.55	3.47	2.99		
1996	-	-	-	-	2.61	3.57	4.17	5.15	6.42	6.00	363	3.14		
1997	2.78	2.62	2.53	2.55	3.25	3.73	5.06	6.42	5.58	5.01	3.91	3.11		
1998	2.71	2.55	2.43	2.56	2,72	2.87	3.57	5.37	6.94	6.15	3.94	3.35		
1999	3.20	3.05	3.03	2.79	3.06	3.25	4.14	5.07	6.82	7.47	4.33	3.37		
2000	3.06	2.88	2.84	2.85	3.03	3.56	4.47	6.42	6.14	4.77	3.28	2.81		
2001	2.76	2.63	2.61	2.64	2.83	3.06	4.14	5.76	6.39	5.14	3.36	2.34		