Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

www.iiste.org

An Assessment of Vegetal Cover Transition in the Zugurma Sector of Kainji Lake National Park, Nigeria

Bako, M.M. J. Musa; M.Y. Suleman; G.I Kuta & G. Eno
Department of Geography, Federal University of Technology, Minna

Abstract
In Nigeria, National Parks and other categories of protected areas have played a major role in modern systems of biodiversity conservation and it is likely to be an important component of national biodiversity conservation strategies in the future. This research work aimed at assessing the vegetal cover transition in Zugurma Sector of Kainji Lake National Park using satellite-derived data. Satellite imageries of 1986, 2000 and 2010 were downloaded from GLCF and classified using ArcGIS, while evaluation of the agricultural resource in the study area was done using Normalized Difference Vegetation Index (NDVI); to comprehend the socioeconomic and human impact on the flora dynamics, questionnaires and interviews were used; and mathematical modeling was used to project the study area to the year 2020. Various softwares (ArcGIS 10.1, SPSS 10.0, Microsoft Office Excel, 2007 and Microsoft Office Word, 2007) were used. The results show that there is significant decrease in the forest cover between 1986 – 2010, while farmlands around the forest experienced an increase in year 2000 but reduced again in 2010. As for settlements, we have more cases of immigration, while the bare lands in and around the forests reduce or increase based on climatic aberrations, soil erosion and human activities. NDVI maps were used to show the changes in the vegetation indices for Zugurma in 1986, 2000 and 2010 derived from the classified satellite imageries. These changes ranged from 0.473684 to 0.503106 then to 0.491525 respectively (for high NDVI values); this suggests that the forest had degraded probably caused by deforestation or climatic factors. The low NDVI values as shown by the maps are -0.0616327, -0.386773 and -0.118644 for 1986, 2000 and 2010 respectively. It is projected that by the year 2020, Forests will have a percentage of 32.878% (from70.52%), while farmlands are expected to increase to 25.815% (from11.34%), Settlements to 29.259% (from 12.85%), and Bare lands will be the least with about 12.048% (from 5.29%).In order to reduce the human pressure on the KLNP, there is a need for constant dialogue and collaboration between the Park authority and the communities around the study area. This constant interaction will facilitate mutual understanding and guarantee sustainable park management. The Nigerian government should enhance biodiversity protection by incorporating biodiversity concerns into development planning, expand and consolidate protected area networks.

Keywords: Biodiversity, National Park, Geographic Information System, Vegetation Index

BACKGROUND TO THE STUDY

Nigeria is very much dependent on biological resources compared to other countries. For example, agricultural production, livestock, logging and fishing account for the bulk of employment, economic output and export earnings. The dependence of the nation on biodiversity is hardly captured in economic statistics. This action of no valuation or under-valuation invariably leads to misuse of biological resources. As these natural resources continue to be essential for future development of the nation, of concern is the serious lack of inventories of these resources and other baseline data that are of fundamental importance for monitoring biodiversity trends. In essence, it is important to know the current status, distribution, rate of exploitation and restoration, and the stakeholders involved in the use of these biodiversity. Equally important is the knowledge of how they are managed from village level decision-making to state policies and to international concern. These issues and conservation practices adopted will no doubt determine how much and in what conditions these natural resources will be available to future generation. The place of gender in biological resources consumption, conservation and management practices is also of importance. Lack of natural resource inventories and other baseline data are inimical for monitoring biodiversity trends. Without this information, many wrong decisions are likely to be adopted and it will be impossible to accurately address the impact of most projects and provide feedback for making corrections and requirements (Ecological Survey of KLNP, 2004).

The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population (Zubair, 2006).

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

the spread and health of the world's forest, grassland, and agricultural resources has become an important priority (Zubair, 2006).

The term 'transition' defines the passage (sudden or gradual) from a state/situation/idea to another, referring to something intermediary, transitory. Physico-geographical transitions may be approached from several viewpoints, yet the study is limited to passages only, in the attempt to see how these are manifested in the case of soils. Geographic regions present themselves as a system resulted from the interactions between natural and anthropogenic components on a certain area. Yet these components maintain close connections to the geospheres they are part of, thus frequently their limits are not clear. In this way are evidenced a series of transition areas between different territorial units, in which a clearer or more graded passage is made towards the neighboring units (Ionut *et al.*, 2010).

Kainji Lake National Park is surrounded by settlements that are either villages, or towns. The area is also bisected by roads, and is under pressure by land hungry farmers. Avoiding human areas of activity when designing the protected areas boundaries has minimized conflicts with the people and other land users in the Park areas. The immediate task, therefore, is the stabilization of land use by these communities.

The survival of indigenous diverse plant and wildlife resources is a paramount issue. Africa in general, has paid a heavy price for overlooking the social realities determining the interaction between its people and National Parks. In the process, indigent people have turned into dispossessed onlookers to wild resources and eventually become trespassers and poachers. Crisis initiative and reactionaries from different quarters are regrettably becoming a fact of everyday life for the management authorities of the Park. There is need to adopt 'conservation measures', either the management measures and means of collection for the purpose of increasing and maintaining the number of plants and animals within species and populations at some optimum level with respect to their habitat.

Aim and Objectives

The aim of this paper is to assess the vegetal cover transition in the Zugurma Sector of Kainji Lake National Park using satellite-derived data. The objectives are to:

i. Map and analyze the vegetal cover changes at a scale of 1:100,000 from the satellite images of 1986, 2000 and 2010;
ii. Evaluate the vegetation in the study area using Normalized Difference Vegetation Index (NDVI);
iii. Project the possible future impact of this vegetal cover transition on the study area.

The Study Area

The Kainji Lake National Park, formerly known as Borgu Game Reserve, was upgraded to its present status in 1991. It is situated between latitudes 9°40'N and 10°30'N and longitudes 3°30'E to 5°50'E. Made up of Borgu and Zugurma sectors, the Park covers a total area of 5,370km, out of which Zugurma occupies 1,370.80 km^2). The Zugurma sector in Borgu and Mashegu Local Government Areas of Niger State to the east of the Lake was joined to the Borgu sector in 1975 to form the Kainji Lake National Park.

The amalgamation of the two reserves and signing into law an enabling decree that backed up the creation, (Decree 46 of 1979) gave birth to the pioneer conservation enclave the "Kainji Lake National Park". It enjoys the privileged of being the first National reserve in the country today; it is smaller than Gashaka-Gumti (the largest National reserve in Nigeria with an area of 6,402.48sq.km) in size and bigger than all other reserves in the country.

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

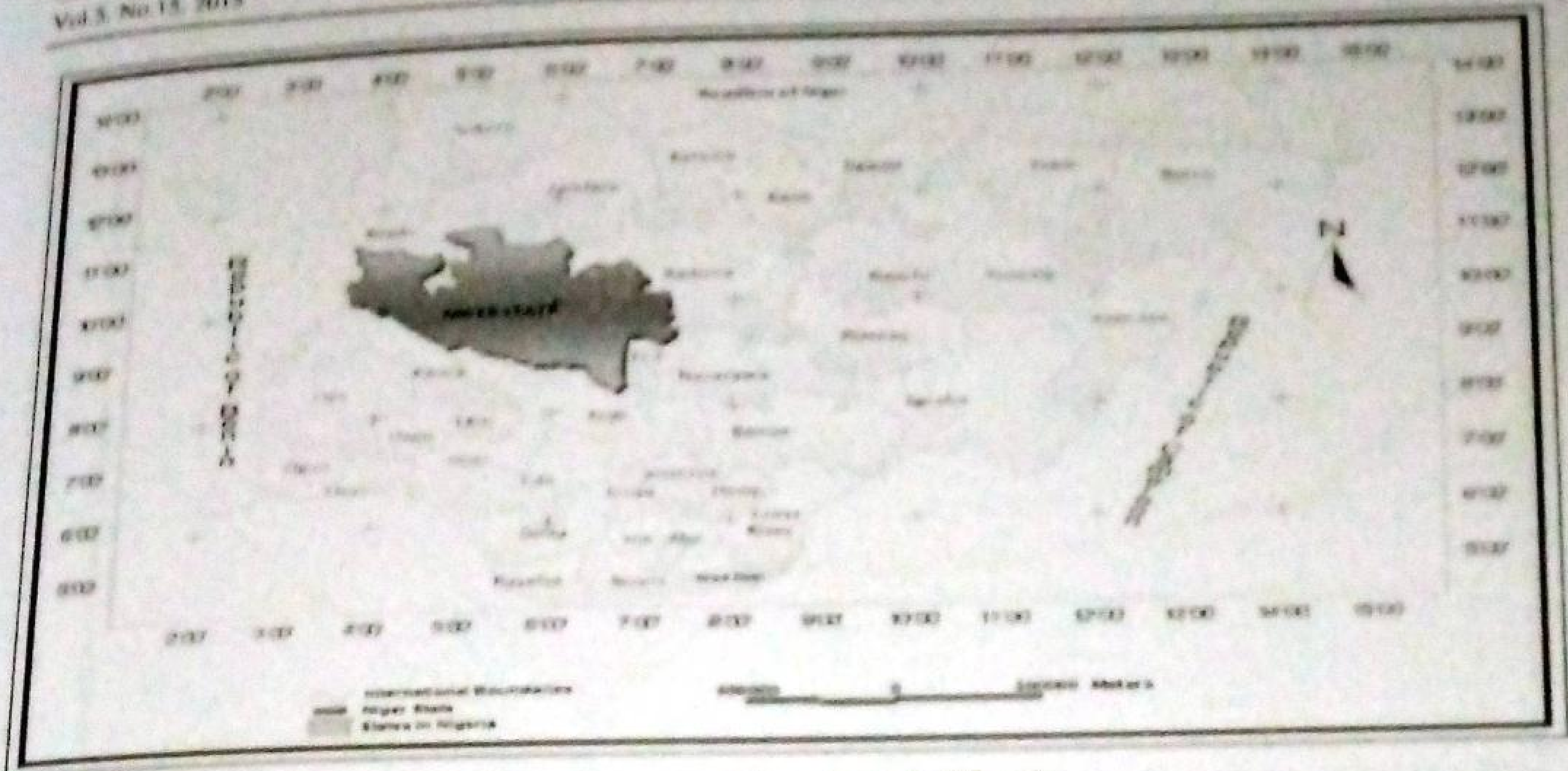


Figure 1: **Niger State in Nigeria**
Source: Department of Geography, FUT Minna

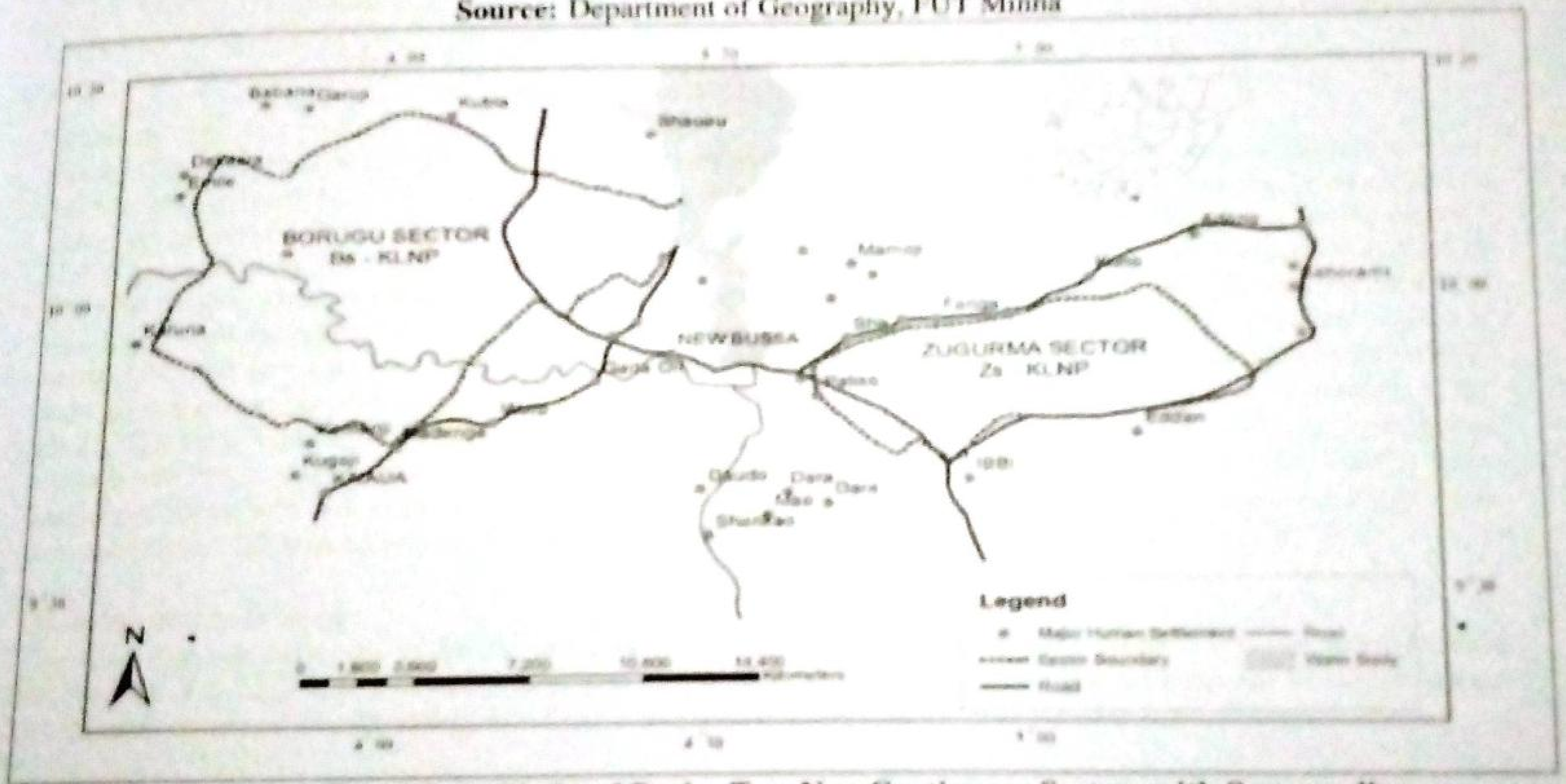


Figure 2: **Kainji Lake National Park - Two Non Contiguous Sectors with Surrounding Communities**
Source: Department of Geography, FUT Minna

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

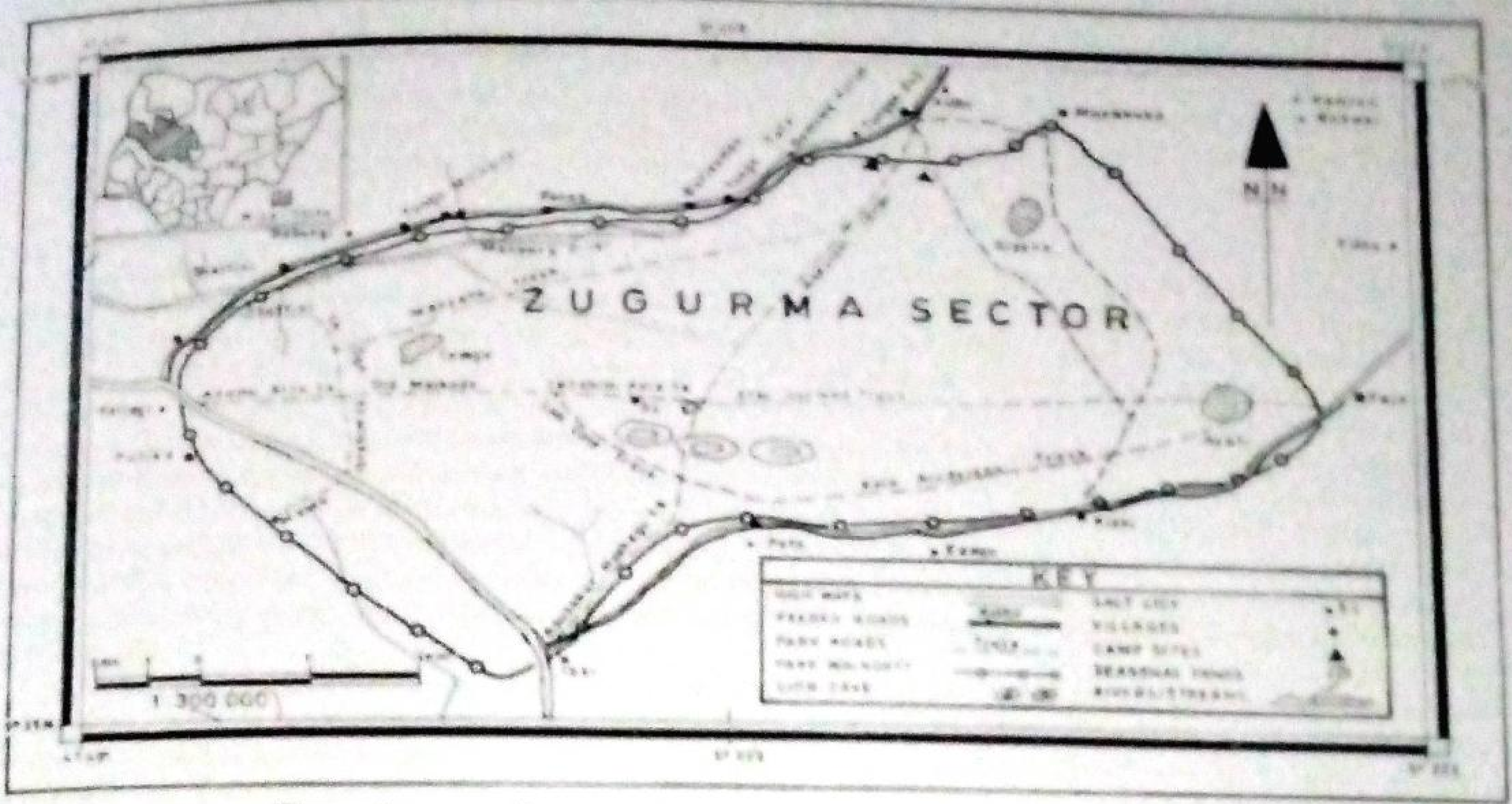


Figure 3: **Zugurma Sector of Kainji Lake National Park**
Source: Geography Department, 2012

Climate

Kainji Lake National Park area enjoys the savanna climate of Nigeria. In this area there are two distinct seasons of wet and dry seasons. The wet season begins around mid - April of every year and ends in October giving about seven months wet season while November to March represents the dry season. Like most part of Nigeria Kainji Lake National Park enjoys the characteristic West Africans climate, marked by distinct seasonal shift in the wind pattern. There is the prevalence of moisture-laden south westerly wind during the wet months while the dust-laden northeasterly wind is associated with the dry months. The mean temperature during the wet season is about 30°C and drops to about 28° C during the dry season being affected by the north east harmatan winds. Rainfall is a major climatic element in the reserve being responsible for vegetal growth and the hydrology of the rivers. The mean annuals rainfall is about 1200mm. The rainfall amount increases to the southeast from Borgu towards the Niger valley. This is due to leeward nature of the reserve site being east of the Yoruba hills. Individual rainstorms are often short and stormy, with high rainfall intensities. The number of rainy days averages about 200 days increasing eastwards to the Niger valley (Ecological Survey of KLNP, 2004).

Drainage and hydrology

The main drainage networks in the Zugurma Sector of the Park are the minor tributaries of larger rivers outside the reserve. The sector is a plateau with few small rivers flowing to the south and the north of the sector (Ecological survey of KLNP, 2004).

Topography

The topography of the Kainji Lake National Park consists of hills, extensive plains and river valleys. On the whole, the entire area is gently undulating with quartzite ridge in few places. Elevation in most parts of the reserve ranges between 250m and 300m. The highest point in the reserve is at the northwestern corner with an elevation of 350m, while the lowest elevation is along the River Niger where the maximum water mark is about 140m. For the Zugurma sector, the highest parts lie east-west across the park forming a drainage divide to streams flowing away in all directions. The rivers develop extensive floodplains because of the relative nearness of the park to River Niger (Ecological Survey of KLNP, 2004).

Geology and soil

Kainji Lake National Park is underlain by the old crystalline basement rocks of the undifferentiated igneous and metamorphic rocks. These rocks have been deeply weathered in the most of the area occupied by the Park but remnants of hard granitic rocks have been exposed on the high grounds forming granitic hills and pediments especially close to the river valleys.

The nature of the underlying rocks, parent material, the topography and the extent of weathering determines the nature of soils in the sectors occupied by Kainji Lake National Park. For the Zugurma sector, the soils are deeply weathered into latosol. The interfluves areas at the centre of the sector are covered with deep gravelly loam with reddish unmolted upper horizons. The soils on the lower slopes are mottled red and well drained. It is common to come across lateritic ironstone in the soil profiles except in the alluvium in the valley bottoms (Ecological survey of KLNP, 2004).

Vegetation

The vegetation of both sectors of Kainji Lake National Park lie within the Northern Guinea Savanna, which is Savanna woodlands dominated by tree species such as *Aflezia Africana*, *Isorberlinia tomentosa*, *Monotewse kerstingii*, *Burkea Africana*, *Isoberlinia doka*, *Crossopbteryx ferbrifuga*, *Anogeissus leicarpus*, *Khaya senegalendis*, *Terminalva avicinoides*, *Butryos permum paradoxum*, *Terminalva macroptera*, *Retarium microcarbum*, *Diospyros mespiliformis* and *Maytemus senegalsio*. Prominent shrubs include *Piliostigma thonningii*, *Anona senegalensi*, *Strychnos inocua* and *Gardenia sp*. The herb layer is dominated by the following grasses: *Andropogon gayus*, *Andropogon tectorum*, *Hyparrhenia sp*. and woody forbs such as *Cochlospermum tinctorum* and *C. Planchoniwith planchoni*. Being largely rural, households in the SZC depend extensively on biological resources for their livelihoods. Very salient among these resources are trees, animals, and timber forest products (NTFPs). Sometimes, herdsmen allow their stock to move into the protected areas for grazing. Poaching also takes place, while wild fires invade it from the surrounding farmlands (Ecological Survey of KLNP, 2004).

The Zugurma sector is devoid of species richness when compared to Borgu sector because of the lack of surface water such as rivers and streams, which are almost absent in the Park. The water is one of the major livelihood of animal species in the Park. However, species like Roan antelope, Hartebeest, Red flanked duiker, Bush buck and Warthog are present at the Park. The three major primate species recorded in the Sector are Mona monkey, Green monkey and Red patas monkey. Further reason that was deduced for scanty species presence in the sector is the numerous villages and enclaves that surrounded the area. The socio-economic activities of the indigenous communities invariably affected the species richness due to various inimical activities such as poaching, farming pervaded the sector. There is a general perception that human activities have been impacting negatively on the biodiversity status of the PA. However, opinion is divided as to whether recent activities create more externalities than those of the past (Ecological Survey of KLNP, 2004).

MATERIALS AND METHODS

Satellite Data Acquisition

Landsat Thematic Mapper (TM) of the 1980s and Landsat Enhanced Thematic Mapper (ETM+) of 2000s (that is 1986, 2000 and 2010) that cover a major part of the study area (Zugurma) was acquired for use in the study in line with Objective 1. Both Landsat TM and ETM+ having 30m spectral resolution at the visible and near infrared spectral region (10.4-12.5μm) but they differ in the spatial resolution while the Landsat ETM+ has enhancements with two bands at the thermal infrared region (Band 61&62). The imageries were acquired through the United States Geological Survey (USGS) Earth Resource Observation Systems Data Centre (Global Land Cover Facility (GLCF)), which will correct the radiometric and geometrical distortions of the images to a quality level of 1G before delivery. The Geo–referencing properties of the imageries are as follows: Data type: rgb8, with Columns 535 and Rows 552, Projection is UTM, Zone 31N and Reference units in meters, Datum: WGS – 84

Software

The software utilized in the research included:

- *ArcGIS 10.1:* This software was used map digitizing and GIS analysis. It was also used to mosaic the various scenes, convert the vector shapefiles to raster data format and also used to mask the study area from the mosaic satellite imagery covering the study area.
- *Microsoft Word 2007:* This was used for the typing and setting of gathered information and presentation of the research.
  Microsoft Excel 2007: This was used in production of the charts or graph and carrying out other statistical operation performed in ArcGIS.
  Statistical Package for Social Sciences (SPSS) 10.0

[De]velopment of Classification Domain

[...]her (1999) considered classification to be the process of pattern recognition of the pattern associated with [...] pixel position in an image in terms of the characteristics of the objects or materials present at the [corre]sponding point of the Earth's surface. Its major functions are spatial, spectral and temporal pattern recognition (Syed and Abdulla, 2002).

The classification approach used here is the Supervised Techniques of Classification which is based on the knowledge of the user about the area under study or research. The delineation of the land cover types is based on statistical characterization data drawn from known examples in the image and this is called training sites or Classification Domains.

Maximum likelihood classification algorithm was used. A classification domain or scheme was developed for the study area based on the prior knowledge of the study area. Maximum likelihood procedure is the most sophisticated and is unquestionably the most widely used classifier in classification of remotely sensed imagery. The classification schemes are shown in Table 3.1 below.

Table 1:Landcover Classification Scheme

Code	Investigated domains
1	Forest
2	Farmland
3	Settlement
4	Bareland

The afore – mentioned domains were examined on the acquired satellite imageries of the study area to obtain information about the change that has taken place over the past 24 years (between 1986 – 2010).

Normalized Difference Vegetation Index

Remote sensing for agricultural resource evaluation use vegetation indices calculated from digital multispectral image data. There are various types of vegetation indices but the one employed in this research is the Normalized Difference Vegetation Index (NDVI). Data from high, medium and low resolution sensors are used and sometimes in combination to monitor crop condition. This is calculated from 2 bands of multi-spectral image data: the visible (red) band and the near infrared (NIR) band as follows:

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

Modeling

This was used in the research to project the study area to 2020 using the data derived from the satellite imagery.

RESULTS AND DISCUSSION

Landuse/Landcover changes in 1986

Figure 4 shows the landuse/landcover map of Zugurma Sector in 1986 and is classified into four (4) landuse/landcover types. These are forests, farmland, settlement, and bareland.

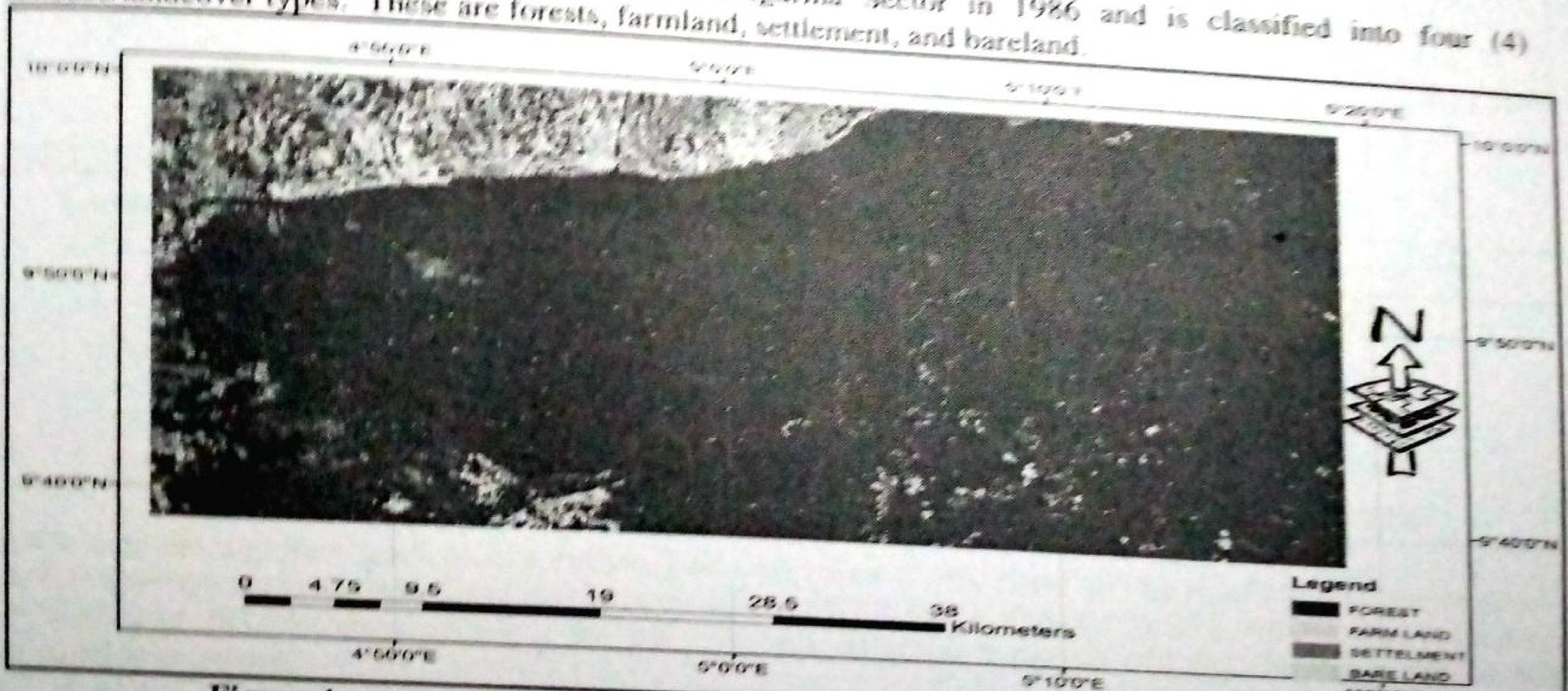


Figure 4: Classified LandSat TM Satellite Imagery of Zugurma in 1986
Source: GLCF, 2014

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

Table 2: Zugurma Landuse/Landcover Statistics in 1986

Landuse/Landcover Type	Count	Area (Hectares) (cm^2)	Percentage (%)
Forest	202,971	231,802.61	87.562
Farmland	614	12,835.25	4.7837
Settlement	1,076	19,846.17	5.4217
Bareland	6	268.75	2.2326
Total	**204,667**	**264,752.78cm^2**	**100%**

Source: Field Work, 2014

Table 2 shows that the bare lands have a statistic land cover area of 268.75cm^2 giving it 2.2326%, farmlands have an area of 12,835.25cm^2 giving it 4.7837%, settlements have 19,846.17cm^2 giving it 5.4217%, while forests have 231,802.61cm^2 giving it 87.562%. By this statistics, it can be said that by 1986, Zugurma had few residents and more forestlands.

Landuse/Landcover changes in 2000

Figure 5 shows the landuse/landcover map of Zugurma Sector in 2000 and is classified into four (4) landuse/landcover types. These are forests, farmland, settlement, and bareland.

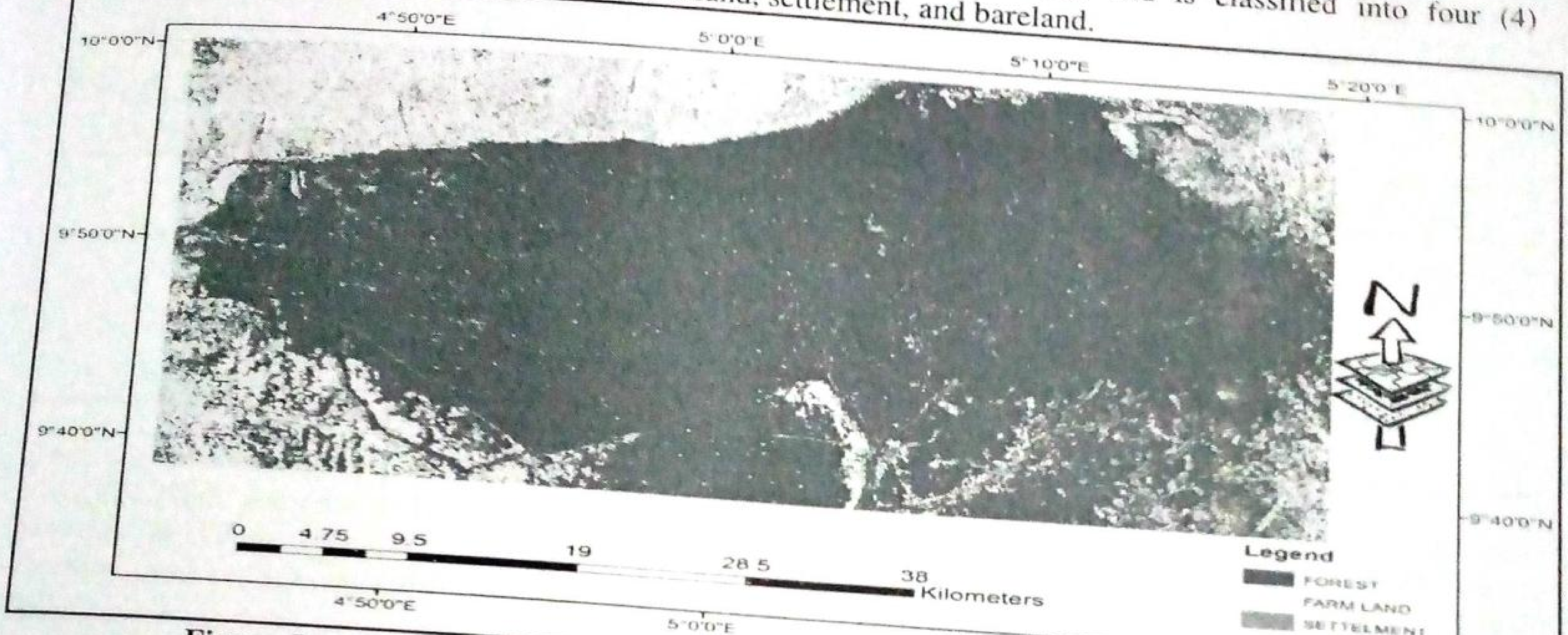


Figure 5: Classified LandSat ETM Satellite Imagery of Zugurma in 2000
Source: GLCF, 2014

Table 3: Zugurma Landuse/Landcover Statistics in 2000

Landuse/Landcover Type	Count	Area (Hectares) (cm^2)	Percentage (%)
Forest	139,350	202,749.89	68.73
Farmland	6,657	55,336.66	12.03
Settlement	772	5,663.98	13.63
Bareland	55	980.39	5.61
Total	**146,834**	**264,730.92cm^2**	**100%**

Source: Field Work, 2014

Table 3 shows that bare lands have a statistic land cover area of 980.39cm^2 giving it 5.61%, settlements have 5,663.98cm^2 giving it 13.63%, farmlands have an area of 55,336.66cm^2 giving it 12.03%, while forests cover the most area of 202,749.89cm^2 giving it 68.73%. By this statistics, it can be said that the forest reduced as population increased.

Landuse/Landcover changes in 2010

Figure 6 shows the landuse/landcover map of Zugurma Sector in 2010 and is classified into four (4) landcover types. These are forests, farmland, settlement, and bareland.

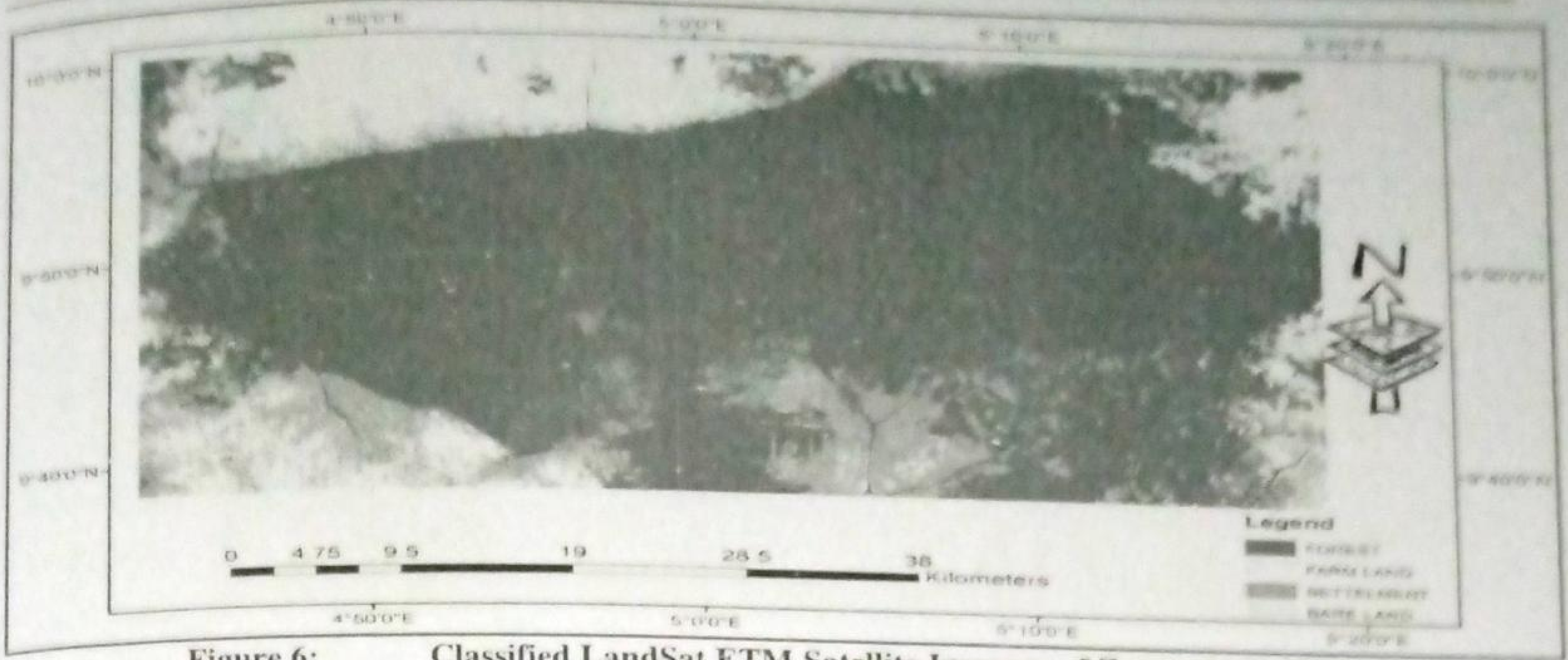


Figure 6: **Classified LandSat ETM Satellite Imagery of Zugurma in 2010**
Source: GLCF, 2014

Table 4: Zugurma Landuse/Landcover Statistics in 2010

Landuse/Landcover Type	Count	Area (Hectares) (cm^2)	Percentage (%)
Forest	87,196	157,769.42	55.268
Farmland	7,202	41,864.79	17.203
Settlement	8,888	45,584.63	19.4978
Bareland	1,567	19,516.75	8.029
Total	**104,853**	**264,735.59cm^2**	**100%**

Source: Field Work, 2014

Table 4 indicates that bare lands have 19,516.75cm^2 giving it 8.029%, farmlands have a statistic land cover area of 41,864.79cm^2 giving it 17.203%, settlements have an area of 45,584.63cm^2 giving it 19.4978%, while forests have 157,769.42cm^2 giving it 55.268%. By this statistics, it can be said that there was fast population growth resulting in more farmlands and fewer bare lands. The forest area, however, has reduced some more by nearly half.

Summary of landuse/landcover changes in 1986, 2000 and 2010

The summary of the landuse/landcover changes in 1986, 2000 and 2010 are shown in the table 5 and figure 7 below:

Table 5: Summary of Landuse/Landcover Changes in 1986, 2000 and 2010

Landuse/Landcover Type	Years 1986	2000	2010	Average Percentage	Differences 1986/2000	2000/2010
Forest	87.562%	68.73%	55.268%	70.52%	-18.832	-13.462
Farmland	4.7837%	12.03%	17.203%	11.34%	7.2463	5.173
Settlement	5.4217%	13.63%	19.498%	12.85%	8.2083	5.8678
Bareland	2.2326%	5.61%	8.029%	5.29%	3.3774	2.419

Source: Field Work, 2014

From Table 5, the summary of the satellite imageries show that bare lands reduced the most over the years due to fast population growth. Farmlands come next as a result of bad farming methods and climate variations. Settlements come not far afterwards as most of the households share compounds. Averagely, the percentage of Forest land is found to be 70.52, that of Farmland is 11.34, Settlement is 12.85, while Bareland is the least with an average of 5.29%. There was sharp decline in the forest area (from -18.832 to -13.462).

Figure 7: **Summary of Landcover Changes in 1986, 2000 and 2010**
Source: Field Work, 2014

Figure 7 shows a graphical representation of Table 5. It is clear from the graph that Zugurma Forest has been recording the highest percentage from 1986 to 2010, although there is obvious decrease in the landcover. As for settlements, we have more cases of migration as the years go by. Farmlands, however, increased over the years, while the barelands increased too.

he Normalized Difference Vegetation Index

DVI generally correlates very well with biomass because healthy plants of a given species tend to have greater mass, thus, it is a good measure of plant vigour. The NDVI values increase from the period when the first t emerges to when they reach their maximum development called the Peak-of-Green (the time when the parts of the plants are fully developed and the green reflectance is maximum). The NDVI values then ne as the plant matures and goes to seed. Particular years when NDVI values are low produce lower hear ower produce/yield. Airborne and multi-spectral images are used for crop identification and condition nent. Figures 8 – 10 show the increase and decrease in NDVI values from 1986 to 2010.

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

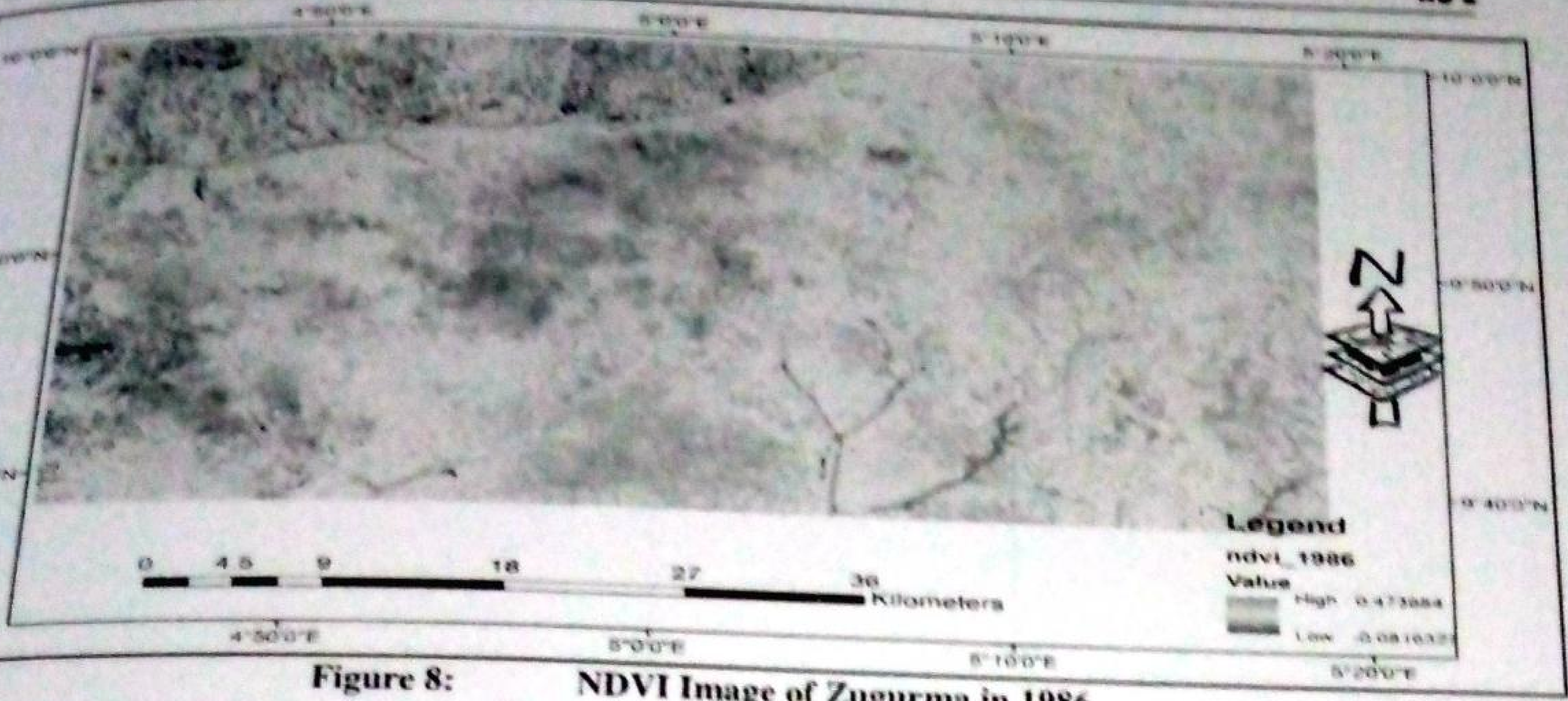


Figure 8: NDVI Image of Zugurma in 1986
Source: Field Work, 2014

ure 8 shows high NDVI values for Zugurma in 1986 (0.473684); this suggests that the vegetation was quite essed in this period in the area (having red reflectance).

Figure 9: NDVI Image of Zugurma in 2000
Source: Field Work, 2014

ows an increase in the NDVI values for Zugurma in 2000 (from 0.473684 to 0.503106); this suggests etation in the area were healthier probably due to increase in rainfall and decrease in temperature at

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.15, 2015

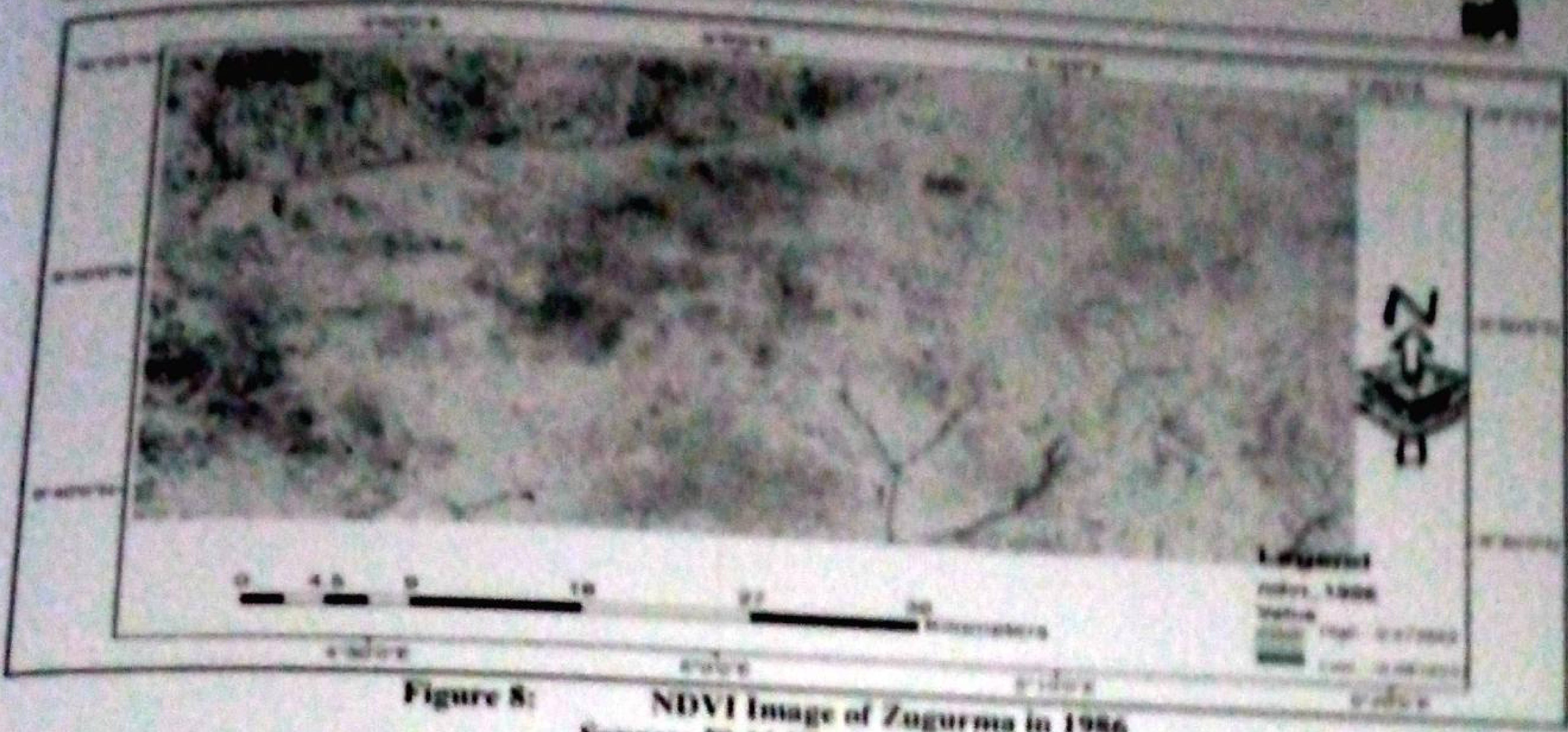


Figure 8: NDVI Image of Zugurma in 1986

Source: Field Work, 2014

Figure 8 shows high NDVI values for Zugurma in 1986 (0.473684), this suggests that the vegetation was quite stressed in this period in the area (having red reflectance).

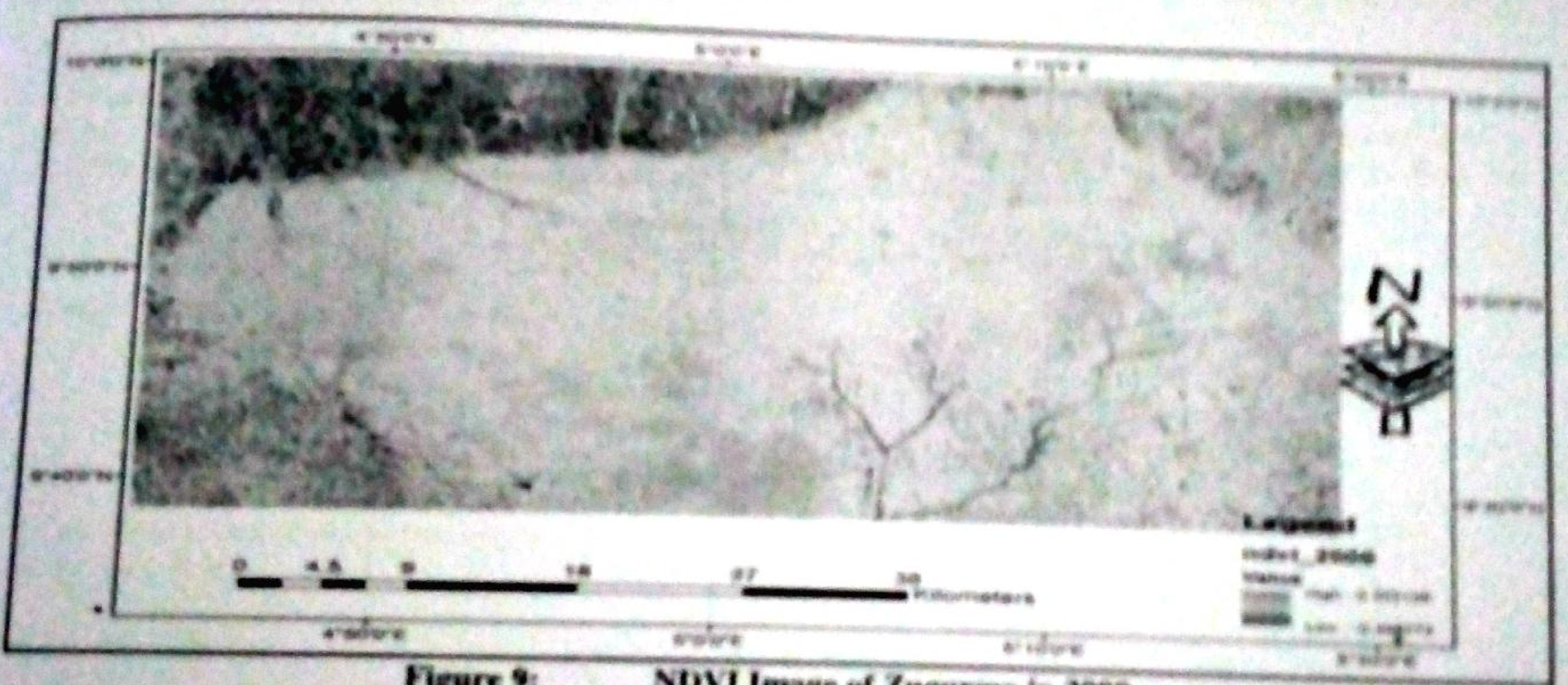


Figure 9: NDVI Image of Zugurma in 2000

Source: Field Work, 2014

Figure 9 shows an increase in the NDVI values for Zugurma in 2000 (from 0.473684 to 0.503106); this suggests that the vegetation in the area were healthier probably due to increase in rainfall and decrease in temperature at the time.

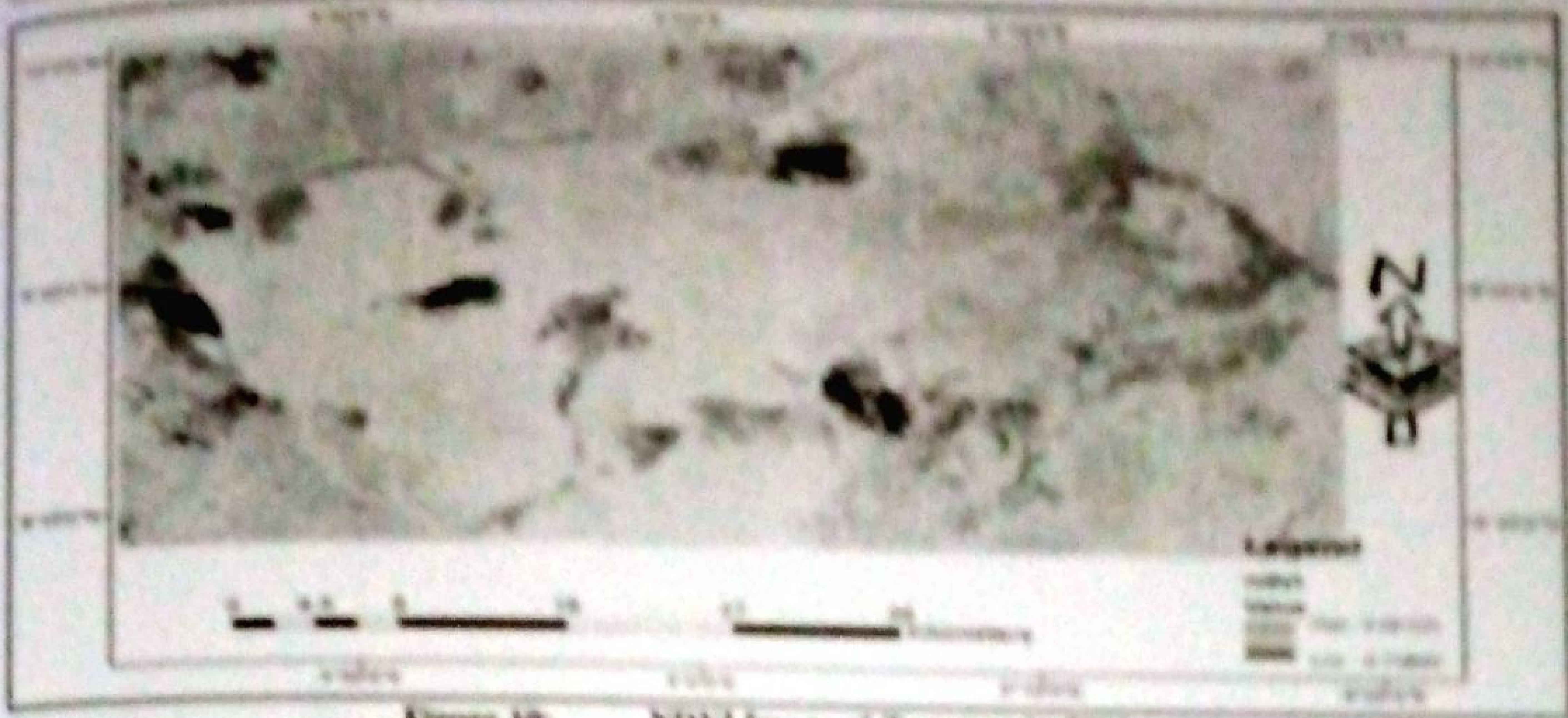


Figure 10: NDVI Image of *Zugurma* in 2010
Source: Field Work, 2014

Figure 10 shows a decline in the NDVI values for *Zugurma* in 2010 (from 0.503106 to 0.491525); this suggests that the forest had degraded probably caused by deforestation or climatic factors.

Projection

The landuse/landcover was projected to predict the extent of change over a period of 10 years (from 2010 to 2020). The projection was meant to give an insight into the rate of vegetal cover decline using results from the satellite imageries of 1986, 2000 and 2010.

$$P = \frac{P_0 Y_0}{Y} - k(Y - Y_0)$$

Where:

P	=	Percentage
P_0	=	Initial Percentage
Y	=	Year
Y_0	=	Initial Year
k	=	Constant

To get the constant of proportionality, k:

$$P_1Y_1 \neq P_2Y_2$$

$$P_1Y_1 = kP_2Y_2$$

$$87.562 \times 1986 = k \times 59.596 \times 2010$$

$$k = \frac{87.562 \times 1986}{55.268 \times 2010}$$

$$k = 1.565$$

To project for Forests:

$$P = \frac{87.562 \times 1986}{2020} - 1.565\,(2020 - 1986)$$

$$P = 86.088 - 53.21 = 32.878$$

To project for Farmlands: 0.3846 (100 – P) = 25.815
To project for Settlements: 0.4359 (100 – P) = 29.259
To project for Barelands: 0.1795 (100 – P) = 12.048

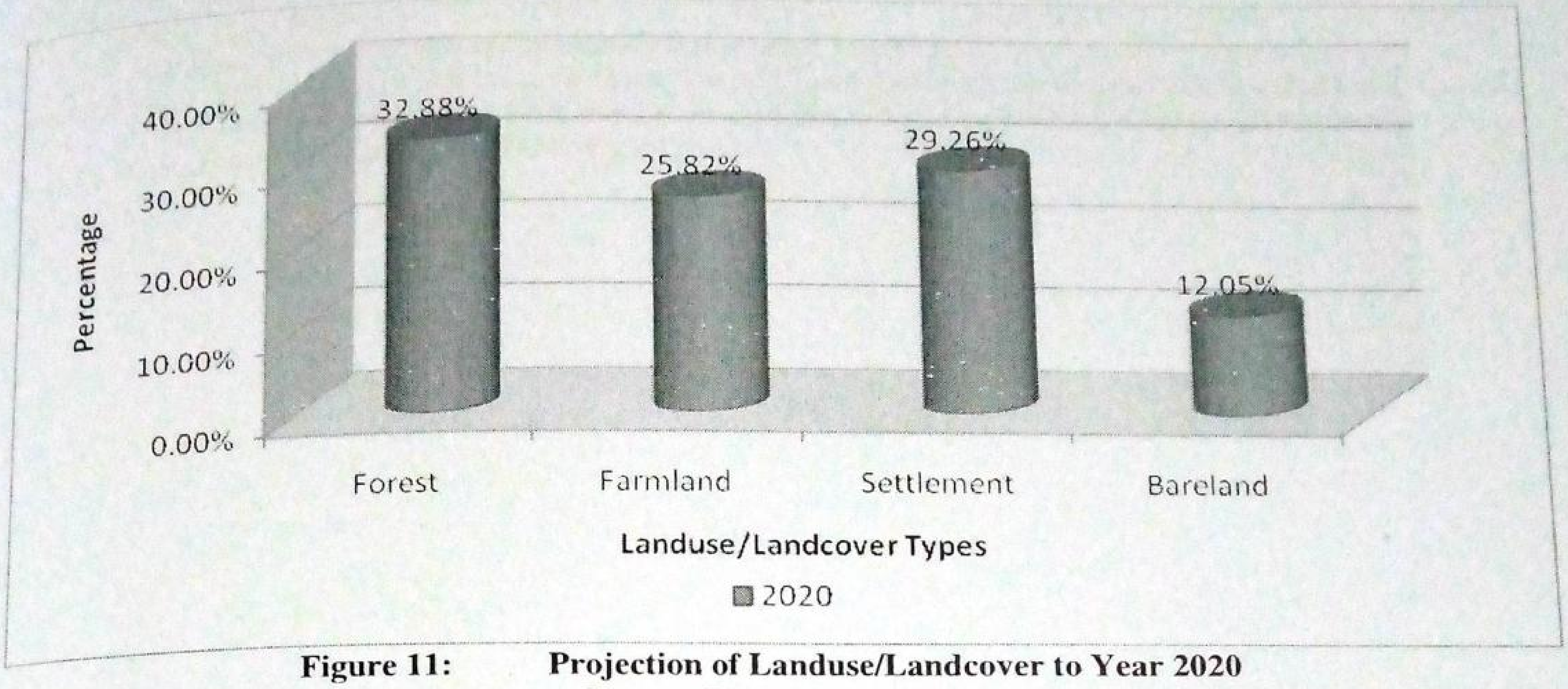


Figure 11: Projection of Landuse/Landcover to Year 2020
Source: Field Work, 2014

Discussion of Results

It is clear from the results and analysis above that Zugurma Forest has been receding and will continue to do so if actions are not taken to reduce bush burning and poaching activities. Although there are laws guiding the Park, residents still encroach on the Park land. From the prediction, year 2020 will have 32.878% Forests (from 70.52%), 25.815% Farmlands (from 11.34%), 29.259% Settlements (from 12.85%), and 12.048% Bare lands (from 5.29%). From the responses of the respondents through the questionnaires, farming is the major source of livelihood and the immigrants keep increasing, thereby stressing the limited resources especially the land. The increase in bareland results from human activities (use of land for brick moulding, construction works, dumpsites, etc), and climatic factors (soil erosion, runoff and high temperatures). The positive socio-economic impact of the Park on the residents of Zugurma Sector include: influx of government officials due to the Park's facilities, diversification of the economy (increase in civil servants), social amenities, and other dividends of civilization.

Conclusion

This research has revealed that the establishment and existence of the Park has taken a large portion of one of the major common properties of the people – the land. The protected area cut into land as a major common resource of the people and thus was seen to have generally affected the size of farmlands that are available to the people and that is put under cultivation. In addition, it has placed some restriction on shifting cultivation practice. The modern concept of conservation (the wise maintenance and utilization of the natural resources most especially in the tropical region), is based on combination of two ancient principles: these are the need to plan resource management on the basis of accurate inventory and the need to take protective measures to ensure that resources do not become exhausted.

REFERENCES

Ecological Survey of KLNP (2004). Report on the Ecological Survey of the Kainji Lake National Park.

Ionut V., Adrian U. &Lilian N. (2010). Soil Cover Transitions in the Vrancea Region. University Al. I. Cuza, Faculty of Geography and Geology, Department of Geography, Iaşi, Carol I, no. 20A, 700505.

Syed, M. & Abdullahi, A. (2002). Analysis and estimation of deforestation using satellite imagery.*Science,* 232:520-530.

Van Der Maarel, E. (2004). *Vegetation Ecology.* Oxford: Blackwell Publishers. http://en.wikipedia.org/wiki/Vegetation Retrieved 15/05/2013

Wolter, P.T., Johnston, C.A. & Niemi, G. (2005).Mapping Submergent Aquatic Vegetation in the US Great Lakes using Quickbird Satellite Data. *International Journal of Remote Sensing, 2005; 26:5255-74.* http://jpe.oxfordjournals.org/content/1/1/9. Retrieved 15/05/2013

Xiao, X.M., Zhang, Q. & Braswell, B. (2004).Modeling gross primary production of temperate deciduous broadleaf forest using satellite images and climate data. *Remote Sensing of Environment, 2004; 91:256-70.* http://jpe.oxfordjournals.org/content/1/1/9.Retrieved 15/05/2013

Zheng, C.H., Zeng, C.S. & Chen, Z.Q. (2006) A study on the changes of landscape pattern of estuary wetlands of the Minjiang river. *Wetland Science*, 2006; *4*:29-35. http://jpe.oxfordjournals.org/content/1/1/9 Retrieved 15/05/2013

Zubair, A.O. (2006). Change Detection in Land Use and Land Cover Using Remote Sensing Data and GIS (A Case Study of Ilorin and Its Environs in Kwara State). *An Unpublished M.Sc. Project Submitted to the Department of Geography, University of Ibadan.*

LAJOST

LAPAI JOURNAL OF SCIENCE AND TECHNOLOGY

Volume 2, Number 2, 2014 ISSN: 2346-7371

A Publication of the

IBRAHIM BADAMASI BABANGIDA UNIVERSITY,

Lapai, Niger State, Nigeria.

Dedicated to

Science & Technology
Research & Development

Sponsored by:

tetfund

Scanned by TapScanner

Lapai Journal of Science and Technology, Vol. 2, No.2 (2014)

A REVIEW ON DISASTER RISK REDUCTION AND SUSTAINABLE DEVELOPMENT IN NIGERIA

[1]Bako, M. M., [1]Musa, J., [1]Suleiman, M. Y., [1]Hassan, A. B., [1]Muhammed, B. Y., [1]Kuta, G. I., [2]Dangana, K., [3]Maiwada, K.

[1]Department of Geography, Federal University of Technology, Minna

[2]Department of Geography, Ibrahim Badamasi Babangida, University, Lapai

[3]Department of Geography, Umaru Musa Yar'Adua University, Katsina

Corresponding author's e-mail: mbmatazu@futminna.edu.ng

ABSTRACT

The occurrences of disaster often call for the support of both government and non government organization. Consequently, disaster relief remains extremely important in disaster management. However, this approach alone does not proactively address the need to adduce the human and environment impacts of future disasters. Recent thinking in the area of disaster management is indicative of the need for a new paradigm that focuses on reducing the risk of disasters with the involvement and participation of communities. This paper reviews the need for communities to place more emphasis on a holistic approach to disaster risk reduction. This approach involves risk assessment, risk reduction, early warning and disaster preparedness in order to effectively address the reduction of social, economic, and environmental costs of disasters nationally and at the global level.

Keywords: Disaster, Vulnerability, Risk Management, Early Warning, Relief

INTRODUCTION

A disaster describes a situation where the occurrence of abnormal or infrequent hazard events has impact on vulnerable communities, causing substantial damage, disruption and possible casualties and unable to function normally without external assistance. A disaster is therefore conceived as a severe disruption to the survival and livelihood systems of a society or community, resulting from their vulnerability to the impact of one or a combination of hazards involving loss of lives and property on a scale which overwhelms the capacity of those affected to cope unaided (NEMA, 2014).

In contemporary academic, disasters are seen as the effect of hazards on vulnerable area. This is because hazards that occur in areas with low vulnerability do not result in a disaster, as in the case of uninhabited regions. Hazards are routinely divided into Natural or man-made, although complex disasters where there is no single root cause are more common in developing countries. A special disaster may spawn a secondary disaster that increases the impact. A classic example is an earthquake that causes a tsunami, resulting in coastal flooding. A disaster is therefore, disruption of the functioning of a community causing widespread human, mental, economic or environmental losses which exceed the ability of the affected community to cope with using its own resources (Cuny, 1983).

Disasters having an element of human intent, negligence, error or the ones involving the failure of a system are called man made disasters which could be technological (results of failure of technology, such as engineering failure, transport accidents, or environmental disasters) or sociological hazards (such as crime, stampede, riots and war) while natural disasters could occur as hydrological, climatic or geologic events (such as volcanic eruption' earthquake, flood, drought, hurricane, tornado, landslide epidemic, and famine (Adefolalu, 2001).

The paper is aimed to review Disaster Risk Reduction strategies with the view of providing holistic approach to achieving sustainable development in Nigeria.

Disaster Management

Disaster risk management is a system i.e. process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises of all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit invitation and preparedness) adverse effects of hazards.

Disaster Risk Reduction (DRR)

According to UNDP (2004) DRR is a conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks, to avoid or limit the adverse impacts of hazards, within the broad concept of sustainable development. The DRR framework consists of the following fields of action:

a) Risk awareness and assessment including: hazard analysis and vulnerabilities/ capacity analysis.
b) Knowledge development including education, training, research and information.
c) Public commitment and institutional framework, including organizational, policy, legislation and community action.
d) Application of measures including environmental management, landuse and urban planning, protection of critical facilities, application of science and technology, partnership, networking and financial instructments.
e) Early warning systems including forecasting, dissemination of warnings, preparedness measures and reaction capacities.

The Concept of Disaster Management

The concept of disaster management is the discipline of dealing with and avoiding risks. It is a discipline that involves preparing, supporting and rebuilding society when natural or man-made disaster management is the continuous process by which individual, groups and communities manage hazards in an effort to avoid or ameliorate the impact of disasters resulting from the hazards.

Phases of Emergency Management

According to Haddow and Jane (2004), Disaster Emergency Management has overlapping phases as follows.

Mitigation:

Mitigation efforts attempts to prevent hazards from developing into disasters or to reduce the effects of disasters when they occur. Mitigative measures can be structural or non-structural.

a) Structural measures use technological solutions like flood levees.

b) Non structural measures include legislation, landuse planning

Preparedness:

Here, managers develop plans of action for when the disaster strikes common preparedness measurers including the;-

- Communication plans with easily understandable terminology and chain of command.
- Development and practice of multi-agency coordination.
- Proper maintenance and training of emergency services.
- Development and exercise of warning methods combined with emergency shelters and evacuation plans.
- Stock- piling, inventory, and maintenance of supplies and equipment.

Response

The response phase includes the mobilization of the necessary emergency services and first responders in the disaster area. This is likely to include the first wave of core emergency services. Such as fire fighters, police, ambulance crews and non- governmental organizations.

Recovery

The aim of this phase is to restore the affected area to its previous state. Recovery efforts are concerned with issues and decisions that must be made after immediate needs are addressed. These efforts are primarily concerned with actions that involve rebuilding destroyed property, re-employment and the repair of other essential infrastructure.

Disaster Risk Reduction and Development Nexus

Without going into controversies in the meaning of development, it is referring to situation where economic growth is accompanied by improved living standards. Consequently, development may be seen as improving the society in terms of the provision of social services, acquisition of economic assets improved productivity and reducing vulnerability. However, sustainable development defined, may focus on conditions for economic growth while maintaining the stock of natural resources at or above their current level.

Table 1: Disaster-Development Relationship

Disasters limits or destroy relationship	- Destruction of physical assets and loss of production capacity - Damage to infrastructure - Death, disablement or migration of productive labour force
Development causes disaster risk	- Unsustainable development practices that create unsafe working conditions and degrade the environment
Development reduces disaster risk	- Access to safe drinking water and food and secure dwelling which increases people resilience - Fair trade & technology can reduce poverty and social security can reduce vulnerability. - Development can build communities and broaden the provision of opportunities for participation and involvement in decision making recognizing excluded group such as women enhancing education and health capacity.
Disasters create development opportunities	- Favorable environment for advocacy for DRR measures - Decision makers more willing to allocate resources in the wake of a disaster - -Rehabilitation and reconstruction activities create opportunities for integrating disaster risk measures

Source: A challenge for development UNDP, 2004.

In fact, it is when disaster strikes that the ingenuity and creativity in all of us come to the fore. This is a very true statement. Examples abound of local people acting as first responders when there is a major disaster, such as multi- vehicle, road accident, a plane crash, a boat mishap or fire disaster. In the case of a slow onset disaster, such as drought, we find people in rural areas putting into practice a whole array of coping mechanisms that they had built up over time.

But people and communities should not be made to wait for disasters to strike before they put their ingenuity and creativity to work. Rather, they should be empowered to use these attributes to reduce the occurrence or the impact of disasters. Every community has some form of capacity, no matter how small, to reduce the disaster risk to which they are exposed. For most communities in Nigeria, this capacity needs to be identified, developed and used for disaster reduction. But, what does this capacity consist of? It may be grouped into four categories (NEMA, 2014):-

1. Physical or material resources
2. Social organization resources
3. Knowledge and skills, and
4. Attitudes and motivation

1) Physical / material resources:- these include:-

- Able bodies' people who can do physical work
- Work tools (for building, earth works etc)
- Land
- Food storage facilities
- Stored food
- Domestic animals
- Public buildings that could serve as temporary shelters, etc.

2) Social organizational resources:-these include:-
- Traditional institutions (chieftaincy)
- Religious organizations
- Community development associations
- Cooperative group
- Social clubs

3) Knowledge and skills:-

Knowledge may be in such areas of the local environment (e.g. knowledge of local terrain, disaster threats, footpaths, etc), while skills may be in farming, wood work, black smithing, commerce, healthcare, transportation, swimming etc.

4) Attitudes and motivation:-

These determine people's outlook on life in general and on disasters in particular positive attitudes and appropriate motivation are required for disaster reduction and sustainable development.

These recourses need to be identified, mobilized, developed and applied to reduce the occurrence of disasters or minimize their impact. An excellent example of the role that communities could play in disaster mitigation is provided by flood control activities within the hadejia valley in jigawa and yobe states. In this flat- lying area, the blockage of river channels by sediment deposition and the growth of typha grass over the years, coupled with unusually heavy rainfall upstream result in widespread, damaging floods. The British department for international development (DFID) has been working with relevant stake holders to develop and implement sustainable solution to this problem including:

a) Structural measures, such as construction of embankments and flood diversion channels and the clearance of blocked river channels.

b) Non structural measures, such as raising people's awareness of the problem, what needs to be done, promoting flood preparedness and flood forecasting.

In fact, developing the capacity of Communities' for Disaster Reduction involves:-

- Public education
- Training
- Social mobilization
- Technical assistance, and
- Provision of materials

Climate Change as a Major Threat in the 21st Century

Over the last 200 years ,man in his quest for better living standard have resulted in increasing emission of green house gases (primarily $C0^2$) above natural levels from the burning of fossils fuels, forest fires and other forum of deforestation which have altered the composition of the atmosphere and caused an enhanced green house effect.

Projections made by IPCC (2007) are summarized as follows:-

a) Deserts are likely to become extremely hotter but not significantly wetter

b) Global hydrological cycle will be intensified with changes in precipitation. Its total amount, frequency and intensity.

c) Agricultural production (including forestry), will increase in dome areas and decrease in others taking into account the beneficial effect of C02 concentration

Implications for Nigeria

According to chronicled events by (UNDP, 2004) natural disasters are estimated to claim yearly 250,000 lives and on the average cost between US$ 50 billion and US$100 billion [illegible] millions in [illegible] in property damage. In 1991 alone, more than 90% of those killed were by storm-related hazards.

In Nigeria, studies since the year 2000 shows that while mean surface temperature has risen by about 0.2-0.6°C within the past 100 years (1901-2005), in general, the change in the Gulf of Guinea, from about 25°c in 1960 to 29°c in 2000 has been phenomenally high. Investigations so far conducted confirm that, the country is one of the most vulnerable nations with impacts already including:

a) Floods in both north and south and erosion in the south; the worst occurring in 1999 with losses of life property and agricultural produce in excess of ₦450 billion.

b) A 0.2°c increase of sea surface temperature (SST) in the gulf of guinea from 26°c in 1979 to about 28.5°c in 1998. Thus, severe storms could generate into tornado type storms that will combine with sea level rise (SLR) to ravage the coastal areas of Nigeria.

c) Hot dry season with record breaking temperatures that exceed 50°c in the extreme north east in 2005 resulting in deaths.

d) Drought and desertification that have taken over states north of 12° parallel. Sand dunes advancing Yobe and Borno states in the north east geopolitical zone is wiping out vegetation and settlements. A situation that could lead to acute migrations (in near future) to create congestion in southern states similar to what occurred in the wake of the wake of the 1972-73. In fact, Lake Chad has diminished to 'little Chad' losing about 90% of its original size in 1960s.

It is now obvious that Nigeria will suffer from future unprecedented climate episodic events of which the following will take 'centre stages':

i) Devastating wind storms and flooding especially along poor drainage basins in many parts of the country at the peak of the monsoon rains

ii) Severe drought in all the 19 northern states.

iii) Pollution and related health effects in both humans and livestock.

iv) Loss of biodiversity, especially aquatic life, exotic plant species and medicinal plants and some soil enriching organic natural plants.

Strategies for Coping with Climate Change

While climate change is a global phenomenon, it has regionally variable characteristics and impacts, and therefore, regional strategies for overcoming or adapting to the future situation are required. Besides data collection, there are several other areas that need to be improved in Africa in order to better the continent's chances of adapting to climate change such include

- Forecasting techniques and early warning systems,
- Capacity building
- Data and information dissemination
- Natural Resources management

The above mentioned strategies as already highlighted by Benoit (1977) will help build the capacity of communities to generate, effectively communication decision without this information on the climatic risks and the adaptation measures appropriate for such risks, no sound decisions can be made to sustainable harness available resources for development.

CONCLUSION

It is clear from the paper that financial resources available for disaster management are increasingly becoming limited in the face of competing demands from the other sections of the economy. We therefore have no choice but join the international community in promoting disaster reduction and mitigation activities; moreover, disaster management is a shared responsibility.

REFERENCES

Adefolalu, D. O. (2001). Climate Change and Natural Disaster in Nigeria. FUT Minna Lecture Series.

Benoit, P. (1977). The start of Growing Season in Nigeria. *Agricultural Meteorology*, 18: 19-29.

Cuny, F. C. (1983). *Disaster and Development*. Oxford: Oxford Univ. Press. Pp 28- 99

Haddow, G. D. & Jane, A. (2004). Introduction to Emergency Management. Amsterdam: Butter worth – Heinemann. Pp7689-2.

IPCC (2007). Intergovernmental Panel on Climate Change. Fourth Assessment Report

UNDP (2004). A Global Risk Assessment Report. Tech note 112.

NEMA (2014). National Emergency Management Agency. Retrieved from www.nema.gov.ng Accessed on 12th July, 2014.

JOSTMED 14 (1) MARCH, 2018

ISSN: 0748 – 4710

JOURNAL OF SCIENCE, TECHNOLOGY, MATHEMATICS AND EDUCATION (JOSTMED)

website: www.futminna.edu.ng
E-mail: jostmedscience@yahoo.com, jostmed@futminna.edu.ng
Phone: +234-816-680-7534

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA
Technology for Empowerment

PUBLISHED BY:
DEPARTMENT OF SCIENCE EDUCATION
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA, AFRICA

EVALUATION OF TREND IN FLOOD EVENTS ON RIPARIAN COMMUNITIES OF SHIRORO DAM, NIGERIA

GARBA, I. K.[1]; NKOFOR, G. N.[1]; ABUBAKAR, A. S.[1] & ABDULKADIR, A.[1]
Geography Department, Federal University of Technology, Minna
Email: [illegible] Phone No: +234-803-678-1076

Abstract
With reference to global climate change which possibly causes heavy downpour, overflowing ... have led to upstream dam sedimentation, overflowing and large volume of water into Shiroro dam from the main river and its tributaries which may have been causing upstream spill ... (back flow) water and also force the dam managers to release large volume of water downstream sector in order to safe the dam from collapse. In the course of doing this, the downstream communities are exposed to river bank over flow into their houses, farmlands ... displacement. Therefore the aim of this study was to evaluate the trend in flood events in riparian communities of Shiroro dam, Nigeria. The techniques used for data analysis were different statistical techniques such as Analysis of Variance (ANOVA), Regression analysis, percentage, frequency tables and graphs. The result shows monthly rainfall of August for 34 years (1980 to 2013) and the monthly rainfall tends to be increasing from 174.1mm in 2009 ... 663.8mm in 1980. This has translated to more flooding activities in the study area due to ... inflow and outflow data. Recently, August for the years 2012, 2014 and 2015 has high monthly rainfall and the people in the study area confirmed that it resulted in more flooding activities with resultant effects on infrastructure, farm produce and lives of the inhabitant living in the area. The finding also shows that R^2 was 0.32 for annual rainfall. Thus, rainfall account for 32.0% of the explained variance between annual rainfall and annual inflow in the study area. This shows that other climatic variables like temperature and relative humidity also play important role in inflow data since there is remaining 68%. It is therefore recommended that town planners as well as NSEMA should mark habitable and non-habitable area in riparian communities of Shiroro dam so as to avoid the flood hazard from affecting the lives and properties of the people.

Keywords: Flood events, Riparian communities, Rainfall, Inflow, Outflow and Shiroro dam

Introduction

International Water Power and Dam Construction (IWPDC) (2011) offered definitions of dam as an enlarged natural or artificial lake, storage pond or impoundment created using a lock to store water. Dams can be created by controlling a stream that drains an existing body of water. They can also be constructed in river valleys and gorge as in the case of Shiroro dam on Kaduna River and Shiroro gorge. Alternatively, a dam can be built by excavating flat ground and/or constructing retaining walls and levees. IWPDC (2011) added that, dams can be used in a number of ways to control how water flows through downstream waterways: Downstream water supply (ii) Irrigation (iii) Flood control (iv) Canals (v) Recreation.

Etuonovbe (2011) defined flood as an overflowing of the great body of water over land not usually submerged. It is an extreme weather event naturally caused by rising global temperature which results in heavy downpour, thermal expansion of the ocean and glacial melt which in turn result in rise in sea level, thereby causing salt water to inundate coastal lands. Caribbean Disaster Emergency Management Agency (CDEMA) (2010) offered definition of flood as an abnormal progressive rise in the water level of streams or rivers which may result in the overflowing. Floods in the Caribbean can often be caused by heavy rainfall, dam or levee failures, tsunamis, storm surges or burst water mains. Mitigation on the other hand, is perceived as any structural or non-structural measure undertaken to limit the adverse impact of flood. UNESCO and WMO (1992) defined flood as relatively high flow as measured by stage height or discharge. According to Dever (1988), all rivers are subject to flooding in the hydrological sense of inundation of riparian areas by stream flow that exceeds bankful capacity. In water resources engineering practice, flood is defined as unusually high stage. It is a flow of water in a river or stream channel beyond the capacity of that channel to carry, the excess overflowing the banks to form flood water hazards.

According to Ologunorisa and Abawua (2005), the obvious reason for flooding especially in municipalities and coastal areas in Nigeria lies in the wide distribution of low-lying coastal areas and river floodplains and because these areas have fast become a long standing attraction for human settlement, which Ojigi et al, (2013) concluded that this subsistence attraction has become a high risk factor in most part of Nigerian floodplain regions. On the causes and impacts of flood hazards, Ojigi et al, (2013) asserted that flood hazards are natural phenomenon, but the damages and losses from floods are the consequences of human actions because it has been known that floods can be caused by anthropogenic activities and human interventions in the natural processes such as increase in settlement areas, population growth and economic assets over low-lying plains prone to flooding which may lead to alterations in the natural drainage and river basin patterns, deforestation and climate change. Following the annual increase of flood disaster especially the devastating 2012 flood hazards in Nigeria coupled with improvement in the use of modern technologies for environmental monitoring such as remote sensing and GIS, the government of Nigeria and the relevant agencies such as National Emergency Management Agency (NEMA) and National Research Space and Development Agency (NARSDA) have recently put all efforts on environmental monitoring and management especially flood disaster (Ikusemoran et al., 2013). Therefore this study evaluate trend in flood events on riparian communities of Shiroro dam, Nigeria.

Statement of the Problem

With reference to global climate change which possibly causes heavy downpour, river erosion have led to upstream dam sedimentation, overflowing and large volume of water into Shiroro dam from the main river and its tributaries which may have been causing upstream spill over (back flow) water and also force the dam managers to release large volume of water to downstream sector in order to safe the dam from collapse. In the course of doing that, the downstream communities are exposed to river bank over flow into their houses, farmlands, displacement etc. Similarly, with increasing population in the study area, human activities through deforestation due to farming, fuel wood demand, grazing and local mining at the upstream sector may lose the soil for easy runoff and erosion causing upstream sedimentation thus, back flow flood (Lawal & Nagya, 2009).

Several researches have been carried out on trend in flood events across the world and in Nigeria; notable among them are the works of Adger (2008) on Disaster risk reduction, Climate change adaptation and human security in Norway; International Strategy for Disaster Reduction (ISDR) (2009) on United Nation International Strategy for Disaster Reduction (UNISDR); European Union (EU) (2011) on Environmental Impact Assessment and its Amendments in Europe; World Commission on Dams Report (WCDR) (2013) on Dam Structure for Water Impoundment; Mohan (2008) on National Disaster Management Guidelines, Management of Floods in India; Abubakar (1997) on Environmental Impact Assessment of Shiroro Dam some hydrometeorological variables in the Kaduna River Basin; Salami and Sule (2010) on overview on Reservoir Operational Impact of Kainji, Jebba and Shiroro Dams on the environment; Usman and Ifabiyi (2012) on Socio economic Analysis of the Operational Impacts of Shiroro Hydropower Generation in the lowland Areas of Middle River Niger; National Emergency Management Agency (NEMA) (2012) on Nigeria Lost N2.6 trillion to 2012 Floods Disaster. Studies have also been carried out by Zago (1999), Tyabo (2005), etc. on the hydrological, ecological and climatological impact of Shiroro dam to the immed environment. None has been carried out on trend in flood events on riparian communitie Shiroro dam, Nigeria which is part of the missing gap that this paper was intended to Therefore the aim of this study was to evaluate the trend in flood events on ripar communities of Shiroro dam, Nigeria.

Study Area

Shiroro Hydroelectric Dam is situated in confluence between Rivers Kaduna and Dinya with Shiroro Local Government Area of Niger State. The lake is located on River Kaduna at Confluence of Kaduna River and Dinya River. The lake is located on Latitude 8°51'01"N 10°20'04"N and Longitude 5°50'01"E to 07°10'41"E (See Figure 1) Kaduna River is the ma River feeding the lake. The River takes its source from the west and Northwest of Jos Platea The river flows westward from the plateau at an elevation of 1,500 metres to 1,800 metre through Kaduna town at an elevation of 633metres, the major left hand tributaries of th Kaduna River at the upstream of Shiroro reservoir are the River Sarkin/Pawa and River Dinya They rise from hilly areas within the basement complex plains near Kaduna (Garba an Mohammed, 2011).

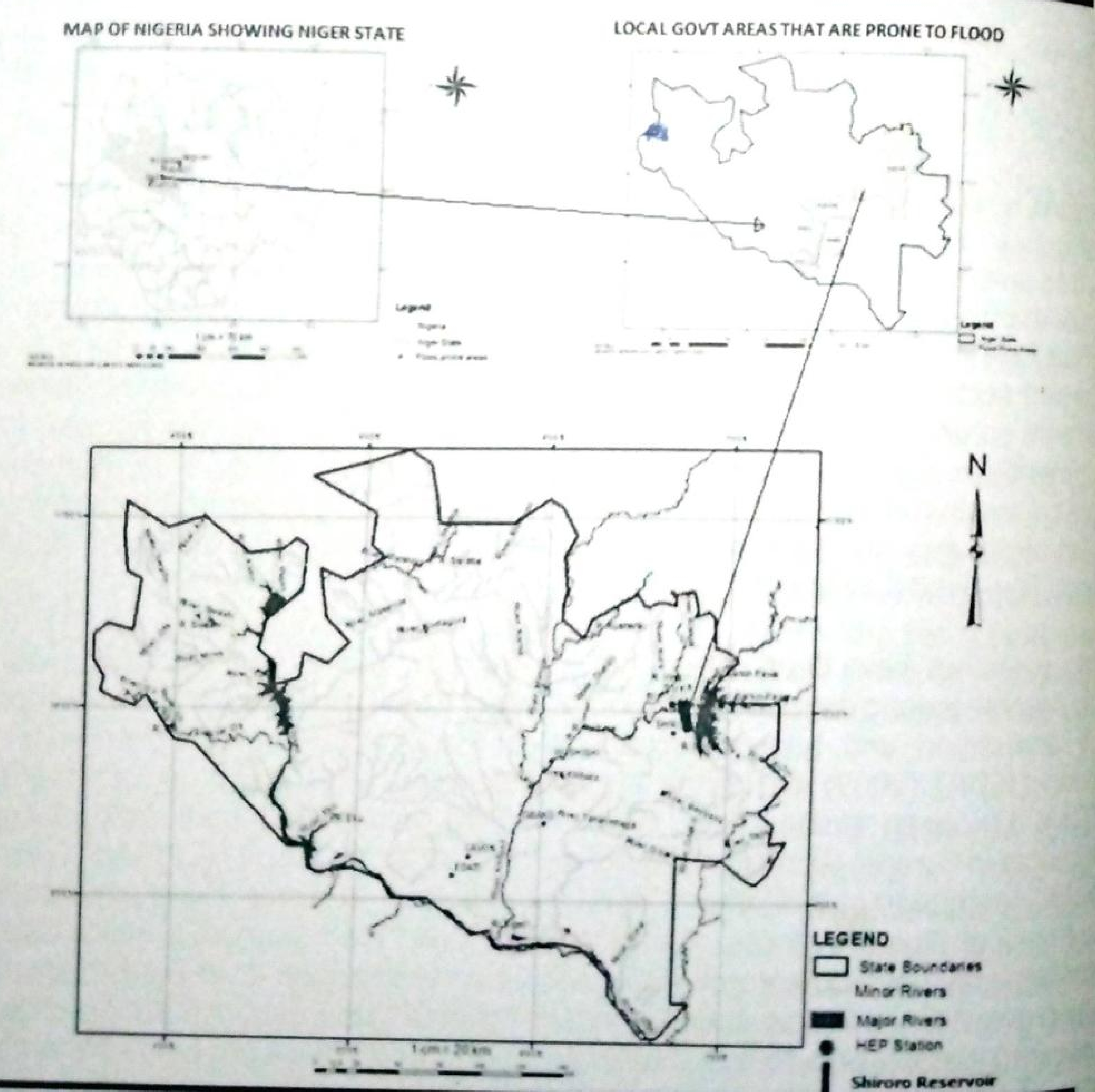


Figure 1: Location of Shiroro dam on River Kaduna and its tributaries

Materials and Methods

The techniques used for data collection and analysis of flood disaster management study of upstream and downstream communities of Shiroro Dam in Niger State include reconnaissance survey and used annual rainfall, in-flow and outflow data. To achieve the aim of this study which was to examine the trend in flood events in the study area; annual rainfall data from 1990 to 2015 as well as in-flow and out-flow data for the same period were sourced from Shiroro Hydroelectric Power Station (SHPS) in Hydrology Department and Nigeria Meteorological Agency NIMET (Abuja airport or Minna airport). The study used tables to show the rainfall amount, in-flow and out-flow data from the dam and the mean total annual rainfall occurrence in millimeters to identify the most wet and drought seasons which could have possibly caused flood or not in the study area. Also a trend in flood events was determined from the above secondary data. Different statistical techniques such as Analysis of Variance (ANOVA), Regression analysis, percentage, frequency tables and graphs were used for flood trend and analysis of effects.

Results and Discussion

As shown in Figure 2, mean monthly rainfall for the period under study (1990 - 2015) tend to be increasing, higher in the months of August to September and the least in the months of January to February.

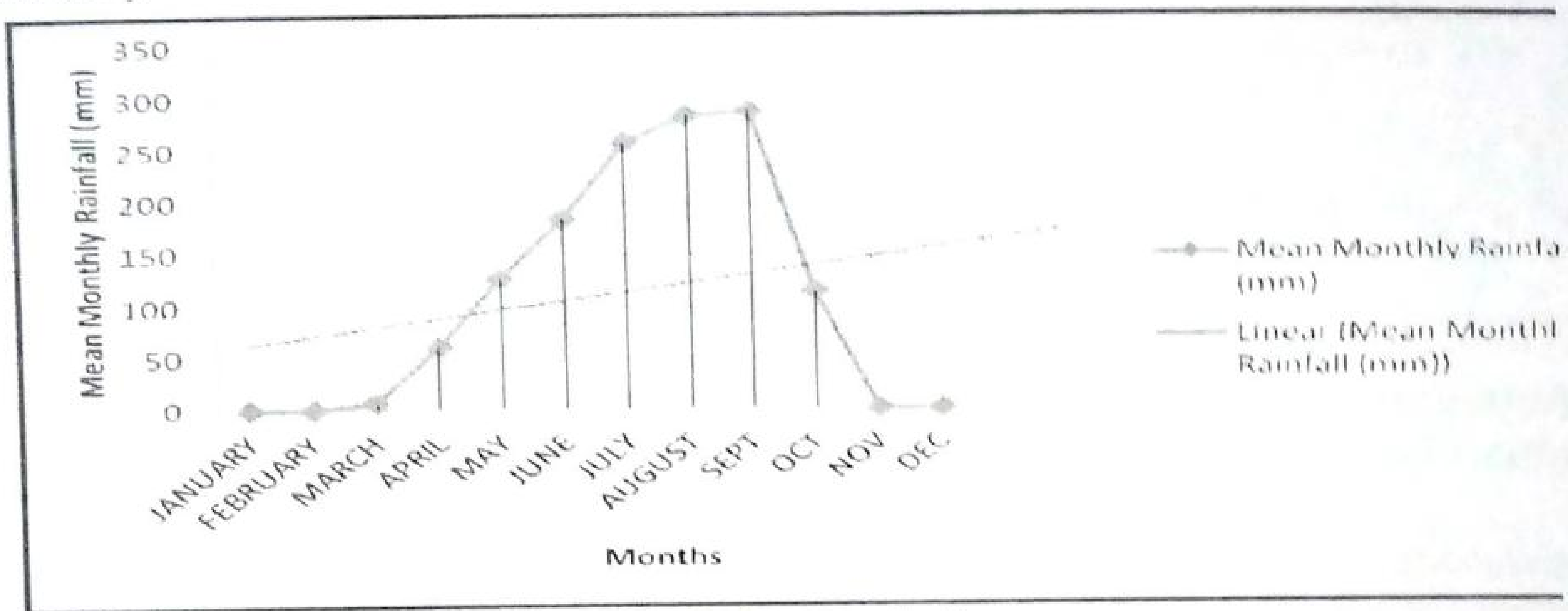


Figure 2: Mean Monthly Rainfall of the Study Area
Source: Authors Data Analysis, 2016

The highest monthly rainfall was in the month of August with a value of 282.58mm and the least were in the months of November to February with a value of 0.0mm. The highest monthly rainfall has lead to flooding in both up and downstream of the study area and this was as a result of more rainfall which have lead to more inflow and outflow within the operational area of Shiroro dam, thus, this process have been leading to frequent flooding in the months of July to September. This implies that its only in wet season that flood events occurred in the study area.

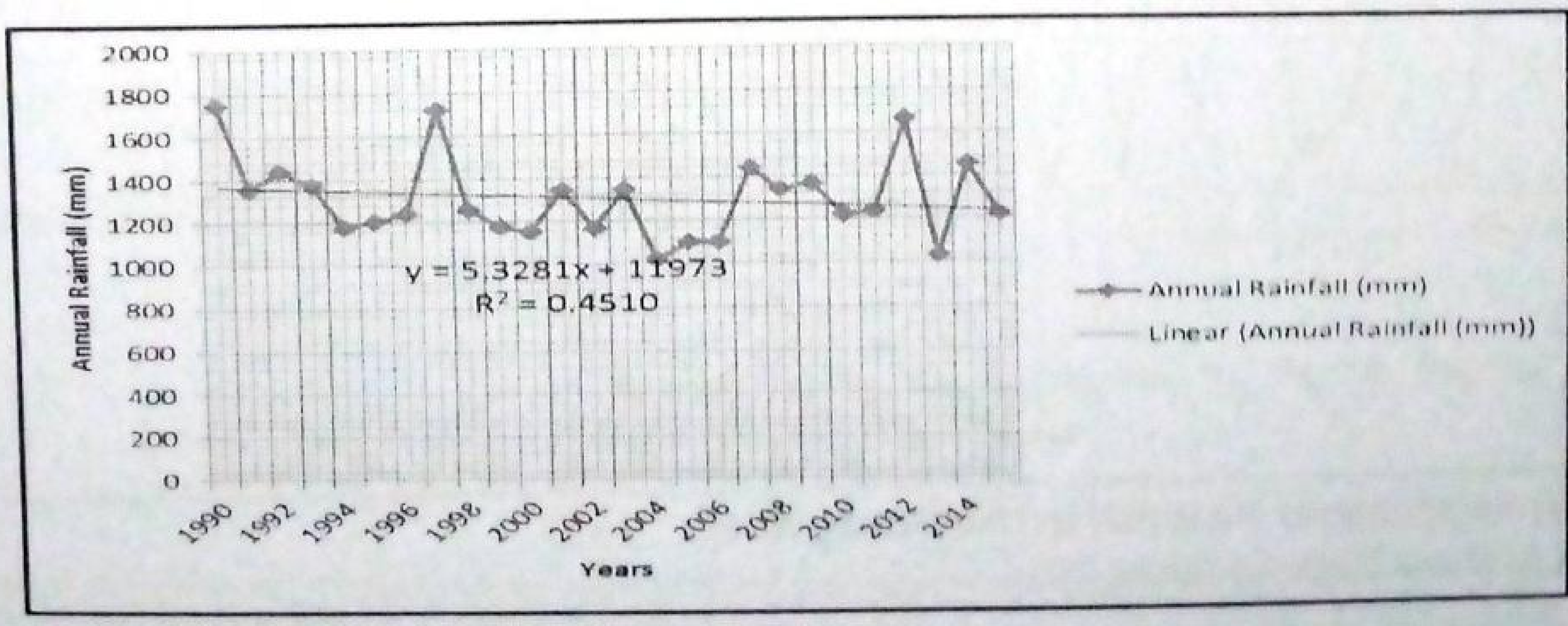


Figure 3: Annual Rainfall in the Study Area
Source: Authors Data Analysis, 2016

Considering the mean annual rainfall of about 1303.6mm in 26years (1990 to 2015), ... to 1993, 1997, 2001, 2003, 2007 to 2009, 2012 and 2014 has annual rainfall data ... mean; while the remaining 14 years revealed annual rainfall below the average ... that annual rainfall is decreasing despite some fluctuation. This shows that annual ... decreasing which has affected Shiroro dam through its inflow and outflow negatively.

R-square (R^2), or the square of the correlation coefficient, is a fraction between 0.0 and ... R^2 value of 0.0 means that there is no any correlation between X and Y and ... relationship exist between X and Y. On the other hand, when R^2 approaches ... correlation becomes strong and with a value of 1.0 all points lie on a straight line. ... shows that there is linear relationship between the annual rainfall and the years.

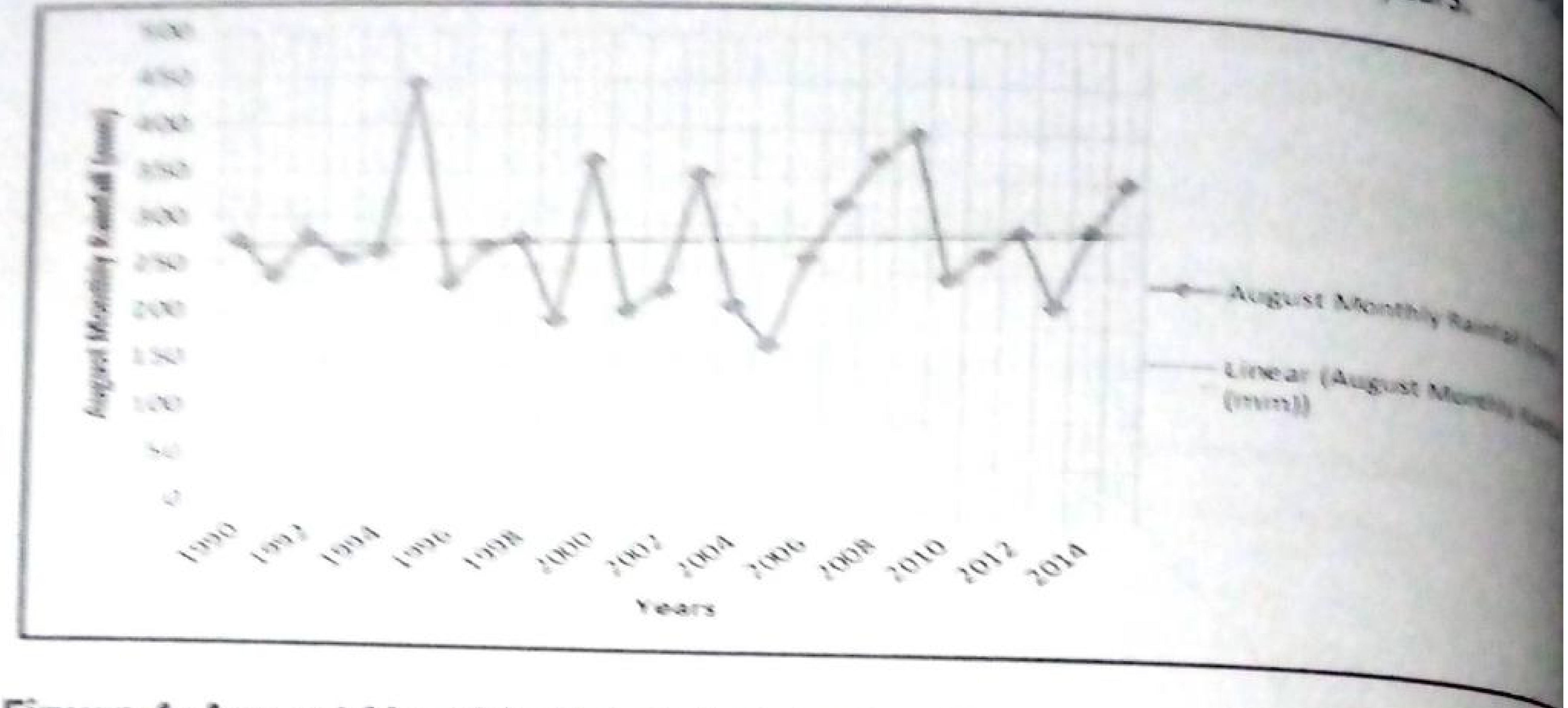


Figure 4: August Monthly Rainfall of the Study Area
Source: Authors Data Analysis, 2016

Figure 4 shows monthly rainfall of August for 26 years (1990 to 2015) and the monthly ... tends to be increasing from 174.1mm in 2005 to 443.8mm in 1995. This has translated to ... flooding activities in the study area due rise in inflow and outflow data. Recently, more ... August for the years 2012, 2014 and 2015 has high monthly rainfall and the people in the ... area confirmed that it resulted in more flooding activities which has effected ... infrastructure, farm produce and lives of the inhabitant living in the area.

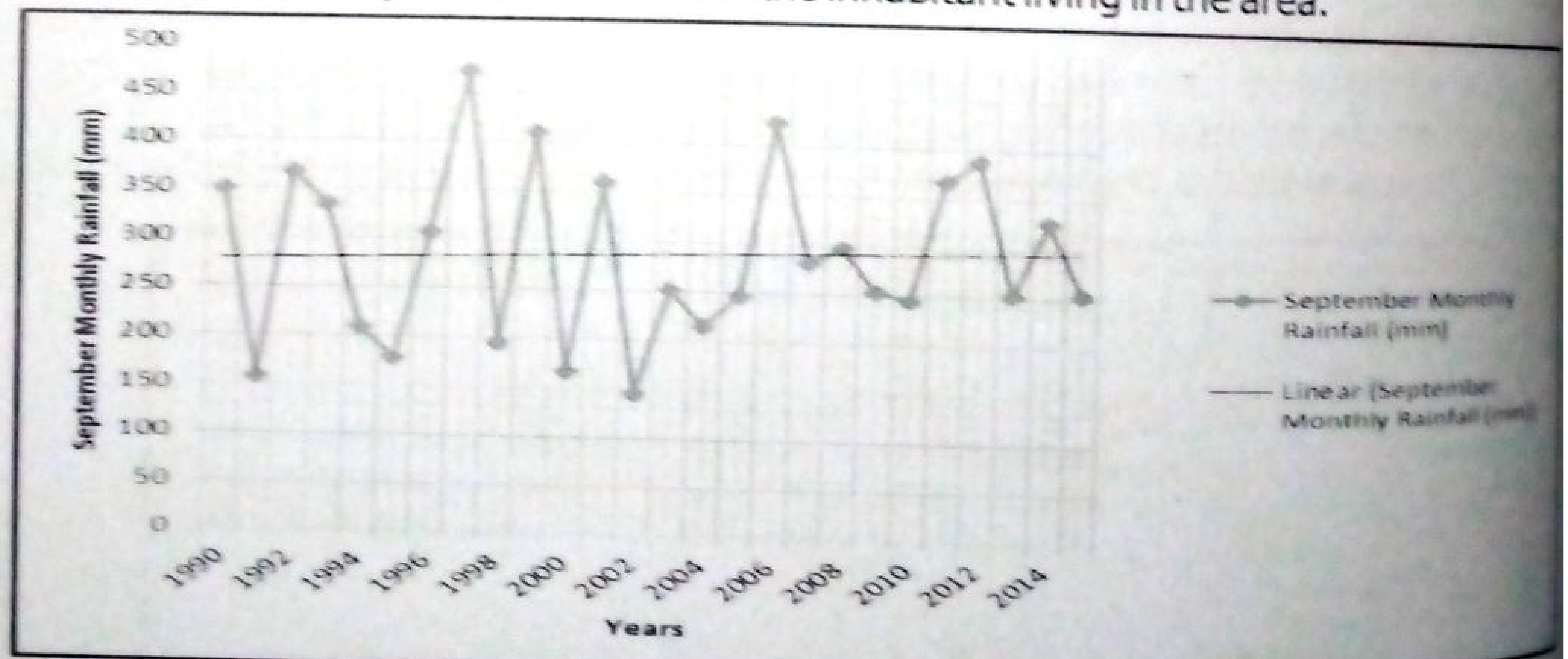


Figure 5: September Rainfall in the Study Area
Source: Authors Data Analysis, 2016

Considering the monthly average of 287.2mm from Figure 5 which was derived from linear trendline, 12 years have monthly rainfall above average and the years include 1990, 1993 to 1994, 1997 to 1998, 2000, 2002, 2007 to 2008, 2011 to 2012 and 2014. This shows that more flooding were likely to be recorded in those months of the years with higher magnitude due to the magnitude of inflow in to Shiroro dam. The remaining years like 1991, 1994 to 1995 have less magnitude considering both the total volume of rainfall in September and the daily rainfall record. This finding was in line with the finding of Inflow analysis of the study.

The hydrologic variables considered in this study include Inflow and Outflow. As indicated in Figure 6, the mean monthly Inflow has the highest value in the month of September with 1045m^3/sec and the lowest was in the month of April with the value of 29.03m^3/sec.

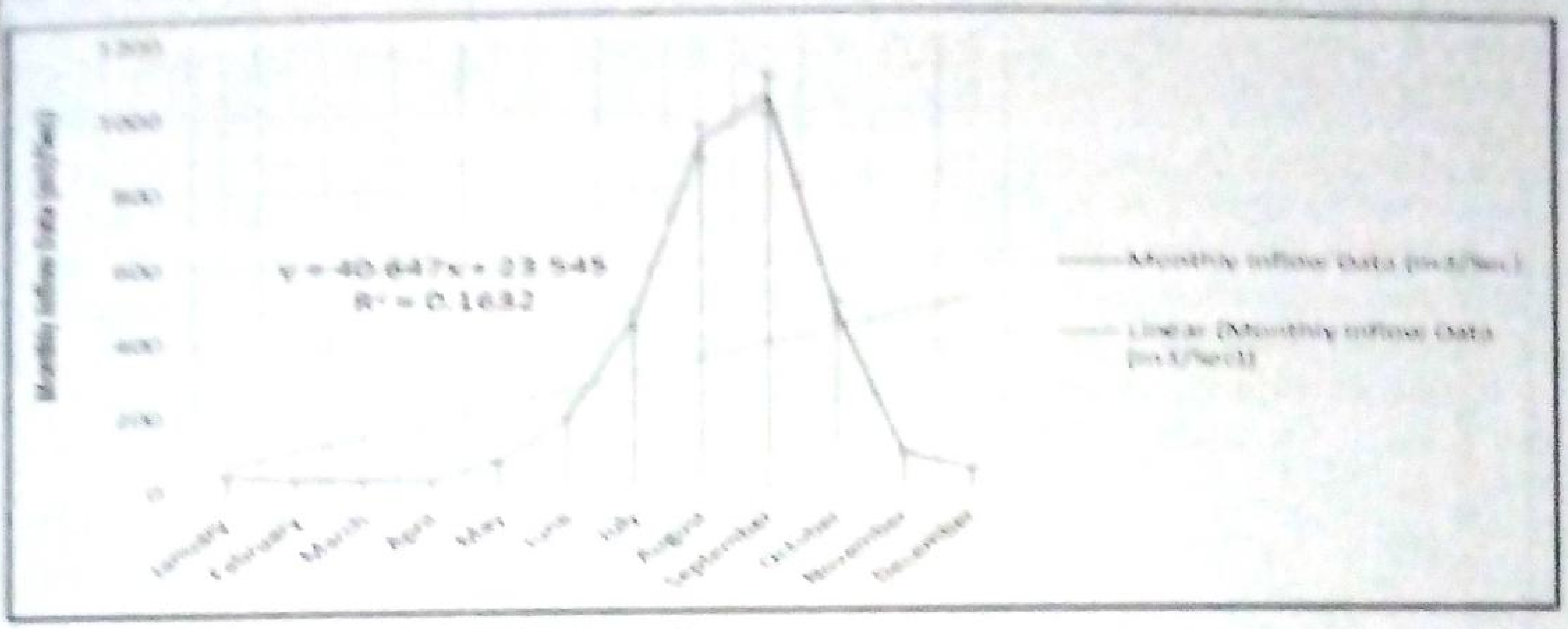


Figure 6: Monthly Inflow of Shiroro Dam
Source: Authors Data Analysis, 2016

The monthly Inflow started increasing from May with 78.72m^3 and got to its peak in the month of September with 1123.48m^3, then started decreasing as rainfall decreased from 506.4m^3 in November to 26.68m^3 in April. R^2 of 0.1632 shows that there is linear relationship between the monthly Inflow and the monthly rainfall and this relationship comes to play as monthly Inflow increases. As indicated in Figure 6, the Linear Forecast Trendline shows that mean monthly inflow will continue to increase as long as rainfall increases along River Kaduna and evaporation decreases.

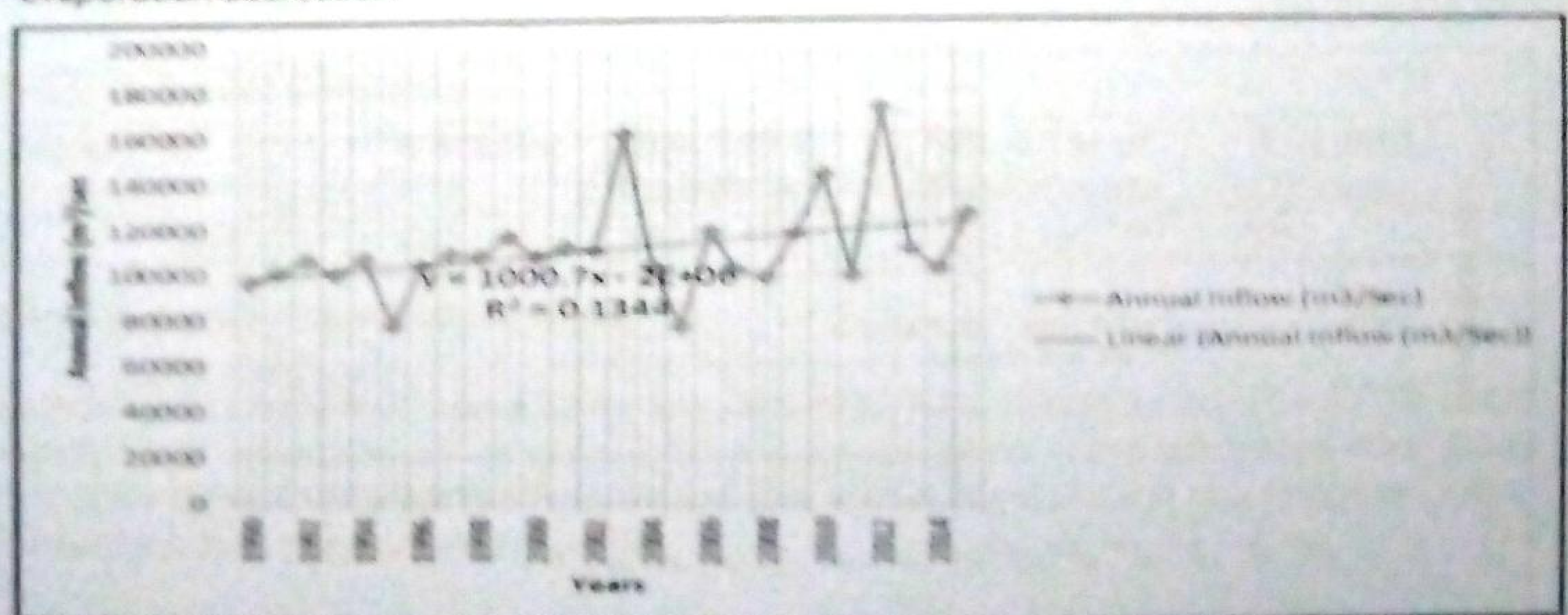


Figure 7: Annual Inflow of the Study Area
Source: Authors Data Analysis, 2016

Figure 7 shows that annual inflow has been increasing despite some fluctuation in ... Year 2012 has the highest annual inflow with 171839m^3/sec while 2005 has the lowe... inflow (76897m^3/sec). From Figure 7, mean annual Inflow was 110931m^3/sec and th... that 8 years which include 1991 to 1992, 1994, 1998, 2000, 2003, 2007, 2010 and 201... 0.1344 shows that there is linear relationship between the annual Inflow and the years... relationship come to play as years Inflow increases.

Dam operations play an important role in the quantity of Inflow and outflow produ... Shiroro dam. This is because the performances of hydrology depend on the rules guiding... intake and release. Where there is an inefficient reservoir rules water intake will be aff... and this will consequently affect outflow in the study area. Efficient operation rules... reservoir would be difficult to design without knowing the relative importance o... contribution of individual hydrology elements like inflow and outflow; especially on mon... basis.

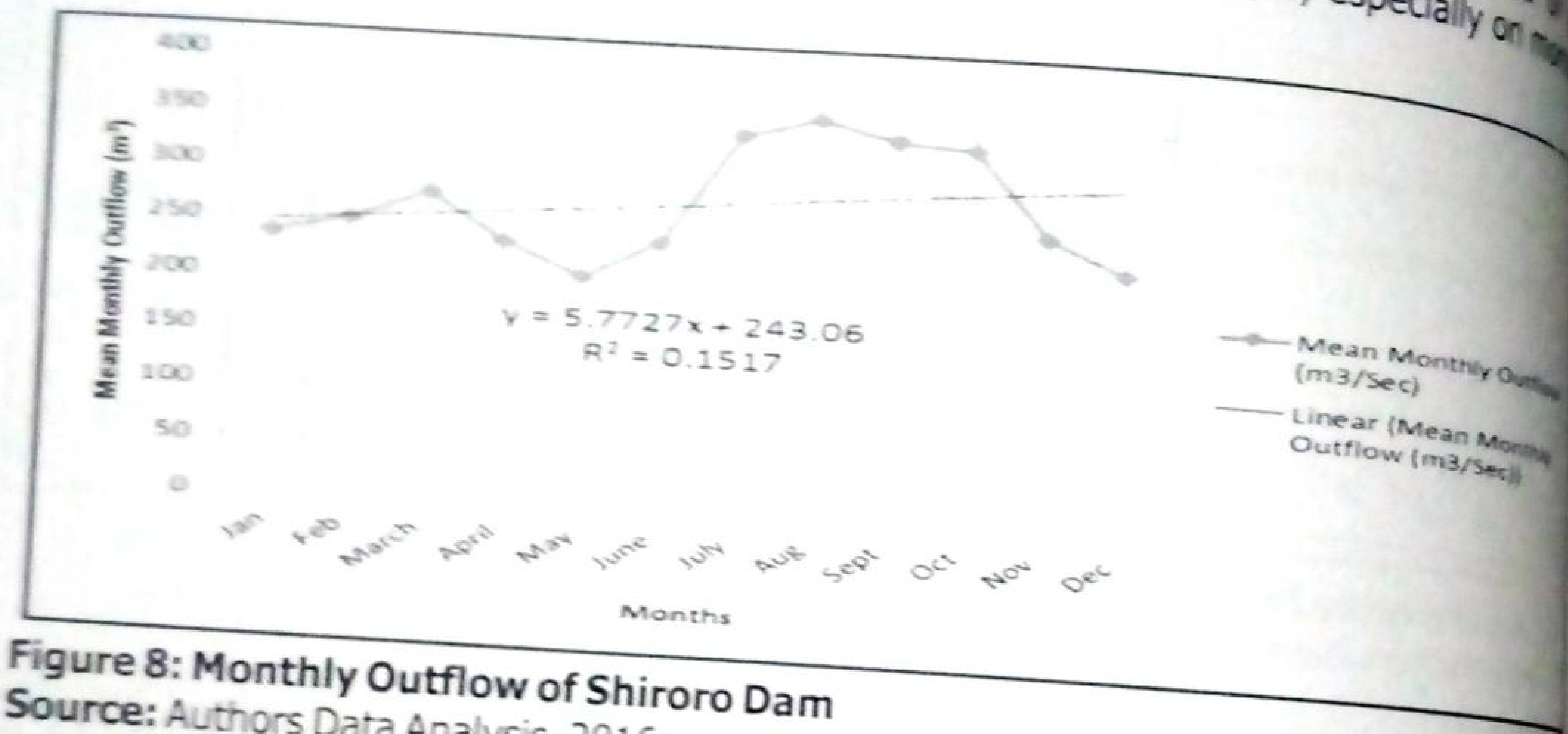


Figure 8: Monthly Outflow of Shiroro Dam
Source: Authors Data Analysis, 2016

The mean monthly outflow of Shiroro dam has its peak in the month of August with a value of 351m^3/sec and the lowest was in the month of May with 211m^3/sec. This shows that mean monthly Outflow follows the pattern of monthly rainfall and monthly Inflow of Shiroro dam. This also shows that flooding phenomena was more active in the months of July to September from the findings.

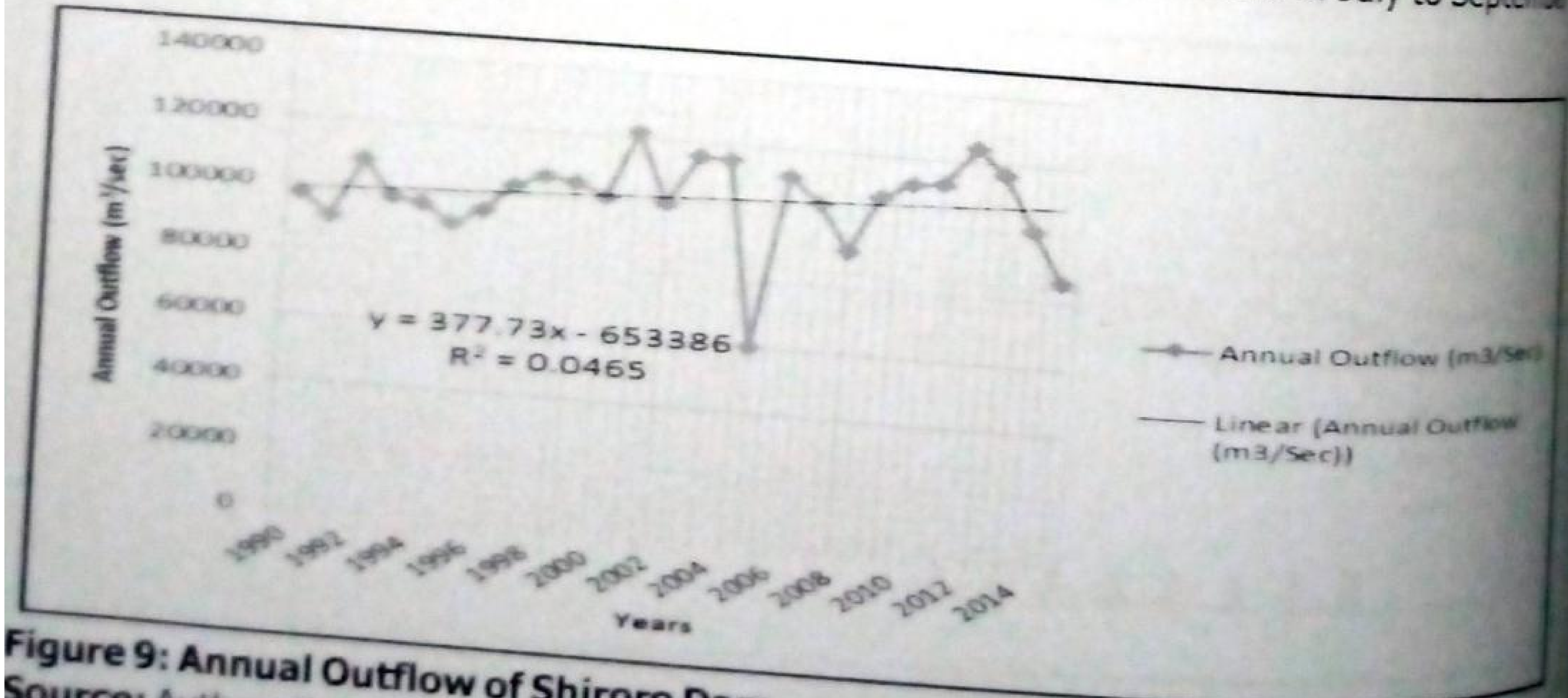


Figure 9: Annual Outflow of Shiroro Dam
Source: Authors Data Analysis, 2016

Annual outflow of Shiroro dam have been increasing since 1990 despite some fluctuation and the peak outflow was in year 2012 with a value of 124472m^3/sec; while the lowest value was in the year 2005 with a value of 60135m^3/sec. This highest outflow which was in 2012 correspond to one of the worst flood in the history of the study area. Shiroro reservoir inflow which is being closely monitored has recorded a few surges since May in response to the prevailing hydrological trends and events on the basin as confirmed by instrumental records. For instance an unusually high average daily inflow magnitude of 1389m^3/sec was recorded on the 31st May 2012. Similarly, another high inflow value of 2004m^3/sec was recorded on the 18th of August. All other records up to the 9th September were generally around 1000m^3/sec. Furthermore, inflow from 9th September have been high but quite normal and generally above 2000m^3/sec with a peak of 2406m^3/sec on the 13th.

However, this trend suddenly changed on the 16th September as a flash flood induced by prolonged heavy downpour lasting more than 48hours from within the immediate vicinity of the reservoir and adjacent basins pushed inflow to unprecedented levels. As a result of the long duration and high-intense rainfall which measured up to 120mm at Shiroro, inflow sharply increased from the 2026m^3/sec of 15th to an extraordinary and unprecedented magnitude of 4000m^3/sec (average) on the 16th leading to extra rapid reservoir filling. Reservoir operation for flood management and reservoir control which was embarked upon immediately thus became very hectic and unavoidable. The need to keep the reservoir at safe and steady state therefore necessitated the release of large volumes of water through the spillway gates.

Table 2: ANOVA for Annual Rainfall and Annual Outflow

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	454652620.301	1	454652620.301	1.045	.317^b
1	Residual	10440527592.315	24	435021983.013		
	Total	10895180212.615	25			

a. Dependent Variable: Annual Inflow (m^3/Sec)
b. Predictors: (Constant), Annual Rainfall (mm)

Source: Authors Data Analysis, 2016

From the table of the F-distribution, critical value of F at 0.05 = 4.26 since the calculated F of 1.04 < 4.26, thus, there is a significant linear relationship between annual rainfall and annual Inflow of Shiroro dam.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change
1	.204^a	.052	.002	20857.181	.052

Source: Authors Data Analysis, 2016

As indicated in Table 3, R^2 was 0.52 for annual rainfall, thus, rainfall account for 52.0% of the explained variance between annual rainfall and annual Inflow in the study area. This shows that other climatic variables like temperature and relative humidity also play important role in Inflow data since there is remaining 48%.

Conclusion
As indicated in the findings of this study, it shows that rainfall, inflow and outflow are the major players in trend of flood events in the study area. The results shows that August and

September monthly rainfall couple with inflow and outflow of the stated month... controller of flood events in the study area which in turn has affected the environ... socio-economic activities of the riparian communities negatively. This study confirm... significant increase in monthly rainfall will lead to inflow, outflow and subsequen... events across the riparian communities of Shiroro dam, Niger State. It's ... recommended that town planners as well as NSEMA specify habitable and non-habit... in riparian communities of Shiroro dam so as to avoid the flood hazard from affecting ... and properties of the people.

References

Abubakar, A. S. (1997). Environmental impact assessment of Shiroro Dam ... hydrometallurgical variables in the Kaduna River Basin. Unpublished Ph.D ... Federal University of Technology, Minna, Nigeria.

Adger, D. (2008). Disaster risk reduction, climate change adaptation and human secu... Commissioned Report for the Norwegian Ministry of Foreign Affairs.

CDEMA, (2010). Caribbean disaster emergency management agency, flood prepared... http://weready.org/flood/index.php?option=com/content&view=article-

Deyer, J. L. (1988). Human responses to floods :Perspective in water uses and Abuses ... H. Speidel (Eds). Oxford University Press. Pp 286-287.

Etuonovbe, A. K. (2011). The devastating effect of flooding in Nigeria. FIG Working Week 20... Bridging the Gap between Cultures, Marrakech, Morocco, available ... http://www.Figurenet/pub/fig2011/papers/ts06j etuonovbe 5002.pdf, last asses... November 11, 2011.

European Union (EU) (2011). Directives on environmental impact assessment and ... amendments, relevant for EU member state. Retrieved fro... http://ec.europa.eu/environment/eia/eia-legalcontext.htm

Garba, I. K., & Mohammed, A. E. (2011). The socio-economic impact of Shiroro hydroelect... power dam project on the surrounding inhabitants. Journal of Science, Technolog... Mathematics and Education, 8(1), 43-59.

...usemoran, M., Anthony, D., & Maryah, A. U. (2013). GIS based assessment of flood risk an... vulnerability in the Benue floodplains, Adamawa State, Nigeria. Journal of Geograph... and Geology, 5(4), 148-160.

...DR, (2009). International strategy for disaster reduction. United Nation Internation... Strategy for Disaster Reduction (UNISDR) Terminology on Disaster Risk Reduction.

...DC, (2011). International water power & dam construction: The relationship betwee... large reservoirs and seismicity.

...al, A. F., & Nagya, M. T. (2009). Socio-economic effects of flood disaster on farmers i... Mokwa Local Government Area, Niger State, Nigeria. A paper presented at the 33[rd] AnnualConference of Agricultural Society of Nigeria held at National Cereal Research Institute Badeggi, Niger State Nigeria.Pp.1-10.

Mohan, K. (2008). National disaster management guidelines: Management of floods. *International Journal of Environmental Studies*, 61(1), 31-38.

NEMA, (2012). Nigeria Lost N2.6tn to 2012 flood disaster. *This Day Live Newspaper* by Onyebuchi, E.

Ojigi, M. L., Abdulkadri, F. I., & Aderoju, M. O. (2013). *Geospatial mapping and analysis of the 2012 flood disaster in central part of Nigeria*. A Paper presented at the 8th National GIS symposium, Dammam, Saudi Arabia April 15-17 2013.

Ologunorisa, T. E., & Abawua, M. J. (2005). Flood risk assessment: A review. *Journal of Applied Sciences and Environmental Management*, 9(1), 57-63.

Salami, A. W., & Sule, B. F. (2010). *An overview on reservoir operational impact of Kainji, Jebba and Shiroro Dams on the environment*. Department of Civil Engineering National Centre for Hydropower Research Development (NACHRED), University of Ilorin, Ilorin, Nigeria.

Tyabo, M. S. (2005). *Environmental impact of hydro-electric dams in Niger State*. Seminar Paper for National Conference on Peace Education and Challenges of Nigeria Nationhood, held in Minna, Niger State College of Education from 22nd to 26th June, 2005. Pp. 1-13.

UNESCO & WMO (1992). *A glossary of hydrological terms*.

Usman, A., & Ifabiyi, I. P. (2012). Socio-economic analysis of the operational impacts of Shiroro hydropower generation in the lowland areas of middle River Niger. *International Journal of Academic Research in Business and Social Sciences*, 2(1), 57-76.

WCDR, (2013). World commission on dams report: Dam structures for water impoundment. Pp1-20.

Zago, I. I. (1999). *Some effects of Shiroro Dam on climate and hydrological characteristics in parts of River Kaduna Basin*. Unpublished M.Sc. Thesis, Department of Geography, Bayero University Kano, Nigeria.

Sokoto Journal of the Social Sciences

(Formerly Journal of Social Science and Administration)

ISSN: 1595-2738

www.[illegible].com Vol. 7: Nos. 2, December, 2017

Scanned by TapScanner

Print ISSN 1595-2738
Online ISSN 2384-7654

ON DETERMINING EFFECTIVE ONSET RAINFALL AND ITS VARIABILITY OVER SOKOTO, NIGERIA (1971-2015)

Ibrahim Ishiaku[1], Badaru Yahaya Usman[2], Emigilati M.A[2], Garba Inuwa Kuta[2]

[1]Department of Geography Federal University Birnin Kebbi

[2]Department of Geography Federal University of Technology Minna

***Corresponding Author's email:** ishiaku.ibrahim@fubk.edu.ng*

DOI: ***10.29816/sjss.7.2.10***

...RACT

...asant crop farming is the major economic activity especially in the Sahel and sub-humid area of ...rica whose fortunes can easily be affected by fluctuations in the rainfall regime. In the light of ...e above this study investigated the historical record rainfall data to determine effective onset ...infall and its variability over Sokoto. Daily rainfall data of 1971-2015 were acquired from ...nvironmental Management Programme Federal University of Technology Minna. A drought ...onitoring and Early Warning (EW) methodology based on an intra-seasonal Rainfall Monitoring ...ndex (IRMI) were adopted. The findings revealed that effective onset rainfall have been variable ...with the mean onset date at 40th pentad (20th July). The years with an early onset date were ...ound to have higher rainfall distribution and intensity (figure 3a – i). Of the two rainfall ...xtreme (flood and drought), the result revealed a prevalence of drought (table 2). The mild ...rought (0.1<IRMI≤1) revealed 28%, severe drought (0.010<IRMI≤0.1) 8% and very severe ...rought (IRMI≤0.01) representing 7%. Owning to variability in the inter-seasonal onset rainfall we ...ecommend a continue monitoring of the rainfall scenarios to effectively communicated it exact ...ffective date to rain-fed farmers for proper agricultural planning in the region.

...words: Onset Rainfall, Inter-Seasonal Variability, Intra-Seasonal Variability, Drought

...Introduction

...fall onset is defined as the period, at the ...nning of the rainy season, when rainfall ...ibution has become adequate for crop ...elopment (Odekunle, *et al* 2005). Of all the ...ate parameters, rainfall is said to be a ...or input which significantly impacts on ...o-economic wellbeing of the population ... depend on rain-fed agriculture (Recha, et ... 2012). The rainfall over Sokoto is ...erstood to show high temporal and spatial ...ability on a wide range of scales. The implication of this is that the large rural population of the area, who mainly depend on rain-fed agriculture, are greatly influenced by climate variability.

It is noted generally that considerable studies exist on onset rainfall in marginal and sub-humid areas of West Africa (Recha, et al., (2012), Hachigonta, *et al*, (2008), Odekunle *et al* (2005), Camberlin and Okoola, (2003), Omotosho, *et al*, (2000), and Usman (2000)). Most of the methods adopted to determined

Scanned by TapScanner

of West percentage mean rainfall to generate the rainfall onset when the value exceeds a given threshold. These methods only consider cumulative totals, with little or no consideration for the spread over time, which is the most important stress factor for plants. Similarly, most of these methods has been mainly concerned with onset and cessation date. Other methods within this study area have used cumulative rainfall and defined the onset of rains as the end of a 30-day period within which one decade with at least 25 mm of rain is followed by two consecutive decades where at least 20 mm of rain falls. The weakness of this scheme is that after the first rainfall event, the farmer may need to wait another 30 days to know whether the onset of the rains has occurred. This may be worrisome as it is understood that in rain-dependent farming regimes, time is of critical essence and this period of indecision is one farmer can ill afford (Tadross et al. 2003).

The pertinent issues remain as to what happen to the rainfall in between the onset and the cessation. This worth investigating as it has been revealed that a high frequency of damaging dry spells within the growing season can set in (Mugalavai, *et al.*, 2008). In addition, the onset date of the rainy season as well as other characteristics such as the number of

than seasonal rainfall ... such as farmers, water ... health and tourism officials ... 2008).

In this study, we determine ... inter-seasonal and ... within the growing season ... October each year.

2 Materials and Methods

2.1 Data Used

The daily rainfall data for the ... 2015 from globally ... stations of Sokoto ... Environmental Management ... Federal University of Technology ...

2.2 Data Analysis

To achieve objective of the ... monitoring and early ... methodology based on ... Rainfall Monitoring Index (IRMI) (Usman & Abdulkar, 2013) ... IRMI is a tool for determining ... date of the summer monsoon ... computed on a pentad-by-pentad ... the beginning of May ... here under:

$$IRMI = \frac{(Cpt)^2}{(hpt \times Nb \times 100}$$

Cpt = Cumulative pentad rainfall since May 1

hpt = The highest pentad total rainfall since May 1

Nb = Number of breaks in rainfall (pentads with less than 5mm of rainfall) and

100 = a factor

The 'actual' or 'real' onset of rains is taken as the pentad within which the index ... time. IRMI is classified to indicate abundant, adequate, deficient, very deficient ... deficient moisture conditions (see table 1). Similarly the inter-seasonal variability ... by subtracting the succeeding onset date from the previous. The value is negative ... onset rainfall date were earlier to succeeding onset date and the reverse is true ...

were earlier. In addition the average onset pentad value were subtracted from the t pentad to give the deviation from the mean.

MI based drought-monitoring scheme

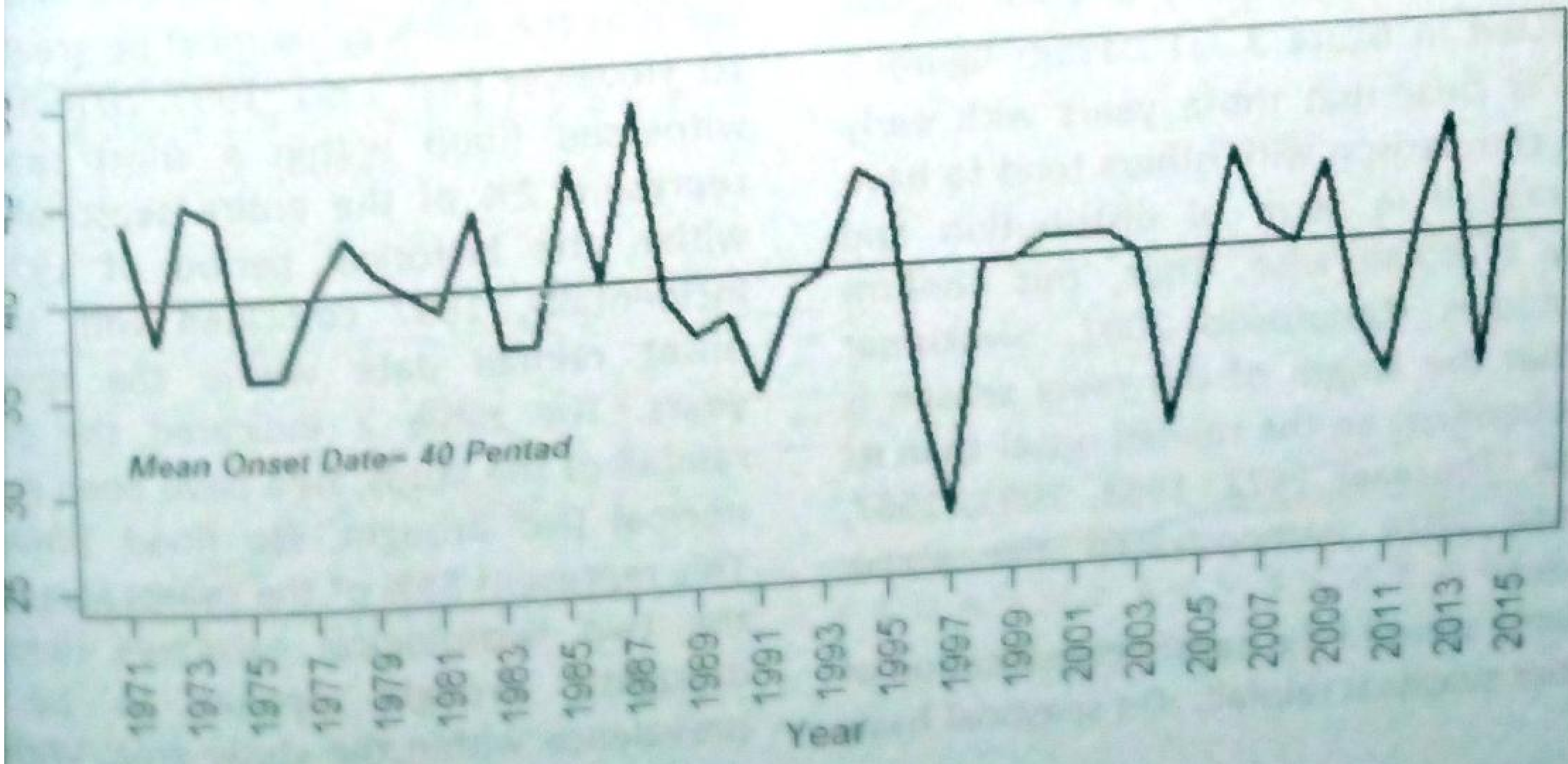
ification		Rainfall receipt (moisture supply condition)	Hazard
		IRMI classes	
	1	Abundant (high rainfall total within short time spans)	Flood
	2	Adequate	No drought, No flood
1	3	Deficient	Mild drought
IRMI≤0.1	4	Very deficient	Severe drought
	5	Extremely deficient (low rainfall totals over long time spans)	Very severe drought

Adopted from Usman and Abdulkadir (2014)

ults and Discussion

tive Onset Date

ctive onset date is depicted in figure 1. rage onset date within the considered s 40 pentad (20th July). The best onset s found in 1997 (27 pentad onding to 15th May). The worst onset s found in 1987 (49 pentad onding to 5th September). The pattern nset date reveal high rate of variability n seasons. The general onset pattern in the study area is reveal to be poor as Usman & Abdulkadir, (2014) noted that "if rainfall is not effective before pentad 36 (30 June), it should be an indication of a problem of some sort as this will impact negatively on the length of the growing season and should be used to issue an advisory statement to farmers and similarly if effective onset of rain is at about pentad 41 (25 July), this should be an indication of deficient moisture conditions".



1: Onset Series of Sokoto

Scanned by TapScanner

3.2 Deviation ...

The uncertainty to which rain-fed farmers are exposed to seasonal wise is depicted in Figure 2. The figure shows both the inter-seasonal variability as well as deviation from mean of onset date. Years with negative value indicated that the onset date were earlier compare to the preceding years. The year 1973, 1977, 1978, 1982, 1985, 1987, 1990, 1992, 1993, 1994, 1998, 2000, 2005, 2006, 2009, 2012, 2013 and 2015 all demonstrated this. The remaining years within the considered period show the reverse

The figure 2 also indicat... negative deviation of onset ... the mean. The negatives value ... 1997, 2004, 2005, 2006, 2010, ... indicated below the mean onset ... while remaining positive values ... the mean onset rainfall date. ... Figure 2 show high uncertainty ... rainfall between seasons. The ... this is that inter-seasonal variability ... uncertainty) got progressively ... believed to have caused ... difficulties to the farmers.

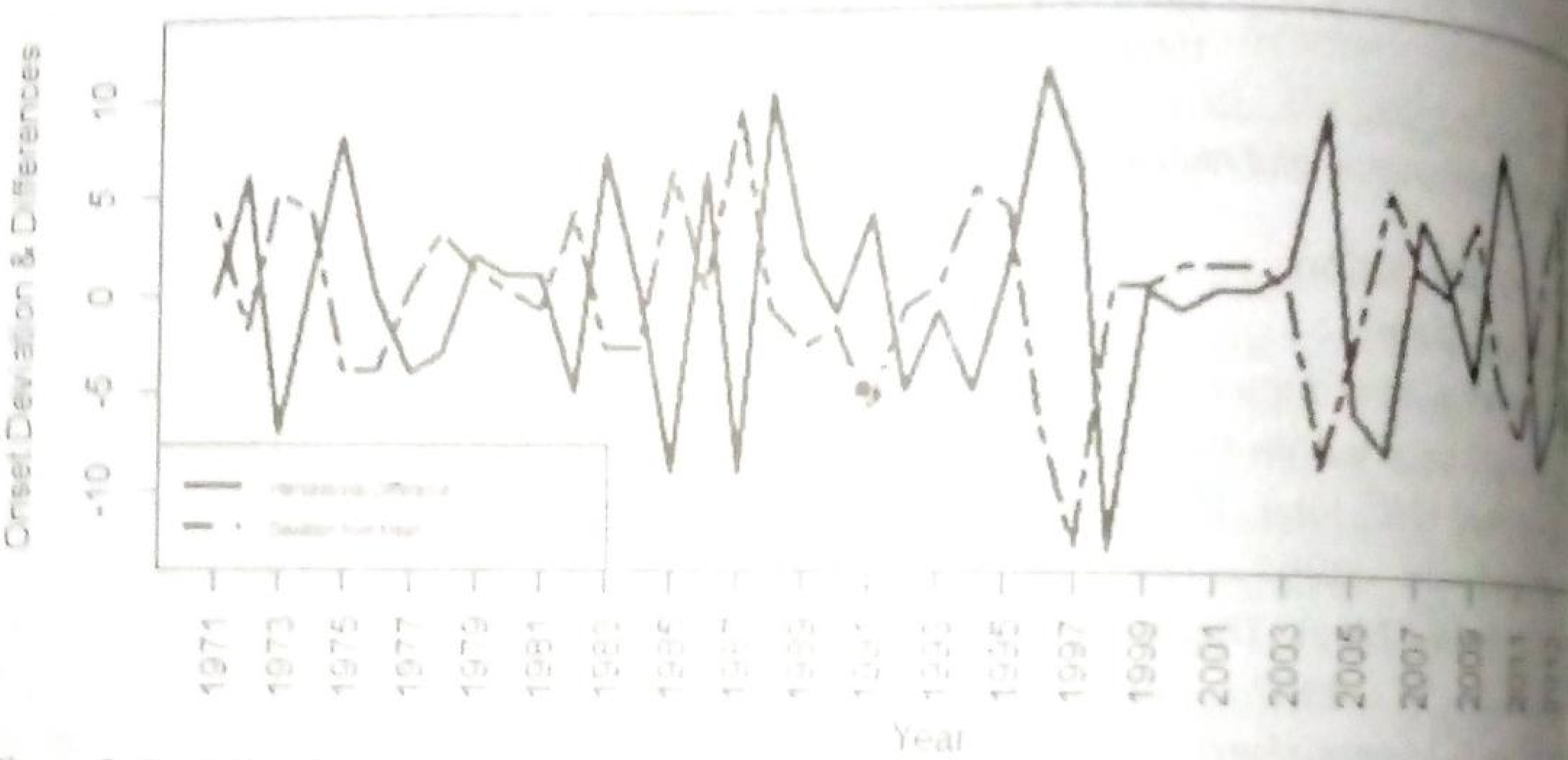


Figure 2: Deviation from Mean and Inter-Seasonal Variability of Onset

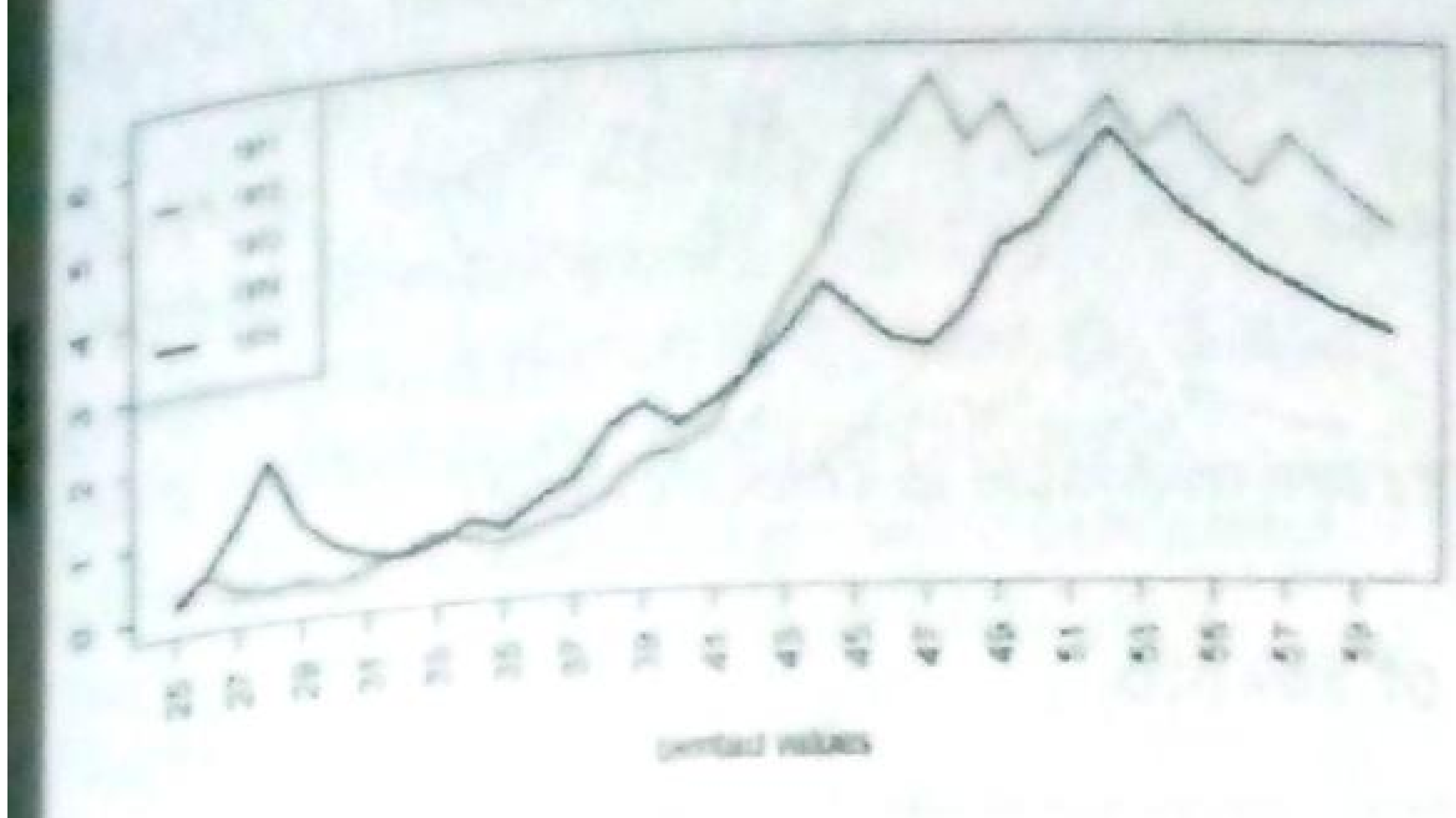
3.3 Intra-Seasonal Variability

The intra-seasonal variability of each season are depicted in figure 3 $-i$. From figure 3 $a-i$ it is clear that those years with early onset in comparison with others tend to have higher rainfall in term of distribution and intensity seasonal wise. Thus, this confirm other studies (Omotosho 2002, Sivakumar 1988) that the length of the rainy season is more dependent on the rainfall onset than its cessation. The year 1972, 1983, 1991, 1987, 2010 and 2014 demonstrated the above statement.

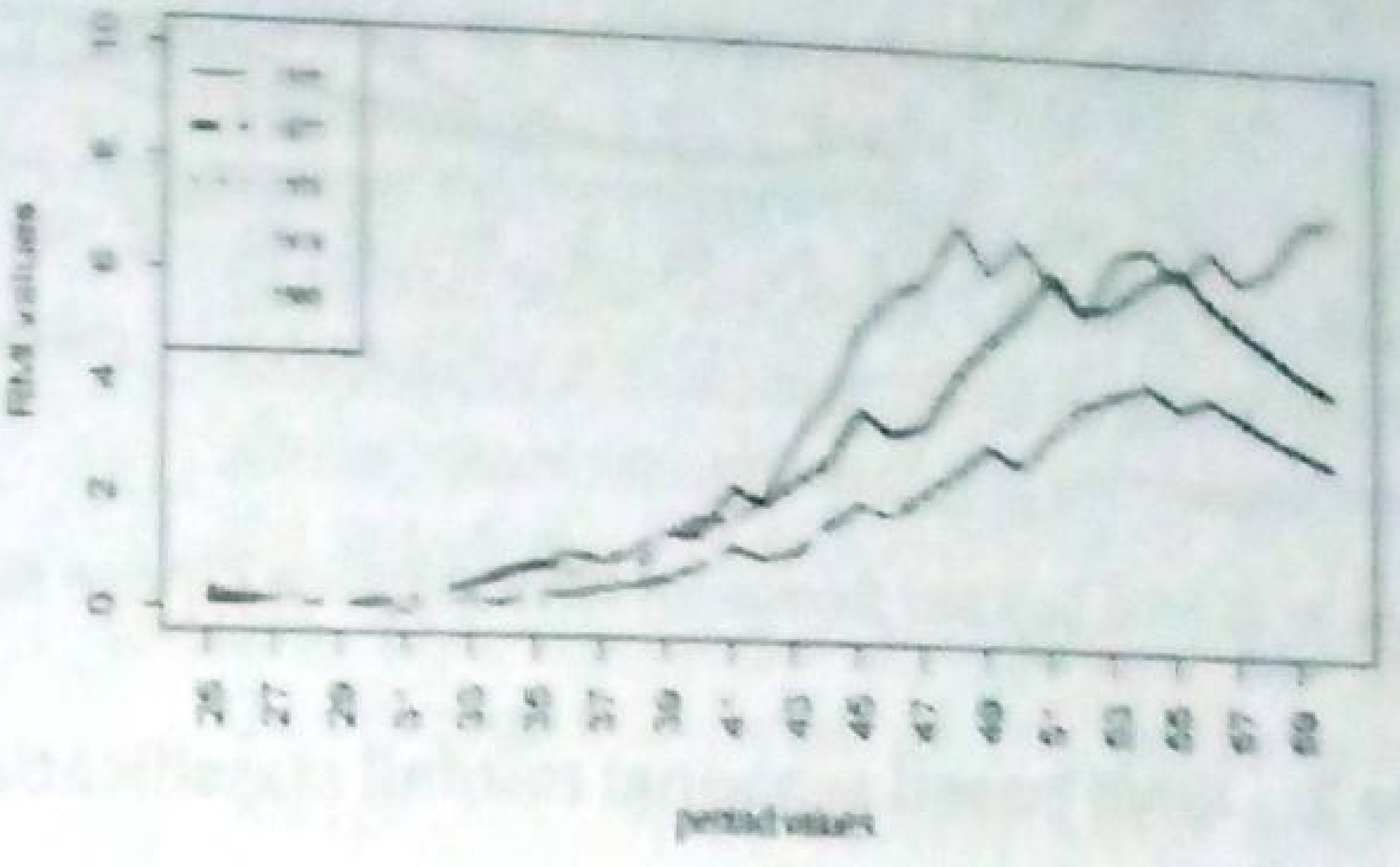
Table 2 showed the hazard classification of the entire seasonal rainfall. On seasonal basis the study area has not witnessed ... event as the index value must be ... 10. However year 1991, 1997, ... witnessed flood within a short ... represent 2% of the entire season ... within the historical period of ... Incidentally, 1997 coincided with ... onset rainfall date within the ... years. The table 2 indicated the ... rainfall of the study area have been ... normal (No drought, No flood ... This represent 55% of the seasonal ... the two hydrological extremes ... drought), drought appear to ... prevalence within the study area ...

...ught categories, mild drought ($0.1<IRMI\le1$) ...the highest with 28%. This is followed by ...vere drought ($0.010<IRMI\le0.1$) 8% and very ...vere drought ($IRMI\le0.01$) representing 7%.

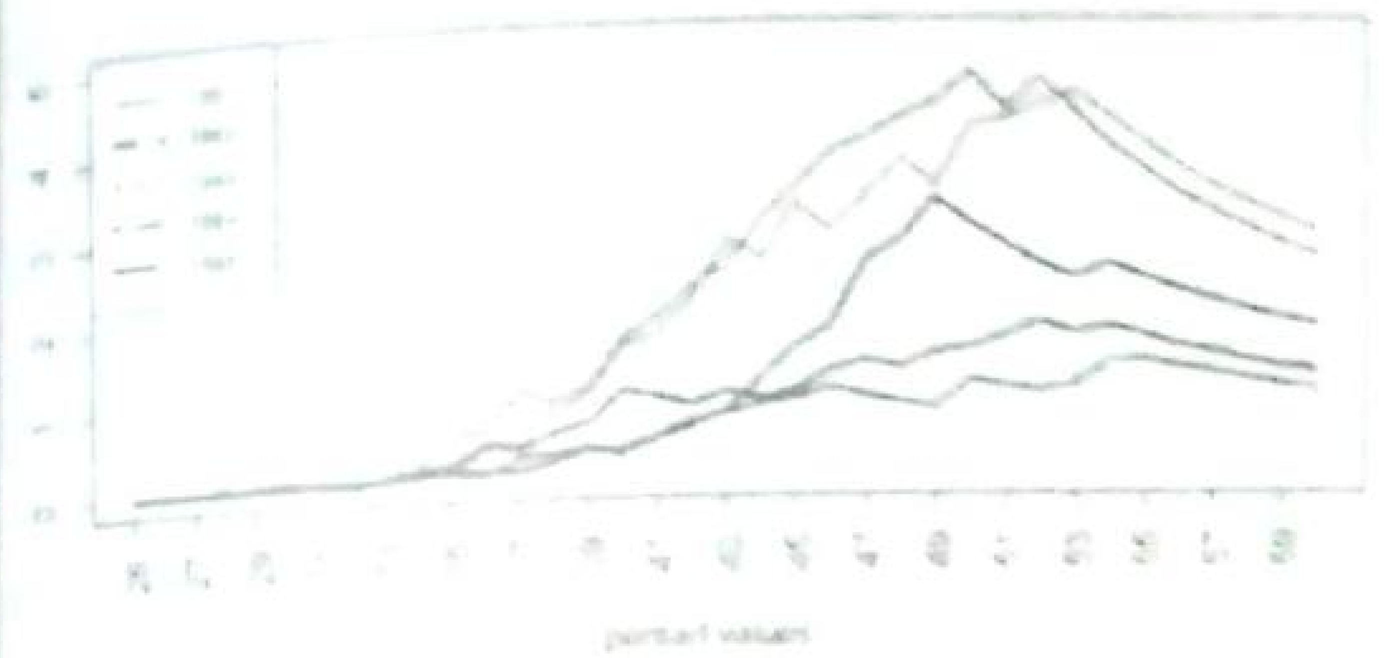
The year 1973, 1978 1987 1988 1994 and 2003 are most significance as they revealed major severe drought events



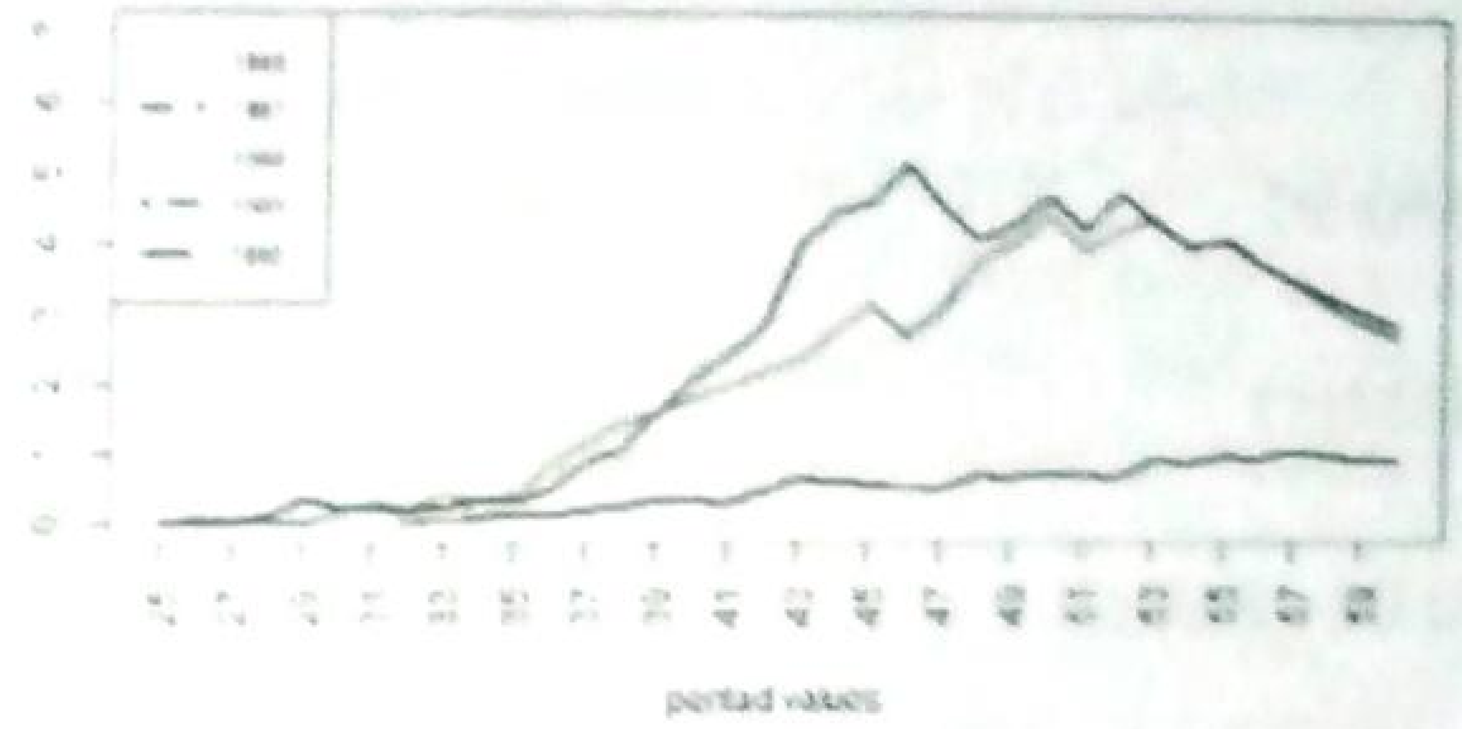
a



b

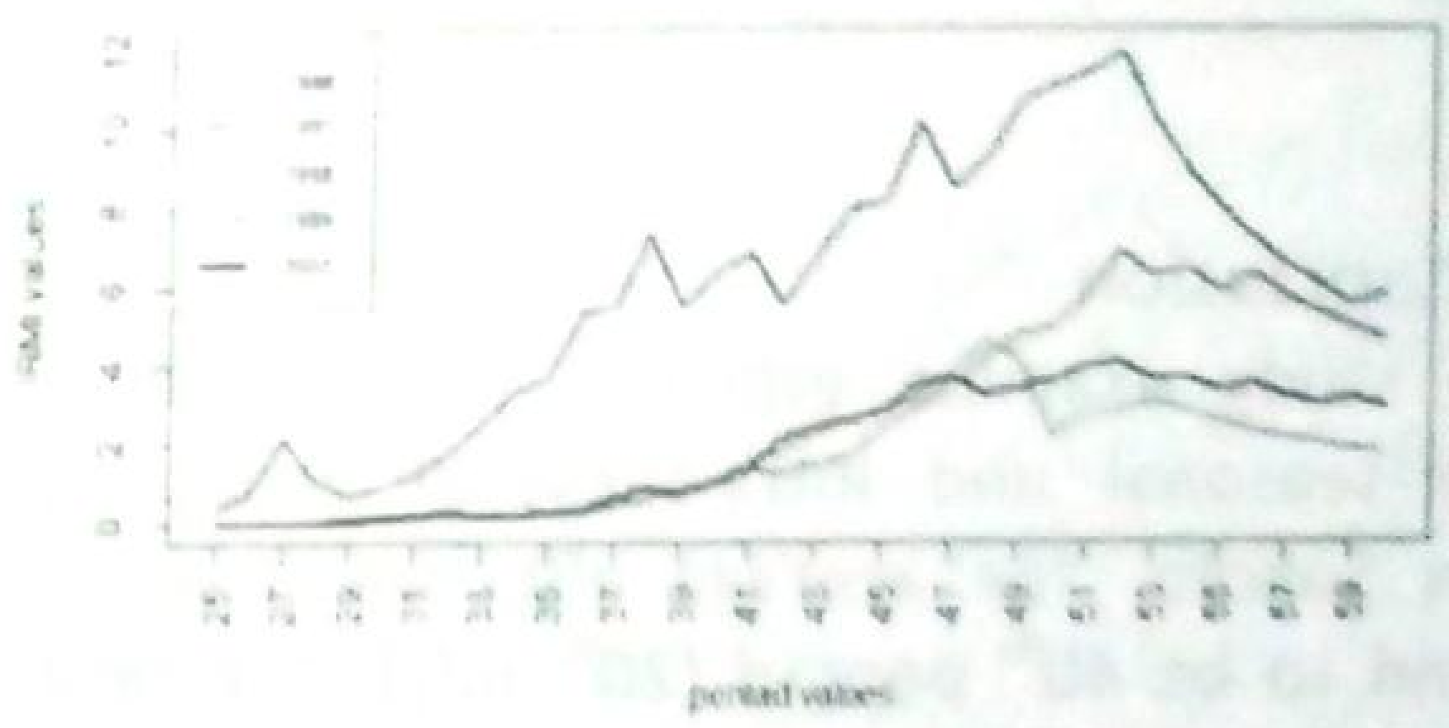


c

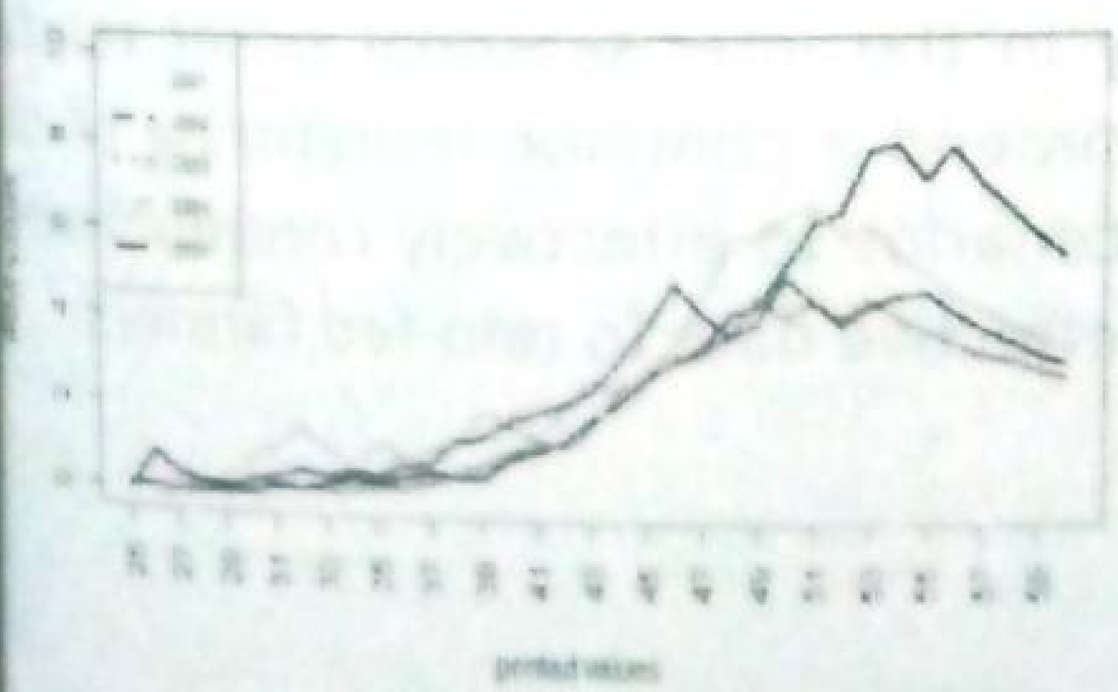


d

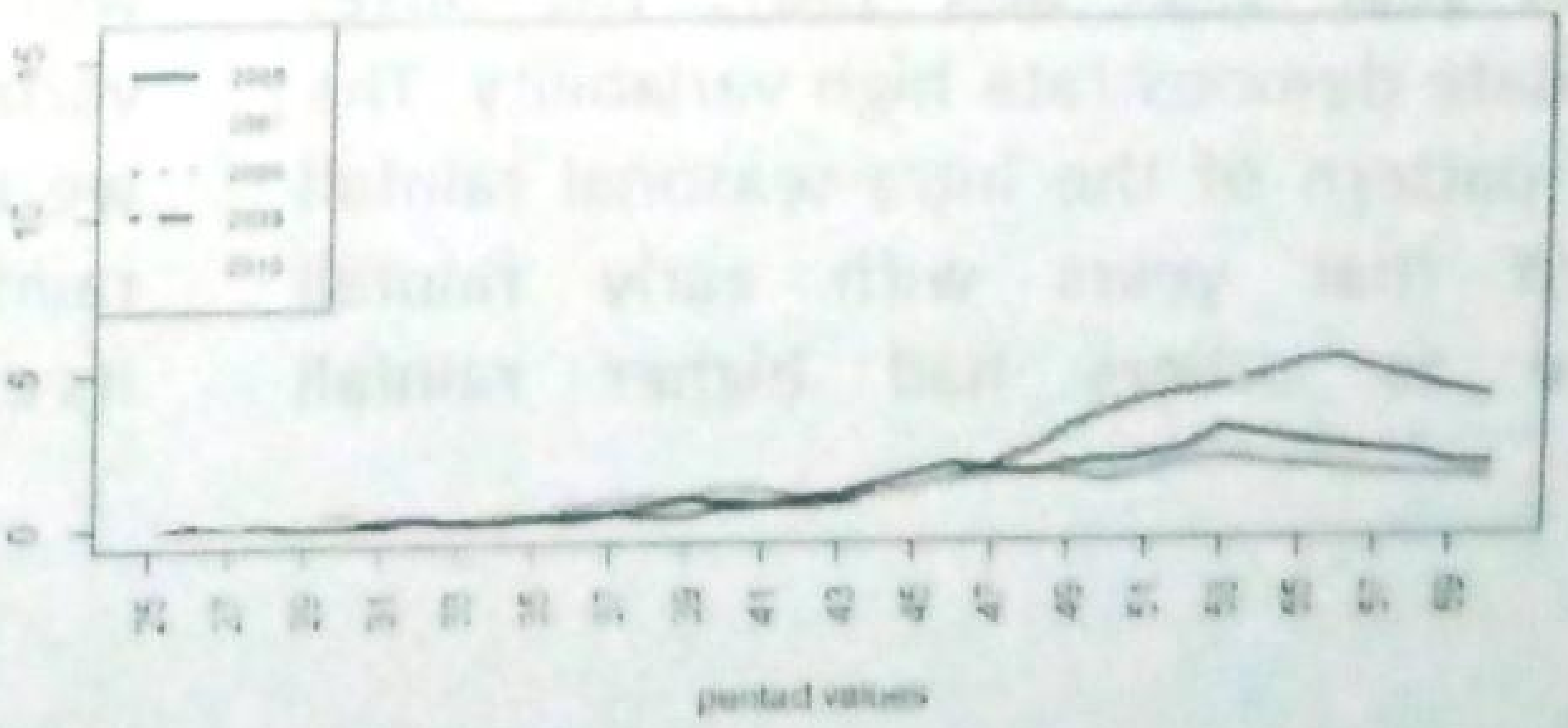
e



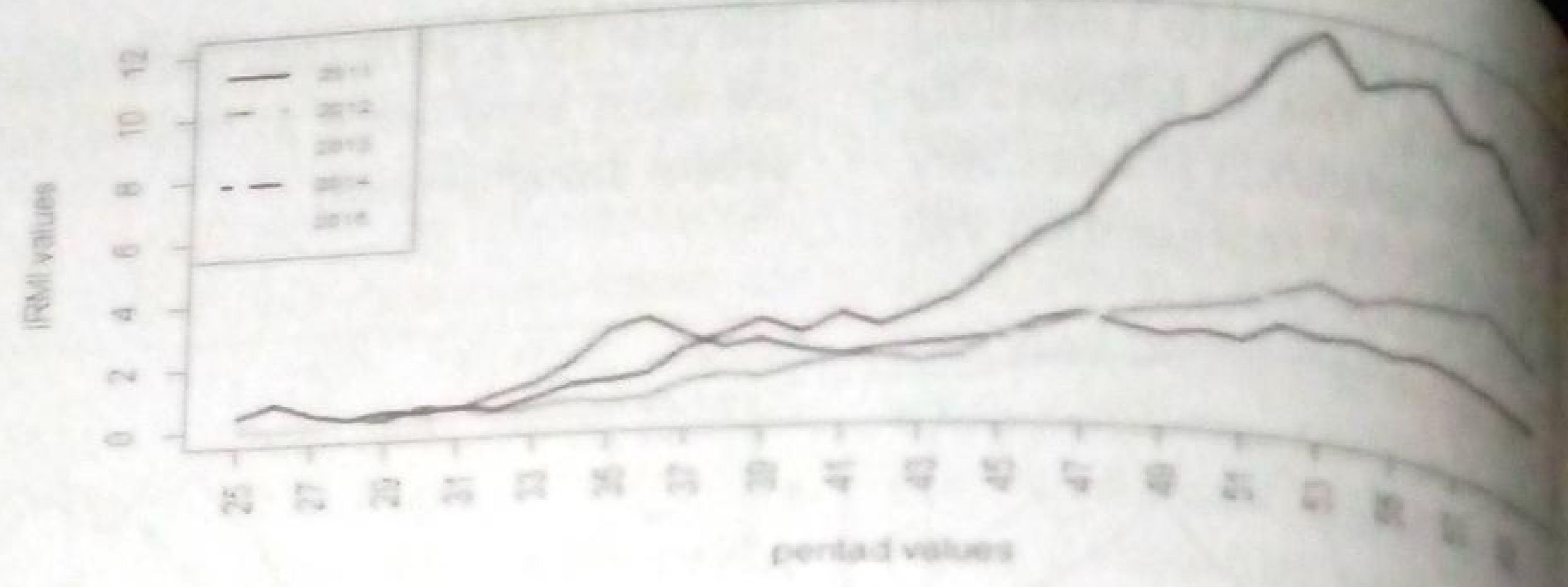
f



g



h



i.

Figure 3: a − i Sokoto Seasonal IRMI Pattern (These figures are available in colour onl...

Table 2. . IRMI based seasonal rainfall classification of Sokoto

IRMI ranges	Frequency	Percentages (%)	Hazard
IRMI>10	28	2	Flood
1<IRMI≤10	891	55	No drough...
0.1<IRMI≤1	460	28	Mild drough...
0.010.01<IRMI≤0.1	124	8	Severe droug...
IRMI≤0.01	117	7	Very severe
Total	1620	100	

4 Conclusion

The study examine effective onset rainfall, inter-seasonal and intra-seasonal variability over Sokoto. The average effective onset is found to be 40th pentad (20th July). The best and worst case scenarios of onset rainfall were found in year 1997 and 1987. The onset rainfall date demonstrate high variability. The general pattern of the intra-seasonal rainfall indicated that years with early rainfall compare to others had higher rainfall distribution and intensity thus ... other study that the length of the ... is more dependent on the rainfall ... its cessation. General findings ... mild to severe drought have bee... within the study area. To overcom... variability in the inter-seasonal ... we recommend a continue moni... rainfall scenarios to effectively ... its exact effective date to rain-fed ...

...erences

...berlin , P., & Okoola, R. E. (2003). The onset and cessation of the "long rains" in eastern Africa and their interannual variability. *Theorectical and Applied Climatology, 75*, 43-54.

...higonta, S., Reason, C. J., & Tadross, M. (2008). An analysis of onset date and rainy season duration over Zambia. *Theorectical and Applied Climatology, 91*, 229-243.

...galavai, E. M., Kipkorir, E. C., Raes, D., & Rao , M. S. (2008). Analysis of rainfall onset, cessation and length of growing season for western Kenya. *Agricultural and Forest Meteorology, 148*, 123 -13 5.

...ekunle S, T. O., Balogun, E. E., & Ogunkoya, O. O. (2005). On the prediction of rainfall onset and retreat dates in Nigeria. *Theorectical and Applied Climatology, 81*, 101-112.

...otosho, B. J., Balogun , A. A., & Ogunjobi, K. (2000). Predicting Monthly and Seasonal Rainfall, Onset and Cessation of the Rainy Season in West Africa Using only Surface Data. *International Journal of Climatology, 20*, 865-880.

...otosho, J. (2002). Synoptic meteorology: Pathway to seasonal rainfall prediction for sustainable agriculture and effective water resources management in West Africa but Nigeria in particular. *Journal of Nigeria Meteorological Society, 3*, 81–89.

Recha, C. W., Makokha , G. L., Traore, P. S., Shisanya, C., Lodoun, T., & Sako, A. (2012). Determination of seasonal rainfall variability, onset and cessation in semi-arid Tharaka district, Kenya. *Theorectical and Applied Climatology, 108*, 479-494.

Sivakumar, M. (1988). Predicting rainy season potential from the onset of rains in Southern Sahelian and Sudanian climatic zones of West Africa. *Agricultural and Forest Meteorology, 42*, 295–305.

Tadross MA, Hewitson B, Usman M (2003) Calculating the onset of the maize growing season over Southern Mrica using GTS and CMAP data. CLIVAR Exch 27, 48–51

Usman M.T (2000). An operational index for assessing inter annual rainfall variability and agricultural droughts over the Sahel, African. Climatol Res Ser 3(1):23–33

Usman, M. T., & Abdulkair, A. (2013). On determining the 'real' onset date of seasonal rains in the semi-arid and sub-humid areas of West Africa. *Natural Hazards* (66), 749-758.

Usman, M. T., & Abdulkadir, A. (2014). An experiment in intra-seasonal agricultural drought monitoring and early warning in the Sudano-Sahelian Belt of Nigeria. *International Journal of Climatology, 34*, 2129-2135.