Ethiopian Journal of Environmental Studies & Management 9(5): 534 – 544, 2016.
ISSN:1998-0507 doi: http://dx.doi.org/10.4314/ejesm.v9i5.1
Submitted: January 20, 2016 Accepted: August 30, 2016

FLOOD RISK ANALYSIS AND HAZARD ASSESSMENT IN GUSORO COMMUNITY DOWNSTREAM OF SHIRORO DAM USING GEOSPATIAL APPROACH

***MUSA, J.,[1] YUNUSA, M.B.,[1] ADAMU, M.[2] IBRAHIM, I.[3] AND MOHAMMED, A.[4]**
[1]Department of Geography, Federal University of Technology, Minna, Nigeria
[2]Evans Medical, Isoro, Lagos, Nigeria
[3]Department of Geography, Federal University, Birnin Kebbi, Nigeria
[4]Department of Geography, Ibrahim Badamasi Babangida University, Lapai, Nigeria

Abstract

The study undertakes flood risk analysis and hazard assessment in Gusoro downstream of Shiroro dam using remote sensing technique. The study is anchored on three objectives; to create land use-land cover map, to map flood prone areas within the study area and to proffer options for flood hazard mitigation and adaptation in the study area. Data were sourced from satellite imageries Landsat ETM of 2006, topographic map of the study area Niger State Geographic Information System (NIGIS) and hydrological data for 10 years (2003-2013) from Shiroro Hydro Electric Power Dam Niger State., The image was analyzed with the aid of flood frequency, Geo-Referencing, Image Enhancement, Image Classification, Buffering, Boolean Analysis and Proximity Analysis. The results revealed that in year 2012, the total rainfall was 1659.7(mm) and the heavy downpour affected the surrounding environment of the river. The result indicated that most of the river flooding in the study area is seasonal (rainy season only) and it is aggravated by two main factors i.e. when the spill ways of the dam are open and secondly human and anthropogenic activities. The study further revealed that human activities by the river side contribute to flooding in the area. The study recommended that buffer zone should be created by the riverside, to restrict people from erecting structures or agricultural activities along the river banks.

Key Words: *Flood Risk, Hazard, Downstream, Environmental, Urban Development*

Introduction

Flood is described as any abnormally high water level of flow overland (Agasa, 2002). Like other natural disasters such as hurricanes, tornadoes, earthquakes, volcanic eruptions, earth tremor, thunder storms, landslides, typhoons, soil erosion etc, the consequences of flood are followed by a significant damage of property, environment and even loss of lives. Flood occurs almost every year in different parts of Nigeria and the world at large (Agasa, 2002).

However, floods are natural phenomena that often occur as natural disaster in environment where man has

*Corresponding Author: Musa, J.
Email: maljibrin@gmail.com

interfered with the natural course of rivers. These floods occur when a body of water rises to over flow land which is normally not submerged, usually after an intensive rain event, causing inundation and damage to lives and properties (NCRS, 2006).

Most human activities produce potential adverse environment effects, some of these activities include the construction and operation of Dams, high ways, power plants commercial and residential development projects, land full, sanitation and hazardous waste disposal operations, large scale irrigation projects and Mineral mining (Melack and David, 2004).

In Nigeria, natural and anthropogenic induced flooding is a threat to physical infrastructure such as residential properties, Roads rail lines and bridges (Funke, 2007). Funke, (2007), further state that rural areas flooding has destroyed farm lands and economic crops worth millions of Naira in Nigeria. As reported by the National committee on the International decade for natural disaster reduction (IDNDR) 1994, at least 20% of the population of Nigeria is at risk from one form of flooding or another. Riggs (1985), stated that in a situation where data are not available hazard assessments base on remote sensing and GIS can serve as a reliable substitutes. Melack and David (2004), further state that a change to proactive management of natural disaster requires an identification of the risk, the development of strategies to reduce risk and creation of policies and programs to put these strategies into effect

Research Objectives

- To creates land use-land cover map.
- To map flood prone areas within the study area.
- To proffer options for flood hazard mitigation and adaptation in the study area

Study Area

The study covers Gusoro village which is situated at the downstream of Shiroro hydroelectric Dam built on River Kaduna in Niger State Nigeria. It lies between latitude 9°55′60″N and longitude 6°54′0″E and Gusoro which lies between latitude 9°57′42′N and longitude 6°50′13″E of the Greenwich meridian with total population size of about 1,300 people.

Geology

Gusoro, like other communities on the same latitude, is covered by two major rock formations the sedimentary and basement complex rocks. The sedimentary rocks to the south are characterized of sandstones and alluvial deposits. To the north is the basement complex, characterized by granitic outcrops or inselbergs which can be found in the vast topography of rolling landscape.

Climate

The area experiences two distinct seasons the dry and wet seasons. The annual rainfall varies from about 1,600mm in the south to 1,200mm in the north. The duration of the rainy season ranges from 150-210 days or more from the north to the south. Mean maximum temperature remains high throughout the year, hovering about 32Â°F, particularly in March and June. However, the lowest minimum temperatures occur usually between December and January when most parts of the state come under the influence of the tropical continental air mass which blows from the north. Dry season in Niger State commences in October.

Figure 1: Map of Niger State
Source: Niger State Geographic Information System (NIGIS)

Methodology

Landsat ETM imagery of 2006 covering the study area of Shiroro dam and Gusoro community was obtained from global land facilities from the internet and Topographic map covering the study area was obtained from Niger state Geographic information system (NIGIS), Minna and re-digitized. The image was analyze with aid of flood frequency, Geo-Referencing, Image Enhancement, Image Classification, Buffering, Boolean Analysis and Proximity Analysis

Result and Discussion

The importance of this research work was the use remote of sensing and GIS to map out areas prone to flooding in Gusoro downstream of Shiroro dam, and also to provide a flood risk map, and to identify areas of high and low vulnerability from the land use types.

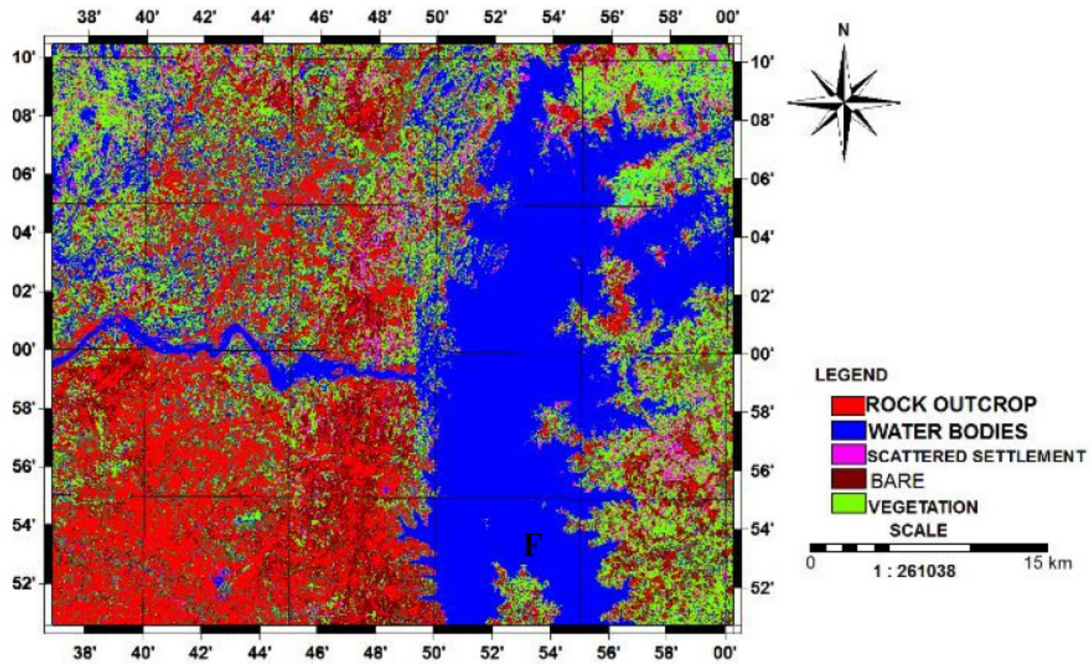

Figure 2: Land use Imagery of the Study Area
Source: Global Land Cover Facility (GLCF)

Ground truth was carried out despite the fact that the image used was more than two years old, using physical features (floodable, vegetation and areas of high relief) as sample points. The interpreted image showed that area with high relief cover about 50 hectares (ha). Water body occupied about 35(ha) made up mainly of rivers which flow through the study area with stream flowing into it. Vegetation and farms as this cover just 15(ha).

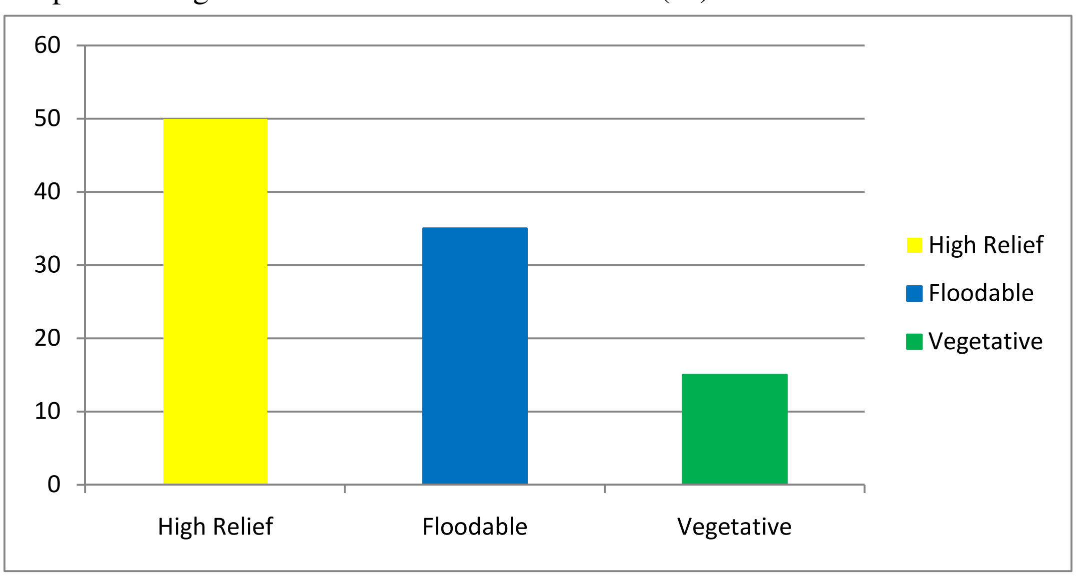

Figure 3: Category of Land use in the Study Area

Flood Risk Map of the Study Area

River flooding in this area is as a result of natural factors such as rainfall intensity, duration, orientation of the river basin and presence of large bare exposed surface as well as human induced factors such as excess water spillage from the dam, the expansion of agricultural activities at the upper stream course of the river leading to serious environmental, social and economical problems.

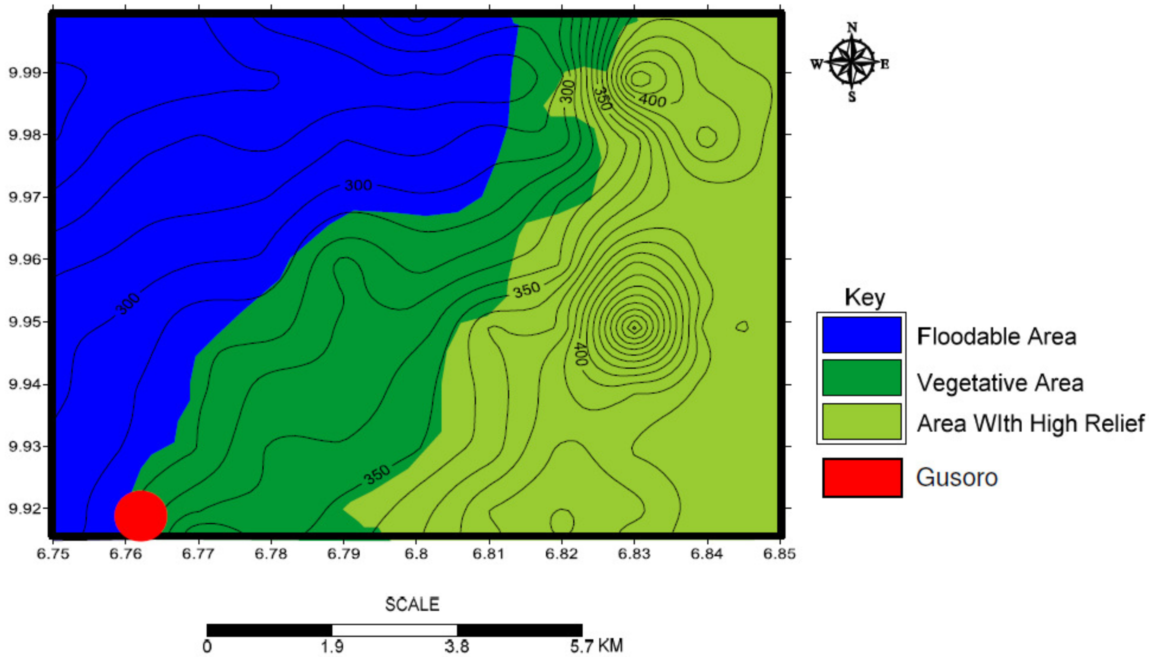

Figure 4: Flood Risk map of the Study Area
Source: Vineyard Geological Company (2013)

Seasonal Variability

The monthly rainfalls have been computed to obtain the seasonal variability of the flow pattern on the dam. Figure 5 indicates that the highest rainfall occurs in September and the minimum average discharge occurs in the month of April.

The table values have been used to develop the flood map shown in figure.5.

At first, there is a striking resemblance to the seasonal rainfall induced. The highest peak, which range from 371mm to 310mm, corresponds to the flood generated during the wet season experienced between May and October. The shorter peak corresponds to the flood period, which occurs between October and April the following year.

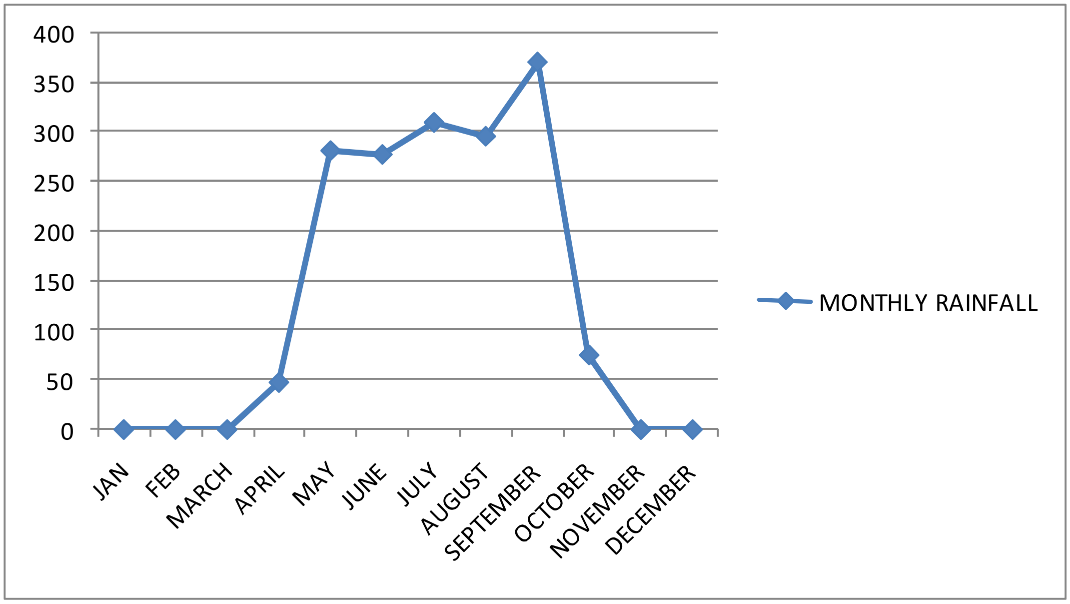

Figure 5: Monthly Rainfall Chart
Source: Shiroro Hydroelectric Power Station (2013)

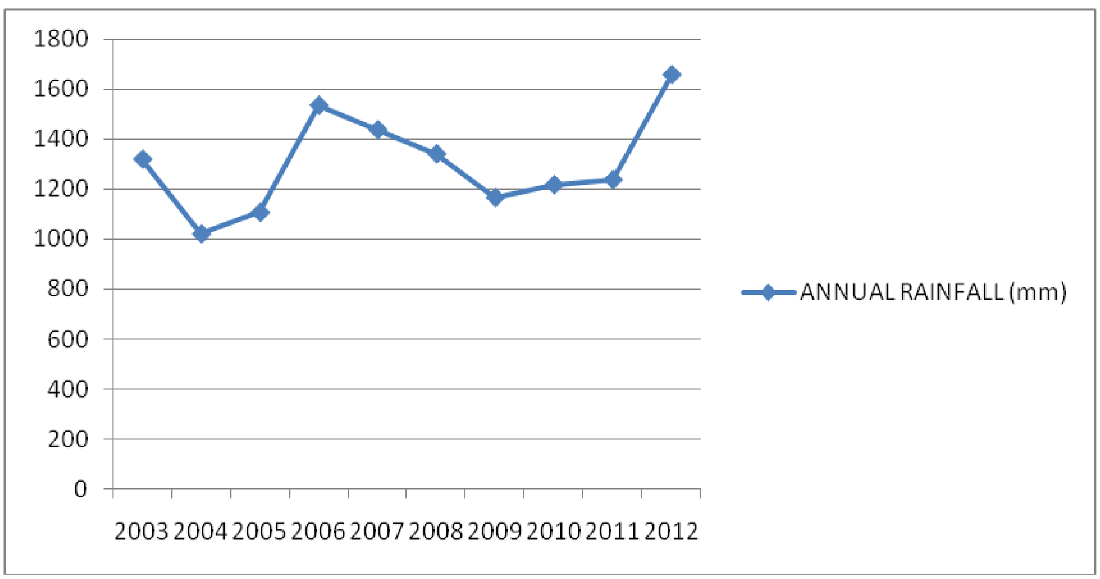

Figure 6: The Annual Rainfall Pattern in the Study Area
Source: Shiroro Hydroelectric Power Station (2013)

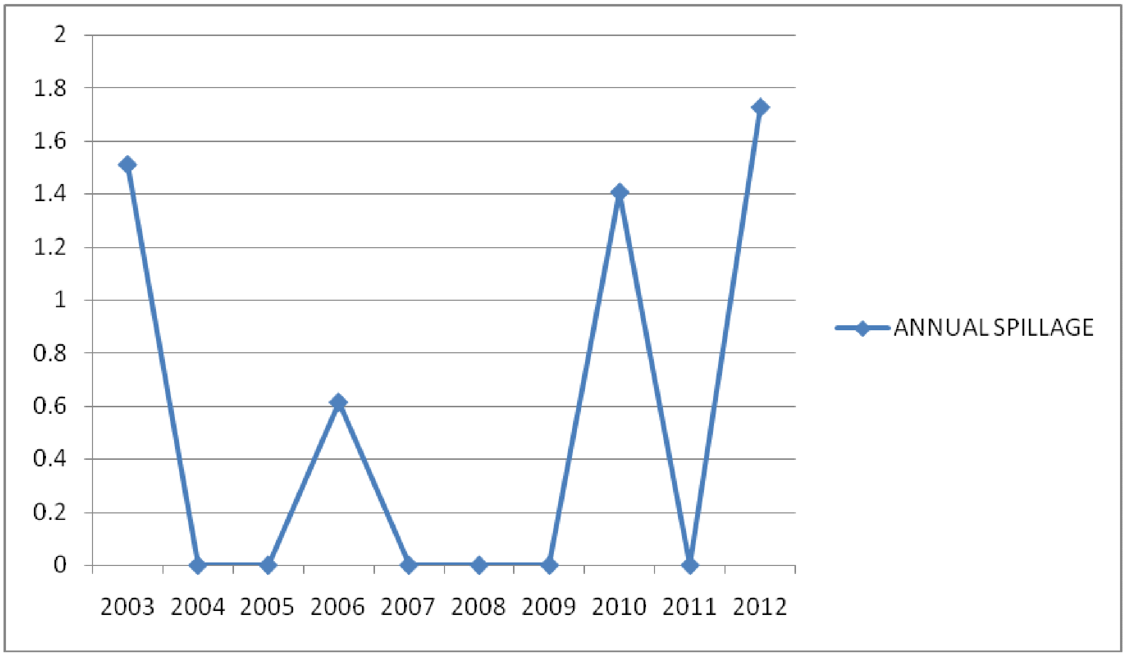

Figure 7: The Annual Spillage in the Study Area
Source: Shiroro Hydroelectric Power Station (2013)

TABLE 1: Annual Spillage

YEAR	TOTAL
2003	1.5091
2004	0
2005	0
2006	0.6138
2007	0
2008	0
2009	0
2010	1.4055
2011	0
2012	1.7251

Source: Shiroro Hydroelectric Power Station (2013).

As a result of the distinctive demarcation between the wet and dry seasons in the region as indicated by the rainfall regime, Shiroro flow also varies accordingly. The resultant effect is that the dam is characterized with high annual rainfall of 1659.7mm recorded in 2012. About 60% of the total annual discharge is received at Gusoro, Gurmana and other neighboring communities in Niger state during the flood season of July to September and the remainder is distributed over the rest of the year.

Figure 8 shows the relief map of the study area, and figure 9 shows the contour map of the area, indicating the nature of the terrain including the relief map.

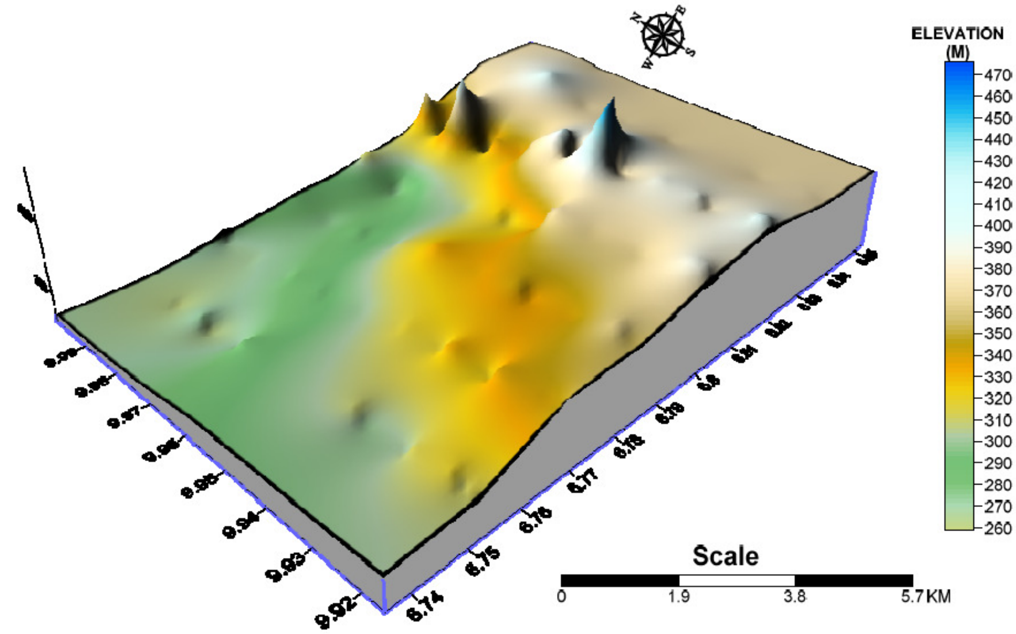

Figure 8: Relief map of the study area
Source: Vineyard Geological Company (2015)

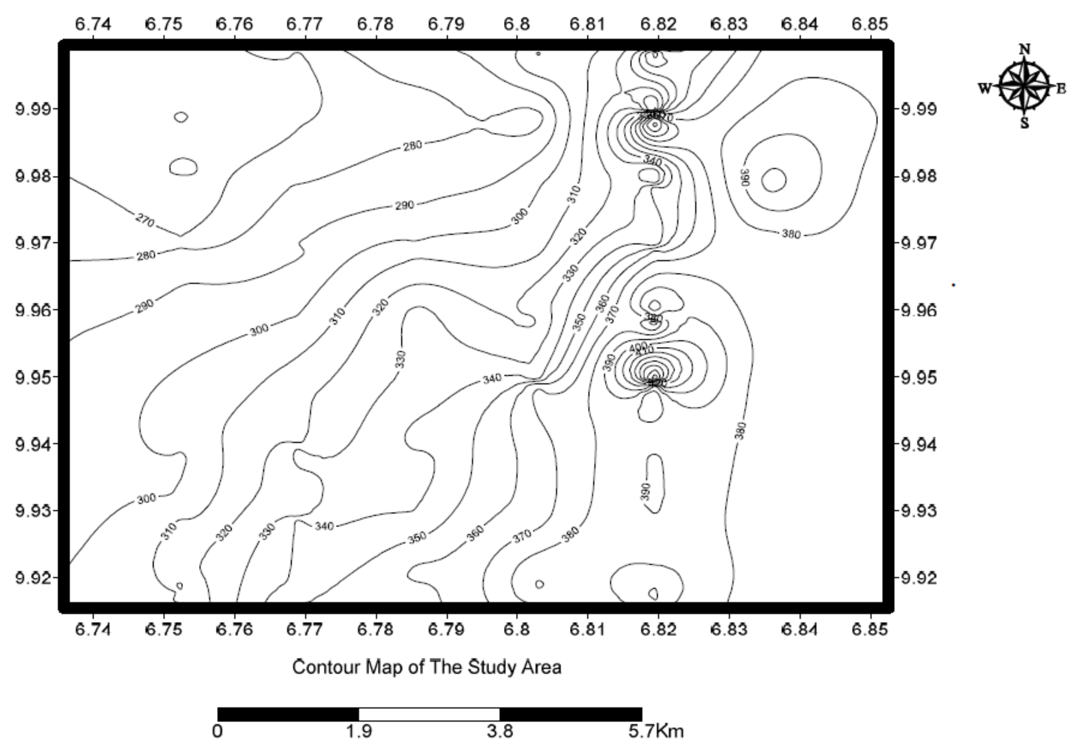

Figure 9: Contour map of the Study Area
Source: Vineyard Geological Company (2015)

During the research, it was observed that high amount of rainfall and human activities are the major contributor to floodingat the downstream of the dam.
Because of the difference in the wet and dry season in the region as shown by the rainfall figure 5, Shiroro flow also varies accordingly. The effect is that the dam is characterized with high annual rainfall of about 1659.7mm recorded in 2012 figure. 6 About 60% of the total annual discharge is received at Gusoro, Gurmana and other neighboring communities in Niger state during the wet season of April to October as indicated by figure. 5 and the remainder is distributed over the rest of the year.

Flood Frequency Analysis

As a result of this research, table 4.1 show the estimation of the annual spillage which was as a result of excessive rainfall received from the month of April to October in the year 2012.

There, the flooding recorded during this period was a result of excessive rainfall. From this research it is obvious that the past records can be used in representation of the future, meaning that the flow records of the precipitation distribution and rainfall will be used in modeling to produce flow distribution.

The ability to look days into future to see how many city blocks and roads might be flooded is becoming clearer with flood mapping. The National Oceanic and Atmospheric Administration (NOAA), National Weather Services (NWS) and National Ocean Service (NOS) Coastal services Center (CSC) are collaborating with the federal Emergency Agency (FEMA) and other partners, to develop inundation maps for inland fresh water flooding. Libraries are been developed which include map layers depicting the spatial extent and the depth of water for various flood levels ranging from minor flooding all the way through the flood of record in the vicinity of NWS river forecast location. These new flood hazard graphics will help emergency managers and impacted citizens are better prepared to making important decisions regarding evacuation, moving property and other mitigation efforts.

Combined with traditional NWS river forecast and flood bulletin information, these new flood maps show the area of likely inundation based on current conditions and future rainfall. Maps are produced using GIS and data based created in production of FEMA's Food Insurance Rate Maps.

These libraries are accessible via the Advanced Hydrological Prediction Service (AHPS) web portal, the NWS engine that host its vital river and flood forecast information. The national flood insurance program (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community flood plain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of CRS.

- Reduce flood losses
- Facilitate accurate insurance rating
- Promote the awareness of flood insurance.

Impact of Shiroro Dam on Gusoro Community

Resources and optimizes power supply of other generating options (thermal and variable renewable). It also have positive social cost such as creating opportunities for capacity building by local/indigenous governments, companies and individuals, often provides flood protection, may enhance navigation conditions, often enhances accessibility of the territory and its resources (access roads, ramps and bridges), provides opportunities for construction and operation with high percentage of local manpower, may improve living conditions, through sustained livelihoods, (freshwater, electricity and food supply). The positive environmental implications may also include: production of no atmospheric pollutants and only very few Green House Gases (GHGs) emission, enhances air quality, produces no waste, and avoids depleting non renewable fuel resources (coal, gas and oil). It can also create new freshwater ecosystem with increased productivity, enhances knowledge and improves management of valued species due to study results, finally it neither consumes nor pollutes the water it uses for electricity generation purposes.

The impacts of hydro-electric dams have been widely studied across the world. For examples, in Costa Rica hydro power dams has led to transformation of free flowing rivers of sarapique into altered system physically and biologically it has devastated 10% of streams length in the watershed upstream and 31km of stream have been devastated, it has increased competition and conflicts over freshwater resources and it has also promoted river conservation.

Conclusion and Recommendations

This research focused on flooding analysis and in particular on the mapping of floodable areas of Gusoro downstream of Shiroro dam. However, the result shows that there is a general increase in Dam, which is characterized with high annual rainfall of about 1659.7mm recorded during this period. About 60% of the total annual discharge is received at Gusoro and other neighboring communities in Niger state during the wet season of April to October as recorded in figure. 4.4.

Remote sensing and Geographic Information System (GIS) technologies provide effective means of studying the flood problem as shown by the Landsat imagery in figure5 It is clear that proper monitoring, using remote sensing will enhance the positive environmental effects and reduce the effect of the negative ones.

Based on the findings of this study the following are therefore recommended.

- Flood control structures or buffer zone should be created in areas of high vulnerability like Gusoro.
- Given to the nature of the flood problem in Niger state; a quantitative methodology is required using very high resolution satellite imagery to estimate the lives at risk due to the flooding at each of the subject communities and comparison of lives at risk with available guideline or criteria of any.

References

Agasa S.J. (2002). The use of Remote sensing and GIS in Assessing the effectiveness of Land Management in Kaduna South. B.Sc. Dissertation Geography Department, ABU, Zaria.

Funke, J. (2007). Effects of flooding to the environment using Remote Sensing Techniques. www.cast-uark.edu/home/.../abstract-and-cited referenced-html

IDNDR (1994). International decade for natural disaster reduction. *Nigeria national report prepared for the IDNDR mid-term review and the 1994 World Conference on Natural Disaster Reduction*, Yokohama, Japan, 23-27 May 1994

Melack, J. and David, K. (2004). Flooding and it effects, Panckula University Press. Haryan State; India.

National Centre for Remote Sensing Jos (2006). Newsletter of the NCRS, Jos.

National Weather Sciences (NWS) National Oceanic and Atmospheric Administration (NOAA) (2008). Flood Inundation Hazard Mitigation Application retrieved from http:www.floodsafety noaa-gov/inundationshtm. on 2nd October 2015

U.S. Geological Survey (2012). Retrieved from http.//pubs.usgs.gov/fs/FS-229-96. On 2ndOctober 2015