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JAEED2022
Hummingbird Publications
Journal of Applied Ecology Env. Design
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Analysis of Flood Risk along Galma Dam in Kubau Local Government Using Geospatial Technique

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Keyword:
Construction professionals, Construction projects delivery, Mean item score, Most critical effects of non-implementation, Public procurement policy, Reforming public procurement processes.

Abstract

Flood is the most common occurring natural disaster that affect humans and their surrounding environment. It regularly claims over 20,000 lives per year and adversely affects around 75 millions people world-wide. Flooding in various parts of Nigeria have displaced millions of people from their homes, polluted water sources, destroy farmland produces and also increase the risk of diseases. This study examined the land inundation of Galma Dam using the Digital elevation model (DEM) to create awareness for future purpose. The work is limited to elevation, slope and land use and land cover (LULC) of the study area. The LULC of the study area, shows that agriculture/farmland covers 86.7% of the study area. The Digital elevation reveals that most of the areas are low land, meaning that this areas will be submerge at the release of much rain or opening of the dam in order to reduce tension on it. As such, it could be seen that agriculture /farmland are the most vulnerable to flood while a little portion of the settlement will be affected since most of it are located upland.

Introduction

Flood is an overflow of water which covered the land surfaces that are normally dry. This includes overflow from water bodies like river, lake, sea, dams and also overflow as a result of heavy rainfall, snow melt and/or dam break resulting in which some of the water escape out of its natural boundaries (Leinster, 2009). Flood is the most common occurring natural disaster that affects humans and their surrounding environment (Leinster, 2009). This natural disaster is common in Nigeria, it has been occurring in almost every raining season. According to Nigerian National Emergency Management Agency (NEMA), in 2012 alone about 1.3 million Nigerians have been displaced and 431 have died from various floods occurrences. In that same year 30 of 36 Nigeria's states were affected by the floods. A lot of physical damages were recorded, including destruction of houses and farmlands. Economic activities were halted, people displaced and some lost their lives. It is understood that flood is a hazard that can be avoided or minimize not only by building more dams or constructing more flood defence systems but also by the use of modern technologies and appropriate urban planning that provide information on flood risk areas (Cinque, *et al.*, 2003).

Flood is the most common environmental hazards. Every year over 20,000 lives and adversely affect around 75million people worldwide, the reason lies in the wide spread geographical distribution of river flood plains and low laying coasts together with the long standing attraction for human settlement (Smith, 2002).

Severe flooding events have become a frequent phenomenon facing communities and authorities in Nigeria each year, for example in 2010 and 2011 extreme flood events resulted in devastation and economic damages worth millions of dollars in the affected urban cities such as Lagos, Kano and Ibadan and rural settlements communities in Sokoto and Kebbi State. In 2010 more than 270,000 people were affected in states like Sokoto, Kebbi, Lagos and Bayelsa as the most affected states. Flood hazard is a major problem of the world these days; however with the help of flood risk analysis, the effect of flood can be streamline, therefore, there is a need to obtain information about the areas that are vulnerable to flood

Ejenma, *et al*. (2014) used GIS techniques to produce flood probability map and landuse/landcover pattern information of part of Lagos Eastern region, this was used to estimate flood risk and probable peak discharge of the different landuse/landcover classes. The study integrated these information into a GIS decision support system to provide a detailed flood pre-disaster and lead time geo-information services within the city.

More emphasis is placed on the relevance and suitability of Geo-information techniques in flood risk assessment as shown in Ogwuche and Abah (2014) work, in which remotely sensed data have been utilized; focusing on the risk vulnerability of residential areas in parts of Makurdi floodplain, Benue State, Nigeria. The data were processed to produce a topographic map and digital elevation model. The study carried out overlay operation to produce the level of flood risk vulnerability for the residential areas as well as the catchment areas. The result showed that the highest catchment area of 22.01% fell within the moderate risk zone affecting Gaadi, Wurukum and Logo while the least of 4.15% was for the low risk zone affecting part of Lobi.

Flood Mapping is a vital component for appropriate land use planning in flood-prone areas. It creates easily-read, rapidly-accessible charts and maps which facilitate the identification of areas at risk of flooding and also helps priorities mitigation and response efforts. Flood maps are designed to increase awareness of the likelihood of flooding among the public, local authorities and other organizations.

This study focused on the assessment of flood prone areas of Galma dam. It utilizes DEM data (ASTER DEM), Landsat 7satellite imagery and administrative map of the study area for the period of eighteen years (2000-2018), two different satellite images; 2000 and 2018 (Landsat imagery).

CAUSES OF FLOOD

(i) Climate

According to Manuta and Lebel (2005), climate change compounds the existing challenges of managing floods. Firstly, the anticipated sea level rises could have a major impact on flood risks in the coastal cities. Secondly, but less certainly, increases in the frequency or intensity of extreme precipitation events exacerbate risks of disastrous flooding in parts of the world. Thirdly, climate change may alter flood regimes in some basins in other more complex ways, for example, through impacts on melting of glaciers in the uppermost reaches or reduced precipitation in inland continental areas.

Bariweni *et al.,* (2012) documented that climate change causes flooding because when the climate is warmer it results to: heavy rains, sea level will continue to rise around most shorelines and extreme sea levels will be experienced more frequently including storm surges. Snoussi *et al.,* (2008) said that it has been recognized that climate change and sea level rise will impact seriously upon the natural environment and human society in the coastal zones. In Morocco, for example, the coastal zone forms one of the main socio-economic areas of the country with more than 60% of the population inhabiting the coastal cities as well as incorporating 90% of the industry, making them more susceptible to flooding

Other causes of flooding include; (2) Heavy rainfall (3) Release of water from dams eg. Lagdo Dam in 2012 (4) Human factors (5) Topography and Geology

Types of floods

Floods can occur anywhere in the world at any time and they are one of the most common weather hazards in the world. Floods can occur within a matter of minutes. Flood effects can be local, impacting a neighbourhood or a community; it can even go beyond single community, affecting entire river basins and multiple areas (NOAA, 2013). There are different classifications of flooding; Flash flood, River flooding, Coastal flooding, Urban flooding, and Areal flooding

Table 2.1: Some case studies on flood mapping in Nigeria

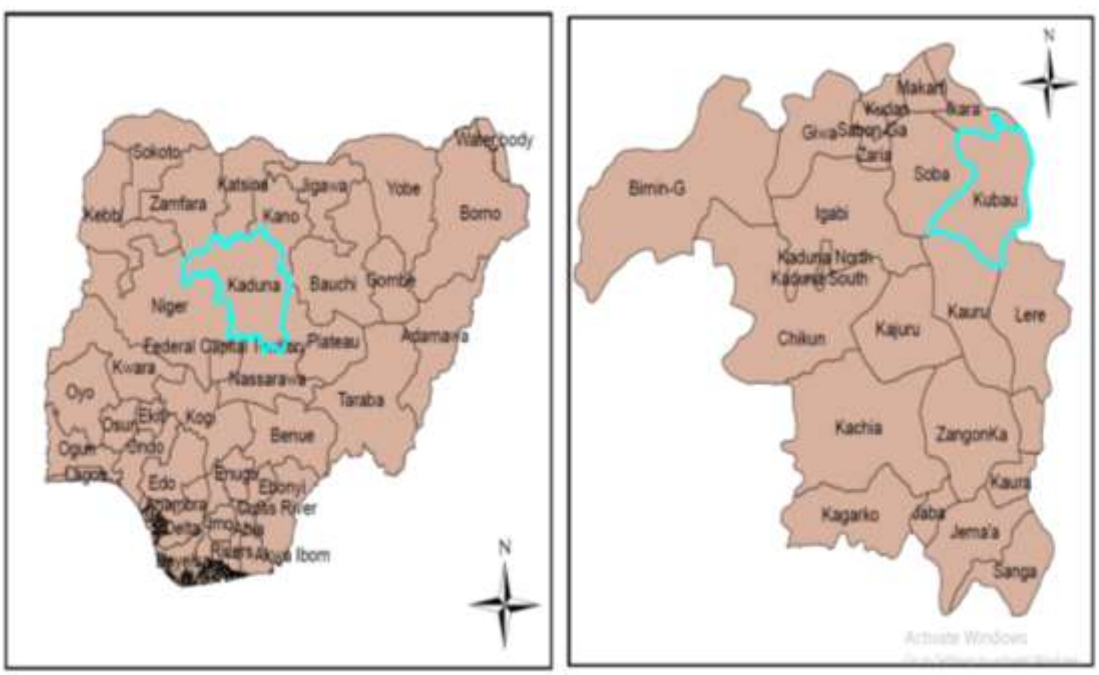
Major Outputs	Methods	Study Area	References
Flood hazard extent	GIS and Remote Sensing	Niger-Benue-Kogi	Ojigi *et al*., (2013)
Flood hazard extent	GIS and Remote Sensing	River Kaduna	Ismail and Saanyol (2013)
Flood hazard extent	GIS and Remote Sensing	Kogi state	Aderoju *et al*., (2014)

Flood vulnerability, probable peak discharge	GIS and Remote Sensing	Lagos	Adeaga (2009)
Inundation model	Remote sensing and GIS, digital elevation model (DEM), flood discharge	Kaduna metropolis	Jeb and Aggarwal (2008)
Flood risks zone	GIS and Remote Sensing	Markudi	Abah (2013)
River discharge for each climate change scenarios	Hydrological modelling	River Kaduna	Haruna *et al.*,(2013)
Flood Inundation Analysis	Remote sensing and Digital elevation model	Birnin Kebbi	Nanoh *et al.*, (2014)

Source: (Nanoh *et al.*, 2014; Akintola *et al*., 2015)

Study Area

The study area is situated in Kubau local government area, Kaduna state, Nigeria. It geographical coordinates lies between latitudes 10°48’ 45” to 10°48’ 49”and longitudes 8°23’ 9” to 8°22’ 11”. Galma dam is drained by its numerous tributaries. These tributaries include among others river Baki, Anchau and Danwata. The Galma river catchment area belongs to the north eastern part of Kaduna river basin which borders the Chad basin to the north, The Galma river is one of the main tributaries of River Kaduna. It has its headwaters near the north western edge of the Jos Plateau and falls near the Magami village into Kaduna plains.



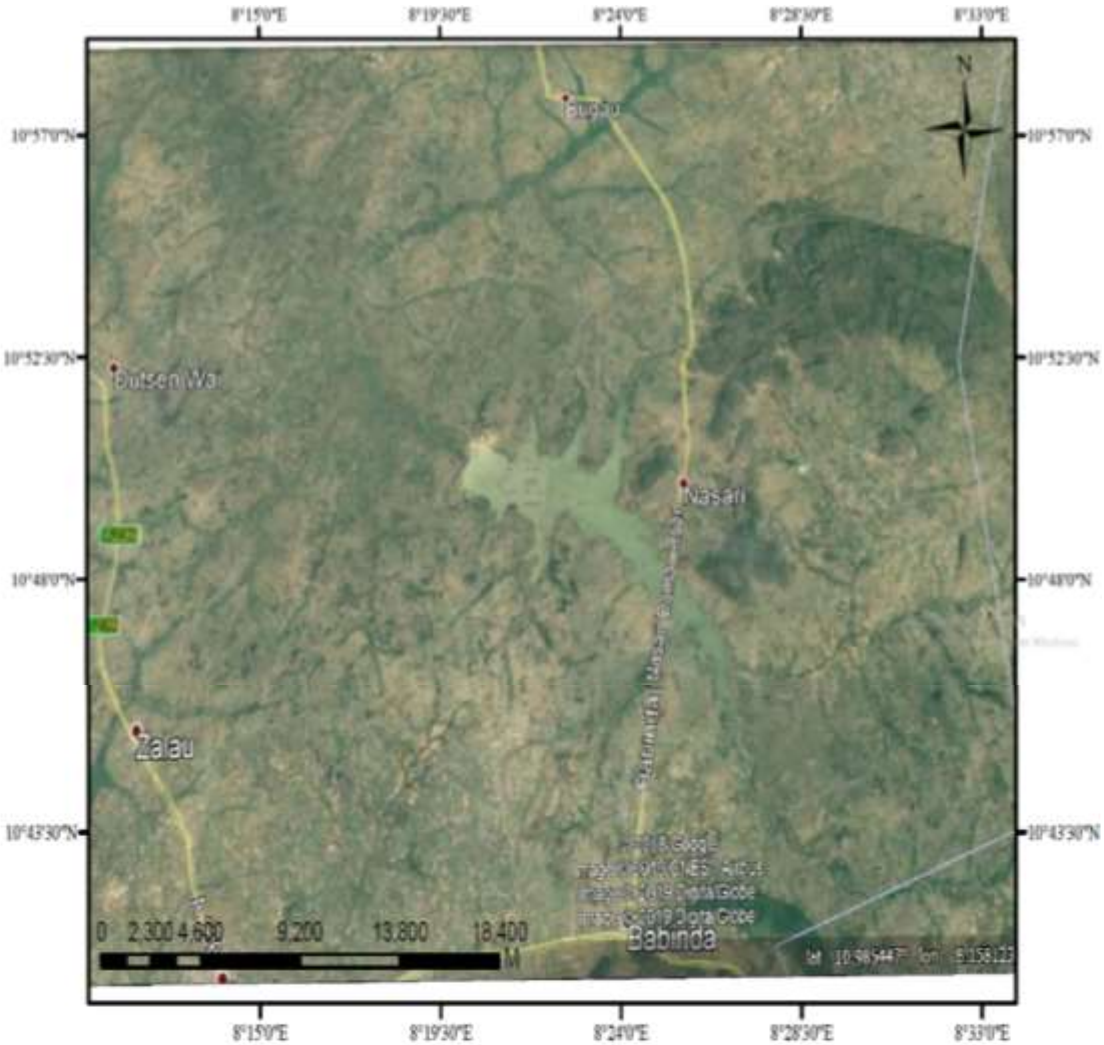


Figure 1.1: Map of the Study Area.

The local Government covers approximately 2505sq km, is bounded by Ikara Local Government to the North, Soba Local Government to the North-west, Kauru LGA to the south-west and Lere LGA to the South-East respectively. It has a typical climate characterized by two distinct seasons that is dry and rainy seasons. The rainy season, like in most parts of the savannah (Sudan), extends from May-September while the dry season covers the period of October to march. There is the cold, dry harmattan which accompanies the North-Eastern winds.

Agriculture flourishes in the LGA with the presence of a large population of farmers occupied both during the dry and wet season.

Methodology

This section discussed the methodology adopted during the data capture and analysis to achieve the aim of the project for the study area.

Datasets and source

The data used in this research was acquired from both primary and secondary sources.

Table 3.1 Summarizes the data type, date, source, resolution and relevance to the study.

S/n	Data type	Source	Date acquired	Resolution	Relevance
1	Landsat 7	United States Geological Survey (USGS)	2017	30x30m	Land use and Land cover classification
2	Aster Dem	United States Geological Survey (USGS)	2018	30m	Generation of slope and elevation layer
3	Google Earth Pro	www.googleearth.com	2018	296m	Imagery of the study area
4	Literature from journals, reports etc	Online sources and Geomatics Dept Library, ABU-Zaria	Varied period	………..	Used for literature review

3.2.1 **Software used**

The following software were used in this study;

i ArcGIS 10.5 - to produce and integrate the thematic maps for analysis

ii Erdas imagine 2014 was used for land use and land cover classification

iii ENVI 5.1 was used for gap filling of Landsat imagery with scan line error

iv Microsoft word 2007

v Snipping tool

RESULTS AND DISCUSSION

Factors Contributing To Flooding In the Study Area

Land use and land cover

The land use and land cover of the study area was acquired from the satellite imagery downloaded from United State Geological Survey (USGS). The classes used were water body, bare land, vegetation and built-up area (is shown in figure 4.1).

The land use land cover of the study area shows that vegetation covers most of the area accounting for 86.7% while water body, bare land and built-up accounted for 7.6%, 0.9%, and 4.7% respectively

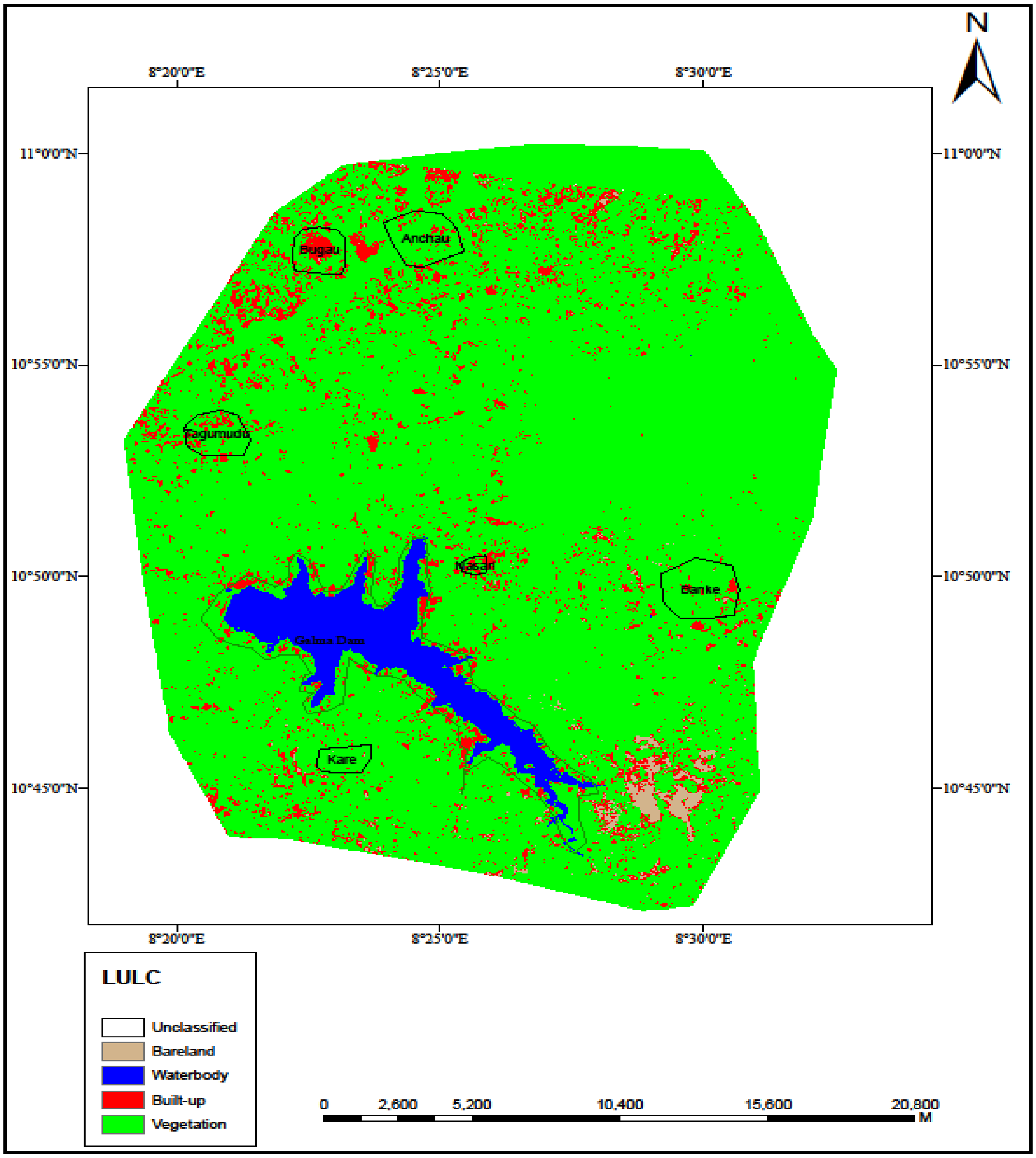


Figure 4.1: Land use and Land cover of the Study Area.

Table 4.1: Element at risk

LULC	Area in Ha	%
Bare land	593.73	0.9
Water body	3046.77	4.8
Built-up	4881.15	7.6
Vegetation	55672.4	86.7
Total	64194.05	100.00

Elevation

The elevation of the study area was obtained from the DEM of the study area which was downloaded from USGS (United State Geological Survey) with a 30m resolution. The DEM shows that the elevation of the study area ranges from 643 to 985 meters. From the map (Fig 4.2) it can be concluded that the area is dominated by low lands.

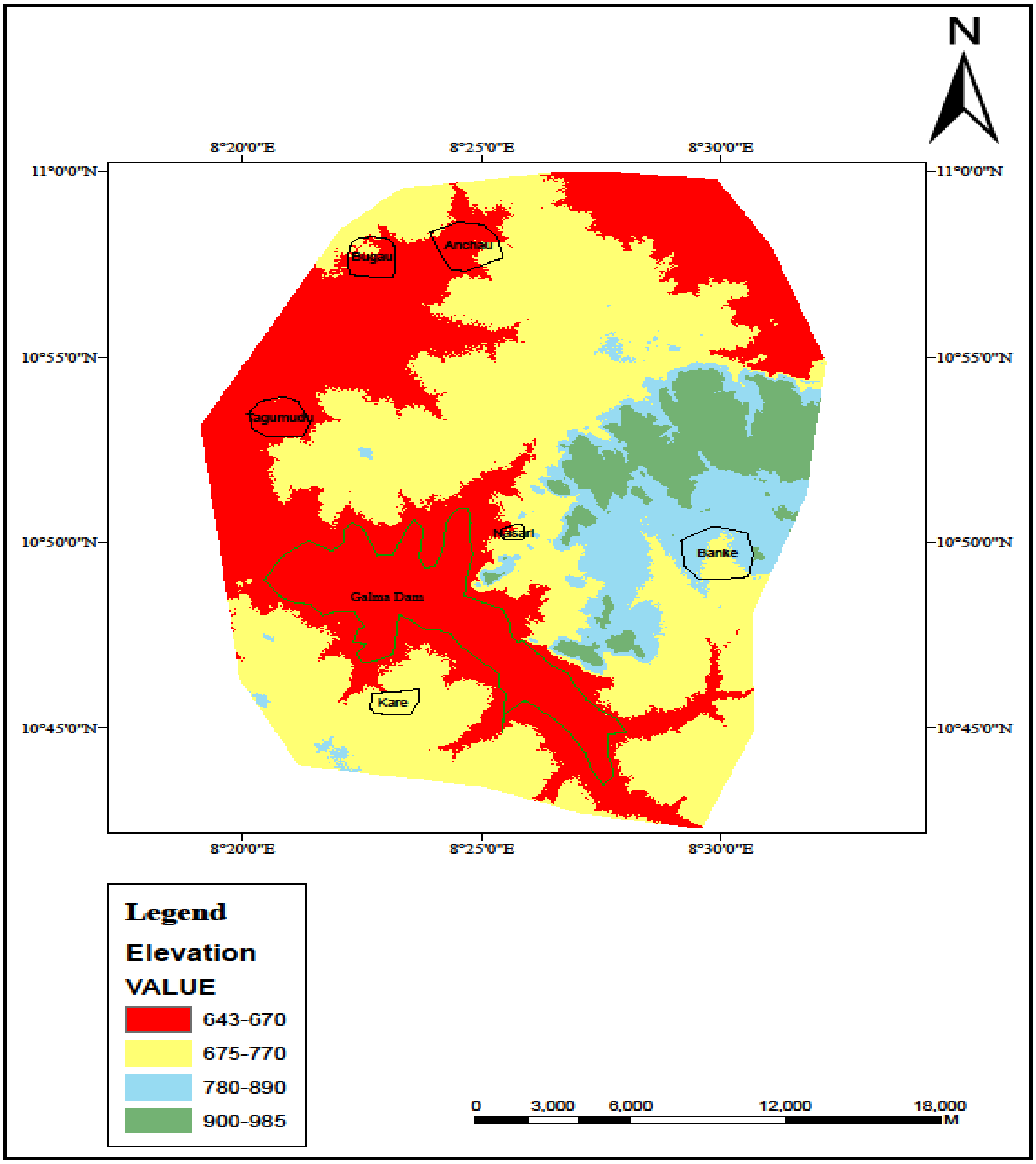


Figure 4.2: Elevation of the Study Area.

SLOPE

The slope of this study was generated from Aster DEM of the study area. From the map (Figure 4.3), shows that the slope of the study area ranges from 0 to 9.2 degrees and it can be seen that the area is dominated by low slopes ranging from 0 to 1.5.

Therefore, it can be stated that flat areas where the slope amount is low are capable of holding water which can be a major factor of flood while in elevated areas where the slope amount is high, there will be run off of water.

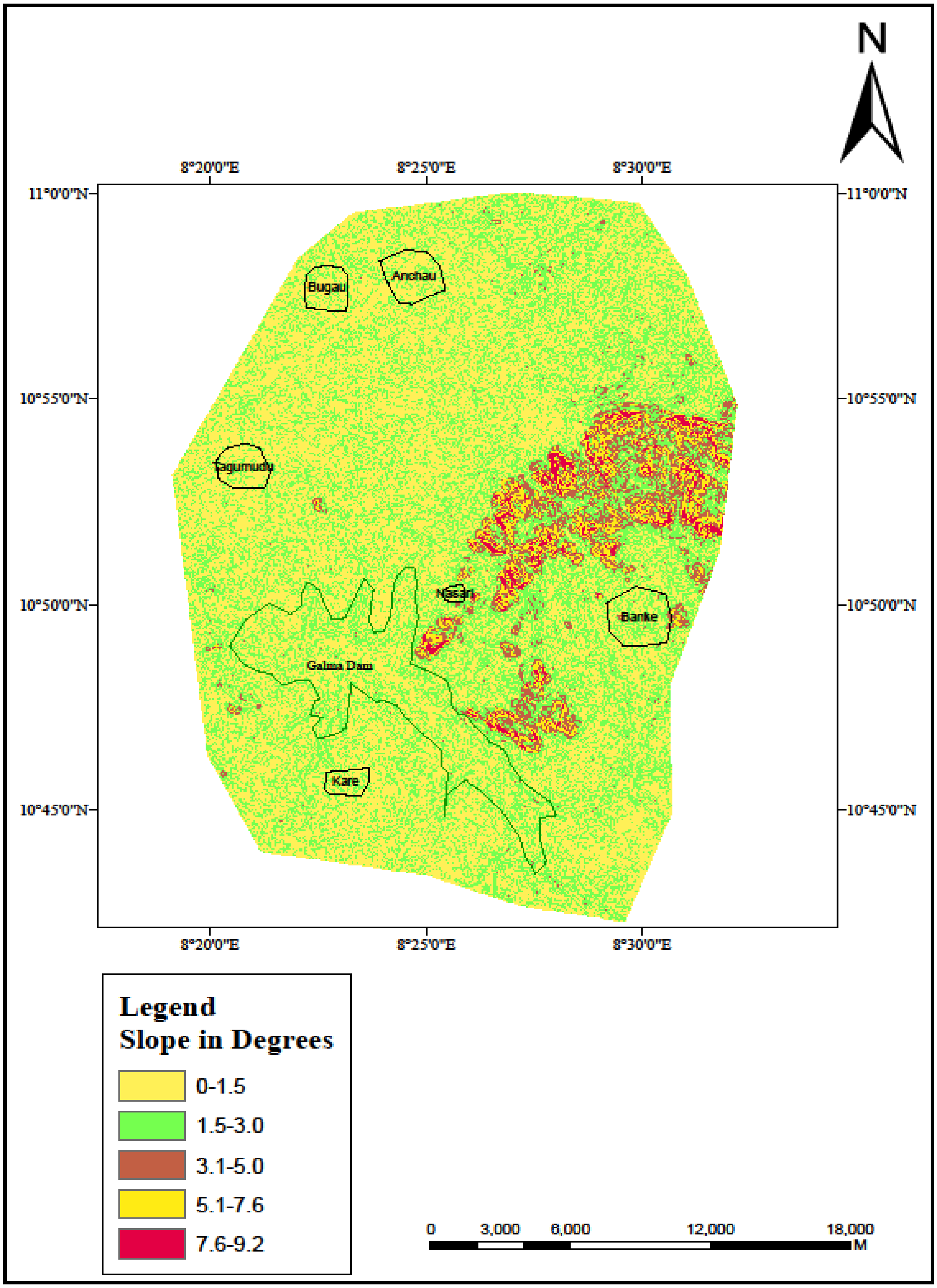


Figure 4.3: Slope of the Study Area.

Area That Are Vulnerable to Flooding

Weight for elevation

This section is divided into two part. The first part shows the results of the pair-wise comparison carried out for the three dataset and the weight computed based on satyr's fundamental scale of pair-wise comparison (Table 3.2). The second part shows the result of the pair wise comparison carried for the three factors contributing to flooding. The manual computation was done in excel to obtain the pair wise comparison for the factors.

Table 4.2: Weight for Elevation

	643-670	675-770	780-890	900-985	Weight	Vulnerability
643-670	1	2	5	7	0.52	High
675-770	1/2	1	3	1/4	0.18	Low
780-890	1/5	1/3	1	1	0.09	Very low
900-985	1/7	4	1	1	0.21	Moderate

Consistence Ratio= 0.09

Weight for slope

The pair-wise comparison and weight for slope angle was generated based on the fact that the flatter the topography (low slope angle), the greater the chances of water accumulation on the surface.

Table 4.3: Weight for Slope

Slope (Degrees)	0-1.5	1.5-3.0	3.1-5.0	5.1-7.6	7.6-9.2	Weight	Vulnerability
0-1.5	1	3	5	7	9	0.47	Very High
1.5-3.0	1/3	1	4	1	5	0.19	High
3.1-5.0	1/5	1/4	1	1/6	1/2	0.10	Very low
5.1-7.6	1/7	1	6	1	1/8	0.13	Low
7.6-9.2	1/9	1/5	2	8	1	0.14	Moderate

Consistence Ratio= 0.07

WEIGHT FOR LAND USE/ LAND COVER

The pair-wise comparison scale for land use and land cover was carried for the four classes generated in Erdas imagine.

Table 4.4: Weight for Land use/ Land cover

	Bare land	Built-up	Waterbody	Vegetation	Weight	Vulnerability
Bare land	1	5	4	7	0.60	Very Poor
Built-up	1/5	1	1/2	3	0.14	Moderate
Waterbody	1/4	2	1	3	0.19	Poor

Vegetation	1/7	1/3	1/3	1	0.06	Very good

Consistence Ratio= 0.03

Weight for overlay

This part presents the result of the pair wise comparison carried out for the three factors contributing to flood based on saaty's fundamental scale of pair-wise comparison (is shown in table 3.2).

Table 4.5: Weight for overlay

	Elevation	Slope	LULC	Weight	Vulnerability
Elevation	1	3	7	0.62	High
Slope	1/3	1	1/5	0.12	Low
LULC	1/7	5	1	0.25	Moderate

Consistence Ratio= 0.06

The weights generated show that elevation with 62 as its weight has the greatest impact on flood occurrences in the study area.

Element at Risk In The Study Area

The digitize satellite imagery of the study area overlaid on the vulnerability zones (shown in Figure 4.4). Element that are high risk are shown in red colour while those at moderate and low risk are shown in yellow and blue colour respectively.

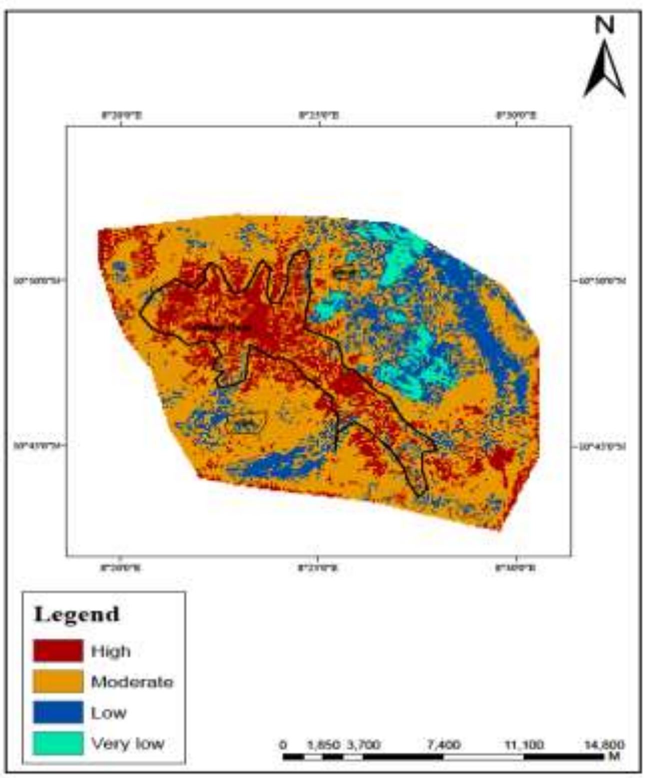


Figure 4.4: Flood vulnerability Map.

Conclusion

Remote sensing and GIS is an efficient tool for flood mapping and suitability analysis and can be useful for emergency response and disaster preparedness. Based on the result of this case study, it can be concluded that geospatial technology provides the best potential to analyse and provide results required for prompt and effective decision making on flood. The study has raised awareness on areas that are vulnerable to flood and their magnitude.

Farmland/agriculture accounted for most of the areas liable to flood with small portion of settlement encroaching into the flood prone areas.

Recommendations

The study concludes by proffering a number of recommendations aimed at addressing issues on flooding

i. Encroachment of built-up into the flood prone areas should be monitored
ii. Farmers should avoid planting their crops close to the water area in order to prevent loss of lives and farm produce.
iii. Constantly monitor the risk of flooding or find a means of measuring or checking water levels of rivers, streams and dams.
iv. In order to reduce the risk of flood, government should provide adequate funding for disaster management bodies and agencies to enable them perform and execute their duties effectively and efficiently.
v. Government/citizen should construct drains and ditches or embankments to protect buildings construction utilities.

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