

Original Research Article

FLOOD RISK ASSESMENT OF ZARIA METROPOLIS AND ENVIRONS: A GIS APPROACH

Abstract

Zaria is a Nigerian City constantly threatened by floods due to its low-lying nature and numerous streams. Remote sensing and GIS data were reclassified and weighted using Ahp-multi criteria evaluation technique. A spatial model constructed by combining spatial data from slope, elevation drainage distance and wetness information was able to identify and delineate areas of low to high flood risk. This resulting flood risk map reveals the central and north eastern part of the study area as the highest flood risk zones, while the southwestern part of the study area has the lowest flood risk factor. Also, areas delineated as having very low flood risk account for 28.3% of the study area and covers some 86.88km². Areas delineated as having low flood risk accounted for 29.5 % of the study area and covers 90.56km². Areas depicted as having high flood risk accounted for about 32.1% covering some 98.545km². Areas depicted as having very high flood risk accounted for 10% of the study area and covers an area extent of 31.007 km². Future infrastructural development must be guided by technical reports forecasting high risk, flood prone areas.

Keywords: *Zaria, floods, spatial model, risk, development*

Introduction:

The world have experienced an increasing impact of disaster in the past decade. Many regions are exposed to natural hazards with unique characteristics. In Tropical Africa, one of the most common hazard is flooding, due to the severe impact of climate change. Flooding represents a severe human hazard (Marriott and Alexandar 1999). And are among the most recurring and devastating natural hazards impacting human lives and causing severe damage throughout the world (Khan *et al.*, 2011). Majority of floods are harmful to human settlements and yearly flooding on average victimize 20,000 lives and affect 75 million people (Coburn 1994). It is understood that flood risk will not subside in the future and with the onset of climate change, flood intensity and frequency will threaten many regions of the

world (Jonkman and Dawson 2012). The Intense rainfall is the key factor influence on floods, however, some other factors like geomorphological features, siltation, and land use pattern contribute to create floods. Flood impact is more pronounce in low lying areas due to rapid growth in population, poor governance, decaying infrastructure and lack of proper planning and management (Odufuwa *et al.*, 2012). For years, flood management studies have been expensive and unwieldy, with much of the analysis performed by hand using papers. Recently, the advancement in computer aided technology has been extensively used in formulating models used for flood calculation and hazard analysis (Duan *et al.*, 2009). Use of GIS, GPS and Remote Sensing are helping flood managers to create accurate flood hazard maps with improved efficiency and speed at reasonable cost. The main advantage of using GIS for flood analysis is that it does not only generate visualization for flooding but also creates a potential to further analyze these events to estimate the probable damage due to flood (Ouma and Tateishi 2014). Flooding in most Nigerian cities is a major environmental challenge that has continued to defy solution as more people are rendered vulnerable to hazards involved (Odufuwa *et al.*, 2012). In 2012, Nigeria experienced an unprecedented flood that affected about twenty seven states, killed three thousand people and displaced about two million from their home. Though zaria was not affected that much Zaria have often experienced small scale flooding. The probability of Zaria experiencing large scale flood is high due to the low lying nature of the terrain, present of large river and changing weather patterns due to climate change. Because of this threat cause by flooding it is necessary to identify potential areas likely to be affected by floods. Identification of such areas will aid in proper decision making enabling government authorities to reduce the effect of flood in this strategic Nigerian city.

Location:

The study area is located on the Crystalline Province of northern Nigeria, within the Guinea Savannah belt. It is located on the Federal Surveys 1:50,000 Series Topographical Sheet 102 Zaria SW, between Latitudes $11^{\circ} 02'N$ to $11^{\circ} 10'N$ and Longitudes $7^{\circ} 38'E$ to $7^{\circ} 50'E$ (Fig. 1).

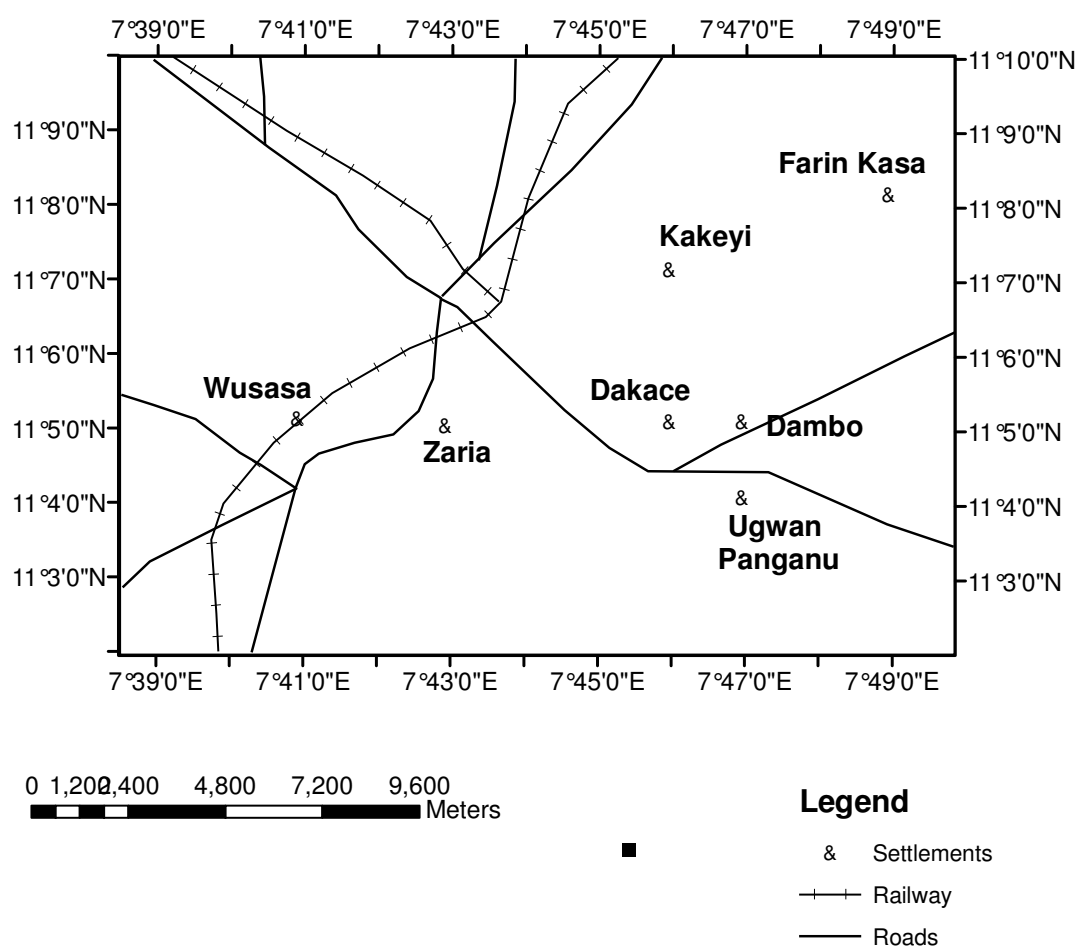


Figure 1: The Location Map of the study area

The topography of the area is generally low. Easy accessibility in the study area was possible by the road linking Zaria to Kano in the northwest, also similar roads in the south and river channels and footpaths that link the villages with the major town. The area is accessible through a major road and several footpaths interconnecting the entire study area. Within the study area, there are numerous footpaths that link settlements.

Methods:

The methodology for identifying flood prone areas with Zaria and environ is presented on Fig. 2. In this study flood risk map was produced with the aid of spatial data such as Digital elevation model and satellite imageries. From digital elevation models, Elevation, slope and drainage data were extracted. From satellite images, wetness information was extracted. Multi criteria evaluation was used to assigned weight to different classes within each spatial data.

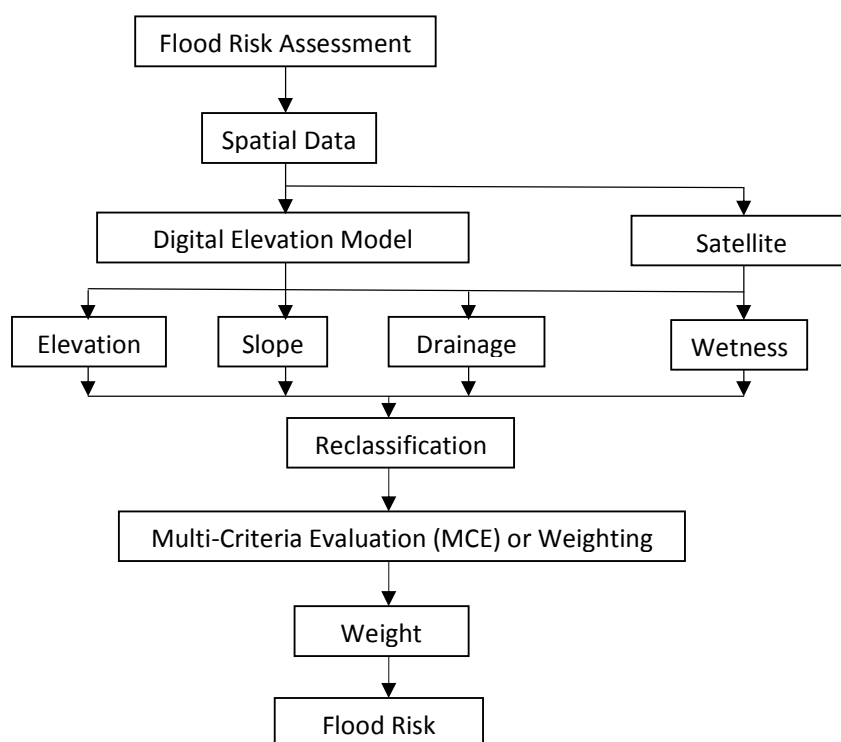


Figure 2: A flow chart of the methodology adopted in the study.

Slope:

The slope of any area, has direct effect on the flood. Flat areas are more prone to flooding than steep areas. Using Arc GIS software, slope data was extracted from digital elevation model followed by reclassification into five classes (Fig. 3). Weighting was then carried out

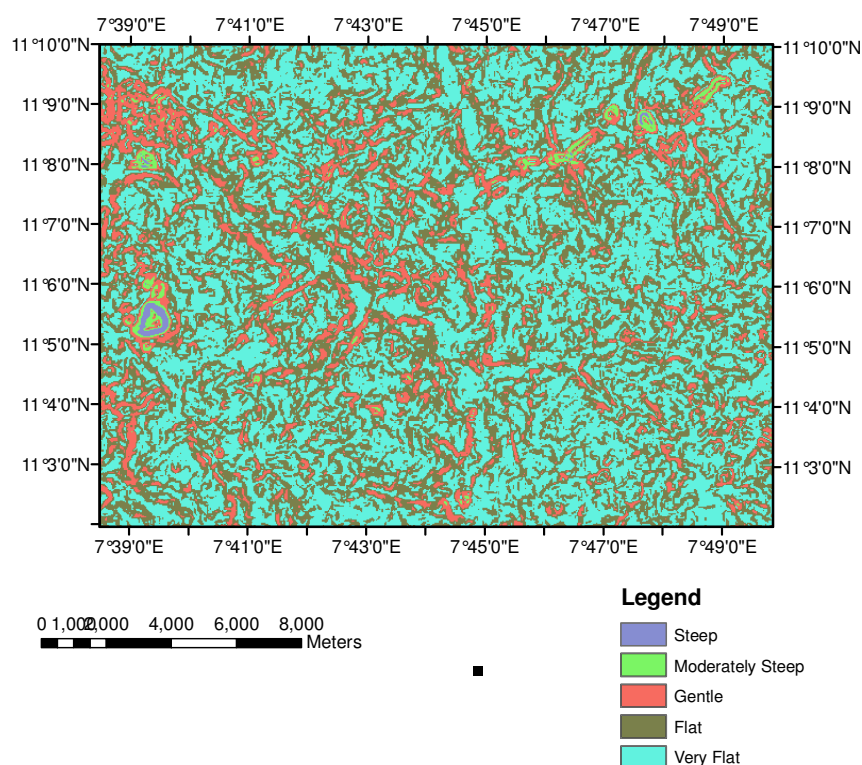
92 using Ahp- Multi Criteria Evaluation (Table 1). Flat areas were given a higher weighting than
93 steep areas.

94 **Table 1 : Weighting for slope within Zaria**

S/N	Slope	Weighting
1	Steep	43
2	Moderate	27
3	Gentle	18
4	Flat	8
5	Very Flat	5

95 Consistency ratio =0.03

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98 **Figure 3: Slope map within the Study area.**

99 **Elevation:**

100 Flooding generally affect low land areas, therefore elevation can be considered as an
101 important determinant of flooding. Elevation data were extracted from digital elevation
102 model (DEM) using Arc GIS software. The classification into four classes of the elevation
103 data was then performed (Fig. 4). Weighting for each class was assigned using Ahp- multi

criteria evaluation. Low lying areas susceptible to flooding were given higher weighting than high lands (Table 2).

Table 2: Weighting for Elevation within the study area

S/N	Elevation	Weighting
1	Extremely High	55
2	High	23
3	Moderately High	14
4	Low	8

Consistency ratio = 0.02

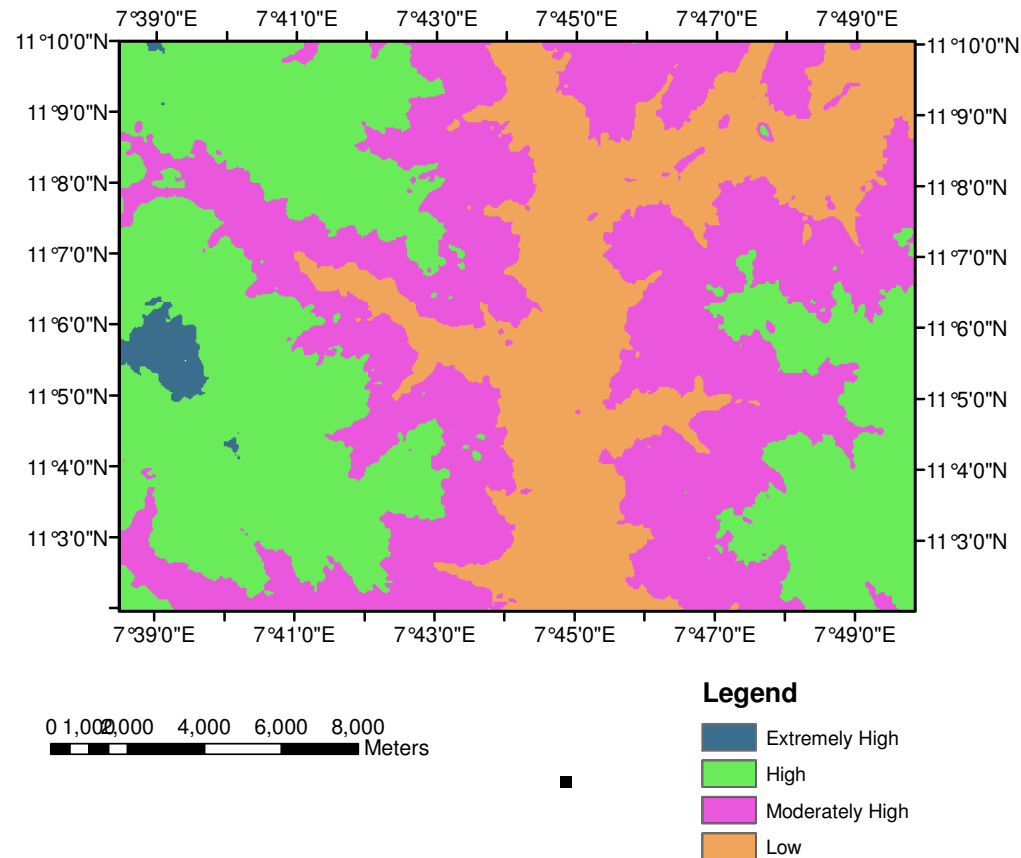


Figure 4: Elevation within the study area

Distance to Drainage:

The distance to drainage is considered as a very important factor when it comes to flood modelling. Areas that are close to drainage will be more prone to flooding than areas further away from drainage. Using the digital elevation model (DEM), drainage was extracted with the aid of software known as GLOBAL MAPPER 17.0 software. The drainage information was exported into Arc GIS where buffering was performed. Reclassification and weighting

was later performed (Fig. 5). Areas closed to the drainage were given higher weighting than areas further away from the drainage (Table 3).

Table 3: Weighting for Distance to drainage

S/N	Buffered Distance	Distance to Drainage	Weighting
1	200	Close	57
2	500	Far	22
3	800	Very Far	14
4	2000	Extremely Far	7

Consistency ratio = 0.04

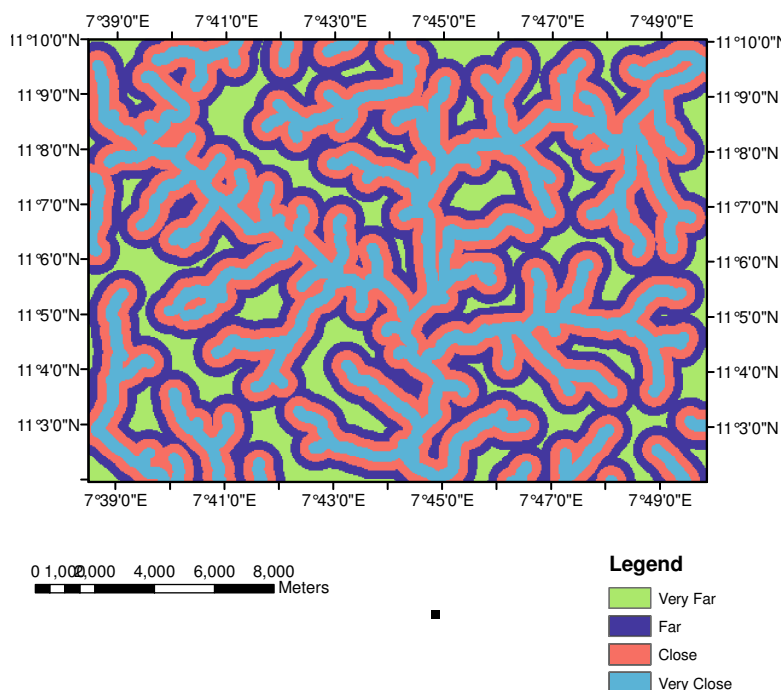


Figure 5: Buffer map for drainage in the study area.

Wetness:

The degree of moisture in flood prone areas is very high due to its ability to retain water for a long period of time. Information on wetness for the study area was acquired by processing Landsat images using Tasseled Cap technique on ENVI 5.0 software. Wetness information was exported to Arc GIS software where classification was performed (Fig. 6). Using Ahp-Multi criteria evaluation technique, areas with higher wetting were given higher weighting than areas with lower wetting (Table 4).

Table 4 : Weighting for Wetness

S/N	Wetness	Weighting
1	Extremely Wet	51
2	Very Wet	22
3	Wet	15
4	Dry	7
5	Very Dry	4

Consistency ratio = 0.02

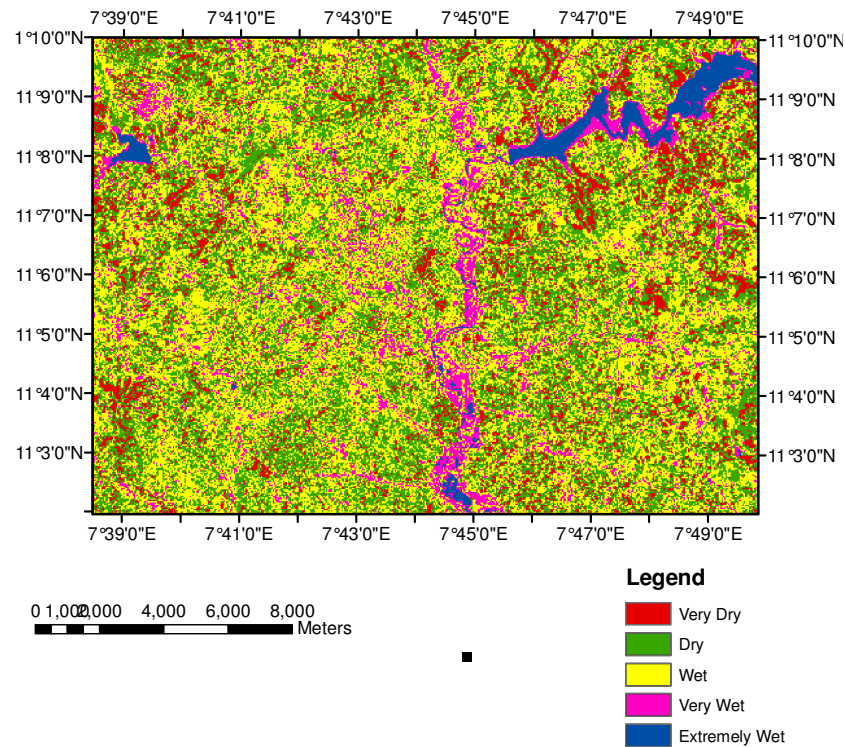


Figure 6: Surface wetness map for study area.

Flood risk map:

After the generation and classification of individual layers related to flood, a flood risk map was eventually produced by combination of slope data, elevation data, Drainage distance data and wetness data using the following formula below. The result of this is the production of a flood map (Fig. 7).

$$\text{Flood risk map} = \text{Slope} + \text{Elevation} + \text{Drainage distance} + \text{Wetness}$$

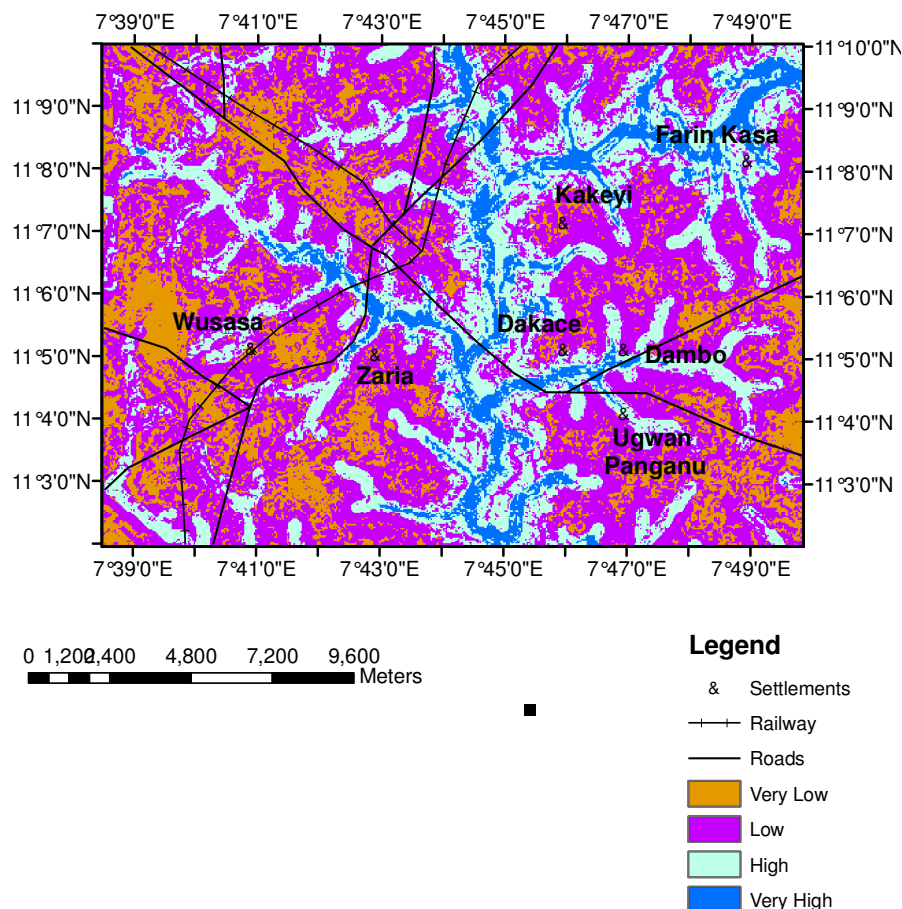


Figure 7: The flood risk map obtained for the study area.

Result and Discussion:

Application of GIS and remote sensing in identifying flood prone areas have produced fascinated results. In order to maintain a high degree of accuracy, the consistency ratio for calculated weight was kept below 0.1. Flood hazard map reveals areas having very low risk of flooding 28.3% of the total area and covers some 86.88 Km². Areas with low flood risk account for 29.5% of the study area and covers an areas extend of 90.565 Km². Areas with high risk accounted for 32.1% of the study area and has an area extend of 98.547 Km². Areas identified as having very high flood risk potential account for 10% of the study area and has an area extend of 31.007 Km². From the flood risk map it is observed that the central and North Eastern part of the study area has the highest risk of experiencing flooding, while the south western part of the study areas has the lowest risk (Fig. 7).

Conclusion:

Application of remote sensing and GIS is effective in identification of flood risky areas within Zaria. Flood risk maps are essential for planning any city and for strategic decision making with regards to mitigating hazards. The risk of flooding within Zaria is more in the central and north eastern part of the study area more commonly along streams. Such areas identified must be properly manage to prevent losses in case of any flood incidents. Also, Future infrastructural development must be guided by technical reports forecasting high risk, flood prone areas.

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