Flood Vulnerability Mapping of Mubi, Nigeria, using Satellite Data

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K**eywords:** Flood, Vulnerability, Settlements, Topographical map, SRTM data

ABSTRACT

One of the many natural calamities that affects people and property is flooding. It causes the loss of lives and property. Due to its topography and the presence of sizable streams, Mubi in Adamawa State, Nigeria, is prone to floods. Various methodologies and materials have been used by many scholars to investigate flood mitigation mapping. This includes ground survey method, Photogrammetry and Remote sensing techniques and social survey method. However, the Mubi region in Nigeria's Adamawa state was not mentioned. This study identifies flood-vulnerable villages in the Mubi North and Mubi South Local Government Areas (LGA) using a Topographical map and the Shuttle Radar Topography Mission (SRTM). Geographic Information System (GIS) approaches were employed to identify locations susceptible to flooding. The SRTM was used to develop an elevation model, while the Topographic map helped locate roads, waterways, and settlements. Using ArcGIS 10.8, the elevation model was applied to analyse streams, roads, and settlements. Based on the level of flood vulnerability, five categories were established. Flood-vulnerable areas were classified as very high, high, moderate, low, and very low. The results indicate that 78% of all settlements in Mubi North are vulnerable to flooding, compared to only 22% in Mubi South. Furthermore, 48% of all settlements are at very high risk, while only 5% are at very low risk. The study will serve as a tool for Town Planners and Engineers to develop appropriate flood mitigation strategies, contributing to the realisation of Sustainable Development Goal (SDG) Target 13.1.3, which involves implementing local disaster risk reduction strategies.

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1. Introduction

One of the many natural calamities that impacts people and properties is flooding. A flood occurs when a body of water overflows and submerges land, breaching levees and allowing some water to flow beyond its normal borders (Barrocu & Eslamian, 2022). In northern Nigeria, numerous communities have experienced floods of various sizes. Because of the seasonal rainfall, the majority of these floods happen once a year. Floods caused by extremely strong rains or rain that lasts for several days frequently cause property damage and fatalities. One typical example of a location that experiences flooding is the Mubi senatorial district in Adamawa state, Nigeria. Numerous studies on mapping and flood control were conducted for the purpose of making decisions; flood maps were made (Bonasia & Lucatello, 2019; Korah & Cobbinah, 2017). To address a particular area's flood problem, researchers presented a number of flood mitigation mapping techniques (Mudashiru et al., 2021; Ahmed et al., 2021). Additionally, studies that identified properties susceptible to flooding were carried out in Yola (Isa & Musa, 2014). Nevertheless, there is not much research on flood mitigation mapping for Mubi, despite the area's ongoing flooding.

In this study, vulnerable locations that are susceptible to flooding are identified using topographical maps and GIS approaches. The STRM data was used to create an elevation model. Roads and settlements were taken from a topographical map. ArcGIS 10.3 was used to analyse the two datasets, and the results indicate that five distinct kinds of locations are extremely vulnerable to flooding. Vulnerability to floods can be classified as very high, high, moderate, low, or very low. The study's findings will be used as a tool for decision-making that can lessen the impact of the flood disaster in the local government regions of Mubi North and Mubi South.

2. Materials and Methods

In order to determine which settlements are vulnerable to floods, the process entails data collection, data preparation, and geographical analysis of the prepared data. Carefully chosen feature data classes produced in the Arc Catalogue were employed in the

analysis. The area's elevation model was created from the STRM image. Areas susceptible to floods were identified using spatial analysis using mathematical approaches, interpolation, classification, union, and intersection of the elevation model and features developed in the Arc GIS environment.

2.1 Study Area

The site of this study was Mubi North and Mubi South LGAs in Adamawa state, Nigeria. This study concentrates on settlements that are within the floodplain of the area. Mubi lies between the latitude 13º 07' 12''N and 13º 28' 26''N and between the longitude 09º 52' 52''E and 10º 23' 49''E. Figure 1 shows the map of the study area.

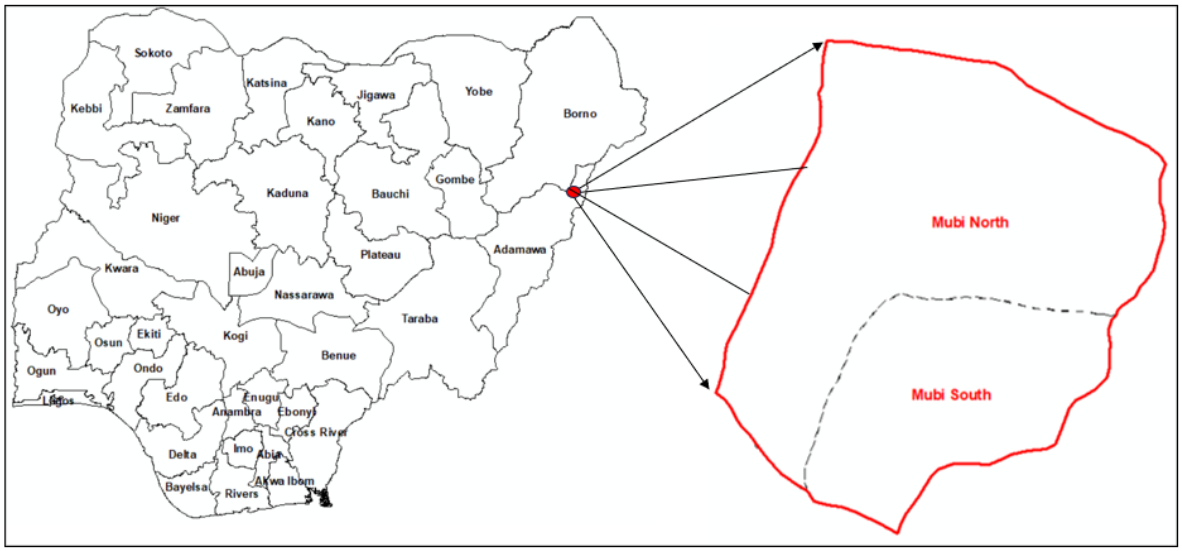

Figure 1: The study area.

2.2 Materials

For this study, two primary sources were employed. (a) elevation data; (b) a topographic map displaying the research area's roads, waterways, and settlements. The SRTM is the elevation data. It gathers the elevation of predetermined sites at 30-meter intervals using radar signals.

2.3 Method.

The Arc catalogue was used to create these features. A Mubi was assigned to the newly established Personal Geodatabase from the flood geodatabase. Three datasets were produced. Roads and streams were linear features, and towns were point features. The chosen projected coordinate system was UTM WGW1984 Zone 33N. Africa's vertical control system, Lagos, 1955. From the topographical map, the road network, waterways, and settlements were located. The SRTM data were used to create the elevation model, which was then divided into five classes: very high, high, moderate, low, and very low flood risk. The lowest area was chosen as the most flood-vulnerable area based on the

calculated SRTM elevation model. To determine which communities are located in the flood plain and at what elevation category, settlements were superimposed on the elevation model.

3. Results

Mubi North has fifty settlements, and Mubi South has fourteen settlements, totalling sixty-four. Figure 2 shows the settlements in both Mubi North and South local government areas.

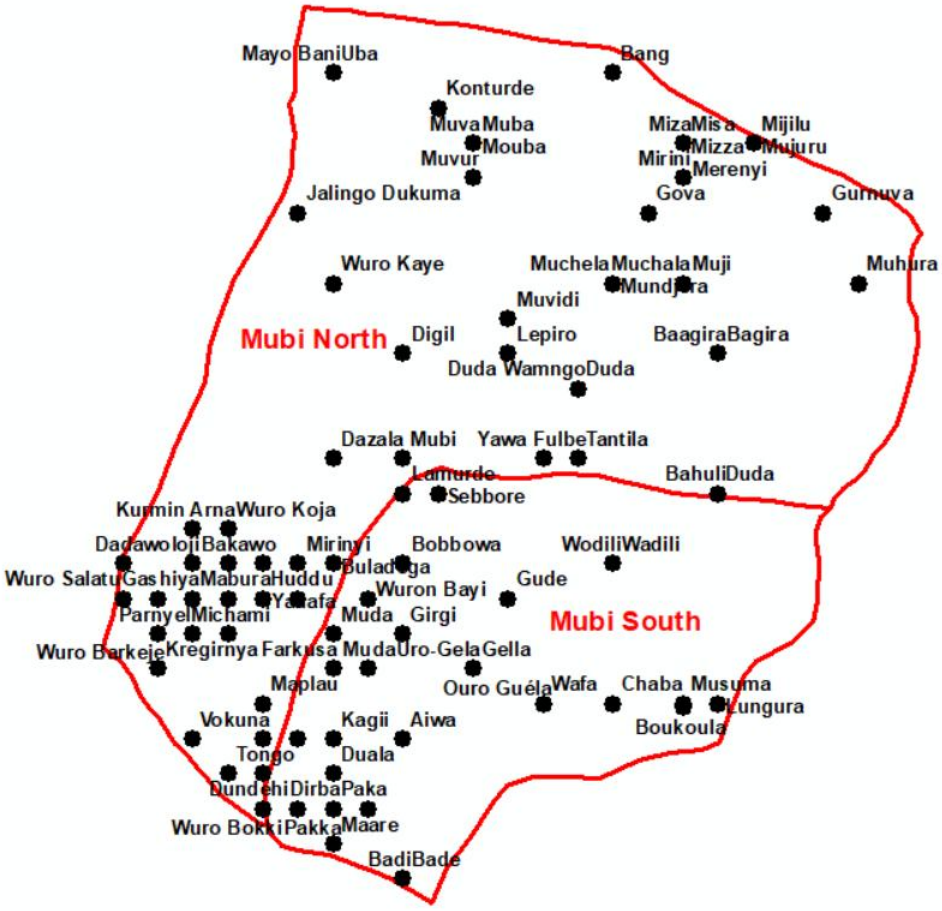

Figure 2. Settlements in Mubi North and South Local Government Areas

The elevation model was classified into five groups at an irregular interval from 116 to 288 meters above the mean sea level (MSL). The classes range from the highest (963m – 1,251m) to the lowest (481 m– 557m). The lowest plain is the very high flood vulnerable area, while the highest plain is the lowest area in terms of flood vulnerability. Figure 3 is the classified STRM.

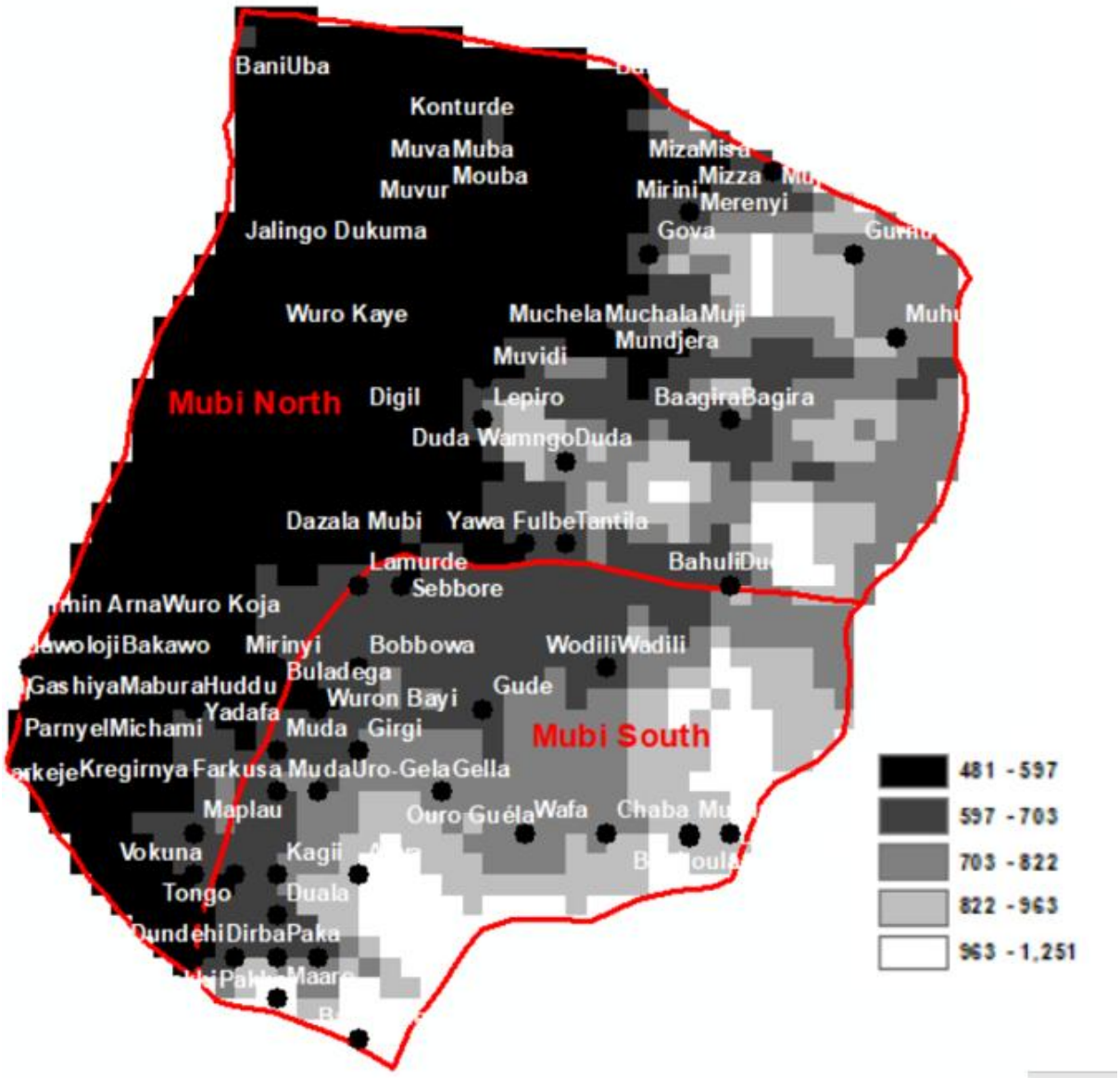

Figure 3. Elevation model of Mubi North and South Local Government Areas

The results indicate that 31 settlements were at a very high risk of flooding, 18 are at a high risk, 8 are moderate, 4 settlements have low risk, while 3 are at a very low risk of flooding. Table 1 presents the settlements that were at risk of flooding in different categories, from very high to very low.

Table 1: Different categories of flood vulnerability

Very High	High	Moderate	Low	Very Low

Settlement	LGA	Settlement	LGA	Settlement	LGA	Settlement	LGA	Settlement	LGA
Bani Uba	MN	Muju	MN	Gurnuva	MN	Duala	MS	Aiwa	MS
Konturde	MN	Mirini	MN	Muhura	MN	Nduku	MS	Maare	MS
Muva muba	MN	Gova	MN	Muji	MN	Boukoula	MS	Badi bade	MS
Jalingo dukuma	MN	Lepiro	MN	Bagira	MN	Musuma	MS		
Wuro kaje	MN	Yawa	MN	Duda wango	MN				
Digil	MN	Fulbe tantila	MN	Wuro gela	MS				
Bang	MN	Bahuli duda	MN	Wafa	MS				
Mizza	MN	Sebore	MN	chaba					
Muchalla	MN	Lamurde	MS						
Mubi central	MN	Wodili	MS						
Sebore	MS	Gude	MS						
Dazala	MN	Wuro babbawo	MN						
Mayo lope	MN	Girgir	MS						
Wuro koja	MN	Muda	MN						
Dada waloji	MN	Bajanle	MN						
Bakawo	MN	Farkusa	MN						
Mojongo	MN	Kwadakin	MN						
Njarengol	MN	Paka	MN						
mirinyi	MN								
gashiya	MN								
Buladega	MN								
Tapare	MN								
Parnyel	MN								
Mugulbu	MN								
Wuro bayi	MN								
Wuro barkeje	MN								
michami	MN								
vokna	MN								
tongo	MN								
Wuro bokki	MN								

MN = Mubi North
MS= Mubi South

4. Discussion

The Mubi area has an undulating terrain ranging from 481 to 1,251 meters above the MSL. It also has multiple streams across the entire area (Figure 4). This makes it more vulnerable to flooding.

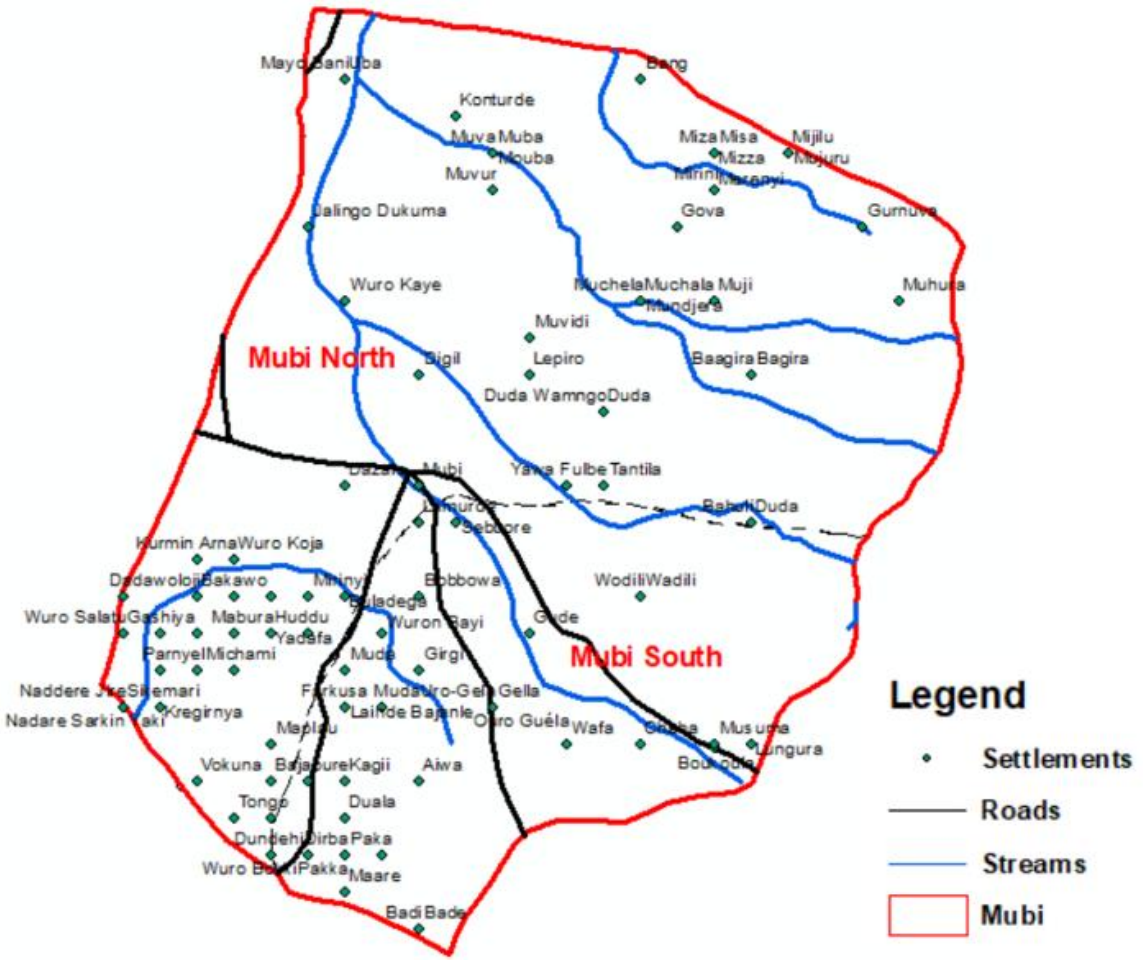

Figure 4: Map showing the Mubi area.

Most of the settlements that have very high and highly vulnerable were in Mubi North local government, with 48% and 28% respectively (Table 2). Mubi South has a moderate, low and very low flood vulnerability with 13%, 6% and 5% respectively. Table 2 shows the number of settlements under different categories of vulnerability.

Table 2. Settlements under different categories of vulnerability.

Vulnerability	Settlements	Percentage	Remarks
Very high	31	48	Most of the settlements were in Mubi North
High	18	28	Most of the settlements were in Mubi North
moderate	8	13	Few in Mubi North and Mubi South
Low	4	6	All the settlements were in Mubi South
Very low	3	5	All the settlements were in Mubi South

Statistically, the result shows that most of the settlements in Mubi are at the highest risk of flooding. Almost half of all the settlements are at risk of flooding whenever there is high rainfall or when the streams are overflooded to their banks. This was presented as a graph in Figure 5.

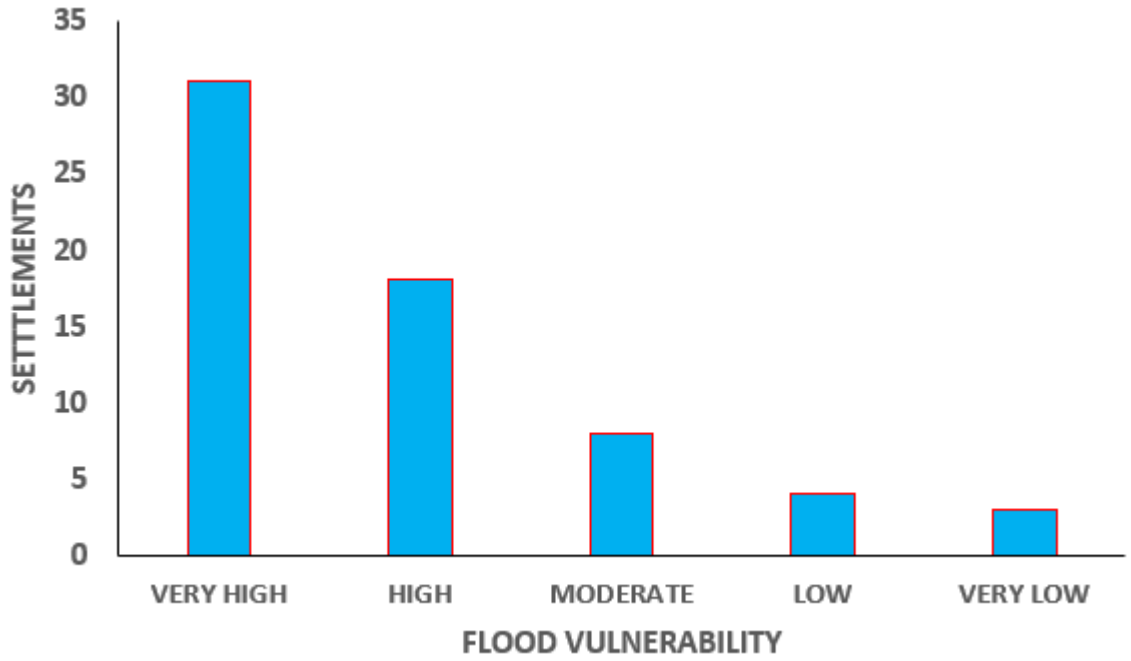

Figure 5. Flood vulnerability chart of Mubi area

Conclusion

Mubi North and Mubi South LGAs were the areas that had the most undulating terrain in Adamawa state, Nigeria. The area also has the highest number of streams and rivers than any other local government in the state. Due to this high undulating terrain with streams and rivers, the area is more vulnerable to flooding, which causes loss of lives and properties annually. This study uses SRTM and a topographical map and identifies that 31 out of 64 settlements are at a very high risk of flooding. The result further revealed that only 3 settlements stand to be at a very low risk. Adequate flood mitigation measures are therefore needed urgently in most parts of the two local governments. The result of this study will contribute immensely towards the realisation of Sustainable Development Goal (SDG) Target 13.1.3: Implementation of local disaster risk reduction strategies.

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