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DELINATION AND MAPPING OF FLOOD RISK ZONES ACROSS OGBARU L.G.A, ANAMBRA STATE USING GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

Flooding is a devastating environmental hazard affecting the riverine and low-lying communities in Nigeria, particularly in Ogbaru Local Government Area of Anambra State. The aim of the study is to delineate and map out flood risk zones across Ogbaru L.G.A using Geographic Information System (GIS) and Analytical Hierarchy Process (AHP). Results revealed that flood risk is extremely high in Ogbaru L.G.A, the very high flood risk zones covered 31.41% of the total area, while the high flood risk zone covered 16.83% which together make up a total of 48.24% of the entire L.G.A, indicating that almost half of the area is exposed to flood risk. Settlement analysis further show that 66.67% of the mapped settlements falls within high and very high flood risk zones while 21.14% fall within the low flood risk zones. This indicates that flood management in Ogbaru should prioritize settlement-based vulnerability reduction, especially evacuation planning, early warning dissemination, resilient housing, drainage improvement, and land-use control. The study also identified Ogwu-Ikpele, Oniocha, Atani I, Akili/Obeagwe, and Atani II as the most exposure wards to flood risk. The findings indicate that these areas should receive priority attention in flood preparedness, emergency response planning, structural mitigation, and settlement planning. Based on the finding, the study recommends (i) government agencies should utilize the use of flood map in development planning; (ii) infrastructures in high risk zone should be discourage; (iii) drainage channels and flood control structures should be constructed and; (iv) public awareness to residents on flood warnings, preparedness and emergency response should be encouraged.

Key words: Flood Risk, Geographic Information System and Analytical Hierarchy Process

1.0. Introduction

1.1. Background to the Study

Floods are considered one of the most catastrophic natural disasters on a global scale [12]. In recent years, the frequency of flood disasters has been on the rise [22]. Such incidents markedly disturb regional functions, causing traffic bottlenecks, ecological damage, and the unfortunate possibility of casualties and property destruction [24]. The impacts of flooding are far reaching, affecting various aspects of society, including the economy, infrastructure, and daily life (Srivanit

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et al., 2024). Statistics show that global losses from flood disasters account for 20 percent (%) of all natural disaster-related losses [26]. Since the beginning of the 21st century, it has been estimated that global flood-related losses have reached approximately USD 651 billion, while the percentage of the population at risk of flooding has risen by nearly 24% [25]. Floods can be triggered by natural events, human activities, or a combination of both, and have the potential to cause fatal injuries, displace large populations, and damage the environment [3].

In Nigeria, floods are the most frequent and severe natural hazards which have significantly affected lives and properties negatively [16]. Flood hazard has displaced more people in the country than any other natural hazard with the population at risk estimated to be 20% [6]. The country has experienced several flood episodes with the 2012 flood episode being tagged the most severe and devastating flood episode ever witnessed in the country over the years [3, 8, 14]. The 2012 flood episode affected over 30 states in the country with an estimated total of seven million people affected and an economic loss estimate of 2.6 trillion naira [14]. Anambra state was among the states affected by 2012 flood disaster with the four Local Government Areas of Anambra west, Anyamelum, Anambra East and Ogbaru being the worst hit in the state [15].

Anambra State, located in the southeastern part of Nigeria, is characterized by its complex terrain and diverse hydrological features. The state's topography includes low-lying floodplains, river systems, and varied LULC patterns, all of which contribute to its flood susceptibility [20, 5]. The state's geographical location within the lower Niger River Basin further exacerbates its vulnerability to flooding, particularly during the rainy season when river levels rise significantly. Given these challenges, there is a critical need for a comprehensive flood risk assessment framework that can guide effective flood management and mitigation strategies [23].

Ogbaru Local Government has continued to wreak havoc every rainy season though many of these incidences were unreported [8]. Onyeizugbe & Onyejiaka, [18] attributed the major causes of flood hazard in Ogbaru Local Government Area of Anambra State to the water body present in the area, the topography of the area and human encroachment.

In this regard, an integrated approach of the knowledge of remote sensing and Geographical Information System (GIS) can be used to investigate and map out areas that are less or more vulnerable to flooding. Remotely sensed imagery and GIS can be very effective in identifying the

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spatial component of floods for management [11]. Remote sensing offers a synoptic view of the spatial distribution and dynamics of hydrological phenomena such as flood and erosion. They are used to measure and monitor the extent of flooded areas, provide a quantifiable estimate of the land area and infrastructure affected by flooding and erosion [17].

1.2. Statement of the Problem

Ogbaru L.G.A is at risk for floods because of its location along the floodplains of the River Niger and Anambra River. Its low-lying terrain and wetland environment add to this risk [9]. Communities such as Atani, Ossomala, Ogwuikpele, Odekpe and many more communities experiences recurrent flood event. The 2012 and 2022 floods displaced thousands of residents, destroyed farmlands, buildings and distrupted the livelihood of those areas. Despite the frequent flooding, current strategies for management and mitigation have been ineffective [2].

One major problem is the limited use of geospatial technologies, such as Geographic Information Systems (GIS) and remote sensing, for assessing flood risk in the area. Studies show these tools can effectively identify and map flood-prone areas [17]. However, their use in Ogbaru is restricted due to insufficient data, inadequate technical skills, and a lack of integration into planning processes. Consequently, flood risk maps often lack accuracy and do not reflect local variations in vulnerability. Given these challenges, there is an urgent need to effectively use geospatial techniques to generate accurate data that show localized variations in flood vulnerability in Ogbaru L.G.A. This study tends to address this critical knowledge gap by delineating and mapping flood zones across Ogbaru Local Government Area using Geographic Information System techniques.

1.3. Aim and Objectives

The aim of the study is to delineate and map out flood risk zones across Ogbaru Local Government Area using GIS.

To achieve this aim effectively, the following objectives were pursued:

1. To map the flood risk zones using Analytical Hierarchy Process (AHP) in the study area and

2. To determine the level of settlement exposure to flood risk in the study area.

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2.0 The Study Area

Ogbaru Local Government Area is one of the 21 Local Governments in Anambra State, Nigeria (fig, 3.2). Geographically it is located at Latitudes 5^0 42' N and 6^0 08' N and Longitudes 6^0 42' E and 6^0 50' E. The study area (fig.3.3) is surrounded by the River Niger in such a way that most of the communities are located at the bank of the river [9]. The towns that make up the Local Government includes; Atani, Akili-Ogidi, Akili-Ozizor, Amiyi, Mkputu, Obagwe, Ohita, Odekpe, Ogbakugba, Ochuche Umuodu, Ossomala, Ogwu-Aniocha, Umunankwo, Umuzu, Okpoko and Ogwu-Ikpele with the headquarters at Atani. To the North, the study area is bounded by Onitsha South, Idemili North and South Local Government Areas in Anambra State, to the South, it is bounded Imo and River States, to the East it bounded by Ekwusigo and Ihiala Local Government Area of Anambra State, and to the west, it is bounded by River Niger and Delta State [9]. The study area has flat and low-lying topography with a slope angle of $1\text{-}3^0$. Thus some of the communities are flooded for over 8 months in a year[1]. The relief is a plain land of height ranging between 0-50m and it is characterized by swampy conditions due to its alluvial mud content [7] The study area has two major Rivers, River Niger and Ulasi River which is a major tributary, though there are creeks and ponds all over the landscape [7]. The water of the aquifer is quite shallow with the average elevation of 25m above sea level [7]. The average climatic conditions of the study area are wet season which starts from March to October and dry season which starts from November to February. The highest rainfall is recorded from June to September. The average annual rainfall ranges from 1800mm to 2000mm. it has a mean annual temperature as 30^0C and 27^0C respectively. The average relative humidity ranges between 60%-70% in January and 80%-90% in July [19]. Ogbaru floods during the rainy season and dries up during the dry season though the flood lasts for a long time before receding. The vegetation is a mixture of fringing forests along the banks of the River Niger and Guinea Savannah in the hinterland [7]. Ogbaru lies on the sedimentary basin; the terrain in Ogbaru is predominantly flat and low-lying with extensive floodplains. The geology of Ogbaru is characterized by alluvial deposits from River Niger, consisting of sand, silt and clay [9].

The population of study according to the 2006, National Population and Housing Census was 223,317 with the population projection in 2025; the population of Ogbaru L.G.A of Anambra State was projected to be 342,166.

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Figure 2.1. Map of Nigeria showing Anambra State
Source: Department of Surveying and Geo-Informatics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria (2024).

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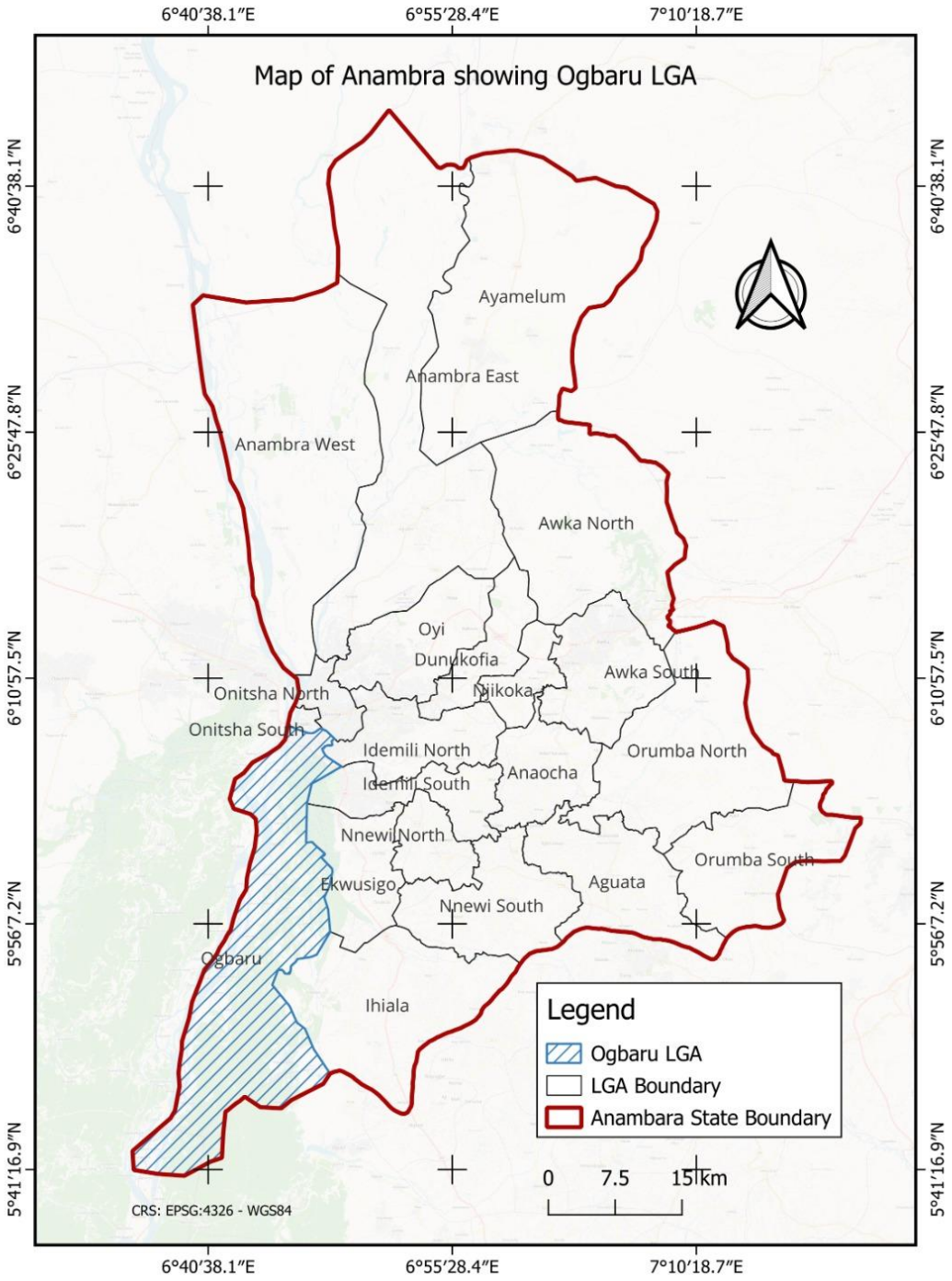


Figure 2.2: Map of Anambra State showing Ogbaru L.G.A.
Source : Department of Geography, University of Jos(2026).

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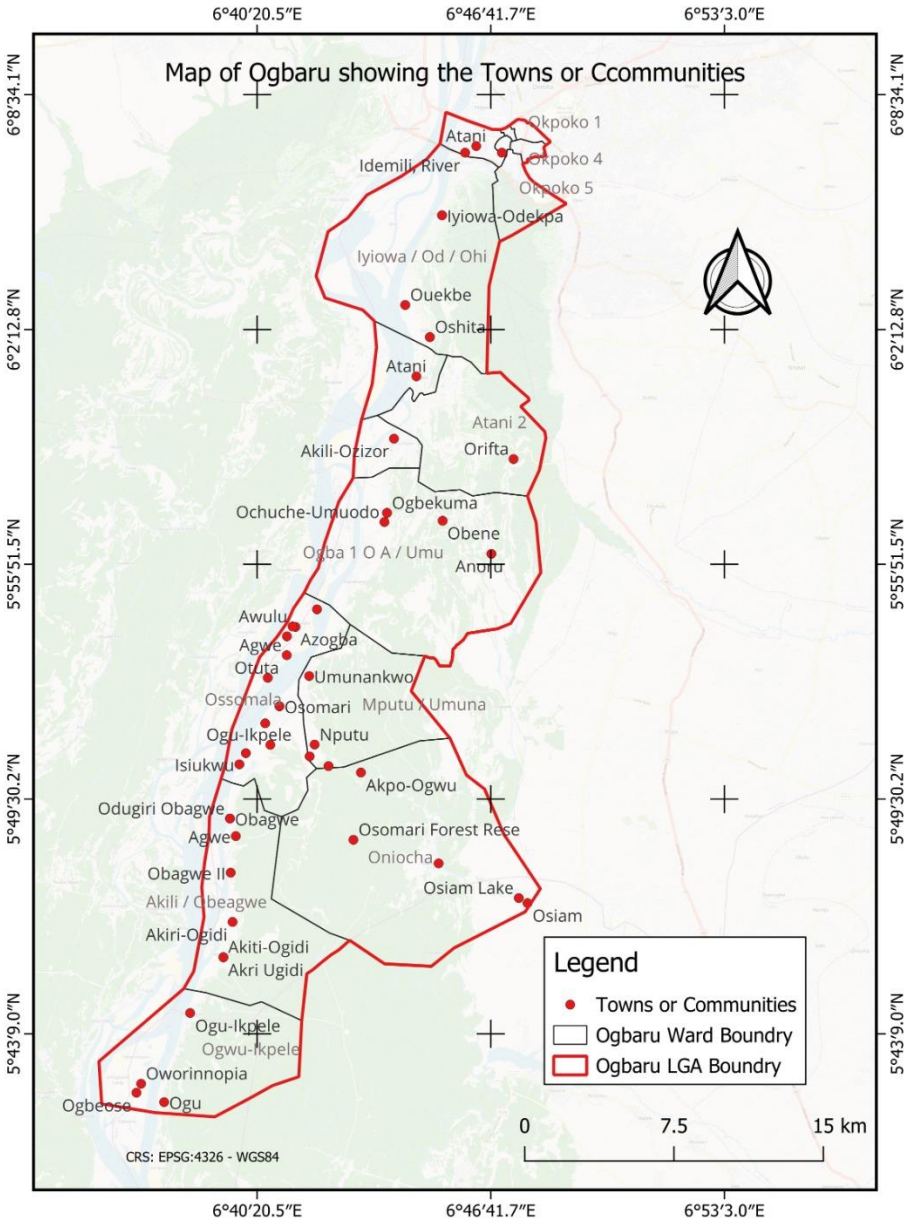


Figure 2.3: Map of Ogbaru Local Government Area Showing the Study Areas
Source : Department of Geography, University of Jos(2026).

3.0 Methodology

The study adopted geospatial analytical approach involving the integration of GIS and remote sensing techniques with Analytical Hierarchy Process (AHP) for assessment and mapping of flood risks zones across Ogbaru Local Government Area of Anambra State.

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4.0. Data Presentation and Discussion of Findings

4.1. Data Presentation

Table 4.1: Areal Distribution of Flood Risk Zones in Ogbaru L.G.A

Risk Zone	Area	Percentage of Total Area
Very Low Risk	82.59	20.78%
Low Risk	63.53	15.98%
Moderate Risk	59.64	15.00%
High Risk	66.88	16.83%
Very High Risk	124.83	31.41%
Total	397.47	100.00%

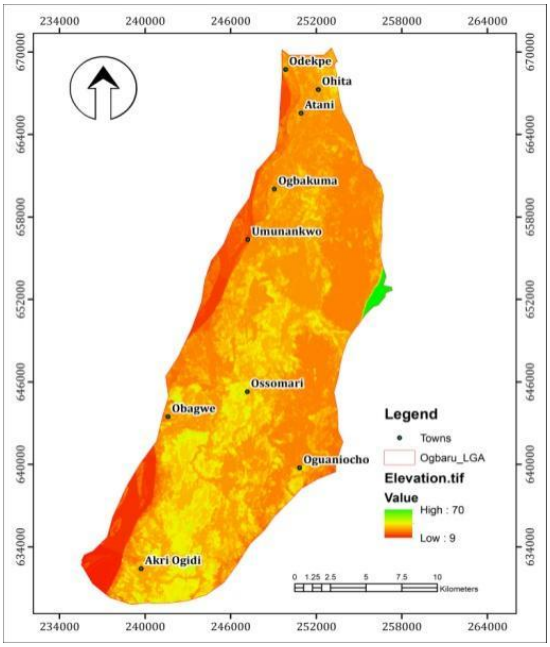


Figure 4.1. Elevation map of Ogbaru L.G.A

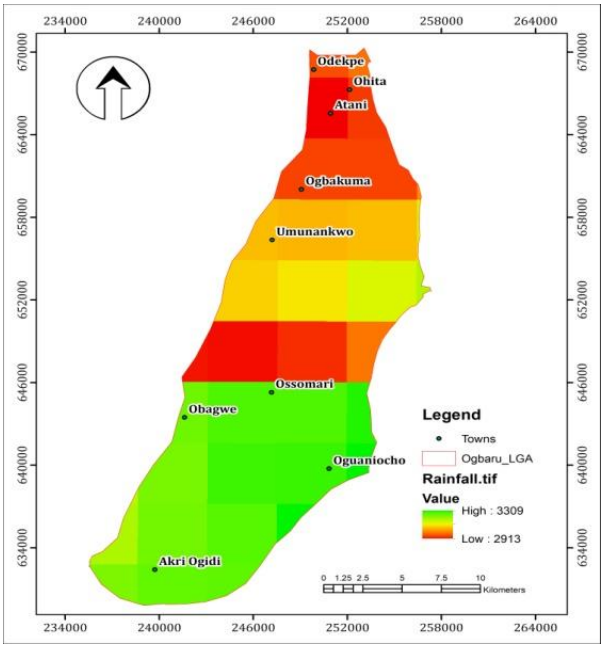


Figure 4.2. Rainfall map Ogbaru L.G. A.

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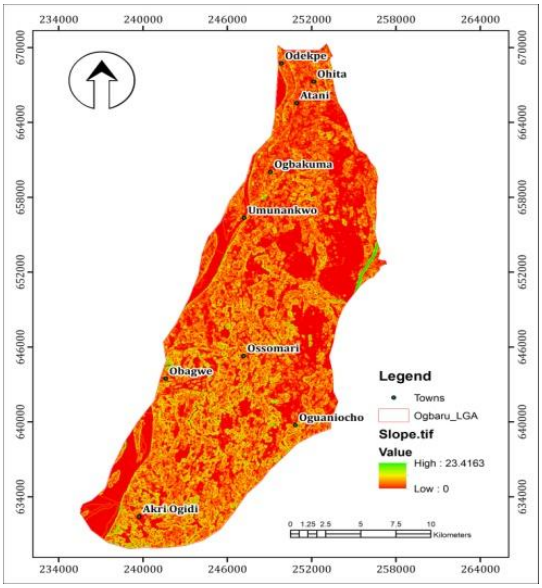


Figure 4.3. Slope map of Ogbaru L.G.A. L.G.A.

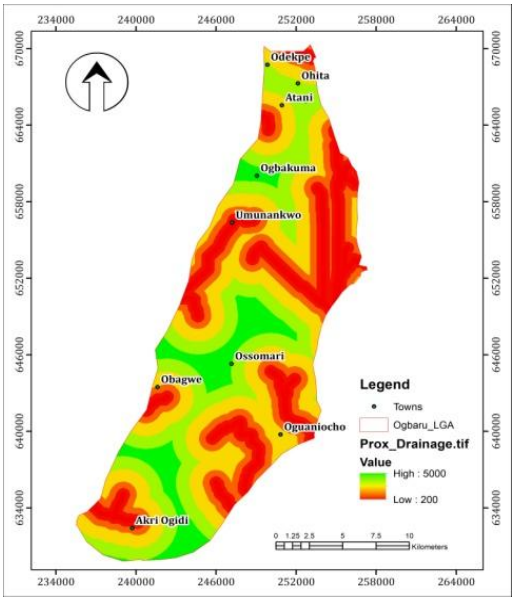


Figure 4.4. Drainage map of Ogbaru

The resulting flood maps (Figure 4.1. 4.2, 4.3 and 4.4) represent the four conditioning factors such as Elevation, Slope, Rainfall Close to drainage/ water bodies. The delineated flood risk pattern reflects the geomorphological and hydrological characteristics of Ogbaru L.G.A, where low-lying terrain, gentle slopes, and close proximity to the River Niger and associated drainage networks contribute significantly to flood susceptibility. Areas characterized by lower elevations, flatter terrain, and shorter distances to major water bodies and natural drainage channels were predominantly classified within the high and very high flood risk categories, whereas relatively elevated locations situated farther from hydrological features were classified as low or very low risk zones. The generated flood risk map therefore provides a spatial representation of flood susceptibility (Table 4.1) across the L.G.A and serves as a basis for identifying vulnerable areas requiring priority attention for flood mitigation, land-use planning, and disaster risk management.

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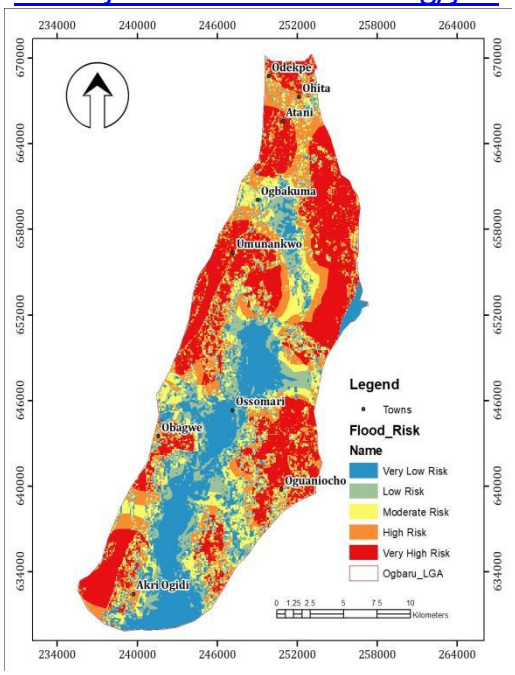


Figure 4.5: Flood Risk Zone Map of Ogbaru Local Government Area, Anambra State.

The result (Figure 4.5 and Table 4.1) shows that the very high flood risk zone occupies the largest portion of Ogbaru L.G.A, covering 124.83 km², representing 31.41% of the total mapped area. This indicates that nearly one-third of the L.G.A falls within the most flood-prone category. The high-risk zone covers 66.88 km², representing 16.83% of the area. When the high and very high risk zones are combined, they account for 191.71 km², equivalent to 48.24% of Ogbaru L.G.A. This means that almost half of the entire L.G.A is exposed to severe flood risk. The moderate risk zone covers 59.64 km², representing 15.00% of the study area. This class represents transitional zones where flood susceptibility is not as severe as the high-risk zones but remains significant enough to require planning attention. The low risk zone covers 63.53 km², representing 15.98%, while the very low risk zone covers 82.59 km², representing 20.78%. These lower-risk areas may correspond to relatively better-drained, slightly elevated, or less hydrologically exposed locations.

Table 4.2: Settlement Distribution by Flood Risk Zone

Risk Zone	Number of Settlements	Percentage of Settlements
Very Low Risk	9	7.32%
Low Risk	17	13.82%
Moderate Risk	15	12.20%
High Risk	27	21.95%

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Very High Risk	55	44.72%
Total	123	100.00%

To further the analysis, settlement exposure was analyzed and the results show that 55 settlements, representing 44.72% of all mapped settlements, fall within the very high flood risk zone. A further 27 settlements, representing 21.95%, fall within the high-risk zone. Therefore, 82 out of 123 settlements, equivalent to 66.67%, are located within high and very high flood risk zones. This is a strong indication that flood risk in Ogbaru is not only spatially extensive but also directly affects populated places.

Only 9 settlements, representing 7.32%, fall within the very low risk zone, while 17 settlements, representing 13.82%, are located within the low-risk zone. This means that only 21.14% of the mapped settlements are situated in areas of relatively low flood exposure, this is summarized in table 4.2. The implication is that flood management in Ogbaru should prioritize settlement-based vulnerability reduction, especially evacuation planning, early warning dissemination, resilient housing, drainage improvement, and land-use control.

Table 4.3: Ward-Level Settlement Exposure to Flood Risk

Ward	Very Low	Low	Moderate	High	Very High	Total	High and Very High	% High and Very High
Ogba 1 O A / Umu	4	10	6	6	11	37	17	45.9%
Atani 2	0	2	3	8	5	18	13	72.2%
Oniocha	0	1	0	1	11	13	12	92.3%
Atani 1	0	1	0	4	7	12	11	91.7%
Akili / Obeagwe	1	0	2	2	7	12	9	75.0%
Mputu / Umuna	4	1	0	4	3	12	7	58.3%
Ogwu-Ikpele	0	0	0	0	5	5	5	100.0%
Ossomala	0	1	1	0	4	6	4	66.7%
A Ozizor	0	1	1	1	2	5	3	60.0%
Iyiowa / Od / Ohi	0	0	2	1	0	3	1	33.3%

Ward-level analysis was also conducted and the result (Table 4.3) shows that Ogwu-Ikpele has the highest proportional exposure, as all its mapped settlements fall within the very high risk zone. Oniocha and Atani 1 also show severe exposure, with 92.3% and 91.7% of their mapped

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settlements respectively located in high and very high risk zones. Akili / Obeagwe records 75.0%, while Atani 2 records 72.2% exposure to high and very high flood risk.

Ogba 1 O A / Umu has the largest number of mapped settlements, with 37 settlements, out of which 17 are in high and very high risk zones. Although its proportional exposure is lower than that of Ogwu-Ikpele, Oniocha, and Atani 1, its absolute number of exposed settlements makes it highly significant for flood risk management.

The spatial pattern indicates that flood risk is concentrated in riverine and low-lying settlement clusters. This agrees with earlier GIS-based flood studies in Anambra State, which found that flood vulnerability is strongly influenced by proximity to rivers, elevation, drainage conditions, land cover, and terrain characteristics. The delineated flood risk map shows that Ogbaru L.G.A is predominantly flood-prone, with the very high risk class forming the largest spatial category. The result reveals that flood risk is not evenly distributed across the L.G.A, but is concentrated in specific wards and settlements. The most exposed wards are Ogwu-Ikpele, Oniocha, Atani 1, Akili / Obeagwe, and Atani 2. These areas should receive priority attention in flood preparedness, emergency response planning, structural mitigation, and settlement planning.

The analysis further shows that the flood problem in Ogbaru is both an areal and settlement-based hazard. Spatially, 48.24% of the L.G.A lies within high and very high flood risk zones. Demographically, 66.67% of the mapped settlements fall within these two severe categories. This confirms that flood risk in Ogbaru has direct implications for human settlements, infrastructure, agriculture, transportation, and emergency access.

4.2. Discussion of Results

The findings the study delineation and mapping of flood risk zones across Ogbaru L.G.A. revealed 48.24% of the study area and 66.67% of the mapped settlements fall within the high and very high flood risk categories. The predominance of low-lying terrain, gentle slopes and the proximity of Ogbaru to the River Niger and its associated drainage network provide important physical conditions that explain the concentration of flood risk within substantial portions of the L.G.A. and its settlements. The result also corresponds closely with findings from other GIS-AHP-based flood risk studies reviewed in the literature. Nkeki *et al.* [13], for example, reported that 48.2% of the

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Ona River Basin was exposed to moderate and very high flood risk. This figure is remarkably close to the 48.24% obtained in the present study and provides support for the application of the spatial flood risk delineation approach used in Ogbaru. Similarly, Bello *et al.* [4] identified extensive medium to high and very high flood risk zones across Nigeria's coastal states. Ikusemoran *et al.* [10], also found out that valley and plain terrains in Niger State, which share some hydrological characteristics with the Ogbaru floodplain, recorded more than half of the state's vulnerable land area. The synthesis of these findings suggests that elevation, slope, terrain characteristics and proximity to water bodies are important conditioning factors in the spatial distribution of flood risk across different Nigerian environments.

The findings further extend the work of Chukwuma *et al.* [5], that mapped flood-prone areas in Onitsha and Awka in Anambra State, but identified lack of integration of community involvement in data collection and validation as an important research gap. The present study addresses this limitation by incorporating settlement level and ward level exposure analysis and subsequently triangulating the geospatial results with community survey and interview data. This provides a more locally grounded understanding of flood risk than approaches based solely on GIS based information. Spatially, the findings demonstrate that flood risk is not uniformly distributed across Ogbaru L.G.A., but is concentrated in particular riverine wards. The wards of Ogwu-Ikpele, Oniocha, Atani 1, Akili/Obeagwe and Atani 2 recorded more than 70% settlement exposure to high and very high flood risk categories. This concentration has important implications for flood risk management because it indicates that mitigation measures, evacuation planning and land-use control should be informed by the spatial variation of vulnerability rather than implemented uniformly throughout the L.G.A.

5.0. Conclusion and Recommendations

5.1. Conclusion

The study delineated and mapped out flood risk zones across Ogbaru Local Government of Anambra State using Geographic Information System (GIS) and Analytical Hierarchy Process (AHP). The Analytical Hierarchy Process technique analyzed the four major conditioning factors such as elevation, slope, distance to water bodies and distance to natural drainage, which were integrated to develop a flood risk map in the study area.

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From the results, it revealed flood risk is extremely high in Ogbaru L.G.A, the very high flood risk zones covered 31.41% of the total area, while the high flood risk zone covered 16.83% which together make up a total of 48.24% of the entire L.G.A, indicating that almost half of the area is exposed to flood risk. Settlement analysis further show that 66.67% of the mapped settlements falls within high and very high flood risk zones while 21.14% fall within the low flood risk zones. This indicates that flood management in Ogbaru should prioritize settlement-based vulnerability reduction, especially evacuation planning, early warning dissemination, resilient housing, drainage improvement, and land-use control.

The study also identified Ogwu-Ikpele, Oniocha, Atani I, Akili/Obeagwe, and Atani II as the most exposure wards to flood risk. The results indicate that these areas should receive priority attention in flood preparedness, emergency response planning, structural mitigation, and settlement planning.

5.2. Recommendations

Prior to the findings, the following were recommended

i. Government agencies should utilize the use of flood map in land use planning and development control in Ogbaru Local Government Area in Anambra State.

ii. Development of residential and public infrastructural projects in very high flood risk zones should be discouraged.

iii. Public awareness campaigns should be organized to educate residents on flood preparedness, early warning and emergency response.

iv. Drainage channels, embankments and other flood control structures should be constructed and maintained effectively to reduce flood impacts.

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