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GEOSPATIAL ASSESSMENT OF DRAINAGE NETWORK SYSTEMS IN UYO LOCAL GOVERNMENT AREA, AKWA IBOM STATE.

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ABSTRACT

There are numerous effects of natural disaster like flooding in different places all over the world. However, the application of GIS and remote sensing technology to map out these areas vulnerable to flood makes it easy to plan measures, aimed at mitigating flood damages and risks involved. The study aimed at identifying drainage network systems within flood vulnerable areas in Uyo LGA with a view to suggesting control measures. The GIS software, ArcMap 10.4 environment, Landsat-8 OLI and Digital Elevation Model (DEM) images of 2022 of the area were used to select slope, land use, drainage network, and soil layers. Annual rainfall data were acquired from NASA/NiMET. The DEM was used to generate slope, flow direction, flow accumulation, stream network and distance from water channel. Flood vulnerability impact map was produced identifying high, moderate, and low vulnerable areas. Flood mapping was done to determine flood locations based on a 3D terrain assessment from where the drainage network system was developed. Factors that influence drainage in the study area were: hydrological factors, water management factors, and institutional factors. The mean annual rainfall of the study area ranges from 4426 mm to 4927 mm. The flood vulnerability increases with the increase in rainfall. The mean annual rainfall classes in the study area were categorized into: very low, Low, moderate, high, respectively. However, the region is characterized by high slope angle and elevation. As such, all flood waters easily flow downstream to many parts of Ekamba Nsukkara and Idu communities, putting them at a high risk of floods.

Keywords: Geospatial, Assessment, Drainage, Network-System, Uyo

1.0 INTRODUCTION

Drainage systems are a fundamental component of both urban and rural infrastructure, comprising a network of structures and channels designed to manage the flow of water, particularly excess rainwater. They serve multifaceted purposes, ranging from flood mitigation, flow conveyance to wastewater management, with a central focus on environmental and public health preservation (Chow, *et al.*, 1988; Beven, 2018; Fletcher, *et al.*, 2015; Hsu, *et al.*, 2022; Jiang, *et al.*, 2023). In a general sense, drainage systems can be defined as integrated systems that perform several vital functions including flood mitigation (Hsu, *et al.*, 2022), wastewater management (Jiang, *et al.*, 2023), environmental protection (Fletcher, *et al.*, 2015, Malinay, *et al.*, 2024, Adamu *et al.*, 2025), and public health preservation (Beven, 2018; Li, *et al.*, 2024). Drainage systems are primarily engineered to prevent or minimize flooding events by efficiently collecting and diverting surplus water away from inhabited areas. This function is especially critical in regions characterized by heavy precipitation, such as Uyo Local Government Area (LGA) (Chow *et al.*, 1988; Hsu, *et al.*, 2022). These systems play a pivotal role in transporting wastewater originating from residential, industrial, and commercial zones to treatment facilities. This function significantly contributes to preventing the contamination of natural water bodies and reducing potential health hazards (Chow *et al.,* 1988; Jiang, *et al.,* 2023). Properly designed drainage systems contribute to soil erosion control by effectively channeling runoff water away from susceptible areas. This helps maintain the integrity of the landscape and infrastructure. A comprehensive understanding of drainage network systems is critically important for the well-being of communities, effective urban planning, and disaster management. This significance is underpinned by a range of environmental, economic, and social factors, all of which contribute to the resilience and safety of communities (Fletcher, *et al.,* 2015; Beven, 2018; Hallegatte, *et al.,* 2011; Wisner, *et al.,* 2004; Birkmann and Cardona, 2001; Malinay, *et al.,* 2024; Li *et al.,* 2024; Adamu *et al.,* 2025). It a known fact that Uyo LGA is very prone to severe flooding annually majorly due to uncoordinated human activities coupled with not following plans put in place by successive administration. To address this pressing issue of flooding, which is a direct product of drainage network distribution and efficiency, a geospatial assessment of the drainage system and flood impact in Uyo LGA is imperative. The need for such an assessment cannot be overstated, as Uyo LGA is vulnerable to flooding due to several factors. Firstly, it is located in a coastal region with a tropical climate characterized by heavy rainfall during the wet season. The average annual rainfall in the region is approximately 4,000mm, making it highly prone to flooding Akwa Ibom State Ministry of Environment (AKSME), (AKSME, 2019; Ahuchaogu, *et al.,* 2019; Umoh and Brendan, 2025). Additionally, rapid urbanization and population growth have led to increased land-use changes, including the conversion of wetlands and natural drainage channels into residential and commercial areas (Udoimuk, 2018; Mishra, *et al*., 2021).

Geospatial technology, encompassing Geographic Information Systems (GIS), remote sensing, and spatial analysis, offers a promising approach to assess and manage drainage systems and flood impact. GIS provides a powerful tool for spatial data integration and analysis, allowing planners and policymakers to make informed decisions (Orovwuje, *et al.,* 2019; Madusanka, *et al.,* 2022). By harnessing these technologies, a geospatial assessment of Uyo LGA's drainage system and flood impact can provide valuable insights for effective flood risk management and disaster resilience. The geospatial assessment of drainage systems and flood impact in Uyo Local Government Area (LGA), Akwa Ibom State, Nigeria, is a critical issue that demands comprehensive investigation. Uyo LGA, located in the coastal region of Nigeria, faces recurrent challenges related to flooding, which not only disrupt daily life but also pose significant threats to infrastructure, agriculture, and the overall well-being of its residents. This statement of problem aims to elucidate the key issues associated with the drainage system and flood impact in Uyo LGA, emphasizing the need for a geospatial assessment to address these challenges effectively. One of the primary problems is the inadequacy of the existing drainage systems in Uyo LGA. Over the years, rapid urbanization, population growth, and unplanned construction have led to the encroachment and blockage of drainage channels and canals. This has disrupted the natural flow of water during the rainy season, causing widespread flooding in both urban and rural areas (AKSME, 2019). This inadequacy hinders the efficient management of rainwater, leading to erosion, property damage, and health hazards. Uyo LGA has experienced a surge in the frequency and severity of flooding incidents in recent years. This can be attributed to various factors,

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including climate change, deforestation, and improper land use practices. These floods have adversely affected communities, leading to displacement, loss of livelihoods, and damage to public infrastructure (Nwafor, *et al.,* 2010). Understanding the patterns and causes of flooding is essential for devising effective mitigation strategies.

In the context of Uyo Local Government Area (LGA) in Akwa Ibom State, Nigeria, the geospatial assessment of drainage systems and flood impact emerges as a paramount research initiative. Its far-reaching significance unfolds through its potential to address numerous interconnected environmental, social, and economic challenges that beset the region. This research work explores how this study's multifaceted importance weaves a tapestry of solutions for the community which has repeatedly suffered the devastating consequences of flooding, affecting residences, infrastructure, and agricultural land (Onoduku, *et al.,* 2020). By scrutinizing the drainage system's efficacy and identifying flood-prone areas, this geospatial assessment equips local authorities with actionable insights. These insights enable targeted flood mitigation strategies, such as the enhancement of drainage infrastructure and the establishment of early warning systems (Ezeh and Ezeomedo, 2020). The net result is a marked reduction in the community's vulnerability to floods. The region is witnessing rapid urbanization, often haphazard and encroaching upon natural drainage channels (Oloke, *et al.,* 2022). Herein, the geospatial assessment plays a pivotal role by illuminating the existing drainage network, which, in turn, guides urban planning decisions. Informed zoning, construction permits, and land-use policies promote sustainable urban development (Aderibigbe, *et al.,* 2022). By accommodating the drainage systems capabilities within urban planning, this study proactively curtails the risks associated with future flooding. Agriculture forms the backbone of Uyo LGA's economy, sustaining numerous livelihoods. However, floods can wreak havoc on crops and livestock, jeopardizing both food security and economic stability (Akintoye and Oloke, 2021). This assessment of flood-prone agricultural regions allows for proper alignment of drainage networks and mitigates uncontrolled flooding. Therefore, farmers could make informed choices about crop selection and planting schedules (Akintoye and Oloke, 2021). Moreover, it paves the way for flood-resistant agricultural practices and infrastructure, thus shielding food security from potential shocks (Aderibigbe, *et al.,* 2022). Existence of coordinated drainage network systems in the study are will not only arrest incessant flooding but make more arable land available for crops (food) production, there solving security and economic problems.

2.0 METHODOLOGY

2.1 Study Area

The research was carried out in Uyo Local Government Area the capital city of Akwa Ibom State of Nigeria. It is geographically located on latitude $5^o40'$N and $5^o59'$N and longitude $7^o51'$E and $7^o59'$E, with a total population of 305,961 (NPC, 2006). It covers a land mass of about 188.024km which is situated 55km inland from the coast and is characterized by a gentle undulating terrain. The temperature regime of Uyo is humid and ranges between 26^oC and 35^oC with an annual temperature of 28.4^oC (Ukpong and Udofia, 2009; Onyegbule, *et al.,* 2025), It bothered eight (8) local government areas of the State. However, each of the eight L.G.A. bordering Uyo has flooding issues which are not comparable in magnitude and devastating nature to Uyo, hence the choice of Uyo. Uyo is the commercial and political hub of the state hence emphasis on it as the study area.

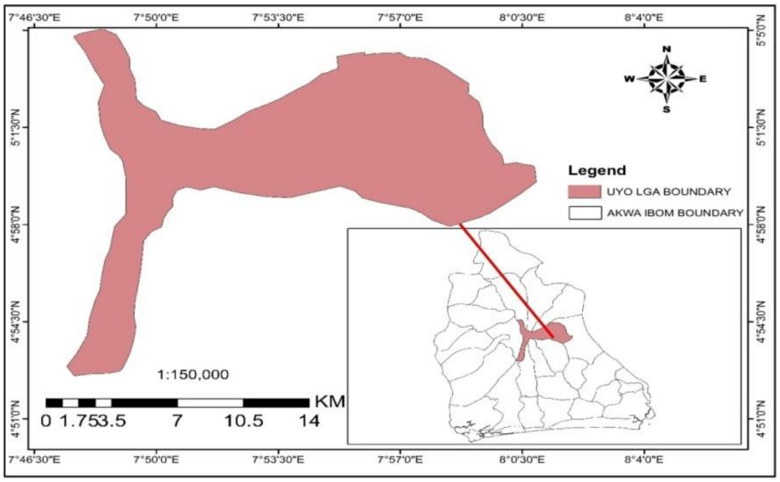


Figure 1: Location of Uyo, LGA in Akwa Ibom State,Nigeria**,** *Source: (ASTAL, 2025)*

2.2 Source and Data Collection

In carrying out this research work different categories of data were used, the data were downloaded online, and five (5) thematic-layer factors were considered and created using Geographic Information Systems (GIS) software, ArcMap 10.4 environment. Slope, Annual rainfall, land use, Drainage network, and Soil layers were carefully selected on the software for assessing the flood vulnerability in the study areas. (Behanzin, *et al.,* 2016, Ibe, *et al.,* 2024)

The Table 1 below shows all the information on the datasets used, sources, and their format in the data processing stages to successfully delineate flood risk areas and produce a flood vulnerability map.

Table 1: Data Source. *Source: (ASTAL, 2025)*

S /no	Data	Source	File format	Resolution	Date
1	Landsat-8 OLI	USGS	Raster	30m	2021
2	Digital Elevation Model (DEM)	Open Topography	Raster	30m	2022
3	Soil type	FAO Soil Data	vector		

The Shapefile of the study area was extracted from the Nigerian Administration map, Landsat-8 OLI 30m resolution satellite imagery of 2021, of the study area was acquired from the United States Geological Surveys, (USSGS) online database. Digital Elevation Model DEM (30 X 30m pixel) resolution was acquired from United States Geological Surveys, (USGS), and 2021 Annual Rainfall data from World precipitation data was downloaded from the Climate Research Unit (CRU) while soil data was acquired from the Food and Agriculture Organization of the United Nation (FAO).

2.3Method of Data Analysis

Landsat images of 30m resolution of the study area were classified into four (4) classes namely; vegetation areas, built-up areas, waterbody, and bare land from ArcGIS 10.4 toolbox, Supervise Classification technique" of maximum likelihood was used by combining band 5, 4, and 3 of Landsat 8 image, (Behanzin, *et al.,* 2016). The hydrology toolbox, an extension of ArcGIS, was used to analyze and map out areas prone to flooding. Modeling the movement of water across the surface was done to determine the source of the water and where the accumulation of water may occur, (Essien, *et al.*, (2018). A series of processes including filling the Digital Elevation Model (DEM) data to make it devoid of sinks and generation of a flow direction map by using the filled DEM data as input raster were conducted to generate a flow accumulation map, flow direction map, Knowing the flow accumulation, a stream network was obtained which indicates the natural course of run-off water, (Essien, *et al*., (2018).

2.4 Analytical Hierarchy Process (AHP) analysis.

Descriptive and analytical methods of data analysis were adopted. GIS technology was used for the production and presentation of flood risk information; it played a central role in integrating, organizing, processing, and visualizing spatial data. However, the interpretation and analysis of remotely sensed data were also based on ArcGIS software, (Malczewski, *et al,* 1997). Spatial analyses employed include Euclidean distance, inverse distance weight, reclassification analysis, weighted overlay analysis, and multi-criteria analysis (MCA). The analytical Hierarchy Process (AHP) method, which was developed by (Saaty, 1980), is an effective approach to extracting the relative importance weights (RIW) of criteria. It is based on pair-wise comparisons which are used to determine the relative importance of each criterion. The pair-wise comparison method involves three steps: (1) Development of a pair-wise comparison matrix. The method uses a scale with values ranging from 1 to 9 to show how one criterion is more important than another. (2) Computation of the weights: The computation of the weights involves three steps. The first step is the summation of the valves in each column of the matrix. Then, each element in the matrix should be divided by its column total (the resulting matrix is referred to as the normalized pair-wise comparison). Then the average of the element in each row of the normalized matrix should be computed, including dividing the sum of normalized scores for each row by the number of criteria. These averages provide an estimate of the relative weights of the criteria being compared (Saaty, 1984). The empirical application suggests that the pair-wise comparison method is one of the most effective techniques for spatial decision-making including GIS-based approaches (Malczewski, *et al*, 1997).

2.5 Estimation of the consistency ratio:

The aim of this is to determine if the comparison is consistent or not, This Consistency ratio (CR), is calculated using equation 3. Equations 1 and 2 were used to obtain the maximum eigenvalue (λmax), and the Consistency Index (CI) respectively.

The Random Index (RI) was obtained according to the Random Index Table (Table 2) which is based on several criteria (Saaty 1984)

Table 2: Random Index Table (Saaty 1984)

Matrix size (n)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Random Index (RI)	0.00	0.00	0.58	0.90	1.12	124	1.32	1.41
Matrix size (n)	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
Random Index (RI)	1.45	1.49	1.51	1.48	1.56	1.57	1.59	

$$\gamma max = Average\ (ws/wc) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{\textit{(1)}}$$

Where, λmax is the maximum eigenvalue.
Ws = Weighted sum
Wc = Weights of the criteria

$$CI = (\gamma max - n)/\ (n - 1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{\textit{(2)}}$$

Where n is the number of criteria.

$$\text{CR} = \text{CI/RI} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{\textit{(3)}}$$

The advantage of this method is in fact that only two criteria have to be considered at a time, it can be implemented in a spreadsheet environment, and it is incorporated into GIS-based decision-making procedures (Kirwood, 1997).

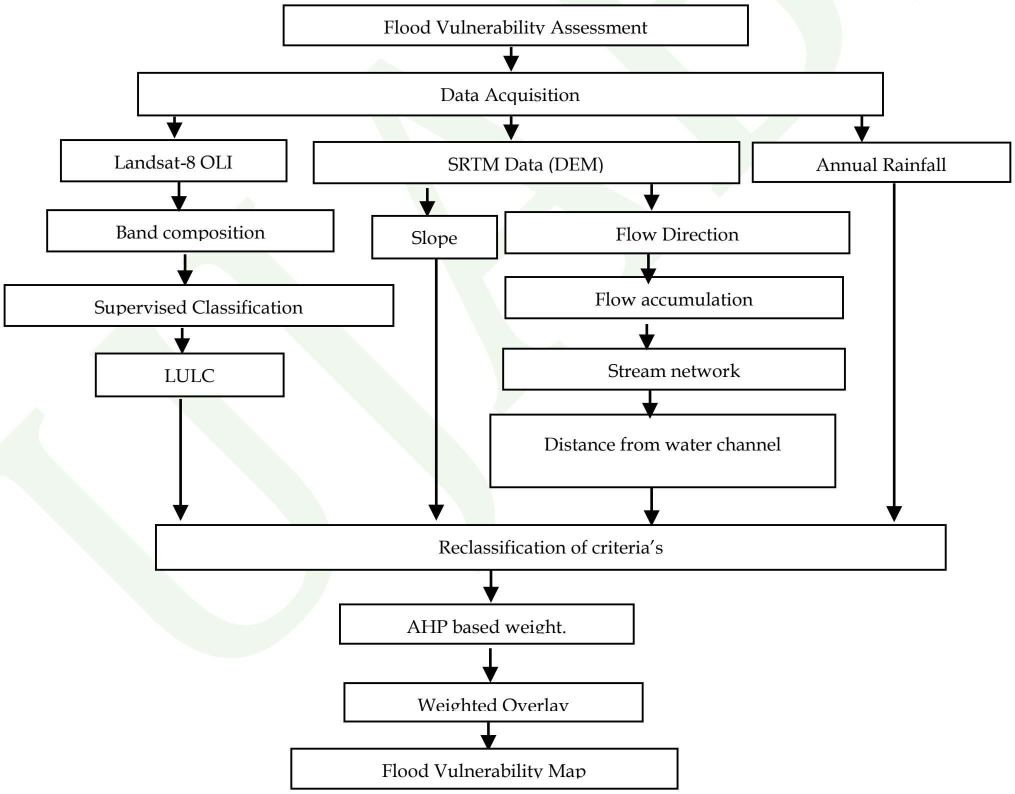


Figure 2: The flow chart for the Methodology. *Source: The Researcher, 2025*

3.0 RESULTS AND DISCUSSION

3.1 Results

To achieve the Objective of the study, hydrologic modeling tools in the ArcGIS Spatial Analyst extension toolbox were utilized. This involved analyzing the data using DEM to create Fill, flow direction, flow accumulation, and stream-to-feature to generate stream order networks. The flow direction shows the possible direction of water run-off on the elevation model. This analysis was performed using the flow direction tool in ArcToolbox Spatial Analyst tools. The image below, (Figure 3), is the resulting flow direction from a digital elevation model (DEM) of the study area. The blue color represents high elevation with 64 – 128m while the onion color represents steep areas with 1-2m shows that the low area receives a high amount of water, which will accumulate during a downpour.

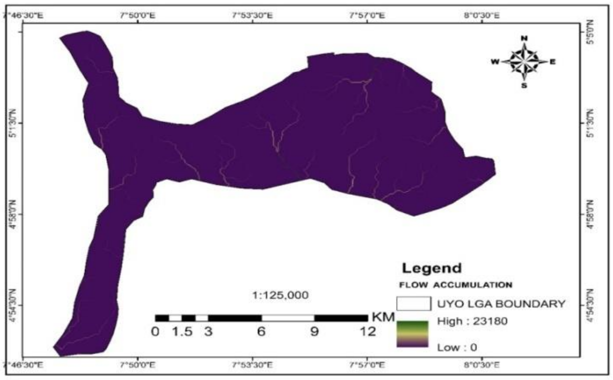


Figure 3: The flow direction

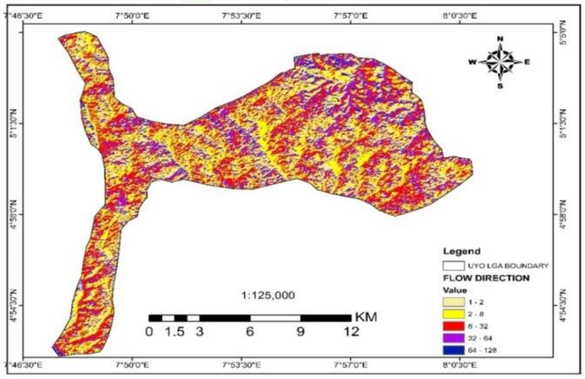


Figure 4: Flow accumulation

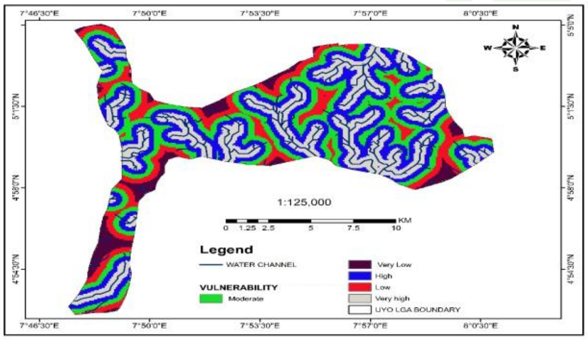


Figure 5: Drainage Network

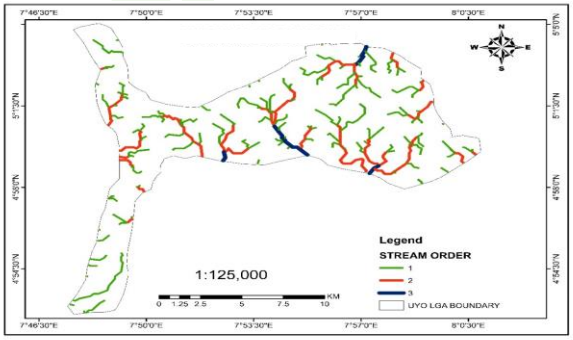


Figure 6: Reclassified Drainage Network Map

Source: (ASTAL, 2025)

Flow Accumulation is a raster of accumulated flow to each cell, as determined by accumulating the weight for all cells that flow into each downslope cell. Flow Accumulation analysis was performed to show the cells within the study area where water accumulates as it flows downwards. Thus, settlements around these cells will receive much water during an event of rainfall or any sudden release of water. A threshold value was applied to the results of the Flow Accumulation tool using Raster calculator tools. A stream network was created from a flow accumulation raster to show the path of streams on the elevation. Figure 4 and Figure 5 below are the resulting flow accumulation and stream network derived from a digital elevation model (DEM) of the study area. A drainage network is a connected set of surface-water drainage channels that are oriented in the downhill direction with the flow of water. It includes all the stream channels that drain toward a reference point. A drainage network begins with first-order streams to which no other stream is tributary. In the most used method of stream orders, a second-order stream begins at the junction of two first-order streams, and a third-order stream begins at the junction of two second-order streams, (Wohl, 2009). In the research work, the Strahler method of stream ordering was applied, and the 3rd order was established in the study area. Stream order only increases when streams of the same order intersect. Therefore, the intersection of a first order and second-order link will remain a second-order link, rather than creating a third-order link. (Strahler 1952) The results of the Flow Accumulation tool were used to create a raster stream network by applying a threshold value to select cells with a high accumulated flow. Three colors were used to present the numbers of the stream order, green represents order 1, red color order 2, and blue color order 3, and however, the map revealed that order 3 is the pour point of a basin in the study area, Figure 5.

Different criteria were prepared using remote sensing data and GIS techniques for the mapping of the flood zones. The layers considered for this analysis were the distance from the drainage network, slope, Annual rainfall, soil type, and land use land cover (LULC). They were reclassified into five classes and weights were attached to each according to their ability to encourage or reduce flooding (Shuaibu, *et al.*, 2022). Distance from the drainage network was carefully selected as a factor that contributes to flood hazards because areas close to water channels experience more frequent flooding than areas further away from rivers (Mahmoud and Gan, 2018). Euclidean distance analyses were carried out on the drainage network to determine the ranges of the vulnerable areas to the drainage system. It indicates that areas within 170m from the drainage network represent a very high vulnerability to floods, whereas areas within distances of 354m, 560m, and 1807m from the drainage network are considered to represent high, moderate, and low vulnerability to flood, respectively, Figure 6. Rainfall is a significant factor that plays a crucial role in creating a flood situation. Flood situations occur when surface runoff increases with increasing rainfall at that time river channel cannot cater to the extra load of water (Malczewski, 1999). The distribution of rainfall in the study area is increased moving to the Western side. The mean annual rainfall of the study area ranges from 4426mm to 4927 mm. The flood vulnerability increases with the increase in rainfall. Figure 7 shows the mean annual rainfall classes in the study area, which are very low (4426 –4573mm), Low (4573 - 4699mm) moderate (4699 - 4776mm), high (4776 - 4841mm), and very high (4841 – 4927mm). The western side and north-southern parts of the study area receive the highest mean annual rainfall. Rainfall values of (4841 – 4927mm), and (4776 - 4841mm), are concentrated in the western and north-southern increasing the chance of severe flood events in the region. However, the region is characterized by high slope angle and elevation. As such, all flood waters easily flow downstream to many parts of EkambaNsukkara and Idu community, putting them at a high risk of floods.

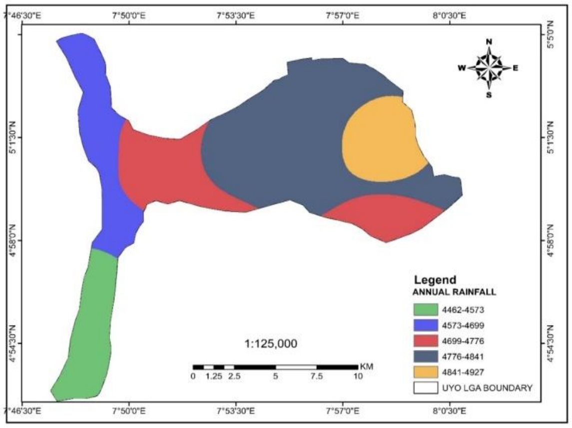


Figure 7: Reclassified Annual Rainfall

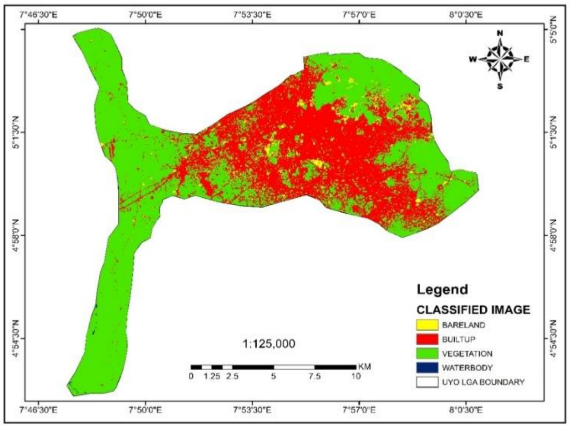


Figure 8: Land use/land cover

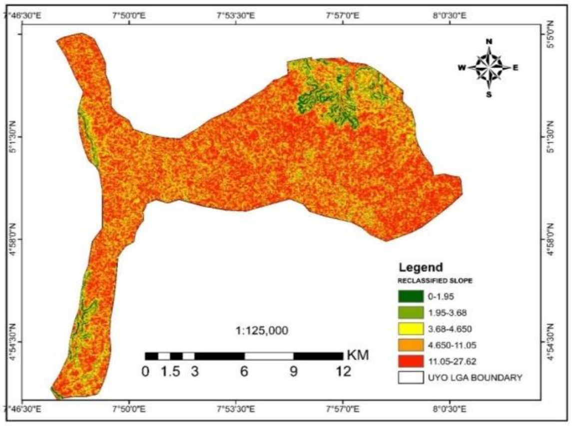


Figure 9: Slope

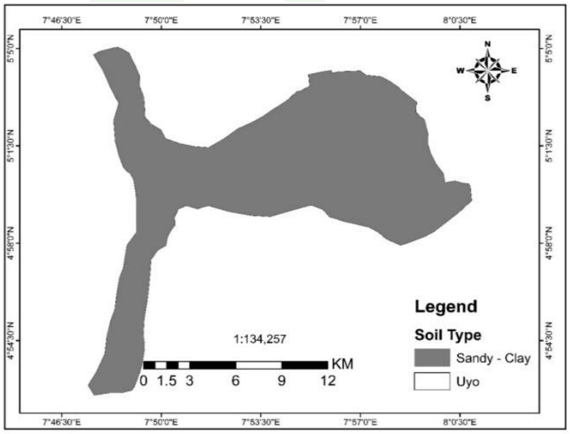


Figure 10: Soil Type

Source: (ASTAL, 2025)

Land use/land cover plays an essential role in pinpointing zones vulnerable to flooding. Urbanization growth such as residential areas and roads increase storm runoff generation. Bare lands tend to increase the erosion of soils and high runoff flow downstream of the watershed, whereas areas with high vegetation concentration generally have low potential for flooding, as vegetation enhances infiltration and decreases runoff generation (Ghosh and Kar, 2018). Figure 8 presents the land use map of the study area, which was classified into four classes: vegetation, bare land, built-up areas, and water bodies. The land use map shows that the area of water body is very highly vulnerable, bare land and built-up areas are high and moderate respectively while vegetation was low vulnerable. Community susceptibility is based on the terrain of the land especially the gradient of the slope. This has been an important factor in accessing vulnerability since this determines the flow of water (Kai, *et al*, 2012). The slope was considered one the highest influences on the pair-wise comparison for this analysis. The lower the slope value indicates flat terrain and the higher the slope value shows steeper terrain (Jensen, 2004). The output slope dataset of this analysis was calculated in degrees. A slope map is generated based on the contour line in Arc GIS. It was reclassified into five classes based on very high, high, moderate, low, and very low. Most of the study area falls under the slope category of less than 11.05-27.62°, which covered the highest percent of the total study area (Figure 9). The low degree of the slope has been assigned the highest weight, and a high degree of slope has been assigned the lowest weight. Soil was considered to be one of the important factors that contribute to flooding; the soil type determines the infiltration rate. The soil map of the study area is presented in Figure 10, showing one distinct soil type. Xanthic ferralsols represent sandy, clay, and silty soil and each soil has a percentage representation of 52.6% sandy, 39.5% clay, and 7.8% silty soil in the study area. The Xanthic Ferralsols soil represents moderate flood vulnerability because of its moderate infiltration rate (FAO-UNESCO 1974 and 1978).

3.2 AHP Table and Matrix Representation and Calculating Factor Weights and Overlaying Identified Suitable Sites

Flood vulnerability assessment involves a comparison of different options based on flood-causing parameters and their impacts. Different weights were assigned to all criteria. The larger the weight, the more critical the criterion is in the overall utility. The weights were developed by providing a series of pair-wise comparisons of the relative importance of factors to the vulnerability of pixels for the activity being evaluated. The procedure by which the weights were produced follows the logic developed (Saaty 1980) under the Analytical Hierarchy Process (AHP). Weight rates were given based on a pair-wise comparison 5-point continuous scale (Table 3). This pair-wise comparison was analyzed to produce weights that sum to 1. The factors and their resulting weights were used as input for the multi-criteria evaluation (MCE) module for the weighted linear combination of overlay analysis. According to Lawal and Akeem (2011), if the consistency ratio is less than or equal to 0.1, it signifies an acceptable reciprocal matrix. The consistency ratio of the study area indicated that 0.01 was acceptable. To combine all the layers to process overlay analysis, standardization of each data was set to a standard scale of 1, 2, 3, 4, 5 (value 1 = Very high, value 2 = high, value 3 = moderately, value 4 = low, and value 5 = very low).

The flood vulnerability maps in Figure 11, and Figure 12 were categorized into three levels of risk, namely low, moderate, and high. The green color represents areas that are low vulnerable with 3%, the yellow color in the map represents areas that are moderately vulnerable with 11.6% while the red color shows the areas that are highly vulnerable with 3.8%. However, the combination of moderate and high vulnerability zones occupies 15.4% of the total study area. This shows that Uyo is highly prone to flood whenever there is excessive rainfall as it contributes the highest influence (33.8%) in this research. The study also indicated that floods have severely affected the communities in the area, such communities are (Table 4), Effiat Ikot Edo, Atan Usun Effiat, Anan, AfahaIdoro, Use Ikot EbioIkotNsung, and Mbiabong Ikot Essien areas are highly and moderately Vulnerable respectively. While Uyo village Offot, Ibiaku, AnuaOffot, Use Mbak, Ata Nsukara, and EwetOffot are moderately and low vulnerable. Therefore causing serious damage to homes, agricultural land, businesses, and infrastructure. This disruption has led to economic hardship and posed a significant threat to public safety, particularly on major roads in the Uyo metropolis, where excessive rainfall and poor water channels exacerbate the situation.

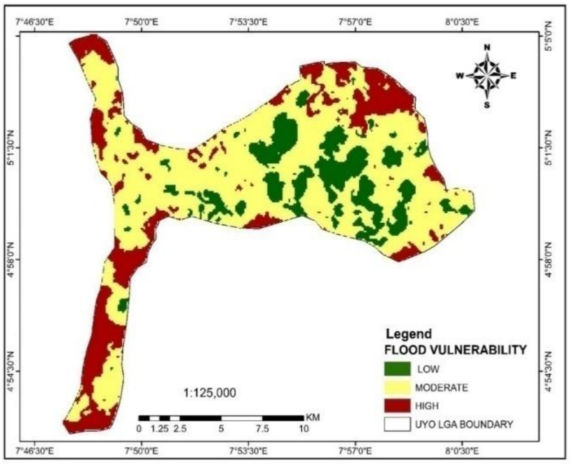


Figure 11: Vulnerability map

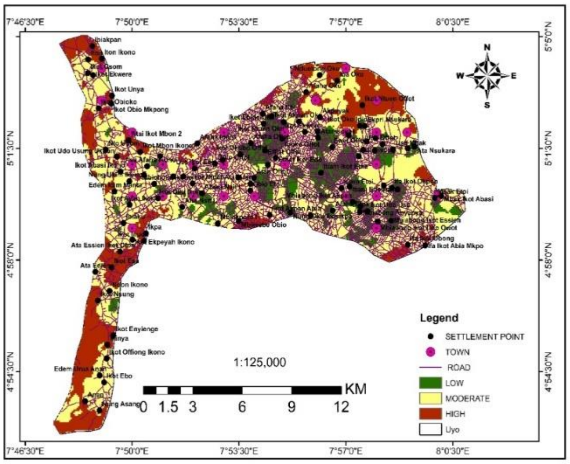
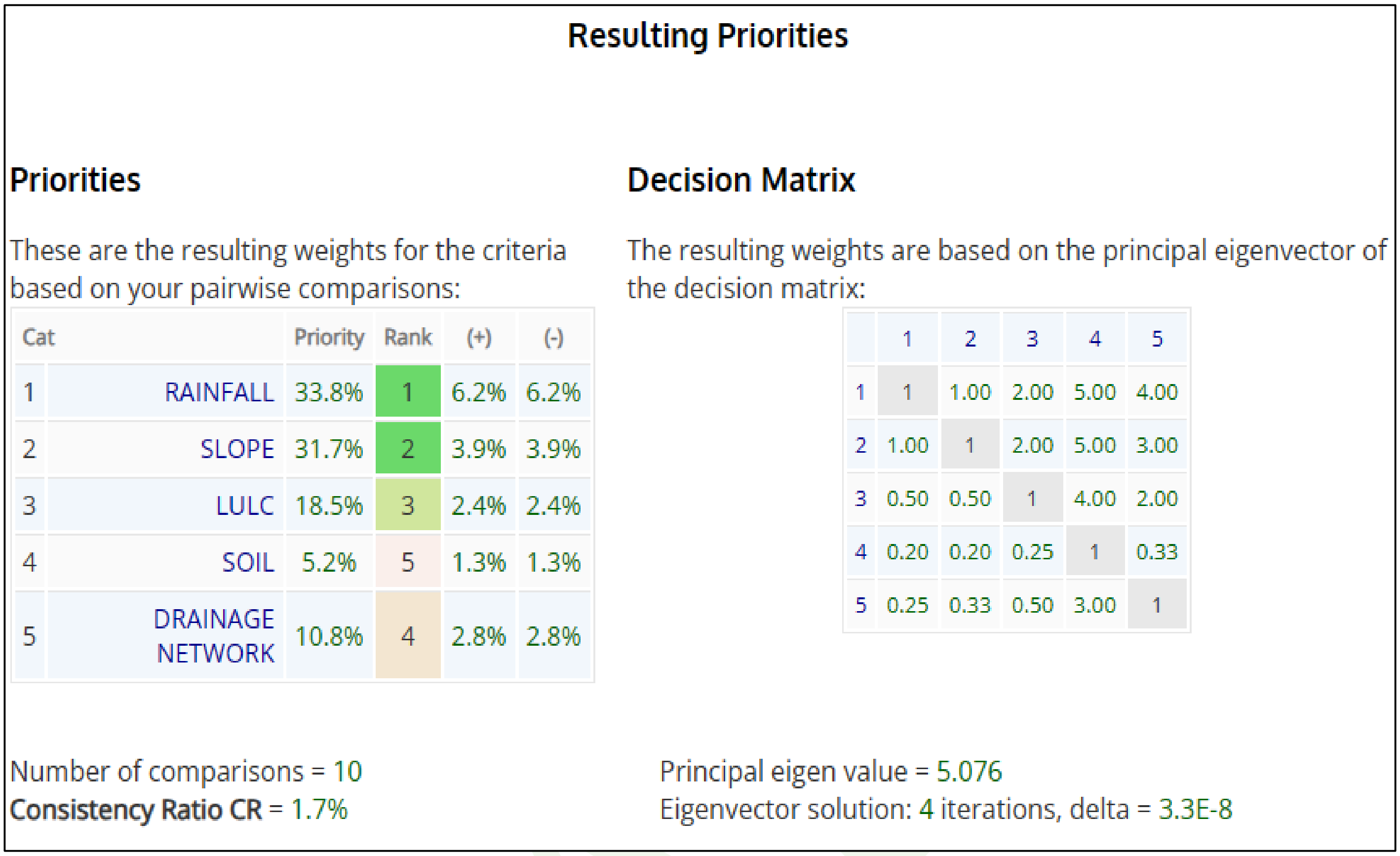


Figure 12: Impact of Flood risk map

Source: (ASTAL, 2025)

Table 3: Pairwise comparison table for Weighted Overlay

S/N	Criteria	Unit	Classes	Susceptibility range and rating	Class Range	Weight Influence %
1	Lulc	level	Waterbody Built-up areas Bare land Vegetation	Very High High Moderate Low	1 2 3 4	18.5%
2	Slope	degree	<1.19 1.19 – 3.68 2.68 – 4.65 4.65 – 11.05 11.05-27.62	Very High High Moderate Low Very low	5 4 3 2 1	31.7%
3	Rainfall	mm	4426–4573 4573-4699 4699-4776 4776-4841 4841–4927	Very low Low Moderate High Very High	5 4 3 2 1	33.8%
4	Distance from the drainage network	m	<170 170– 354 4354 – 560 560 – 822 822 - 1807	Very High High Moderate Low Very low	1 2 3 4 5	10.8%
5	Soil Type		Sandy - clay	Moderate	3	5.2%



Resulting Priorities

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	RAINFALL	33.8%	1	6.2%	6.2%
2	SLOPE	31.7%	2	3.9%	3.9%
3	LULC	18.5%	3	2.4%	2.4%
4	SOIL	5.2%	5	1.3%	1.3%
5	DRAINAGE NETWORK	10.8%	4	2.8%	2.8%

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5
1	1	1.00	2.00	5.00	4.00
2	1.00	1	2.00	5.00	3.00
3	0.50	0.50	1	4.00	2.00
4	0.20	0.20	0.25	1	0.33
5	0.25	0.33	0.50	3.00	1

Number of comparisons = 10
Consistency Ratio CR = 1.7%

Principal eigen value = 5.076
Eigenvector solution: 4 iterations, delta = 3.3E-8

Figure 13: The Resulting Comparison Matrix for flood criteria. ***Source: (ASTAL, 2023)***

Table 4: Level of Vulnerability zone, Areas, and Area percentage of the flood vulnerability area.

S/no	Vulnerability level	Areas Coverage (Sqm)	Areas Coverage in Percentage (%)	Communities covered
1	High	3878.90	20.99	Ikot NsungAnan,IkotNtuenOffot and AfahaIdoro
2	Moderate	11596.6	62.75	Mbiabong Ikot Essien, Effiat Ikot, Atan Usun Offot, AnuaOffot, and IkotEkkonOffot
3	Low	3004.97	16.26	EwetOffot, Use Mbak, Atai Eniong, Ata Nsukarra, Itiam Ikot Ebia, IbokoOffort and Ataniyosak etc.

3.3 Identification of Factors Responsible for Flooding in the Study Area.

The set of spatial analyzing information system criteria and factors responsible for flooding and that could be used as solutions to mitigate flood vulnerability in the study area were identified based on different literature reviews (Ologu-Marisa, *et al* 2005, Olaseha, *et al* 2004), and relevant expert knowledge were identified as: Hydrological factors, Waste management factors, Institutional factors.

4.0 CONCLUSION

The study identified and visualized flood prone areas by creating flood hazard and control zones in Uyo LGA and has expounded the importance and usefulness of GIS in flood risk management. The identifications guided in implementing of nonstructural flood control measures to prevent flood menace in the study area. In the process, several analyses and models were performed on flood causative using Arcmap 10.4, Landsat-8 OLI, DEM and GIS software. The making available spatial information for future references. A combination of the stream network, rainfall data and the slope of the area were used in developing flood vulnerable zones for Uyo LGA. Three zones were specified: high, moderate and low flood vulnerable zones. It was concluded from this study that annual rainfall, land cover and high slope angle and elevation play a vital role in increasing the vulnerability of the area to flooding, the supervised classification of Landsat imagery, accumulated rainfall data and Arcmap GIS showed the percentage changes all in form of the reduction in vegetation cover in the area to increase surface runoff and possible overflow of low-lying areas and flood vulnerability increases with increase in rainfall. The physical properties of the areas also contribute to increase or decrease in surface runoff.

Furthermore, it was concluded that the factors that influence flooding significantly in this region are population explosion and urbanization. Significant growth in population over the years resulted to increased human activities and environmental degradation (vegetation lose and deforestation) therefore the vulnerability of the area to flooding is significantly increased. Non-structural control measures provided sustainable flood control decisions and support that balance social, economic, and environmental development wellbeing of the populace using Geographic Information Systems. These measures were introduced to control flood as structural measures alone could not tackle flood problem in Uyo capital city.

REFERENCES

Adamu, B., Buba, M. O., Nguh, B. S., Yengeh, M. J. C., & Zeh, A. F. (2025). Urban Drainage Systems and Implications on the Inhabitants and Physical Environment of Buea Urban Area, South West Region of Cameroon. _Journal of Environmental and Geographical Studies_, _4_(1), 61–88. https://doi.org/10.58425/jegs.v4i1.340

Aderibigbe, K. A., Akankpo, J. O., and Adeyemo, A. O. (2022). Flood hazard assessment and mapping using geospatial information system (GIS) in Abeokuta, Nigeria. *_Journal of African Earth Sciences_, 191, 104591.

Ahuchaogu, I. I., Ewemoje, T. A. and Etim, I. (2019). Best Probability Distribution for Rainfall Analysis Suited for University of Uyo, Ikpa Watershed of Akwa Ibom State, Nigeria. _International Journal of Engineering Research & Technology. Vol. 8 Issue 09_, Pp 556 – 565. Paper id IJERTV8IS090133. http://www.ijert.org. ISSSN: 2278 – 0181.

Akintoye, O. S., and Oloke, T. A. (2021). Assessment of flood hazard and vulnerability of coastal communities in Nigeria using geospatial techniques. _Geo-spatial Information Science_, 24(2), 255-268.

Akwa Ibom State Ministry of Environment. (2019). Annual Report on Environmental Impact Assessment.

ASTAL. (2025). Geographic Information Systems (GIS) and flood hazard modeling: A comprehensive guide. ASTAL Publishing.

Behanzin, M. and Thiel, J. S, (2016) GIS-based mapping of flood vulnerability and risk in the Bénin Niger River Valley *International Journal ofGeomatics and Geosciences Year: 2016, Volume: 6, Issue: 3*

Beven, K. J. (2018). Rainfall-runoff modelling: The philosophy of simplification versus complexity. *Water Resources Research*, 54(12), 9842-9868.

Birkmann, J., and Cardona, O. D. (2001). Integrating disaster risk management and climate change adaptation: Experiences from research and practice. *United Nations Environment Programme (UNEP*).

Chow, V. T., Maidment, D. R., and Mays, L. W. (1988). Applied Hydrology. McGraw-Hill.

Essien E. E., Unigwe-Idoko O. C., and Nwabueze I. O. (2018). Flood Risk Assessment in Uyo Urban, Nigeria using Geospatial Tools. *International Research Journal of Engineering and Technology*, 2018, 5(6): 603-609

Ezeh, E. C., and Ezeomedo, V. C. (2020). Flood risk mapping of Ibadan metropolis, Nigeria using geospatial technologies. *Journal of Environmental Management*, 270, 110830.

Fletcher, T. D., Shuster, W., & Butler, D. (2015). Stormwater management in urban areas. John Wiley & Sons.

Hallegatte, S., Ranger, N., Mestre, O., Dumas, P., Corfee-Morlot, J., Herweijer, C., and Wood, R. M. (2011). Assessing climate change impacts, sea level rise and storm surge risk in port cities: a case study on Copenhagen. *Climatic change*, *104*, 113-137.

Hsu, M.-H., Chou, Y.-J., and Chen, S.-H. (2022). Flood mitigation strategies for urban drainage systems: *A review. Water*, 14(14), 2104.

Ibe, K ., Igbokwe, J.I ., Oliha, A.O ., Ezeh, F.C (2024). Flood Vulnerability Assessment of AWKA South LGA in Anambra State Using Flood Simulation Model. International Journal of Engineering Research and Development e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com Volume 20, Issue 11 (November, 2024), PP 34-47

Jensen, J. R. (2004). *Introductory digital image processing: A remote sensing perspective* (3rd ed.). Prentice Hall.

Jiang, W., Shen, Z., and Chen, W. (2023). A review of recent advances in wastewater management using green infrastructure. *Journal of Environmental Engineering*, 149(3), 03123012.

Kai, S.A, Masoud B, Soodabeh P, and Wan N. A., (2012). An artificial neural network model for flood simulation using GIS. Johor River Basin, Malaysia. Enviro. *Earth Sci, 67,251-264.*

Kirkwood, (1997). Strategic Decision Making; Multi-objective Decision Analysis with Spreadsheets. An evaluation of Waste Control Measures in the Construction Industry in Nigeria

Lawal A.B, and Akeem F.L (2011). An evaluation of Waste Control Measures in the Construction Industry in Nigeria.

Li, H., Wang, Y., Luo, Y., Jiang, C., and Yang, Z (2024). Constructing an Efficient Health Assessment Model for Drainage Network to Evaluate the Drainage Network in Zone A of Zhenjiang City. MDPI, *Processes* 2024, *12*(3), 586; https://doi.org/10.3390/pr12030586

Madusanka, S., Abenayake, C. Jayasinghe, A and Perera, C. (2022). A Decision-Making Tool for Urban Planners: A Framework to Model the Interdependency among Land Use, Accessibility, Density, and Surface Runoff in Urban Areas. *Sustainability* **2022**, *14*(1), 522; https://doi.org/10.3390/su14010522

Malczewski, J., Rinner, C., and Zhiyong, L. (1997). GIS-based approach for participatory decision making and land suitability assessment. *Geographical Information Science*, 15(2), 200-211.

Malczewski, J. (1999). *GIS and multicriteria decision analysis*. John Wiley & Sons.

Malinay, G.L.C., Samieto, G. A. M. B, and Sanson, D. B. (2024). A Review of Approaches to Drainage system management: current status and future research direction. https://www.researchgate.net/publication/378001252

Mahmoud, S.H and Gan, T.Y. (2018) multi-criteria approach to developing flood susceptibility maps in arid regions of the Middle East. *J. Clean. Prod*. 2018, 196, 216–229

Mishra, H. S., Bell, S., Wilczyriska, A. and Balicka, J. (2024). Urban wetlands and storm water management. https://www.researchgate.net/publication/354302267

National Population Commission (NPC). (2006). *Population and housing census of the Federal Republic of Nigeria: Latitude and geographic information*. NPC Publishing.

Nwafor, C. A., Abia, A. A., and Akpabio, E. J. (2010). Assessment of the Impact of Flooding on Agriculture in Uyo, Akwa Ibom State, Nigeria. *Journal of Environmental Management, 276, 111275.*

Olaseha, O. O., Adekunle, O. M., and Shittu, O. K. (2004a). Flood problems in Ibadan, Nigeria: Causes and solutions. In Proceedings of the 3rd International Conference on Sustainable Development, 1, 573-580.

Ologu-Marisa, G. U., Oti, E. E., and Edem, V. E. (2005). Flood vulnerability assessment of Uyo Local Government Area, Akwa Ibom State, Nigeria. *International Journal of Disaster Prevention and Management*, 14(1), 59-68.

Oloke, T. A., Adedeji, K. A., Olatunde, O. E., and Oketola, O. J. (2022). Flood hazard assessment and mapping using geospatial techniques in Lagos, Nigeria. Modeling Earth Systems and Environment, 1-13.

Onoduku, U. P., Adeyemo, A. O., and Oloke, T. A. (2020). Flood risk assessment and mapping using geospatial techniques in Lokoja, Nigeria. **Geoinformatics, Geostatistics and Geospatial Information Management*, 4(1), 1-15.

Onyegbule, C. L., Mbong, E. O., Ogbemudia, F. O. and Anwana, E. D. (2025). Seasonal variation in meteorological parameters and atmospheric oxides around Eket wetlands, Akwa Ibom State, Nigeria: Environmental and public health implications. FUDMA Journal of Sciences (FJS), Vol. 9 No. 6, June, 2025. Pp 57 – 63.DOI: https://doi.org/10.33003/fjs-2025-0906-3716

Orovwuje, P. N., Ogidi, O. S., and Ologun, O. S. (2019). Application of GIS and Remote Sensing in Flood Assessment and Mitigation: A Case Study of Delta State, Nigeria. *Nigerian Journal of Technology*, 38(1), 184-192.

Saaty, T.L. (1984). The Analytic Hierarchy Process: Decision Making in Complex Environments.

Saaty, T.L., (1980). The analytic hierarchy processes. New York: Mc Graw Hill.

Shuaibu, A., Ibrahim, M. Y., and Bello, I. (2022). *Flood risk assessment using GIS and remote sensing in Northern Nigeria*. *Journal of Environmental Science and Technology*, 15(3), 120-135. https://doi.org/10.1016/j.jenvsci.2022.05.007.

Strahler, A. N. (1952). *Dynamic basis of geomorphology*. Geological Society of America Bulletin, 63(9), 923-938. https://doi.org/10.1130/0016-7606(1952)63 [923: DBOG]2.0.CO;2

The FAO-UNESCO (1978) Soil Map of the World at 1:5 000 000 scale. 1974 and 1978.

Udoimuk, U. U. (2018). Urban Expansion and Land-Use Transformation in Uyo Metropolis, Nigeria. *Geographical Journal*, 7(1), 1-13

Ukpong I. E and Udofia E. P (2009). Domestic Solid Waste Management in a Rapidly Growing Nigerian City of Uyo. *int. j. geographical information science, 2001, vol. 15, no. 2, 129± 151Research Article*

Umoh, J. I., Brendan, M. P. (2025). Floods and Public Health Concerns in Uyo LGA, Akwa Ibom State, Nigeria. Public Health Epidemiol OA, 1(1), 01-07

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). At risk: Natural hazards, people's vulnerability and disasters. Routledge.

Wohl, E. E. (2009). Of rock and rivers: Seeking a sense of place in the American West. Univ of California Press.

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