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# Assessment of Flood Vulnerability in Egor Local Government Area, Edo State Using Analytical Hierarchical Process (AHP) Model

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**Abstract.** Floods are entirely natural disasters caused by a variety of fundamental factors, the most common of which are climatological in character. However, human misuse or exploitation of the environment is also a major contributing factor. Floods are regarded as the world's worst natural disaster which motivates this research. This research aims to investigate the flood vulnerability in Egor local government area of Edo state by integrating the Analytical Hierarchy Process (AHP) and remote sensing/GIS to derive a flood vulnerability map of Egor local government area. In this research seven parameters elevation, slope, drainage density, soil type, distance from streams, rainfall and land use and land cover were considered and their weight of importance were determined from pairwise comparison using the responses of professionals in the area of flood modelling and geoinformatics. Multiple sources of secondary data like 30M resolution Landsat 9 (Band 8 Panchromatic 0.503 – 0.676) satellite data derived from United States Geological Services (USGS), Tropical Rainfall Measuring Mission (TRMM) as well as other primary data gotten from response of questionnaire administered. The resulting map was classified into five levels of flood vulnerability and the communities were characterized according to their level of vulnerability. Findings showed that the villages Ogunwenyi, Obanyotor, Ogboyoko, Useh and Oghoghugbo were all classified under highly vulnerable to flooding. Although, Ugbowo and Oghoghugbo are not threatened at the moment but projection shows that they may become threatened if the conditions contributing to flooding are not appropriately managed. This research offers an approach that is very useful in flood management and mitigation. It also creates avenue for land planners and policy makers to know the areas that are projected to suffer from flooding and those that are less threatened which preventive measures can be developed against these challenges. The vulnerability model produced in this work should serve as a guide to policy makers, and planners for appropriate managements of flood events and initiation of enlightenment programs to citizens on sustainable ecological land conservation.

**Keywords:** Flood vulnerability mapping, Analytic Hierarchy Process (AHP), Remote sensing and GIS, Land use/land cover, Landsat 9

## 1. Introduction

Flooding, defined as the temporary inundation of normally dry land due to the overflow or accumulation of water (UNISDR, 2004), is recognized as the most frequent and economically damaging natural hazard globally (Galy and Sanders, 2002; Mukoro et al., 2015). In Nigeria, flooding has become a persistent environmental challenge, driven by heavy rainfall, deforestation, rapid urbanization, poor drainage systems, and unregulated land development (Ehiorobo and Izinyon, 2011; Komolafe et al., 2020). Egor LGA, located within the Benin City metropolis, experiences recurrent flooding that results in destruction of infrastructure, displacement of residents, traffic disruption, and loss of lives and livelihoods.

The primary aim of the study is to contribute to disaster vulnerability reduction in Nigeria's South–South geopolitical zone by assessing and spatially delineating flood-prone areas in Egor LGA through a GIS-based AHP model. The specific objectives are to determine the relative weights of flood vulnerability parameters, generate a flood vulnerability map using graphical modelling techniques, and assess the level of vulnerability of villages within the study area. Previous flood studies in Nigeria have often relied on limited parameters such as rainfall or elevation, resulting in incomplete vulnerability assessments (Ehiorobo and Ogirigbo, 2013). This study addresses that gap by adopting a multi-criteria decision-making approach that integrates expert judgment and spatial analysis.

Seven flood-conditioning parameters are elevation, slope, drainage density, soil type, rainfall, land use/land cover, and distance from streams were selected based on their proven influence on surface runoff, water accumulation, and flood extent (Ouma and Tateishi, 2014; Komolafe et al., 2020). The relative importance of these parameters was established using the Analytical Hierarchy Process developed by Saaty (1980), which employs pairwise comparisons to generate consistent and transparent weighting schemes. Primary data were obtained through AHP-designed questionnaires administered to hydrologists, GIS analysts, environmental scientists, surveyors, and urban planners, while secondary data were sourced from satellite imagery and geospatial databases. The weighted parameters were integrated in a GIS environment to produce a flood vulnerability map, which was subsequently overlaid with village locations to determine localized vulnerability levels.

The study is justified by the urgent need for proactive flood management and climate adaptation strategies in flood-prone regions of Nigeria, particularly in the South–South zone characterized by high rainfall and rapid urban growth (Berezi et al., 2019; Cirella et al., 2019). The findings provide a decision-support tool for policymakers, urban planners, and disaster management agencies such as NEMA, enabling targeted interventions, improved emergency routing, and sustainable land-use planning. Although the study focuses primarily on spatial and physical determinants of flooding, it recommends the integration of socio-economic variables in future research to achieve a more comprehensive flood vulnerability assessment.

## 2. Methodology

To determine flood-prone locations in Egor LGA, this study combines spatial analysis in GIS with a structured multi-criteria decision method which is the modern Analytic Hierarchy Process (AHP). The workflow integrates remotely sensed and vector datasets, expert judgments (AHP questionnaires), and raster algebra to produce a flood vulnerability index and map. All geospatial processing (digitization, reprojection, clipping, resampling and raster calculations) was performed in ArcGIS Desktop / ArcGIS Pro, QGIS and ENVI; AHP numeric computations and pairwise matrices were calculated in Microsoft Excel after converting expert qualitative assessments to crisp numeric values. The methodology workflow is presented in figure 1.

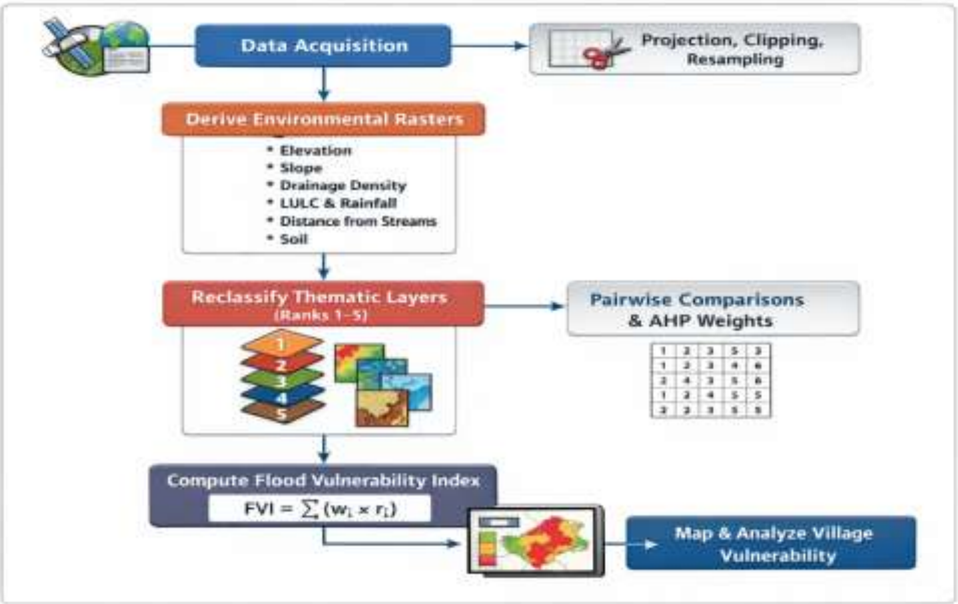


***Figure 1:*** *Flood Vulnerability Map workflow using GIS and AH/PP*

## 2.1 Study Area

Egor Local Government Area (LGA), created in 1991 from the larger Benin City metropolitan area under the Ibrahim Babangida administration, is headquartered in Uselu and is one of the Bini-speaking LGAs in Edo State (Edo State Government, 2020). The LGA lies approximately between Northings 677500–710000 m and Eastings 115000–130500 m on the UTM grid Zone 31N (Ebohon and Ebohon, 2021) and covers an estimated land area of about 93 km² (NPC, 2006). It comprises communities including Obanyotor, Useh, Uwelu, Evengie, Ogboyoko, Ogunwenyi, Evbogida, and Oghoghugbo and is predominantly inhabited by the Bini people with minority Esan, Yoruba and Igbo groups (Aigbe et al., 2004). The 2006 National Population Census recorded 340,287 residents, with the National Bureau of Statistics projecting growth to approximately 502,700 by 2020 at an annual rate of 2.5% (NPC, 2006; NBS, 2020). Topographically, Egor is characterized by low-lying plains and gentle slopes drained mainly by the Ikpoba River and its tributaries, and underlain largely by red clay and loamy soils that influence infiltration and runoff (Ologunorisa and Abawua, 2005). Climatically the area falls within the Tropical Savannah zone with a rainy season from April to October and a dry season from November to March, mean annual temperature near 28 °C, and annual rainfall between about 1,524 mm and 2,032 mm (NIMET, 2019; Komolafe et al., 2020). Egor LGA shares boundaries with Oredo LGA to the north, Ikpoba-Okha LGA to the east, Ovia South-West LGA to the south and Uhunmwonde LGA to the west (Edo State Ministry of Lands and Survey, 2021). The study area 2D map is shown in figure 2.

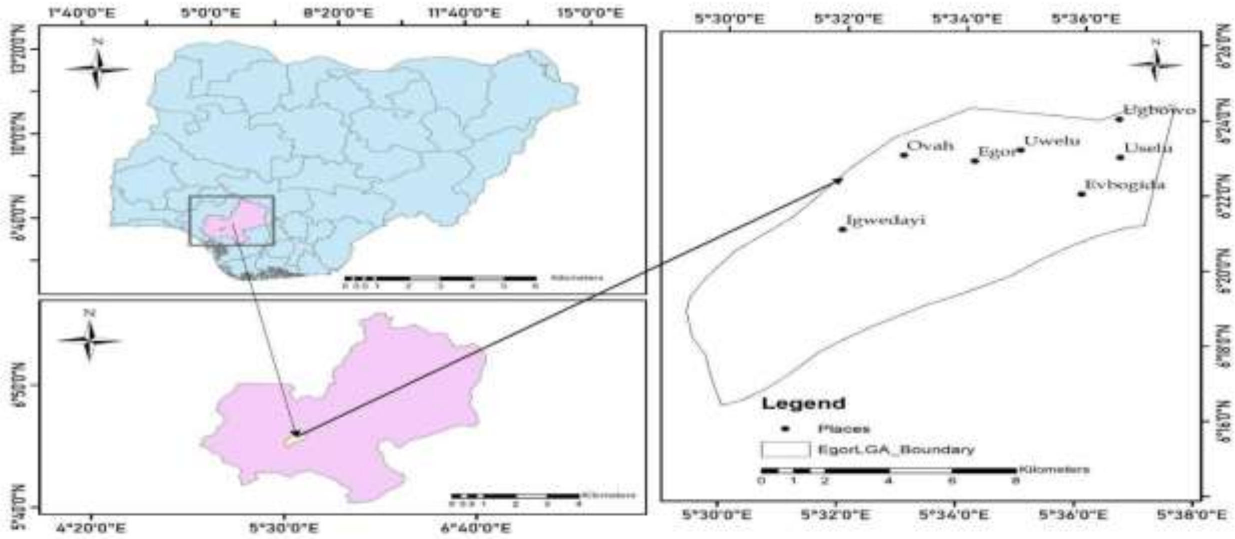


*Figure 2: Study Area Map*

## 2.2 Data Acquisition and Datasets

A multi-source dataset was compiled to represent the physical and meteorological controls on flooding in Egor LGA. Key datasets and their roles are summarized below in table 1.

**Table 1:** Summary of Derived Datasets

| Dataset / Source | Resolution / Type | Provider / Institution | Purpose / Derived Map or Use |
|---|---|---|---|
| SRTM DEM | 30 m (1-arc second) raster | United States Geological Survey (USGS) | Derive Elevation, Slope, Flow direction and Drainage density maps |
| Landsat 9 (Band 8 Panchromatic 0.503–0.676 µm) | 30 m (multispectral/radiometric) | United States Geological Survey (USGS) | LULC classification (supervised maximum-likelihood) to identify built-up areas, vegetation, wetlands, bare land and water |
| TRMM rainfall (daily, 2020) | Interpolated to 30 m grid (kriging) | Tropical Rainfall Measuring Mission (TRMM) | Generate Rainfall distribution raster (spatial rainfall variability used in vulnerability modelling) |
| Soil map | Vector / polygon | Food and Agriculture Organization (FAO) / Nigerian Geological Survey (NGS) | Produce Soil type map and infer infiltration/drainage characteristics |

| Dataset / Source | Resolution / Type | Provider / Institution | Purpose / Derived Map or Use |
|---|---|---|---|
| Administrative boundaries / streams | Vector / shapefile | NASRDA / DIVA GIS | Delineate study area boundary, village locations and river/stream network (used to compute distance from streams) |
| Expert questionnaires (primary data) | Qualitative / AHP pairwise responses | Professionals in flood modelling and geoinformatics (hydrologists, GIS analysts, environmental scientists, surveyors, urban planners) | Provide AHP pairwise comparisons to calculate criterion weights for the flood vulnerability model |

## 2.3 Data Quality and Preprocessing

Landsat scenes selected had <10% cloud cover. Vector layers were checked for topology errors (slivers, dangles) and DEM voids. Coordinate reference system chosen: WGS 1984 UTM Zone 31N, enabling metric distance measures. All raster were resampled to a uniform 30 m spatial resolution to ensure layer homogeneity.

### 2.3.1 Preprocessing

All spatial datasets were first clipped to the Egor Local Government Area boundary to ensure consistency in spatial extent, after which they were reprojected to the WGS84 / UTM Zone 31N coordinate system where necessary. Resampling was then carried out to achieve a uniform spatial resolution of 30 m, using the nearest neighbor method for categorical datasets such as land use/land cover and soil, and bilinear interpolation for continuous datasets including the DEM and rainfall. To improve hydrological accuracy, DEM sinks were filled through hydrologic conditioning to enable the reliable derivation of flow direction and drainage density. Stream networks were subsequently extracted from the conditioned DEM using appropriate flow accumulation thresholds and were validated by comparison with existing hydrographic vector data. These preprocessing steps ensured spatial integrity and prepared all thematic layers for vulnerability ranking and integration.

*Environmental variable processing and derived maps*

### 2.4.1 Elevation and Slope

DEM source was from the SRTM 1-arc second (30 m). Elevation raster was clipped to Egor LGA, while Slopes were derived from DEM using standard slope algorithms (rise/run) and expressed in percent (%).

Lower elevations and low slopes were ranked as more vulnerable (prone to waterlogging) while steep slopes were ranked less vulnerable (yielding faster runoff).Figures 3a and 3b shows the slope and study area map.

Primary symbology

Classify

Field: VALUE

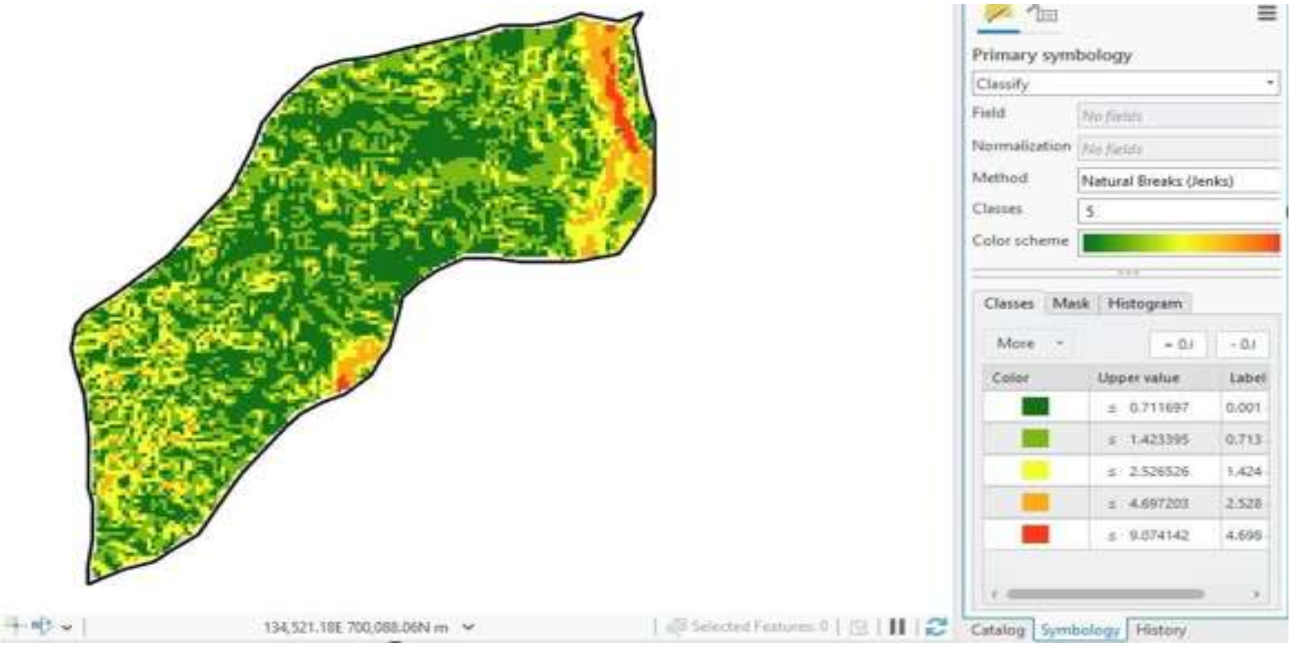
Normalization: <None>

Method: Natural Breaks (Jenks)

Classes: 5

| Color | Upper value | Label |
|---|---|---|
| ▨ | ≤ 59.0 | 36.001 |
| ■ | ≤ 74.0 | 59.001 |
| ■ | ≤ 86.0 | 74.001 |
| □ | ≤ 99.0 | 86.001 |
| □ | ≤ 122.0 | 99.001 |

*Figure 3a: Study Area Elevation Map*



Primary symbology: Classify
Field: No fields
Normalization: No fields
Method: Natural Breaks (Jenks)
Classes: 5

| Color | Upper value | Label |
|---|---|---|
| 🟩 | ≤ 0.711697 | 0.001 |
| 🟩 | ≤ 1.423395 | 0.713 |
| 🟨 | ≤ 2.526526 | 1.424 |
| 🟧 | ≤ 4.697203 | 2.528 |
| 🟥 | ≤ 9.074142 | 4.698 |

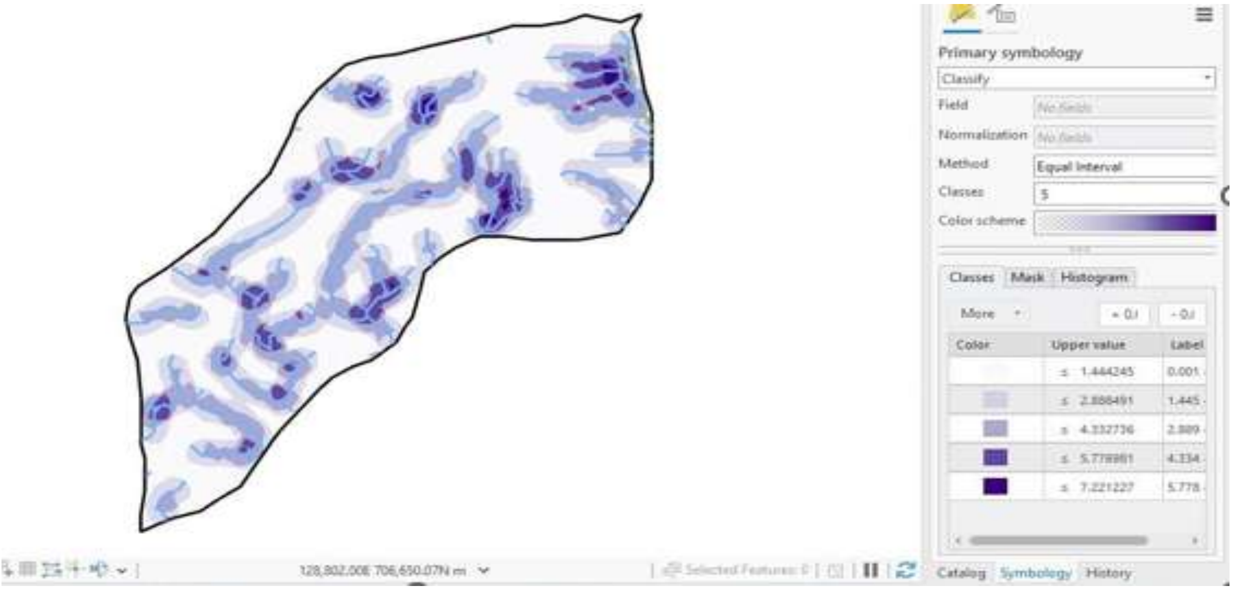
***Figure 3b:*** *Slope Map*

### 2.4.2 Drainage Density

Drainage density (Dd) = total length of stream channels (L) ÷ basin area (A).

$$D_a = \frac{L}{A} \qquad (1)$$

Drainage density was derived from Streams extracted from DEM flow accumulation; drainage density calculated per watershed/sub-catchment inside Egor LGA, and the raster reclassified. In this study, lower drainage density receives a higher vulnerability rank (because long inter-stream distances reduce rapid conveyance in some contexts), following the review of Ogato et al. (2020) and Wondim (2016).The drainage density map is displayed in figure 3c.



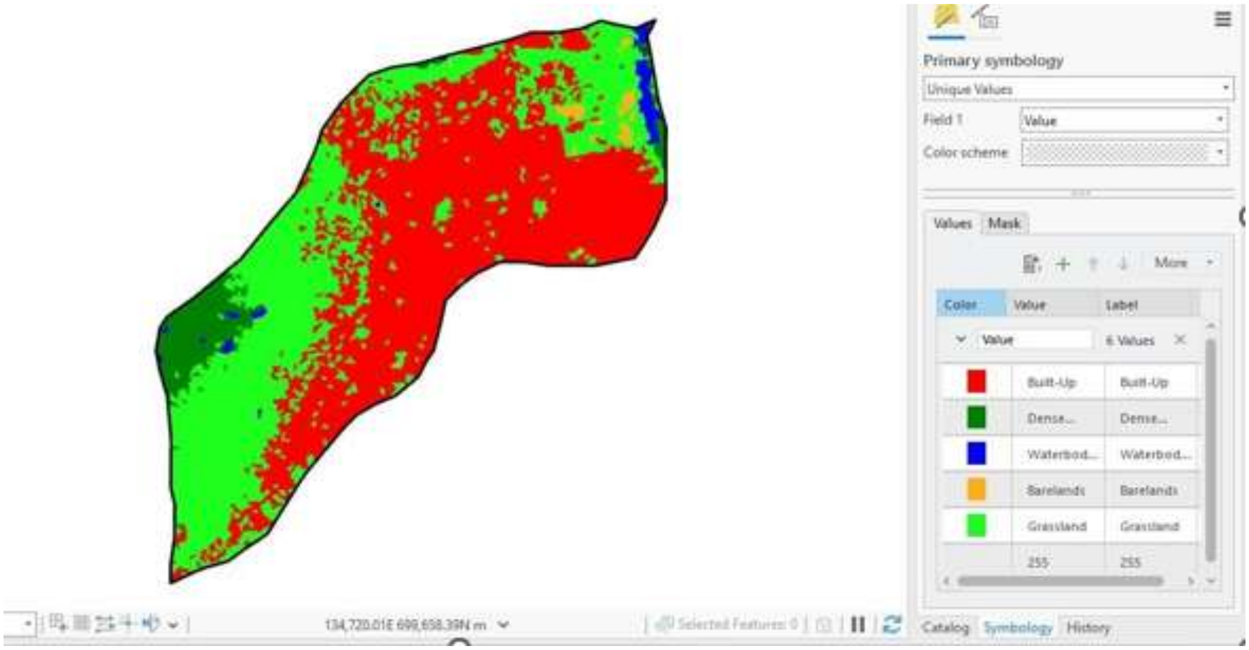
Primary symbology: Classify
Field: No fields
Normalization: No fields
Method: Equal Interval
Classes: 5

| Color | Upper value | Label |
|---|---|---|
| ⬜ | ≤ 1.444245 | 0.001 |
| 🟪 | ≤ 2.888491 | 1.445 |
| 🟪 | ≤ 4.332736 | 2.889 |
| 🟪 | ≤ 5.778981 | 4.334 |
| 🟪 | ≤ 7.221227 | 5.778 |

***Figure 3c:*** *Drainage Density Map*

### 2.4.3 Land Use / Land Cover (LULC)

Supervised classification (maximum likelihood) of Landsat 9 bands to produce LULC classes: dense vegetation, grassland, bare land, built-up/urban, wetlands/water bodies. Built-up areas were assigned highest vulnerability (impervious surfaces), while wetlands and dense vegetation had lower vulnerability. A 2D map is provided in figure 3d.



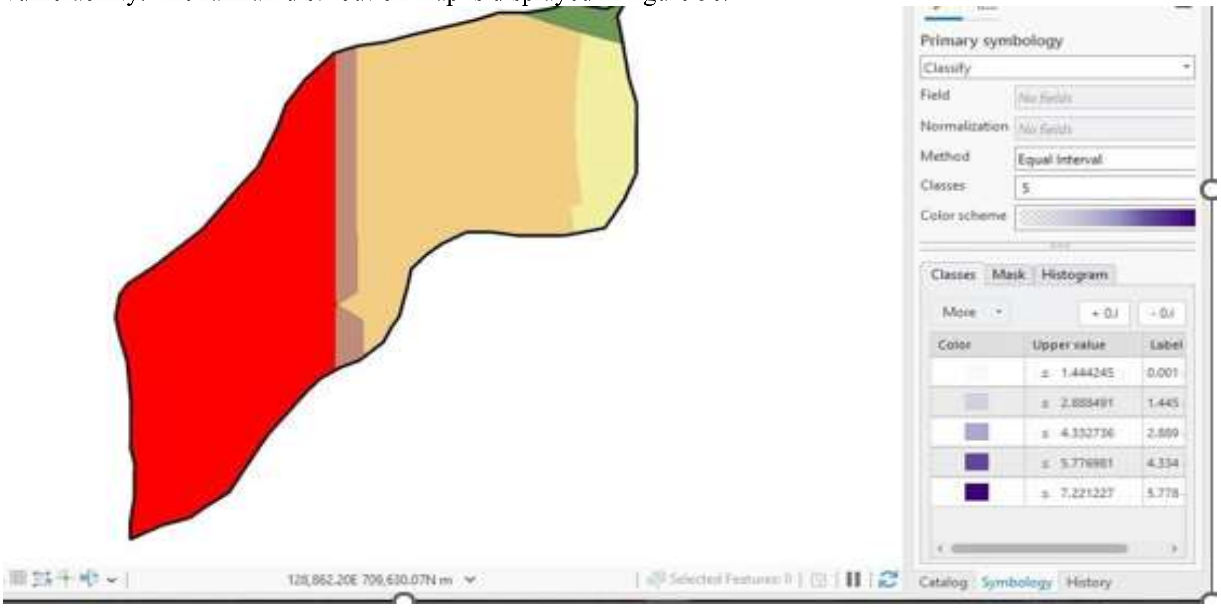
Primary symbology: Unique Values
Field 1: Value

| Color | Value | Label |
|---|---|---|
| 🟥 | Built-Up | Built-Up |
| 🟩 | Dense... | Dense... |
| 🟦 | Waterbod... | Waterbod... |
| 🟧 | Barelands | Barelands |
| 🟩 | Grassland | Grassland |
|  | 255 | 255 |

***Figure 3d:*** *Land Use and Land Cover Map (LULC)*

### 2.4.4 Rainfall Distribution

Data was obtained from TRMM daily rainfall reports for the year 2020). Interpolations were carried out using the Ordinary kriging to generate continuous rainfall raster across the Egor LGA. Reclassification was done by dividing the rainfall raster map into five classes representing increasing rainfall totals; higher rainfall classes assigned higher vulnerability. The rainfall distribution map is displayed in figure 3e.



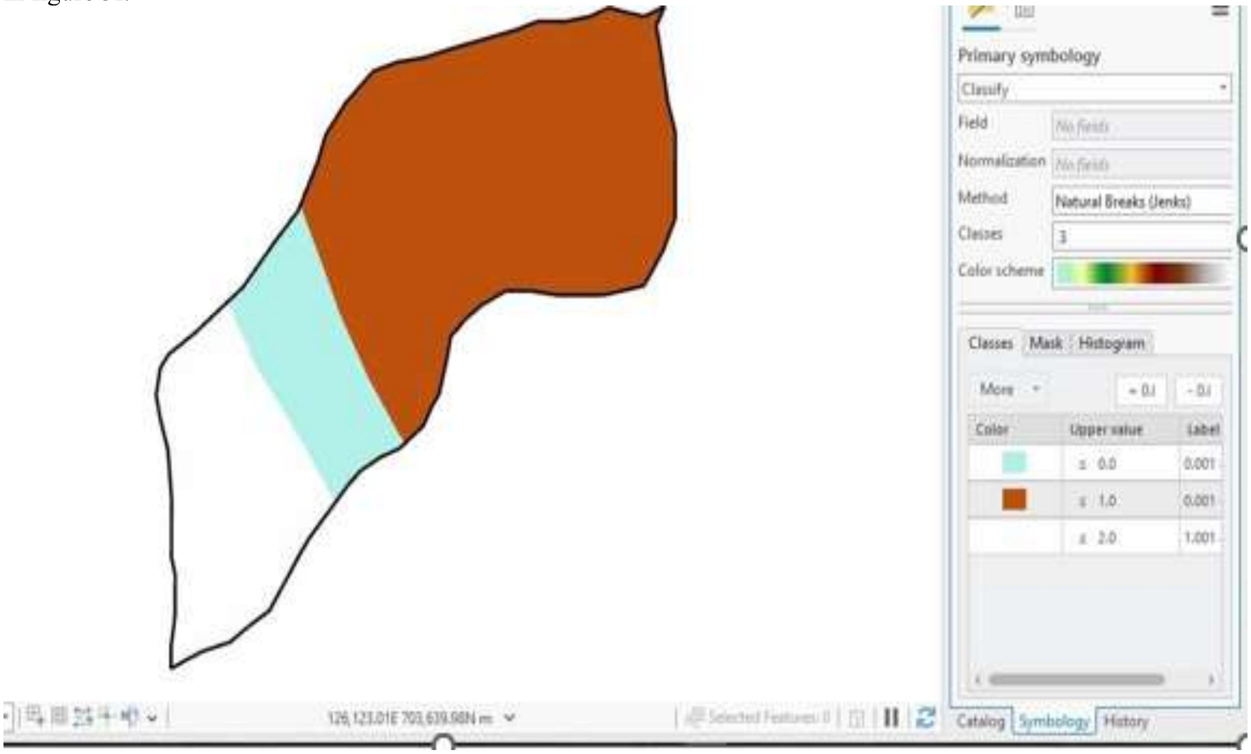
Primary symbology: Classify
Field: No fields
Normalization: No fields
Method: Equal Interval
Classes: 5

| Color | Upper value | Label |
|---|---|---|
| ⬜ | ≤ 1.444245 | 0.001 |
| ⬜ | ≤ 2.888491 | 1.445 |
| 🟪 | ≤ 4.332736 | 2.889 |
| 🟪 | ≤ 5.776981 | 4.334 |
| 🟪 | ≤ 7.221227 | 5.778 |

***Figure 3e:*** *Rainfall Distribution Map*

### 2.4.5 Soil Type

Soil map was derived from the FAO soil polygons. Soil textures and drainage classes were used to infer infiltration capacity. Poorly drained soils = high vulnerability while well drained soils = low vulnerability. A 2D map is presented in figure 3f.



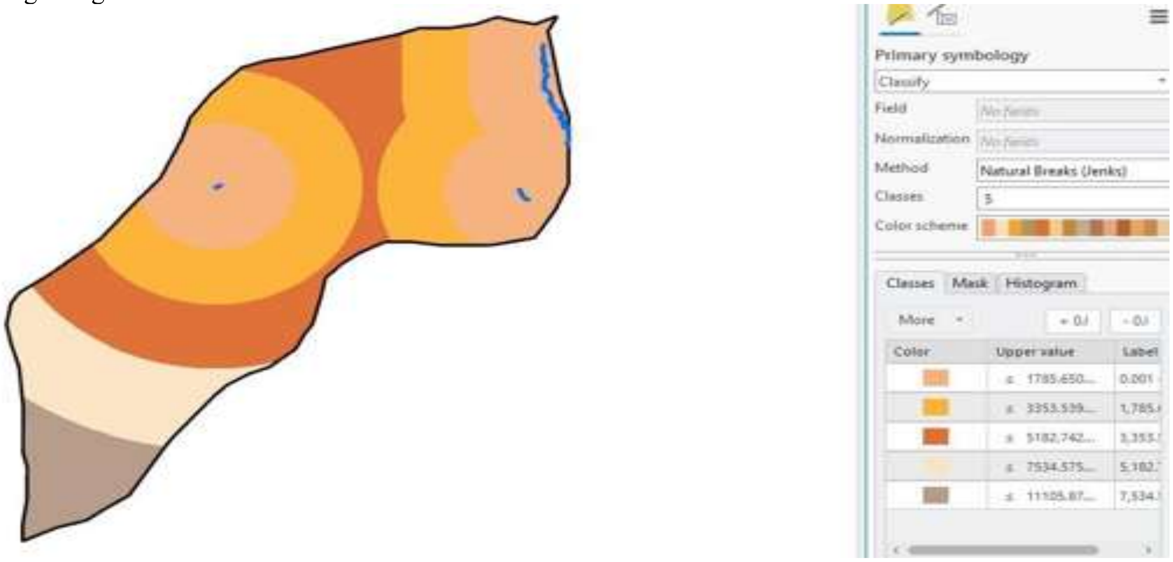
Primary symbology: Classify
Field: No fields
Normalization: No fields
Method: Natural Breaks (Jenks)
Classes: 3

| Color | Upper value | Label |
|---|---|---|
| 🟦 | ≤ 0.0 | 0.001 |
| 🟫 | ≤ 1.0 | 0.001 |
| ⬜ | ≤ 2.0 | 1.001 |

**Figure 3f***:* *Soil Type Map (reclassified)*

### 2.4.6 Distance from streams

The Euclidean distance raster method was computed from the river/stream vector network and
Interpretated Cells closest to streams received higher vulnerability ranks while farther cells received lower ranks as displayed in figure 3g.



Primary symbology: Classify
Field: No fields
Normalization: No fields
Method: Natural Breaks (Jenks)
Classes: 5

| Color | Upper value | Label |
|---|---|---|
| 🟧 | ≤ 1785.650... | 0.001 |
| 🟧 | ≤ 3353.539... | 1,785. |
| 🟧 | ≤ 5182.742... | 3,353. |
| ⬜ | ≤ 7534.575... | 5,182. |
| 🟫 | ≤ 11105.87... | 7,534. |

**Figure 3g***:* *Distance from streams raster*

### 2.5 Multi-Criteria Decision Making (AHP): theory and implementation

For this study, 10 experts in flood modelling and geoinformatics were consulted, of which only 8 met the desired criterion of AHP computations. AHP provides a structured means to convert expert qualitative judgments into numeric weights for each criterion. The implementation steps include pairwise comparisons, normalization, weight extraction, and consistency checks. The sequential execution is given below;

#### ***Define the Problem, Criteria and Importance Scale***

Begin by identifying the criteria relevant to the decision problem (e.g., slope, land use, distance to roads). The Analytic Hierarchy Process (AHP) uses Saaty's 1–9 fundamental scale to convert qualitative judgments into quantitative values, where 1 = equal importance, 3 = moderate importance, 5 = strong importance, 7 = very strong importance, and 9 = extreme importance, with 2, 4, 6, and 8 as intermediate values (Saaty, 1980). This scale ensures consistent numerical representation of expert opinions.

#### ***Construct Pairwise Comparison Matrices***

For each expert, construct an $n \times n$pairwise comparison matrix $P$, where each element $p_{ij}$represents the relative importance of criterion $i$ over criterion $j$using Saaty's scale (Saaty, 1980). The matrix must satisfy reciprocity and unity conditions to ensure logical coherence.
Reciprocal condition:
$p_{ji} = \frac{1}{p_{ij}}$(1)

Diagonal condition:
$p_{ii} = 1$ *(2)*

This structure ensures that comparisons are logically consistent across all criteria.

*Aggregate expert judgments (if multiple experts are involved)*
When multiple experts provide pairwise comparison matrices, their judgments are combined using the geometric mean, which preserves the reciprocal property and is recommended for group decision-making in AHP (Saaty, 1980). If $m$experts are involved, the aggregated value for each matrix element is calculated as:
$g_{ij} = \left(\prod_{k=1}^{m} p_{ij}^{(k)}\right)^{\frac{1}{m}}$ (3)

The resulting aggregated matrix becomes the consensus matrix used for further analysis. When multiple experts provide pairwise comparison matrices, their judgments are aggregated cell-by-cell using the geometric mean to produce a single consensus matrix. The geometric mean is preferred because it preserves the reciprocal property of AHP matrices and is theoretically justified for aggregating individual priorities in group decision-making (Forman and Peniwati, 1998). It also minimizes the dominance of extreme individual judgments while maintaining proportional consistency in multiplicative scales (Ishizaka and Labib, 2011). This aggregation approach is consistent with the original formulation of the Analytic Hierarchy Process proposed by Saaty (1980), which recommends structured mathematical procedures for deriving collective priorities from expert evaluations.

*Normalize the matrix and derive weights*
Weight extraction follows a column normalization and row averaging procedure commonly applied in practical AHP implementations. First, compute the column sums:
$S_j = \sum_{i=1}^{n} p_{ij}$ (4)

Next, normalize each element:
$n_{ij} = \frac{p_{ij}}{S_j}$ (5)

Then compute the preliminary weight for each criterion by averaging across rows:

$w_i = \frac{1}{n}\sum_{j=1}^{n} n_{ij}$ (6)

Finally, normalize the weight vector so that the weights sum to one:
$\sum_{i=1}^{n} w_i = 1$ (7)

The resulting vector $\mathbf{w} = (w_1, w_2, \ldots, w_n)$represents the relative importance of each criterion.

*Compute the consistency vector and estimate the maximum eigenvalue*
To verify the logical consistency of expert judgments, multiply the pairwise comparison matrix $P$by the derived weight vector $\mathbf{w}$(Saaty, 1980):
$A\mathrm{w} = P\mathrm{w}$ (8)

Then compute the consistency vector:
$c_i = \frac{(A\mathbf{w})_i}{w_i}$ (9)

The maximum eigenvalue $\lambda_{\max}$is estimated as:
$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} c_i$ (10)

A perfectly consistent matrix yield $\lambda_{\max} = n$. Deviations indicate inconsistency.

*Calculate Consistency Index (CI) and Consistency Ratio (CR)*
The Consistency Index (CI) measures the degree of deviation from perfect consistency (Saaty, 1980):
$CI = \frac{\lambda_{\max} - n}{n-1}$ (11)

The Consistency Ratio (CR) compares CI with the Random Index (RI), which depends on matrix size (Saaty, 1980):
$CR = \frac{CI}{RI}$ (12)

A CR ≤ 0.10 (10%) is generally considered acceptable. If CR exceeds 0.10, the pairwise comparisons should be reviewed and revised.
*Revise inconsistent judgments (if necessary)*
If CR is greater than 0.10, examine criteria associated with the largest deviations between $(A\mathbf{w})_i$and $w_i$. Experts should re-evaluate the most inconsistent pairwise comparisons rather than reconstructing the entire matrix. The process is repeated until acceptable consistency is achieved (Saaty, 1980).

*Apply AHP weights in GIS to compute Site Suitability Index (SSI)*
After validating the weights, reclassify each thematic raster into vulnerability classes (e.g., very low = 1 to very high = 5) using natural breaks or literature-based thresholds. The weighted linear combination method is then applied to compute the Site Suitability Index (SSI):
$SSI = \sum_{i=1}^{n} w_i \cdot r_i$ (13)

where $w_i$is the AHP weight and $r_i$is the reclassified raster value for criterion $i$. The resulting SSI raster represents the overall suitability score for each spatial unit.

***Flood Vulnerability Index (FVI)***

The Flood Vulnerability Index (FVI) was computed as a weighted linear combination of seven reclassified thematic layers (criteria) derived from the Analytic Hierarchy Process (AHP). Each thematic raster $r_i$was reclassified into five vulnerability ranks (1 = very low … 5 = very high) using natural-breaks and literature-based thresholds. AHP weights $w_i$were obtained by aggregating eight experts pairwise comparison matrices using the geometric mean, extracting priorities by column-normalization/row-average;( Saaty, 1980), and normalizing the resulting weight vector so that $\sum_{i=1}^{7} w_i = 1$. Individual expert consistency ratios (CR) ranged from 0.031 to 0.088 (all ≤ 0.10), therefore no expert matrix was excluded; the aggregated consensus matrix and final weights are reported in Table 10.
Raw (unscaled) FVI:

$\mathrm{FVI} = \sum_{i=1}^{n} w_i \ r_i \text{with } n = 7, \ r_i \in \{1,2,3,4,5\}.$ (14)

Because the AHP weights were normalized ($\sum w_i = 1$), the theoretical bounds of the raw FVI are 1 (minimum) and 5 (maximum). In this study we report both the raw weighted sum and a 0–1 normalized FVI to facilitate interpretation and comparison. The min–max normalization used here maps the natural 1–5 range to 0–1:

$\mathrm{FVI}_{0-1} = \frac{\mathrm{FVI}-\mathrm{FVI}_{\min}}{\mathrm{FVI}_{\max}-\mathrm{FVI}_{\min}} = \frac{\mathrm{FVI}-1}{5-1} = \frac{\mathrm{FVI}-1}{4}.$ (15)

(For transparency we note that an alternative, simpler scaling sometimes used is $\mathrm{FVI}/5$, but this yields a 0.20–1.00 range and was not used here.

### 2.6.1 Raster Calculation and Mapping

In the raster calculator (ArcGIS/ QGIS): Compute FVI raster as the sum of (weight × reclassified raster) for each thematic layer. The resulting continuous FVI raster was reclassified into discrete vulnerability classes (very high, high, moderate, low, very low) for visualization and for overlay analysis with village centroids.

## 3. Results and Discussions

The pairwise comparison matrices for experts 1-8 are presented in tables 2 to 9.

**Table 2:** Pairwise Comparison Matrix from Expert 1

| EXPERT 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 4.00 | 5.00 | 3.00 | 1.00 | 3.00 | 4.00 | 30.45 |
| DRAINAGE DENSITY | 0.25 | 1.00 | 1.00 | 1.00 | 0.33 | 1.00 | 2.00 | 8.96 |
| SLOPE | 0.20 | 1.00 | 1.00 | 1.00 | 0.50 | 3.00 | 2.00 | 11.34 |
| ELEVATION | 0.33 | 1.00 | 1.00 | 1.00 | 0.50 | 3.00 | 4.00 | 13.53 |
| RAINFALL | 1.00 | 3.00 | 2.00 | 2.00 | 1.00 | 3.00 | 4.00 | 23.48 |
| SOIL TYPE | 0.33 | 1.00 | 0.33 | 0.33 | 0.33 | 1.00 | 1.00 | 6.87 |
| DISTANCE FROM STREAMS | 0.25 | 0.50 | 0.50 | 0.25 | 0.25 | 1.00 | 1.00 | 5.37 |
| SUM | 3.37 | 11.50 | 10.83 | 8.58 | 3.91 | 15.00 | 18.00 | 100.00 |
| | | | | | | | CR = 0.046 | |

**Table 3:** Pairwise Comparison Matrix from Expert 2

| EXPERT 2 | 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 6.00 | 1.00 | 1.00 | 0.25 | 1.00 | 2.00 | 15.02 |
| DRAINAGE DENSITY | 0.17 | 1.00 | 0.33 | 0.33 | 0.25 | 3.00 | 1.00 | 7.91 |
| SLOPE | 1.00 | 3.00 | 1.00 | 1.00 | 0.33 | 1.00 | 1.00 | 11.71 |
| ELEVATION | 1.00 | 3.00 | 1.00 | 1.00 | 0.33 | 3.00 | 2.00 | 15.02 |
| RAINFALL | 4.00 | 4.00 | 3.00 | 3.00 | 1.00 | 4.00 | 3.00 | 34.03 |
| SOIL TYPE | 1.00 | 0.33 | 1.00 | 0.33 | 0.25 | 1.00 | 1.00 | 8.01 |
| DISTANCE FROM STREAMS | 0.50 | 1.00 | 1.00 | 0.50 | 0.33 | 1.00 | 1.00 | 8.31 |
| SUM | 8.67 | 18.33 | 8.33 | 7.17 | 2.75 | 14.00 | 11.00 | 100.00 |
| | | | | | | | CR = 0.088 | |

**Table 4:** Pairwise Comparison Matrix from Expert 3

| EXPERT 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 3.00 | 2.00 | 2.00 | 1.00 | 3.00 | 4.00 | 22.64 |
| DRAINAGE DENSITY | 0.33 | 1.00 | 1.00 | 1.00 | 0.33 | 0.33 | 1.00 | 11.32 |
| SLOPE | 0.50 | 1.00 | 1.00 | 1.00 | 0.33 | 3.00 | 2.00 | 11.32 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ELEVATION | 0.50 | 1.00 | 1.00 | 1.00 | 0.33 | 4.00 | 3.00 | 11.32 |
| RAINFALL | 1.00 | 3.00 | 3.00 | 3.00 | 1.00 | 3.00 | 3.00 | 33.96 |
| SOIL TYPE | 0.33 | 3.00 | 0.33 | 0.25 | 0.33 | 1.00 | 2.00 | 3.77 |
| DISTANCE FROM STREAMS | 0.25 | 1.00 | 0.50 | 0.33 | 0.33 | 0.50 | 1.00 | 5.66 |
| SUM | 3.92 | 13.00 | 8.83 | 8.58 | 3.67 | 14.83 | 16.00 | 100.00 |
| | | | | | | | CR = 0.074 | |

**Table 5:** Pairwise Comparison Matrix from Expert 4

| EXPERT 4 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 3.00 | 4.00 | 4.00 | 1.00 | 4.00 | 3.00 | 22.64 |
| DRAINAGE DENSITY | 0.33 | 1.00 | 1.00 | 1.00 | 0.33 | 2.00 | 1.00 | 5.66 |
| SLOPE | 0.25 | 1.00 | 1.00 | 1.00 | 0.33 | 3.00 | 3.00 | 11.32 |
| ELEVATION | 0.25 | 1.00 | 1.00 | 1.00 | 0.33 | 3.00 | 3.00 | 11.32 |
| RAINFALL | 1.00 | 3.00 | 3.00 | 3.00 | 1.00 | 3.00 | 3.00 | 33.96 |
| SOIL TYPE | 0.25 | 0.50 | 0.33 | 0.33 | 0.33 | 1.00 | 1.00 | 11.32 |
| DISTANCE FROM STREAMS | 0.33 | 1.00 | 0.33 | 0.33 | 0.33 | 1.00 | 1.00 | 5.66 |
| SUM | 3.37 | 11.50 | 10.83 | 8.58 | 3.91 | 15.00 | 18.00 | 100.00 |
| | | | | | | | CR = 0.049 | |

**Table 6:** Pairwise Comparison Matrix from Expert 5

| EXPERT 5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 3.00 | 4.00 | 4.00 | 1.00 | 4.00 | 3.00 | 30.22 |
| DRAINAGE DENSITY | 0.33 | 1.00 | 1.00 | 1.00 | 0.33 | 2.00 | 1.00 | 10.04 |
| SLOPE | 0.25 | 1.00 | 1.00 | 2.00 | 0.50 | 1.00 | 0.50 | 9.64 |
| ELEVATION | 0.25 | 1.00 | 0.50 | 1.00 | 0.50 | 1.00 | 1.00 | 8.55 |
| RAINFALL | 1.00 | 3.00 | 2.00 | 2.00 | 1.00 | 3.00 | 2.00 | 22.76 |
| SOIL TYPE | 0.25 | 0.50 | 1.00 | 1.00 | 0.33 | 1.00 | 1.00 | 7.95 |
| DISTANCE FROM STREAMS | 0.33 | 1.00 | 2.00 | 1.00 | 0.50 | 1.00 | 1.00 | 10.83 |
| SUM | 3.42 | 10.50 | 11.50 | 12.00 | 4.17 | 13.00 | 9.50 | 100.00 |
| | | | | | | | CR = 0.031 | |

**Table 7:** Pairwise Comparison Matrix from Expert 6

| EXPERT 6 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 4.00 | 2.00 | 2.00 | 0.33 | 2.00 | 2.00 | 19.34 |
| DRAINAGE DENSITY | 0.25 | 1.00 | 0.50 | 0.50 | 0.33 | 2.00 | 1.00 | 8.62 |
| SLOPE | 0.50 | 2.00 | 1.00 | 1.00 | 0.33 | 1.00 | 2.00 | 11.42 |
| ELEVATION | 0.50 | 2.00 | 1.00 | 1.00 | 0.33 | 1.00 | 3.00 | 12.63 |
| RAINFALL | 3.00 | 3.00 | 3.00 | 3.00 | 1.00 | 3.00 | 3.00 | 31.46 |
| SOIL TYPE | 0.50 | 0.50 | 1.00 | 1.00 | 0.33 | 1.00 | 1.00 | 8.92 |
| DISTANCE FROM STREAMS | 0.50 | 1.00 | 0.50 | 0.33 | 0.33 | 1.00 | 1.00 | 7.62 |
| SUM | 6.25 | 13.50 | 9.00 | 8.83 | 3.00 | 11.00 | 13.00 | 100.00 |
| | | | | | | | CR = 0.047 | |

**Table 8:** Pairwise Comparison Matrix from Expert 7

| EXPERT 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 2.00 | 1.00 | 1.00 | 0.33 | 2.00 | 2.00 | 14.85 |
| DRAINAGE DENSITY | 0.50 | 1.00 | 1.00 | 1.00 | 0.33 | 1.00 | 2.00 | 11.29 |
| SLOPE | 1.00 | 1.00 | 1.00 | 1.00 | 0.33 | 2.00 | 1.00 | 12.18 |
| ELEVATION | 1.00 | 1.00 | 1.00 | 1.00 | 0.33 | 2.00 | 2.00 | 13.47 |
| RAINFALL | 3.00 | 3.00 | 3.00 | 3.00 | 1.00 | 3.00 | 2.00 | 31.09 |
| SOIL TYPE | 0.50 | 1.00 | 0.50 | 0.50 | 0.33 | 1.00 | 1.00 | 8.22 |
| DISTANCE FROM STREAMS | 0.50 | 0.50 | 1.00 | 0.50 | 0.50 | 1.00 | 1.00 | 8.91 |
| SUM | 7.50 | 9.50 | 8.50 | 8.00 | 3.17 | 12.00 | 11.00 | 100.00 |
| | | | | | | | CR = 0.037 | |

**Table 9:** Pairwise Comparison Matrix from Expert 8

| EXPERT 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Weight |
|---|---|---|---|---|---|---|---|---|
| LULC | 1.00 | 3.00 | 2.00 | 2.00 | 0.33 | 1.00 | 3.00 | 17.93 |
| DRAINAGE DENSITY | 0.33 | 1.00 | 2.00 | 2.00 | 0.33 | 0.50 | 0.50 | 10.26 |
| SLOPE | 0.50 | 0.50 | 1.00 | 1.00 | 0.33 | 2.00 | 2.00 | 11.55 |
| ELEVATION | 0.50 | 0.50 | 1.00 | 1.00 | 0.33 | 1.00 | 1.00 | 8.86 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RAINFALL | 3.00 | 3.00 | 3.00 | 3.00 | 1.00 | 3.00 | 2.00 | 29.78 |
| SOIL TYPE | 1.00 | 2.00 | 0.50 | 1.00 | 0.33 | 1.00 | 2.00 | 12.05 |
| DISTANCE FROM STREAMS | 0.33 | 2.00 | 0.50 | 1.00 | 0.50 | 0.50 | 1.00 | 9.56 |
| SUM | 6.67 | 12.00 | 10.00 | 11.00 | 3.17 | 9.00 | 11.50 | 100.00 |
| | | | | | | | CR = 0.082 | |

**Table 10*:*** Analytical Hierarchy Process (AHP) Weight of Flood Vulnerability Parameters

| EXPERTS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | WEIGHT |
|---|---|---|---|---|---|---|---|---|---|
| LULC | 30.448 | 15.015 | 22.642 | 22.642 | 30.219 | 19.339 | 14.851 | 17.928 | 21.635 |
| Drainage Density | 8.955 | 7.908 | 11.321 | 5.660 | 10.040 | 8.617 | 11.287 | 10.259 | 9.256 |
| Slope | 11.343 | 11.712 | 11.321 | 11.321 | 9.642 | 11.423 | 12.178 | 11.554 | 11.312 |
| Elevation | 13.532 | 15.015 | 11.321 | 11.321 | 8.549 | 12.625 | 13.465 | 8.865 | 11.837 |
| Rainfall | 23.483 | 34.034 | 33.962 | 33.962 | 22.763 | 31.463 | 31.089 | 29.781 | 30.067 |
| Soil Type | 6.866 | 8.008 | 3.774 | 11.321 | 7.952 | 8.918 | 8.218 | 12.052 | 8.388 |
| Distance From Streams | 5.373 | 8.308 | 5.660 | 5.660 | 10.835 | 7.615 | 8.911 | 9.562 | 7.741 |
| Sum | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |

From the table 10; Rainfall, with a weight of 30.067%, was identified as the most important driver of flooding in the study area, as intense precipitation events increase surface runoff and can overwhelm existing drainage capacity. Land use/land cover (LULC), weighted at 21.635%, also plays a significant role, since human activities such as urbanization, deforestation, and agricultural expansion reduce infiltration and promote increased surface runoff. The terrain-related factors of slope (11.312%) and elevation (11.837%) further influence flood vulnerability by controlling runoff velocity and the formation of accumulation zones, with low-lying and relatively flat areas being more prone to water concentration. Drainage density, which accounts for 9.256% of the total weight, can facilitate efficient runoff conveyance but may also indicate concentrated flow paths that enhance flood risk under high rainfall conditions. Soil type (8.388%) and distance from streams (7.741%) contribute to local susceptibility, as soils with low water retention capacity and areas closer to stream channels are more easily inundated.

Overall, the dominance of rainfall and LULC in the weight distribution suggests that flood risk in Egor Local Government Area is largely governed by the interaction between climatic forcing and land management practices, while slope and elevation reinforce the spatial patterns of vulnerability by directing runoff from higher grounds into lower-lying basins.

Table 11: Final pair-wise comparison table (AHP)

Below is the table 3 7×7 pair-wise comparison matrix derived from the final AHP weights. Each cell (a_{ij}) = weight(i) / weight(j). Values rounded to 3 decimal places.

The pair-wise comparison table 11 expresses the relative importance of the flood-vulnerability parameters based on the final AHP weights. Rainfall consistently dominates the matrix, showing strong preference ratios over all other factors, particularly soil type and distance from streams, which confirms its role as the most influential driver of flooding in the study area. Land use/land cover (LULC) also exhibits high dominance over most parameters, highlighting the significant effect of human-induced surface modification on runoff generation. Slope and elevation show near-equal importance, as reflected by values close to unity between them, indicating their closely related influence on runoff velocity and water accumulation. Drainage density occupies an intermediate position, being more important than soil type and distance from streams but less influential than rainfall and LULC. Soil type and distance from streams display the lowest relative importance, though their ratios indicate they still contribute meaningfully to

| Parameter | LULC | Drainage Density | Slope | Elevation | Rainfall | Soil Type | Distance From Streams |
|---|---|---|---|---|---|---|---|
| LULC | 1.000 | 2.337 | 1.913 | 1.828 | 0.720 | 2.579 | 2.795 |
| Drainage Density | 0.428 | 1.000 | 0.818 | 0.782 | 0.308 | 1.103 | 1.196 |
| Slope | 0.523 | 1.222 | 1.000 | 0.956 | 0.376 | 1.349 | 1.461 |
| Elevation | 0.547 | 1.279 | 1.046 | 1.000 | 0.394 | 1.411 | 1.529 |
| Rainfall | 1.390 | 3.248 | 2.658 | 2.540 | 1.000 | 3.585 | 3.884 |
| Soil Type | 0.388 | 0.906 | 0.742 | 0.709 | 0.279 | 1.000 | 1.084 |
| Distance From Streams | 0.358 | 0.836 | 0.684 | 0.654 | 0.257 | 0.923 | 1.000 |

localized flood susceptibility. Overall, the table demonstrates a logical and consistent hierarchy in which climatic forcing and land management factors outweigh terrain and soil controls, while topographic parameters help refine the spatial distribution of flood risk within Egor Local Government Area.

### 3.1 Distance from Stream Parameter Map

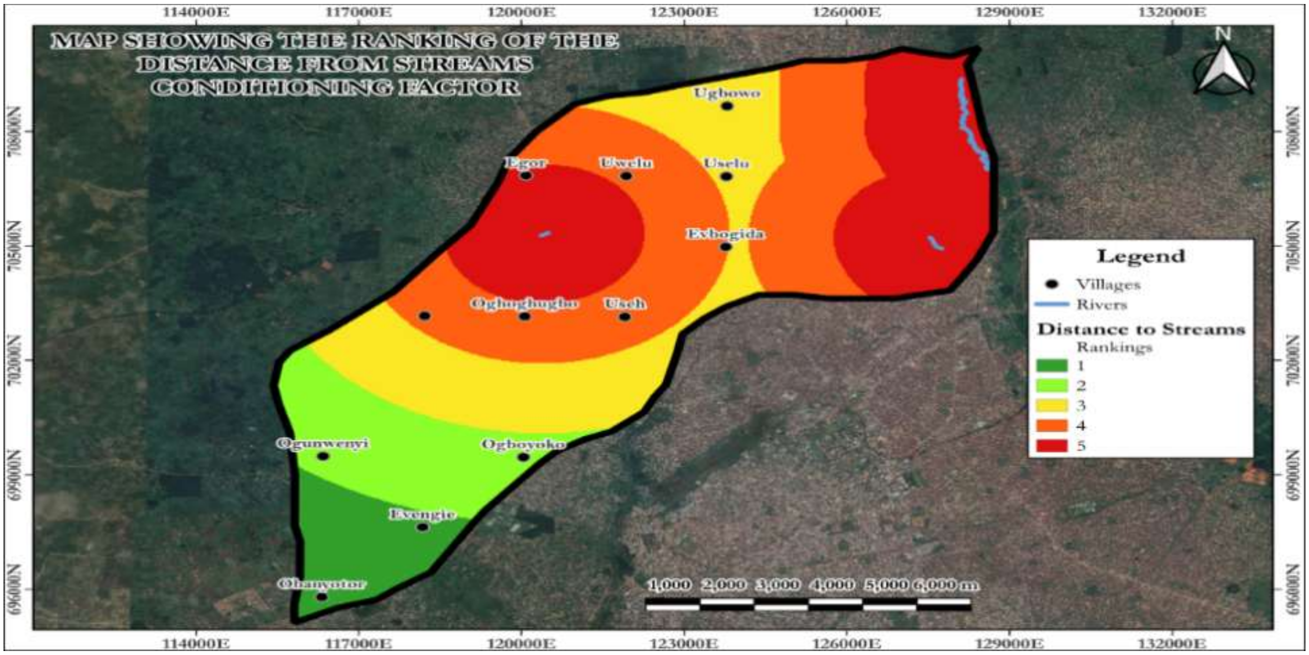


***Figure 4:*** *Criteria Levels for the Distance from Streams Parameter across all streams and rivers*

The figure 4 map illustrates the ranking of distance from streams, with values increasing from dark green (rank 1, farthest from streams) to red (rank 5, closest to streams). Rivers are shown in blue, while black dots represent the settlements within the study area. The highest vulnerability zones are concentrated in the northern and north-western parts of the area, where red and orange colours dominate. Settlements such as Egor and those around Oghughughue and Useh fall within these zones, indicating that they are located very close to stream channels and are therefore highly exposed to stream-related flooding. Toward the central portion of the map, yellow zones represent moderate vulnerability. Villages including Ebhogida and Uselu/Uwelu are situated within this band, suggesting an intermediate distance from streams and a moderate level of flood exposure.

In contrast, the southern part of the study area is largely characterized by green shades, which signify low vulnerability due to greater distance from streams. Settlements such as Ogunwenyi, Ogboyoko, Evengle, and Ohanyator are located in these zones, indicating relatively safer conditions with respect to stream proximity. Overall, the map shows a clear spatial trend of increasing flood vulnerability toward the northern sections of the study area where settlements are closer to stream networks.

### 3.2 Drainage Density Parameter Map

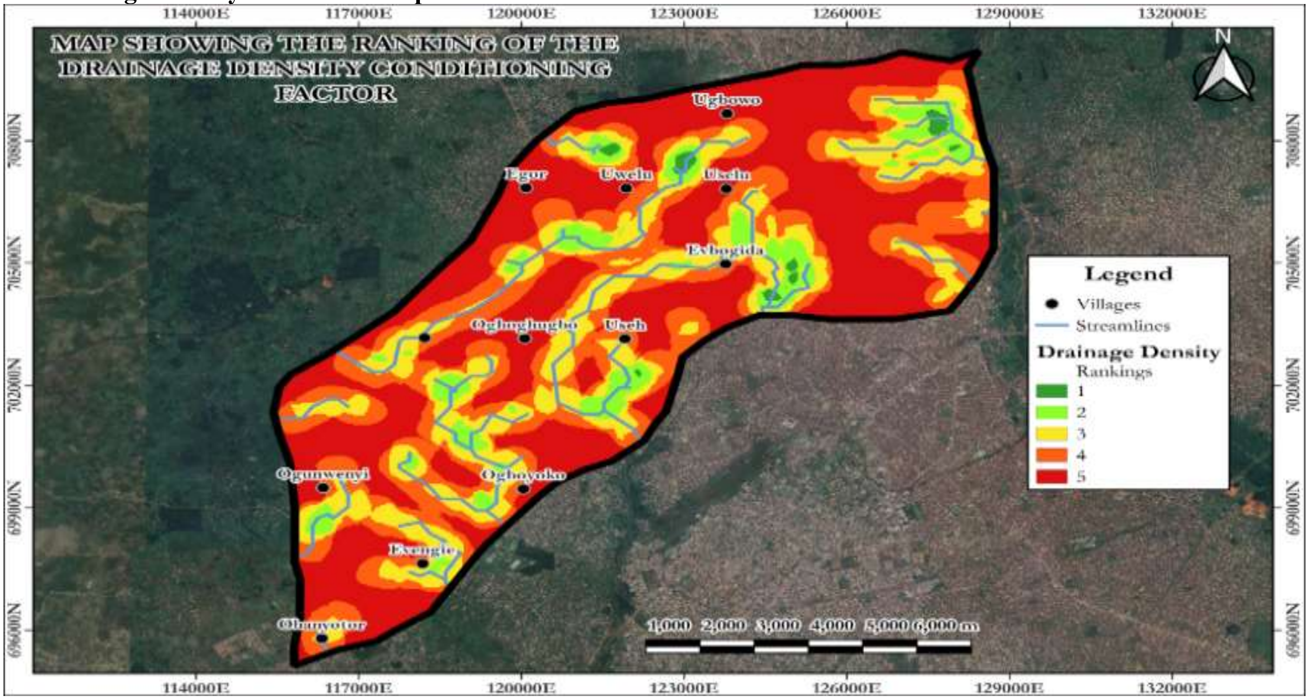


***Figure 5:*** *Criteria Rank for Drainage Density Parameter*

Map contained in Figure 5 illustrates the ranking of the drainage density conditioning factor for various communities using a color-coded system to represent different drainage density rankings, from very low (green) to very high (red). Communities like Egor and Useh have very low drainage density, indicating sparse stream networks. This can mean less surface water runoff and potentially lower erosion risk but could also indicate limited water availability for agriculture and other uses. Uwelu and Uselu fall within the low drainage density category. The slightly higher density compared to the very low areas suggests more developed stream networks, which can help in managing surface water runoff and reducing flood risk, while still maintaining relatively low erosion rates. While Evbogida, and Ugbowo have moderately low drainage density, indicating a balance between surface water runoff and water availability. This ranking suggests an intermediate level of stream networks that can efficiently manage runoff while providing adequate water resources. Places like Oghoghugbo, and Ogbojoko are characterized in high drainage density areas, these communities experience more developed stream networks, which can lead to efficient water runoff management but may increase the risk of soil erosion. Proper land management practices are necessary to mitigate erosion while benefiting from the efficient drainage system. Ogunwenyi, Evengie, and Obanyotor villages are situated in very high drainage density areas, characterized by extensive stream networks. This high density can lead to significant soil erosion due to the rapid removal of surface water. While flood risks might be lower due to efficient drainage, substantial soil conservation measures are required to prevent land degradation. Overall, the map shows a gradient of drainage density from very low in the northern regions to very high in the southern regions. Communities in very low to low drainage density areas might face challenges related to water availability, whereas those in high to very high-density areas must manage increased erosion risks. Effective land and water management strategies are crucial for optimizing the benefits and mitigating the risks associated with varying drainage densities.

### 3.3 Elevation Parameter Map

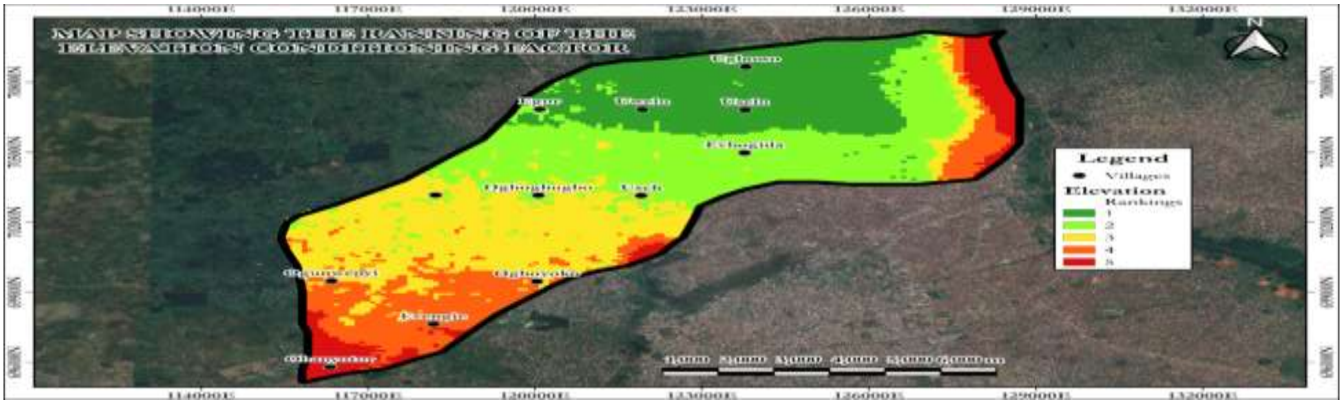


*Figure 6:* *Criteria Ranks for the Elevation Parameter for all 12 villages*

The map in figure 6 illustrates the ranking of the elevation conditioning factor for various communities using a color-coded system to represent different elevation rankings, from very low (green) to very high (red). Locations such as Ugbowo, Egor, Uwelu, Uselu, and Evbogida are located in areas with very low elevation, indicating relatively flat terrain. This flatness is beneficial for infrastructure development and agriculture but may increase susceptibility to flooding, especially in regions with poor drainage systems. Also, Oghoghugbo, Useh fall within the low elevation category. The terrain is still relatively flat but slightly higher than the very low elevation areas. This can reduce flood risk compared to very low elevation zones, but land use planning is essential to manage runoff and erosion effectively. Useh also extends into the moderately low elevation category, indicating gentle slopes and a higher altitude compared to low elevation areas. This reduces flood risk further but requires careful management of runoff and erosion. Ogunwenyi, and Ogbojoko are situated in high elevation areas characterized by steeper slopes. Higher altitudes reduce flood risk but can present challenges for construction and require measures to control erosion. While communities such as Evengie, and Obanyotor are located in very high elevation areas, these communities experience significant elevation differences with steep slopes. The high altitude offers advantages like scenic views and reduced flood risk but poses challenges such as increased erosion and higher construction costs. Robust soil and water conservation practices are necessary to manage runoff and erosion effectively. In general, the map shows a clear elevation gradient, with the northern communities predominantly in very low to low elevation zones and the southern communities in high to very high elevation zones. This spatial variation necessitates tailored land use and infrastructure planning to address the unique challenges and opportunities of each elevation level, from flood management in lower areas to erosion control in higher regions.

### 3.4 Land Use and Land Cover Parameter Map

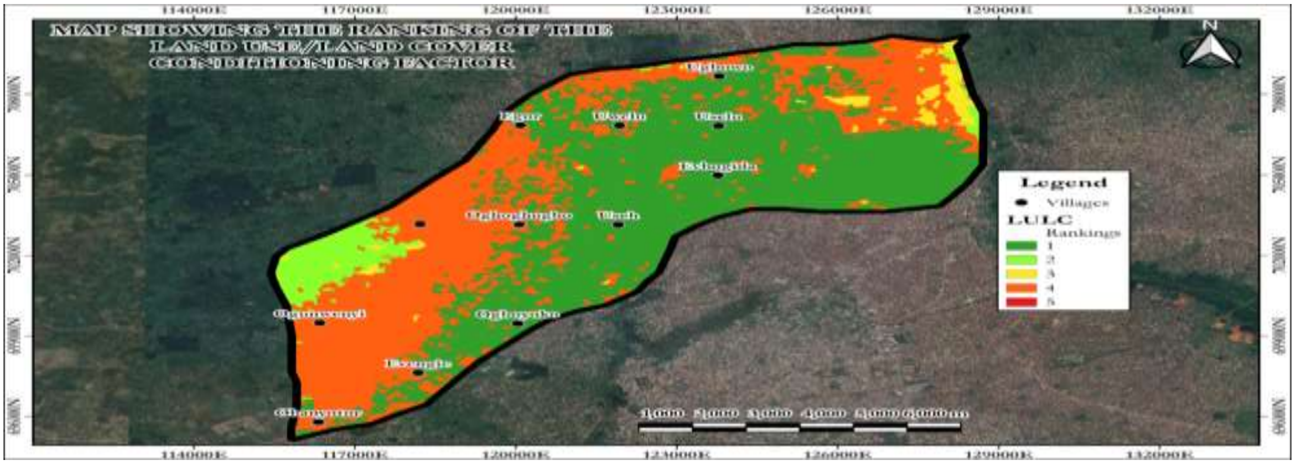


*Figure 7:* *Criteria Ranks for Land Use/Land Cover Parameter across all 12 villages*

Figure 7 illustrates the ranking of the land use/land cover (LULC) conditioning factor for various communities, using a color-coded system to represent different LULC rankings from very low (green) to very high (red). Some communities like Egor, Ugbowo, Uwelu, Uselu, and Evbogida are characterized by very low LULC, indicating that the land cover is predominantly natural or less altered by human activity. This could mean more vegetation, which can contribute to lower erosion rates and better water infiltration. While Ogunwenyi falls within the low LULC category, suggesting a slightly higher degree of land use and human activity compared to the very low areas. This can still maintain a good balance of natural vegetation, aiding in soil and water conservation. Oghoghugbo has a moderately low LULC ranking, indicating a moderate level of land use. This could mean more agricultural activity or urban development, leading to a moderate impact on the natural land cover. Ogbojoko and Useh are in high LULC areas, which mean significant alteration of the land cover due to human activities such as agriculture, urbanization, or deforestation. This can lead to higher soil erosion and reduced natural vegetation cover. Evengie, and Obanyotor are situated in very high LULC areas, characterized by extensive land use and significant alterations to the natural land cover. This high degree of human activity can lead to severe soil erosion, reduced water infiltration, and increased runoff. Effective land management practices are essential to mitigate these impacts. The map in figure 6 generally shows a gradient of LULC rankings, from very low in the central and northern regions to very high in the southern regions. Communities in very low to low LULC areas have better-preserved natural land cover, while those in high to very high LULC areas experience significant human-induced changes. Sustainable land use practices are crucial in high and very high LULC areas to prevent land degradation and maintain ecological balance.

### 3.5 Rainfall / Precipitation Parameter Map

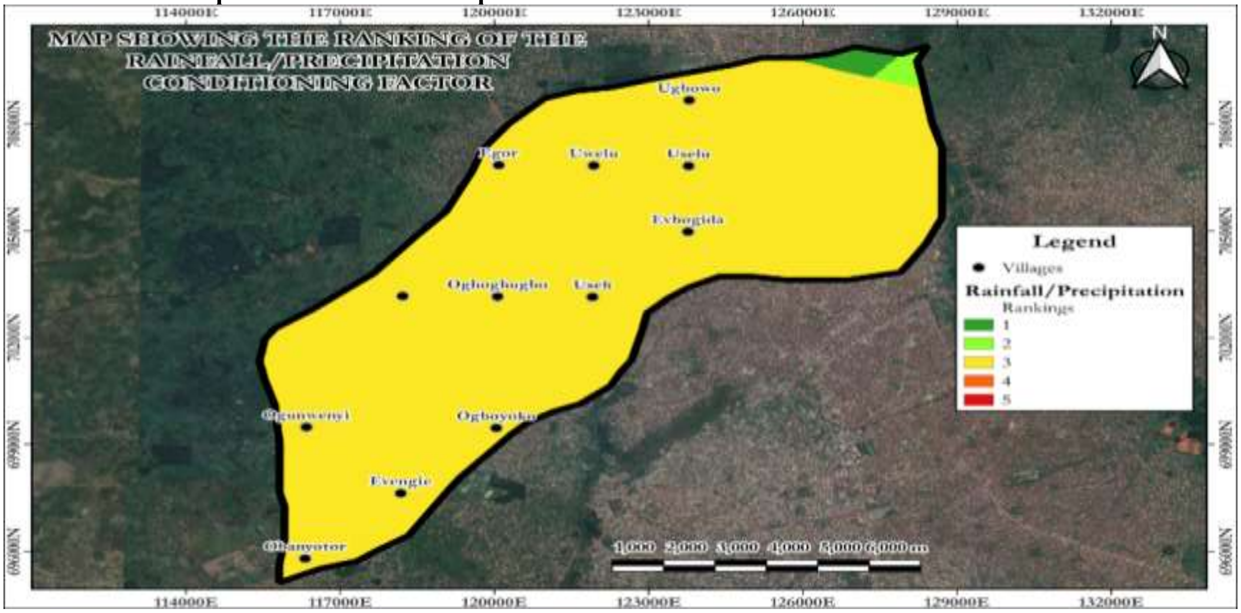


***Figure 8:*** *Criteria Ranks for the Rainfall/Precipitation Parameter across all villages*

The ranking of the rainfall/precipitation conditioning factor for various communities, using a color-coded system to represent different rankings from very low (green) to moderately low (yellow) is illustrated in figure 8. Northeast of Ugbowo experiences very low rainfall, which could result in limited water availability and potentially more arid conditions compared to the rest of the region. Other communities like Egor, Ugbowo, Uwelu, Uselu, Evbogida, Oghoghugbo, Useh, Ogunwenyi, Ogbojoko, Evengie, and Obanyotor experience moderately low precipitation, indicating a relatively uniform distribution of rainfall across these areas. This level of precipitation supports moderate vegetation and agricultural activities but may require efficient water management practices to ensure sustainability during drier periods. In totality, the map shows that most communities are in areas with moderately low rainfall, which suggests that while there is a consistent level of precipitation, water management and conservation measures are necessary to maintain agricultural productivity and natural ecosystems. The area with very low precipitation may need targeted strategies to mitigate the impact of lower water availability.

### 3.6 Slope Parameter Map

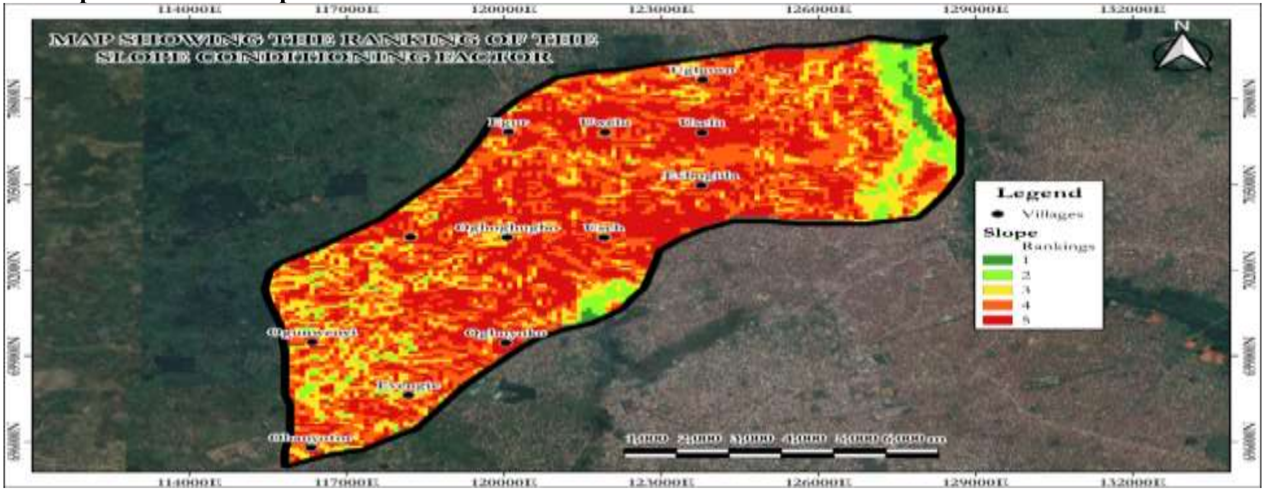


*Figure 9:* *Criteria Ranks for the Slope Parameter across all villages*

Figure 9 contains the map that shows the ranking of the slope conditioning factor for various communities, using a color-coded system to represent different rankings from very low (green) to very high (red). Northeast of Egor and Ugbowo experience very low slope, indicating relatively flat terrain that is less prone to erosion and landslides. While southeast of Useh and Uwelu regions have low slopes, which also suggest minimal erosion risks and stable ground for construction and agriculture. Egor, Uwelu, Evbogida, Oghoghugbo, and Useh areas feature moderate slopes, indicating some risk of soil movement and requiring considerations for water runoff management. The southwest of Ogbojoko, Evengie, and Ogunwenyi have high slopes, which could lead to significant runoff and soil erosion, necessitating erosion control measures. While Central and northern parts of Uselu, Ugbowo, Egor have very high slopes, posing substantial risks for erosion and landslides, making them critical zones for soil conservation and slope stabilization strategies. Summarily, the map indicates that the slope varies significantly across the region, with the central and northern parts having the highest slopes. Proper land management and soil conservation practices are crucial in these areas to prevent erosion and maintain land stability.

### 3.7 Soil Type Parameter Map

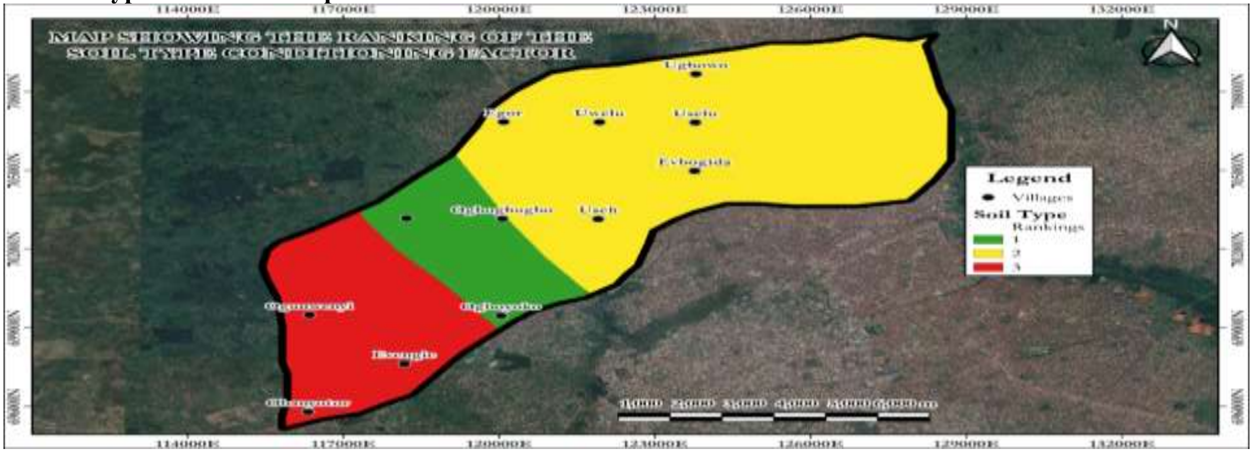


*Figure 10:* *Criteria Ranks for the Soil Type Parameter*

Figure 10 shows the map that displays the ranking of the soil type conditioning factor for various communities, using different colors to represent the rankings. Oghoghugbo and Useh have the most favorable soil types, indicating low susceptibility to erosion and suitable conditions for agriculture and construction. While Egor, Uwelu, Uselu, and Evbogida regions have moderately suitable soil types, suggesting some limitations that may require management practices for optimal use. Ogunwenyi, Ogbojoko, Evengie, and Obanyotor areas have the least suitable soil types, indicating high susceptibility to erosion or other limitations, requiring significant interventions for safe use and management. This map shows that the soil type varies significantly across the region, with areas in red requiring careful management to mitigate potential erosion risks and maintain soil health for sustainable land use.

### 3.7 Flood Vulnerability Map of Egor Local Government Area Using AHP

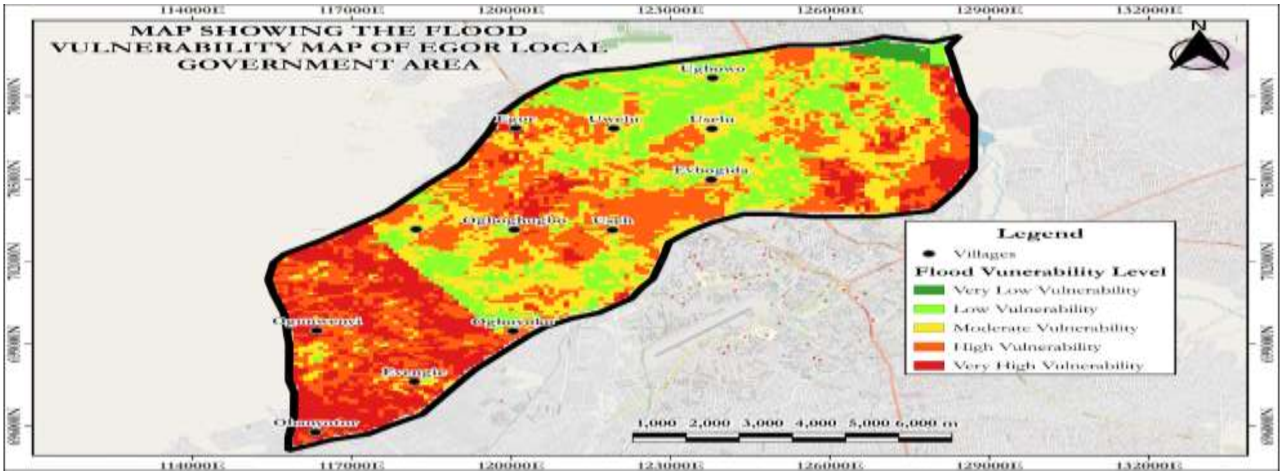


***Figure 11:*** *The Map of Egor LGA showing all flood vulnerability levels across all 12 villages.*

The AHP-derived flood vulnerability map of Egor Local Government Area in figure 11 identifies eleven communities as very low, low, moderate, high, and very high. Egor village, Ogunwenyi, and Obanyotor are classified as very high vulnerability, indicating a high risk of destruction due to flooding. Ogboyoko, Useh, and Oghoghugbo are classified as high vulnerability, facing significant threats to their infrastructure. Ugbowo and Oghoghugbo are moderately vulnerable, with a high possibility of future flooding if factors contributing to flooding worsen. Addressing these vulnerabilities is crucial to reduce the impact of projected flooding and ensure the safety of the communities in the area.

### 3.8 Discussion of Results

The results show a clear dominance of climatic and land-use drivers over more localized controls: rainfall (30.07%) and land use/land cover (21.63%) together account for over half of the AHP weight. Rainfall dominates because it is the primary input that generates run-off; intense precipitation events produce immediate, system-wide responses that can overwhelm drainage regardless of local soil properties. In contrast, soil type influences infiltration and storage at a finer spatial scale and often moderates, rather than controls, the timing and extent of flooding; hence its lower relative weight. Likewise, LULC magnifies rainfall effects where urbanization and reduced vegetation cover increase runoff and peak flows.

This pattern majorly emphasizes on precipitation and surface sealing, with terrain and drainage refining spatial patterns; is consistent with many applied flood-vulnerability studies in Nigeria and other tropical regions, which find climatic forcing and urban land-use change to be leading drivers while soil and distance-to-channel explain local variation. The greater importance of slope and elevation in our weights reflects their role in routing water from higher to lower zones, concentrating flow in low-lying basins and floodplains.

Translating vulnerability classes into community impacts clarifies the stakes for local residents. Large portions of the northern part of Egor Local Government Area are classified as very low/low vulnerability, so communities such as Evbogida, Ugbowo, Uselu, and Useh are comparatively less exposed to frequent inundation. By contrast, southern communities identified as highly vulnerable; such as Ogboyoko, Evengie, and Ogunwenyi; face repeated runoff accumulation, crop loss, and infrastructure damage.

Recurrent flooding in these high-vulnerability zones is likely to cause immediate food shortages through destruction of farmlands and storage, contaminate drinking water leading to outbreaks of waterborne diseases (e.g., cholera, typhoid), increase vector breeding sites and thus vector-borne illnesses, and force temporary displacement that undermines livelihoods. To reduce these impacts the discussion should explicitly link observed vulnerability drivers to targeted interventions: strengthen early-warning and rainfall monitoring, implement land-use controls and urban drainage upgrades in high LULC-weight areas, apply soil-conservation and infiltration enhancement where soil retention is poor, and prioritize natural buffer restoration and localized detention basins in low-lying southern zones. Reporting these cause-to-effect links (driver → physical process → community outcome → targeted intervention) makes the implications of the FVI actionable for planners and disaster-risk managers.

## 4. Conclusions and Recommendations

### 4.1 Conclusion

This study applied an integrated Geographic Information Systems (GIS) and Analytical Hierarchy Process (AHP) framework to assess flood vulnerability in Egor Local Government Area (LGA), Edo State. By incorporating seven flood-conditioning parameters such as rainfall, elevation, slope, drainage density, soil type, land use/land cover, and distance from streams. The research successfully quantified and visualized the spatial variability of flood susceptibility across the LGA.

The resulting flood vulnerability map revealed a heterogeneous pattern, with distinct zones ranging from very low to very high vulnerability. Communities such as Ogunwenyi, Obanyotor, and Egor were identified as being in the very high vulnerability class due to their low-lying topography, gentle slopes, poorly drained soils, and close proximity to drainage channels. High vulnerability zones, including Ogboyoko, Useh, and Oghoghugbo, exhibit similar physical characteristics, though with slightly improved drainage conditions, while areas such as Ugbowo and Uselu show moderate to low vulnerability associated with better terrain and soil infiltration capacity.

The findings demonstrate that flood vulnerability in Egor LGA is the outcome of complex interactions between environmental and anthropogenic factors. Intense rainfall, flat terrain, and high drainage density combine with rapid urbanization, inadequate drainage infrastructure, and indiscriminate development on floodplains to increase flood risk. From a vulnerability perspective, high exposure of populations and infrastructure, elevated sensitivity of the physical environment, and low adaptive capacity due to limited institutional preparedness and weak planning controls collectively contribute to the area's high overall flood vulnerability. The study confirms that without sustainable land management and proactive flood mitigation strategies, flood impacts in Egor LGA are likely to intensify, and areas currently classified as moderately vulnerable may transition into higher-risk categories. Importantly, the GIS–AHP approach proved to be an effective and reliable decision-support tool for urban flood risk assessment, offering a scientific basis for identifying priority areas for intervention and strengthening flood resilience planning.

### 4.2 Recommendations

Based on the outcomes of this research, several measures are recommended to reduce flood vulnerability in Egor LGA. The flood vulnerability map produced in this study should be adopted by relevant government agencies and environmental management stakeholders as a core planning tool for flood preparedness, mitigation, and response. Targeted infrastructural interventions, particularly the upgrading and maintenance of drainage networks in high and very high vulnerability zones, should be prioritized to enhance runoff conveyance and reduce surface water accumulation.

There is a strong need for stricter enforcement of land-use planning regulations to prevent indiscriminate construction on floodplains and to ensure that land-use practices in flood-prone areas are compatible with flood risk reduction objectives. Urban development should be guided by zoning regulations and flood-resilient building standards, with particular attention given to discouraging development in areas identified as high-risk. Public enlightenment and community-based education programs should also be strengthened to improve awareness of flood risks and to encourage local participation in flood mitigation and management efforts.

Furthermore, the methodological framework adopted in this study can be used to develop and maintain a comprehensive flood vulnerability database for Egor LGA, supporting continuous monitoring and evidence-based decision-making. Integrating community-based flood early warning systems, sustainable land management practices, and institutional capacity building will significantly enhance adaptive capacity and long-term resilience. Collectively, these recommendations, if implemented, will contribute to reducing flood impacts, safeguarding lives and property, and promoting sustainable urban development in Egor Local Government Area.

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