

GIS-Based Flood Susceptibility Mapping Using Weighted Overlay Method in Barabai Sub-District, South Kalimantan, Indonesia

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Manuscript received: 12 March 2026; Received in revised form: 26 June 2026; Accepted: 17 July 2026

Abstract

Flooding is a major hydrometeorological hazard in Indonesia. This study assesses flood susceptibility in Barabai Sub-District, Hulu Sungai Tengah Regency, South Kalimantan, using a GIS-based weighted overlay approach. Six flood-conditioning factors were integrated in the analysis, namely slope, elevation, soil texture, rainfall, land use/land cover (LULC), and distance from river networks. The analysis used multi-source geospatial data, including a 30 m SRTM DEM, CHIRPS rainfall (2021–2025), FAO DSMW soil data, ESRI Sentinel-2 LULC data, administrative boundaries, and satellite imagery. The results show that flood susceptibility in Barabai Sub-District is dominated by high and very high classes. High-susceptibility areas cover 26.66 km², equivalent to 70.44% of the study area, whereas very high-susceptibility areas occupy 9.18 km², or 24.25%. In contrast, low and very low susceptibility zones account for only 1.78 km² (4.70%) and 0.23 km² (0.61%), respectively. Overall, 94.69% of the study area falls within the high to very high susceptibility classes. Land cover analysis indicates notable changes between 2021 and 2025, including a reduction in cropland and the emergence of a water body associated with a government-built reservoir for flood mitigation. The spatial pattern of flood susceptibility is mainly controlled by low elevation, proximity to river channels, fine- to medium-textured soils, intensive agricultural and built-up land use, and the dominance of Quaternary alluvial deposits, while high annual rainfall acts as the primary triggering factor. These findings support flood mitigation and land-use planning, while future studies should incorporate field validation and hydrological modeling.

Keywords: Barabai; Geographic Information System; Hydrometeorological Hazard; Land-Cover Dynamics; Multi-Criteria Spatial Analysis; Thematic Mapping.

Citation: Erfani, S., Nailatussa'adah, N., Ma'rifah, R. A., Putra, M. R. A., Andika, E., & Kurniawan, A. (2026). GIS-Based Flood Susceptibility Mapping Using Weighted Overlay Method in Barabai Sub-District, South Kalimantan, Indonesia. *Jurnal Geocelebes*, 10(2): 217–240, doi: 10.70561/geocelebes.v10i2.50269

Introduction

Flooding is among the most frequent and destructive hydrometeorological hazards, affecting both urban and rural areas through damage to communities, infrastructure, agricultural land, and local economies (Dhungana & Liu, 2024; Khan et al., 2025). Flood occurrence is commonly driven by the interaction of intense rainfall, low-lying topography, limited river capacity, and rapid land-use change (Sulaeman et al., 2017; Briantama et al., 2024). As flood impacts continue to increase in many

regions, spatially explicit information on flood-conditioning factors has become essential for disaster risk reduction, mitigation planning, and sustainable land management.

In Indonesia, flooding remains the dominant and most frequently recorded hydrometeorological hazard, recurring annually across many regions and showing a significant increasing trend over the past decade (Aji et al., 2025; Ramadhan et al., 2026). Its impacts are often amplified by rapid regional development, particularly

the conversion of permeable land into built-up areas and intensive agricultural land, which reduces water retention capacity and increases surface runoff (Handayani et al., 2020; Fatmala et al., 2023). Beyond direct physical damage to settlements and infrastructure, floods also generate substantial social and economic consequences, especially in areas where communities, infrastructure, and productive land are highly exposed and where the capacity for recovery remains limited (Meng et al., 2022; Rentschler et al., 2022).

Barabai Sub-District, Hulu Sungai Tengah Regency, South Kalimantan, is one of the areas repeatedly affected by flooding. Several major flood events have been recorded, including floods in 2013 and a severe event in 2021 that was regarded as one of the worst floods in the region (Prabowo, 2018; Rizani et al., 2023)

(Figure 1). Barabai Sub-District covers approximately 40.71 km² and consists of 18 villages, with a population density of 1,368 people km² (Badan Pusat Statistik Kabupaten Hulu Sungai Tengah, 2024). Physiographically, Barabai is located in a lowland area on the western side of the Meratus Mountains and is crossed by the Barabai River, resulting in a relatively extensive floodplain environment. Geologically, the area forms part of the Barito Basin, a Cenozoic sedimentary basin situated between the Schwaner Complex to the west and the Meratus Complex to the east (Witts et al., 2012). The area is predominantly underlain by alluvial deposits composed of unconsolidated materials such as clay, silt, sand, peat, gravel, and boulders, which generally have low infiltration capacity and increase susceptibility to inundation (Heryanto & Sanyoto, 1994; Pandey et al., 2021) (Figure 2).



Figure 1. Conditions on Murakata Street, one of the worst-hit areas by flooding in Barabai District in 2021 (Poros Kalimantan, 2021).

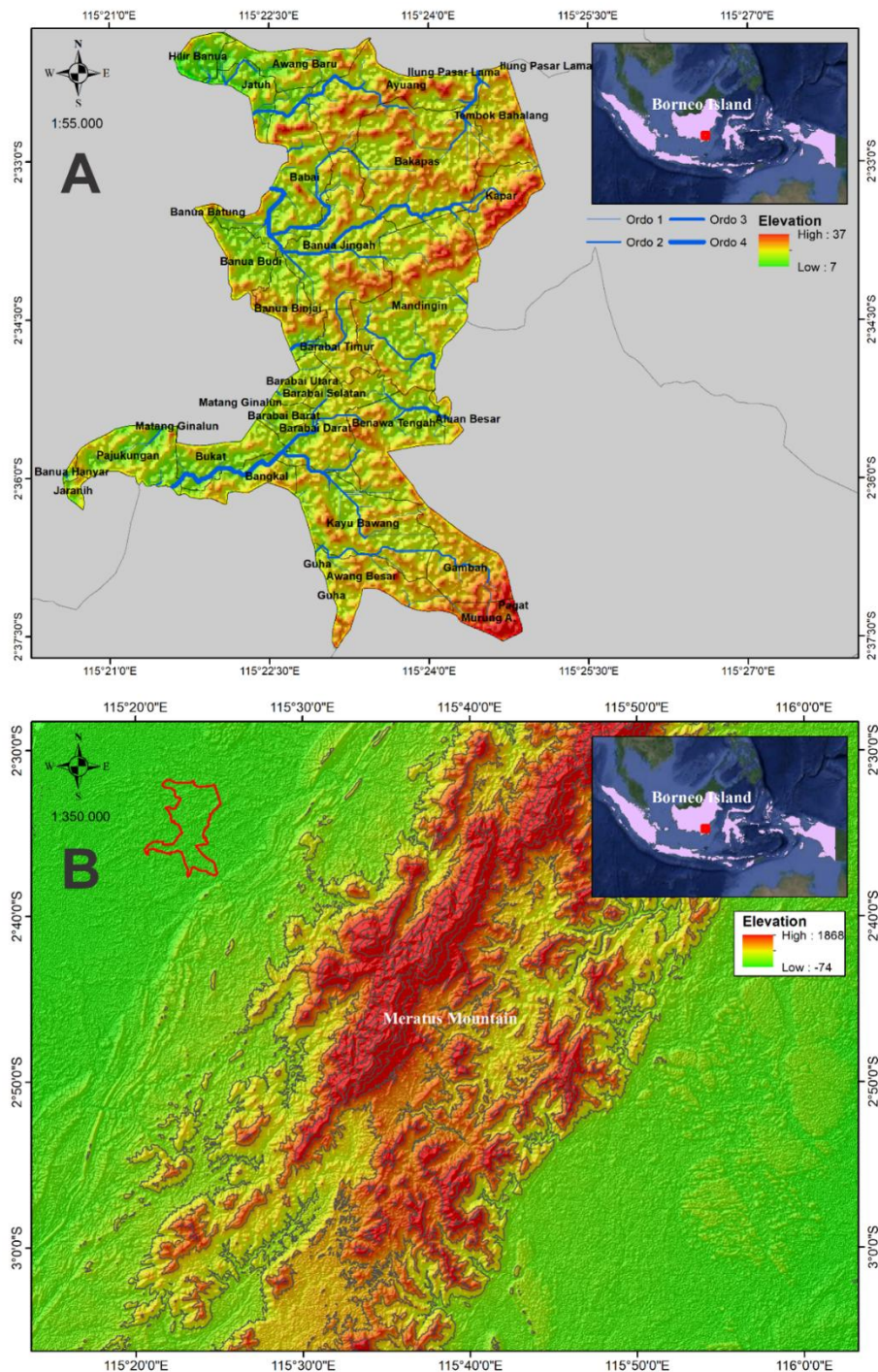


Figure 2. a) Geomorphological map of Barabai Sub-District with a maximum elevation of 37 meters shown in red; b) Topographic map of Barabai Sub-District which is located in the western part of the Meratus Mountains.

In addition to its physiographic and geological setting, land-use change has further increased flood susceptibility in Barabai Sub-District. The expansion of residential areas and agricultural land has reduced open and permeable surfaces that previously functioned as water retention and infiltration zones (Handayani et al., 2020; Izzati & Rustandi, 2025). Development along river corridors,

including agricultural expansion and settlement growth near riverbanks, may restrict channel capacity and increase the likelihood of overflow during intense rainfall events (Mondal & Patel, 2018; Sapoeira et al., 2024). Moreover, Barabai Sub-District still has limited disaster mitigation infrastructure, including early warning systems, while river maintenance, embankment management, and drainage

normalization remain insufficient in many villages (Badan Pusat Statistik Kabupaten Hulu Sungai Tengah, 2024). These conditions highlight the need for a spatially explicit assessment that can identify areas with different levels of flood susceptibility and support more targeted flood mitigation planning.

Several approaches have been developed to identify and map flood-prone areas, ranging from hydrological and hydraulic modeling to Geographic Information System (GIS)-based spatial analysis (Efraimidou & Spiliotis, 2024; Gasmi & Aly, 2026; Zhou et al., 2021). GIS-based scoring and weighted overlay methods are widely applied because they can integrate multiple flood-conditioning factors in a transparent, reproducible, and relatively simple manner, particularly in areas where detailed hydrological and field-based data are limited (Hanie et al., 2017; Septian et al., 2020; Latue et al., 2023). This approach enables the spatial evaluation of flood susceptibility by considering the relative contribution of topography, rainfall, land cover, soil characteristics, and proximity to river networks.

Although GIS-based flood susceptibility mapping has been widely applied in many regions (Amatebelle et al., 2025), sub-district-scale studies that integrate physical, geological, hydrological, and land-use characteristics remain limited, particularly for Barabai Sub-District. Existing studies and reports have documented flood occurrence in the region; however, spatial information that explicitly delineates flood susceptibility zones and relates them to their controlling factors is still insufficient for local mitigation planning. Therefore, this study aims to develop a GIS-based flood susceptibility map for Barabai Sub-District using a weighted overlay approach. The analysis integrates six flood-conditioning factors: rainfall, slope, elevation, soil texture, land use/land cover, and distance from river networks level.

The main contribution of this study is the development of a sub-district-scale flood susceptibility map that links spatial susceptibility patterns with key environmental and land-use controls. By integrating multi-source geospatial datasets within a GIS-based weighted overlay framework, this study provides practical spatial information for identifying priority areas for flood mitigation, supporting land-use planning, and strengthening disaster risk reduction strategies in Barabai Sub-District.

Materials and Methods

Barabai Sub-District is located in Hulu Sungai Tengah Regency, South Kalimantan, Indonesia, and comprises several villages and urban wards that provide the administrative framework for this spatial analysis. The study area lies in a lowland setting on the western flank of the Meratus Mountains and forms part of a downstream watershed system that receives runoff from surrounding upstream areas. Its relatively flat to gently sloping terrain, combined with the dominance of alluvial deposits and a history of recurrent flooding, makes the area highly susceptible to inundation, particularly during periods of intense rainfall (Indrasari & Rudiarto, 2020; Gultom et al., 2022). In this study, the administrative boundary of Barabai Sub-District was overlaid on high-resolution Google Earth satellite imagery to define the spatial extent of the analysis and to support visual interpretation of the study area, as shown in Figure 3.

Several secondary geospatial datasets were used to derive the flood-conditioning factors in this study, as summarized in Table 1. Topographic parameters, including elevation, slope, and drainage-related variables, were derived from the 30 m Shuttle Radar Topography Mission (SRTM) Digital Elevation Model. The administrative boundary of Barabai Sub-District was obtained from the Indonesia

Geospatial Portal and used to delineate the study area. Rainfall was represented using CHIRPS data for the 2021–2025 period, whereas soil texture information was obtained from the FAO Digital Soil Map of the World (DSMW). Land use/land cover (LULC) data for 2021 and 2025 were extracted from the Esri Sentinel-2 Land Cover Explorer. High-resolution Google

satellite imagery was used to support visual interpretation and verification of land cover conditions. In addition, the InaRISK-BNPB flood hazard map was used as an independent reference for comparison with the resulting flood susceptibility map. All datasets were processed and standardized in a GIS environment to ensure consistency in spatial extent, projection, and analysis.

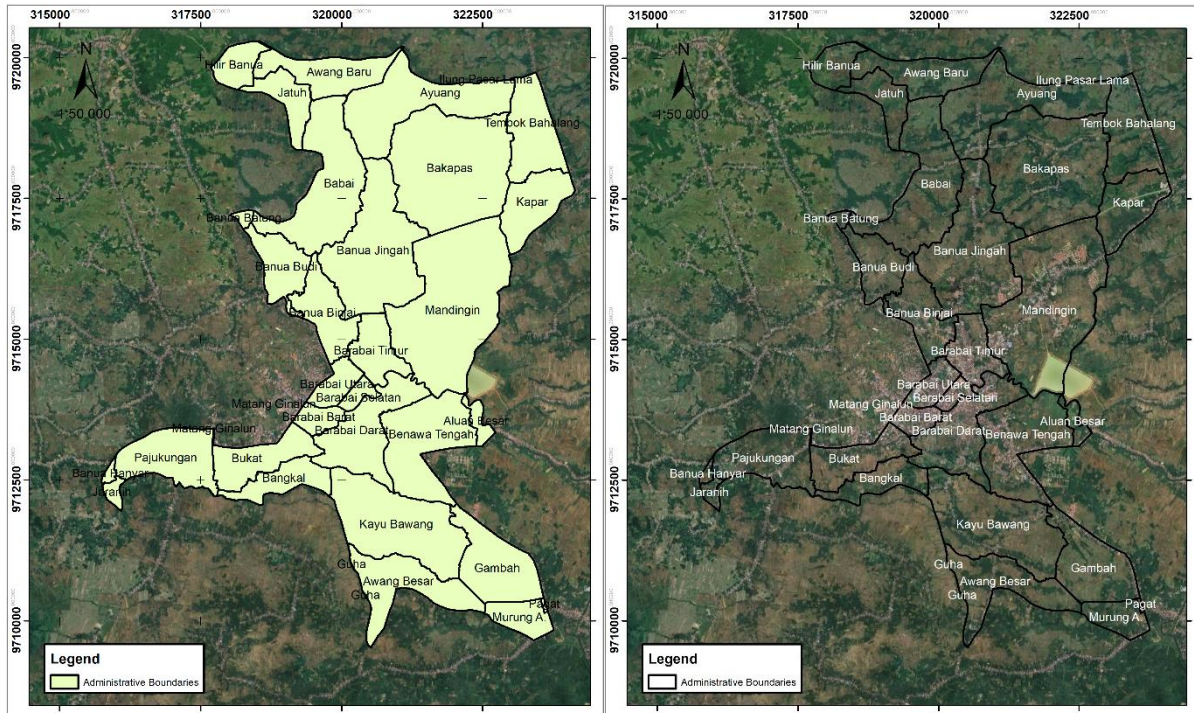


Figure 3. shows the administrative boundaries of Barabai Sub-District displayed on Google Earth satellite imagery. The study area consists of several villages and urban wards (kelurahan/ desa), which provide the spatial framework for flood susceptibility mapping and GIS-based analysis.

Previous spatial flood susceptibility studies have commonly incorporated rainfall, elevation, slope, land cover, soil characteristics, and drainage-related parameters as key flood-conditioning factors (Sihaini et al., 2026; Putri & Triyatno, 2025). Guided by these studies, the analytical framework in this study was designed to integrate six conditioning factors: rainfall, elevation, slope, land use/land cover, soil texture, and distance from river networks. Prior to the weighted overlay analysis, all spatial datasets listed in Table 1 were preprocessed in a GIS environment through coordinate reference system standardization, clipping to the Barabai Sub-District boundary, spatial

resolution harmonization, and data format conversion where necessary. These procedures were applied to ensure consistency in spatial extent, projection, and analytical units across all input layers.

After preprocessing, each dataset was processed according to its role in the flood susceptibility analysis. The InaRISK flood hazard data were converted into polygon format to generate a reference flood hazard map. Land use/land cover data for 2021 and 2025 were used to produce LULC maps and to assess land cover changes in Hulu Sungai Tengah Regency and Barabai Sub-District. CHIRPS rainfall data were processed using the Cell Statistics tool and interpolated

using the Inverse Distance Weighting (IDW) method to generate the average annual rainfall distribution map. The DEM was used to derive elevation, slope, and river network parameters through hydrological processing, including sink filling, flow direction, and flow

accumulation analysis, followed by the generation of river buffer zones. Soil texture information was extracted from the DSMW dataset to represent the influence of soil properties on infiltration capacity and surface runoff.

Table 1. Research Data Information

Data	Source	Year	Spatial Resolution / Scale	Format	Coordinate Reference System	Purpose in Analysis
SRTM DEM	USGS Earth Explorer (https://earthexplorer.usgs.gov/)	2014	30 m	Raster (GeoTIFF)	WGS 84, UTM Zone 50S	Derivation of elevation, slope, and stream parameters for flood susceptibility analysis
Administrative Boundary of Barabai Regency	Indonesia Geospatial Portal (https://tanahair.indonesia.go.id/)	2017	1:50,000	Vector (Shapefile)	WGS 84, UTM Zone 50S	Delineation of study area boundary
Rainfall Data (CHIRPS)	Climate Hazards Group – CHIRPS	2021 – 2025	0.05° (~5 km)	Raster (Bil/HDR)	WGS 84 Geographic Coordinate System	Rainfall parameter for flood susceptibility analysis
Soil Type Data (DSMW)	Digital Soil Map of the World (FAO)	2007	1:3,000,000	Vector (Shapefile)	WGS 84 Geographic Coordinate System	Soil texture classification for flood susceptibility analysis
Land Cover Data of South Kalimantan	Esri Sentinel-2 Land Cover Explorer (https://livingatlas.arcgis.com/landcoverexplorer/)	2021 & 2025	10 m	Raster	WGS 84 Geographic Coordinate System	Land use/land cover parameter for flood susceptibility analysis
Basemap Imagery	Google Satellite Imagery (Google Maps)	2025	High-resolution imagery	Raster imagery	WGS 84 Web Mercator	Visual interpretation and validation of land cover conditions
Flood Hazard Map	InaRISK-BNPB (https://inarisk.bnpb.go.id/)	2024	30m	Raster	WGS 84 Geographic Coordinate System	Validation and comparison of flood susceptibility results

All derived parameters were then reclassified according to their relative influence on flood occurrence and converted into a common spatial analysis

format. Each parameter class was assigned a score, while each parameter was assigned a weight based on its relative contribution to flood susceptibility. In this study, soil

texture was assigned the highest weight of 25%, followed by land use/land cover and slope, each with a weight of 20%. Rainfall was assigned a weight of 15%, whereas elevation and distance from rivers were each assigned a weight of 10%. The weighted scores were then integrated using the weighted overlay method to calculate the flood susceptibility index.

GIS-based multi-criteria approaches have become an effective framework for flood susceptibility and risk assessment by integrating multiple flood-conditioning factors and supporting decision-making for flood mitigation and land-use planning (Efraimidou & Spiliotis 2024).

The final map was evaluated by comparing it with the InaRISK-BNPB flood hazard map and available historical flood records. This comparison was conducted to examine whether areas classified as high and very high susceptibility corresponded to previously reported flood-affected zones. In addition, land use/land cover changes between 2021 and 2025 were analyzed to assess how land cover dynamics may influence flood susceptibility patterns in Hulu Sungai Tengah Regency and Barabai Sub-District. The results of these analyses were used to support the interpretation of flood-controlling factors and to formulate recommendations for flood risk reduction and regional management. The overall workflow of the study is presented in Figure 4.

Results and Discussion

Regional Geology of Barabai Sub-District

Regional geological information indicates that Barabai Sub-District is predominantly underlain by alluvial deposits associated with fluvial and swamp environments (Figure 5). These deposits consist mainly of unconsolidated materials, including

kaolinitic clay, silt, sand, peat, gravel, and loose boulders boulder (Heryanto & Sanyoto, 1994). Alluvial deposits commonly develop in low-lying geomorphic settings through the transport and accumulation of sediments by surface runoff and river processes (Vio et al., 2025). Because these materials are generally loose and poorly consolidated, they tend to have limited drainage capacity and are easily reworked during high-flow conditions. Consequently, the dominance of alluvial deposits in Barabai Sub-District supports the formation of floodplain environments and contributes to the area's susceptibility to inundation.

Slope Gradient Classification Results

The slope parameter was classified into six gradient classes adapted from (Fauzi, 2022), and each class was assigned a score according to its relative influence on flood susceptibility, as shown in Table 2. The slope map indicates that Barabai Sub-District is predominantly characterized by flat (0–3%) and gently sloping (3–8%) terrain (Figure 6). These low-gradient areas occupy most of the study area and provide favorable conditions for surface water accumulation during periods of intense rainfall. In contrast, moderately sloping (8–15%) and moderately steep (15–30%) terrain is mainly distributed in the northern part of the study area, where runoff is generally more efficient and surface water is less likely to accumulate. The predominance of flat to gently sloping terrain, together with the low-lying physiography of Barabai Sub-District, reduces runoff velocity and promotes temporary water storage on the land surface. Consequently, these topographic conditions increase the susceptibility of the area to prolonged inundation and flooding, particularly when high-intensity rainfall coincides with limited drainage capacity.

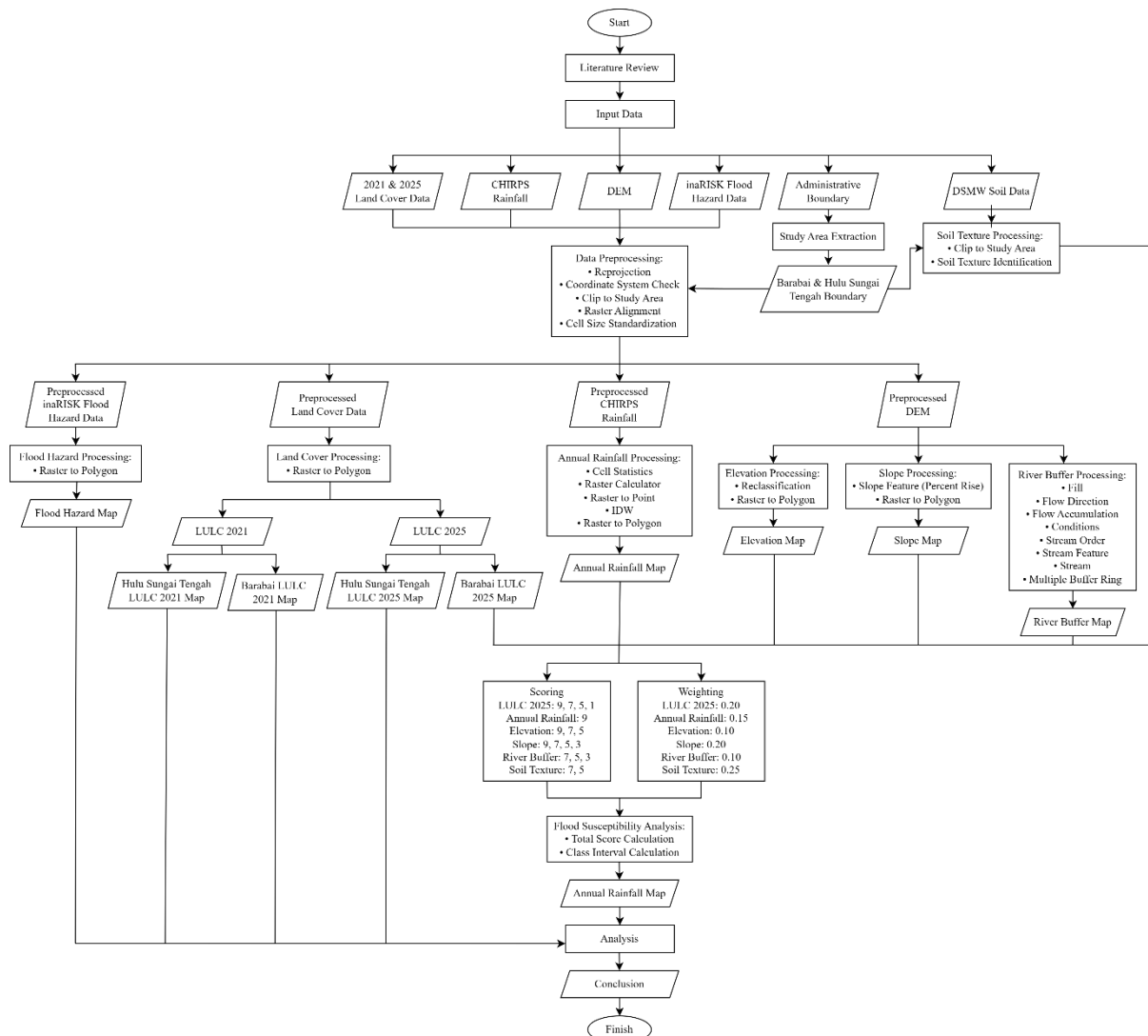


Figure 4. Workflow of the GIS-based flood susceptibility analysis conducted in Barabai Sub-District.

Table 2. Slope Gradient Classification Scoring.

No.	Slope Gradient	Score
1	Flat (0–3%)	9
2	Slightly Slope (3–8%)	7
3	Moderate Slope (8–15%)	5
4	Moderately Steep Slope (15–30%)	3
5	Steep Slope (30–45%)	1
6	Very Steep Slope (>45%)	0

The elevation map and its classification scores are presented in Figure 7 and Table 3, respectively. Elevation was classified into six classes according to its influence on flood susceptibility, with lower elevation classes assigned higher scores because they are generally more prone to inundation. Following the classification adopted from Utama et al., (2021), the elevation classes range from 0–12.5 m to more than 100 m

above sea level, with scores decreasing as elevation increases.

The elevation map shows that Barabai Sub-District is dominated by low-lying terrain, particularly elevations between 12.5 m and 25 m above sea level, while the overall elevation ranges from approximately 7 m to 37 m. This low-elevation setting indicates that much of the study area has limited topographic relief, which can reduce natural drainage efficiency and promote surface water accumulation. Low-lying areas are also more likely to receive runoff from surrounding higher terrain, thereby increasing their susceptibility to inundation during intense rainfall events.

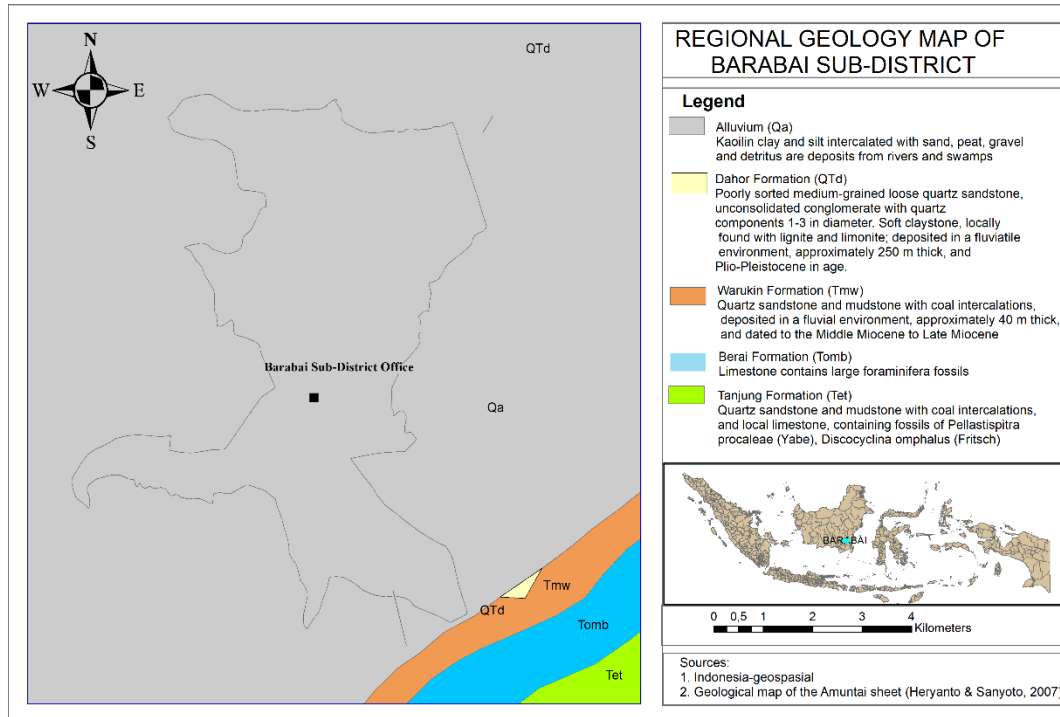


Figure 5. Regional Geological Map of Barabai District showing the dominance of alluvial deposits.

Table 3. Elevation Class Scores (Utama et al., 2021).

No.	Elevation Class (m)	Score
1	0–12.5	9
2	12.5–25	7
3	25–50	5
4	50–75	3
5	75–100	1
6	>100	0

Soil Texture Classification

Soil texture in Barabai Sub-District is dominated by the Sandy Clay Loam (Fine) class, whereas the Loam (Medium) class is mainly distributed in the southeastern part of the study area, particularly around Gambah, Pagat, and Murung A (Figure 8). The dominance of fine-textured soils suggests relatively low infiltration capacity and higher water retention near the surface, which can enhance surface runoff and increase flood susceptibility during intense rainfall events. Soil texture was classified into five classes according to its influence on infiltration capacity and runoff generation, based on the classification framework adopted from (Nkeki et al., 2023). Finer soil textures were assigned

higher scores because they generally have lower permeability and are more likely to restrict vertical water movement, whereas coarser textures were assigned lower scores due to their higher infiltration potential (Table 4).

Table 4. Soil Texture Class Scores.

No.	Soil Texture Class	Score
1	Very Fine	9
2	Fine	7
3	Medium	5
4	Coarse	3
5	Very Coarse	1

Land Use/Land Cover (LULC)

Table 5. Land Use/Land Cover (LULC) classes and their assigned scores for the weighted overlay analysis.

No.	Land Cover Class	Score
1	Paddy Fields, Bare Land, Water Body	9
2	Dryland Agriculture, Built Area	7
3	Shrubland, Grassland, Rangeland	5
4	Crops	3
5	Vegetation	1
6	Clouds and Cloud Shadows	1

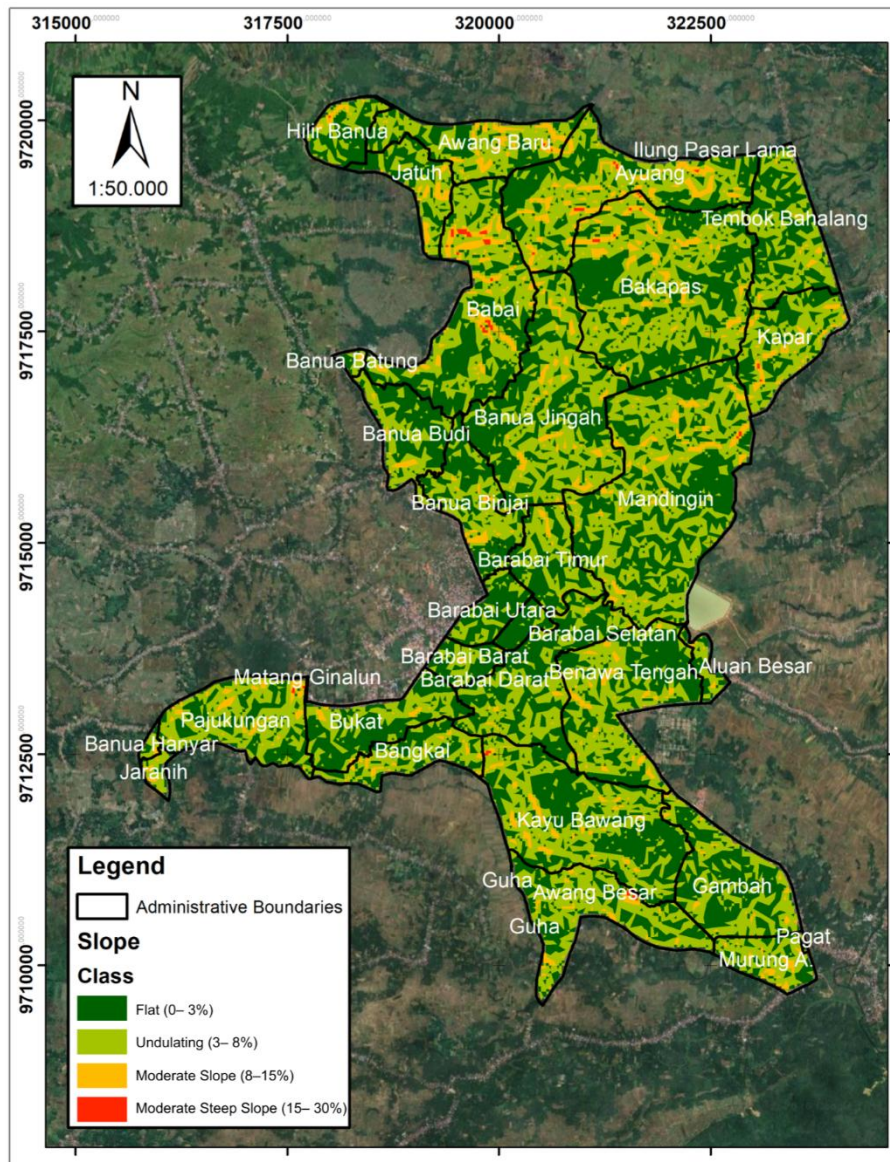


Figure 6. Slope Map of Barabai Sub-District shows variations in slope predominantly characterized by flat (0–3%) and gently sloping or undulating (3–8%) terrain.

Barabai Sub-District experienced noticeable land use and land cover (LULC) changes between 2021 and 2025, although cropland remained the dominant land cover class throughout the study period (Figure 9). Cropland is widely distributed across most villages and urban wards, whereas built-up areas are mainly concentrated in the central part of Barabai, particularly in Barabai Darat, Barabai Timur, Barabai Selatan, and Barabai Utara. Vegetation and rangeland occur as scattered patches, especially in the southern and northeastern parts of the study area. These spatial patterns of land cover can influence infiltration capacity, surface runoff

generation, and water retention, thereby affecting flood susceptibility in Barabai Sub-District. A comparison between the 2021 and 2025 LULC maps shows several changes, including the emergence of a water body class in 2025 that was not identified in the 2021 map. This water body corresponds to a reservoir developed as part of the government's flood management initiative, which is expected to improve water retention capacity and support local flood mitigation efforts (Antara Kalsel, 2022). Each land cover class was assigned a score based on its relative influence on flood susceptibility, based on the classification framework adopted from

Irmawati et al. (2023), and was subsequently incorporated into the weighted overlay analysis (Table 5).

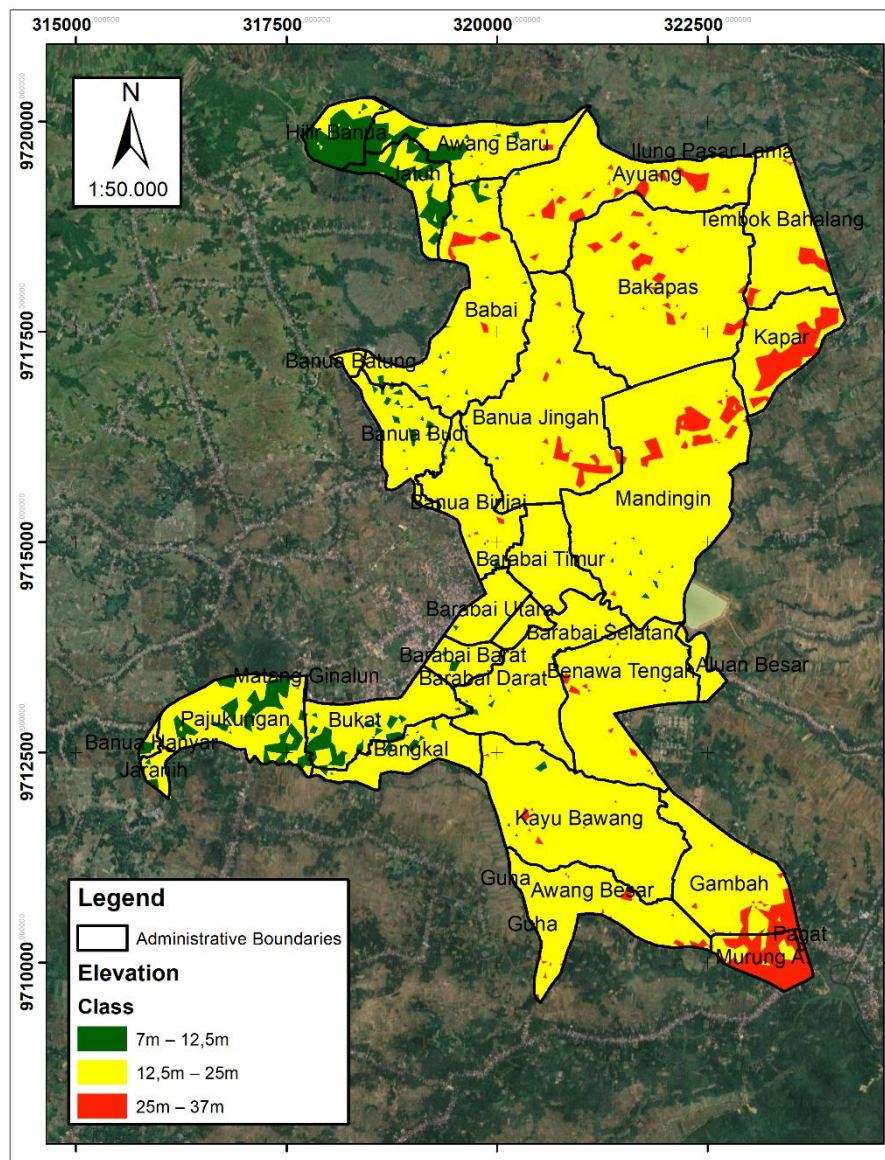


Figure 7. Barabai Sub-District is mainly dominated by elevations of 12.5–25 m, with an overall elevation range of approximately 7–37 m above sea level.

Table 6. Land Use/Land Cover (LULC) Distribution in Barabai Sub-District in 2021

No.	Class	Area (km ²)	Percentage (%)
1	Vegetation	1.97	5.02
2	Crops	26.87	68.53
3	Built-up Areas	10.09	25.73
4	Rangeland	0.28	0.71

The Land Use/Land Cover (LULC) distribution in Barabai Sub-District for the years 2021 and 2025 is presented in Tables 6 and 7, respectively. These datasets were used to evaluate changes in land cover and

their influence on flood susceptibility. The comparative diagram shown in Figure 10 illustrate the changes in land use and land cover (LULC) between 2021 and 2025 in Barabai Sub-District. Crops remained the dominant land cover class; however, their area decreased from 26.87 km² (68.53%) in 2021 to 24.21 km² (61.76%) in 2025. In contrast, built-up areas increased from 10.09 km² (25.73%) to 10.81 km² (27.58%), indicating ongoing urban development. Rangeland also exhibited a

considerable increase, while vegetation showed a slight decline. In addition, a new water body class covering 0.27 km² (0.69%) was identified in the 2025 LULC map, whereas it was absent in 2021. These changes may alter infiltration capacity and surface runoff patterns, thereby affecting flood susceptibility in the study area.

Table 7. Land Use/Land Cover (LULC) Distribution in Barabai Sub-District in 2025.

No.	Class	Area (km ²)	Percentage (%)
1	Water	0.27	0.69
2	Vegetation	1.56	3.98
3	Crops	24.21	61.76
4	Built-up Areas	10.81	27.58
5	Rangeland	2.35	5.99
6	Total	39.20	100.00

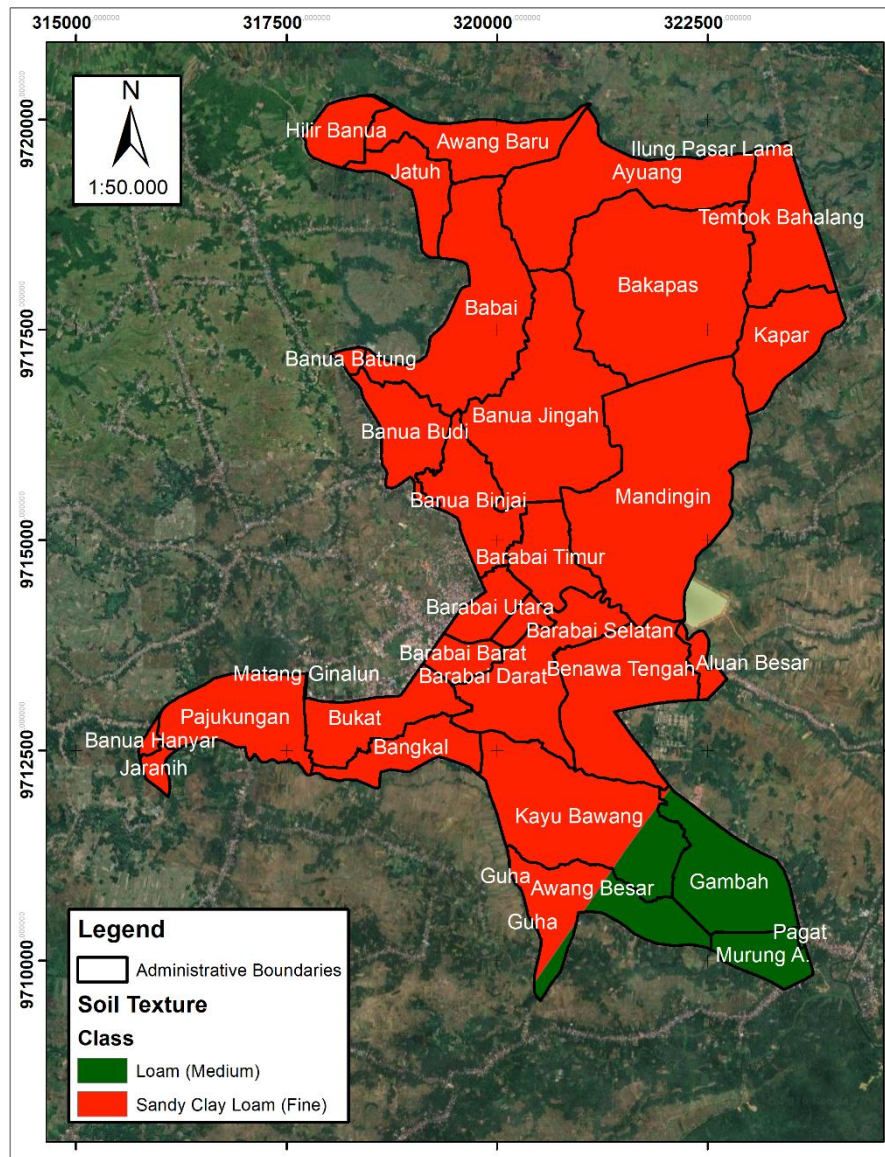


Figure 8. Spatial distribution of soil texture classes in Barabai Sub-District.

To provide a broader perspective, the LULC maps were analyzed for the entire Hulu Sungai Tengah Regency in 2021 and 2025. Figure 11 shows changes in land cover distribution between the two years. Notably, the extent of flooded vegetation decreased in 2025 compared to 2021, indicating a reduction in vegetated areas

affected by inundation. Furthermore, the LULC distribution diagram (Figure 12) highlights variations in the area of several land cover classes between 2021 and 2025, expressed in km². These changes indicate shifts in land cover composition across the regency, reflecting ongoing environmental

and land-use dynamics during the study period.

Rainfall Classification Results

Table 8. Rainfall Classification and Scores Used in Flood Susceptibility Analysis (Helmi et al., 2019).

No.	Rainfall Class (mm/year)	Category	Score
1	> 3000	Very Wet	9
2	2501–3000	Wet	7
3	2001–2500	Moderate/Humid	5
4	1501–2000	Dry	3
5	< 1500	Very Dry	1

Rainfall is one of the most important factors influencing flood susceptibility, as it directly affects surface runoff and water accumulation. Table 8 presents the rainfall classification and the corresponding scores used in the weighted overlay analysis. Based on the annual rainfall map derived from CHIRPS data for the 2021–2025 period, Barabai Sub-District is characterized by a single rainfall class ranging from 2501 to 3000 mm/year (Figure 13), which is classified as a wet category. This indicates that the study area receives relatively high annual rainfall, which may increase flood susceptibility.

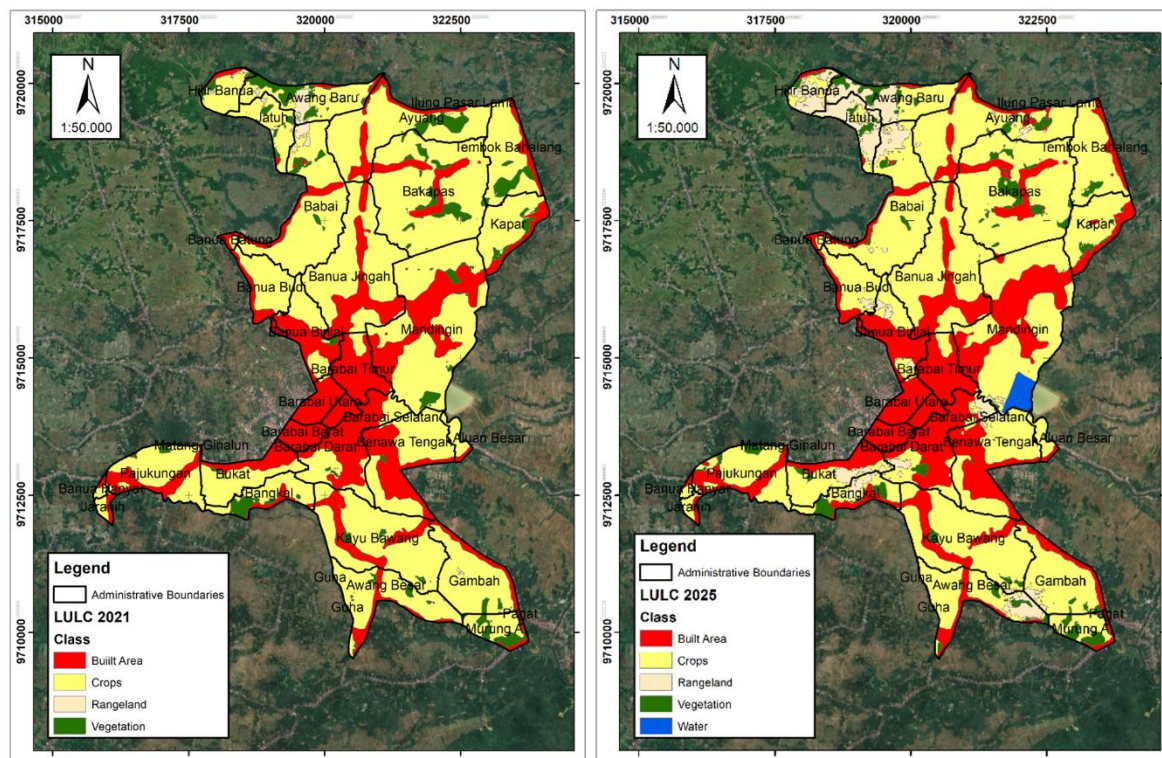


Figure 9. Spatial distribution of Land Use/Land Cover (LULC) classes in Barabai Sub-District for 2025.

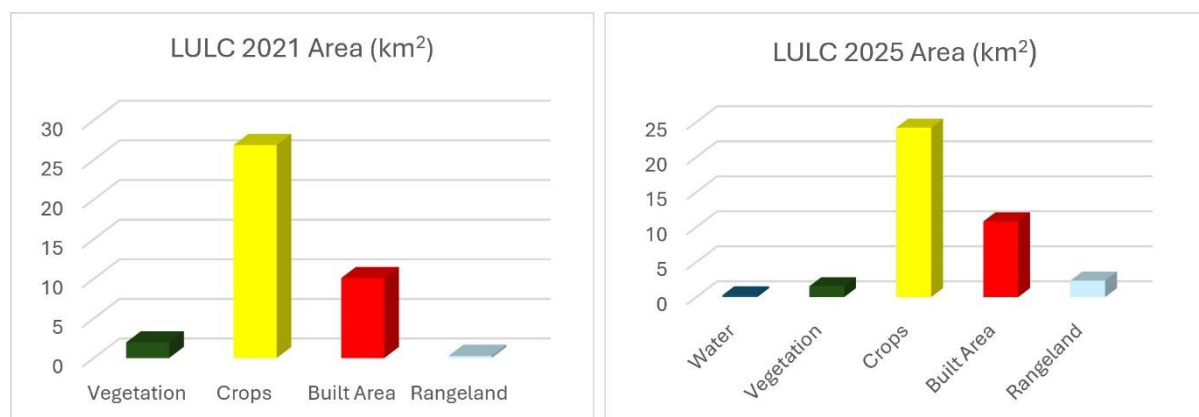


Figure 10. Comparison diagram illustrates the Land Use Land Cover (LULC) area distribution, measured in km², for the years 2021 and 2025.

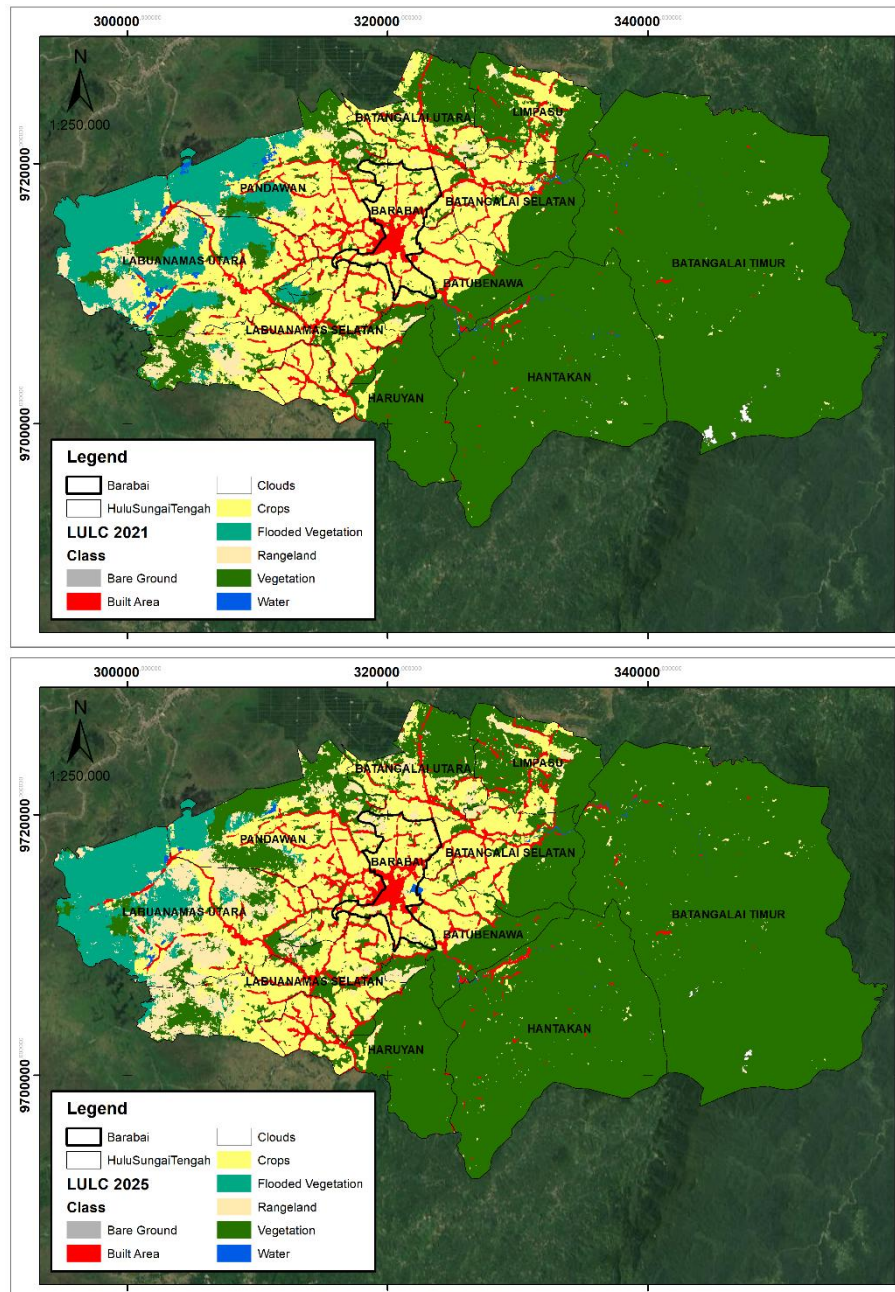


Figure 11. Comparison of Land Use/Land Cover Class Areas in Hulu Sungai Tengah Regency in 2021 and 2025.

River Buffer

Table 9. River Buffer Distance Classification (Utama et al., 2021).

No.	Class	Buffer Distance	Score
1	Very High	0–25 m	7
2	High	>25–100 m	5
3	Moderate	>100–250 m	3

The river network was derived from the Digital Elevation Model (DEM) through a series of hydrological processing steps. The resulting river buffer map was classified into four distance classes to represent the influence of proximity to rivers on flood

susceptibility. Table 9 presents the river buffer classification and the corresponding scores used in the weighted overlay analysis. In general, areas located closer to the river receive higher scores because they are more susceptible to flooding, whereas areas farther from the river are assigned lower scores due to their relatively lower flood risk. As shown in Figure 14, several villages and urban wards in Barabai Sub-District, including Barabai Darat, Barabai Utara, Barabai Selatan, Banua Jingah, Awang Baru, Ayuung, and Gambah,

Pajukungan are directly connected to the river network. This condition may increase the likelihood of river overflow during

periods of high rainfall, thereby increasing flood susceptibility in these areas.

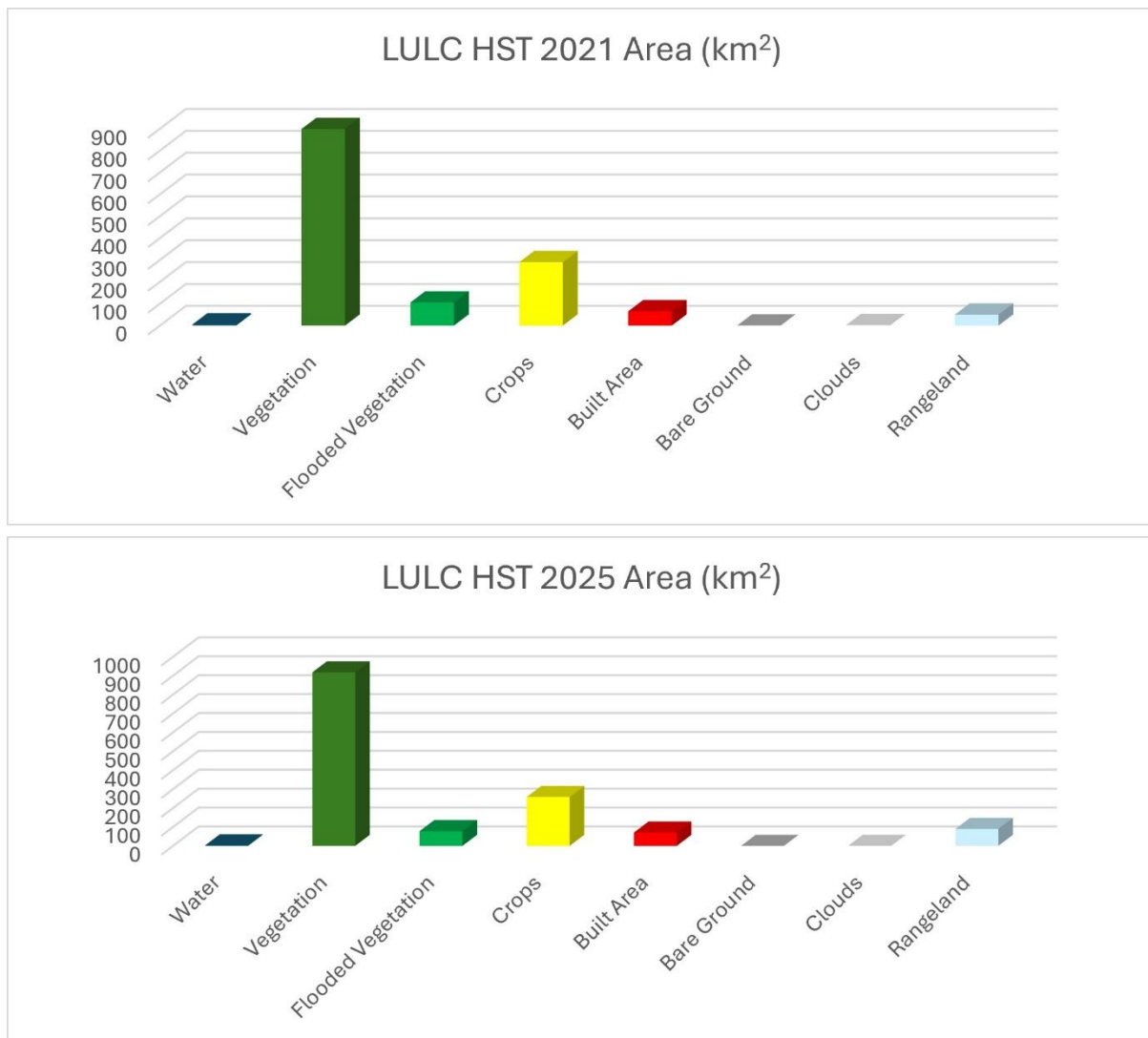


Figure 12. Comparison of LULC class areas in Hulu Sungai Tengah Regency between 2021 and 2025

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periods of high rainfall, thereby increasing flood susceptibility in these areas.

Flood Susceptibility Map Results

Flood susceptibility was assessed by integrating six flood-conditioning factors, namely slope, elevation, soil texture, rainfall, land use/land cover, and distance to river networks, using a GIS-based weighting and scoring approach. Following the general weighted overlay framework applied by Diriba et al. (2024), each reclassified thematic layer was multiplied by its assigned weight and subsequently summed to generate a composite flood susceptibility index. The normalized

weights applied to the flood-conditioning factors are presented in Table 10, with their total equal to 1.00. The flood susceptibility index was calculated using Equation (1).

$$K = \sum_{i=1}^n (W_i \times X_i) \quad (1)$$

Where:

K : Flood susceptibility value

W_i : normalized weight assigned to the i -th flood-conditioning factor

X_i : score assigned to the corresponding class of the i -th factor; and

n : total number of flood-conditioning factors

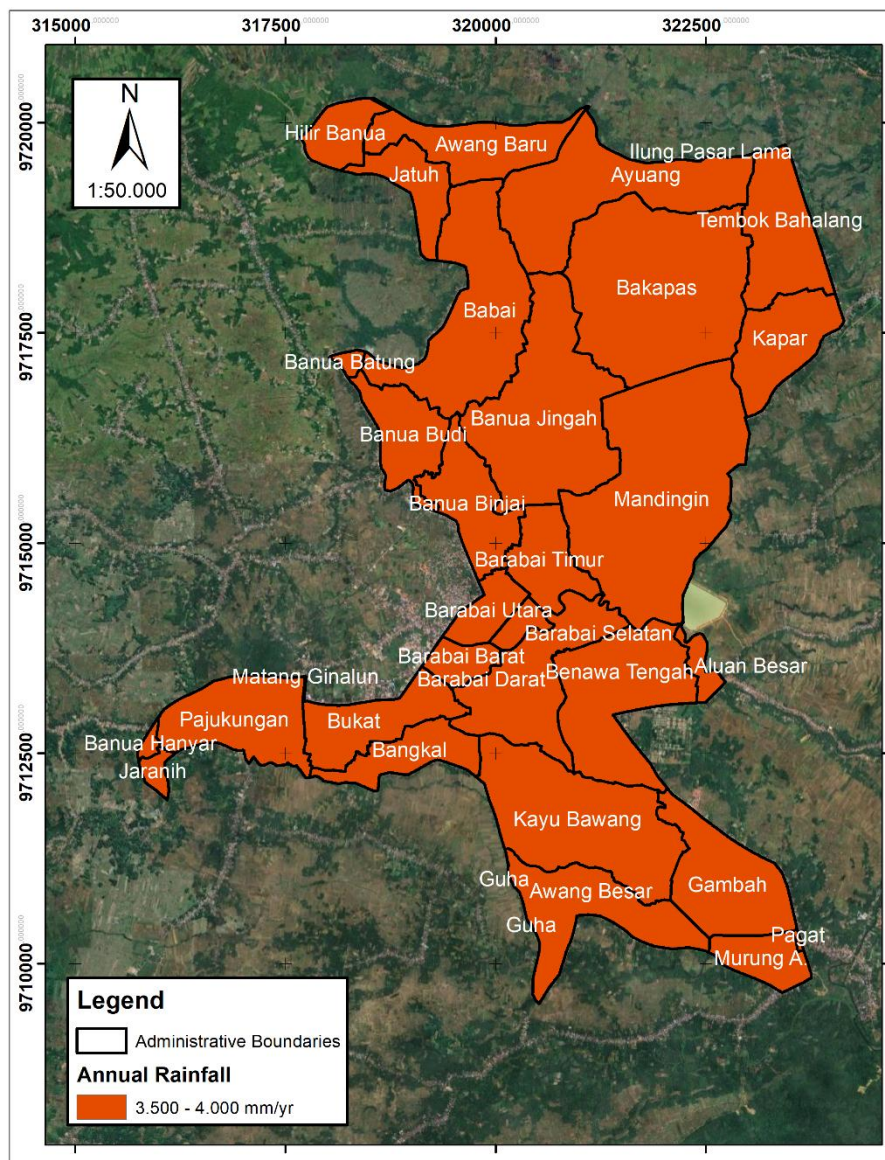


Figure 13. Spatial distribution of average annual rainfall in Barabai Sub-District based on CHIRPS data for the 2021–2025 period.

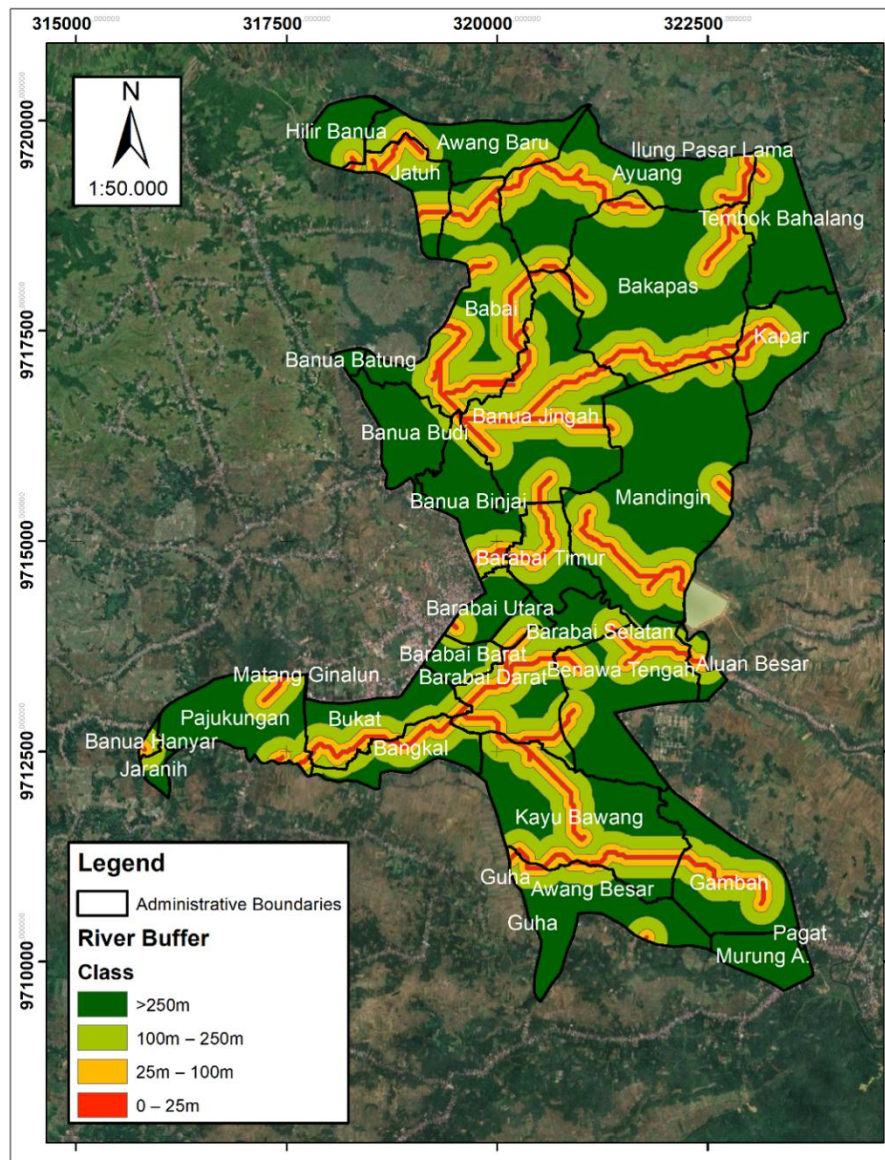


Figure 14. River buffer map of Barabai District derived from DEM data. The widespread distribution of river channels indicates that a large portion of the district is potentially susceptible to flooding, particularly in areas located close to the river network.

The weighted overlay analysis produced flood susceptibility index values ranging from 3.9 to 8.3. These values were classified into four susceptibility classes (Very Low, Low, High, and Very High) using the Equal Interval classification method. This method divides the total range of index values into intervals of equal width (ESRI, 2024). The classified index was subsequently used to generate the final flood susceptibility map of Barabai Sub-District. The class interval width was calculated using Equation (2).

$$i = R/n \quad (2)$$

Where:

- i : class interval width
- R : range of the flood susceptibility index, calculated as the difference between the maximum and minimum index values
- n : number of flood susceptibility classes

Based on the minimum and maximum flood susceptibility index values of 3.9 and 8.3, respectively, and four predefined susceptibility classes, the calculated class interval width was 1.1. The flood susceptibility map presented in Figure 15

and the corresponding area statistics in Table 11 indicate that the study area is dominated by the High and Very High susceptibility classes.

Table 10. Normalized Weights Assigned to the Flood-Conditioning Factors.

No	Flood-conditioning factor	Weight
1	Slope	0.20
2	Elevation	0.10
3	Soil Texture	0.25
4	Rainfall	0.15

5	Land Use	0.20
6	River Buffer	0.10

Table 11. Area and Percentage of Each Flood Susceptibility Class.

Flood Susceptibility Class	Area (km ²)	Percentage (%)
Very Low	0.23	0.61
Low	1.78	4.70
High	26.66	70.44
Very High	9.18	24.25
Total	37.85	100.00

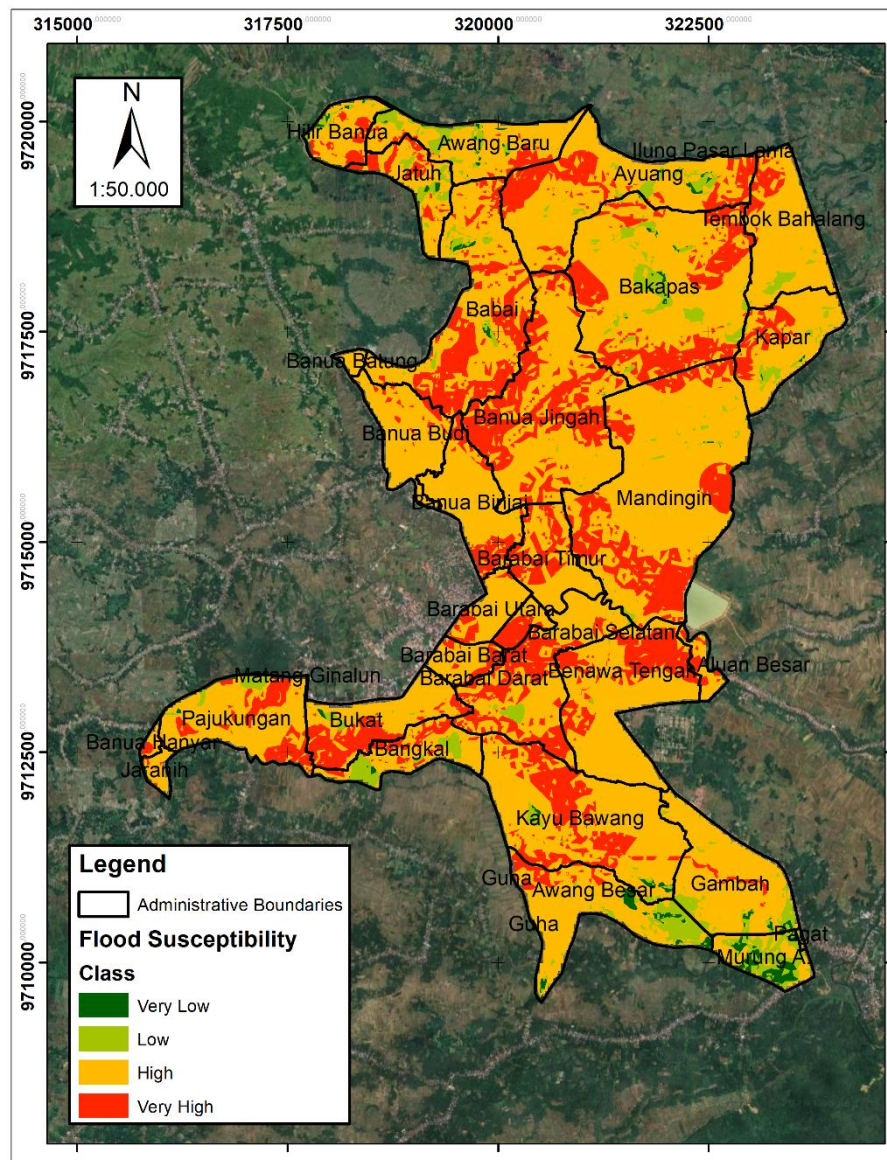


Figure 15. Flood susceptibility map of Barabai District showing the dominance of high and very high susceptibility classes.

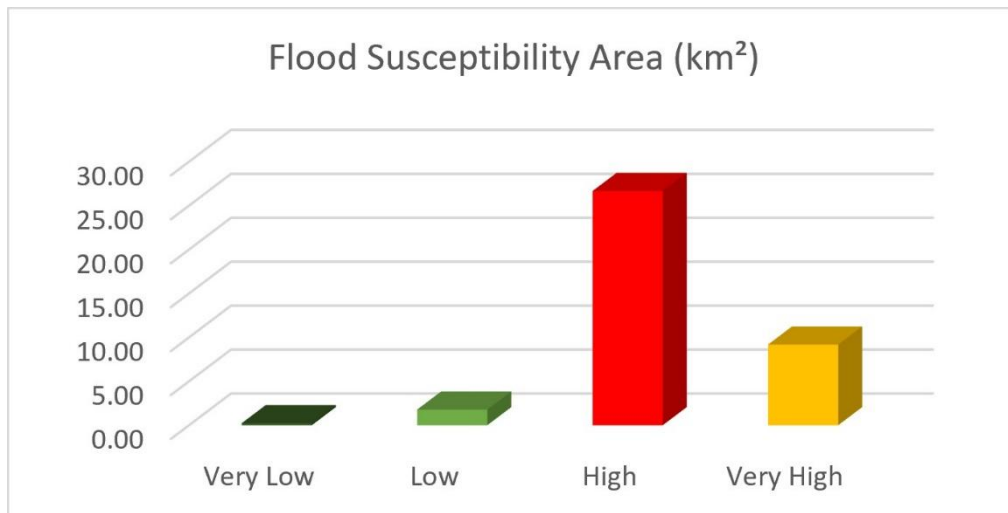


Figure 16. Illustrates the area distribution of flood susceptibility classes, indicating that the study area is predominantly characterized by High and Very High susceptibility levels, which together account for approximately 94.69% of the total area.

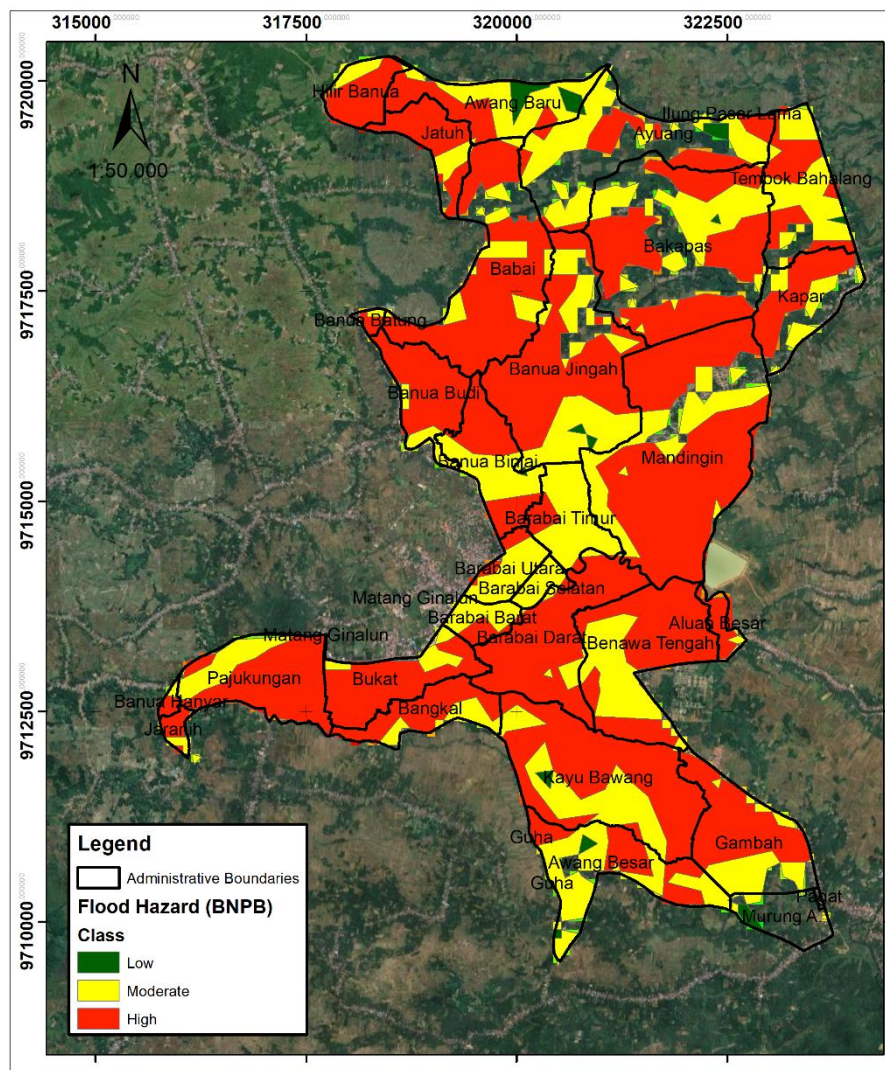


Figure 17. Validation of the flood susceptibility map using BNPB flood hazard data, indicating that most parts of Barabai District fall within moderate to high flood hazard categories.

The flood susceptibility map indicates that Barabai District is dominated by High and

Very High susceptibility classes, covering 26.66 km² and 9.18 km², respectively. Combined, these classes represent approximately 94.69% of the total study area, suggesting a widespread potential for flooding (Figure 16).

Historical flood events in 2021 affected Barabai Darat, Barabai Timur, Barabai Utara, Barabai Selatan, Benawa Tengah, Mandingin, Pajukungan, and Banua Jingah, with inundation depths ranging from 30 to 70 cm (detikNews, 2021). Recent floods reported by Antara Kalsel (2026) also impacted several areas, including Barabai Darat, Barabai Timur, Barabai Selatan, Barabai Utara, Bukat, Mandingin, and Pajukungan, affecting 28–650 houses and 133–1,967 residents, with water depths of 50–85 cm. These records indicate the recurring nature of flood hazards and their significant impacts on local communities within the study area. These areas correspond well with the high-susceptibility zones identified in the present study, providing preliminary evidence of the model's validity. In addition, the resulting flood susceptibility map was compared with the BNPB flood hazard map, which indicates that most parts of Barabai District fall within moderate to high flood hazard categories (Figure 17). The consistency between the susceptibility map, historical flood records, and BNPB hazard data further supports the accuracy of the mapping results.

Conclusions

The integration of six flood-conditioning parameters into a GIS-based weighted overlay model reveals that Barabai Sub-District is overwhelmingly dominated by high to very high flood susceptibility, indicating that the majority of the district faces substantial flood risk. This distribution is largely governed by the combined influence of low-lying, flat terrain, close proximity to river channels, moderately fine-textured soils, Quaternary

alluvial deposition, and land dominated by cultivation and built-up areas, while intense rainfall functions as the principal triggering mechanism. The strong correspondence between the model's output and documented flood occurrences in the area lends confidence to the robustness of the approach applied, underscoring the urgency of incorporating these findings into flood mitigation strategies and land-use planning in the region.

From a practical perspective, mitigation efforts should be prioritized in highly susceptible areas, particularly in Barabai Darat, Barabai Timur, Barabai Selatan, Barabai Utara, Bukat, Mandingin, and Pajukungan, which have frequently experienced flood impacts based on both the susceptibility analysis and historical flood records. These measures should include structural approaches such as improving drainage capacity, maintaining river channels, and developing flood control infrastructure. In addition, non-structural measures, including land-use regulation, riverbank protection, and community-based flood preparedness programs, should be implemented to reduce future flood impacts.

This study has several limitations. The resulting map represents flood susceptibility rather than a fully validated flood vulnerability or flood risk assessment, as comprehensive validation using historical flood extent data, field observations, and hydrological simulations was not conducted. Therefore, the results should be interpreted as a preliminary spatial assessment that can support spatial planning and flood management within the study area. Therefore, the results should be interpreted as a preliminary spatial assessment that can support spatial planning and flood management within the study area. Future studies should incorporate historical flood extent data, field observations and hydrological modeling to further improve the accuracy

and reliability of flood susceptibility assessments.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors gratefully acknowledge the National Digital Elevation Model (DEMNAS) for providing open access the topographic data and Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) to use in this study. We also thank the journal editor and anonymous reviewers for their constructive comments, which helped improve the quality of this manuscript.

Author Contribution

Sandri Erfani led the research, including conceptualization, methodology design, formal analysis, visualization, and preparation of the initial draft. Nailatussa'adah and Rosna Amaliaatul Ma'rifah contributed to data collection and accuracy, map creation, and weighting. Eka Andika and M. Rayya Andisa Putra assisted in the creation of the geological and topographic maps and editing the manuscript. Andri Kurniawan provided supervision and contributed to the review and editing of the manuscript.

Conflict of Interest

There were no funds or finances exchanged in this study, neither among the authors nor between the parties involved in the research.

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