Vol. 8, No. 2, July 2026: 240-250

Jambura Geoscience Review

p-ISSN 2623-0682 | e-ISSN 2656-0380

Department of Earth Science and Technology, Universitas Negeri Gorontalo

Spatial Analysis of Flash Flood Susceptibility in Ulu Ogan District

Salmaa Aulia Az-zahra[1], Budhi Setiawan[1], Yogie Zulkurnia Rochmana[1]

[1] *Geological Engineering Study Program, Universitas Sriwijaya, Jl. Srijaya Negara, Palembang, South Sumatra, 30139, Indonesia*

ARTICLE INFO

Article history:
Received: 12 March 2026
Accepted: 27 June 2026
Published: 03 July 2026

Keywords:
AHP; Flash Flood; GIS; Susceptibility; Ulu Ogan

Corresponding author:
Yogie Zulkurnia Rochmana
Email:
yogie.zrochmana@ft.unsri.ac.id

ABSTRACT

Ulu Ogan District, Ogan Komering Ulu Regency, is an area with a history of flash flood events triggered by high rainfall intensity and steep topographic conditions. This study aims to analyze flash flood susceptibility using the Analytical Hierarchy Process (AHP) to determine parameter weights and a Geographic Information System (GIS)-based Weighted Overlay technique to produce a susceptibility zoning map. The parameters used include rainfall, slope, river distance, soil type, land cover, and elevation. Rainfall data were obtained from CHIRPS, while the Digital Elevation Model (DEM) was derived from DEMNAS with a spatial resolution of 30 m. Land use data were obtained from the Ina-Geoportal (RBI dataset) provided by the Indonesian Geospatial Information Agency (BIG). All spatial datasets were processed in ArcGIS and resampled to a uniform spatial resolution to ensure consistency in the overlay analysis. The results indicate that areas classified as high susceptibility cover 1.35 km² (0.52%) and are concentrated along the Ogan River, particularly in low-lying areas located very close to the river channel. Moderate susceptibility areas cover 54.38 km² (21.12%) and generally follow the pattern of valleys and river networks. Meanwhile, low susceptibility areas dominate the study area, covering 201.99 km² (78.37%), and are mostly located in higher topographic regions farther from the main river channel. Despite the dominance of low susceptibility areas, river valley zones remain vulnerable to flash floods due to the localized and rapid nature of flash flood events.

How to cite: Az-zahra, SA. (2026). Spatial Analysis of Flash Flood Susceptibility in Ulu Ogan District. *Jambura Geoscience Review, 8*(1), 240-250. https://doi.org/10.37905/jgeosrev.v8i2.37786

1. INTRODUCTION

Flash floods are rapid hydrometeorological hazards that commonly occur in tropical watersheds with high rainfall intensity, steep topography, and dynamic land use conditions. These events may develop within a short period, generate high-energy flows, and transport debris that increases the potential damage to settlements, infrastructure, and watershed environments. Their occurrence is strongly controlled by the interaction between rainfall, slope, elevation, river proximity, soil characteristics, and land cover conditions, which collectively influence runoff generation, infiltration capacity, and flow concentration (Atmajayani, 2022; Putra et al., 2022; Sapan et al., 2023).

Spatial-based assessment has become an important approach for identifying areas susceptible to flash floods, particularly in regions with limited hydrological observation data. Geographic information systems (GIS) enable the integration of multiple environmental parameters into susceptibility maps, whereas multicriteria decision-making methods provide a systematic basis for assigning the relative importance of each factor (Bansal et al., 2022; Mustikaningrum et al., 2023). Among these methods, the analytical hierarchy process (AHP) is widely used because it allows for pairwise comparisons among criteria and evaluates the consistency of the weighting process (Saaty, 1987; Rehman et al., 2022). The integration of AHP and GIS has therefore been recognized as an effective framework for flood and flash flood susceptibility assessments in data-limited areas.

Previous studies have shown that rainfall, slope, elevation, land cover, soil type, and hydrological connectivity are key factors controlling flood and flash flood susceptibility (Dinata et al., 2021; Suryadi et al., 2024; Rahmanita & Idarwati, 2025). However, many GIS-based flood studies still rely on conventional overlay techniques or equal-weight assumptions, which may reduce the transparency of parameter contribution. In the Ogan Komering Ulu Regency, flood-related studies have addressed flood hazards and hydraulic modeling in the Ogan watershed system (Wulandari & Setiawan, 2024); however, specific flash flood susceptibility assessments in the Ulu Ogan District remain limited. This gap is important because the area has experienced recurrent flash flood events in several villages, indicating the need for a spatially explicit and systematically weighted susceptibility model.

This study analyzed the spatial distribution of flash flood susceptibility in the Ulu Ogan District using an integrated AHP–GIS approach. Six parameters–rainfall, slope, river distance, land cover, elevation, and soil type–were considered. The novelty of this study lies in the application of an AHP-based weighting framework to quantify the relative influence of flash flood-conditioning factors in the Ulu Ogan District, followed by a GIS-based weighted overlay to produce a susceptibility zoning map. This study is limited to a regional-scale relative susceptibility assessment and does not predict flash flood depth, discharge, timing, or magnitude. Its findings are expected to provide baseline spatial information for disaster mitigation, watershed management, and land-use planning in the study area.

2. METHOD

2.1. Study Area

The study area is in Ulu Ogan District, Ogan Komering Ulu Regency, South Sumatra Province, and includes seven villages: Pedataran, Sukajadi, Belandang, Ulak Lebar, Mendingin, Gunung Tiga, and Kelumpang (Figure 1). Geographically, it lies at approximately 4°6′26.39″ S and 103°45′55.38″ E, covers 257.72 km², and ranges from 280 to 1,820 m above sea level, with flat to very steep slopes. Annual rainfall exceeds 3,000 mm, the Ogan River drains the area, and Qhv breccia dominates, making it highly susceptible to flash floods and therefore suitable for susceptibility studies.

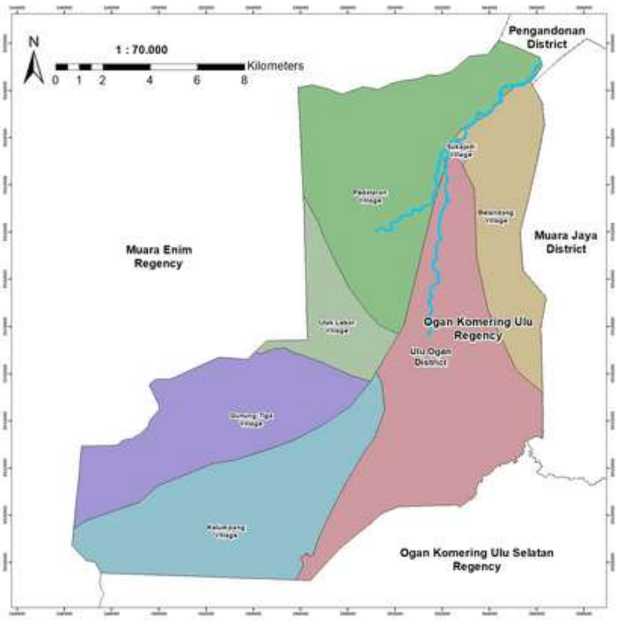

Figure 1. Map of the research location

2.2. Analytical Hierarchy Process

The analytical hierarchy process (AHP) method was used to determine the relative weights of each susceptibility-related parameter (Saaty, 1987). The process begins with the construction of a pairwise comparison matrix for each criterion using the Saaty scale (Table 1), where the comparison values were assigned based on a synthesis of previous studies, hydrological principles, and expert judgment to reduce subjectivity in the weighting process. The weighting scheme was developed by considering the relative influence of each parameter on flash flood occurrence. Although AHP provides a structured decision-making framework, the resulting weights are subject to interpretation.

Table 1. Saaty Scale for Pairwise Comparison

Score Value	Definition	Example
1	Equal importance	Both parameters contribute equally
3	Moderate importance of one over another	One parameter is slightly more important
5	Strong importance	One parameter is strongly important
7	Very strong importance	One parameter is very strongly more important
9	Extreme importance	One parameter is extremely more important
2, 4, 6, 8	Intermediate value between two adjacent judgment	Intermediate value score
Reciprocals	Inverse comparison	Used for inverse comparison between parameters

Source: (Saaty, 1987; Rehman et al., 2022)

The weight of each parameter was determined by calculating the mean value of every row in the normalized matrix, known as the priority vector. These weights represent the relative importance or influence of each criterion on the hazard being analyzed. A consistency test was performed to verify that the pairwise comparison judgments were reliable. The consistency ratio (CR) was then computed using Equation (1).

$$CR = \frac{CI}{RI} \tag{1}$$

where CR represents the consistency ratio derived from the AHP matrix, CI is the consistency index calculated based on Equation (2), and RI indicates the random index, which serves as a reference value to evaluate the consistency level of the pairwise comparison matrix (Table 2).

$$CI = \frac{\lambda \max - n}{n - 1} \tag{2}$$

where λmax is the maximum eigenvalue of the AHP comparison matrix, and n is the number of criteria used.

Table 2. Random index value

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,52	0,89	1,11	1,25	1,35	1,40	1,45	1,49

Source: (Saaty, 1987; Rehman et al., 2022)

2.3. Flash Flood Assessment

This study applied the Spatial Multi-Criteria Evaluation (SMCE) approach, in which each criterion was assigned a score based on its relative influence on flash flood susceptibility and subsequently multiplied by the corresponding weight obtained from the Analytical Hierarchy Process (AHP). (Mustikaningrum et al., 2023). The analysis was conducted in ArcGIS using the Weighted Overlay tool, where all spatial datasets were converted into raster format, projected to a uniform coordinate system (WGS 84, Zone 48S), and resampled to a consistent spatial resolution of 30 × 30 m to ensure compatibility in the overlay process. Each parameter was reclassified into five classes with scores ranging from 1 (lowest) to 5 (highest). The final susceptibility map was produced by integrating all weighted raster layers, and the mathematical expression of the SMCE method is presented in Equation (3).

$$S = \sum_{i=1}^{n} WiXi \quad (3)$$

where S represents the flood susceptibility value resulting from spatial multicriteria evaluation (SMCE), Wi is the weight of each parameter, and Xi is the score assigned to each parameter.

Table 3. Parameters Influencing Flash Flood Susceptibility

Parameters	Class	Score	Source	Classification Method
Rainfall	<1.500 mm	1	CHIRPS (2025)	(Anbalagan, Chakraborty, & Kohli, 2008)
	1.501 – 2.000 mm	2		
	2.001 – 2.500 mm	3		
	2.501 – 3.000 mm	4		
	>3.000 mm	5		
River Distance	>100 m	1	SHP (Indonesia Geospasial)	(Rakuasa & Latue, 2023)
	75 – 100 m	2		
	50 – 75 m	3		
	25 – 50 m	4		
	0 – 25 m	5		
Slope	0 – 8%	1	DEMNAS (Geoportal BIG, 2018)	(PERMEN PU, 2007)
	8 – 15%	2		
	15 – 25%	3		
	25 – 45%	4		
	>45%	5		
Land Cover	Rice Field	1	SHP (Indonesia Geospasial, 2019)	(KLHK, 2020)
	Plantation Forest	2		
	Mixed Dryland Agriculture	3		
	Bare Land	4		
	Built-up Area	5		
Elevation	>1.000 m	1	DEMNAS (Geoportal BIG)	(Widyatmanti, Wicaksono, & Syam, 2016)
	500 – 1000 m	2		
	200 – 500 m	3		
	50 – 200 m	4		
	0 – 50 m	5		
Soil Type	Regosol, Lithosol, Organosol, Rendzina	1	FAO Digital Soil Map of the World (FAO, 2008)	(PERMEN PU, 2007)
	Non-calcic Brown Forest Soil	2		
	Latosol	3		
	Andosol, Podzolic Soil	4		
	Alluvial Soil, Gleysol, Hydromorphic Soil	5		

The classification and scoring of each parameter were based on its hydrological relevance to flash flood processes. Rainfall influences runoff generation, slope affects flow velocity, land cover controls infiltration capacity, river distance represents exposure to overflow, and soil type reflects permeability and water retention characteristics. Parameters with greater influence on runoff and flow concentration were assigned higher susceptibility scores.

The parameters used in this study were selected based on their relevance to flash flood susceptibility and data availability at the study scale. Rainfall, slope, elevation, land cover, soil type, and river distance were chosen as primary control factors because of their direct influence on surface runoff generation, flow velocity, and water accumulation processes. Rainfall data were obtained from the CHIRPS rainfall data (CHIRPS, 2025). Although flash floods are commonly triggered by short-duration and high-intensity rainfall events, annual rainfall data were used in this study to represent the long-term spatial distribution of moisture availability and regional rainfall patterns. In data-limited regions, such as the Ulu Ogan District, annual CHIRPS rainfall data provide consistent spatial coverage and have been widely applied in regional-scale susceptibility assessments. Therefore, the rainfall parameter in this study should be interpreted as a proxy for relative climatic wetness rather than a direct representation of extreme rainfall events. Other parameters, such as drainage density, flow accumulation, watershed morphometry, channel slope, stream power, lithology, and historical flood inventory, were not included because of limitations in data availability and the focus on a simplified, data-driven susceptibility approach suitable for regional-scale analysis.

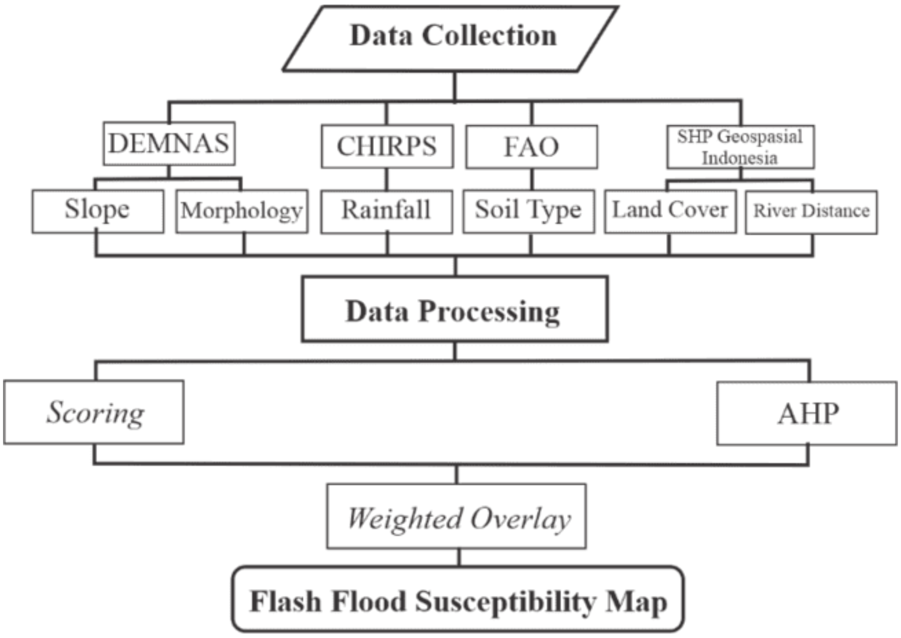

Figure 2. Flow chart of the flash flood susceptibility assessment method

3. RESULTS AND DISCUSSION

Six parameters were used to assess flash flood susceptibility in the Ulu Ogan district: rainfall, distance from rivers, slope gradient, land cover, elevation, and soil type (Figure 3). These parameters represent the main physical controls of flood occurrence because they influence runoff generation, infiltration capacity, flow velocity, and concentration of water toward river channels (Dinata et al., 2021; Suryadi et al., 2024). All spatial datasets were processed at a 30 m spatial resolution using the UTM Zone 48S coordinate system to ensure consistency during the overlay analysis.

Rainfall data derived from CHIRPS (2025) show that most of the study area is classified as very wet, with annual rainfall exceeding 3,000 mm, based on the classification of Anbalagan et al. (2008). Although flash floods are commonly triggered by short-duration, high-intensity rainfall, annual rainfall data provide an indication of regional wetness and general runoff potential. Therefore, rainfall in this analysis should be interpreted as a climatic proxy, rather than a direct representation of extreme rainfall intensity. Areas with high rainfall have a greater potential to generate surface runoff, particularly when combined with steep slopes and limited infiltration capacity (Pramono & Savitri, 2018; Sapan et al., 2023).

The river distance parameter indicates that areas located within 0–25 m from river channels have the highest susceptibility score. This condition reflects the direct exposure of river-adjacent areas to increased rapid discharge during intense rainfall events. The Ogan River and its tributaries act as the main flow pathways, where runoff from surrounding slopes is concentrated. Therefore, areas located close to river channels are more likely to experience flash flood impacts, especially in narrow valleys and low-lying zones (Rakuasa & Latue, 2023; Syafitri et al., 2024).

Slope also plays an important role in controlling flash flood susceptibility. Steeper slopes increase flow velocity, reduce infiltration opportunities, and shorten the time required for rainfall to reach river channels. In the study area, steep to very steep slopes are mainly distributed in the southwestern part, characterized by hilly and mountainous terrain. These conditions may accelerate runoff and sediment transport, thereby increasing the possibility of high-energy flood flows (Ananda et al., 2019; Dinata et al., 2021; Juliansyah et al., 2026).

A land cover analysis reveals that mixed dryland agriculture dominates the northern part of the study area, whereas plantation forests are more common in the southwestern region. Areas with reduced vegetation cover, such as bare land and built-up areas, tend to produce higher surface runoff because of lower interception and infiltration compared with vegetated areas. This confirms the important role of vegetation in regulating runoff, reducing erosion, and controlling sediment transport in watershed systems (Savitri et al., 2021; Suryadi et al., 2024).

Elevation and soil type further influence the spatial pattern of susceptibility. The elevation map indicates that the study area consists of hilly to mountainous terrain, with lower areas generally located along the river network. These low-lying zones are more prone to flow accumulation, whereas higher areas are generally less exposed to direct flood impacts. Soil type analysis indicates that podzolic soils dominate the study area. These soils may have moderate to low permeability, which can reduce infiltration and increase runoff under wet conditions (Widyatmanti et al., 2016; Simanjuntak et al., 2025).

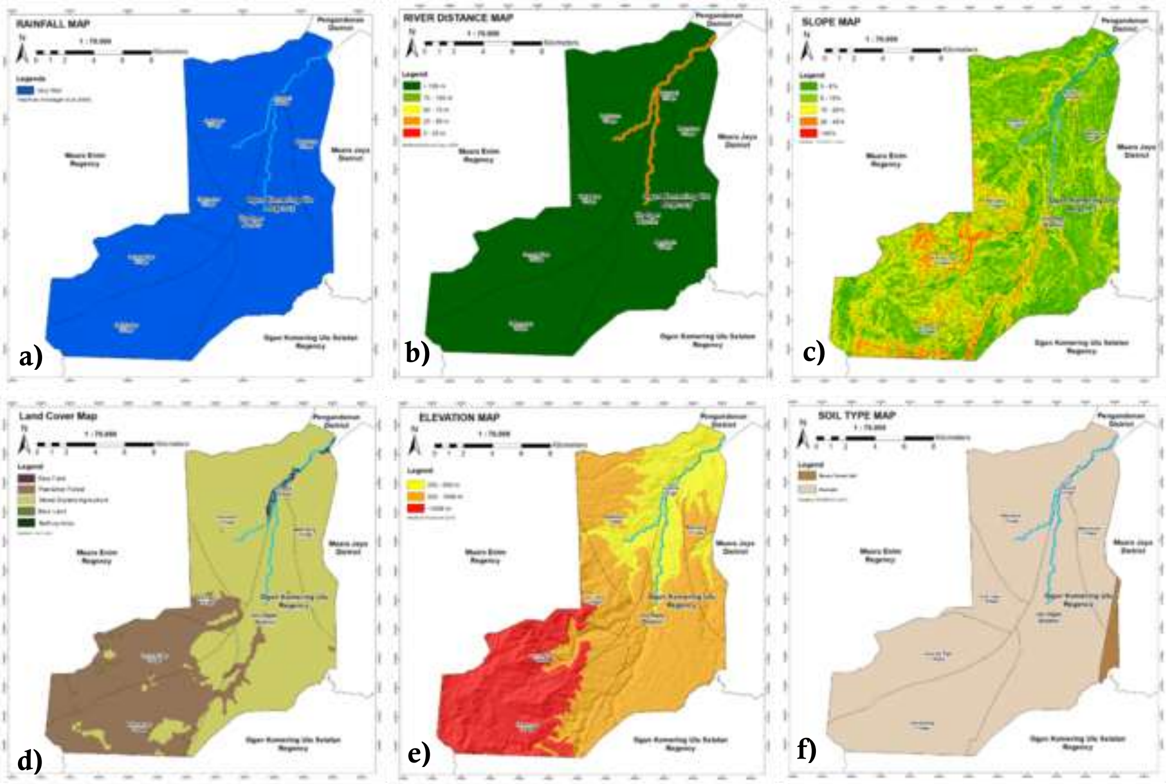

Figure 3. Parameter maps used in flash flood susceptibility analysis: a) rainfall, b) slope, c) land cover, d) river distance, e) elevation, and f) soil type.

Before the weighted overlay analysis was conducted, the relative importance of each parameter was determined using the analytical hierarchy process (AHP). The pairwise comparison matrix is presented in Table 4. Rainfall was assigned the highest relative importance because it is the main triggering factor for flash floods. River distance was also assigned a high importance value because areas close to river channels are directly exposed to rapid discharge increases. Slope was considered important because it controls flow velocity and runoff concentration, whereas land cover, elevation, and soil type were assigned lower weights because their influence is more indirect and mainly related to infiltration, surface roughness, and flow accumulation (Saaty, 1987; Rehman et al., 2022).

Table 4. Pairwise comparison matrix

Parameters	Rainfall	River Distances	Slope	Land Cover	Elevation	Soil Type
Rainfall	1	2	3	5	5	7
River Distances	0,50	1	3	3	5	5
Slope	0,33	0,33	1	2	3	5
Land Cover	0,20	0,33	0,50	1	3	5
Elevation	0,20	0,20	0,33	0,33	1	3
Soil Type	0,14	0,20	0,20	0,20	0,33	1
Total	2,37	4,06	8,03	11,53	17,33	26

The normalized matrix and final parameter weights are listed in Table 5. Rainfall obtained the highest weight of 0.38, followed by river distance with a weight of 0.27 and slope with a weight of 0.15. Land cover, elevation, and soil type obtained weights of 0.11, 0.06, and 0.03, respectively. These results indicate that flash flood susceptibility in the study area is primarily controlled by hydrometeorological triggering and proximity to river channels, whereas topographic and surface characteristics provide additional controls on runoff and flow concentration. Similar multicriteria flood studies have also emphasized rainfall, river proximity, slope, and land cover as dominant factors in flood susceptibility mapping (Bansal et al., 2022; Syafitri et al., 2024).

Table 5. Normalized matrix

Parameters	Rainfall	River Distances	Slope	Land Cover	Elevation	Soil Type	Weight
Rainfall	0,42	0,49	0,37	0,43	0,29	0,27	0,38
River Distances	0,21	0,25	0,37	0,26	0,29	0,19	0,27
Slope	0,14	0,08	0,12	0,17	0,17	0,19	0,15
Land Cover	0,08	0,08	0,06	0,09	0,17	0,19	0,11
Elevation	0,08	0,05	0,04	0,03	0,06	0,12	0,06
Soil Type	0,06	0,05	0,02	0,02	0,02	0,04	0,03
Total	1	1	1	1	1	1	1

The consistency test indicates that the pairwise comparison matrix is internally consistent. The calculated maximum eigenvalue produced a consistency index (CI) of 0.03 and a consistency ratio (CR) of 0.02 (Table 6). Because the CR value is lower than the acceptable threshold of 0.10, the AHP judgment matrix is considered consistent and suitable for weighted overlay analysis. However, a low CR value only indicates logical consistency among pairwise comparisons and does not necessarily represent empirical model accuracy (Saaty, 1987; Rehman et al., 2022).

Table 6. CI and CR values

Consistency Index (CI)	0,03
Consistency Ratio (CR)	0,02

A weighted overlay analysis produced a flash flood susceptibility map classified into three categories: low, moderate, and high susceptibility (Figure 4). The spatial distribution of these classes shows that low-susceptibility areas dominate the Ulu Ogan District, whereas moderate- and high-susceptibility zones are mainly distributed along river valleys and near the Ogan River corridor. This pattern indicates that flash flood susceptibility is strongly associated with river proximity, lower topographic positions, and local valley morphology, which are commonly identified as key controls of flood concentration in watershed systems (Dinata et al., 2021; Rakuasa & Latue, 2023)

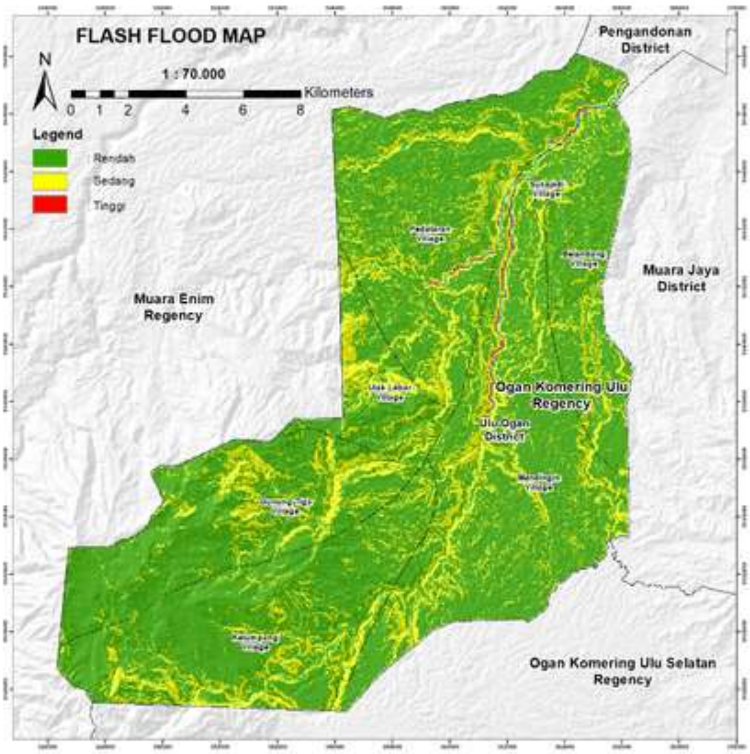

Figure 4. Flash flood susceptibility map.

The areas of each susceptibility class are listed in Table 7. Low-susceptibility areas covered 201.99 km², which is equivalent to 78.37% of the study area. These areas are generally located at higher elevations and farther from the main river channels, where direct exposure to flash flood flows is lower than in other areas. Moderate-susceptibility areas covered 54.38 km², or 21.12% of the study area. These zones typically follow minor valleys, tributaries, and areas adjacent to drainage networks. Although they are not classified as high-susceptibility zones, moderate zones remain important because they may experience flood impacts during extreme rainfall or when runoff concentrations increase rapidly (Pramono & Savitri, 2018; Sapan et al., 2023).

Table 7. Area of each flash flood susceptibility

Villages	Classification					
	Low		Moderate		High	
	Area (Km²)	Per cent (%)	Area (Km²)	Per cent (%)	Area (Km²)	Per cent (%)
Belandang	22	8,54	4,84	1,89	0,06	0,02
Gunung Tiga	33,40	12,96	7,92	3,07	0	0
Kelumpang	42,12	16,35	9,25	3,59	0	0
Mendingin	50,91	19,75	14,31	5,55	0,73	0,28
Pedataran	43,29	16,80	13,11	5,09	0,56	0,22
Sukajadi	0,36	0,14	0,17	0,07	0	0
Ulak Lebar	9,91	3,84	4,78	1,86	0	0
Total	201,99	78,37	54,38	21,12	1,35	0,52

High-susceptibility areas covered only 1.35 km², equivalent to 0.52% of the total study area. These areas are mainly located along the Ogan River corridor, particularly in Mendingin, Pedataran, and Belandang villages. Although the spatial extent of high susceptibility is relatively small, these zones represent critical locations because flash floods are typically localized, rapid, and concentrated along river channels or narrow valleys. Therefore, the small proportion of high-susceptibility areas should not be interpreted as having low hazard significance, but rather as an indication that the most critical hazard zones are spatially concentrated (Hidayat & Iswardoyo, 2019; Wardhani et al., 2024).

The dominance of low-susceptibility areas reflects the mountainous and elevated character of much of the Ulu Ogan district. However, the concentration of moderate- and high-susceptibility zones along the river network indicates that flood impacts are spatially controlled by local geomorphology. This finding is consistent with the nature of flash floods, which often affect specific corridors rather than broad lowland areas. Villages with river-adjacent settlements may remain vulnerable, even when the district as a whole is dominated by low susceptibility classes (Sapan et al., 2023; Suryadi et al., 2024).

To provide qualitative validation, historical flash flood events reported by the Regional Disaster Management Agency (BPBD) were compared with the susceptibility classes, as presented in Table 8. The comparison shows that several villages affected by historical flash floods correspond to moderate- and high-susceptibility zones, respectively. Kelumpang Village, which experienced a flash flood on March 25, 2019, was classified as moderate. During the May 22–25, 2024 event, Belandang, Pedataran, and Mendingin were associated with high susceptibility classes, whereas Ulak Lebar, Kelumpang, and Gunung Tiga corresponded to moderate susceptibility classes.

Table 8. Historical flash flood events and corresponding susceptibility classes in Ulu Ogan District

Village	Historical Flash Flood Event	Susceptibility Class
Kelumpang	25 March 2019	Moderate
Belandang	Flash flood event on 22–25 May 2024	High
Ulak Lebar	Flash flood event on 22–25 May 2024	Moderate
Kelumpang	Flash flood event on 22–25 May 2024	Moderate
Pedataran	Flash flood event on 22–25 May 2024	High
Mendingin	Flash flood event on 22–25 May 2024	High
Gunung Tiga	Flash flood event on 22–25 May 2024	Moderate

This qualitative correspondence suggests that the susceptibility map generally reflects the spatial pattern of recorded flash flood events. Villages located in high-susceptibility classes are mainly associated with lower topographic positions and close proximity to river channels, whereas villages in moderate-susceptibility classes are generally linked to valley systems and tributary networks. However, validation remains limited because detailed flood inventory data, event coordinates, inundation depths, discharge measurements, and damage records are unavailable. Therefore, the comparison should be interpreted as a qualitative indication of model consistency rather than a quantitative accuracy assessment (Mustikaningrum et al., 2023; Rehman et al., 2022).

Overall, the results demonstrate that the integration of AHP and GIS can identify the relative spatial distribution of flood hazards in the Ulu Ogan District. This method is useful for data-limited areas because it allows multiple environmental parameters to be combined through a transparent weighting process. The susceptibility map can support early-stage disaster mitigation by identifying critical river corridors, prioritizing field verification, and guiding land-use planning in areas exposed to flood hazards. Nevertheless, future studies should incorporate short-duration rainfall intensity, detailed flood inventory data, drainage density, flow accumulation, channel slope, and sensitivity analysis to enhance the reliability of susceptibility assessments (Bansal et al., 2022; Mustikaningrum et al., 2023; Wardhani et al., 2024).

4. CONCLUSIONS

This study demonstrates that the integration of AHP and GIS can be used to assess the relative spatial distribution of flood hazards in the Ulu Ogan District. The results indicate that high-susceptibility areas cover 1.35 km² (0.52 %) of the study area and are mainly concentrated along the Ogan River corridor, particularly in river-adjacent and low-lying zones. Moderate-susceptibility areas cover 54.38 km² (21.12 %), while low-susceptibility areas dominate the study area with an area of 201.99 km² (78.37 %).

The spatial pattern of susceptibility indicates that flash flood potential is mainly controlled by rainfall, proximity to river channels, slope, elevation, land cover, and soil type. Although high-susceptibility zones occupy a relatively small area, they are critical locations because flash floods are typically rapid, localized, and concentrated along river valleys. Therefore, these zones should be prioritized for mitigation planning, field verification, and land-use control.

The findings provide baseline spatial information for disaster risk reduction and watershed management in the Ulu Ogan district. However, this study is limited to a relative susceptibility assessment because validation was conducted qualitatively using historical flood records. Future studies should incorporate detailed flood inventory data, short-duration rainfall intensity, discharge records, and sensitivity analysis to improve model accuracy and reliability.

5. REFERENCES

Ananda, S., Azmeri, & Nizamuddin. (2019). Investigation of Flash Flood Threats Using Spatial Data in Lawe Sigala-gala District, Southeast Aceh District, Aceh. *International Journal of Multicultural and Multireligious Understanding*, *6*(3), 173–181. tp://dx.doi.org/10.18415/ijmmu.v6i3.808

Anbalagan, R., Chakraborty, D., & Kohli, A. (2008). *Landslide hazard zonation (LHZ) mapping on meso-scale for systematic town planning in mountainous terrain*. *67*(July), 486–497.

Atmajayani, R. D. (2022). Analisis kondisi lingkungan fisik dan sosial ekonomi masyarakat di Daerah Aliran Sungai Brantas akibat penambangan pasir (Studi kasus Kali Brantas Kecamatan Srengat, Kabupaten Blitar). *BRILIANT: Jurnal Riset dan Konseptual, 7*(1), 74–84. https://doi.org/10.28926/briliant.v7i1.728

Bansal, N., Mukherjee, M., & Gairola, A. (2022). Evaluating urban flood hazard index (UFHI) of Dehradun city using GIS and multi - criteria decision analysis. *Modeling Earth Systems and Environment*. https://doi.org/10.1007/s40808-021-01348-5

Climate Hazards Group Infrared Precipitation with Station Data. (2025). CHIRPS: rainfall estimates from rain gauge and satellite observations. Retrieved from https://www.chc.ucsb.edu/data/chirps

Dinata, A., Dhiniati, F., & Diansari, L. E. (2021). Delineation of flash flood hazard zones based on morphometric parameters using GIS technique in upper Lematang sub-watershed. *IOP Conf. Series: Earth and Environmental Science*, *208*(012051), 1–11. https://doi.org/10.1088/1755-1315/708/1/012051

Food and Agriculture Organization. (2008). FAO/UNESCO Soil Map of the World. Retrieved from https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/

Geoportal BIG. (2018). Demnas tahun 2018. Retrieved from https://tanahair.indonesia.go.id/portal-web/login?page=/unduh/demnas

Hidayat, R., & Iswardoyo, J. (2019). Banjir Bandang di Alasmalang Banyuwangi dan Alternatif Penanganannya. *Jurnal Penelitian Pengelolaan Daerah Aliran Sungai*, *3*(2), 127–140.

Indonesia Geospasial. (2019). Kumpulan shapefile (SHP) terlengkap dan terbaru seluruh Indonesia. Retrieved from https://www.indonesia-geospasial.com/2020/05/download-data-peta.html

Jamalludin, Riduansyah, & Krisnohadi, A. (2023). Studi Karakteristik DAS dan Kualitas Air untuk Irigasi pada Sub Daerah Aliran Sungai (DAS) Tayan Bagian Hilir Kabupaten Sanggau. *Jurnal Sains Pertanian Equator*, 892–903. https://doi.org/10.26418/jspe.v12i4.66878

Juliansyah, I., Harnani, H., & Nurohim, D. (2026). GIS-Based Landslide Susceptibility Mapping Using Weighted Overlay in Ogan Komering Ulu. *Jambura Geoscience Review, 8*(1), 139-149. doi:https://doi.org/10.37905/jgeosrev.v8i1.36391

KLHK. (2020). Kelas Tutupan Lahan KLHK. Retrieved from https://www.kehutanan.go.id/

Luliana. (2025). Kajian Tingkat Kerentanan Bencana Banjir di Kecamatan Baturaja Barat Kabupaten Ogan Komering Ulu Menggunakan Data Spasial dan Metode Overlay Berbasis Sistem Informasi Geografis. *Jurnal Publikasi Rumpun Ilmu Teknik*, *3*(5). https://doi.org/10.61132/venus.v3i5.1200

Mustikaningrum, M., Widhatama, A. F., Widantara, K. W., Ibrohim, M., Hibatullah, M. F., Larasati, R. A. P., … Hadmoko, D. S. (2023). Multi-Hazard Analysis in Gunungkidul Regency Using Spatial Multi-Criteria Evaluation. *Forum Geografi*, *37*(1), 35–45.

https://doi.org/10.23917/forgeo.v37i1.19041

PERMEN PU, N. 41/PRT/M/200. (2007). *Pedoman kriteria teknis*.

Pramono, I., & Savitri, E. (2018). Flash flood in Arau watershed , West Sumatera : a mitigation study. *MATEC Web of Conferences*, *03002*, 1–5. https://doi.org/10.1051/matecconf/201822903002

Putra, D., Sofwany, B., Zulfinanda, H., & Kamaruddin, I. (2022). Flash Flood (Δ) Risk and Damage Assessment in Batu , East Java. *Jurnal Teknosains*, *12*(1), 72–84. https://doi.org/10.22146/teknosains.78483

Rahmanita, D., & Idarwati, I. (2025). Mapping Flood-Prone Zone Using CMA and NDWI in Muaradua District, South OKU. *Jambura Geoscience Review,* *7*(2), 68-76. doi:https://doi.org/10.37905/jgeosrev.v7i2.28483

Rakuasa, H., & Latue, P. C. (2023). *Spatial Analysis of Flood Problem Area in Wae Heru Watershed , Ambon City*. *10*(1), 75–82. https://doi.org/10.21776/ub.jtsl.2023.010.1.8

Rehman, A., Song, J., Haq, F., Mahmood, S., Ahamad, M. I., Basharat, M., … Mehmood, M. S. (2022). Multi-Hazard Susceptibility Assessment Using the Analytical Hierarchy Process and Frequency Ratio Techniques in the Northwest Himalayas, Pakistan. *Remote Sensing*, *14*(3), 1–31. https://doi.org/10.3390/rs14030554

Saaty, R. W. (1987). The analytic hierarchy process-what it is and how it is used. *Mathematical Modelling*, *9*(3–5), 161–176. https://doi.org/10.1016/0270-0255(87)90473-8

Sapan, E. G. A., Santosa, B. H., Ridwansyah, I., Fakhrudin, M., Pravitasari, A. E., Novianti, R., … Setiawan, A. M. (2023). Understanding Flash Floods in Hilly Tropical Watersheds : A Trigger Factor Analysis. *IOP Conf. Series: Earth and Environmental Science*, *1226*(012046), 1–10. https://doi.org/10.1088/1755-1315/1266/1/012046

Savitri, A., Achmad, A., & Fadhly, N. (2021). The change of land use patterns and cover on the surface runoff in Krueng Meuraksa sub-watershed. *IOP Conf. Series: Earth and Environmental Science*, *847*(012008), 4–12. https://doi.org/10.1088/1755-1315/847/1/012008

Simanjuntak, N. R., Umar, Gunarto, D., & Soeryamassoeka. (2025). Flood Hazard Level Analysis of Kapuas Hulu Sub-watershed Using Geographic. *Jurnal Teknik Sipil*, *24*(4), 1437–1448.

Suryadi, D., Asdak, C., & Kendarto, D. R. (2024). Analisis Tingkat Kerawanan Banjir Bandang Menggunakan Metode Flash Flood Potential Index (Studi Kasus : Sub DAS Cipeles , DAS Cimanuk). *Teknotan*, *18*(3), 331–338. https://doi.org/10.24198/jt.vol18n3.10

Syafitri, D. R., Arysandi, S. A., Purboyo, A. A., Fitri, A., Febriani, Y., Fitri, W., … Rachmawati, R. (2024). Flood Assessment Through Integrated-Mixed-Method in The Western Downstream Area of Citanduy River Basin , Pangandaran. *Jurnal Geografi Gea*, *24*(1), 25–45. https://doi.org/10.17509/gea.v24i1.60691

Wardhani, F. A., Pravitasari, A. E., & Ridwansyah, I. (2024). Vulnerability Assessment to Flash Floods Disasters in the Upper Cisadane Watershed. *Journal of Natural Resources and Environmental Management*, 1–12. https://doi.org/10.29244/jpsl.14.1.1-12

Widyatmanti, W., Wicaksono, I., & Syam, P. D. R. (2016). Identification of topographic elements composition based on landform boundaries from radar interferometry segmentation (preliminary study on digital landform mapping) Identification of topographic elements composition based on landform boundaries from r. *IOP Conference Series: Earth and Environmental Science*, *37*. https://doi.org/10.1088/1755-1315/37/1/012008

Wulandari, Z., & Setiawan, B. (2024). Analisis Zonasi Kawasan Rawan Banjir Menggunakan Pemodelan HEC-RAS Pada Sub DAS Ogan, Sumatera Selatan. *Bulletin of Scientific Contribution*, *22*, 205–216. https://doi.org/10.24198/bsc.v22i3.57923