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Mapping of Potential Flood Prone Areas Using the Scoring Method and Overlay in Batanghari Regency

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Mapping of potential flood-prone areas using scoring and overlay methods in Batanghari Regency has been carried out. This study aims to determine the level of flood vulnerability and the distribution of flood-prone areas. The parameters used are rainfall parameters, soil type parameters, river distance parameters, slope parameters, land cover parameters, and elevation parameters. The methods used are scoring and overlay methods with the assistance of ArcGIS 10.8 software. The level of flood vulnerability is classified into three categories: not vulnerable, vulnerable, and highly vulnerable. The results obtained in this study show that the majority of Batanghari Regency has a flood vulnerability level in the not vulnerable class, covering an area of 397,158.03 Ha (72%), with areas in the vulnerable category covering 132,119.089 Ha (24.22%), and highly vulnerable areas covering 15,380.96 Ha (2.82%). In contrast, the area that is relatively safe from flooding is the Bajubang District, which covers an area of 102,592.1 hectares (90.17%). This indicates that some areas of Batanghari Regency are prone to flooding, making it very important to take disaster mitigation actions in the Batanghari Regency.

Keywords: *flood, mapping, overlay method, scoring method*

1. INTRODUCTION

Based on data from the Central Statistics Agency (BPS), there were 24 floods in 2023 in Jambi Province. Based on data released by the National Disaster Management Agency (BNPB) in 2019, the districts of Kerinci, Tanjung Jabung Timur, Batanghari, Sarolangun, and Merangin are flood-prone areas. The factors causing flooding in Batanghari Regency include high rainfall, a drainage system that does not function properly, and an increase in the water discharge of the Batanghari River. The flood disaster can have negative impacts on the community, namely disrupting community activities. Causing casualties and negatively impacting community activities (Virianita et al., 2021).

Flood disasters are caused by two categories, namely natural floods caused by high rainfall, physiography, erosion, sedimentation, and drainage capacity (Wibowo and Abadi, 2022). Floods caused by human activities result in environmental changes such as damage to land drainage and destruction of forests. Therefore, disaster mitigation is necessary to deal with flood disasters (Kau et al., 2021). There are two types of flood hazard mitigation: structural and non-structural. In structural mitigation, several efforts can be made, such as building embankments and regulating the speed and discharge of water. Non-structural mitigation efforts can be implemented through providing assistance and conducting outreach and education, analyzing data related to flooding, including mapping flood-prone areas (Urbanus et al., 2021).

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There are six parameters that determine the level of flood vulnerability. The first is soil type: the higher the soil's water absorption capacity, the lower the risk of flooding. Conversely, soil with low absorption capacity is more prone to flooding(Darmawan and Suprayogi, 2017). The second is slope gradient: the gentler the slope, the greater the risk of flooding. Conversely, the steeper the slope, the lower the risk of flooding (Kusumo and Nursari, 2016). Third, prolonged rainfall over a certain period of time means that the drainage system is unable to accommodate the amount of water flowing in. This causes water to pool on the ground and flow to lower areas, resulting in flooding. Fourth, areas adjacent to rivers have a higher risk of flooding because they are prone to inundation when water discharge increases, while areas further away are relatively safer from inundation (Simanjuntak et al., 2023). Fifth, land cover affects the ability of soil to absorb water, where changes in natural land such as forests and rice fields cause an increase in surface runoff and river discharge, thereby increasing the potential for flooding (Wardhana et al., 2018). Sixth, flooding is influenced by land elevation. The lower the elevation of an area, the greater the risk of flooding. Conversely, the higher the elevation of an area, the lower the risk of flooding(Laila Nugraha, 2018).

For soil, permeability is defined as the property of soil that allows water to flow through the soil pores. In soil, resistance to flow depends on the type of soil, mass density, temperature, and the geometric shape of the porous space. Theoretically, almost all types of soil have pore spaces; in other words, permeable refers to soil types that have the property of allowing water to pass through. Conversely, impermeable refers to soil that has a very low ability to allow water to pass through (Hardiyatmo, 2019)

In the FAO/UNESCO International Classification (1974), alluvial soils are classified as fluvisols, which are young soils formed from alluvial deposits. Podzolic soils in Indonesia are equivalent to acrisols, which have a base saturation of < 50%. The acrisol soil type consists of several types, including plinthic acrisols, gleyic acrisols, humic acrisols, ferric acrisols, and orthic acrisols. Alluvial soil has a coarser texture (dusty clay with permeability <0.00001 m/s). Podzolic soils have a clayey to sandy texture with soil permeability of 0.005-0.003 m/s. Meanwhile, gleisols have a clayey and loamy texture with permeability <0.00001 m/s (Gunawan et al., 2020).

Scoring is the assignment of scores to each class of flood vulnerability parameters. Scoring is based on the influence of each parameter on flood vulnerability(Sholikhan et al., 2019). Meanwhile, weighting is the assignment of weights to each parameter that has an influence on flooding. Scoring is based on the consideration of each parameter in relation to flooding events(Tanesib et al., 2018).

Several studies have been conducted on flood-prone areas using scoring and overlay methods. A study using Geographic Information Systems to analyze flood vulnerability mapping in West Bontang District, Bontang City, used parameters such as soil type, land use, topography, rainfall, slope, and distance to rivers (Aziza et al., 2021). Mapping based on Geographic Information Systems in Jambi City used scoring and overlay methods using parameters such as land use, soil type, slope, rainfall, and elevation (Pryastuti, 2021). Mapping of areas prone to forest and peatland fires based on Geographic Information Systems in West Kalimantan (Dicelebica et al., 2022). Mapping of flood-prone areas in Medan City in 2020 (Anggraini et al., 2021). Mapping of flood-prone areas in Bondowoso Regency using Geographic Information Systems (Raharjo, 2021). Mapping of flood-prone areas in South Pontianak District using Geographic Information Systems (Kurnia et al., 2019).

2. METHOD

According to (Kusumo and Nursari, 2016), the flood vulnerability value in Batanghari Regency can be determined from the total sum of the scores of parameters that affect flooding (rainfall, slope, land elevation, soil type, land use, and distance to rivers).

$$\mathrm{K}= Xi \times Wi \qquad (1)$$

Based on the above formula, it is known that K is the vulnerability value, Wi is the weight for parameter i, and Xi is the score for parameter i. According to (Natannael et al., 2024), a region's vulnerability to flooding is determined by the total score of all parameters that influence flooding. The vulnerability value is determined using the following equation:

(2)

$$I=\frac{R}{K}$$

Based on the formula that I is the width of the interval, R is the difference between the maximum score and the minimum score.

The stages of this research can be seen in the flow chart below (Figure 1).

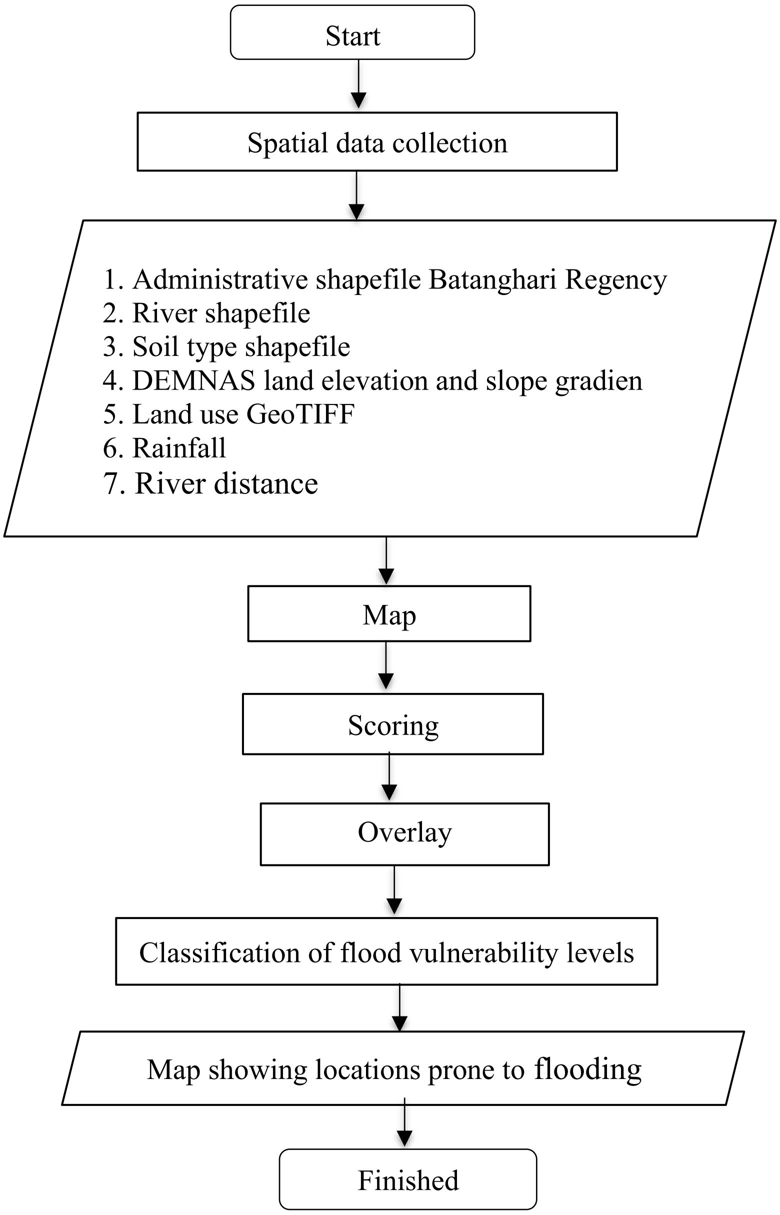

Figure 1 Flowchart of the research

3. RESULTS AND DISCUSSION

Based on administrative areas, Batanghari Regency has 8 subdistricts consisting of 124 villages/kelurahan and borders Muaro Jambi Regency, Tanjung Jabung Barat Regency, and Tebo Regency to the north. To the east, it borders Muaro Jambi Regency; to the south, it borders South Sumatra Province, Sarolangun Regency, and Muaro Jambi Regency. To the west, it borders Tebo Regency. The following is a table of the administrative areas of Batanghari Regency (Table 1).

Table 1 Administrative Area of Batanghari Regency

District Name	Area (Ha)	Percentage (%)
Mersam	73,803.74	13.53 %
Muara Tembesi	31,651.86	5.80 %
Muara Bulian	43,911.54	8.05 %
Batin XXIV	92,004.27	16.86 %
Pemayung	85,416.26	15.66 %
Maro Sebo Ulu	76,953.75	14.11 %
Bajubang	113,763.00	20.85 %
Maro Sebo Ilir	28,040.83	5.14%

3.1 Types of Soil

The soil type map of Batanghari Regency can be seen in Figure 2. The soil distribution in Batanghari Regency reflects the strong influence of humid tropical conditions, resulting in the dominance of highly weathered soils. The region is primarily covered by Orthic Acrisols (Ao), commonly referred to as podzolic soils, which occupy approximately 404,291.81 hectares. Acrisols are typically characterized by low base saturation, high acidity, and intensive leaching processes driven by high rainfall, which significantly limit their natural fertility and agricultural productivity without appropriate soil amendments. These soils are widely distributed across tropical regions and are often associated with forested and plantation landscapes.

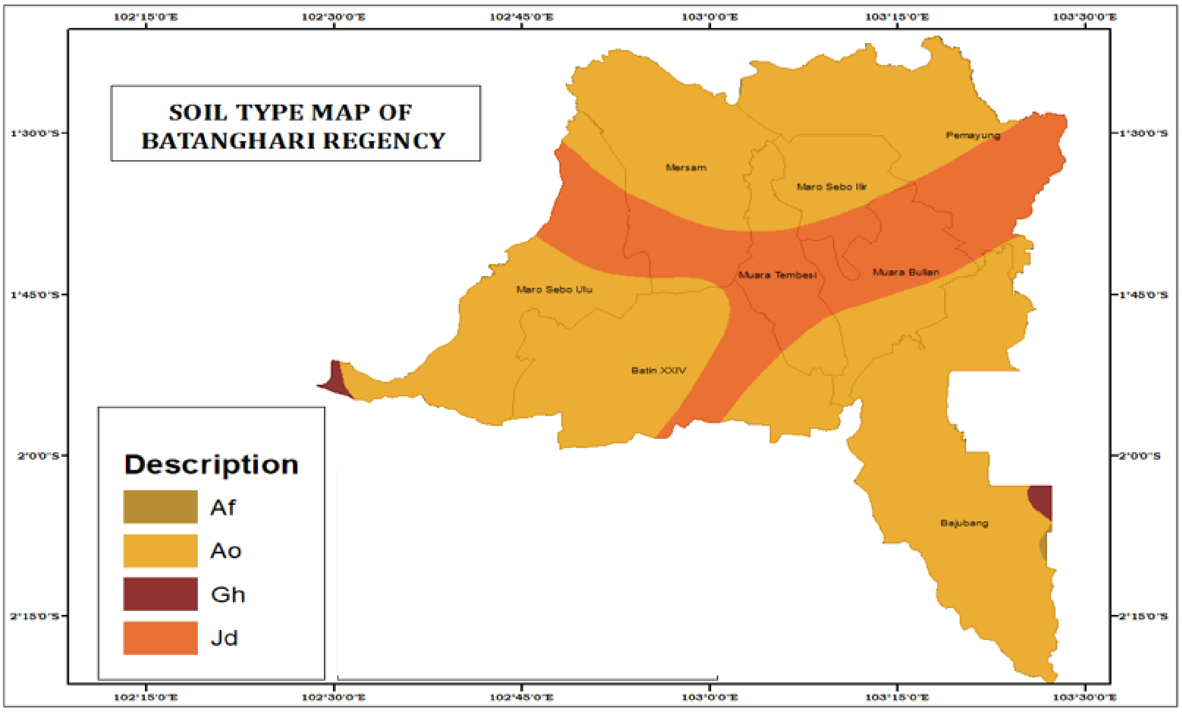

Figure 2 Map based on types of soil

In addition, Dystric Fluvisols (Jd) are distributed along river basins, covering an estimated 136,453.88 hectares. These soils develop from recent alluvial deposits and generally exhibit more favorable physical and chemical properties compared to Acrisols. Their relatively higher nutrient availability and better structure make them important for agricultural utilization, although their fertility can vary depending on sediment sources and flooding regimes (Qin et al., 2020). The dynamic nature of Fluvisols also makes them sensitive to hydrological changes and land-use alterations.

Humic Gleysols (Gh), which are hydromorphic soils formed under conditions of prolonged water saturation, are found only in limited areas, particularly in parts of the Maro Sebo Ulu Subdistrict. These soils are characterized by high organic matter content and reducing conditions, which influence nutrient cycling and soil chemistry. However, poor drainage and oxygen deficiency often constrain their suitability for intensive agriculture unless appropriate water management practices are implemented (Rinklebe & Shaheen, 2017).

Meanwhile, Ferric Acrisols (AF), which are identified in Bajubang Subdistrict and cover approximately 374,093 hectares, represent a more intensely weathered subgroup of Acrisols. These soils are enriched with iron oxides, giving them a distinct reddish coloration and indicating advanced pedogenic processes. Similar to other Acrisols, Ferric Acrisols exhibit low cation exchange capacity and limited nutrient reserves, requiring careful management strategies such as liming and fertilization to sustain crop production (Zhang et al., 2021).

Overall, the dominance of Acrisol-type soils in Batanghari Regency highlights the role of long-term weathering and intense rainfall in shaping soil properties in tropical environments. This condition has important implications for land-use planning, soil conservation, and sustainable agricultural development in the region.

3.2 Land Use

The following is a map of land use in Batanghari Regency (Figure 3). Based on the results of land cover classification in Batanghari Regency, the landscape is predominantly dominated by forested areas, covering approximately 461,628.88 hectares or 84.62% of the total regency area. This dominance of forest cover reflects the ecological characteristics of tropical regions in Sumatra, where natural and secondary forests still play a significant role in land cover composition and ecosystem services. Tropical forests are known to provide essential functions such as carbon storage, biodiversity conservation, and climate regulation, making their spatial extent a critical indicator in environmental assessments (Hansen et al., 2013).

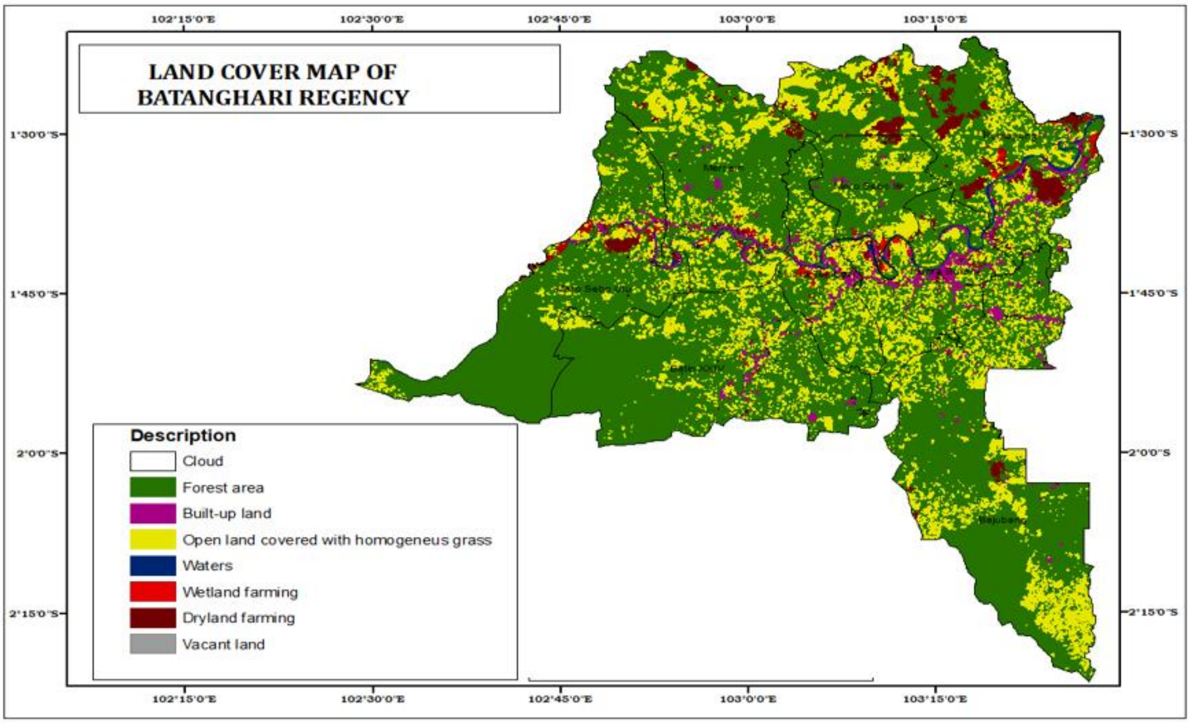

Figure 3 Land use map

The remaining land area consists of a mixture of land cover types, including built-up areas, water bodies, wet agricultural land (such as paddy fields), dry agricultural land, open land dominated by homogeneous grass, and cloud-covered regions. Built-up areas indicate increasing anthropogenic activities and land conversion, which are commonly associated with population growth and regional development. Meanwhile, agricultural lands—both wet and dry—reflect the socio-economic dependence on farming activities in the region and contribute to land-use dynamics that may influence hydrological and ecological processes (Ellis & Ramankutty, 2008).

It is also important to note that a portion of the classified imagery is categorized as cloud cover. These cloud-covered areas represent portions of satellite imagery that were obscured during data acquisition, making it impossible to accurately identify the underlying land use or land cover. Cloud contamination is a well-known limitation in optical remote sensing, particularly in humid tropical regions such as Indonesia, where persistent cloud cover can significantly affect the accuracy and completeness of land cover classification results (Zhu & Woodcock, 2012). Consequently, the presence of clouds introduces uncertainty and may require additional image processing techniques, such as multi-temporal compositing or cloud masking, to improve classification reliability.

Overall, the predominance of forest cover combined with the presence of diverse secondary land uses highlights the dynamic interaction between natural ecosystems and human activities in Batanghari Regency. These land cover patterns have important implications for sustainable land management, environmental conservation, and regional planning.

3.3 River Distance

The following is a map of river distances in Batanghari Regency (Figure 4). The spatial relationship between land areas and river systems in Batanghari Regency reveals significant variation in flood susceptibility across districts. Pemayung District represents the area with the largest extent of land directly adjacent to river systems, covering approximately 2,355.748 hectares. Proximity to rivers is a key determinant of flood risk, as areas located within floodplains are highly vulnerable to inundation, particularly during periods of increased river discharge driven by intense or prolonged rainfall events. Hydrological studies have consistently shown that floodplain zones experience higher flood frequency and magnitude due to their low elevation and direct connectivity to river channels (Merz et al., 2007). Consequently, Pemayung District can be categorized as the zone most prone to flooding within the regency.

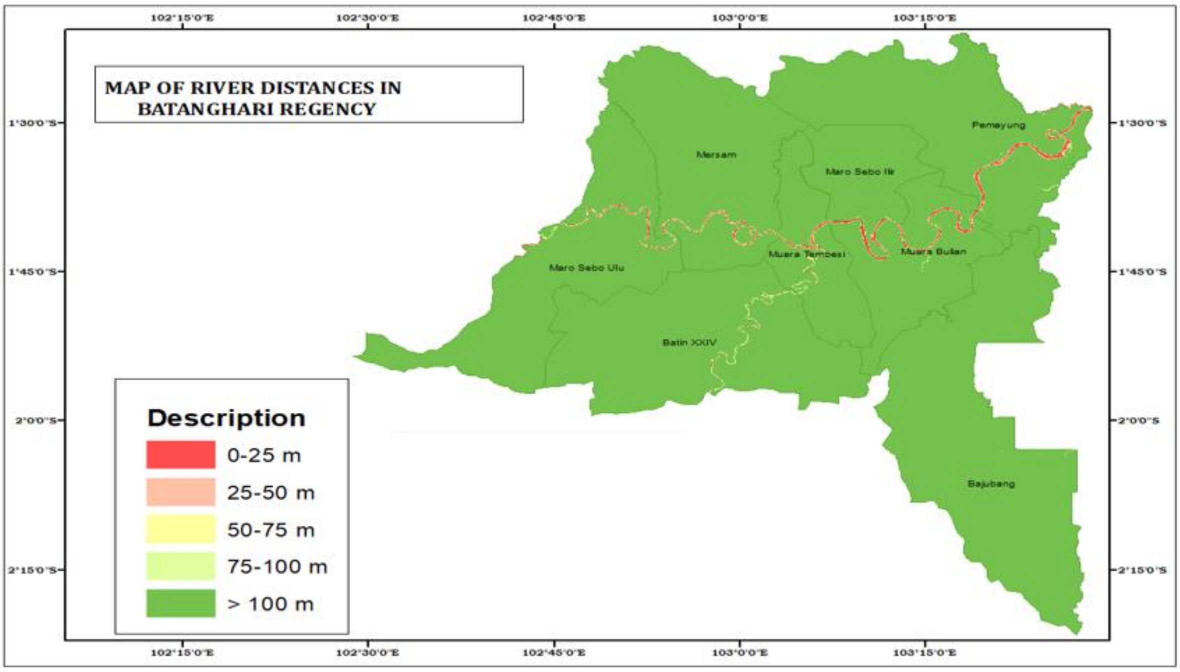

Figure 4 River distance map

Flood risk in such areas is further exacerbated by climatic variability and land-use changes, which can alter runoff patterns and increase peak discharge. In tropical regions like Sumatra, high rainfall intensity combined with watershed characteristics significantly influences river flow dynamics, often leading to rapid increases in water levels and subsequent overbank flooding (Ward et al., 2013).

Therefore, the extensive river-adjacent area in Pemayung highlights the need for careful flood risk management, including land-use planning and early warning systems.

In contrast, Bajubang District represents the area least influenced by river proximity, with a spatial extent of approximately 113,660.61 hectares located relatively far from major river systems. This distance reduces direct exposure to riverine flooding, although it does not entirely eliminate hydrological risks such as surface runoff accumulation or localized flooding. Areas farther from river channels typically exhibit lower flood hazard levels due to reduced hydraulic connectivity with river discharge processes (Tehrany et al., 2014).

Overall, the contrast between Pemayung and Bajubang Districts illustrates the critical role of spatial proximity to rivers in determining flood vulnerability. These differences provide important insights for regional planning, particularly in the context of disaster risk reduction, infrastructure development, and sustainable watershed management.

3.4 Slope Gradient

The following is a map of slope inclination in Batanghari Regency (Figure 5). The topographic characteristics of Batanghari Regency indicate that the region is predominantly composed of low-relief terrain. The slope classification is dominated by the 0–8% class, which covers approximately 346,794.39 hectares, reflecting generally flat to gently undulating landforms. Additional areas fall within the 8–15%, 15–25%, and 25–45% slope classes, representing moderate to steep terrains that are more limited in spatial extent. Meanwhile, very steep slopes (>45%) are extremely rare, occupying only about 2.39 hectares, indicating that rugged or mountainous landscapes are largely absent in the regency.

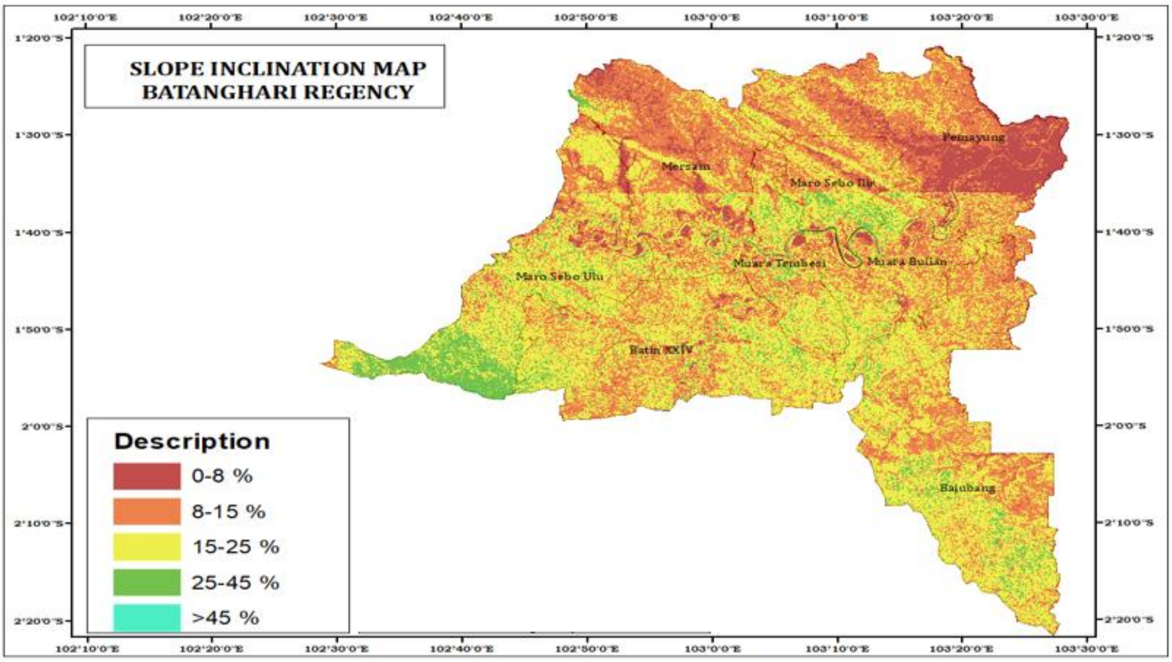

Figure 5 Slope gradient map

The slope class in Batanghari Regency is dominated by the 0-8% class, covering an area of 346,794.39 hectares. Some areas are in the 8-15%, 15-25%, and 25-45% slope classes. Meanwhile, the slope class > 45 is only found in a few areas covering an area of 2.39 hectares. The results show that the average slope grade in the areas surrounding the riverbanks is 0-8%, meaning that the morphological conditions make these areas more susceptible to flooding in the event of increased river discharge.

The dominance of low slope gradients has important hydrological implications, particularly in areas adjacent to riverbanks. The results show that the average slope in riverbank zones is within the 0–8% category, which significantly influences surface runoff behavior and water accumulation patterns. In low-slope environments, water movement tends to be slower, reducing drainage efficiency and increasing the likelihood of water stagnation and overbank flooding when river discharge rises. Previous studies have demonstrated that flat floodplain areas are more susceptible to flooding due to limited gravitational flow and prolonged water retention (Tehrany et al., 2013).

Furthermore, slope is a critical parameter in flood susceptibility analysis, as it directly affects infiltration, runoff velocity, and flow concentration. Areas with gentle slopes tend to accumulate runoff, especially during high rainfall events, thereby increasing flood hazard levels. In contrast, steeper slopes facilitate faster runoff and reduced water accumulation, although they may contribute to downstream flooding (Nachappa et al., 2020). In tropical regions, where rainfall intensity is often high, the interaction between low slope gradients and high precipitation further amplifies flood risk in low-lying areas.

3.5 Rainfall

Below is a map of rainfall in Batanghari Regency (Figure 6). The climatic conditions in Batanghari Regency indicate that the region falls within the category of very wet tropical climates, with annual rainfall generally exceeding 2,500 mm/year. Such high precipitation is characteristic of equatorial regions, where convective rainfall processes and monsoonal influences contribute to consistently high rainfall totals throughout the year. This level of precipitation plays a crucial role in shaping hydrological processes, including river discharge, soil moisture dynamics, and flood occurrence (Aldrian & Susanto, 2003). Recent studies also indicate that Indonesia has experienced increasing trends in extreme rainfall indices over recent decades, suggesting a growing intensity and frequency of heavy precipitation events (Tugiyo Aminoto et al., 2026). These trends may further amplify hydrological responses in regions such as Batanghari Regency, thereby increasing the likelihood of flood events, particularly in low-lying and river-adjacent areas.

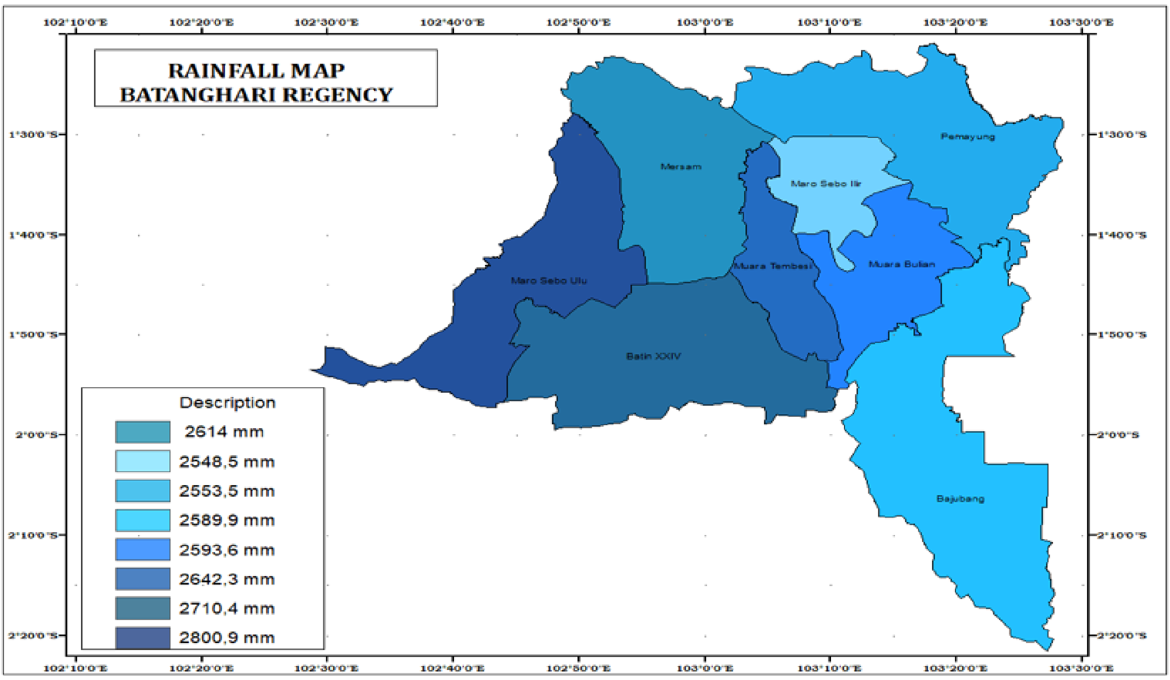

Figure 6 Rainfall Map

Spatial variability in rainfall distribution is evident across the regency. Maro Sebo Ulu Subdistrict records relatively higher annual rainfall compared to other areas, which may be attributed to its higher elevation. Orographic effects are known to enhance precipitation in elevated regions, as moist air masses are forced to rise, cool, and condense, resulting in increased rainfall intensity and accumulation (Bookhagen & Strecker, 2008). This phenomenon is commonly observed in tropical regions with varied topography, where elevation acts as a key control on rainfall distribution.

In contrast, the lowest average rainfall is observed in Maro Sebo Ilir District, with an annual average of approximately 2,548.5 mm/year. Although still classified as very wet, this comparatively lower rainfall may be associated with its lower elevation and proximity to riverine lowlands. Areas at low to moderate elevations, particularly those near river flows, often experience slightly reduced or more uniform rainfall patterns due to weaker orographic influences and more stable atmospheric conditions (Qian et al., 2010).

3.6 Scoring and Weighting

Table 2 presents the scoring scheme applied to different land use types in assessing flood susceptibility in Batanghari Regency. Each land use category is assigned a score ranging from 0 to 5, reflecting its relative contribution to flood risk. These scores are then multiplied by a uniform weight of 25 to obtain the final value used in the analysis.

Land use types such as water bodies and bare or empty land receive the highest score (5), indicating the greatest susceptibility to flooding. This is due to their limited capacity to absorb water and their tendency to accumulate surface runoff. Built-up land and wetland agriculture are assigned a slightly lower score (4), as impervious surfaces in urban areas and saturated soils in wetlands can significantly increase runoff and reduce infiltration capacity (Yao et al., 2016).

Dryland farming areas are given a moderate score (3), reflecting their intermediate infiltration characteristics depending on soil management practices. Open land covered with homogeneous grass is assigned a lower score (2), as vegetation cover can enhance infiltration and reduce runoff velocity. Forested areas receive the lowest score (1), highlighting their important role in mitigating flood risk through canopy interception, evapotranspiration, and improved soil structure (Bradshaw et al., 2007).

Cloud-covered areas in satellite imagery are assigned a score of 0 because their land use cannot be identified, and therefore, they are excluded from contributing to the flood susceptibility analysis. The use of weighted scoring methods such as this is common in spatial multi-criteria evaluation for flood risk mapping, allowing different environmental parameters to be systematically integrated into a composite index (Tehrany et al., 2015).

Table 2 Land Use Scoring for Flood Susceptibility in Batanghari Regency

Land Use	Score	Weight	Value
Water, empty land	5	25	125
Built-up land, Wetland Agriculture	4	25	100
Dryland farming	3	25	75
The open land is covered with homogeneous grass	2	25	50
Forest	1	25	25
Clouds	0	25	0

3.7 Flood Vulnerability Level

To determine the flood vulnerability level of an area (Table 3), an overlay can be used by adding the multiplication between the score value by the weight on the parameters of soil type, land use, elevation, slope, rainfall, and distance to rivers.

Table 3 Flood Vulnerability Interval

Value	Vulnerability Level
180-287	Not vulnerable
288-394	Vulnerable
395-500	Highly vulnerable

Figure 7 shows a flood vulnerability map of Batanghari Regency after overlaying all flood vulnerability parameters using intersect. Batanghari Regency has a flood-prone area of 131,912.87 (24.67%), a highly flood-prone area of 5,542.09 (1.04%), and a non-flood-prone area of 397,176.76 (74.29%). Pemayung Subdistrict is the largest area in the flood-prone and highly flood-prone categories, making it the subdistrict most at risk of flooding in Batanghari Regency. Meanwhile, the safest area in terms of flood risk is Bajubang Subdistrict, which is not prone to flooding, covering an area of 102,595.1 hectares (90.19%). Highly vulnerable areas are located near rivers, with an average elevation of 0-20 meters above sea level, a slope of 0-8%, and land cover consisting of built-up land with Dystric Fluvisols soil types. Moderately vulnerable areas are located at an average elevation of 21-50 meters above sea level, with a slope of 8-15% and land cover consisting of open land covered by homogeneous grass. Areas not prone to flooding are located furthest from the river, with an average elevation of > 51 meters above sea level, a slope gradient of > 15%, Orthic Acrisols soil type, and land cover consisting of open land covered with homogeneous grass and forest areas.

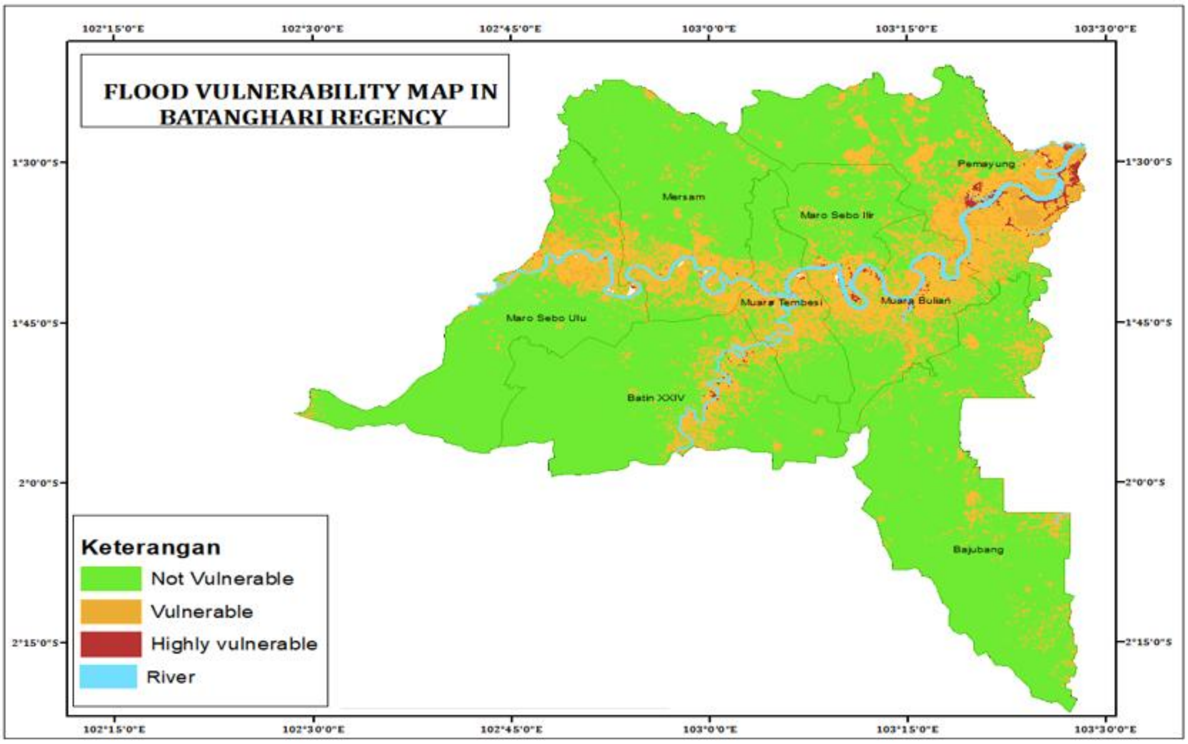

Figure 7 Flood vulnerability map

Rainfall data play a crucial role in determining flood potential, as variations in rainfall distribution significantly influence surface runoff and watershed response. Previous studies have shown that regional rainfall patterns and their spatial-temporal characteristics can be effectively analyzed using high-resolution climate models such as CORDEX-SEA (Aminoto et al., 2024a; Aminoto, 2024b; Aminoto & Faqih, 2024c). Integrating rainfall characteristics derived from such models with geospatial analysis techniques enhances the accuracy of flood susceptibility mapping. The results of this research are expected to support local governments in flood risk management and to serve as a reference for developing adaptive strategies to minimize flood impacts in Batanghari Regency.

4. CONCLUSION

The flood vulnerability assessment in Batanghari Regency reveals a clear spatial differentiation of risk levels across the region. The results indicate that the majority of the area (74.29%) falls within the non-vulnerable category, covering approximately 397,176.76 hectares. Meanwhile, 24.67% of the regency, equivalent to 131,912.87 hectares, is classified as vulnerable, and a smaller proportion, 1.04% (5,542.09 hectares), is identified as highly vulnerable to flooding. Although the highly vulnerable class occupies a relatively limited area, it represents critical zones that require priority attention due to their high exposure and potential impact. The spatial distribution of flood-prone and highly flood-prone areas is predominantly concentrated in Pemayung, Muara Bulian, and Mersam subdistricts. These areas are closely associated with river systems, low slope gradients, and high rainfall intensity, which collectively increase flood susceptibility. In contrast, Bajubang Subdistrict is relatively less affected by flooding, likely due to its greater distance from major river channels and more favorable topographic conditions. This pattern confirms that flood vulnerability is strongly influenced by the interaction of geomorphological, hydrological, and land-use factors, particularly river proximity and terrain characteristics.

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