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# Determining flood vulnerable parameters: A spatial overlay analysis in Kurau subdistrict, South Kalimantan province

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**Abstract**

Flood has become one of the most common and damaging natural disasters in Indonesia, especially in coastal areas like Kurau Subdistrict, Tanah Laut Regency. In these regions, the combination of geographical features, land use patterns and climatic influences increases the vulnerability of communities that makes it more challenging to implement effective disaster management. This research focuses on evaluating the spatial distribution of flood vulnerable by determine various environmental and human-induced factors uses based on study an overlay method to parameter of flood vulnerability such as land use, buffer river, elevation, rainfall, slope and soil type. The results of the study shows that a flood hazard map was created as considerable part of the area is categorized as having very high and high flood vulnerability, mainly due to factors like widespread agricultural land use, tendency to river channels and low elevation, which emphasizes the need to integrate flood vulnerability evaluations.

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## INTRODUCTION

Disasters can have profound impacts on human life, economic stability, and socio-political conditions. The potential risk posed by a disaster of a given magnitude is typically evaluated based on the probability of its occurrence and the severity of its consequences. In this context, vulnerability is often conceptualized as the product of the likelihood of a disaster and the extent of its impact. In Indonesia, various types of natural disasters, including floods, landslides, earthquakes, volcanic eruptions, tornadoes, and tsunamis, have been recorded across multiple provinces. These events have led to loss of life, injuries, severe damage to infrastructure, and significant economic losses. Given the unpredictable nature of such hazards, access to timely and accurate predictive information is essential for early warning and disaster preparedness. Early forecasts enable communities in high-risk areas to take precautionary measures to reduce the potential damage. The success of disaster risk reduction and emergency response efforts in the

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affected regions largely depends on the active involvement of local communities and the effectiveness of key institutional stakeholders, particularly the Regional Disaster Management Agency (BPBD) and the National Disaster Management Authority (BNPB) (Rohman et al., 2024).

Natural disasters can strike at any time and in any location. In Indonesia, such events have become a recurring annual cycle making quick and effective mitigation efforts essential. Among these, flooding poses a significant challenge on it occurs when excessive water inundates land areas, often leading to severe damage to residential properties and posing serious vulnerable to human safety (Petrucci, 2022). Some previous researches have demonstrated that flood hazards are complex, arising from the interaction of multiple elements and their root causes. Damage and disturbances in flood event patterns are influenced by socio-economic variables such as population density, infrastructure susceptibility, topography, land use, soil type and other environmental factors that may threaten flood vulnerable (Agonafir et al., 2023; Bhattacharjee et al., 2021; Douglas, 2017; Hochrainer-Stigler et al., 2024; Ighile et al., 2022; Nguyen and Liou, 2019). In addition, flooding is often influenced by changes in land use that are crucial to the cycle of tidal movement of water that initially originates around rivers or water bodies. Some of the natural elements that influence it such as slope, land elevation, rainfall rate and soil type in an area are also considerations for disaster vulnerability. In contrast, human-induced flooding results from anthropogenic activities that disrupt the natural environment —such as land use changes in watersheds, the development of settlements along riverbanks, infrastructure damage, deforestation, and poorly designed flood control systems. (Harefa et al., 2024). Researchers have observed that how land use changes will have an impact on water movement (Abdelkarim et al., 2019).

South Kalimantan Province is among the most disaster-prone regions in Indonesia, particularly vulnerable to flooding as well as forest and land fires. According to the National Disaster Management Agency (BNPB, 2024), floods remain the most frequent type of natural disaster in the country. In 2024 alone, approximately 3,427 disaster events were recorded nationwide, with floods accounting for the largest share, 1,420 incidents. During the same year, South Kalimantan experienced 26 disaster events, predominantly floods, followed by forest and land fires, droughts, and extreme weather occurrences. Tanah Laut Regency is geographically situated between 114°30'20'' and 115°23'31'' East Longitude and between 3°30'33'' and 4°11'38'' South Latitude. According to the Minister of Home Affairs Decree No. 100.1-6117 of 2022, dated November 9, 2022, the regency spans an area of 3,841.37 km², which constitutes approximately 10.34% of South Kalimantan Province. Tanah Laut Regency is administratively divided into 11 subdistricts. The largest is Kintap Subdistrict, covering 857.21 km² or 22.32% of the regency's total area (BPS, 2025). In contrast, the smallest is Kurau Subdistrict, with an area of only 68.76 km², accounting for just 1.79% of the regency.

As explained by the Economic and Social Commission for Asia and the Pacific in 2019, Indonesia as a developing nation with widespread coastal regions is particularly vulnerable to climate events-related disasters. Approximately 60% of its population resides along the country's 100.000 kilometers coastline that significantly increasing exposure to coastal hazards. Vulnerability is a critical aspect of disaster management particularly in sustainable flood management (Masselink & Lazarus, 2019). Vulnerability differs across regions, and the extent of this variation has a direct impact on how policies are implemented (Bera et al., 2018). Therefore, identifying areas that are highly vulnerable to flooding is crucial for effectively addressing community vulnerability. This also highlights the importance of assessing the community's capacity to cope with and respond to the effects of floods (Chan et al., 2022). The geographical location of Tanah Laut Regency especially in Kurau Subdistrict is located in the coastal hazard area, which certainly has an impact on the vulnerability of flood disasters. The high rainfall, which is influenced by the land use conditions of many settlements and agricultural land, makes the slope and land elevation factors also contribute to the intensity of water tides and the area, which in turn tends to make the land experiencing flood water inundation take a long time to recede in a few days. Riverine and coastal inundations can happen at the same time, leading to severe flooding caused by intense river discharge and substantial rainfall (Ming et al, 2022). Remembering that in November 2024, our Geography colleagues including myself had conducted a disaster research visit and there were conditions where the intensity of flooding overflowed to inundate most of Bumi Makmur Subdistrict for several days which is right in the northern direction and clearly on coastal area of Kurau Subdistrict. Geographical conditions and land use conditions that are almost the same cause flood disasters to hit more widely and spread to many subdistricts in Tanah Laut Regency. This is certainly an alert for the community around Kurau Subdistrict to be better prepared for future flood disasters.

This research was conducted with the aim to determine a flood hazard map based on various parameter of flood vulnerability. This can be achieved through a spatial data analysis using Geographic Information Systems (GIS), which helps in identifying flood vulnerable and estimating the extent to which village areas in Kurau Subdistrict may be affected. By using such tools, efforts can be made to prevent disasters or at least minimize their impact (Purwanto et al., 2024). The purpose and structure of this research are centered on identifying the influence of various parameters that contribute to flood disasters. The study aims to serve as a relevant reference for understanding the frequency of such disasters in the Kurau Subdistrict. The findings are intended to support local governments in designing effective community capacity-building initiatives to reduce flood vulnerability in the region.

The structure of this research is organized as follow: Section 1 provides a general definition of disasters and reviews several studies that highlight the complexity of flood events. It also discusses the frequent occurrences of floods in South Kalimantan Province, particularly in Kurau District. Additionally, it includes an account of field visits to Tanah Laut Regency to observe flood disasters firsthand and outlines the research framework involving spatial analysis of flood vulnerability. Section 2 describes the research stages, study area, data and tools used, the research flow diagram, and the geographical profile of Kurau Subdistrict. It defines flood vulnerability and explains the scoring and weighting of parameters related to flood causes, including land use, river buffers, elevation, rainfall, slope, and soil type. Section 3 presents the research findings, starting with spatial analysis results of flood vulnerability parameters. It includes the area (in hectares) for each parameter classification and culminates in the creation of a flood vulnerability map. Section 4 summarizes the key findings and provides recommendations for future research, encouraging the application of similar approaches in diverse case studies.

## METHOD

### Research Stages and Location

This study is grounded in a comprehensive analysis of secondary data obtained from various credible sources. To assess flood hazard levels, the research employs a spatial overlay technique that integrates multiple geospatial parameters—land use, river buffer zones, elevation, rainfall, slope, and soil type. Each parameter is assigned specific weights and scores based on established classifications (see Tables 1 to 6). The overlay analysis is conducted using ArcGIS software, which facilitates the spatial integration of these variables to produce a flood hazard map and identify areas with varying levels of vulnerability (Rakuasa et al., 2022; Sholahuddin, 2013; Fauzi, 2022). The research location is in Kurau Subdistrict, Tanah Laut Regency, South Kalimantan Province, Indonesia which as Figure 1.


**Figure 1.** Map of research location in Kurau Subdistric

## Data and Equipment

The datasets utilized in this study include administrative boundary shapefiles (SHP) for South Kalimantan Province, Tanah Laut Regency, and Kurau Subdistrict; land use SHP for Kurau Subdistrict; buffer river polygons and polylines; digital elevation model (DEM) data; CHIRPS rainfall data; slope SHP; and soil type SHP based on FAO/UNESCO classification. All datasets are specific to the Kurau Subdistrict area. The primary software used for spatial analysis is ArcGIS, which supports data integration, overlay analysis, and the generation of flood hazard maps.

## Geographical Profile of Kurau Subdistrict

Kurau Subdistrict is one of the sub-districts of Tanah Laut Regency located in South Kalimantan Province, Indonesia. This subdistrict has an area of approximately 68.76 km² or 6876 hectares with a population of 14,765 people (BPS, 2025) which is located at 114.583° - 114.711° East Longitude and 3.56309° - 3.72364° South Latitude and is adjacent to various other subdistricts such as Bumi Makmur Subdistrict to the north, Takisung Subdistrict to the south, Bati-Bati Subdistrict and Tambang Ulang Subdistrict to the east and the Java Sea to the west.

## Research Flow Diagram

The conceptual framework and research workflow are illustrated in Figure 2.

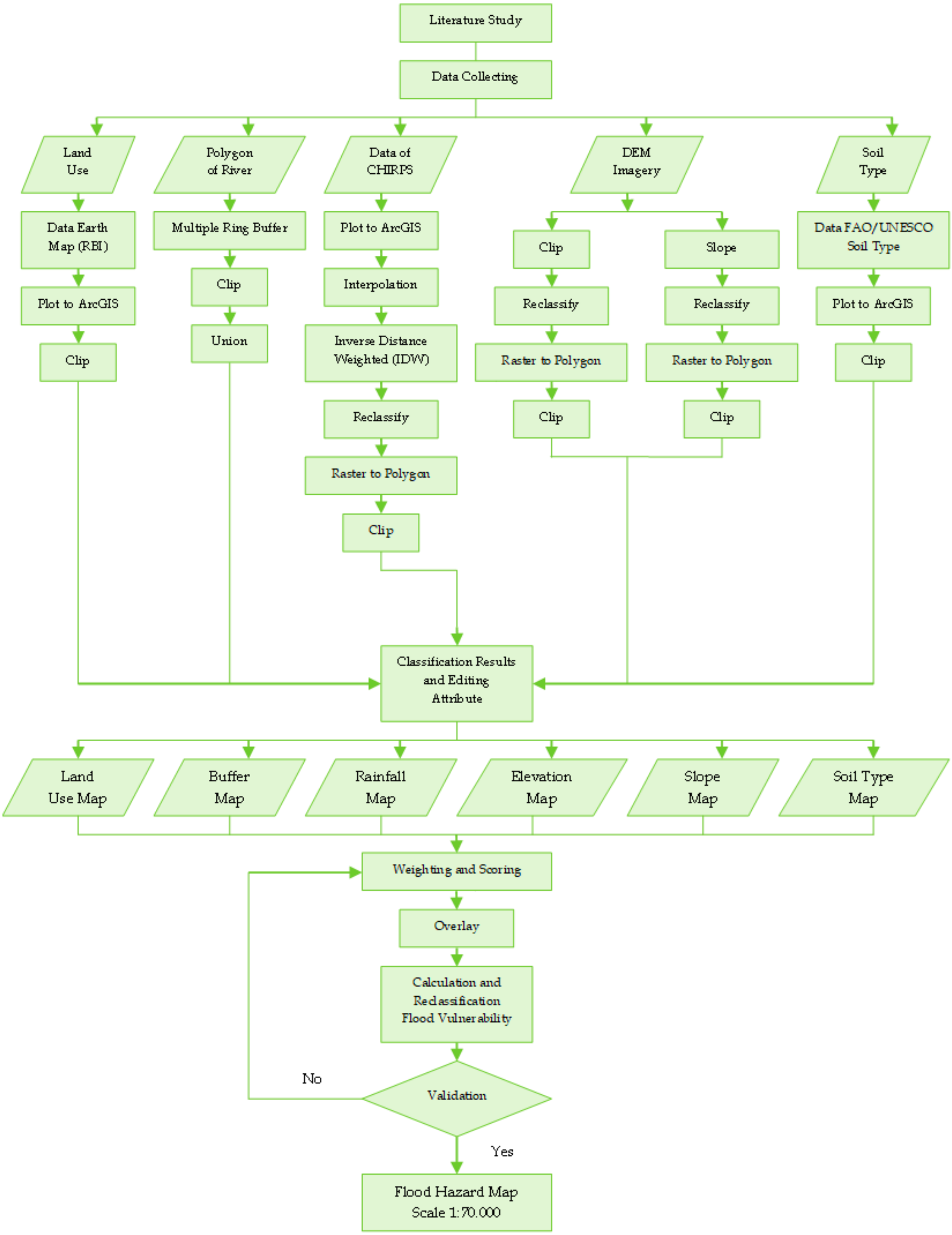


**Figure 2.** Research framework

### Weighting and Scoring of Parameters

Weighting involves assigning a numerical value to each parameter based on its level of influence on flooding, as represented in thematic maps. This process helps determine the potential vulnerable of flood disasters associated with each parameter. Scoring refers to evaluating the impact of each class within a parameter on flood vulnerability. The higher the impact, the higher the assigned score. Scores typically range from 1 to 5. The final scoring value is derived by combining both the score and the weight, where parameters with greater influence on flood vulnerability are given higher weights. This approach allows for a more accurate assessment of flood vulnerable areas (Darmawan & Suprayogi, 2017).

### Parameters of Flood Vulnerability

Land cover represents the evolving relationship between human activities and natural land resources. This relationship is distributed across the landscape, providing valuable insights into the area's biophysical features (Rakuasa et al., 2022). Land use plays a key role in environmental changes by affecting how water moves through an area. It can influence things like how much water soaks into the ground, how much evaporates, and how rainfall behaves (Banjara et al., 2024). The residential roads or houses, emphy land, swamp, forest and commercial areas changes how water flows over the land by increasing the runoff coefficient. This affects how runoff moves through the area and can lead to higher peak runoff levels that making the area more vulnerable to flooding (Birhanu et al., 2019). Below is the classification of land use at Table 1.

**Table 1.** Land use classification

| Land Use | Description | Score | Weight |
|---|---|---|---|
| **Agricultural, Empty Land** | Very High | 5 | |
| **Dryland Farm, Residential Land, Water Body** | High | 4 | |
| **Swamp, Weeds** | Medium | 3 | |
| **Shrubbery, Plantation** | Low | 2 | |
| **Forest** | Very Low | 1 | 25 |

Source: Modification of Akhbar (2019)

Buffer in Geographic Information Systems (GIS) are areas created around points, lines or polygons that encompass all locations within a specified distance from the selected feature. By generating a buffer, a coverage zone is created to enclose or protect specific spatial features on the map —known as the buffer area object within a defined distance (Harefa et al., 2024). Buffer areas can help slow the flow of surface water, absorb excess water, and reduce flood peaks when they occur (Sabegh et al., 2011). They act as a natural barrier between land and waterways. Protecting and managing these areas near streams is important because it helps keep the water clean and supports biodiversity. It also helps reduce the amount of sediment carried by surface runoff by making the land rougher, which slows down water flow and allows more sediment to settle (Lind et al., 2019). The vulnerable of flooding increases in areas that are situated close to rivers because of their nearness to the water source. In addition, scoring will be higher if the distance of a river is closer namely distance. Conversely, if the distance is further from the river then the score will be lower. Below is the classification of buffer river (m) at Table 2.

**Table 2.** Buffer river classification

| Buffer River (m) | Description | Score | Weight |
|---|---|---|---|
| **0 – 100** | Very Dense | 5 | |
| **100 – 200** | Dense | 4 | |
| **200 – 300** | Medium | 3 | 20 |
| **300 – 500** | Loose | 2 | |
| **>500** | Very Loose | 1 | |

Source: Modification of Pratiwi et al., (2017) Elevation plays a significant role in flood vulnerability, with low-lying areas at higher vulnerable (Palla et al., 2018; Bado et al., 2018). The likelihood of flooding is influenced by elevation, as water naturally flows from higher to lower ground. Consequently, regions situated at higher elevations tend to have a lower vulnerable of flooding whereas those at lower elevations are more vulnerable to it (Kusumo et al., 2016). Flood studies often employ a Digital Elevation Model (DEM) as a foundational tool for flood assessment. DEMs are also used as a key parameter in analyzing flood characteristics and spatial distribution (Muthusamy, 2021). In addition, elevations near sea level or lakes are particularly vulnerable to rising water levels caused by heavy rainfall or rising sea levels as well as Kurau Subdistrict's region topography. Below is the classification of elevation at Table 3.

**Table 3.** Elevation classification

| Elevation (m) | Description | Score | Weight |
|---|---|---|---|
| **<10** | Very Low | 5 | 20 |
| **10 – 50** | Low | 4 | |
| **50 – 100** | Medium | 3 | |
| **100 – 200** | High | 2 | |
| **>200** | Very High | 1 | |

Source: Modification of (Pratiwi et al., 2017)

Rainfall refers to the total height of rainwater that falls on a flat surface, under the assumption that no evaporation or absorption occurs during the event. Floods are commonly linked to intense rainfall events, where the primary triggers are the amount of rainfall over a given period and how long the rainfall persists (Wang et al., 2025). The intensity of rainfall is directly linked to flood potential —higher rainfall intensity increases the vulnerable of flooding, while lower intensity reduces it. Alongside slope, rainfall is considered one of the most significant triggering factors, as it directly affects river discharge and contributes to flood events (Rakuasa & Latue, 2023). The overall level of flood vulnerability in a given area is determined by the cumulative score of various parameters, the higher the total score, the greater the flood vulnerable.

The Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS) is a rainfall database that integrates three types of data: global climatology, satellite-derived precipitation estimates, and ground-based rainfall observations (Cipto et al., 2023). The limited availability of rainfall data from nearby stations in the Kurau Subdistrict area, CHIRPS data was utilized as an alternative. Developed by the Climate Hazards Group at the University of California, Santa Barbara, this dataset provides rainfall records dating back to 1981 and continues to be updated to the present day. The use of the CHIRPS satellite has reliability in estimating rainfall that occurs in a region or watershed (Gilang et al., 2022). Below is the classification of rainfall (per year) at Table 4.

**Table 4.** Rainfall classification

| Rainfall (per year) | Description | Score | Weight |
|---|---|---|---|
| **<2500 mm** | Very Light | 5 | 15 |
| **2500 – 3500 mm** | Light | 4 | |
| **3500 – 4500 mm** | Medium | 3 | |
| **4500 – 5500 mm** | Dense | 2 | |
| **>5500 mm** | Very Dense | 1 | |

Source: Modification of Darmawan & Suprayogi (2017)

Slope is another commonly considered topographical factor alongside elevation that refers to the inclined portion of the Earth's surface, typically expressed as a percentage ratio between vertical elevation (height) and horizontal distance (length). It plays a significant role in influencing surface runoff and drainage capacity (Krisnantara et al., 2021). According to Nuryanti et al. (2021); Bruwier et al. (2020), steeper slopes tend to reduce the likelihood of flooding due to faster water runoff, generally experience shallower average water depths and diminished peak levels of stored surface runoff. Whereas gentler or flatter slopes increase flood vulnerable, as water is more likely to accumulate and drain slowly across the surface. Below is the classification of slope at Table 5.

**Table 5.** Slope classification

| Slope (%) | Description | Score | Weight |
|---|---|---|---|
| **0 – 8** | Flat | 5 | 10 |
| **8 – 15** | Ramps | 4 | |
| **15 – 25** | Slightly Steep | 3 | |
| **25 – 45** | Steep | 2 | |
| **>45** | Very Steep | 1 | |

Source: Guidelines for the Preparation of Land Rehabilitation and Soil Conservation Patterns, 1986. Modification of Amaliyah & Maman (2022)

Soil type plays a crucial role in the infiltration process, which is the absorption of surface rainwater into the soil profile in a vertical direction under the influence of gravity. The rate of infiltration is affected by various physical factors, including soil type, density, and moisture content. Soil type significantly impacts infiltration capacity, fine-textured soils tend to have lower infiltration rates, leading to increased surface runoff (Anggraini et al., 2021). In contrast, coarse-textured soils allow for higher infiltration, thereby reducing surface runoff and lowering the vulnerable of flooding. Below is the classification of soil type at Table 6.

**Table 6.** Soil type classification

| Soil Type | Description | Score | Weight |
|---|---|---|---|
| **Aluvial, Planosol, Gray Hydromorph, Groundwater Lateric** | Desentized | 5 | 10 |
| **Latosol, Histosols** | Ramly Sensitive | 4 | |
| **Brown Forest Soil, Mediterranean Soil** | Medium | 3 | |
| **Andosol, Inceptisol, Entisol, Grumosol, Podsol, Laterik, Podsolic** | Sensitive | 2 | |
| **Regosol, Litosol, Organosol, Renzina** | Highly Sensitive | 1 | |

Source: RTKRLH-DAS, 2009. Modification of Anggraini et al. (2021)

## Determination of Flood Vulnerability Class Interval Classification

To determine the classification levels of each class, the following formula is used in the calculation process.

$$I = \frac{HS - LS}{TC} \quad (1)$$

with

*I* : Class Interval

*HS* : Highest Score of Flood Hazard

***LS*** : Lowest Score of Flood Hazard
***TC*** : Total of Classes

## RESULTS AND DISCUSSIONS

### 3.1 Flood Vulnerability Classification Results

Based on the analysis of both spatial and non-spatial data related to flood vulnerability in the Kurau Subdistrict, the area has been categorized into the following classifications.

### Land Use Classification on Flood Vulnerability

Figure 3 displays that Kurau Subdistrict has seven categories of land use, with agricultural land contributing the most to flood vulnerable, covering an area of 4182 hectares. In contrast, empty land areas represent the smallest portion only 0,02 hectares as shown in Table 7.

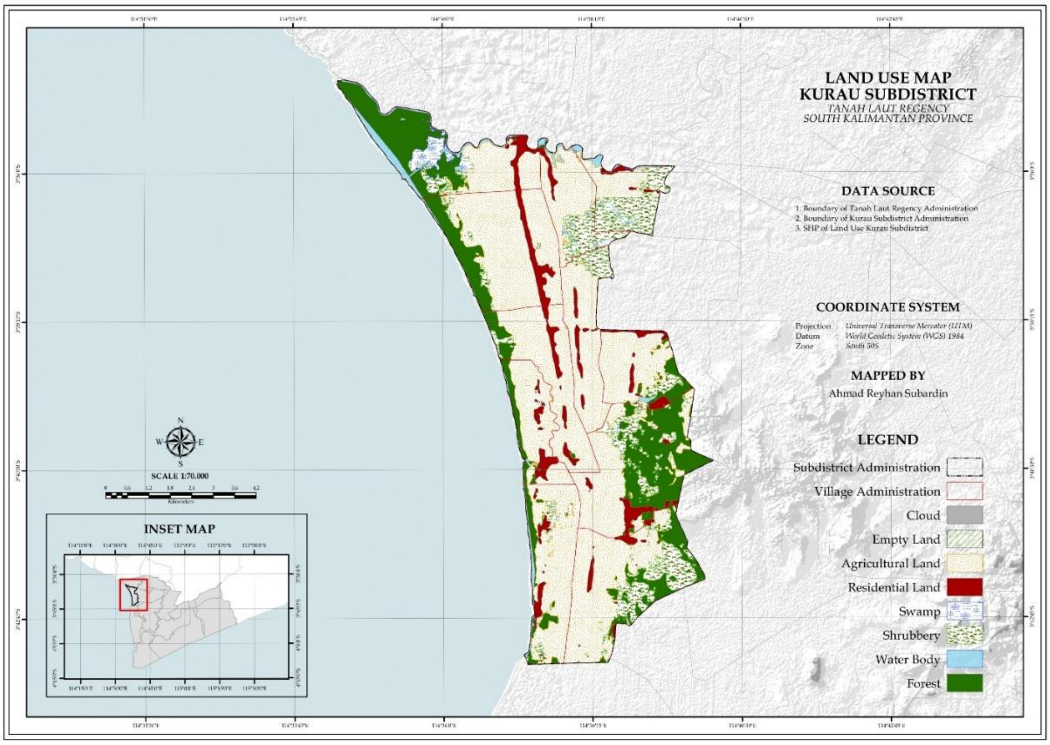


**Figure 3.** Map of land use in Kurau Subdistrict

**Table 7.** Land use area of Kurau Subdistrict

| Land Use | Area (Ha) | Percentage (%) |
|---|---|---|
| **Agricultural Land** | 4182 | 60,8 |
| **Forest** | 1252 | 18,2 |
| **Shrubbery** | 705 | 10,3 |
| **Residential Land** | 392,3 | 5,7 |
| **Swamp** | 179,6 | 2,6 |
| **Water Body** | 164,7 | 2,4 |
| **Empty Land** | 0,02 | 0,00029 |
| **Total** | **6876** | **100** |

The area's coastal location further increases its vulnerability to flooding, adding to the existing vulnerable factors. Improper land utilization, including development in watershed regions may disrupt natural surface water flow and heighten the vulnerable of flooding.

Additionally, Kurau Subdistrict of geographical features —consisting of lowland terrain, river networks, and expansive agricultural areas along with a light average annual rainfall, make the area increasingly vulnerable to frequent and severe floods, especially when land use changes are unregulated and poorly managed.

## Buffer River Classification on Flood Vulnerability

In Kurau Subdistrict based on Figure 4, the majority of the area —approximately 3513,3 hectares or 51.1% falls within the buffer zone located more than 500 meters from the river. This category predominantly includes land uses such as agriculture and forest. Meanwhile, the buffer zone closest to the river, ranging from 0 to 100 meters, covers about 1114,2 hectares or 16.2% of the subdistrict as shown in Table 8. This area is primarily used for residential land purposes, particularly in villages such as Handil Negara, Padang Luas, Tambak Sarinah, and Tambak Karya Village.

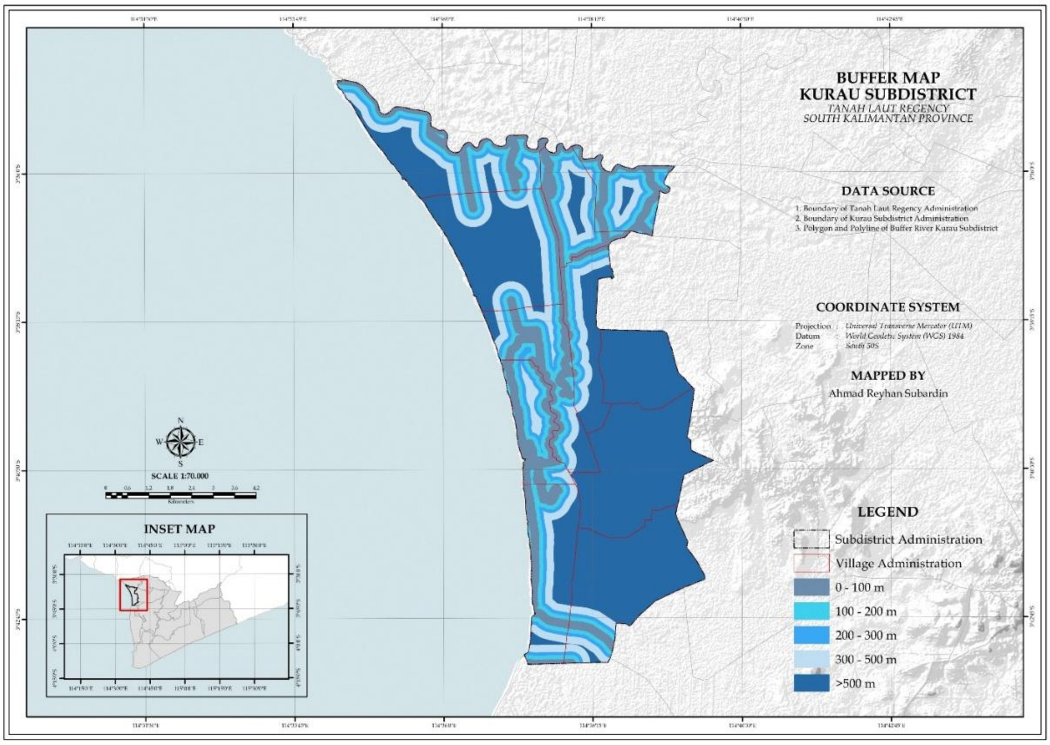


**Figure 4.** Map of buffer river in Kurau Subdistrict

**Table 8.** Buffer river area of Kurau Subdistrict

| Buffer River (m) | Area (Ha) | Percentage (%) |
|---|---|---|
| **0 - 100** | 1114,2 | 16,2 |
| **100 - 200** | 705,9 | 10,2 |
| **200 - 300** | 603,4 | 8,7 |
| **300 - 500** | 939,4 | 13,6 |
| **>500** | 3513,3 | 51,1 |

The tendency of residential areas to the river increases their exposure to flood vulnerability, making them more vulnerable to the impacts of flooding compared to regions situated farther from the river. It typically refers to a defined distance from the riverbank within which human activities are controlled or limited to ensure the preservation of the river and its surrounding areas.

### Elevation Classification on Flood Vulnerability

Elevation in Kurau Subdistrict in Figure 5 is categorized into two levels that align with the area's slope characteristics. Geographically, elevations below 10 meters are predominantly found in the western region of Tanah Laut Regency, including Kurau Subdistrict. This elevation category accounts for approximately 6349.7 hectares, or 92.3% of the district's total area. The remaining 526.3 hectares fall within the 10 – 50 meters elevation range as shown in Table 9. The predominance of low elevation indicates a higher potential for inundation, as flood vulnerability tends to be more evenly and widely distributed in lowland areas making flood events more persistent.

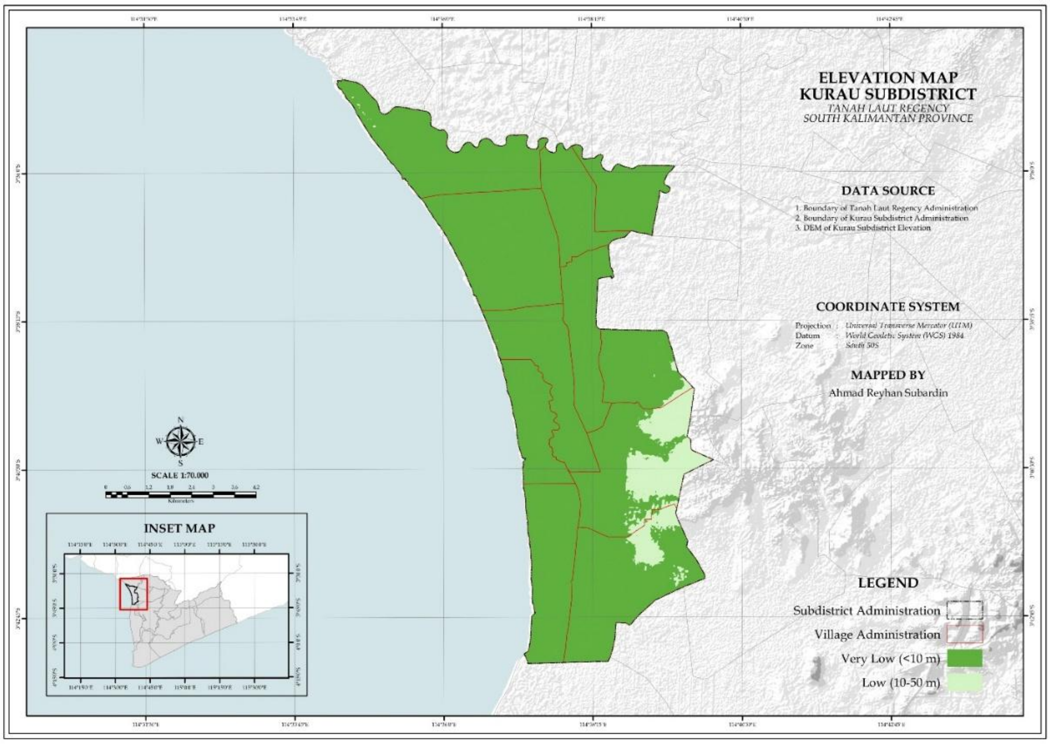


**Figure 5.** Map of elevation in Kurau Subdistrict

**Table 9.** Elevation area of Kurau Subdistrict

| Elevation (m) | Area (Ha) | Percentage (%) |
|---|---|---|
| **<10** | 6349,7 | 92,3 |
| **10 - 50** | 526,3 | 7,7 |

### Rainfall Classification on Flood Vulnerability

The average annual rainfall in Kurau Subdistrict ranging from 2808 to 2866 mm as shown in Figure 6 above, falls under the light rainfall category. Despite being relatively low, this eainfall factor ranks as the fourth most significant contributor to flood vulnerability following land use, buffer river and elevation.

### Slope Classification on Flood Vulnerability

The terrain in Kurau Subdistrict is predominantly flat as shown in Figure 7, with slopes covering approximately 6515 hectares, accounting for 94.7% of the subdistrict's total area that displays as Table 10.

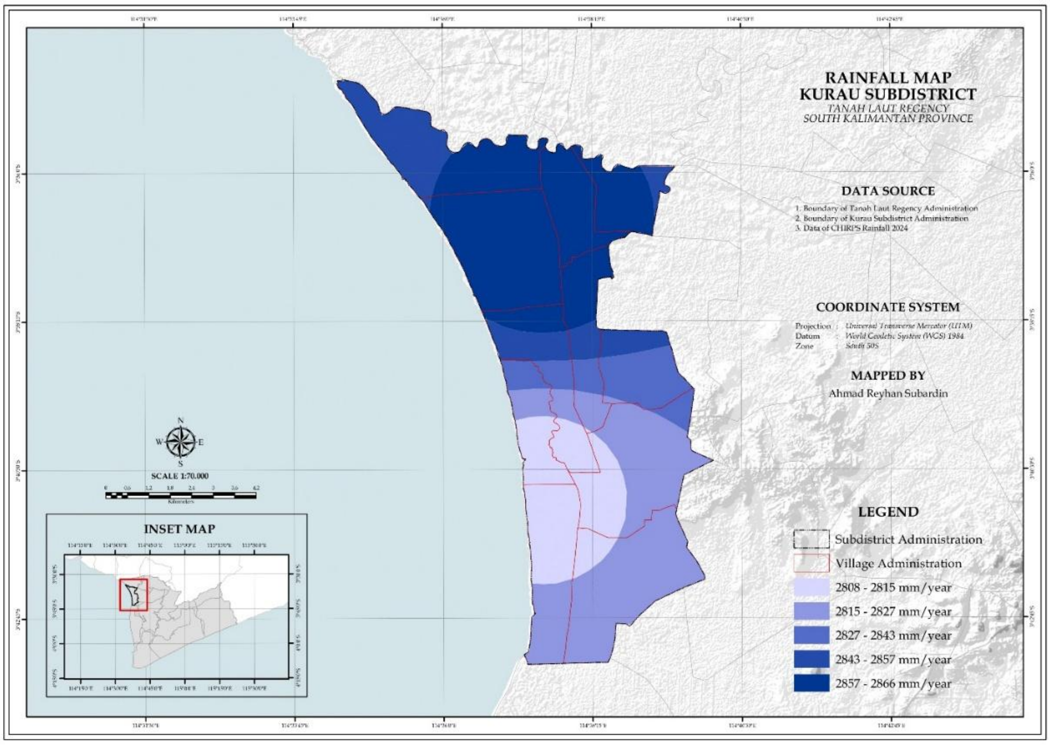


**Figure 6.** Map of rainfall in Kurau Subdistrict

**Table 10.** Slope area of Kurau Subdistrict

| Slope (%) | Area (Ha) | Percentage (%) |
|---|---|---|
| **0 - 8** | 6515 | 94,7 |
| **8 - 15** | 318,4 | 4,6 |
| **15 - 25** | 40,9 | 0,59 |
| **25 - 45** | 1,58 | 0,02294 |

This dominance of flat slopes results in slower surface runoff in several areas, thereby increasing the potential for water accumulation and flooding. This condition is influenced by the slope gradient which affects the direction, velocity, and concentration of rainwater flow.

### Soil Type Classification on Flood Vulnerability

According to the USDA 1975 Soil Taxonomy, the soil type found in Kurau Subdistrict is histosols —classified as Dystric Histosols (Od) by FAO/UNESCO that can be seen on Figure 8, commonly known as peatland which is spread over an area of 6091 hectares or 88.6% in the subdistrict as shown in Table 11. These soils are high in organic content and possess hydrophilic properties, allowing them to easily absorb and blend with water. However, under conditions where the moisture level falls below full saturation (100%), they can exhibit hydrophobic behavior. This type of organosol soil, which belongs to the histosols category, is also prevalent in various villages across Tanah Laut Regency. Peatland are known for their exceptional water retention ability, with water content ranging from 4.5% to 30% of their dry weight when saturated. Furthermore, the large pore structure of these soils facilitates quick groundwater infiltration, thereby placing them in a high flood vulnerability category from a water absorption standpoint.

As the least soil type with an area of 785 hectares in Kurau Subdistrict, podsolic soil —classified as Ferric Acrisols (Af) soil by FAO/UNESCO is belongs to the Ultisol group and is typically characterized by a red-yellow hue. It has a pH range of approximately 3.10 to 5, classifying it as acidic to very acidic. This type of soil has a relatively thin top layer and tends to dry out quickly, as its clay content has a low capacity to retain water.

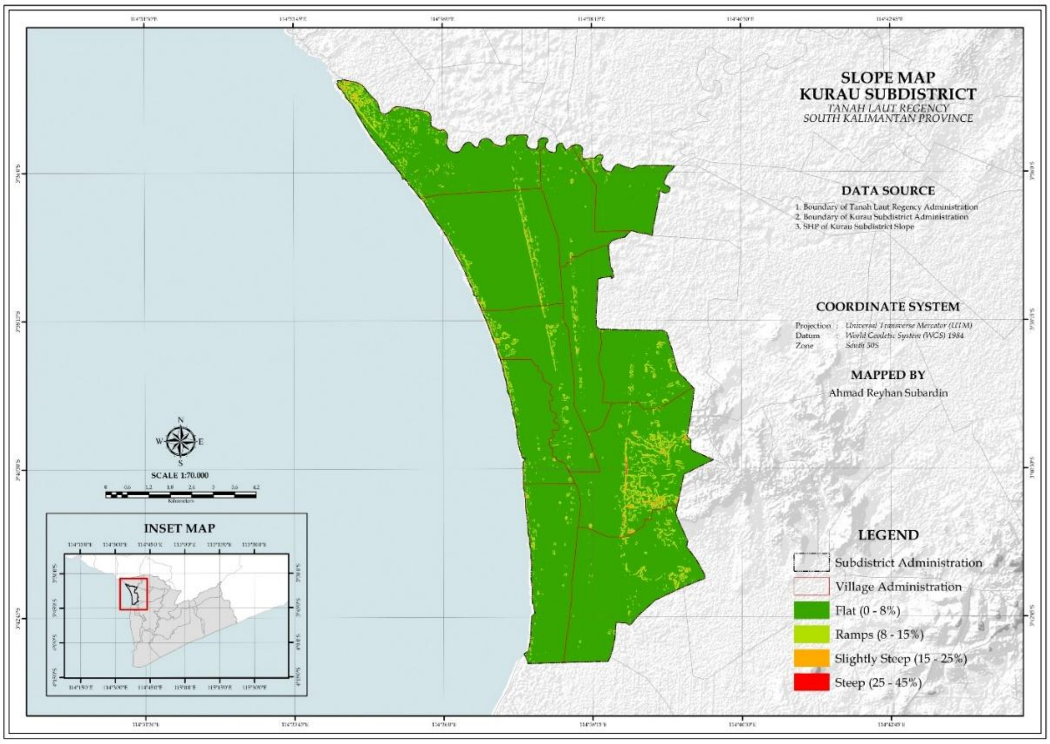


**Figure 7.** Map of slope in Kurau Subdistrict

**Table 11.** Soil type area of Kurau Subdistrict

| Soil Type | Area (Ha) | Percentage (%) |
|---|---|---|
| **Af (Podsolic)** | 6091 | 88,6 |
| **Od (Histosols)** | 785 | 11,4 |

### 3.2 Flood Hazard Map Kurau Subdistrict

The results of determine flood vulnerability are based on Figure 9 that using an overlay method, incorporating parameters such as land use, buffer river, elevation, rainfall, slope, and soil type. Each parameter was classified into interval categories within the flood vulnerability map. Using a specific formula, the highest and lowest vulnerability scores were then identified as follows.

$$\boldsymbol{I} = \frac{28 - 14}{5} = 2.8$$

The classification of flood vulnerability intervals identified the following distribution; (1) Very Low at 14, (2) Low at 16.8, (3) Medium at 19.6, (4) High at 22.4, and (5) Very High at 25.2 as shown in Table 12. Each of these flood vulnerability intervals is then used to calculate the total interval by summing the corresponding values from each category. The interval results for each flood hazard category are found as follows.

Map as shown in Figure 9, it was found that the largest distribution of flood disaster vulnerability is in the High category —orange color on the map where the main influence of flooding is caused by land use which is mostly agricultural land, supported by elevation factors between 0 - 10 m to flat slopes (0 - 8%) and other several results of flood vulnerability levels listed on the map. The results of this finding contain the magnitude of the influence of each parameter causing flood disasters which is seen through the highest and lowest weighting which is useful for spatial overlay method analysis. In addition, the implementation of scoring for classifications on its parameters is also something that is considered in order to be interpreted in the spatial disaster. This is based on previous research with similar disaster studies as a comparison material for the analysis that has been carried out (Akhbar, 2019; Amaliyah & Maman, 2021; Anggraini et al., 2021; Darmawan & Suprayogi, 2017; Fauzi, 2022; Krisnantara et al., 2022; Kusumo & Nursari, 2016; Nuryanti et al., 2018; Rakuasa et al., 2022).

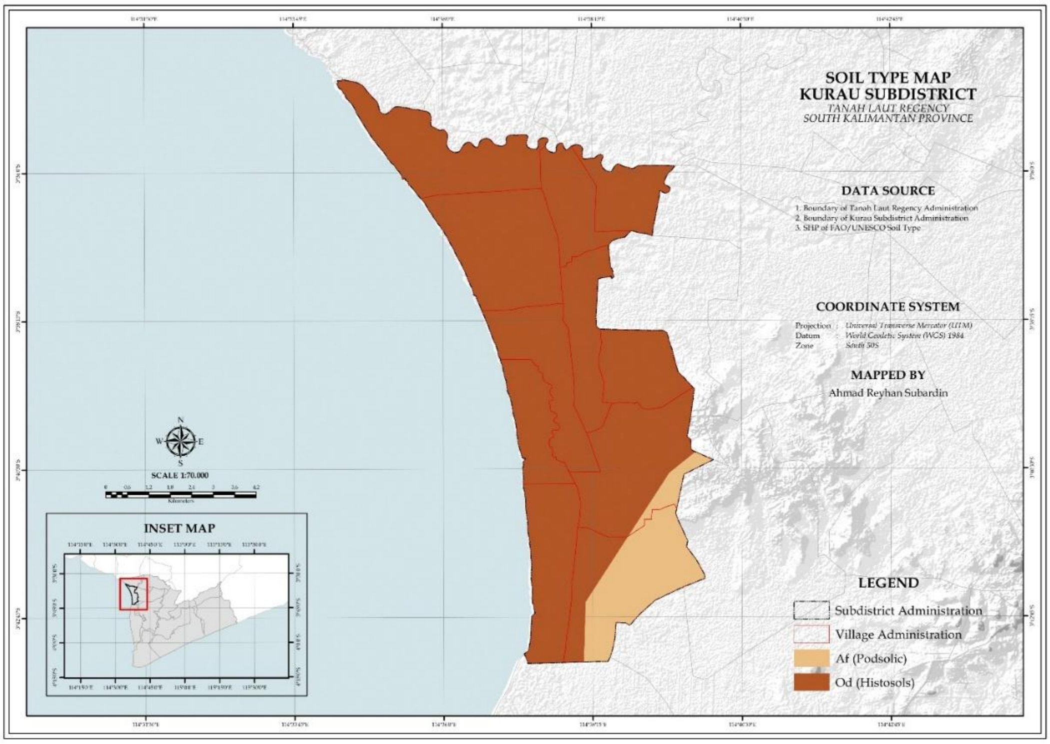


**Figure 8.** Map of soil type in Kurau Subdistrict

**Table 12.** Flood Hazard interval results of Kurau Subdistrict

| No. | Flood Hazard Interval | Description |
|---|---|---|
| 1 | 14 – 16.8 | Very Low |
| 2 | 16.8 – 19.6 | Low |
| 3 | 19.6 – 22.4 | Medium |
| 4 | 22.4 – 25.2 | High |
| 5 | 25.2 - 28 | Very High |

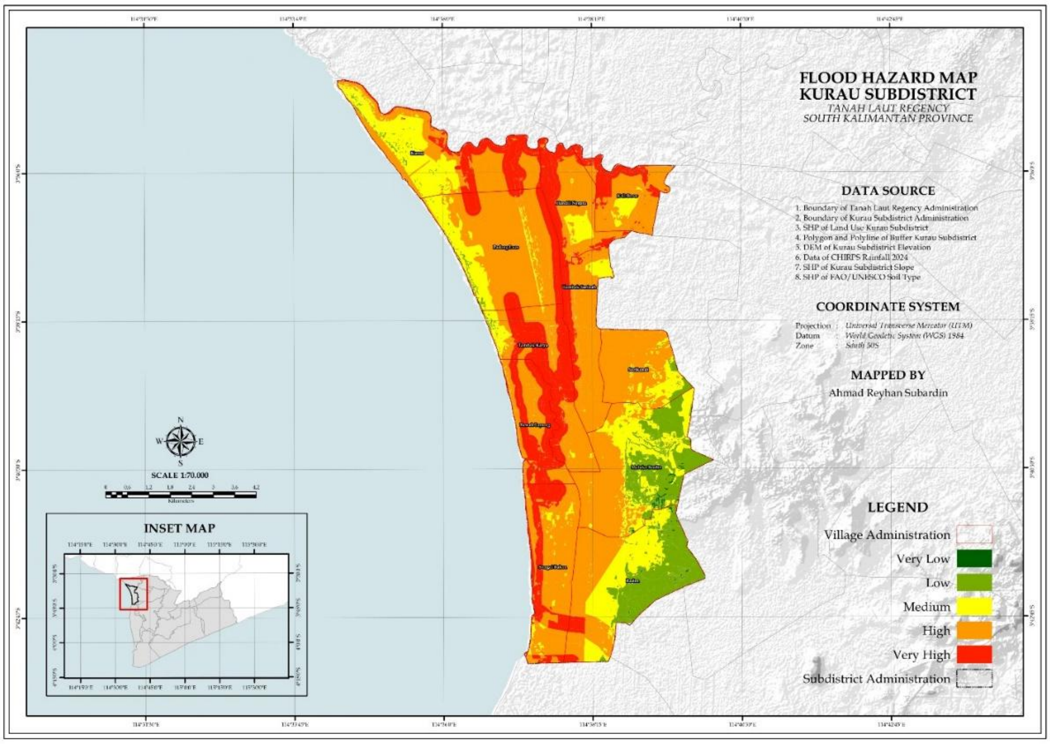


**Figure 9.** Flood Hazard Map in Kurau Subdistrict

## CONCLUSION

The flood hazard map in Figure 9 reveals the spatial distribution of flood vulnerability across Kurau Subdistrict, classified into five levels: very high (red), high (orange), medium (yellow), low (green), and very low (dark green). The majority of the area falls under the very high vulnerability category. This classification is based on six key parameters: (1) land use, assigned the highest weight (25), with agricultural areas covering 4,182 hectares (60.8%); (2) proximity to rivers, weighted at 20, with areas within 0–100 meters from rivers comprising 1,114.2 hectares (16.2%); (3) elevation, also weighted at 20, with low-lying areas (<10 meters) covering 6,349.7 hectares (92.3%); (4) rainfall, with a weight of 15 and annual totals ranging from 2,808 to 2,866 mm/year, categorized as light; (5) slope, weighted at 10, predominantly between 0–8%, encompassing 6,515 hectares (94.7%); and (6) soil type, also weighted at 10, with histosols occupying 6,091 hectares (88.6%).

These findings underscore the urgency of integrating flood vulnerability assessments into spatial planning and infrastructure development. The extensive agricultural land use, proximity to river channels, and low elevation collectively heighten the region's exposure to flood risks. Therefore, local authorities should align land use regulations with flood hazard analyses and implement mitigation strategies such as preserving riparian buffer zones and protecting peatlands. For future research in other regions, it is recommended to strengthen the literature review, clearly structure the spatial analysis through methodological flow diagrams, standardize spatial projections, and secure data permits early. Careful scoring and weighting—particularly by considering the six core parameters—and increasing the number of validation samples will significantly enhance the accuracy, reliability, and policy relevance of flood vulnerability studies.

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