FLOOD DISASTER EVACUATION ANALYSIS (CASE STUDY: LONG PAHANGAI I VILLAGE AND LONG PAHANGAI II VILLAGE, MAHAKAM ULU REGENCY)

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Abstract

Flood disasters are caused by high rainfall intensity and the close proximity of residential areas to the river, as observed in Long Pahangai I and Long Pahangai II Villages. Flooding in these villages occurs frequently every year, with varying water levels. In 2024, floods occurred more than twice in May, reaching a water level of 3 meters above the road surface. Currently, there are no designated evacuation points for flood disasters in the study area. However, during flooding events, affected residents typically seek refuge in unaffected homes within the community. Given this situation, it is crucial to consider the characteristics of the area when planning for flood disaster evacuation. The evacuation point planning process takes into account the capacity and characteristics of the study location, while evacuation routes are determined using Network Analysis to identify the most effective paths. The analysis results indicate the identification of two temporary evacuation points, one final evacuation point, and three flood disaster evacuation routes distributed across Long Pahangai I and Long Pahangai II Villages.

Keywords: Flood Disaster, Evacuation Points, Evacuation Routes

INTRODUCTION

Natural disasters are catastrophic events caused by natural phenomena or a series of events resulting from natural processes, leading to environmental damage, material losses, and human casualties (Kamadhis UGM, 2007). A disaster is defined as a natural occurrence or a potential event that poses a threat to public health, safety, well-being, or the economic functions of a community or broader governmental organization (Fitriadi et al., 2017). Natural disasters can occur unexpectedly; some can be predicted, while others cannot. The occurrence of disasters is influenced by two primary factors: natural processes and human activities. Based on their types, natural disasters include earthquakes, floods, volcanic eruptions, landslides, and tsunamis. These disasters have significant impacts on the environment, infrastructure, property, and human lives.

The study of disaster potential is closely linked to disaster mitigation management, which is a strategic approach to addressing spatial problems arising from the direct impacts of disasters (Rivi, 2019). Disaster mitigation refers to a series of efforts aimed at reducing disaster risks, either through physical development or raising awareness and enhancing the capacity to respond to disaster threats. The ultimate goal is to minimize casualties and material losses when disasters occur (Disaster Management Book, Rivai & Nur Ayini, 2022).

Floods are defined as water flow that exceeds the normal river water level, causing inundation in lowland areas along riverbanks (Cabrera & Lee, 2020). Flooding is a common issue frequently experienced by communities in flood-prone regions. Therefore, effective flood control measures and designated evacuation sites are essential to ensure public safety. Additionally, well-planned evacuation routes are necessary to facilitate the safe movement of affected populations during flood events.

The rapid pace of urban development has both positive and negative impacts. While it fosters economic growth, social development, and tourism, it also contributes to several challenges, including increased disaster risk due to rapid population growth. The expansion of urban settlements, often without proper land-use planning, has led to the emergence of unplanned and vulnerable housing areas. This phenomenon significantly exacerbates environmental disaster risks, with flooding being a major concern. The impact of floods on residential areas manifests in various forms, including structural damage to houses and vehicles, health hazards, infrastructure destruction, and physical alterations to buildings due to prolonged exposure to floodwaters.

As an archipelagic country, Indonesia is geographically located along the equator, situated between two continents—Asia and Australia—and flanked by two major oceans, the Pacific Ocean and the Indian Ocean. Additionally, Indonesia lies at the convergence of three major tectonic plates: the Eurasian Plate, the Indo-Australian Plate, and the Pacific Plate, making it highly susceptible to natural disasters, including floods. The country's tropical climate results in seasonal disasters, where hydrometeorological hazards such as floods, extreme weather, landslides, and coastal erosion occur during the rainy season, while droughts and wildfires prevail during the dry season.

In 2023, Indonesia recorded 5,400 disaster events across the country, marking an increase from 3,544 incidents in the previous year. Hydrometeorological disasters, both wet and dry, accounted for the majority of these occurrences, emphasizing the nation's ongoing vulnerability to climate-related hazards.

Mahakam Ulu Regency spans an area of approximately 15,315 km², accounting for around 7.26% of the total land area of East Kalimantan Province. Geostrategically, Mahakam Ulu serves as a terrestrial border region, acting as a gateway between Indonesia and Malaysia's Sarawak territory. The region is characterized by undulating topography, with elevations ranging from 0 to 1,500 meters above sea level and slopes varying between 0% and 25%. The regency is traversed by ten major rivers, which flow through all its districts, contributing to its high susceptibility to flooding.

Mahakam Ulu Regency experiences a humid tropical climate, with the highest average rainfall recorded in April and the lowest in August. There is no distinct dry season, as each month receives a minimum of seven days of rainfall. Long Pahangai 1 and 2 are villages located in Long Pahangai District, with an area of 126.95 km² and 146.27 km², respectively. Both villages are situated along the Mahakam River Basin (DAS Mahakam), where numerous structures are located in flood-prone zones. The area experiences an average annual rainfall of 184.91 mm, significantly increasing the risk of flooding.

Despite the evident disaster risks, Long Pahangai 1 and 2 currently lack designated evacuation sites for flood-affected residents. A major flood event occurred in 2024, marking the most severe flooding since 2012. This disaster impacted not only Long Pahangai 1 and 2 but also all villages within Mahakam Ulu Regency, including those in Long Pahangai District. The flood, triggered by several consecutive days of heavy rainfall, resulted in 118 houses being submerged under two meters of water for 2–3 days, leading to extensive losses. The absence of proper evacuation shelters further exacerbated the challenges faced by the affected communities, highlighting the urgent need for disaster mitigation and preparedness measures.

REVIEW OF LITERATURE

Disaster

According to the World Health Organization (WHO) (2007), a disaster is any event that causes damage, ecological disruption, loss of life, or a decline in health services to a certain extent, requiring a specific level of health response or service. Natural disasters, as defined by Kamadhis UGM (2007), are disasters caused by an event or series of events triggered by natural phenomena, which can result in environmental destruction, material losses, and human casualties. Furthermore, Fitriadi et al. (2017) describe disasters as natural events or potential occurrences that pose threats to public health, safety, community well-being, economic functions, or broader governmental organizational units.

Disaster Risk

The International Strategy for Disaster Reduction (ISDR) (2004) defines risk as the probability of harmful consequences or expected losses—including loss of life, injuries, damage to assets, livelihoods, economic activities, or environmental degradation—arising from the interaction between natural or human-induced hazards and vulnerable conditions. In simpler terms, according to BNPB (2012), disaster risk is the interaction between a region's vulnerability level and existing hazard threats. The widely used formula for calculating disaster risk is as follows:

$$\text{Risk (Hazard)} = \text{Hazard} \times \text{Vulnerability}$$

Factors Contributing to Disasters

According to Nurjanah et al. (2012), the factors influencing disasters include hazards, vulnerability, and disaster risk. Hazards refer to natural or human-induced phenomena with the potential to significantly impact human life, cause property damage, and degrade the environment. Disaster risks originate from geological, hydrological, meteorological, biological, and conflict-related factors.

Moreover, community vulnerability plays a critical role in disaster resilience, as it determines the extent to which a population can cope with risks such as flooding. Vulnerability factors include physical, social, economic, and environmental weaknesses. Disaster risk, therefore, represents the level of regional susceptibility to both natural and non-natural hazards, indicating the likelihood of disaster occurrence.

Flood Disasters

A flood is an event in which normally dry land (not wetlands) becomes inundated with water. This phenomenon is primarily caused by high rainfall and topographical conditions characterized by lowland or concave areas. Additionally, flooding occurs due to surface water runoff that exceeds the drainage system or river channel capacity. Flood disasters can also result from low soil infiltration capacity, rendering land unable to absorb water effectively. Other contributing factors include rising water levels due to higher-than-usual rainfall, temperature changes, dam failures, rapid snowmelt, and obstructed water flow in neighboring regions (Ligak, 2008). A flood is defined as the inundation of an area caused by excessive water overflow beyond the region's drainage capacity, leading to physical, social, and economic losses (Rahayu et al., 2009).

Flood Hazards

Flood hazards refer to the conditions that determine the susceptibility of a region to flood threats, which can disrupt economic activities and other essential functions. The mapping of flood hazard areas aims to provide a comprehensive assessment and identify regions prone to flooding, allowing for the implementation of preventive measures (Seftiani et al., 2023). According to Kodoatie & Sjarief (2006), several factors contribute to flood hazards, including:

1. Duration of inundation – Prolonged water stagnation can cause environmental damage and lead to the spread of diseases.
2. Water flow velocity – High-speed water flow has the potential to carry away humans and materials.
3. Type of transported materials – Floodwaters may carry debris and hazardous materials that can pose risks to human life and infrastructure.
4. Flood depth – Excessive water depth increases the risk of submerging individuals and structures.

Disaster Management

Disaster management is categorized into three phases: pre-disaster, where prevention efforts are prioritized, and preparedness is at a medium level; during the disaster, where emergency response becomes the most critical activity; and post-disaster, where recovery and reconstruction are key processes. According to Disaster Management: Health and Humanitarian Perspectives (2018), disaster management activities include:

1. Prevention, such as prohibiting forest burning for farming, banning rock mining in steep areas, and restricting improper waste disposal.
2. Disaster Mitigation, which involves both physical infrastructure and awareness-building to enhance disaster preparedness (Law No. 24/2007). Efforts include:
   - Structural Mitigation: Constructing check dams, reservoirs, river embankments, earthquake-resistant housing, etc.
   - Non-Structural Mitigation: Implementing regulations, conducting training, and raising awareness.
3. Preparedness, which consists of organizing activities to anticipate disasters, including communication facilities, command posts, and evacuation site preparation (Law No. 24/2007).
4. Early Warning System, ensuring prompt public notification regarding potential disasters. The warnings must be widespread, immediate, clear, unambiguous, and official.
5. Emergency Response, involving immediate actions to address the disaster's impact, including victim rescue, property protection, evacuation, and sheltering.
6. Emergency Relief, aimed at providing essential supplies such as food, clothing, temporary shelter, healthcare, sanitation, and clean water.
7. Recovery, which includes:
   - Emergency Recovery: Restoring affected communities by rehabilitating basic infrastructure and services (roads, electricity, clean water, markets, health centers, etc.).
8. Rehabilitation, supporting affected communities in rebuilding homes, public infrastructure, and social services, while revitalizing economic activities.
9. Reconstruction, a medium- and long-term program to restore physical, social, and economic conditions to their previous state or improve them. A structured disaster management plan ensures effective control over disaster-related fatalities and facilitates prompt post-disaster recovery.

Evacuation

According to Purbo (2002), an emergency within a building is an unusual and hazardous situation that endangers its occupants. Such emergencies may result from natural disasters (e.g., earthquakes, volcanic eruptions, flash floods) or human-related incidents (e.g., fires, structural failures due to construction errors).

Evacuation Points

Evacuation is conducted to minimize risks and consequences, even in unpredictable disaster-prone areas (Zuilekom et al., 2006). Designing multiple evacuation points facilitates emergency response efforts, such as treating the injured. An effective evacuation point must be:

- Easily accessible to disaster victims and rescue teams.
- Safe from potential disasters.

- Recognized as a public facility meeting safety criteria (Harsini, 2014).

Evacuation Routes

Evacuation routes refer to designated pathways that allow people to move quickly and directly from hazardous areas to safe locations (Pratiwi et al., 2022). Identifying these routes requires an assessment to determine the fastest and safest path to designated evacuation gathering points (Sandi, 2020).

RESEARCH METHOD

According to (Ramberger, 2000), research approaches can be broadly classified when viewed from several research sectors. In the field of social sciences, research approaches can be divided into three types: qualitative, quantitative, and mixed-method approaches.

Data Collection Method

The data collection methods used in this study comprise both secondary and primary data collection. Secondary data allows researchers to simplify complex information, presenting research findings in a more straightforward manner, such as in tables, diagrams, and analyses. The secondary data utilized includes shapefiles representing flood hazard levels as well as demographic data. Meanwhile, primary data collection is conducted through interviews and questionnaires to gather information regarding flood disaster vulnerability, along with field observations to identify evacuation points and flood evacuation routes.

Data Analysis Method

Identifying Flood Hazard Levels in Long Pahangai I and Long Pahangai II Villages

To identify flood hazard levels in Long Pahangai I and Long Pahangai II Villages, the analysis tool employed is an overlay using Geographic Information Systems (GIS). Shapefiles obtained from Inarisk are clipped to the boundaries of Long Pahangai I and Long Pahangai II Villages to determine the respective flood hazard levels.

Identifying Flood Disaster Vulnerability in Long Pahangai I and Long Pahangai II Villages

To determine the level of flood disaster vulnerability in Long Pahangai I and Long Pahangai II Villages, the following analytical methods are applied:
A. Descriptive Analysis to describe the factors influencing flood disaster vulnerability.
B. Analytical Hierarchy Process (AHP)
C. Weighted Overlay Analysis

Identifying Flood Disaster Risk Levels in Long Pahangai I and Long Pahangai II Villages

Disaster risk refers to the potential hazard and vulnerability map created by overlaying hazard and vulnerability maps. Disaster risk maps are developed for each type of disaster that threatens a particular region. The disaster risk is calculated using the following formula:

$$Risk = H \times V$$

Where:

- H: Hazard
- V: Vulnerability

Identifying Flood Disaster Evacuation Points and Evacuation Routes in Long Pahangai I and Long Pahangai II Villages

The analysis used to determine evacuation points and evacuation routes involves scoring and Network Analysis.

RESULTS AND DISCUSSION

Long Pahangai I and Long Pahangai II Villages are located in Long Pahangai District, Mahakam Ulu Regency, covering an area of 273.22 km². Long Pahangai I Village consists of four neighborhood units (RTs), while Long Pahangai II Village consists of two neighborhood units (RTs). The administrative boundaries of these villages are as follows:

- North: Malinau Utara Regency, North Kalimantan
- East: Long Tuyoq Village, Long Pahangai District
- South: Murung Raya Regency, Central Kalimantan
- West: Long Isun Village, Long Pahangai District

Identifying Flood Hazard Levels

Flood hazard levels are identified using DEMNAS data from Inarisk for Mahakam Ulu Regency. The data is processed into shapefiles and clipped for each village. Based on the flood hazard analysis, the hazard level in Long Pahangai I Village is classified as moderate, while in Long Pahangai II Village, it is classified as high. The results are presented in the table and map below.

Table 1.
Flood hazard level

Village	Scoring	Classification	Area (ha)
Long Pahangai I	2	Moderate	262.06
Long Pahangai II	3	High	1,755.41

Source: Analysis Results, 2025

1. Identifying Flood Disaster Vulnerability

A. Descriptive Analysis

Variable	Existing Conditions	Factors
Aspek Sosial		
Population Density	The population density of Long Pahangai I in 2024 is 6.82 people/km², while in Long Pahangai II, it is 1.82 people/km². This indicates that the population in these areas is very low compared to the total land area.	The population density of Long Pahangai I (6.82 people/km²) in 2024 and Long Pahangai II (1.86 people/km²) shows that the number of residents is significantly low relative to the area size..
Age Group Ratio	The population is categorized into three groups: non-productive, productive, and post-productive. In the study area, the non-productive population consists of 189 individuals, while the post-productive population consists of 119 individuals. Children under five years old and elderly individuals above 65 years old often face difficulties in evacuation during disasters due to their limited physical capabilities and higher dependency on adults in the productive age group.	The age group ratio in Long Pahangai I is 1.75, and in Long Pahangai II, it is 0.42, which reflects the population segment affected in the event of a flood disaster.

Disabled Population Ratio	There are 19 disabled individuals in the study area. During floods, people with disabilities often experience difficulties in movement, making self-evacuation more challenging. These limitations can slow down evacuation processes and increase the risk of injury or fatalities	The ratio of disabled residents in Long Pahangai I is 0.018, and in Long Pahangai II, it is 0.015, indicating those affected during flood disasters.
Physical Aspects		
Houses	The number of houses assessed based on vulnerability and damage caused by flooding is 118. The community suffered losses, particularly in damaged house floors due to the force of floodwaters. The estimated loss per unit varies between 1-2 million IDR.	A total of 118 houses were submerged, with damage mainly affecting the flooring due to strong flood currents, causing financial losses ranging from 1-2 million IDR per unit.
Road Network	The road network in the study area is located near the river basin, and 3.79% of the roads were submerged or damaged due to flooding.	A 3.79% road network damage ratio significantly impacts flood vulnerability, caused by river overflow and heavy rainfall in Long Pahangai I and Long Pahangai II.
Environmental Aspects		
Rainfall	The annual rainfall in the study area exceeds 4000 mm/year, contributing to flood vulnerability due to excessive runoff in Long Pahangai I and Long Pahangai II.	Annual rainfall exceeding 4000 mm increases flood risk in both villages.
Soil Type	The soil in Long Pahangai I and Long Pahangai II consists mainly of red-yellow podzolic, lithosol, and latosol complexes. These soil types are infertile and prone to erosion, increasing flood risks, particularly in areas dominated by red-yellow podzolic soil, which has poor water absorption.	The presence of soil complexes such as red-yellow podzolic, lithosol, and latosol reduces water absorption, leading to a higher risk of flooding, especially during heavy rainfall.
Slope Gradient	In Long Pahangai I, slope classifications are as follows: <2% covering 2,804.45 ha, 16-25% covering 197,464.60 ha, 26-50% covering 510.10 ha, and >40% covering 268,684.69 ha. In Long Pahangai II, the classifications include <2% covering 2,804.45 ha and 16-25% covering 197,464.60 ha. The steep slopes in Long Pahangai I contribute to rapid water flow during heavy rain.	The steep slopes (>40%) in Long Pahangai I increase flood risks by accelerating water runoff, whereas gentler slopes reduce flood vulnerability.
Distance Between River and Settlements	The distance between the river and settlements in the study area is very close, ranging from 5-10 meters. Houses in Long Pahangai I and Long Pahangai II are predominantly located along the riverbanks.	The close proximity of settlements to the river (5-10 meters) makes them highly vulnerable to flooding.

Source: Analysis Results 2025

B. AHP Analysis

The selection of criteria for determining flood disaster vulnerability in Long Pahangai I and Long Pahangai II Villages is based on a consensus reached among stakeholders through the Delphi technique. This iterative process identified the most significant factors influencing vulnerability assessment, ensuring an agreement among experts and decision-makers.

Weighting of Environmental Factors and Sub-Factors

Based on the Analytical Hierarchy Process (AHP) analysis, the weight values for each sub-factor within the environmental aspect are as follows:

Sub-Factor	Weight
Rainfall	0.879
Soil Type	0.111
Slope Gradient	0.129
Distance Between River and Settlement	0.327

The results indicate that rainfall has the highest weight (0.879), signifying its dominant influence on flood vulnerability in the study area.

Furthermore, the consistency ratio was calculated, yielding a consistency value of 1 with an inconsistency value of 0.01. Since this value is within the acceptable threshold, the AHP analysis is considered valid and reliable in determining flood vulnerability factors.

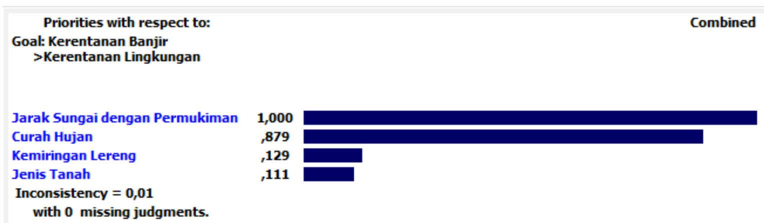

Figure 1.
presents the output of the AHP analysis
Source: Analysis Results with Expert Choice

Weight of Physical Factors and Sub-Factors

Based on the results of the AHP analysis, the weight value for each sub-factor of the physical aspect is House (0.577), Road Network 1, with an inconsistency value of 0.00 so that the sub-factor of the physical aspect is considered valid. Figure 5.2 shows the output results of the AHP analysis.

Figure 2.
AHP Analysis Output Image of Physical Aspect
Source: Analysis Results with Expert Choice

Weight of Social Factors and Sub-Factors

Based on the results of the AHP analysis, the weight values for each sub-factor of the social aspect are population density (0.121), age group ratio (1), and disabled population ratio (0.602), with a consistency value of 0.00167, so that the sub-factors of the social aspect are considered valid. In Figure 5.3, the results of the processed AHP analysis output.

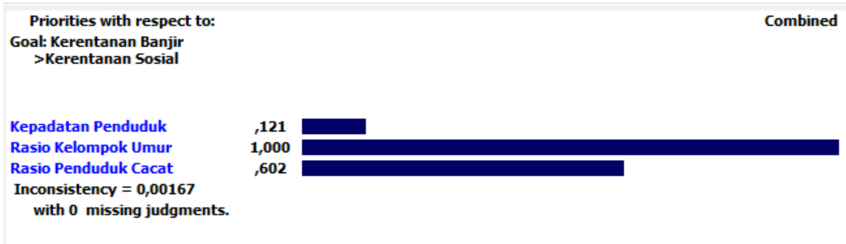

Figure 3.
AHP Analysis Output Image Social Aspect
Source: Analysis Results with Expert Choice

Total Weight of the Combination of 3 Factors

The results of the AHP analysis obtained the weight value of the factors in determining flood disaster vulnerability with an inconsistency value of 0.0, so that the environmental aspect, physical aspect, and social aspect factors are considered valid. The following are the weight values for each factor.

1. Environmental Aspect is 1.000
2. Physical Aspect is 0.111
3. Social Aspect is 0.111

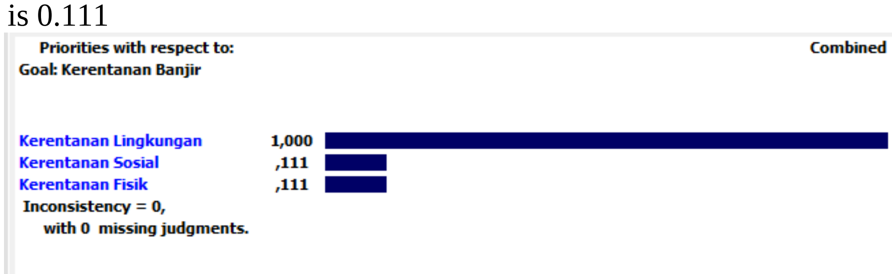

Figure 4.
AHP Output Image of Flood Disaster Vulnerability Factors
Source: Expert Choice Analysis Results

Meanwhile, based on the combined results of the vulnerability assessment between stakeholders, it can be seen in the image below.

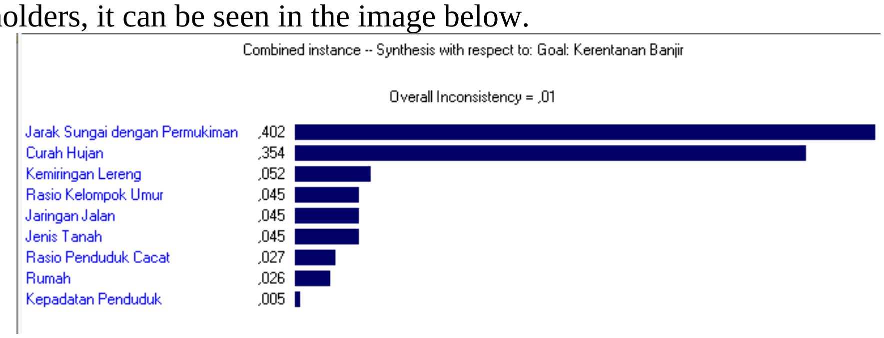

Figure 5.
AHP Output Image of Flood Disaster Vulnerability Factors in Long Pahangai I Village and Long Pahangai II Village
Source: Expert Choice Analysis Results

Based on the output results of the AHP (Expert Choice) analysis, sub-factors were obtained that significantly influenced flood disaster vulnerability in Long Pahangai I Village and Long Pahangai II Village. The sub-factors of flood disaster vulnerability are as follows.

1. Distance of river to settlement (0.402)

2. Rainfall (0.354)
3. Slope gradient (0.052)
4. Age group ratio (0.045)
5. Road network (0.045)
6. Soil type (0.045)
7. Disabled population ratio (0.027)
8. Houses (0.026)
9. Population density (0.005)

Performance Sensitivity for nodes below: AHP Flood Disaster Vulnerability Factors in Long Pahangai I Village and Long Pahangai II Village

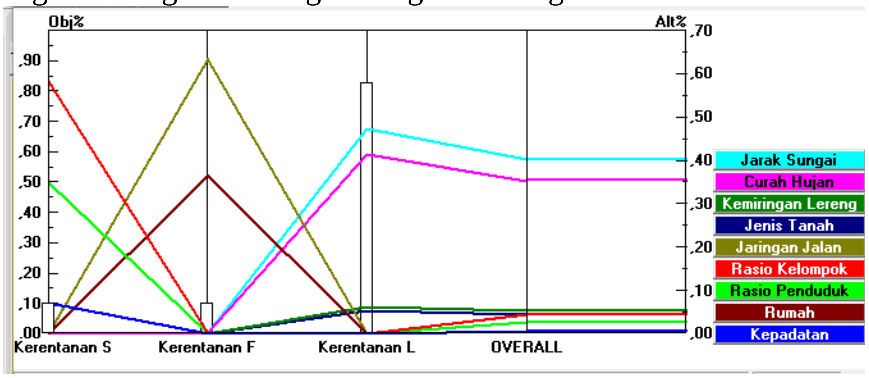

Figure 6.
AHP Priority Sensitivity Performance Image
Source: Analysis Results with Expert Choice

Gradient Sensitivity for Nodes Below: AHP Flood Disaster Vulnerability Factors in Long Pahangai I Village and Long Pahangai II Village

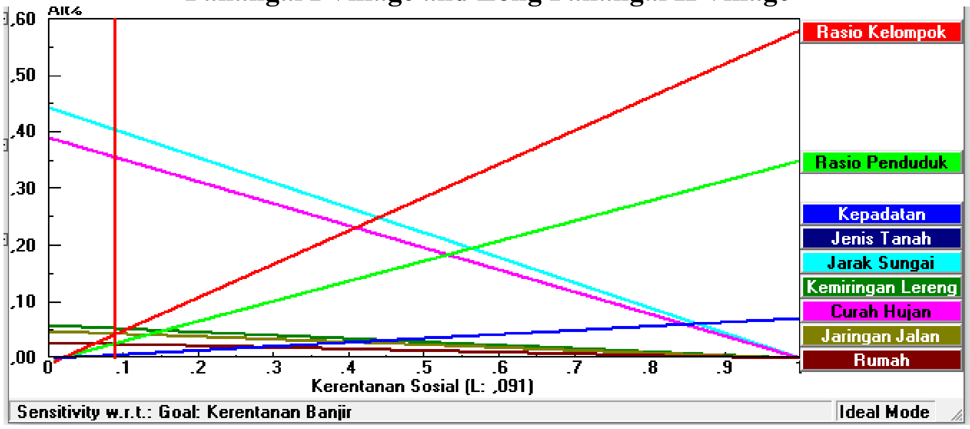

Figure 7.
Gradient Sensitivity Priority AHP Image
Source: Analysis Results with Expert Choice

Dynamic Sensitivity for Nodes Below: AHP Flood Disaster Vulnerability Factors in Long Pahangai I Village and Long Pahangai II Village

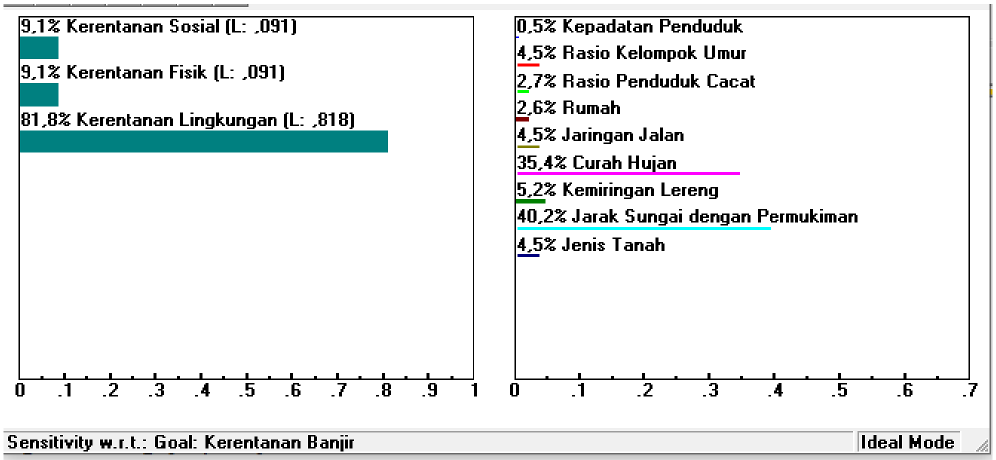

Figure 8.
Dynamic Sensitivity Priority AHP Image
Source: Analysis Results with Expert Choice

The level of flood disaster vulnerability is a measure that states the high or low possibility of a flood disaster indicated by flood disaster vulnerability factors. To determine the level of vulnerability to potential flood disasters, an overlay map of environmental vulnerability variables, physical vulnerability and social vulnerability was carried out in Long Pahangai I Village and Long Pahangai II Village.

Table 2
Assessment Parameter
Sub-Variables, Criteria, Scores, and Weights

Sub-Variable	Criteria	Score	Weight
Population Density	0-63 people/ha	1	0.005
	64-106 people/ha	2	
	107-149 people/ha	3	
Age Group Ratio	<20%	1	0.045
	20-40%	2	
	>40%	3	
Disabled Population Ratio	<20%	1	0.027
	20-40%	2	
	>40%	3	
House Value	<400 million IDR	1	0.026
	400-800 million IDR	2	
	>800 million IDR	3	
Road Network Value	<500 million IDR	1	0.045
	500 million - 1 billion IDR	2	
	>1 billion IDR	3	
Rainfall	2500-3000 mm/year	1	0.354
	3000-4000 mm/year	2	
	>4000 mm/year	3	
Slope Gradient	0-20°	1	0.052
	20-40°	2	

	>40°	3	
Soil Type	Regosol, Litosol, Organosol, Renzina	1	0.045
	Mediterranean Soil, Brown Forest Soil	2	
	Alluvial, Planosol, Hydromorphic Gray, Lateritic Groundwater	3	
Distance Between River and Settlement	100-250 meters	1	0.402
	50-1200 meters	2	
	0-50 meters	3	

Source: 2025 Analysis Results

3. Identifying the Level of Flood Disaster Risk

The risk of flood disaster in Long Pahangai Village uses the formula R = Hazard X vulnerability with the risk level in Long Pahangai Village I and Long Pahangai Village II having a moderate disaster risk classification. The results of the analysis can be seen in the table below.

Table 3
Flood Disaster Risk Level Table

Village	Flood Hazard Score	Combined Vulnerability Score	Risk Score	Classification
Long Pahangai I	3	2.447	7.341	Moderate
Long Pahangai II	3	2.447	7.341	Moderate

Source: 2025 Analysis Results

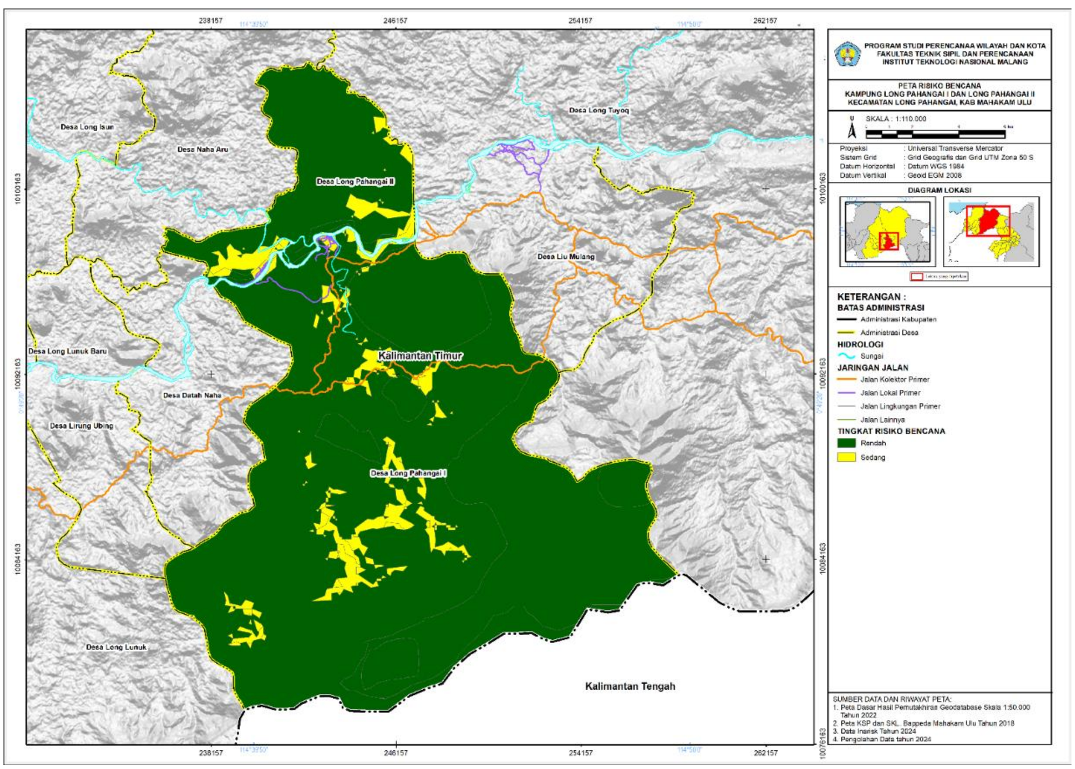

Figure 8.
Flood Disaster Risk Map

1. Identifying Flood Disaster Evacuation

A. Evacuation Points

The analysis of evacuation points is conducted by considering the characteristics of the study area and the flood disaster risk classification. The flood disaster risk analysis determines which areas require evacuation. The analysis of flood disaster evacuation points includes the distance from the river, land use, and shelter capacity. Additionally, the selected buildings for evacuation must be assessed to determine whether they are located in hazardous areas. Thus, the buildings or land designated as temporary and final evacuation points must be situated in areas that are safe from flood hazards.

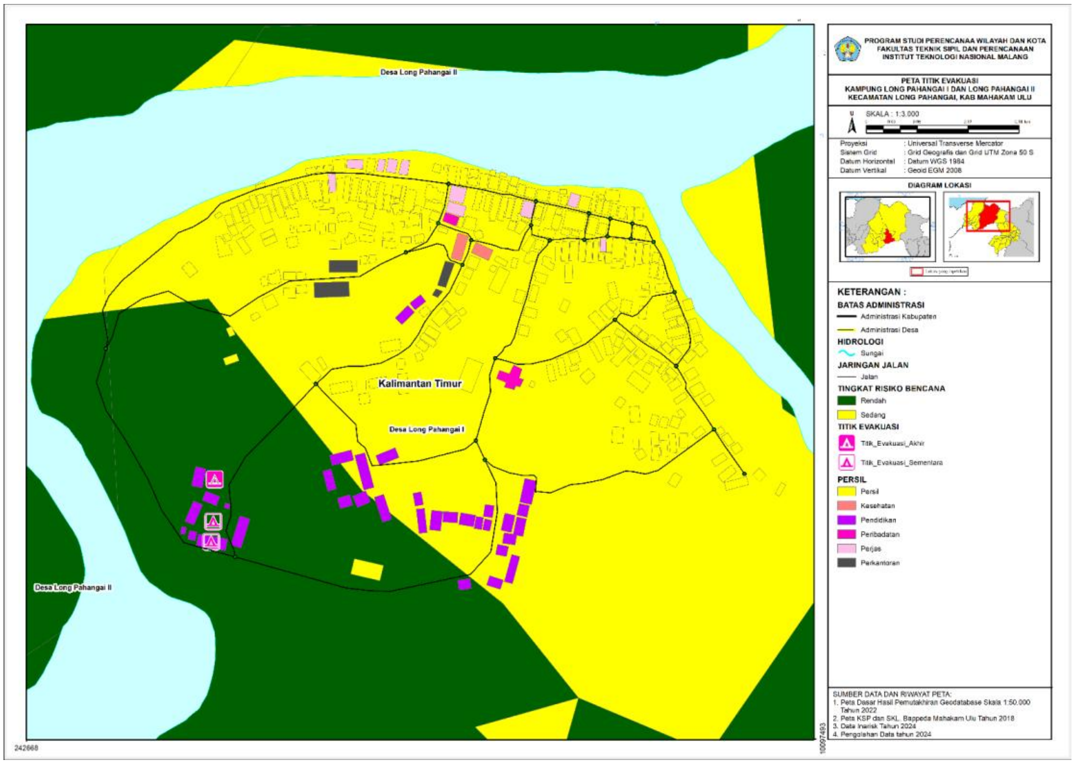

Figure 9.
Evacuation Point Map

B. Evacuation Routes

The analysis of flood disaster evacuation routes includes aspects such as location and evacuation route planning. Key considerations in planning include avoiding river flows, not crossing rivers or bridges, and ensuring adequate road width. The planning of evacuation points and routes aims to relocate residents from disaster-prone areas and minimize the impact of flooding.

No	Route	Distance (House-TES-TEA) (m)	Road Hierarchy	Travel Time	Road Condition	Pavement Condition	Road Capacity	Movement Direction	Total Score	Classification

1	Route 1	865	Local Road	15-30 Minutes	4 Meters	Good	<50	Away from River	14	Feasible
	Scoring	2	1	2	2	3	1	3		
2	Route 2	701	Local Road	15-30 Minutes	4 Meters	Good	<50	Away from River	14	Feasible
	Scoring	2	1	2	2	3	1	3		
3	Route 3	757	Local Road	15-30 Minutes	4 Meters	Good	<50	Away from River	14	Feasible
	Scoring	2	1	2	2	3	1	3		

Source: 2024 Analysis Results

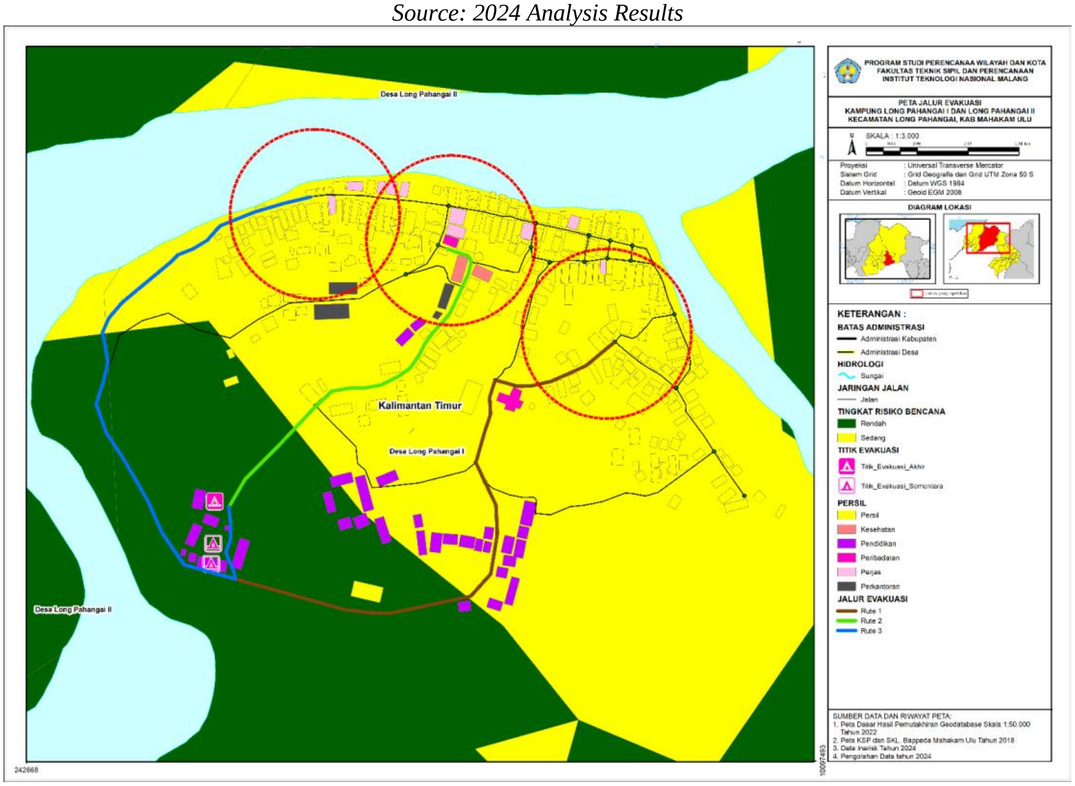

Figure 10.
Evacuation Route Map

Evacuation Route Map

The conclusion of the study "Flood Disaster Evacuation Analysis in Long Pahangai I Village and Long Pahangai II Village" is as follows. Based on the first objective, which is to identify flood hazards in Long Pahangai I and Long Pahangai II, the floods occurring in the study area are similar to those commonly caused by high-intensity rainfall. Additionally, floods in this location occur almost every year, submerging residents' houses. However, despite the frequent occurrence, the community in Long Pahangai I and Long Pahangai II still feels safe from flooding, and most houses are located along the riverbanks. The analysis of this objective shows that the flood hazard level in Long Pahangai is classified as high, with the affected area covering 262.06 hectares in Long Pahangai I and 1,775.41 hectares in Long Pahangai II.

For the second objective, which is to identify the level of flood vulnerability in Long Pahangai I and Long Pahangai II, three aspects were considered: social (population density, age group ratio, and the ratio of disabled residents), environmental (rainfall intensity, slope gradient, distance from the watershed to residential areas, and soil type), and physical (affected houses and road networks). Based on these aspects, the classification results indicate that both Long Pahangai I and Long Pahangai II have a moderate level of vulnerability.

For the third objective, which is to determine the level of flood disaster risk, the risk was calculated using the formula hazard × vulnerability. The classification results indicate that the flood disaster risk level in Long Pahangai I and Long Pahangai II is low. However, when considering the locations of residential settlements, the classification changes to moderate.

For the fourth objective, which is to identify flood evacuation points in Long Pahangai I and Long Pahangai II, it is crucial to consider the characteristics of the study area, how the community responds to floods, and shelter capacity. The findings show that for temporary evacuation sites, Location 5 is moderately suitable, and Location 6 is suitable. For final evacuation sites, Location 3 is suitable, while Location 1 is not suitable due to limited capacity and its location in a high flood hazard area. Similarly, Location 2 is also in a high flood hazard area. After determining the flood evacuation points, the next step is to identify evacuation routes to be used by the community during a flood disaster. The classification results show that Routes 1 and 2 are suitable for evacuation.

CONCLUSION

This study highlights the flood disaster risks faced by Long Pahangai I and Long Pahangai II Villages, which are primarily caused by high rainfall intensity and the close proximity of residential areas to the Mahakam River. The hazard analysis classified Long Pahangai I as a moderate-risk area and Long Pahangai II as a high-risk area, with substantial portions of land inundated during major floods. The vulnerability assessment, based on social, environmental, and physical factors, indicates that both villages fall into the moderate category, with rainfall intensity, settlement proximity to rivers, and steep slopes as the dominant contributing factors.

When combined, the hazard and vulnerability analysis reveals that the overall flood risk in both villages is moderate. Importantly, the absence of proper evacuation sites and routes has intensified the community's exposure to disasters. Through Geographic Information Systems (GIS) and Analytical Hierarchy Process (AHP) methods, this research successfully identified two feasible temporary evacuation points, one suitable final evacuation point, and three reliable evacuation routes to support community safety during floods.

These findings emphasize the urgent need for disaster preparedness and mitigation strategies tailored to the geographic and demographic characteristics of the region.

Strengthening flood risk management through proper land-use planning, designated shelters, and accessible evacuation routes will significantly reduce disaster impacts and enhance community resilience in Mahakam Ulu Regency.

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