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Landslides and other earth movements damage detection at Mountain Village: A case at Garawastu

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ABSTRACT

Many countries have abundant natural resource but, on the other hand, also have the potential to experience land damage, which can result in natural catastrophes including landslides, floods, earthquakes, and volcanic eruptions. Potential land damage can impact the destruction of public facilities and hamper development; socio-economic conditions will stop when land damage occurs. This research aims to find and analyze possible land damage caused by land movement in the Cipari Hamlet area, Garawastu Village. Compiling a map of potential soil damage is the main focus of research because it can help understand the spatial distribution and extent of damage. Apart from using qualitative methods, field observations were also conducted to determine the coordinates of residents' houses affected by land damage by ground movement. Primary information and secondary information are the two categories of data. Original data comprises damage coordinates, UTM GEOMaps software, location maps, ArcGIS software, and documentation. Secondary data consists of maps and data, rainfall data from 2013 to 2022, and explanations of the results from ArcGIS software. Cipari Hamlet, Garawastu Village, experienced high rainfall, 3500-4000 mm. The slope in Cipari Hamlet ranges from 0-140, which is very flat to steep hills. Risks with a low level of damage get 17 points, risks with a medium level of damage are 9 points, and risks with a high level of damage get 9 points. Damage in the Cipari hamlet did not occur due to landslides because the index value for the Cipari hamlet was at a moderate point.

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INTRODUCTION

Many countries have abundant natural resources but, on the other hand, also have the potential to experience land damage, which can result in natural disasters such as earthquakes, volcanic eruptions, floods, and landslides. Land subsidence is considered a threat to developing cities. It is triggered by several natural (geological and seismic) and human (mining, groundwater withdrawal, oil and gas extraction, construction) factors (Bokhari et al., 2023). Potential land damage can impact the destruction of public facilities and hamper development; socio-economic conditions will stop when land damage occurs. Soil damage can also cause soil erosion, making it prone to landslides in the area because damaged soil tends to be challenging to retain and filter rainwater. Deep Soil one method for strengthening and stabilizing such soil conditions is stabilization. In this instance, Asian nations with rapid development in recent decades, such as Malaysia (Jayasinghe et al., 2021).

Potential land damage can be caused by land shifting so that the surrounding land becomes damaged and unstable. Landslides are the most common and frequent hazards in the world's mountainous regions, directly or indirectly affecting the lives of native dwellers (Rehman et al., 2020).

A map is a visual or graphic representation of a specific area or surface of the earth designed to present geographic information in an easy-to-understand and systematic manner. Maps provide an easy-to-understand visual depiction of geographic phenomena' location, topography, and distribution. A map is a symbolized representation of geographic reality, representing selected features or characteristics resulting from the creative

(Lapaine et al., 2021). Maps include carefully selected symbols, colors, and scales to represent geographic features properly. More than standard image scaling is required since it is oblivious to the image content and can typically be applied only uniformly (Avidan & Shamir, 2007). USA also pointed out that the definitions of map and cartography are an essential issue (Lapaine et al., 2021).

The primary purpose of maps is to provide an accurate and easy-to-understand visual representation of the earth's surface or a specific region. Maps have many benefits, such as helping to navigate and find locations, understand the topography and geographic features, and analyze and plan various geographic aspects, such as regional development, population distribution, and natural resources. The geographic extent of the road feature can be a point, a polygon, or a curve in geographic coordinates (Gao et al., 2020). In addition, maps are also an effective communication tool to help many people, including scientists, urban planners, and travelers, understand geographic complexity and dynamics at various levels.

Various categories fall under this type of map, designed to present geographic information with particular emphasis on certain aspects. First, physical maps show natural features such as mountains and administrative regions such as countries, provinces, or cities. Third, thematic maps focus on specific issues like population, climate, or economic distribution. Finally, a base map or reference map shows the spatial variations of data in different regions through patterns or colors. Maps become a very diverse and effective tool for presenting various geographic information when these types of maps are combined. The map representation created from input data directly, with the ability to combine different sensory inputs and use unlabeled data to improve over time (Brahmbhatt et al., 2018).

Expansive soils are generally characterized by a clay mineral of the smectite group (Gourley et al., 2020). Soil like this can cause problems in civil engineering work because its capacity to do large jobs can change volume with water content or suction changes. As a natural resource, habitat, environmental medium, and production factor including the generation of biomass that sustains life on Earth and in other living things soil (Suyarto et al., 2018). The current issue is the lack of data on the extent and degree of land damage, as well as its spatial distribution across different locations. Therefore, data on the state of the soil and its damage must first be studied and then depicted in terms of the potential for and status of soil damage in order to control soil damage.

The mechanical process of rainwater is a phenomenon of loss of nutrients and organic material from the root area, accumulation of salt in the root area, and pollution by various types of waste are some sources of soil damage. The soil gains weight when there is a large water content, allowing the groundmass can move or glide downwards (Sunarta et al., 2018). Apart from that, industrial, household, mining, inorganic, organic, and agricultural waste can damage the structure and quality of the soil, causing the soil to become infertile and polluted. Therefore, it is essential to understand the factors that cause soil degradation to preserve soil quality for agricultural and environmental sustainability.

The effects of soil damage can cause significant damage to infrastructure and infrastructure. While roadways and waterways are subject to severe damage and erosion, building foundations are susceptible to cracking or shifting. This can endanger the sustainability of infrastructure and the security of the people who rely on these facilities, the extinction of endangered animals that depend on the land as a food source, and the destruction of the habitat of the animals that live there. This can cause the extinction of animals in the environment and damage the surrounding ecosystem. The impact on the environment due to Soil damage can cause erosion, leading to landslides and land wastage, which results in pollution and soil contamination. Soil pollution also causes the loss of humus, which makes the soil toxic and pollutes groundwater. Landslides have a complex impact on land use or environmental conditions (Sunarta et al., 2018). Effects on Infrastructure Soil damage can cause damage and reduction in infrastructure such as roads, bridges, and industrial buildings.

The force of gravity acting on the slope, which has a sliding plane, causes the mass movement of the soil or rock that makes up the slope (Arisanty et al., 2022). Land movement is a shift in the position or location of soil material due to human intervention or nature. The various forms of this phenomenon include landslides, lava flows, and soil erosion. Earthquakes, soil surface displacement, soil surface reduction, and subsidence will result from this soil movement (Haris et al., 2019). Natural factors such as excessive rain, earthquakes, or water-saturated soil can cause unwanted ground movement.

Meanwhile, human activities such as deforestation, land use changes, and construction can also cause unwanted land movement. The impact of human activity on landslide events is also correlated with the land use component (Dhianaufal et al., 2018). Understanding ground movement in geology and environmental science is critical to identifying risks, creating mitigation methods, and ensuring societal and environmental sustainability. Therefore, ground movement analysis involves monitoring, modeling, and preventive measures that concentrate on maintaining land stability and protecting people and the environment from the negative consequences of ground movement.

Land movement can significantly impact various aspects, including environmental, social, and economic. Firstly, from an environmental perspective, land movements such as landslides and erosion can

cause fertile soil layers to be lost, damage natural habitats, and threaten the sustainability of ecosystems. Second, from a social perspective, land movements such as landslides and erosion can cause loss of residence and property and even risks to human safety and health. Third, land use changes due to land movement can also impact economic growth and survival. The vibrational processes that occur during cyclic loads in highly compressible dispersed soils are accompanied by a redistribution of ground particles (Lazorenko et al., 2019). Land movement is a big problem in Indonesia covering many areas, including Majalengka, West Java. Land movement can be caused by many things in Indonesia, such as high rainfall, complicated topography, and irregular human activities. Specifically, the problem of land movement in Majalengka requires special attention. Environmental impacts, such as loss of fertile soil, erosion, and degradation of natural habitats, can significantly challenge the sustainability of local ecosystems. Land movement in Majalengka can a social impact by causing loss of residence, loss of property, and increased risk to the safety and health of local communities. One soil improvement method is to reduce the weight of the embankment construction using lightweight materials (Syahril et al., 2019).

Land movement can cause adverse infrastructure phenomena that pose sustainability and safety issues. Shallow, fast-moving landslides triggered by rainfall cause significant damage to infrastructure and affect many lives worldwide (Askarinejad et al., 2018). First, building foundations can experience damage or shift due to changes in soil structure caused by rain, which can threaten the structural integrity and safety of the building. Second, highways are vulnerable to cracking and deformation due to ground movement, threatening transportation networks and mobility. The third symptom is damage to underground water lines or pipes due to shifting soil, which increases the risk of leaks. Finally, signs of ground movement, such as cracks or damage to commercial and industrial structures, can harm the economy and threaten the safety of employees and visitors. In these situations, ongoing mitigation and monitoring are critical to protect infrastructure from the impacts of ground movement.

The abundance of land masses in Kalimantan, Indonesia, are predominantly swamps, with soil types ranging from soft clay to peat (Rusdiansyah et al., 2021). Indonesia is one of the countries whose land has the potential to experience damage due to land shifts. One of the impacts of land shifts in Indonesia is the occurrence of landslides, earthquakes, and volcanic eruptions. Control of land use change is significant because the area of land in an area is permanent. In contrast, the need for land becomes increasingly high as a result of the development and progress of a region (Hermon, 2019).

According to available information, several areas in West Java are areas that have a hilly and mountainous morphology dominated by slopes ranging from slightly steep to steep, so they have the potential for ground movement based on the Map of Land Movement Vulnerability Zones by PVMBG (*Pusat Vulkanologi dan Mitigasi Bencana Bencana Geologi*, Volcanology and Geological Hazard Mitigation Center). West Java Province is an area with seven active volcanoes, one of which is Mount Ciremai. In addition to structural damage, landslides were frequent in the mountainous area (Rawat et al., 2022). The area below the foot of Mount Ciremai has the potential to experience ground movement, which can result in landslides. A landslide is a geological disaster often occurring in West Java, especially during high rainfall (Hermawan et al., 2023). Conducting a field investigation to identify deep cracks in the soil slope and their characteristics is essential (Suryo et al., 2012).

This creates varied geological conditions in each area (Hidayat et al., 2020). In Cipari Hamlet, located at the foot of Mount Ciremai, land shifting is one of the causes of damage, including damage to residential areas, commercial areas, and facilities. Education, and other infrastructure. Land shifts or unstable soil can result in decreased soil fertility, landslides, erosion, floods, and drought. Thus, generally speaking, this condition has the potential for a high level of vulnerability to landslides. Rockfalls and landslides have increased in frequency, which has had unfavorable effects and made people fearful and anxious (Tan et al., 2023). At several points, there were cracks along the shoulder of the road, in the buildings, and in the rice fields sloping due to ground movement.

This research aims to find and analyze possible land damage caused by land movement in the Cipari Hamlet area, Garawastu Village. Compiling maps of potential soil damage is the main focus of research because it can help us understand the spatial distribution and extent of damage. In addition, this research aims to provide relevant information to interested parties, including local governments, as they create disaster mitigation plans. Lastly, this paper aims to add to the scientific literature on the problem of land movement and potential land damage at the local level. The hope is to provide a basis for further research and practical steps to manage disaster risk. So, the HMS-UNMA Research department researched "Map of Potential Land Damage Due to Land Movement in the Cipari Hamlet Area, Garawastu Village."

METHOD

The type of research used this time is qualitative research. Qualitative research is research that usually uses analysis and is descriptive. In qualitative research, data are used to decide which way interpretation should move forward, using data to generate hypotheses and new research questions (L. Haven & Van Grootel, 2019).

The tools and materials used in this research are:

1) Research Tools: The equipment used in this research is:
   a) Hardware: Laptop ASUS (Intel(R) Celeron(R) N4020 CPU @ 1.10GHz 1.10 GHz RAM 8,00 GB OS Windows 11 64-bit)
   b) Smartphone
2) Software: ArcGIS 10.8, Microsoft Office Word 2021, Microsoft Office Excel 2021, and Mobile Topographer

For research data, there are 2, namely primary and secondary data. Primary data includes 2023 Rainfall Data, Slope Map Data, and Land Cover Map Data. Secondary data consists of a Soil Type Map, Road Network Map, Baribis Fault Existence Map, and disaster data for 2023.

The location of this research is in Cipari Hamlet, Garawastu Village, Sindang District, Majalengka Regency, which is in a remote village towards Rajagaluh from the direction of Maja.



Figure 1. Research Location

The data obtained is primary and secondary data, for the primary data itself, namely the coordinates of high-risk areas, UTM GPS software to determine the coordinates, map of the research location. The secondary data are reference maps from the Regional Disaster Management Agency (BPBD), such as Slope Maps, Land Cover Maps, and Rainfall Maps. Rainfall that will be obtained in 2023 is 3500-4000 mm.

RESULTS AND DISCUSSION

Garawastu Village is at the coordinates lat long 6° 51' 5.76" S 108° 19' 46.91" E. With an altitude of 515.0 m above sea level. Geographically, Garawastu Village is in the Sindang sub-district, bordering the Maja sub-district. The administrative boundaries of Garawastu Village are north of Sindang Village, south of Mekarwangi Village and Cikarcak Village, west of Pasirayu and Heubeulisuk Villages, east of Sangkanhurip Village. The map data obtained from BPBD was then processed as research results.

Based on data from the map above, the rainfall in Garawastu Village was 3500-4000 mm. In contrast, rainfall in Garawastu Village is very high as one of the parameters for determining landslide-prone areas. Rainfall factors, rain intensity, and rainfall distribution will determine the likelihood of landslides occurring in the area. For more details, see Figure 2.

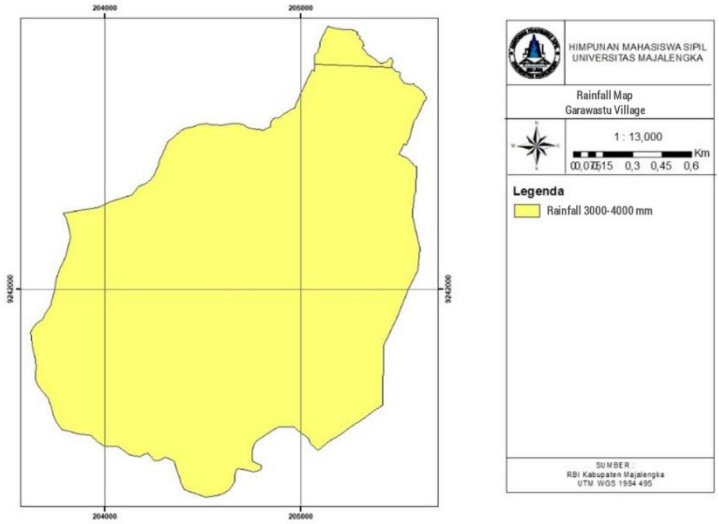


Figure 2. Rainfall Map
Source: ArcGis V.1.8

Geologically, the research location in Cipari Hamlet, Garawastu Village, has a clay rock structure and lapilli tuff rock. In general, the technical properties of rocks are influenced by structure and texture, mineral content, and weather conditions. For more details, the types of rocks in Garawastu Village can be seen in Figure 3.

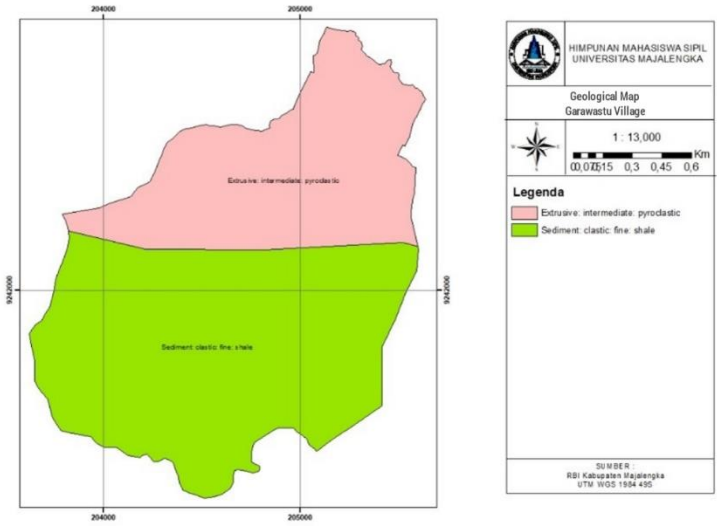


Figure 3. Geological Map
Source: ArcGis V.1.8

The land use map in Grawastu Village is closely related to the economic conditions and type of community living in Garawastu Village. Based on the research results, five types of land use were obtained in Figure 4. Land use has different contributions depending on the nature and conditions of the land use, such as settlements, plantations, rainfed rice fields, shrubs, and rivers. Land use is an influential factor in determining regional vulnerability.

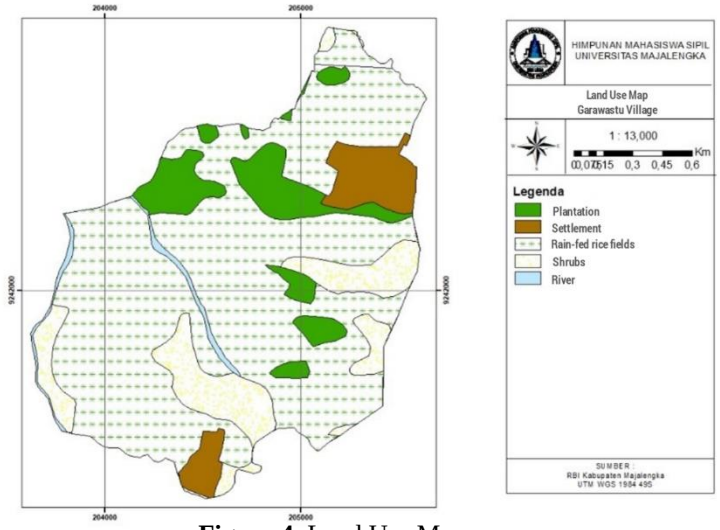


Figure 4. Land Use Map
Source: ArcGis V.1.8

The slope of the land in Garawastu Village varies from flat to steep. Based on the research results in Figure 5, there are 7 results, namely 0-2 very flat, 2-7 gentle slopes, 7-15 gentle hills, 15-30 steep slopes, 30-70 very steep slopes, 70-140 steep hills, 140-160 the hills are very steep. This is an essential factor in physical geography, geology, and civil engineering because the slope can affect soil stability and the risk of landslides.

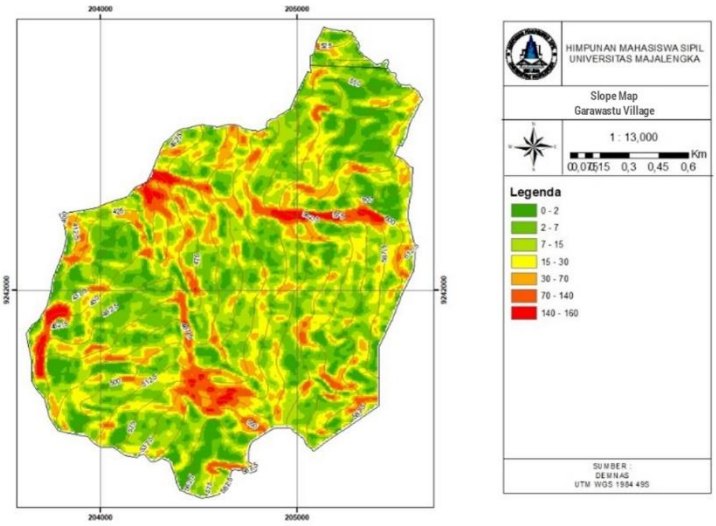


Figure 5. Slope Map
Source: ArcGis V.1.8

Based on the calculation results, it is known that LSI has a minimum value of 0.125 and a maximum value of 2.375. LSI represents the relative susceptibility of landslide events. Therefore, the higher the index, the more vulnerable the area is to landslides. This LSI value is divided into four classes based on the research results, divided into four zones, namely low, medium, high, and very high, as in Figure 6.

Based on the map, Cipari hamlet has a moderate risk of landslides, so the potential for infrastructure damage is not caused by vulnerability to landslides.

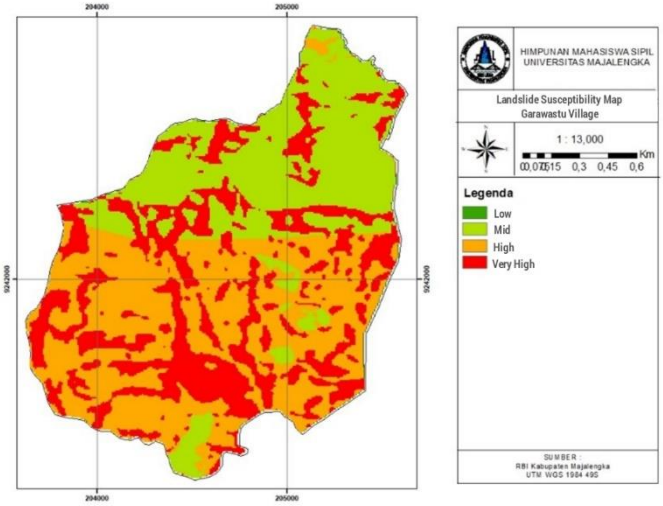


Figure 6. Landslide Susceptibility Map
Source: ArcGis V.1.8

From the research on coordinate points for infrastructure damage, three coordinate points were found in Cipari Hamlet, Garawastu Village: coordinate points with low-risk, medium-risk, and high-risk damage levels. Risks with a low level of damage get 17 points, risks with a medium level of damage are 9 points, and risks with a high level of damage get 9 points. More details are in Figure 7 and Table 1.

Table 1. Garawastu Village Damage Coordinate Point

No	Name	COORDINATES			
		LAT LONG		DECIMAL DEGREES	
		Y	X	XDD	YDD
1	Home Damage 2	6° 51' 24.91" S	108° 19' 37.66" E	108.3271278	-6.856919444
2	Home Damage 3	6° 51' 25.44" S	108° 19' 36.94" E	108.3269278	-6.857066667
3	Home Damage 4	6° 51' 27.67" S	108° 19' 35.42" E	108.3265056	-6.857686111
4	Home Damage 5	6° 51' 27.48" S	108° 19' 35.19" E	108.3264417	-6.857633333
5	Home Damage 6	6° 51' 27.94" S	108° 19' 35.27" E	108.3264639	-6.857761111
6	Home Damage 7	6° 51' 28.25" S	108° 19' 36.08" E	108.3266889	-6.857847222
7	Home Damage 8	6° 51' 28.28" S	108° 19' 34.42" E	108.3262278	-6.857855556
8	Home Damage 9	6° 51' 28.42" S	108° 19' 34.12" E	108.3261444	-6.857894444
9	Home Damage 10	6° 51' 28.78" S	108° 19' 33.66" E	108.3260167	-6.857994444
10	Home Damage 11	6° 51' 29.19" S	108° 19' 31.85" E	108.3255139	-6.858108333
11	Home Damage 12	6° 51' 28.29" S	108° 19' 30.36" E	108.3251	-6.857858333
12	Home Damage 13	6° 51' 27.41" S	108° 19' 29.96" E	108.3249889	-6.857613889
13	Home Damage 14	6° 51' 29.95" S	108° 19' 31.29" E	108.3253583	-6.858319444
14	Home Damage 15	6° 51' 30.34" S	108° 19' 31.89" E	108.325525	-6.858427778
15	Home Damage 16	6° 51' 31.55" S	108° 19' 32.61" E	108.325725	-6.858763889
16	Home Damage 17	6° 51' 31.88" S	108° 19' 32.86" E	108.3257944	-6.858855556
17	Home Damage 18	6° 51' 31.55" S	108° 19' 31.5" E	108.3254167	-6.858763889

No	Name	COORDINATES			
		LAT LONG		DECIMAL DEGREES	
		Y	X	XDD	YDD
1	Road Damage A	6° 51' 23.13" S	108° 19' 37.56" E	108,3271	-6,856425
2	Road Damage A1	6° 51' 23.18" S	108° 19' 37.28" E	108,3270222	-6,856438889
3	Road Damage A2	6° 51' 23.22" S	108° 19 ' 37.13" E	108,3269806	-6,85645
4	Road Damage A3	6° 51' 23.58" S	108° 19' 36.74" E	108,3268722	-6,85655
5	Road Damage A4	6° 51' 24.0" S	108° 19' 36.55" E	108,3268194	-6,856666667
6	Road Damage A5	6° 51' 24.71" S	108° 19' 36.42" E	108,3267833	-6,856863889
7	Road Damage and Home A6	6° 51' 24.86" S	108° 19' 36.49" E	108,3268028	-6,856905556
8	Road Damag A7	6° 51' 25.68" S	108° 19' 36.33" E	108,3267583	-6,857133333
9	Road Damage and Field A8	6° 51' 26.16" S	108° 19' 35.91" E	108,3266417	-6,857266667

No	Name	COORDINATES			
		LAT LONG		DECIMAL DEGREES	
		Y	X	XDD	YDD
1	School Damage	6° 51' 23.91" S	108° 19' 37.84" E	108,3271	-6,856425
2	Risk Damage	6° 51' 32.29" S	108° 19' 33.0" E	108,3270222	-6,856438889
3	Home Damage Risks 1	6° 51' 32.87" S	108° 19' 33.84" E	108,3269806	-6,85645
4	Cracked Wall House Damage	6° 51' 32.38" S	108° 19' 34.88" E	108,3268722	-6,85655
5	Risk Road Damage	6° 51' 32.32" S	108° 19' 34.83" E	108,3268194	-6,856666667
6	Home Damage Risk 2	6° 51' 31.86" S	108° 19' 36.52" E	108,3267833	-6,856863889
7	High Risk Home Damage 1	6° 51' 32.98" S	108° 19' 35.58" E	108,3268028	-6,856905556
8	High Risk Home Damage 2	6° 51' 33.48" S	108° 19' 35.56" E	108,3267583	-6,857133333
9	High Risk Road Damage	6° 51' 32.98" S	108° 19' 35.58" E	108,3266417	-6,857266667

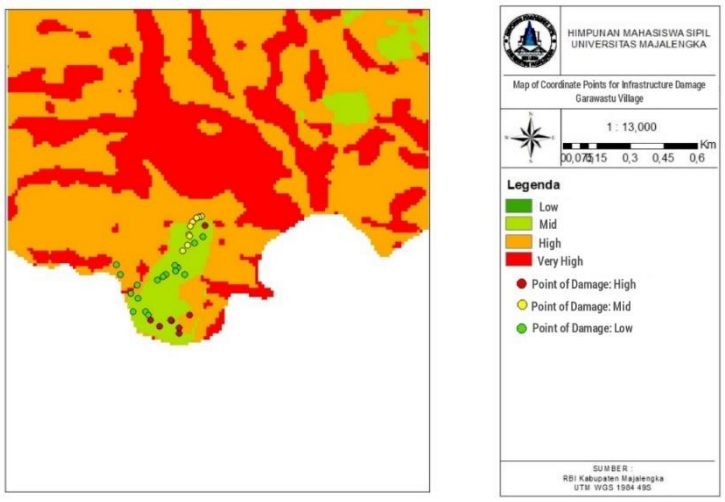


Figure 7. Map of Infrastructure Damage Points
Source: ArcGis V.1.8

The results of a survey in Cipari hamlet in Garawastu Village show that there are 3 levels of risk of damage, including low-level risk of damage, medium-level risk of damage, and high-level risk of damage. In determining the level of risk of damage, look at how the damage ranges from minor damage to severe damage.

For a low-risk level of damage, there are 17 points, as in the table above, dominated by the residents' houses. The level of risk of damage is relatively low because the location is not much affected by land shifts. Low risk of damage.

The level of risk of moderate damage is 7 points; the level of risk of moderate damage is in locations that are heavily impacted by land shifts. The level of risk of moderate damage is also quite risky for residents. For a moderate level of damage risk, one is at the volleyball court and road in Cipari Hamlet, Garawastu Village.

There are 7 high-risk levels of damage: schools, houses, and roads. A high risk of damage is indicated by severe damage to the building, up to structural damage.

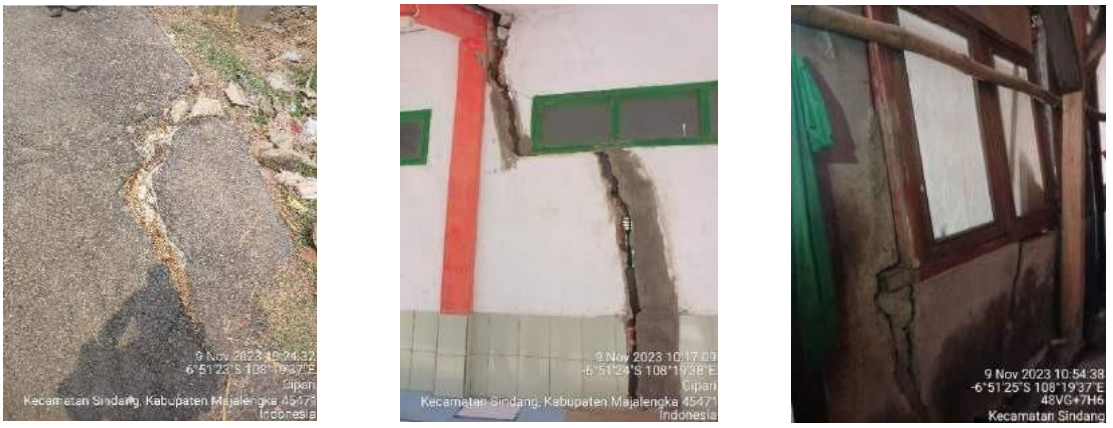


Figure 8. Real Location Damage

CONCLUSION

From the research results, it can be concluded that in Cipari Hamlet, Garawastu Village experienced high rainfall, namely 3500-4000 mm. The slope in Cipari Hamlet ranges from 0-140, which is very flat to steep hills. Risks with a low level of damage get 17 points, risks with a medium level of damage are 9 points, and risks with a high level of damage get 9 points. Damage in the Cipari hamlet did not occur due to landslides because the index value for the Cipari hamlet was at a moderate point.

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