Calamity
Calamity: a Journal of Disaster Technology and Engineering
CALAMITY 1(1): 18-32
ISSN 3025-4140

Research

Landslide disaster risk analysis in Pacet District, Mojokerto Regency, East Java

Widiastutik Chusnaini [1,*], Permatasari Devi I [2], Masniarahma Afdilla [3], Firdiyansah Aldy [4] and Nashrullah M Iqbal [5]

[1] Department of Civil Engineering; Institut Teknologi Adhi Tama Surabaya
[2] Department of Civil Engineering; Institut Teknologi Adhi Tama Surabaya; deviindaaah212@gmail.com
[3] Department of Civil Engineering; Institut Teknologi Adhi Tama Surabaya; afdillam@gmail.com
[4] Department of Civil Engineering; Institut Teknologi Adhi Tama Surabaya; aldyfirr21@gmail.com
[5] Department of Civil Engineering; Institut Teknologi Adhi Tama Surabaya; iqbalawen1927@gmail.com
* Correspondence : neniwidi0707@gmail.com

Received Date: 28 May 2023 Revised Date: 20 June 2023 Accepted Date: 23 June 2023

Cite This Article:
Chandra, H., Zulkarnain, R., Fazal, M. R. (2023). Landslide disaster risk analysis in Pacet District, Mojokerto Regency, East Java. *Calamity: a Journal of Disaster Technology and Engineering. 1*(1), 18-32. https://doi.org/10.61511/calamity.v1i1.2023.113

Abstract
Pacet District, Mojokerto Regency, East Java is one of the areas prone to landslides. Landslides in the area that occur can threaten lives and cause environmental damage and financial losses. This study aims to analyze the risk of landslides in Pacet District, Mojokerto Regency, East Java and apply Early Warning System (EWS) technology based on the Internet of Things (IoT). This type of research is both qualitative and quantitative, the results of the study are based on the level of threat of landslides. Designing a landslide early warning tool is not easy to do because it has to be adapted to local situations and conditions. This program will be directed at technology transfer by implementing an Internet of Things (IoT)-based Early Warning System (EWS).
Keywords: early warning system (EWS); landslide; mitigation

1. Introduction

Landslides are categorized as one of the causes of natural disasters, in addition to earthquakes, floods, hurricanes and others. The danger of landslides has a major impact on human survival and always threatens human safety. In addition, it is also due to the high level of population density in hilly areas, which creates pressure on the ecosystem. Other factors that cause a relatively high vulnerability to landslides in the East Java region are relatively low environmental awareness, as well as poor land and space utilization (Supriyadi, et al., 2020).

In Indonesia, the occurrence of landslides has resulted in great losses, for example loss of human lives, damage to property, and disruption of natural ecosystems. East Java Province is one of the areas that has the potential for landslides to occur. This is due to the topography of most of the area which is hilly and mountainous. From Bakomas Disaster Management data, from 1998 to 2003, more than 647 disaster events were recorded in Indonesia, of which 85% of these disasters were floods and landslides (Naryanto and

Marwanta 2007). According to the National Disaster Management Agency, in 2021-2023, 1,321 landslides were recorded in East Java. From this description it can be seen that landslides are a very threatening natural disaster and it is important to pay attention after floods, because the frequency of occurrence and the number of fatalities caused is quite significant, namely 5-10 fatalities.

Preventing landslide hazards is less expensive than repairing or rebuilding damaged buildings and infrastructure (Adiyoso, 2018). The efforts to prevent disasters are called mitigation, which is defined as actions taken to reduce the impact of a disaster (natural or man-made) on a nation or community, so that people feel safe and carry out activities in their place. While the risk due to landslide hazard is the value of loss due to landslide hazard which involves the misuse of land and infrastructure (Carter, 1991; Priyono & Priyana, 2006). According to Davis & Yasemin (1992), risk is defined as loss of life, damage and destruction of economic activity by certain natural phenomena resulting from the elements of risk and hazard of landslide vulnerability.

The aim of the research is to determine the level of risk and to analyze mitigation efforts for landslide-prone areas in the Pacet District, Mojokerto Regency and to reduce the impact it has to utilize the EWS (early warning system). The benefits in this study are to control property development and land spatial planning in accordance with the carrying capacity of the surrounding environment, to avoid greater risks in the event of a landslide to inform local residents if a potential landslide disaster will occur.

This research gap to previous research (Taufik. M, 2016) on the identification of landslide-prone areas using GIS (Geographic Information System) and refers to research (Zakaria, 2010) on mapping landslide-prone areas with remote sensing and geographic information systems. (Gatot,S. 2011) Soil Testing in the laboratory, Explanations & Guides, Yogyakarta; Graha Ilmu Publish. (Grandis and Gaffar, 2010) Direct Current Resistivity Method: Concept and Application in Sounding, Mapping, and Tomography.

2. Methods

1. Location

The location of this study is in Pacet District, Mojokerto Regency, East Java. The choice of this location is based on the history of landslide disasters in the area throughout 2023 there have been 10 landslides. The vulnerable areas are located in the forestry area, Claket Village and Cepokolimo Village.

2. Data Collection Methods

The data collection method was a reference review/secondary data related to landslides in Pacet Sub-district, Mojokerto District, East Java. Secondary data includes previous research studies on landslide disasters, including area and location, time, records of relevant agencies, population stories, geology, geomorphology, geological structure, environmental geology, technical geology, aerial photographs of rainfall, watersheds and sub-watersheds, water, socio-economic, spatial planning / RTRW, land use, population and others environmental geology, technical geology, aerial photographs, geological structure maps, soil type maps, landsystem maps, Mojokerto District in Figures and others.

3. Method Of Data Analysis

The application of Geographic Information System (GIS) technology is utilized as a support in the research, as an information system used to input, store, recall, process, analyze and produce geo-referenced data or geospatial data, to support in landslide disaster risk analysis. In this research, data processing involves a series of processes to obtain parameters that cause landslides. Data in the form of soil type, geology and land cover maps in shapefile form are processed by clipping the study area (Rahmad, et. Al, 2018).

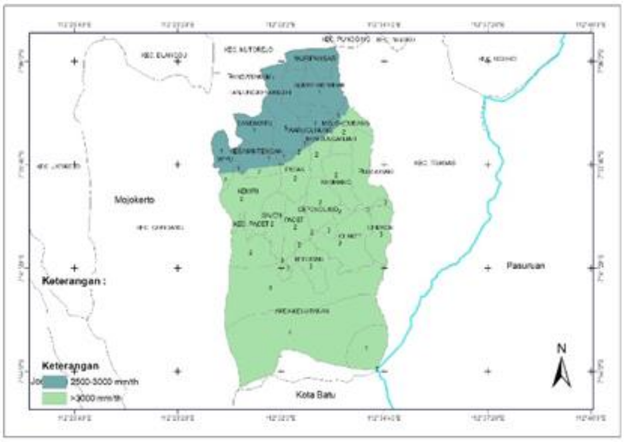

Figure 0. Location Map Area
(Source: Research Results of Data Processing. 2023)

Rainfall processing is done using IDW Interpolation on ArcMap and data obtained from Climate Hazard Group Infrared Precipitation with Station data (CHIRPS) in the form of raster files. CHIRPS is a global rainfall database that combines rainfall observations from satellites with rainfall data measured on land to provide high-level rainfall estimates. The slope data was taken from the Indonesia Geospatial website in the DEM-NAS section, the DEM data was extracted into contours and slopes. DEM slope is classified into 5 classes which can be done by reclassify. The slope of the DEM extraction data is in the form of raster because it must be converted into shapefile data by converting in the arc toolbox then selecting the convert raster to polygon section.

After obtaining the landslide parameters, scoring of each class and weighting is done. Then overlay is done to export the map that has been made. The assessment of landslide prone potential in the area is based on the total score in each area. The determination of landslide prone area in the research area is based on the model of landslide prone area estimation by the Directorate of Volcanology and Geological Hazard Mitigation (2005):

Cumulatice Scores =

(30% x rainfall factor) + (20% x geology factor) + (20% x land use factor) + (15% x slope factor)

After obtaining the cumulative score, it is necessary to group the vulnerable classes by :

$$\frac{Highest\ Score - Lowest\ Score}{Number\ of\ classifications} \quad (1)$$

Table 1. Landslide Weighting Parameters

Parameter	Magnitude	Score	Percentage
	<8%	1	
	8-15%	2	
Slope	15-25%	3	15%
	25-45%	4	
	>45%	5	
	<1000	1	
Rainfall	1000-2000	2	
	2000-2500	3	30%
(mm/year)	2500-3000	4	
	>3000	5	
	Aluvial	1	
	Volcanic-1	2	

Geology	Sediment-1	3	20%
	Volcanic-2	4	
	Insensitive	1	
	Kinda Sensitive	2	
Type of Soil	Less Sensitive	3	20%
	Sensitive	4	
	Very Sensitive	5	
	Forest / vegetation and bodies of water	1	
	Bushes	2	
Land cover	Plantation and irrigated rice fields	3	15%
	Industrial and residential area	4	
	Empty land	5	

Based on research, disaster events and regional topographic conditions, Pacet Sub-district, Mojokerto Regency, East Java has a high potential for natural disaster vulnerability so that disaster risk reduction mitigation activities are always needed to adapt the community to signs of disaster. The application of Early Warning System (EWS) technology based on the Internet of Things is an effort to transfer technology to the community with the hope that the EWS tool can help provide early warning of disasters.

3. Results and Discussion

The section contains both results and discussion of the research.

1) Rainfall

Rainfall data obtained in the form of monthly rainfall maps for 1 year (May 2022 to April 2023) obtained an average rainfall of 3,416 mm / year with high rainfall areas in the Forestry Area. The rainfall distribution map is presented in Figure 1 below.

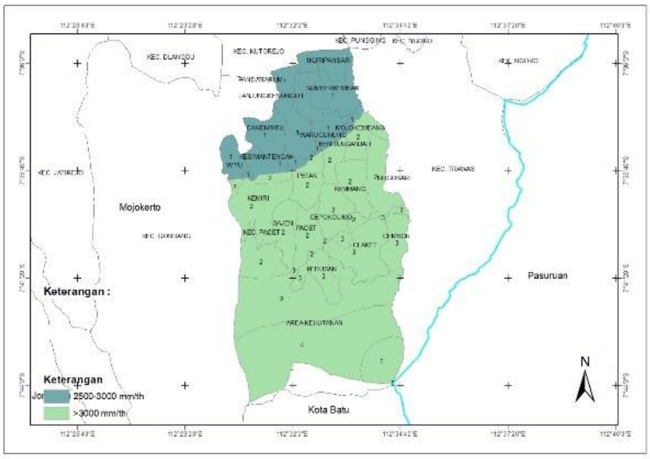

Figure 1. Rainfall Distribution Area
(Source: Research Results of Data Processing. 2023)

In figure 1 The rainfall distribution map is divided into 2 scoring parameters for floods and landslides, namely based on rainfall data 2500-3000 mm/year and >3000 mm/year. From the above research, it is known that the southern area has the highest rainfall which exceeds 3000 mm/year.

The following is the result of rainfall in 2022 which is divided into 5 polygons

Table 2. Rainfall Area of Pacet Sub-district

No.	Rainfall (mm/year)	Area (Ha)	Percentage (%)
1	2800	174547,92	38,87%
2	3200	201618,72	44,90%
3	3600	69369,44	15,45%
4	4000	2625,99	0,58%
5	4400	886,06	0,20%
Total :		449048,13	100,00%

(Source: Research Results of Data Processing. 2023)

From table 2, it can be seen that the area of 201618.72 Ha has a rainfall of 3200 mm/year with a rainfall percentage of 40.88%. This makes it very prone to landslides because it has high rainfall.

2) Land Use

The land use function map is obtained from the Indonesia Geospatial SHP Map shown in the figure below Pacet District is used for several land functions as a means of supporting the community's economy which is presented in Figure 2. Land Use Function Map

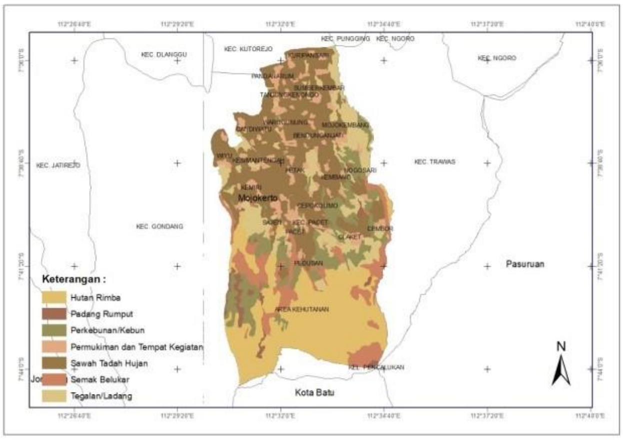

Figure 2. Land Use Function Map
(Source: Research Results of Data Processing. 2023)

In the picture above, it can be seen that the northern area of land use is dominated by rain-fed rice fields, while the southern area is dominated by jungle.

3) Slope Inclination

Pacet sub-district has a variety of slopes classified into 5 classes with <8% Flat, 8%-15% Sloping, 15%-25% Sloping, 25%-40% Steep, and >40% Very Steep. The slope map of Pacet sub-district is presented in Figure 3.

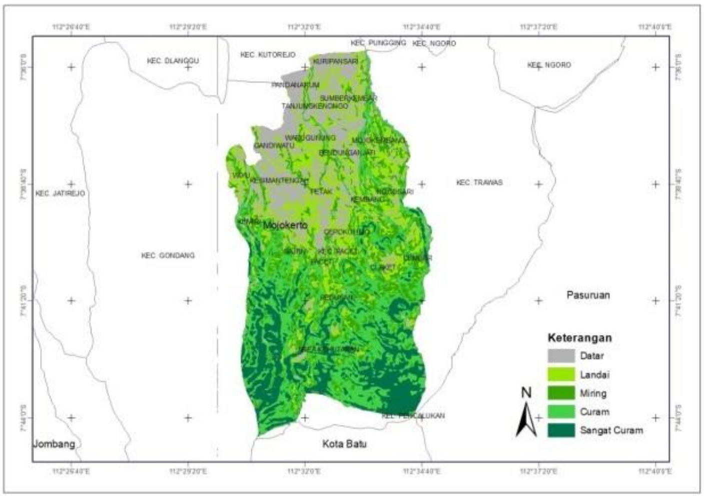

Figure 3. Slope Map
(Source: Research Results of Data Processing. 2023)

In Figure 3 it can be seen that the slope of Pacet sub-district in the village. Kuripansari with a flat slope, Village. Wiyu with a gentle slope, Village. Cepoklimo with a sloping slope, and Village. Claket with a steep slope, and the Forestry Area with a very steep slope.

4) Soil Type

From the data obtained from Indonesia Geospatial, the soil types of Pacet District are classified into Eutric Regosols, Molic Andosols, and Vertic Luvisols. The figure below shows that the soil types in Pacet Sub-district to the north are very sensitive with Eutric Regosol soils, and to the south the level of soil sensitivity to erosion is classified as sensitive.

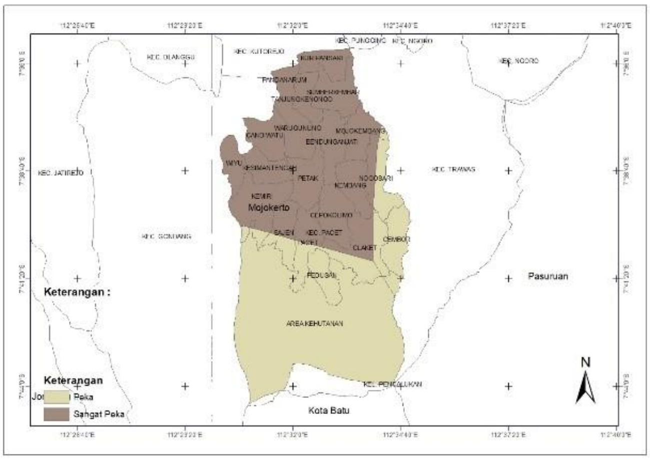

Figure 4. Soil type map
(Source: Research Results of Data Processing. 2023)

5) Geology

Geological factors that cause landslides are determined by the structure and composition of rocks that affect the sensitivity to erosion and landslides. The type of rock present in an area has different levels of hazard. Rocks with fine grains tend to be more at risk of ground motion, while denser and sturdier rocks have a lower probability of being affected by ground motion.

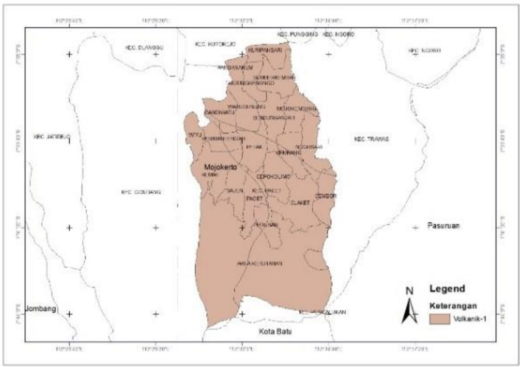

Figure 5. Geology map
(Source: Research Results of Data Processing. 2023)

It can be seen in Figure 5 above, the type of rock or geology in the Pacet Sub-district area consists of one type, namely Volcanic Material-1.

6) Landslide Prone Areas

The provision of landslide prone areas is based on the results of the cumulative score obtained from the entire calculation. Classification of landslide prone areas can be divided into 3 classes: less prone, prone, and very prone.

Table 3. Attribute Table of Landslide Vulnerability in ArcMaps

Table
Rawan_Longsor_Pacet

FID	Shape *	FID_longso	Total_Lere	Total_Geo	Total_PL	Total_Tnh	Total_CH	Nilai_Tota	Kelas_Lgsr	FID_Batas_	FID_Pro_Mj	NAMOBJ	SHAPE_Area	SHAPE_Ar_1	Luas_Ha_1
0	Polygon ZM	12	0.15	0.4	0.15	0.2	1.2	2.1	Kurang Rawan	15	69	TANJUNGKENONG	0.000165	0.000268	1.02
1	Polygon ZM	12	0.15	0.4	0.15	0.2	1.2	2.1	Kurang Rawan	16	75	PANDANARUM	0.000101	0.000268	0.21
2	Polygon ZM	13	0.15	0.4	0.15	0.2	1.5	2.4	Rawan	2	3	KEMIRI	0.000424	0.000268	0.04
3	Polygon ZM	13	0.15	0.4	0.15	0.2	1.5	2.4	Rawan	10	14	AREA KEHUTANAN	0.00305	0.000268	0.77
4	Polygon ZM	13	0.15	0.4	0.15	0.2	1.5	2.4	Rawan	11	18	SAJEN	0.000235	0.000268	0.24
5	Polygon ZM	15	0.15	0.4	0.15	0.4	1.5	2.6	Rawan	4	6	CEMBOR	0.000232	0.000268	3.93
6	Polygon ZM	15	0.15	0.4	0.15	0.4	1.5	2.6	Rawan	10	14	AREA KEHUTANAN	0.00305	0.000268	24.38
7	Polygon ZM	20	0.15	0.4	0.3	0.2	1.5	2.55	Rawan	11	18	SAJEN	0.000235	0.000268	0.5
8	Polygon ZM	23	0.15	0.4	0.3	0.4	1.5	2.75	Rawan	0	1	NOGOSARI	0.000292	0.000268	0.3
9	Polygon ZM	23	0.15	0.4	0.3	0.4	1.5	2.75	Rawan	4	6	CEMBOR	0.000232	0.000268	0.03
10	Polygon ZM	23	0.15	0.4	0.3	0.4	1.5	2.75	Rawan	10	14	AREA KEHUTANAN	0.00305	0.000268	4.26
11	Polygon ZM	23	0.15	0.4	0.3	0.4	1.5	2.75	Rawan	11	18	SAJEN	0.000235	0.000268	0.18
12	Polygon ZM	23	0.15	0.4	0.3	0.4	1.5	2.75	Rawan	12	19	PACET	0.000268	0.000268	0.22
13	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	1	2	KESIMANTENGAH	0.000195	0.000268	2.19
14	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	2	3	KEMIRI	0.000424	0.000268	0
15	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	3	4	WIYU	0.000168	0.000268	1.67
16	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	6	9	PETAK	0.000272	0.000268	1.34
17	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	14	52	SUMBERKEMBAR	0.000285	0.000268	3.67
18	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	18	123	CANDIWATU	0.000244	0.000268	2.82
19	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	19	124	WARUGUNUNG	0.000259	0.000268	1.68
20	Polygon ZM	25	0.15	0.4	0.45	0.2	1.2	2.4	Rawan	21	126	MOJOKEMBANG	0.000233	0.000268	0.82
21	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	0	1	NOGOSARI	0.000292	0.000268	5.77
22	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	2	3	KEMIRI	0.000424	0.000268	0.56
23	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	3	4	WIYU	0.000168	0.000268	0
24	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	6	9	PETAK	0.000272	0.000268	0.33
25	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	7	10	KEMBANG	0.000232	0.000268	2.8
26	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	8	11	CLAKET	0.000465	0.000268	1.39
27	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	9	12	CEPOKOLIMO	0.000285	0.000268	4.11
28	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	11	18	SAJEN	0.000235	0.000268	0.59
29	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	12	19	PACET	0.000268	0.000268	1.83
30	Polygon ZM	26	0.15	0.4	0.45	0.2	1.5	2.7	Rawan	21	126	MOJOKEMBANG	0.000233	0.000268	1.51
31	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	0	1	NOGOSARI	0.000292	0.000268	7.6
32	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	4	6	CEMBOR	0.000232	0.000268	0.85
33	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	5	8	PEDUSAN	0.000174	0.000268	2.4
34	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	8	11	CLAKET	0.000465	0.000268	0.06
35	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	10	14	AREA KEHUTANAN	0.00305	0.000268	11
36	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	12	19	PACET	0.000268	0.000268	1.84
37	Polygon ZM	29	0.15	0.4	0.45	0.4	1.5	2.9	Rawan	21	126	MOJOKEMBANG	0.000233	0.000268	4.51
38	Polygon ZM	31	0.15	0.4	0.6	0.2	0.9	2.25	Kurang Rawan	13	32	KURIPANSARI	0.000201	0.000268	0.43
39	Polygon ZM	32	0.15	0.4	0.6	0.2	1.2	2.55	Rawan	1	2	KESIMANTENGAH	0.000195	0.000268	106.18
40	Polygon ZM	32	0.15	0.4	0.6	0.2	1.2	2.55	Rawan	2	3	KEMIRI	0.000424	0.000268	9.83
41	Polygon ZM	32	0.15	0.4	0.6	0.2	1.2	2.55	Rawan	3	4	WIYU	0.000168	0.000268	46.29
42	Polygon ZM	32	0.15	0.4	0.6	0.2	1.2	2.55	Rawan	6	9	PETAK	0.000272	0.000268	21.14
43	Polygon ZM	32	0.15	0.4	0.6	0.2	1.2	2.55	Rawan	13	32	KURIPANSARI	0.000201	0.000268	164.97
44	Polygon ZM	32	0.15	0.4	0.6	0.2	1.2	2.55	Rawan	14	52	SUMBERKEMBAR	0.000285	0.000268	153.14

0 (0 out of 1098 Selected)
Rawan_Longsor_Pacet

The cumulative score in the table above can be seen in the column Value_Tota, which then finds the lowest and highest values. The lowest score in the table is 2.1 and the highest score is 3.56. The calculation of landslide vulnerability class is as follows:

$$\frac{Highest\ Score - Lowest\ Score}{Number\ of\ classifications}$$

$$= \frac{3{,}56 - 2{,}1}{3} = 0{,}49$$

Table 4. Landslide Vulnerability Score

Landslide Vulnerability Class	Vulnerable Score
Less Vulnerable	2,10 – 2,59
Vulnerable	2,59 – 3,07
Very Vulnerable	3,07 – 3,56

(Source: Research Results of Data Processing. 2023)

Table 4 shows the vulnerability of landslides, which is then displayed in an overlay map as shown in Figure 6.

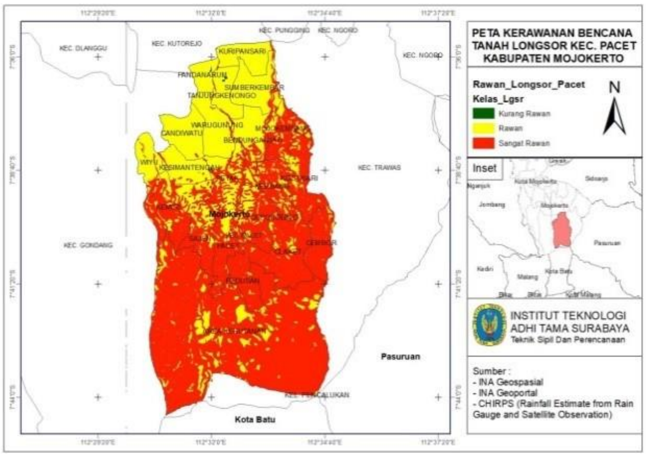

Figure 6. Landslide Disaster Vulnerability Map.
(Source: Research Results of Data Processing. 2023)

It is shown in Figure 6 that Pacet Sub-district is dominated by high landslide potential. The zoning distribution of landslide prone areas in Pacet Sub-district shows similar results to the rainfall map and soil type map. The area that is prone to landslides is the forestry area in the southern part of Pacet Sub-district.

Table 5. Landslide Prone Area

No.	Village	Area (Ha)	% Total	No.	Village	Area (Ha)	% Total
1	FOREST AREA	3350,48	**51,03%**	11	PEDUSAN	205,09	**3,12%**
2	CLAKET	527,47	**8,03%**	12	PETAK	161,35	**2,46%**
3	KEMIRI	360,21	**5,49%**	13	BENDUNGANJATI	103,57	**1,58%**
4	NOGOSARI	300,33	**4,57%**	14	SUMBERKEMBAR	37,1	**0,57%**
5	CEMBOR	272,78	**4,15%**	15	WIYU	31,87	**0,49%**
6	PACET	268,36	**4,09%**	16	KESIMANTENGAH	17,72	**0,27%**
7	CEPOKOLIMO	264,95	**4,04%**	17	WARUGUNUNG	8,94	**0,14%**
8	KEMBANG	222,74	**3,39%**	18	TANJUNGKENONGO	6,36	**0,10%**
9	SAJEN	211,66	**3,22%**	19	KURIPANSARI	3,87	**0,06%**
10	MOJOKEMBANG	208,85	**3,18%**	20	CANDIWATU	1,77	**0,03%**

(Source: Research Results of Data Processing. 2023)

The research results from the Landslide Disaster vulnerability data show that the Forestry Area is prone to landslides with a percentage of 51.03% in an area of 3,350.48 Ha. The data has a match with the landslide disaster vulnerability map which is a high landslide prone classification. The forestry area is quite likely to have landslides, one of the factors is the slope and high rainfall.

7) Early Warning System (EWS)

Wireless technology, Internet of things (IoT), Global System for Mobile (GSM), allows humans to collect data and perform control actions on a phenomenon remotely without having to be in direct contact with the object under study, this technology is very suitable if applied to manage potential disasters, both in the form of landslides, flash floods, volcanic eruptions and so on. Based on a survey that has been conducted at each potential disaster point in the partner village, the data obtained that at each potential disaster point can actually be reached by GSM communication mode, so we see this as its own potential for the application of Early Warning System (EWS) technology based on wireless sensor network and GSM technology in addition to early warning can also be used for flash flood disaster mitigation in partner villages. The outline of the implemented EWS system scheme can be seen in Figure 7.

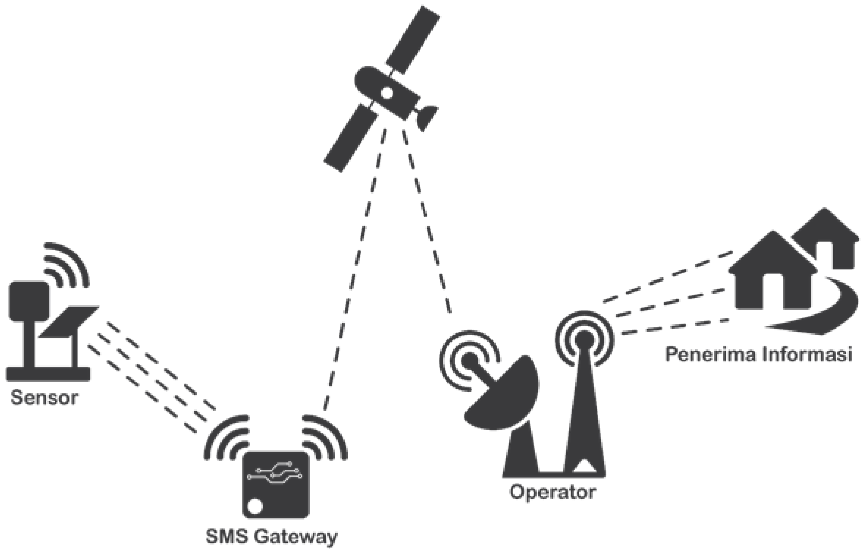

Figure 7. IoT Schematic of the EWS Tool

Wireless technology is needed to collect the latest data on the condition of each potential disaster point in the form of rain intensity data and the rate of soil movement, then the monitored data is sent using a short message service (SMS) to the village security officer for further village security will assess the potential disaster, if from the results of the study there are signs of a disaster, then the security can immediately inform all relevant parties through the radio communication network located at the local village office to evacuate residents quickly to the nearest evacuation point, so it is hoped that when the flood reaches the affected village all residents have been evacuated.

a. Socialization on reading the natural signs of landslides

The attitude of the community in dealing with natural disasters is very influential in minimizing losses, so the community is expected to be proactive and synergize with the village government in responding to existing disasters.

Community members have an important role in disaster management activities which are divided into 3 (three) main activities, namely pre-disaster, disaster activities, and post-disaster activities.

1. Pre-disaster activities include prevention, mitigation, preparedness, and early warning.
2. Activities during a disaster that include emergency response activities to alleviate temporary suffering, such as search and rescue (SAR) activities, emergency assistance, and evacuation.
3. Post-disaster activities that include recovery, rehabilitation and reconstruction activities.

b. Introduction of Early Warning System (EWS) tools

This simple Early Warning System (EWS) serves as an alarm when a landslide occurs around the neighborhood. The purpose of this tool is to provide early warning to the community, especially those who live or whose houses have steep slopes, about the dangers of landslides and anticipation efforts when there is a landslide disaster. Because it is still simple, this tool is only able to detect landslides with a small range such as landslides around people's homes. Because this tool is only able to detect one point for each tool, it is expected that every house that has a steep yard has at least one tool in each house.

This tool is made of several materials such as power jacks and terminals, boxes and lids, sockets for batteries, sirens, batteries, siren support poles, and finally cables. The working principle of this tool is also simple, namely if there is moving soil or landslides, it will pull a steel cable or rope that causes the power jack to be released which will then sound the siren that has been installed at the top of the tool box.

4. Conclusions

From the results of the discussion it can be concluded that Pacet Sub-district, Mojokerto District, East Java is an area with high potential for landslides formed by hills with steep slopes and high rainfall, so the potential for landslides is very large in this area. The combination of anthopogenic factors is often the cause of landslides.

Medium to high landslide potential in Pacet Sub-district, Mojokerto Regency, East Java is located in the forestry area. Landslide risk analysis was conducted qualitatively with the output being a landslide risk map. Data used to conduct the analysis are landslide hazard potential map and land use map (settlement, paddy field, forest area etc.) To reduce the risk of landslides in Pacet Sub-district, Mojokerto District, East Java, it is recommended to conduct a detailed and comprehensive landslide risk analysis, both qualitatively and quantitatively.

Early Warning System (EWS) is used to detect landslides around the area of Pacet Sub-district, Mojokerto Regency, East Java. This tool is classified as a simple tool both in its manufacture and use so it is hoped that the surrounding villagers can have/make the tool so that residents can get quick information when landslides occur around their homes.

Acknowledgement:

Thank you to reviewer and IASSSF team to support this article

Author Contribution:

W.C. (conceptualization, investigation, formal analysis, data curation, validation, and methodology), P.D. and N.M.I (conceptualization, formal analysis, project administration, and resources), M.A. (supervision, funding acquisition, conceptualization, methodology, and writing), F.A. and N.M.I. (conceptualization, review, editing, and validation). All authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding ncy names and the formal grant number.

Ethical Review Board Statement:

Not applicable

Informed Consent Statement:

Not applicable

Data Availability Statement:

Not applicable

Conflicts of Interest:

Authors declare that in this manuscript has no conflict of interest.

References

Adiyoso, W. (2018). Manajemen Bencana Pengantar & Isu-isu Strategis. Jakarta : Bumi Aksara

Adipradana, A. Y., Setyawan, H. T., & Sudarno, S. (2021). Penerapan Teknologi Early Warning System (EWS) Berbasis Internet of Things (IoT) di Desa Sambungrejo, Grabag, Magelang. Community Empowerment, 6(2), 208-215. https://doi.org/10.31603/ce.4281

Bakomas, (1993-2003). Data Bakomas Penanggulangan Bencana, sejak tahun 1998 hingga 2003
Carter, W. Nick. (1991). Disaster management : a disaster manager's handbook / W. Nick Carter. Manila Asian Development Bank (ADB).
Davis, I., and Yasemin, A. (1992). UNDRO/UNDP Disaster Management Training Programme simulation exercise : mitigation planning in the Indian sub-continent to reduce the risk of inland flooding. Geneva.
Direktorat Vulkanologi dan Mitigasi Bencana Geologi (2005). Manajemen Bencana Tanah Longsor.
Gatot, S. B. (2011). Soil testing in the laboratory, explanations & Guides. Graha Ilmu Publish, 123.
Grandis, H., SA, P., & Gaffar, E. Z. (2010). Pencitraan Resistivitas Bawah-Permukaan Daerah Sesar Cimandiri Berdasarkan Data Magnetotelurik: Hasil Pendahuluan. Jurnal Geofisika.
Hartono,. (2017). Teknologi Informasi Geografi Untuk Pembangunan Nasional dan Mitigasi Bencana di Era Global. http://dx.doi.org/10.31227/osf.io/jx8rp
Naryanto, H. S. (2011). Analisis risiko bencana tanah longsor di Kabupaten Karanganyar, Provinsi Jawa Tengah. Jurnal Dialog Penanggulangan Bencana, 2(1), 21-32.
Kemkes. (2016). Mitigasi Bencana Dengan Memanfaatkan SIG (System Information Geografis). Retrived January 1, 2019, from http://pusatkrisis.kemkes.go.id/mitigasi-bencana-dengan-memanfaatkan-sig-system-information-geografis
Naryanto, H. S. Wisyanto, dan Marwanta, B., (2007). Potensi Longsor dan Banjir Bandang Serta Analisis Kejadian Bencana 1 Januari 2006 di Pegunungan Argopuro, Kabupaten Jember. Jurnal Alami, 12(2), 54-65.
Priyono, K. D., & Priyana, Y. (2006). Analisis Tingkat Bahaya Longsor Tanah Di Kecamatan Banjarmangu Kabupaten Banjarnegara (Analysis Landslide Hazard in Banjarmangu Sub District, Banjarnegara District), 175-189. http://hdl.handle.net/11617/259
Rahmad, R., Suib, S., & Nurman, A. (2018). Aplikasi SIG Untuk Pemetaan Tingkat Ancaman Longsor Di Kecamatan Sibolangit, Kabupaten Deli Serdang, Sumatera Utara. Majalah Geografi Indonesia, 32(1), 1-13. https://doi.org/10.22146/mgi.31882
Soepraptohardjo, M. (1961). *Jenis-jenis Tanah di Indonesia*. Lembaga Penelitian Tanah. Bogor.
Supriyadi, S., Hidayatullah, R. H., Aji, M. P., Fitrianto, T. N., & Kusumawardani, R. (2020). [RETRACTED] Identifikasi Gerakan Tanah Longsor Dengan Pendekatan Ground Shear Strain Menggunakan Pengukuran Mikroseismik di Graha Taman Nirwana Kota Semarang. INDONESIAN JOURNAL OF APPLIED PHYSICS, 10(01), 32-37. http://lib.unnes.ac.id/id/eprint/52993
Taufik, M., Kurniawan, A., & Putri, A. R. (2016). Identification of Landslide and Flood Prone Areas using GIS (Geographic Information System)(Case Study: Kediri District). In Proceedings The 2nd International Conference of Indonesian Society for Remote Sensing 2016 (Vol. 47, pp. 281-289). IOP Publishing Ltd.
Zakaria, Z. (2010). Model Starlet, suatu Usulan untuk Mitigasi Bencana Longsor dengan Pendekatan Genetika Wilayah (Studi Kasus: Longsoran Citatah, Padalarang, Jawa). Jurnal Geologi Indonesia, 5(2), 93-112. https://doi.org/10.17014/ijog.5.2.93-112