Landslide Risk Reduction by Using Geographic Information System in District Kaligesing, Purworejo Regency

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Landslide Risk Reduction by Using Geographic Information System in District Kaligesing, Purworejo Regency

D. Prasastiawati, D. R. S. Sumunar

Department of Geography, Faculty of Social Science,
Yogyakarta State University, Kampus Karangmalang, Yogyakarta, Indonesia

Email : dianaprasastiawati.2018@student.uny.ac.id, dyah_respati@uny.ac.id

Abstract. Landslide takes a charge about 614 phenomenon with 3,5 milion more victims as long as 2017 in Indonesia. This study aims to: 1) take a measurement of landslide risk level in District Kaligesing, Purworejo Regency, and 2) to arrange alternatives of landslide risk reduction in District Kaligesing, Purworejo Regency. This is a descriptive quantitative research with GIS analysis using Arc.GIS 10.3 application. This study uses spatial and ecological approach. This population study is 147 landuse units. This study using primary data to measure the capacity level of society on disaster and secondary data to measure the vulnerability level. Data collection using observation, documentation, and interview methods. The data analysis techniques is using GIS analysis by scoring and overlay. The results shows that: 1) the variation of landslide risk level in District Kaligesing, Purworejo Regency divided into three classes: high level (9,41 km^2), medium level (37,55 km^2), and low level (28,94 km^2). The percentage of high level is 12.40%, percentage of medium level is 49.47%, and percentage of low level is 38.13%. The highest risk level of landslides is located in Donorejo covering 6.77 km^2 or 71.92% of the high-level area and the lowest risk level of landslides is located in Sudorogo covering 0.17 km^2 or 0.59% of the low-level areas; 2) the alternatives advice of landslide prevention given through preventive and persuasive methods. The prevention methods such as make any limitation of building plan, and relocation in higher-level areas, infrastructure development at the moderate level, and establishment of sister s and integrated evacuation sites in low-level institutions. Persuasive methods done through grinding functions with disaster management organizations, forming community-based and using social media to give more access information related to landslide disaster.

1. Introduction

Indonesia is an archipelago within 34 rank of disaster risk in the world [1]. In 2017 there were 2,341 disasters with 377 fatalities and 3.5 million displaced and suffering from natural disasters, with the highest frequency of landslides occurring in the amount of 614 incidents [2]. This is a consequence of the location of Indonesia, both geographical, geological, and geomorphological. The National Disaster Management Agency (BNPB) designated Central Java Province as the first rank of the most disaster-prone areas with the occurrence of disasters in 2017 totaling 600 incidents.

Purworejo Regency ranked number two in the most disaster-prone areas after Cilacap Regency. A number of disasters that have been occured in Purworejo include floods, landslides, tsunamis, and earthquakes, with the most frequent occurrences of disasters being floods and landslides [3].

According to BPBD Purworejo in 2017, the worst landslide disaster in the last 10 years was a landslide that occurred in District Kaligesing.

Table 1. Data of damaged and losses cause by Landslide in District Kaligesing

No	date	place	died	injured	suffered	evacuated	Damaged houses
1	24/03/2007	Kec. Bruno	-	-	-	-	5
2	03/11/2008	Kec. Purworejo	-	V	-	11	-
3	20/11/2009	Kec. Bruno	-	-	-	-	50
4	18/10/2010	Kec. Kaligesing	-	-	-	-	-
5	28/02/2014	Kec. Bruno	-	-	-	9	1
6	02/12/2014	Kec. Kemiri	-	-	-	2	1
7	22/12/2014	Kec. Pituruh	-	-	-	5	-
8	28/03/2015	Kec. Pituruh	-	-	3185	-	205
9	15/12/2015	Kec. Bruno	-	-	-	7	2
10	01/02/2016	Kec. Kaligesing	-	-	30	-	5
11	05/02/2016	Kec. Gebang	7	3	-	23	35
12	05/02/2016	Kec. Kemiri	-	2	-	35	10
13	21/03/2016	Kec. Pituruh	-	-	4	-	3
14	09/06/2016	Kec. Pituruh	-	-	4	-	1
15	18/06/2016	Kec. Kaligesing	41	9	-	230	100
16	27/01/2017	Kec. Bener	-	1	-	-	-
17	18/03/2017	Kec. Kaligesing	-	-	12	-	3
TOTAL			48	15+	3235	322	421

This landslide claimed 41 died and more than 200 people suffered property losses. Eventhough this area is at a relatively low altitude of 142 meters above sea level, the distance to the district capital is only 6 kilometers [4]. Through the Purworejo Regional Disaster Management Agency (BPBD), a number of disaster management have carried out such as evacuating victims, rehabilitating infrastructure, installing signs and evacuation route for landslide-prone areas, socializing and simulating landslide disasters. BPBD Purworejo acknowledges that there are still many limitations in landslide disaster management, due to the unavailability of spatial data regarding the distribution of landslide risk levels in District Kaligesing, Purworejo Regency. The villages in District Kaligesing do not even have any digital maps.

Mapping the level of risk of landslides in the District Kaligesing of Purworejo Regency has not been able to carry out because of the unavailability of spatial data on landslide hazards, vulnerability data, and community capacity data in tackling landslides. Though the data is important to be processed and analyzed in order to produce information on landslide prone areas in the community that are able to improve community preparedness, and provide spatial planning directives to reduce the risk of future disasters. Therefore, we need a tool or system to facilitate the government and the community in managing information related to disaster risk reduction. This research has two aims: 1) take a measurement of landslide risk level in District Kaligesing; and 2) to arrange alternatives of landslide risk reduction in District Kaligesing. This research is important to provide information that served as a media that can be easily access so that it can accelerate the flow of information about landslide risk areas in District Kaligesing, Purworejo Regency.

2. Area Study and Data

District Kaligesing is located at 110º 07 '46' '- 110º 08' 20 " BT and 07º 50 '34' - 07º 51 '45' LS in the eastern part of Purworejo Regency. Long stretches from the northeast to the southwest, District Kaligesing is 11 kilometers from the central government of Purworejo Regency. This region is located along the Menoreh hills directly adjacent to the Special Province of Yogyakarta. District Kaligesing divided into 21 areas with a total area of 74.67 km^2. Land use includes; rice fields 1.50 km^2, plantations 45.50 km^2, state forests and other dry land 6.39 km^2, as well as buildings and settlements

21.37 km^2. The primary data is used to measure the capacity level of society on disaster and the secondary data is used to measure the vulnerability level. Data collection using observation, documentation, and interview methods.

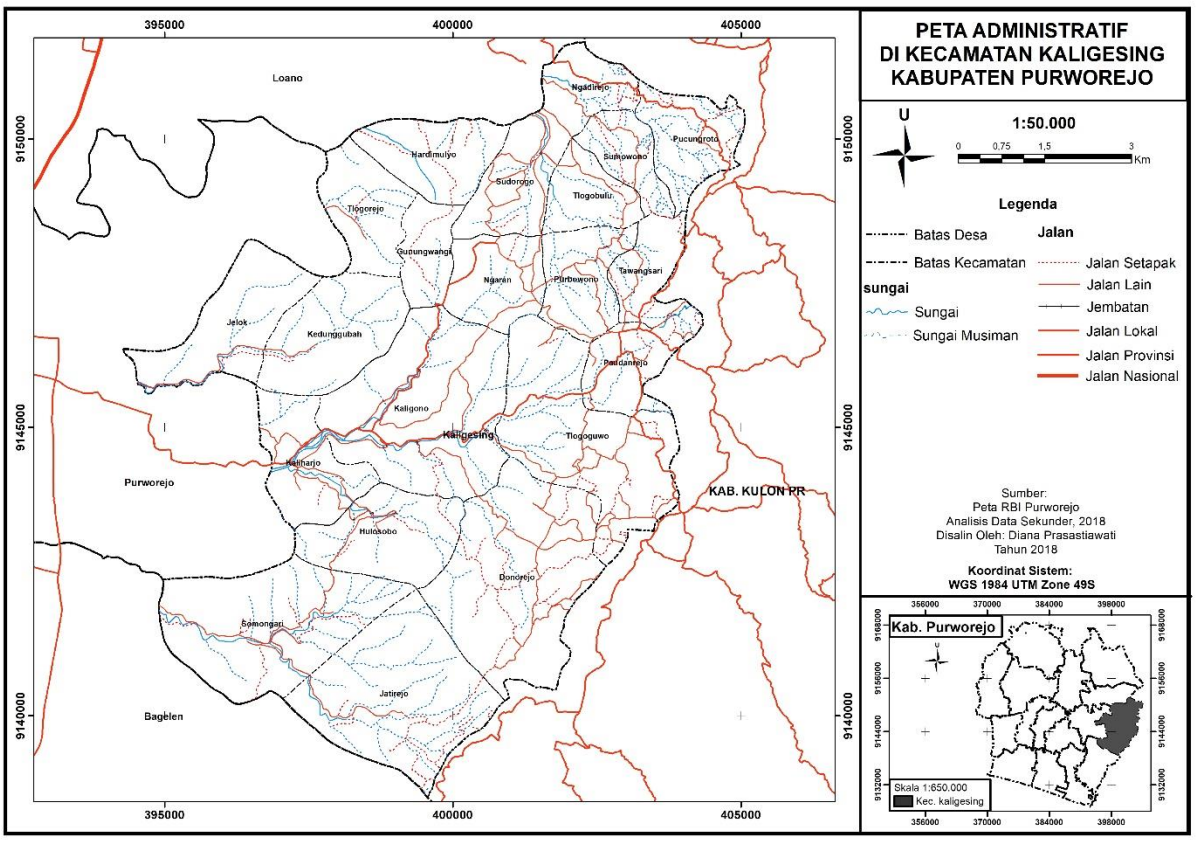

Figure 1. Location of study area

3. Methodology

Data analysis refers to the Regulation of the Head of National Disaster Management Agency (BNPB) Number 02 of 2012 concerning disaster risk assessment [5]. The risk can be known by considering the relationship between hazard, vulnerability, and capacity. Disaster risk studies can be carried out using the following approaches:

$$Risk = \frac{Hazard\ x\ Vulnerability}{Capacity}$$

The hazard, vulnerability, and capacity parameters were analyzed using GIS analysis in the form of scoring and overlaying [6]. The hazard components analyzes by referring to mass-movements maps published by Center for Volcanology and Geological Disaster Mitigation (PVMBG). The vulnerability components are: (1) socials; (2) economics; (3) infrastructures; and (4) environments. The capacity aspects include: (1) disaster management organization; (2) early warning systems; (3) disaster education; (4) based-risk factor reduction; and (5) preparedness.

3.1. Scoring Analysis

An appreciation analysis is carried out on each hazard, vulnerability, and capacity variable to determine disaster risk. The appreciation analysis was carried out with the help of ArcGIS 10.3 software and data calculation assisted by the application of Ms.Excel 2013. An appreciation analysis was carried out based on the General Guidelines for Disaster Assessment contained in the Regulation of the Head of BNPB Number 2 of 2012.

3.2. Stacking Analysis (Overlay)

The overlay technique is a map overlay technique in Geographic Information Systems (GIS) assisted by ArcGIS 10.3 software. Overlay analysis is one of the features in the ArcGIS 10.3 application that makes it possible to place graphics on a basic map above other map graphics that reference the same and display the results into new maps in digital form. The results of the overlay technique are able to display combined attribute data from two or more maps that are stacked together.

4. Result and Discussion

Variations in the level of risk of landslides in District Kaligesing are spread throughout the . However, there is a tendency for some regions that have a high level of danger or a high level of vulnerability which is also at high risk. This proves that the level of landslide risk is directly proportional to the level of hazard and vulnerability in accordance with the risk approach (R) = hazard (H) multiplied by vulnerability (V) divided by capacity (C). The area description is able to show landslide risk classes in general are:

a. Areas with a high risk of landslides are generally characterized by slope > 30%, depth of land > 4 m, rock outcrops, more than 25 times per year, landslides in large scale and small scale.
b. Areas with a moderate risk of landslides are generally characterized by a slope of 15-30%, depth of soil 2-4 m, rock outcrops, landslides occurring 10-25 times a year, both on a large scale and in a small scale.
c. Areas with a low level of landslide risk are generally characterized by slope <15%, depth of land <2 m, less than 10 times a year, landslides occur both on a large scale and in a small scale. [6]

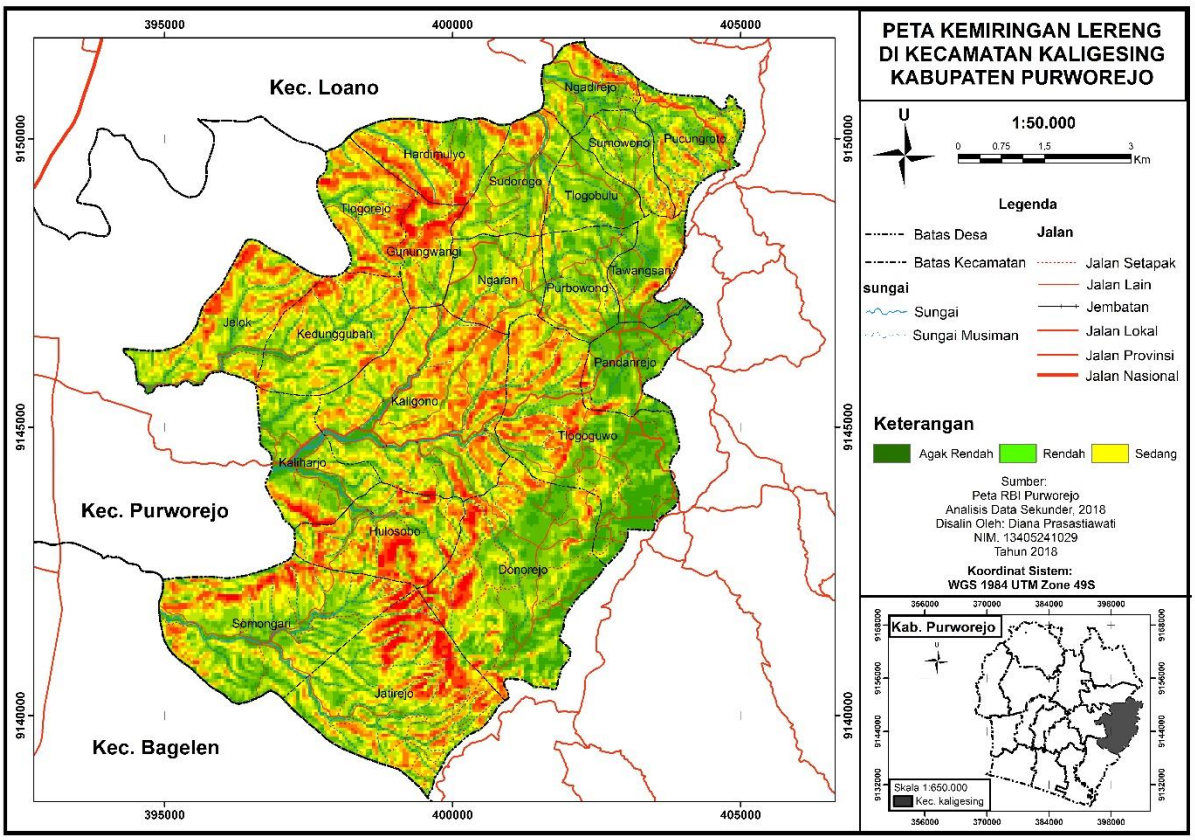

Figure 2. Slope variation area

The results showed that the risk of landslides in District Kaligesing, Purworejo Regency varied and were divided into three classes: high risk level covering an area of 9.41 km^2, the risk level was

covering an area of 37.55 km^2, and a low risk level covered an area of 28.94 km^2. The percentage of high landslide risk is 12.40%, medium risk percentage is 49.47%, and low landslide risk percentage is 38.13% of the total area of the study which is 75.90 km^2. The highest risk of landslides is in the of Donorejo with an area of 6.77 km^2 or 71.92% of the wide area of high risk areas, and the lowest risk is in the of Sudorogo with an area of 0.17 km^2 or 0.59% of the area of low risk areas. The risk of high, medium and low landslides is generally spread in s in the District Kaligesing.

The risk of landslides is dominating parts of the Kaligesing District, but the spread of the risk of low landslides is also quite extensive. Villages with low risk of landslides include: Jelok, Kedunggubah, Hulosobo, most of the area of Somongari, part of the Kaligono area, a small part of the Kaliharjo area, a small part of the Tlogoguwo, a large part of Tlogobulu, some small area of Purbowono, a small part of the Sudorogo area, a small part of the Ngadirejo area, a small part of the Tawangsari area, and a large part of the Sumowono area.

Medium level of disaster risk includes Tlogorejo, Gunungwangi, Jatirejo, most of Hardimulyo area, most of Ngaran area, most of Pucungroto area, most of Pandanrejo area, most of Tlogoguwo area, most of Kaliharjo area, some regions Kaligono, and a small part of the area of Donorejo. The highest level of disaster risk is found in Donorejo, a small part of Kaliharjo, a small part of Hardimulyo, a small part of Ngaran, a small part of Purbowono, a small part of Tawangsari, and a small part of Sudorogo.

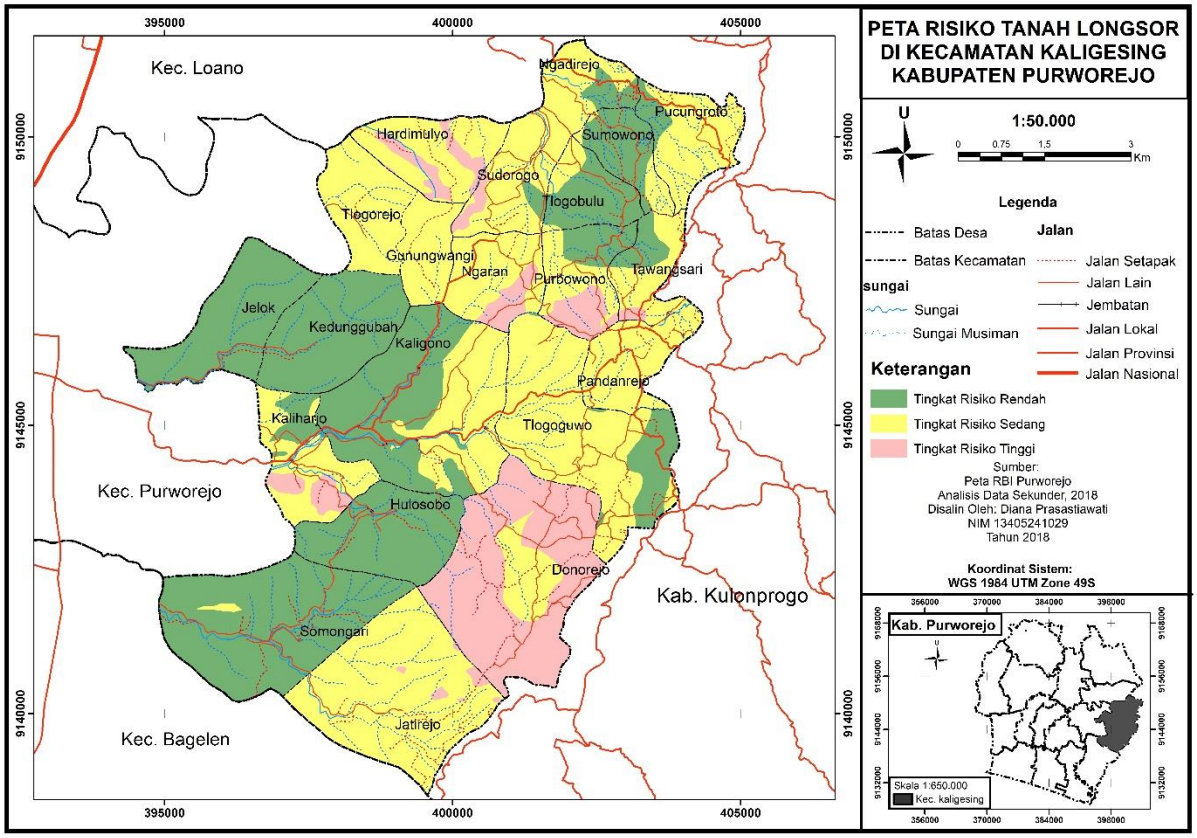

Figure 3. Risk level of landslide

According to the various distribution and level of risk of landslides in District Kaligesing, there is a need for preventive and persuasive disaster risk reduction actions by referring to the three risk reduction components. Preventive disaster risk reduction efforts are carried out by providing alternative spatial planning directions for land use to minimize regional threats. These spatial planning directives are prepared by analyzing regional characteristics and factors related to the risk of landslides. The directions for spatial planning that can be given are:

a. For areas with a high level of risk, the directives that can be applied include: all buildings and infrastructure of settlements and public facilities are prohibited from being established, if it has already occurred it is necessary to immediately relocate, evacuation planning and conditions that apply to residents who will stay must be taken ensure their safety in emergencies through development and evacuation plans, this area is devoted to conservation purposes in all non-built areas, semi-built areas, and development areas. In this study, there is at least one village that has a high level of risk, namely the Village of Donorejo. Donorejo village has a high level of risk because it is located in an area with a relatively high altitude and high distribution of houses and public facilities.
b. For regions with moderate risk levels, directions that can be applied include: buildings and infrastructure permitted with a number of constraints with conditions that must be obeyed, such as certain construction densities (limited) and the application of specific requirements for buildings, evacuation planning must be taken into account in anticipation of people in areas of risk, conservation goals must be taken into account in this area. The majority of villages in Kaligesing Subdistrict are in the category of moderate risk areas, with the widest risky rural areas in Jatirejo and Tlogoguwo Villages. Jatirejo and Tlogoguwo villages are categorized as medium risk areas because although they are located on a relatively steep slope with difficult accessibility because they only have one road but the population density is low.
c. For regions with low risk levels, the directives that can be applied include: all development, infrastructure, and settlements are permitted by following government planning in this field, there are no special requirements that must be met in building construction, this area can be used for agriculture, economically, and productive. In this study, several villages with a high level of vulnerability actually had a low level of risk because the villages were located on the slope of the slope which was sloping and had high capacity in the face of landslides. Some villages that have low risks include: Kedunggubah Village, Kaligono Village, most of Tlogobulu Village, Hulosobo Village, Somongari Village, and Jelok Village. These villages though have body parts of water (rivers) in their area but are still at low risk. In fact, in the village of Jelok which in 2015 caused a landslide that claimed lives, currently all of its areas are classified as low risk. This is because the capacity of the community is relatively high with the fulfillment of the five capacity components in the village.

Disaster risk reduction by reducing vulnerability in threatened areas are the responsibility of all sectors, both village and related governments. It is necessary to have integrated coordination by all stakeholders. Vulnerability reduction includes wise management of human resources, strengthening economic elements in society, as well as appropriate spatial planning and landuse.

The vulnerability reduction in the Kaligesing District is persuasive by disseminating information about landslide prone areas and ways to save themselves in the event of a disaster. The provision of infographics and disaster risk maps needs to be scheduled at strategic places that can be reached and seen by the community. Forms of activities such as counseling, socialization, and integrated disaster simulation need to be carried out regularly and periodically. Strengthening community capacities such as activating disaster management organizations and providing early warning systems, establishing disaster resilient villages and sister villages should be carried out to spur public awareness of landslides.

Strengthen the capacity of this community will be more optimal if it is able to be carried out with the system of edification and strengthening the community utilizing technological advances in this digital era. The use of social media needs to be done in order to adjust to the times. The establishment of a networked social community will further facilitate the dissemination of information related to the risk of landslides, because it is undeniable that currently internet access can be utilized even in remote areas in the Kaligesing District. One of the things that can be done is by providing a disaster information center that is synchronized with the sub-district website. This information center serves to provide information regarding landslides and their mitigation. The first step that can be

attempted to start this activity is to provide guidance and training for community leaders and stakeholders in Kaligesing District by the institution that has the authority to do it (BPBD Purworejo).

5. Conclusion and Recomendation

Distribution and level of landslide risk in Kaligesing District, Purworejo Regency varies and is divided into three classes: high risk areas, medium risk areas, and low risk areas. There is a tendency for the relationship between the level of vulnerability and risk. Some regions that have high levels of danger or high levels of vulnerability generally have a high risk. This proves that the level of landslide risk is directly proportional to the level of hazard and vulnerability in accordance with the risk approach (R) = hazard (H) multiplied by vulnerability (V) divided by capacity (C). Efforts to strengthen community capacity will be more optimal if it is able to be carried out with an education system and strengthening the community to use social media to disseminate information related to the risk of landslides. The use of social media needs to be done in order to adjust to the times. The establishment of a networked social community will further facilitate the dissemination of information related to the risk of landslides, for example by providing disaster information centers that are synchronized with the sub-district website. This information center serves to provide information regarding landslides and their mitigation. The first step that can be attempted to start this activity is to provide guidance and training for community leaders and stakeholders in Kaligesing District by the institution that has the authority to do it (BPBD Purworejo

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