The Analysis of Landslide Vulnerability Map and The Level of School Preparedness in Encountering Landslide in Gumelar Sub-District, Banyumas Regency

A H M Sani*, C Muryani and M G Rindarjono
Universitas Sebelas Maret, Surakarta, Indonesia

*maulidyasani@gmail.com

Abstract. Gumelar is one of sub-districts in Banyumas Regency where landslide frequently occurs. It is because most of areas in Gumelar have the slope from 15% until more than 40% and high rainfall, 1,000-3,000 mm/year. This research aimed to discover how high the level of vulnerability to landslides and the level of school preparedness in encountering the hazards in Gumelar sub-district. Areas vulnerable to landslides were determined by employing overlay method with rainfall, land slope, soil type, and land use as the parameters. While the sample of schools was obtained by employing purposive random sampling, selecting a junior high school located in landslide prone areas. Data of school preparedness was obtained through interview and questionnaire. The research results revealed that there were three categories of landslide vulnerability; high (6572.06 ha), moderate (2653.05 ha) and low (93.79 ha). Villages that had high vulnerability were Samudra Kulon, Tlaga, Cilangkap, Paningkaban, and Karangkemojing; while the level of school preparedness in encountering landslide was categorized as unready.

1. Introduction
Landslide is the process of displacement or movement of the ground in an oblique or vertical direction from its original position as a result of gravity. Landslide can occur because of several factors such as high intensity of rainfall, oblique or steep slopes, thick weathering, various rocks and geologic structure, and land use that is not in accordance with its characteristics [1]. The occurrence of this disaster is difficult to predict, resulting in many casualties as well as material losses such as damaged infrastructure and agricultural land.

Banyumas Regency is located in the Southwestern part of Central Java Province. This region consists of land and mountains. Its mountainous structures involve a part of Serayu River valley for agricultural land, some highlands for settlements and yard, and some mountainous areas for plantations and tropical forests that are located on the slopes of Mount Slamet.

The altitude of the area in Banyumas Regency is mostly in the range of 25-100 mdpl (42,310.3 Ha) and 100-500 mdpl (40,385.3 Ha). Slopes in this regency are divided into 4 categories that are (1) 00-20 in the central and southern regions, (2) 20-150 around Mount Slamet, (3) 150-400 in the slopes of Mount Slamet, and (4) > 450 in the area of Mount Slamet [2].

Landslides or soil movements commonly occur in Banyumas. It is because more than 50% of the area is vulnerable to soil movement, so that in rainy season landslides often occurs [3]. Gumelar is one of sub-districts in Banyumas where landslides frequently occur. It is due to several factors such as slope level that is more than 25%, land altitude, improper land use and high rainfall in the area. Impacts
resulted from the landslide are not only felt by community but also schools that are located around the landslide-prone areas. Knowledge concerning disaster and preparedness before, during, and after it is very important in order to reduce the risks. This study aimed to discover how high the level of landslide vulnerability in Gumelar sub-district and the level of school preparedness in overcoming the disaster.

2. Methods

2.1. Location of the Research
This research was conducted in Gumelar Sub-district, Banyumas Regency, adjacent to Brebes Regency in the north, Lumbir Sub-district in the south, Ajibarang sub-district in the east, and Cilacap Regency in the west.

2.2. Research Population and Sample

2.2.1. Population. The population of landslide vulnerability was all villages in Gumelar sub-district categorized as prone to landslide. While that of school was all junior high schools located in Gumelar sub-district.

2.2.2. Sample. The sample of landslide vulnerability areas were taken from villages belonging to high-risk category. While that of school was taken by employing Purposive Random Sampling technique; the school was taken as the sample based on its location that was in the region/village with high landslide vulnerability and the respondents were students in one class from each grade (VII, VIII and IX) selected randomly.

2.3. Technique of Data Collection
In this research, data were collected through observation method by directly observing the location of landslide as well as looking for early data of it both at related offices and at local government (sub-district and village). While for school preparedness, data were collected by using questionnaire that contained a number of questions and was delivered to the subjects/research respondents. Questions listed on the questionnaire were open-ended (unstructured) questions.

2.4. Data Analysis Technique

2.4.1. Landslide vulnerability mapping. The map was processed by using software called ArcView 3.3. Before processing, data in the form of rainfall, slope, soil type and land use were collected. Then these data were mapped and classified into inputted thematic maps. Each class unit of these maps was given a score associated with its estimated impact on the landslide. The inputted thematic maps were overlaid or integrated through GIS operation so that new units and new attribute tables were obtained. All scores were finally summed so that the cumulative score of the overlay result was obtained. Then it was reclassified into three simpler classes; low, medium and high.

Criteria and parameters used for the analysis were as follows [4]:

| Table 1. Guidelines for Scoring Land Slope |
|-------------------------------|-----|-----|
| Class | Slope | Note | Score |
| 1     | 0-2   | Flat | 20   |
| 2     | 2-5   | Sloping | 40   |
| 3     | 5-15  | Rather steep | 60   |
| 4     | 15-40 | Steep | 80   |
| 5     | >40   | Very steep | 100  |

| Table 2. Guideline for Scoring Rainfall Intensity |
|-----------------------------------------------|-----|-----|
| Class | Rainfall intensity (mm/hm) | Note  | Score |
| 1     | 500-1000                  | Low   | 10    |
| 2     | 1000-1500                 | Moderate | 20   |
| 3     | 1500-3000                 | High  | 30    |
| 4     | >3000                     | Very high | 40   |
Table 3. Guidelines for Scoring Soil Type

| Class | Soil Type                                      | Score |
|-------|-----------------------------------------------|-------|
| 1     | Alluvial                                       | 1     |
| 2     | Mediterranean, Brown Forest, Non Calcic Brown  | 2     |
| 3     | Andosol                                       | 3     |
| 4     | Litosol                                       | 4     |

Table 4. Guidelines for Scoring Land Use

| Class | Land Use                                    | Score |
|-------|---------------------------------------------|-------|
| 1     | Forest                                      | 10    |
| 2     | Garden                                      | 20    |
| 3     | Bush/Grove/Grass                            | 30    |
| 4     | Moor/Yard                                   | 40    |
| 5     | Ricefield/Settlement/Building               | 50    |

The criteria of landslide vulnerability were classified into 3 classes: (1) Low vulnerability; (2) Moderate vulnerability; (3) High vulnerability. After overlay process, new spatial data (data analysis) were produced. In data analysis, the score of each area were summed, and then the score difference was divided by 3 classes of vulnerability by employing the following formula:

\[
\text{Total of Vulnerability Index} = \frac{\text{Max score} - \text{Min score}}{3}
\]

2.4.2. Level of school preparedness

Analysis technique was used to find out the index of school preparedness. Index numbers included index per parameter such as knowledge and attitude (KA), emergency planning (EP); warning system (WS); and resource mobilization capacity (RMC) at each data source in from of survey/questionnaire. The determination of the index score for each parameter is calculated based on the formula:

\[
\text{Index} = \frac{\text{Total real score of parameter}}{\text{Maximum score of parameter}} \times 100
\]

Table 5. Classification of Preparedness Index

| No | Index Score | Category     |
|----|-------------|--------------|
| 1  | 80-100      | Very ready   |
| 2  | 65-79       | Ready        |
| 3  | 55-64       | Almost ready |
| 4  | 40-54       | Less ready   |
| 5  | <40         | Not ready    |

Source: LIPI-UNESCO, 2006

The maximum parameter score was derived from the number of questions in the indexed parameter (each question was worth one point). The total real score of the parameter was obtained by summing the real score of all questions answered "Yes" and worth one in the corresponding parameter. Index was in the range of 0-100; the greater the index score, the higher the level of preparedness [5].

After gaining the index score of each parameter, then composite index was calculated. Each parameter had different score. The score of each parameter for the school community index was as follows:

Index of Teacher (S1) =0,45*PS index + 0,1*EP index + 0,25*WS index + 0,2*RMC index

Index of Student (S2) =0,42*PS index + 0,14*EP index + 0,21*WS index + 0,21*RMC index

Table 6. Index Total Parameter of School Community Preparedness

| Parameter | Formula |
|-----------|---------|
| KA        | = (9/20)*KA index (S1) + (6/14)*KA index (S2)) |
| EP        | = (2/20)*EP index (S1) + (2/14)*EP index (S2)) |
| WS        | = (5/20)*WS index (S1) + (3/14)*WS index (S2)) |
| RMC       | = (4/20)*RMC index (S1) + (3/14)*RMC index (S2)) |
| Total of SC | = (31,96/49,07)*KA index + (6,62/49,07)*EP index + (4,12/49,07)*WS index + (0,89/49,07)*RMC index |
3. Results and Discussion

3.1. Landslide Vulnerability Map

From the result of scoring slope parameters, the average annual rainfall, soil type, and land use which then were overlaid it was revealed that 70.5% or 65.7 km² of Gumelar sub-district included in high vulnerability category, 28.5% or 26.5 km² included in moderate vulnerability category, and 1.0% or 0.93 km² belonged to low vulnerability category.

Based on the map, it was revealed that there were five villages that had the highest landslide vulnerability i.e. Samudra Kulon, Tlaga, Cilangkap, Paningkaban, and Karangkemojing. The result was obtained by scoring each parameter and then was overlaid to be a landslide vulnerability map.

![Figure 1. Landslide Vulnerability Map, Gumelar Sub-district, Banyumas Regency](image)
3.1.1. Rainfall. The intensity of rainfall in Gumelar Sub-district, Banyumas Regency, consisted of two categories; moderate (1000-1500 mm/year) and high (1500-3000 mm/year). Areas or villages where the rainfall intensity was categorized as high in Gumelar sub-district were Samudra and Kedungurang, while the ones with high intensity rainfall were Samudra Kulon, Gumelar, Telaga, Cilangkap, Cihonje, Gancang, Paningkaban, and Karangkemojing. Most of areas in Gumelar had very high rainfall intensity. Rainfall with high intensity will influence landslide. In the winy season, the landslide in some villages in Gumelar Regency happen in almost every month.

3.1.2. Soil Type. Almost all areas in Gumelar Sub-district were composed of Complex Yellowish Red Latosol and Red Podzolic soil (9284,8 ha). This kind of soil is formed because of the highly rainfall (the intensity is between 2500-3000mm/year) and is easy to be washed by rain. This kind of soil has low water saving power so that it will easy to drought, and when the rainy season, the soil will be susceptible to landslides. In Kedungurang Village there was Complex Yellowish Red Podzolic soil (17.21 ha), while in a small part of Karangkemojing village there was Brown Latosol (19.21 ha).

3.1.3. Land Slope. In Gumelar, there were 3 categories of land slope i.e. flat (0-2%), steep (15-40%) and very steep (>40%). Most of land slopes around the areas were >40% thus landslides were easily occurred.

3.1.4. Land Use. Most of the land in Gumelar sub-district was used for gardens and fields. Settlements were mostly located near the cliffs because to build houses people had to cut slopes to obtain a flat plot of land, so that most of the back of the houses was directly adjacent to the cliff/slope that had been cut. Besides, at some points in landslide prone areas there were plants whose roots cannot hold water such as banana, coconut, jackfruit and other seasonal crops. In addition, the large number of rice fields located on the valley of the hills made landslide more possible to occur. Based on those four parameters, five out of ten villages in Gumelar Sub-district had high vulnerability. They were Samudra Kulon, Tlaga, Cilangkap, Paningkaban and Karangkemojing.

Table 7. Landslide Vulnerability in Gumelar Sub-District

| Village          | Low (area ha) | Moderate (area ha) | High (area ha) |
|------------------|---------------|--------------------|----------------|
| Cilangkap        | -             | 60,87              | 660,53         |
| Karangkemojing   | 0,63          | 314,34             | 1278,62        |
| Paningkaban      | -             | 154,82             | 411,11         |
| Samudra Kulon    | -             | 42,61              | 801,15         |
| Tlaga            | -             | 187,03             | 608,52         |

3.2. School Preparedness

SMP Negeri 2 Gumelar is a junior high school located in a high vulnerability area in Paningkaban village. The analysis revealed that the level of preparedness at SMP Negeri 2 Gumelar was categorized as “not ready”. Based on the calculation, it was found that the preparedness index of school community was 30.97. The preparedness index was derived from four parameters, such as:

3.2.1. Knowledge and Attitude. Knowledge of disaster at SMPN 2 Gumelar had started to be learnt especially in Social and Natural Science lessons in accordance with 2013 curriculum. However, the knowledge between teachers and students was slightly different because most teachers realized that the school was located in landslide-prone area but, on the contrary, almost majority of students were not aware of that.

3.2.2. Policy Statement. Disaster-related policies are somewhat necessary to be published by schools as a guide for the school community in reducing risks resulted by disasters that occasionally occur and it is possible that the school will be affected since it is in vulnerable area. At SMP Negeri 2 Gumelar there...
was no disaster-related policy; however, there were several information media in the form of books, posters, and wall magazines which contained knowledge and disaster risk reduction.

3.2.3. Emergency Planning. The planning of school preparedness at SMP Negeri 2 Gumelar was categorized as “not ready” because there was no document that regulated disaster management and preparedness SOP. Besides, landslide-prone maps that actually could be media of information for the entire school community were unavailable, so that the nearest evacuation places/areas if at any time there was a landslide could not be ascertained.

3.2.4. Resource Mobilization Capacity. Utilization of existing resources to overcome the disaster had started to be run by the school by forming Junior Red Cross (PMR) as an extracurricular activity where one material learned was about disaster. But the students tended to be less interested in joining disaster response team because they thought their school was still classified as safe from landslide.

4. Conclusions
Landslide vulnerability mapping in Gumelar Regency employed parameter scoring method, then overlaid toward the parameter of land slope, rainfall, soil type, and land use. From the mapping it was obtained that there were five villages included in high landslide vulnerability category.

| Table 8. Conclusion of Villages with High Landslide Vulnerability |
|-----------------|-----------------|
| Village         | Area (ha)       |
| Karangkemojing  | 1278.62         |
| Samudra Kulon   | 801.15          |
| Cilangkap       | 660.52          |
| Tlaga           | 608.52          |
| Pamingkaban     | 411.11          |

Preparedness to overcome landslide in SMP Negeri 2 Gumelar was categorized as ‘not ready’; the score of the index was 30.97. The parameters of school community preparedness were: Knowledge and Attitude, Policy Statement, Emergency Planning, and Resource Mobilization Capacity.

References
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