The Analysis of Landslide Vulnerability in Settlement of Citizenship Association VI, Sukorejo Village, Semarang

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One of the disasters that must be noticed in mountains and hills is landslide. This is especially if the area is used as settlement. Semarang as metropolitan city with various topography is not separated from the use of its hilly area into residential areas. One of them is in Gunungpati District. However, this utilization of land can cause this area prone to landslide. Sukorejo Village, especially in Citizenship Association (CA) VI, is the landslide prone areas in Gunungpati District, Semarang. Almost every year, Citizenship Association (CA) VI of Sukorejo Village experiences landslide causing damage to infrastructures. Therefore it is needed to analyse the landslide vulnerability in Citizenship Association (CA) VI of Sukorejo Village. Thus, the vulnerability of the area is evaluated as disaster mitigation in accordance with physical, social, economic and institutional criteria. This study utilized quantitative method by scoring analysis to measure the level of landslide vulnerability. The vulnerabilities which were analysed were physical, social, economic, and institutional. The results of this study indicate that settlement in Citizenship Association (CA) VI of Sukorejo Village has high physical vulnerability, moderate to high social vulnerability, moderate economic vulnerability and low institutional vulnerability to disaster.

Keywords : Landslides, Settlements, Disasters Vulnerability

1. Introduction
Landslide fatalities are concentrated in less developed countries, where there is little investment to understand the dangers and risks associated with landslides, mainly due to lack of appropriate resources [1]. This condition indicates that the concentration of handling disaster problems is indeed appropriate to be considered in developing countries..

According to statistical data from the National Disaster Management Agency [2], there have been more than 4,607 landslide cases in Indonesia in the past 10 years. Based on the data, it was also stated that around 24,407 people were victims. Therefore, with an increase in the incidence of landslides every year, it is necessary to determine the level of vulnerability of a region to landslides to make prevention and protection efforts, including the strength of the buildings.

One reason for the high number of cases and landslide victims is the need for settlements. Settlement becomes one of the main human needs as a place for housing and space in carrying out its life activities. The rapid growth rate of the population is very influential on the demand for settlements and housing needs. In fact, the population of residential land is greater than the availability of land to settle (demand is greater than supply) [3] due to. The development of the population in settlements is dynamic while the existing land area is permanent, so it cannot compensate for the growing needs of settlements. This
imbalance of needs affects the compulsion of the community to settle on existing land, even though the land is not feasible to be built in a disaster-prone area [4].

The resilience of the people to choose living in disaster-prone areas can be lately set in making decisions, whether they remain in the area or choose to stay [5]. The choice to stay and settle in a disaster-prone location is influenced by certain factors, one of which is to anticipate potential disasters that will occur with the "resilience" that is owned by the community. On the other hand, the settlement of the community can also be influenced by the socio-economic conditions of the community that do not allow them to move.

The case study in this paper was in the settlement of Sukorejo Village of Semarang City, located in an area prone to landslides in the city of Semarang. Sukorejo Village is included in the zone of high ground movement, namely an area that has a high degree of vulnerability for the occurrence of soil movements [6].

1.1 Literature Review
Landslides are a geological event caused by the movement of rock or soil mass which can be defined as the displacement of the material forming a slope, which is in the form of original rock or embankment material that moves according to the earth's gravitational force [7]. Landslides are due to several factors such as nature and humans. Thus, it is necessary to consider these aspects in identifying vulnerabilities and disaster mitigation efforts. Physical conditions are due to earthquake prone zones, hilly terrestrial forests with high rainfall intensity, where some areas in Java are prone to landslides [8].

Financial capability and knowledge of the community about landslides also affect vulnerable areas [9]. Financial capability will help people adapt to upgrade buildings and regions, while knowledge capabilities will help people adapt to behaviour and actions. This paper analyzes both aspects, such as the physical and human aspects (social, economic and institutional) in terms of vulnerability, in order to provide input on mitigation efforts from both aspects.

2. Methods
This study utilized a quantitative research method with a weighting or scoring approach. The aspects that would be reviewed were aspects of the physical vulnerability of the area, economic vulnerability, social and institutional vulnerability. These three aspects have their own parameters.

2.1 Social Vulnerability Parameter
The physical vulnerability of the land can be determined based on weighting parameters of daily rainfall intensity, slope, soil type, land movement and land use. Variables are divided into 3, which are: low vulnerability (score 1), moderate vulnerability (score 2) and high vulnerability (score 3). The weighting parameters of physical vulnerability are depicted in Table 1.

| Parameter       | Variable                                                                 | Score | Source |
|-----------------|--------------------------------------------------------------------------|-------|--------|
| Daily Rainfall Intensity | Low< 20,7 mm/hr | 1     | [10]   |
|                 | Moderate 20,7-27,7 mm/hr        | 2     |        |
|                 | High 27,7– 34,8 mm/hr          | 3     |        |
| Slope           | 0-15%                        | 1     |        |
|                 | 15%-25%                      | 2     | [10]   |
|                 | >25%                         | 3     |        |
| Soil Type       | Low sensitive: Alluvial, gleisol, planosol, G, laterite groundwater, latosol | 1     | [10]   |
|                 | Less sensitive : Aluvial, glei, planosol, hodromorf kelabu, laterite, latosol | 1     | [10]   |
### Parameter Variable Score Source

| Land Movement | Low<0,0016 | 1 | [11] |
| Land Use | Medium 0,016-0,081 | 2 |
| Land Use | High>0,081 | 3 |
| Land Use | Habitable Settlement | 1 | [12] |
| Land Use | Non-habitable Settlement | 3 |

#### 2.2 Social Vulnerability Parameter
Social vulnerability can be determined based on weighting parameters of population density, percentage of population of vulnerable age groups and average level of education of the household head. Social vulnerability variable is also divided into 3, which are low vulnerability (score 1), moderate vulnerability (score 2) and high vulnerability (score 3). The parameters of weighting social vulnerability are presented in Table 2.

**Table 2.** Weighting parameters of Social Vulnerability in Citizenship Association (CA) VI

| Parameter | Variable | Score | Source |
|-----------|----------|-------|--------|
| Population density | Low (<150 person/ha) | 1 | |
| Percentage of population of vulnerable age groups | Moderate (100-200 person/ha) | 2 | [13] |
| Percentage of population of vulnerable age groups | High (>200 person/ha) | 3 |
| The percentage of the average level of education of the household head | High < 5% | 1 |
| The percentage of the average level of education of the household head | Moderate 5% - 10% | 2 | [14] |
| The percentage of the average level of education of the household head | High > 10% | 3 |
| The percentage of the average level of education of the household head | Low (College) | 1 |
| The percentage of the average level of education of the household head | Moderate (High School) | 2 | [15] |
| The percentage of the average level of education of the household head | High (Secondary School, Primary School/Ungraduated/Uneducated) | 3 |

#### 2.3 Economic Vulnerability Parameters
Economic vulnerability is identified based on the weighting of the parameters of the number of poor people, the percentage of unemployment, and the percentage of decent homes. Variables are divided into 3 as two previous vulnerability reviews, which are low vulnerability (score 1), moderate vulnerability (score 2) and high vulnerability (score 3). The economic vulnerability weighting parameters are depicted in Table 3.

**Table 3.** Parameters of Weighting Economic Development in Citizenship Association (CA) VI

| Parameter | Variable | Score | Source |
|-----------|----------|-------|--------|
| Population density | Low (<150 person/ha) | 1 | |
| Percentage of population of vulnerable age groups | Moderate (100-200 person/ha) | 2 | [13] |
| Percentage of population of vulnerable age groups | High (>200 person/ha) | 3 |
| The percentage of the average level of education of the household head | High < 5% | 1 |
| The percentage of the average level of education of the household head | Moderate 5% - 10% | 2 | [14] |
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| The percentage of the average level of education of the household head | Low (College) | 1 |
| The percentage of the average level of education of the household head | Moderate (High School) | 2 | [15] |
| The percentage of the average level of education of the household head | High (Secondary School, Primary School/Ungraduated/Uneducated) | 3 |
### 2.4 Institutional Vulnerability Parameters

The vulnerability parameter of the institutional aspect is assessed based on the interval level [18], which are: Low Vulnerability = has mitigation institutions as well as disaster management and has a village disaster risk reduction forum, score 1; Moderate vulnerability = only has one of the regional disaster management agencies or village disaster risk reduction forums, score 2; High Vulnerability = There are no regional disaster management agencies and village disaster risk reduction forums, score 3.

### 2.5 Vulnerability Score Calculation

The three aspects of vulnerability are calculated in a score to get the vulnerability. To divide the vulnerability class score, the interval is calculated between the highest score and the finest score divided by the number of interval classes (high, medium and low vulnerability).

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Vulnerability = \frac{\text{Total of High Score} - \text{Total of Low Score}}{\text{Interval Class}}
\] (1)

| Vulnerable Aspects | High | Moderate | Low |
|--------------------|------|----------|-----|
| Physical           | >13  | 12-9     | < 9 |
| Social             | > 7  | 7-6      | < 6 |
| Economic           | > 7  | 7-6      | < 6 |
| Institutional      | 3    | 2        | 1   |

### 3. Results and Discussions

Sukorejo Sub district has experienced several landslides every year which causes damage to infrastructure. In 2014, Sukorejo experienced a landslide caused by a downturn in heavy rains that occurred in the Semarang City area for a long time. This incident resulted in 39 houses being victims of severe damage and some of them actually collapsed by the brunt of the land [19]. Then, in 2015, it experienced a landslide triggered by heavy rain causing several houses damaged by landslides [20]. Furthermore, in February 2017, Sukorejo Village again experienced a landslide at 9:30 p.m. The landslide that occurred was a sinking gutter because it was not strong enough to hold the ground after the area had been rained for 30 minutes [21].
Figure 1. Research Location

In April 2017, landslide occurred in Sukorejo Village [22]. The landslide was quite severe causing the road to collapse and leaving only a few meters wide of the road. Some locations of landslide points in Sukorejo Village are presented in Figure 2.

Figure 2. Landslide Location

The disasters that occurred in Sukorejo Village did not force the community to leave the settlements they occupied, although the settlements often experienced landslides. The local government has offered to relocate them to Rusunawa at Kaligawe, thus they still leave their settlements [23].

3.1. Physical Vulnerability Calculation
Physical conditions at the location have similarities, rainfall intensity of 27.7 mm / day –34.8 mm / day resulting in a score of 3, slope with 15% -25% or score 2, dark brown Mediterranean soil type or score 3, ground motion> 0.08 or score 3, and conformity to the spatial plan that has not matched the designation with a score of 3. The results of the physical vulnerability calculation score indicate a classification of scores less than 9 which means low vulnerability, 9-12 is a moderate vulnerability and more than 12 is high vulnerability. According to that result, Citizen Association (CA) VI of Sukorejo Village has a high physical vulnerability to land.

3.2. Social Vulnerability Calculation
Based on the social vulnerability weighting parameters and the weighting results in Citizen Association (CA) VI of Sukorejo Village (Table 3 and Table 4), the results of the calculation of social vulnerability scores indicate a classification of less than 6 indicating low vulnerability, 6-7 is a moderate
vulnerability, greater than 7 is a high vulnerability. Some spots of Citizenship Association (CA) VI of Sukorejo Village have a high social vulnerability, such as in Neighbourhood Association (NA) 2 and 3.

Table 5. Social Vulnerability Score Results

| CA VI | Social Vulnerability | Total Score | Classification |
|-------|----------------------|-------------|----------------|
|       | Population Density   | Vulnerable Group | Education Level of Household Head |
|       | Existing | Score | Existing | Score | Existing | Score |
| NA 1  | 200      | 2     | 9.3      | 2     | Primary School | 3     | 7    | Moderate Vulnerability |
| NA 2  | 238.2    | 3     | 9.4      | 2     | Primary School | 3     | 8    | High Vulnerability    |
| NA 3  | 71.1     | 1     | 11.9     | 3     | Primary School | 3     | 8    | High Vulnerability    |
| NA 4  | 16.5     | 1     | 11.7     | 3     | Primary School | 3     | 7    | High Vulnerability    |
| NA 5  | 64       | 1     | 9.1      | 2     | Primary School | 3     | 6    | Moderate Vulnerability |
| NA 6  | 28.7     | 1     | 13.1     | 3     | Primary School | 3     | 7    | Moderate Vulnerability |

3.3 Economic Vulnerability Calculation
Based on the economic vulnerability weighting parameters above, the weighting results in Citizenship Association (CA) VI of Sukorejo Village is presented in Table 6. The results of the calculation of economic vulnerability scores indicate a classification less than 5 indicating a low vulnerability, where 5-7 is a moderate vulnerability and more than 7 is a high vulnerability. Some spots of Citizenship Association (CA) VI of Sukorejo Village have a high economic vulnerability, such as in Neighbourhood Association (NA) 1 and 4.

Table 6. Economic Vulnerability Score Results

| CA VI | Economic Vulnerability | Score | Classification |
|-------|------------------------|-------|----------------|
|       | Total of Poor Population | Unemployed Rate | uninhabitable house |
|       | Existing | Score | Existing | Score | Existing | Score |
| NA 1  | 50.85%     | 3     | 29.7     | 2     | 80.43%    | 3     | 8    | High Vulnerability    |
| NA 2  | 32.04%     | 3     | 17.5     | 1     | 80.39%    | 3     | 7    | Moderate Vulnerability |
| NA 3  | 36.30%     | 3     | 15.9     | 1     | 80.00%    | 3     | 7    | Moderate Vulnerability |
| NA 4  | 46.85%     | 3     | 24.2     | 2     | 79.41%    | 3     | 8    | High Vulnerability    |
| NA 5  | 29.55%     | 3     | 16.5     | 1     | 79.07%    | 3     | 6    | Moderate Vulnerability |
| NA 6  | 48.60%     | 3     | 13.3     | 1     | 80.65%    | 3     | 7    | Moderate Vulnerability |
3.4 Institutional Vulnerability Calculation

The vulnerability of institutions is related to the role and function of institutions, where both the community and government are able to manage the risk of landslides. Institutional vulnerability Citizenship Association (CA) VI of Sukorejo Village has a low level of vulnerability; this can be seen from the possession of an agency that manages landslide disaster risks and discussion forums.

Based on field reviews and study of [24], the institutional role in managing landslide disaster risk has been very good. This can be seen from the existence of the Disaster Preparedness Village allowing the community to participate in the implementation of disaster management. This can create a disaster response of community to minimize the impact of disasters; to increase the ability of the community to deal with disasters before, during and after a disaster.

In addition, there are institutions such as the Semarang City Regional Disaster Management Agency which have 3 functions in disaster management, such as in emergency and logistics, prevention and preparedness, and rehabilitation and construction. There is also a Community Service Activity from the academy which holds a Landslide Disaster Mitigation Training that is aimed for women community in Citizenship Association (CA) VI.

4. Conclusion

The conclusion of this study is the settlement of Citizenship Association (CA) VI in Sukorejo Village which has high physical vulnerability. This is because the physical condition of the area is on a slope with high rainfall intensity. The settlement of Citizenship Association (CA) VI in Sukorejo Village has high and moderate social vulnerabilities. In this study, population density and population structure according to education level became one of the factors that drive the high social vulnerability in the study area.

Citizenship Association (CA) VI in Sukorejo Village has medium economic vulnerability. The large numbers of uninhabitable homes in the region, poverty and unemployment rates are included from influencing factors. This must be prevented because many people live in a disaster area thus, it is necessary to have an element of economic readiness in the community to form resilience to disasters. Citizenship Association (CA) VI in Sukorejo Village has low institutional vulnerability; the existence of Disaster Prepared Village has become one of the efforts to realize the disaster response community.

The suggestions are provided to address the majority of high vulnerability in physical, social and economic conditions and settlement locations that are not in accordance with the designation of Semarang City and Regional Spatial Plan in 2011-2031, relocating the people to safety and spatial suitability settlement. The mitigation option in the existing settlement activities is to provide physical strength of the area such as environmental engineering for safeguards because this aspect becomes a high vulnerability at the study area. Another mitigation option is to provide socialization and training related to disaster mitigation to increase community sensitivity and awareness to reduce aspects of social and economic vulnerability.
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