Structuring the Environment of Landslide-Prone Disaster and Its Mitigation in The District of Banyumanik

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Abstract. This research is conducted in the district of Banyumanik Semarang. The objectives of this study are; (a) recognising the distribution of landslide-prone residencies in the district of Banyumanik; (b) recognising the community efforts in dealing with their landslide-prone residency environment. The sample is taken by Purposive Sampling Technique, i.e. by considering the possibility of an area to landslide. The researched variables are (1) Physical parameter of landslide-prone field in residency environment, (2) The efforts accomplished by the community to overcome landslide-prone environment. The result of this research has varied in five categories. They are residencies with very high, high, medium, low and very low of landslide-prone. Two countermeasures from the community to prevent landslide are; (1) physical prevention, covering: constructing embankments and drainage channels, sealing/covering cracks on the ground, building blocks, planting hardwood plantations, and (2) partnership prevention, a cooperation between the community with the related institution, such as disaster socialization and land use planning.

1. Introduction
In consideration of establishing the synergy of the nature productivity and sustainability, the development of settlements needs to be integrated directed. Choosing the right location for the settlement has a strategic meaning, and important in spatial aspect [1]. This may also determine the lastingness of the building, its economic value, and its impact on the surrounding environment.

The yearly increase of Indonesian population has brought its consequence towards the increasing needs of settlements as living space. In contrast, the limited land for housing has caused many buildings and facilities constructed on unfavorable locations, where the inhabitants may get endangered for they are located in a disaster-prone landslide area.

Landslides occur because of the movement of land or rocks along or out of the slopes due to gravity. Landslide is caused by three main factors: (1) Inherence factors, cover the depth of rocks weathering, geological structures, soil solum thickness, soil texture, and soil permeability. (2) External factors of an area, such as, the incline of hill, number of steep walls, the incision density, and land use. (3) Prompt factors, the high intensity of rainfall, and earth quakes [2].

It requires a regional information in any regional development planning, whether for resettlement or other uses. Thus, considering a continuously changing of information, therefore, a quick storing, as well as editing, and analyzing system is needed.
A database collected by Directorate of Volcanology and Geological Disaster Mitigation, and Directorate General of Geology and Mineral Resources shows that disasters due to landslides still have a relatively high frequency, followed by the number of casualties and loss of possessions.

Based on RTRW the City of Semarang, year 2011-2031, Banyumanik is one of the districts in Semarang BWK VII designating for settlement and other buildings. Banyumanik consists of 11 sub-districts with yearly increasing population; 125.796 inhabitants in 2010 and 131.330 in 2014. This condition will affect the use of land for settlements or other buildings that also automatically increasing from 927,63 Ha in 2010 becomes 1.935,56 Ha in 2014. In results, many houses locate in hilly, sloping, even steep areas which are risky to landslide-threat [3].

The instability of sloping area worsened by unaware and reckless human activities, such as deforestation of steep hills, cutting off cliff for opening road, and building settlements on downhills will accelerate the process of the lands to slide. This may lead to many losses [4, 5]

Thus, the purpose of this research is (a) Knowing the escalation of the landslide-prone neighborhood in the district of Banyumanik, Semarang; (b) Knowing the community efforts to overcome the problem of the landslide-prone neighborhoods in the district of Banyumanik.

This research contains two aspects of advantage; Science Development and Construction aspects.

- Advantage for Science Development: (a) Contributing study on settlements and the danger of landslides; (b) Developing geography as science, especially about disasters.
- Advantage for Construction: (a) The results of this study are expected to be used as inputs or information for the party of policy makers related to landslides, in this case; the Local Government Level II, Department of Public Works, Department of Social Service and other parties that are related to development planning and construction of the district of Banyumanik in Semarang; (b) the information in this research can be used as a reference for spatial plan in the research areas, especially those with high level of landslide-threat.

2. Methods
This research is conducted in the district of Banyumanic, Semarang. The object of research is Nature Phenomenon (physical condition) and the lands used for settlements. The population of research is the physical condition and the land used for settlements in the district of Banyumanik.

Sample is taken by using Purposive sampling technique, or sampling on the terrain by considering the possibility for landslide occurrence, by taking 23 samples. The variables in this study include:

a. Physical parameter of landslide-prone areas in the settlement environment, contains of: (1). Variable of Foothills (Slopes), includes: declivity, length, foothill forms; (2). Variable of Soil, includes: soil texture, soil solum thickness, permeability, and soil plasticity index; (3). Variable of Rocks, includes: structure of rock layering, thick density, and rock strength; (4). Variable of Geomorphology process, includes: degree of rocks weathering, depth of rocks weathering, and prior landslide occurrence: (5). Variable of Hydrology condition, includes: the depth of groundwater, centralizing springs or seepages, and water infiltration into the soil.; (6) Variable of Field condition, includes: land use formation, vegetation density, presence or absence of excavation, and number of steep walls. (7). Variable of Rainfall, monthly and yearly rainfalls. As for the variables of land use under this research, is the use of land for existing condition of settlements.

b. The community effort to overcome landslide-prone disaster in their environment

This study consists of primary and secondary data. The primary compiles some data on slopes declivity, soil texture, incision density, land use, depth of rocks weathering, number of steep walls, soil solum, soil permeability, vegetation density, level of rocks weathering, rocks layering structure, rocks strength, depth of groundwater, and seepages.

Secondary data covers; monthly rainfalls from 2006 to 2015, geology and rocks structure, types of soil and its permeating, land used for settlements, slopes declivity, and geomorphology process.
This study applies direct observation/surveying method, that is; observing and measuring the field parameters as one of the research variables, continued by a laboratory work to analyse the physical or biological characteristics of the sample soil. Next, the data is analysed by using:

- a. Analysis of qualitative description; used to generally describe the researched areas.
- b. Analysis of Overlay map, assisted by ArcGIS 10.3 tool, to obtain (1) field unit map, (2) landslide-prone disaster map, and (3) landslide-prone residency environment map.
- c. Analysis of scoring/enhancement, is achieved by accumulating the scores for each of the 18 physical field parameter variables in the settlement environment. The result is, then, used as the basis for determining the level of vulnerability of landslide.

3. Results and Discussion

3.1. Variation of prone to landslide in the district of Banyumanik.

The degree of landslide vulnerability in the district of Banyumanik is determined through the field unit analysis by scoring or enhancement. The scoring analysis is done by accumulating the scores for each of the 18 physical field parameter variables relating to the landslide. This scoring is, then, used for compiling the map. The result for each physical field parameter variable relating to landslide is shown in table 1, as following:

Table 1. Areas breadth that are prone to landslide in the district of Banyumanik

| No | Class of landslide hazards          | Width (Ha) | Width (%) |
|----|------------------------------------|------------|-----------|
| 1  | Very high landslide hazard         | 245.64     | 4.70      |
| 2  | High landslide hazard              | 384.09     | 9.18      |
| 3  | Medium landslide hazard            | 868.27     | 28.08     |
| 4  | Low landslide hazard               | 952.04     | 30.76     |
| 5  | Very low landslide hazard          | 843.55     | 27.25     |
|    | Total                              | 3,092.59   | 100       |

Source: Research, 2016

Table 1 shows that the District of Banyumanik has various of landslide potential, from very high to very low. The highest landslide hazard class width, i.e. low landslide hazard, covering 952.04 Ha or 30.76% of the researched area, extending to the small part of Jabungan and Sondol Kulon sub-districts. The next class is medium landslide hazard, covering 868.27 Ha or 28.08% of the researched area which extends to Jabungan sub-district. The third width; low landslide hazard, covering 843.55 Ha or 27.25% of the total researched area, this class extends to Sondol Wetan, Sumurbroto, and Pedalangan sub-districts. The fourth is high landslide hazard class, covering 384 Ha or 9.18% of the researched area. It extends to Ngesrep, Tinjomoyo, Gedawang, and Pudakpayung sub-districts. The last, is the least width of landslide hazard class, i.e. very high landslide hazard class. It covers 245.64 Ha or 4.70% of the total researched area.

3.2. The Distribution of Landslide-prone Residency Environment in the District of Banyumanik, Semarang

Using the basis of an overlay, supported by SIG ArcGis 10.3. program between the two maps of landslide vulnerability level and land use, in the district of Banyumani, Semarang, this research obtains a map of residency environment with varying degrees of landslide vulnerability, as shown in Table 2.

Table 2. Landslide-prone residency environment breadthness

| No | Housing Classes                           | Width (Ha) | Width (%) |
|----|------------------------------------------|------------|-----------|
| 1  | Settlement having very high landslide hazard | 26,188     | 1.52      |
| 2  | Settlement having high landslide hazard  | 381,091    | 22.14     |
| 3  | Settlement having medium landslide hazard | 27,003     | 1.59      |
| 4  | Settlement having low landslide hazard   | 546,850    | 31.78     |
| 5  | Settlement having very low landslide hazard | 739,374    | 42.97     |
|    | Total                                    | 1,720,30   | 100       |
Table 2 shows that, there are residencies in Banyumanik district which have several variations of landslide vulnerability classes. They are very high, high, medium, low, and very low landslide hazards. The residency in Banyumanik district, located on very low landslide-prone area, settles in 739,374 Ha or 42.97% of the researched area. The residency located on low landslide-prone, settles in 546,850 Ha or 31.78% of the researched area. The residency located on medium landslide-prone, settles in 27,003 Ha or 1.59% of the researched area. The residency located on high landslide-prone, settles in 381,091 Ha or 22.14% of the researched area. The residency located on very high landslide-prone, settles in 26,188 Ha or 1.52% of the researched area. The detail is shown in Figure 1.

Accommodating landslide disaster evacuation and first aid trainings for each group of susceptible community; (l) Avoiding the act of aggregating on the top and cutting the part of foothill; (m) Desiccating puddle, pond, pool, etc. on top of the slopes/foothill. (n) Reforestation barren area using particular plantations; lamtorogung/leucaene, sanakeling/Java palisander, etc.; (o) Controlling the surface water so as not to cause erosion which leads to deeper waterway; (p) Preventing abrasion of rivers adjacent to build area, afflicting balance of the slopes; (q) Closing/Flattening inundated areas that allow puddles; (r) Using of building blocks (poles, walls, etc.); (s) Organizing the planning land use according to conservation guidelines; (t) No trees cutting in sloping area to avoid landslide; (u) Planting hard0rooted plants (such as, mahogany, teak, Java palisander, etc.) in landslide-prone area; (v) Government needs to make maps of landslide-prone disaster for district/sub-district or landslide potential area.
3.3. Discussion

3.3.1. Prone to Landslide in the district of Banyumanik. The degree of vulnerability to landslide illustrates the condition of the tendency or potential of a natural field or slope for landslide. It is closely related to the physical condition of the terrain. The higher the in order to obtain the variation of the hazard level of landslide on various field units, this research classifies the number of digits of each unit such as the classification criteria of the physical characteristics of the terrain that has been presented in the methodology. The sum of the value or variables are used as the basis for determining the degree of vulnerability of landslide disaster.

The district of Banyumanik has a various landslide potential, from the very high to the very low. The highest landslide hazard class width, i.e. low landslide hazard, covering 952.04 Ha or 30.76% of the researched area, extending to the small part of Jabungan and Srona Kulon sub-districts. The next class is medium landslide hazard, covering 868.27 Ha or 28.08% of the researched area which extends to Jabungan sub-district. The third width; very low landslide hazard, covering 843.55 Ha or 27.25% of the total researched area, this class extends to Srona Wetan, Sumbroto, and Pedalangan sub-districts. The fourth is high landslide hazard class, covering 384 Ha or 9.18% of the researched area. It extends to Ngserip, Tinjomoyo, Gedawang, and Pudakpayung sub-districts. The last, is the least width of landslide hazard class, i.e. very high landslide hazard class. It covers 245.64 Ha or 4.70% of the total researched area.

The five variations of the landslide hazard levels indicate that Banyumanik district needs more attention in relation to landslide disaster which may occurs anytime in the area. Considering the situation, the community must be aware and responsive towards the danger of landslides. By having an awareness of the high landslide potential around them, they will be more prepared and ready to affront the landslides.

3.3.2. The distribution of landslide-prone housing environment in the district of Banyumanik, Semarang. Structuring the landslide-prone residency environment in the district of Banyumanik, Semarang is conducted by mean of overlay analysis between the two maps of the land use for settlements, and the level of landslide-risk. In order to determine whether or not an area is positioned in low or high level of landslide-risk, we use the following guidelines; (a) If the level of very low landslide vulnerability is overlaid with the use of settlement land, it will result in a settlement with very low landslide susceptibility; (b) If the level of low landslide vulnerability is overlaid with the use of settlement land, it will result in a settlement with low landslide susceptibility; (c) If the level of medium landslide vulnerability is overlaid with the use of settlement land, it will result in a settlement with medium landslide susceptibility; (d) If the level of high landslide vulnerability is overlaid with the use of settlement land, it will result in a settlement with high landslide susceptibility; (e) If the level of very high landslide vulnerability is overlaid with the use of settlement land, it will result in a settlement with very high landslide susceptibility.

Based on the overlay result using SIG ArcGis 10.3. program between landslide vulnerability map and the map of land use for settlement in the district of Banyumanik, Semarang, thus, a map of residency environment with varying degrees of landslide vulnerability is obtained, i.e. settlements located in areas categorized as having very high, high, medium, low, and very low landslide vulnerability levels.

The settlements in the district of Banyumanik, occupying 739.374 Ha or 42.97% of the researched areas, belong to a very low level of landslide vulnerability. Next, the settlements located in low landslide-prone areas occupy an area of 546.850 Ha or 31.78% of the researched area. Then, the settlements located in medium landslide-prone areas occupy an area of 27.003 Ha or 1.59% of the researched area.

Followed by the settlements positioned in high level of landslide vulnerability, occupying 381.091 Ha or 22.14% of the researched areas. Whereas, the settlements located in very high landslide-prone areas occupy an area of 26.188 Ha or 1.52% of the researched area.
Since the residency environments categorized as high and very high landslide-risk levels cover some area of 407.209 ha, therefore, these settlement areas are necessarily and carefully managed. The fortitude in managing the disaster-prone areas is expected to reduce casualties in case of landslide. In addition, the community needs to put a landslide preventive effort to minimize this kind of disaster in the future.

4. Conclusions
Here are some conclusions based on the results of this research:

- There are five levels of landslide danger in the district of Banyumanik; very low, low, medium, high, and very high levels.
- The distribution of landslide-prone residency environment in the district of Banyumanik, Semarang has 5 variations: very high level of landslide settlements (in the area of 26,188 Ha), high level of landslide settlements (in the area of 381,091 Ha), medium level of landslide settlements (in the area of 27,003 Ha), low level of landslide settlements (in the area of 546,850 Ha), and very low level of landslide settlements (in the area of 739,374 Ha).
- So far, the community has done some efforts to prevent landslide from happening in the residence. Among the physical preventions are; constructing embankments, drainage channels, closing cracks in the ground, building retaining walls, planting perennials, and also prevention by the community in partnership with other related parties; such as disaster socialization, and land use arrangement.

Based on the result of this research, it is recommended that: (1) the community alongside with sub-district government in Banyumanik have the awareness for landslide-prone location. (2) the community are able to settle in the area with low level danger of landslide. (3) the community and government have to cooperate in landslide disaster mitigation in order to minimize the impact and loss in case a landslide occurs.

References
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