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Early Identification for Prospective Housing Area in the Landslide Potential Zone

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Abstract

Identification of area for prospective housing before construction is much needed, especially area with a steep slope and young volcanic that have landslide risk. The risk of landslides is not only caused by high rainfall or steep slope but can be caused by shocks due to earthquakes. It is necessary to identify the rock types in the prospective housing near Mount Salak in Cijeruk area, Bogor Regency. The purpose of this research is early identification types of rocks, soils, and potential of a landslide in prospective housing by geological and soil survey methods. The geological survey method used is to identify morphometry and lithology specially landslide, whereas soil survey identifies soil characteristics. According to results of research, morphometry at prospective housing is included moderately until steep slope category. Steep slopes potentially cause landslides with debris avalanche type. Characteristics of soil at Cijeruk support it has an of high coefficient of linear extensibility; this condition affects the shallow foundation movement. Therefore needs additional material so that the coefficient of linear extensibility value becomes low. The soil in this location comes from volcanic activity with tuff and lapilli types, sometimes found pebbles until boulder, and they are not lithification. If the location of the housing is exposed to an earthquake with a scale of 5 SR, it would be high shocks and areas with steep slopes would cause landslides. For maintenance from landslides, retaining walls need to be made with the type of gravity wall and cantilever wall. The distance between the retaining wall and housing is 15 meters. The type of foundation to be used is the foundation of the spread footing.

Keywords: prospective housing, landslide potential, Cijeruk.

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1. Introduction

House is an investment sector which is rarely founded losses. Observers and property business owners are optimistic that the property sector in Indonesia is predicted to re-grow rapidly in the second half of 2017 [1]. However, if the stability of the land does not support the development of the housing sector, it causes losses. It occurs because Indonesia is also a country that has the potential geological hazards, among which the landslides, earthquakes, volcanic eruptions, and tsunami.

The prospective housing location at Cijeruk, Bogor Residence also has the landslide potential, because it is located in a region with young volcanic lithology and the morphometry at the foot of Mount Salak that has a moderate slope to steep. Base on the data various news online sources (Table 1), Cijeruk area and it is Surrounding have the number of landslide incidents. In the last four years from 2014 to 2017, there was an incident which caused the death of five people, houses were severely damaged, and road damage.

Data the incidents of a landslide at Cijeruk and its Surrounding could be a consideration to avoid losses caused by land instability due to a landslide. So it is crucial to identify soil and lithology, to provide necessary information for identifying potential problem areas before construction [2].

The purpose of this research is to identify the morphometry and analyze the condition of rocks, and the potential of a landslide on the prospective housing land in Cijeruk Bogor Regency.

Table 1: Landslide incidents from 2014-2017.

No	Date of incident	Location	Event Details	Ref
1	28th July 2017	Geblug RT04/01, Palasari village, Cijeruk district,	Geblug RT04/01, Palasari village, Cijeruk district, named Ijma (30), His house was heavly damaged by landslide around 18:30 pm	[3]
2	20thMarch 2016	RT8/RW3 Tanjungsari village, Cijeruk district, Bogor regency, West Java	Pouring rain that flooded in Bogor area on Sunday (20/03/16) afternoon until night caused 20 meter high ground located in Cijeruk village, Palasari Village, Cijeruk district, Bogor Regency.	[4]
3	5thFebruary 2016	in Sungapan village RT 03/01 Wates Jayam village Cigombong distric	Landslide disaster occurred in Sungapan vilage RT 03/01 Wates Jayam village, Cigombong sub-district. As a result, the road to Sungapan and Lengkong village disconnected, because buried by mud soil along approximately 20 meters with a thickness of 80 cm.	[5]
4	29thNovember 2015	RT8/RW3 Tanjungsari village, Cijeruk distric, Bogor regency, West Java	the landslide in Tanjungsari village occurred at 05.00 am on Sunday morning, the incident resulted three people injured by landslide and four houses damaged	[6]
5	6thNovember 2015	Bungur village RT 02/05, Tajur Halang vilage, Cijeruk disric	the occurrence at 17:00 pm, landslide was in the road with the width of landslide 12 meters, a height around 6 meters, and resulting water dragged the official house.	[7]
6	4th October 2011	01/04,Palasari village, Cijeruk Distric, Bogor, West Java.	Landslide that occurred at 05:15 pm resulted 5 people killed	[8]

2. Literature Review

Landslide is a natural phenomenon that would occur with or without human activity. Landslides are the displacement of slope-forming material in the form of rock, debris material, soil, or the mixture material, moving down or out of the slope [9]. To determine the cause of landslides, must examine slope stability, which can be expressed in terms of the forces that act on a slope. Driving and resisting forces on slopes are determined by the interrelationships of the following variables: a. Type of earth materials; b. Slope angle and topography; c. Climate; d. Vegetation; e. Water; f. Time [10]. After determining the force of landslide, then to determine type landslide. Classification of landslide according to USGS [11], that has twelve classifications of the landslide. The purpose of identifying landslides is so that the land to be built has to land suitability for settlements, avoids landslide hazards and knows the techniques to be used if landslides may occur.

Good land suitability for housing has several criteria, i.e., a. slope $<$ 8 percent or gentle to flat slope; b. Low coefficient of linear extensibility; c. No landslide; d. No subsidence; e. Depth of hard lithology $>$ 100 cm and soft lithology $>$ 50 cm; f. Depth of level groundwater $>$ 75 cm; and g. No flood [12]. If the soil according to its geological composition is predicted to be easy to landslide, then the suitability of the land for the house becomes worse [13]. Land suitability research in the Semarang Region includes elements of fault lines, and if there are no faults, it can be said to be very suitable for housing land [14]. Before analyzing further, there are some that must be known in the literature regarding lithology and soil in the Cijeruk area and its surroundings.

2.1. Geological of Cijeruk area and its surrounding

Based on map Sheets of Geology Bogor [15], the geology of Cijeruk and surrounding areas is composed by volcanic lithology of Salak in the form of lava, tufan breccia, and lapilli, andesite basalt arranged. Generally, it is very obsolete (Figure 1). Cijeruk area is the foot of Salak Volcano, young volcanic rocks contained therein are derived from Mount Salak which follows the pattern of the slope. Cijeruk area has been dominated by moderately to very steep hill such as a bumpy hill. Resources in Cijeruk district are sands and stones which are breccias tufan products and lapilli in andesite. However, Cijeruk area is a productive aquifer area with flow through granules and intergrain spaces, but it is local (Kementrian Pekerjaan Umum, 1990 in [16]). The underlying rock is lava. As seen in more important details in Figure 1.

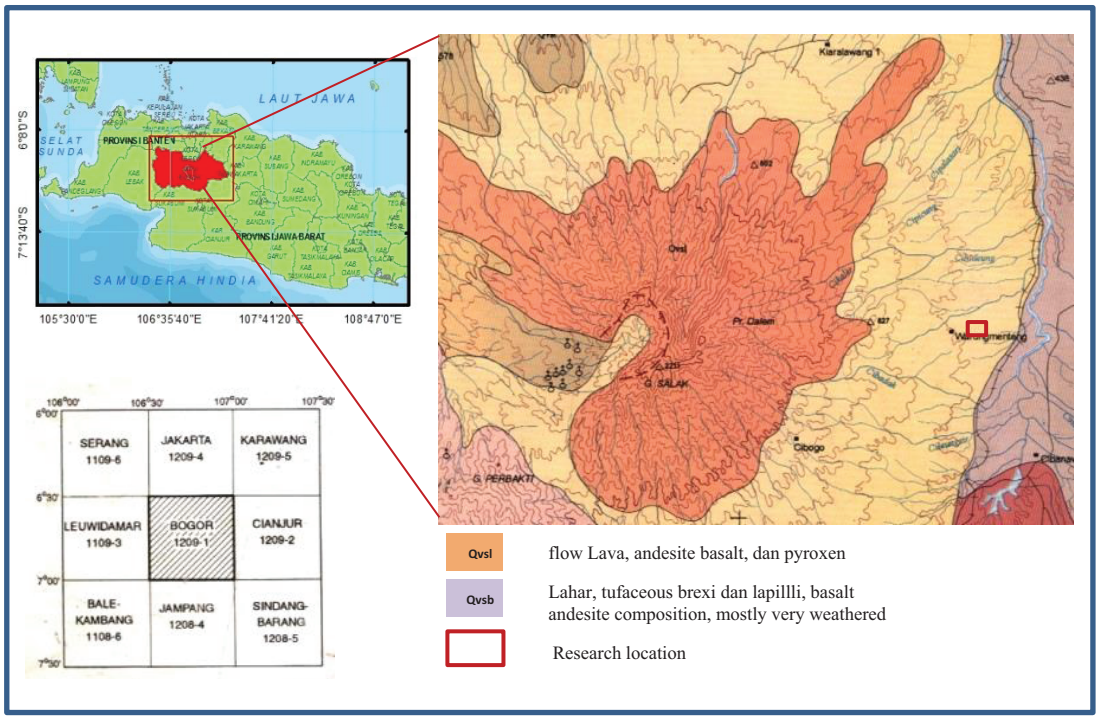

Figure 1: Geological map of Cijeruk area and surrounding [15].

2.2. Land condition and landslide Cijeruk area and surrounding

Based on data that was obtained from the Department of Spatial Planning and Land of Bogor Regency [17], Cijeruk district is dominated by red-yellowish podzolic with large about 1,650.95 Ha, while the type of soil with the least area is Regosol type with large about 254,14 Ha (Table 2). This type of soil is the result of weathering is the result of volcanic eruptions. This soil has the composition of most clay with little sand.

TABLE 2: Soil type in Cijeruk Distric.

No.	type of Soil	Large (Ha)
1	Andosol	566,14
2	Asso Lat brown regosol	1.178,77
3	Pod red yelowish	1.650,95
4	Regosol	254,14
	Total	3.650,00

Source:[17].

Based on Potential Forecast of a Landslide map in West Java in November 2015 [18], Cijeruk district has a medium landslide. Medium landside can occur rainfall above normal in this area especially in the bordering area of river valleys, escarpment, road cliffs or are disturbed.

According to the DESDM [16], said the same thing, in Bogor Regency fourteen districts, are belonging to the middle landslide zone. Most of Cijeruk district area is in the intermediate landslide zone. One of the villages with a medium landslide is Sukaharja village. A small portion of another area belongs to low landslide zone.

According to susceptibility to landslide zone map, Bogor city and Regency [19], in the middle of susceptibility landslide zone could occur mainly in the bordering area of river valleys, mountains, road cliffs, or if the slopes are impaired. The old landslide could reactivate due to high rainfall and active erosion. Range of gentle slope (5 -15%) to steep slope hills (> 70%) depending on the conditions of physical properties and technique of rocks and soil forming slope. The condition of cover vegetation is generally less to very rare.

3. Method

The research method used is a literature study, fieldwork, and studio work. The first stage is literature study such as Geological map, and reports were obtained from relevant government institution such as the Department of Energy and Mineral Resources research results from the Bogor district government [16]; Regional geology map from P3G Bandung Center scale 1: 100.000 [15]; Landslide zone map Bogor city and Regency scale 1: 250.000 [19]; Earthquake Hazards zone map of West Java Province scale 1: 500.000 [20]; Volcanic hazards map of Salak Volcano, West Java Province scale 1: 50.000 [21]; Class of morphometric by van Zuidam (1985) in Noor (2014) [22]; and Land System map from RePProT scale 1:100.000) [23].

After study literature and got the problem for Cijeruk area, so that next stage is fieldwork to collect data primer, i.e., morphological observation, outcrop observation, measurement of a slope, and rock sampling, and soil sampling. Hand auger method used for soil and lithology description. The material for geological and soil mapping uses are, i.e., soil taxonomy by USDA (2014) [24] and LPT (1961) in [25], geology hammer, loop, compass Brunton, sunto clino, and hand auger for soil sampling.

Next stage after field work is studio work. studio work activity is plotting data by using ArcGIS software. The measurement results in the field were then analyzed and compared with previous studies. The analysis of studio work, i.e., morphometry analysis, lithology analysis, soil analysis, potential landslide analysis are used in this study.

4. Discussion

4.1. Morphometry

Based on morphometry or slope class of van Zuidam [22] with the condition of land maturation, slope class of housing location plan includes classification 8-15 percent or slightly sloping category. However, on the edge of Southwest and Southeastern region boundary is classification 15-25 percent or slightly steeper class, in the Northeast until the North region including the slope class> 40% or steep. In the prospective housing, the area is conducted land clearing and land maturation. Besides, it has also created a block by terracing system or per elevation from the North until the South is raised 1 meter per block. Based on land suitability [12], steep slope classes are not suitable for housing area.

If initial reconstruct of this housing estate, initial morphology is two ridges mount by in the middle is an intermittent creek (Figure 2). This is based on location border contours of the eastern and western edge having a higher elevation than the contours in the center of the housing where condition existing is made subdraine (Figure 3). Above the subdraine is made a path between blocks.

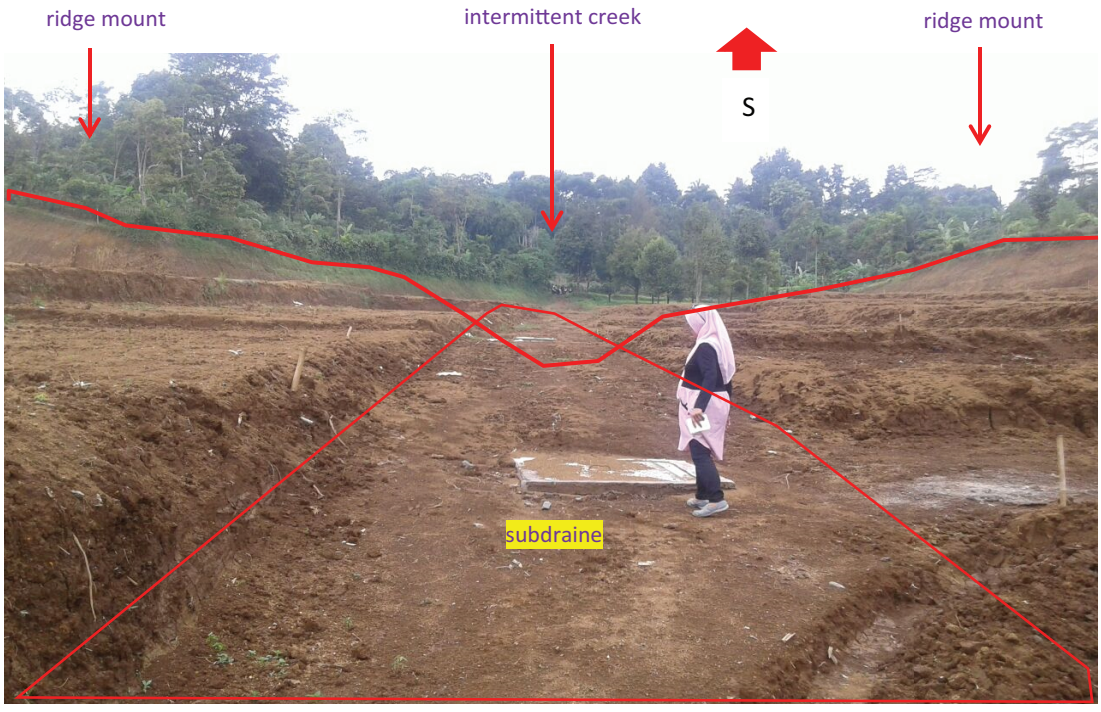

Figure 2: Morphological reconstruction in the prospective housing (Pamungkas et.al., 2018; field work; October 2017).

Land condition in a residential area that opened have including gentle to very steep, also have rainfall hight category cause erosion in this region including the high category. Rate of rainfall infiltration in slope class condition will be reasonable, but infiltration in

steep slopes will be easy to run off. In the Northeast, there is a gabion with a slope 85° following the pattern of the slope. Besides that, there is a subdraine pipe on the part of the gabion.

Figure 3: Gabion condition and subdraine pipe in prospective housing land (Pamungkas et.al., 2018; field work; October 2017).Soil Type at Cijeruk Area.

Soil that formed on the location of the prospective housing is the soil from the destruction of Mount Salak eruption. Morphologically, soil that is built both in texture and structure but not good in nutrient content. This soil type is classified as brown Latosol in LPT 1961 and Typic Dystrudept in USDA 2014 [24].

Latosol soil is deep solum soil, and it undergoes further leaching and weathering. Primary mineral content and low nutrients, loose consistency loose with strong aggregate stability and occurring of relatively cesium oxide buildup in the soil is a result of silicate leaching. Red soil color, reddish brown, brown, yellow or yellow-brown depend on main material, climate, color rock, and elevation. In Indonesia, it is found mainly in volcanic areas both from tuffs and igneous rocks.

Condition of soil layer at the location of the prospective housing is intense, not founded the main rock for soil compiler until the depth> 2 meters (Figure 4). Latosol is an adult-growing soil, characterized by clay mineral deposits in the eluviation layer. Soils with clay content could shrink in dry conditions and expand at wet times. These conditions affect shallow foundation movement. In dry clay soil surface would be a lot of cracks through this crack, water could get into the bottom of the foundation, and it would weaken the soil under the foundation.

The latosol at previous prospective housing was used as a mixed garden and shrub. On the topsoil layer is dominated by clay texture with slow soil permeability and soil susceptible to erosion.

Figure 4: Soil profile of prospective housing (Pamungkas et.al., 2018; field work; October 2017).

4.2. Lithology at Cijeruk area

Lithology at prospective housing is a product of a volcanic eruption from Mount Salak, most of the eruption products are tuff and lapilli, and that is not found rocks that have experienced compaction or lithification. Outcrops colors are light brown to dark brown, generally extraordinarily fragile and cracked, and was found fragment which was granule until pebble size with angular until subangular

This type of Salak Volcano product is very easily eroded if left without land cover. On the wall that has exfoliated in the southern and southwest is found volcanic tape layer showing eruption Salak volcano period (Figure 5). Level of groundwater in this area is 40 cm, hence this area according to land suitability is not functional because of shallow groundwater levels.

Figure 5: Salak Volcano product in prospective housing land (Pamungkas et.al., 2018; field work; October 2017).

Because rock products are only tuff and lapilli, many layers of clay, and do not lithification, then as a basis for construction generally would be easy to crack, as a result of wrinkles from clay layer of the tuff.

On the northern side outside of the housing location precisely in the intermittent creek is found alluvial-sized sand and boulder. Based on observation under the loop, alluvial-sized is fine sands to coarse sand, dark brown, not compact, good porosity, poor sorting. The fragment is dark gray, massive, afanitic, it compositions: olivine, pyroxene, amphibole, plagioclase, orthoclase, and little biotite. Then these rocks included in the basalt rock.

4.3. Landslide

Based on landslide data from various online media sources, the incidence of landslides in Cijeruk district from 2014 to 2017, there are six events recorded that have casualties, heavy damage house, and damage to road infrastructure. Based on field observations could be seen that type of latosol soil have very loose conditions. The slope is slightly sloped until steep slope, and high rainfall, Cijeruk district includes vulnerable to landslide disaster. It is also based on the Department of Energy and Mineral Resources of Bogor Regency (2016) [16]. Cijeruk District is located in the middle landslide zone. Old soil movements could reactivate due to high rainfall and severe erosion. The type

of landslide is debris avalanche [11], because unconsolidated rock and soil, very rapid flow supported by a steep slope.

In the western and eastern part of the housing, there is a steep to an extremely steep slope, with land use is mix garden and shrubs for instance pineapple plants. From this vegetation type, the root to retain soil erosion is not strong enough, so that the soil would be easy to erode.

In the northwestern part of this housing, there is an intermittent creek that has a very steep slope. In this part, the creek is only made a gabion to hang on the bottom, with the position of gabion 75°-80°. Observations results of the housing represent that the position of prone landslide occurrence is in two borders the East and West of the house. In Figure 6 is marked red and yellow lines. Yellow line area has a medium level of land movement, and red lines area has a high level of ground movement.

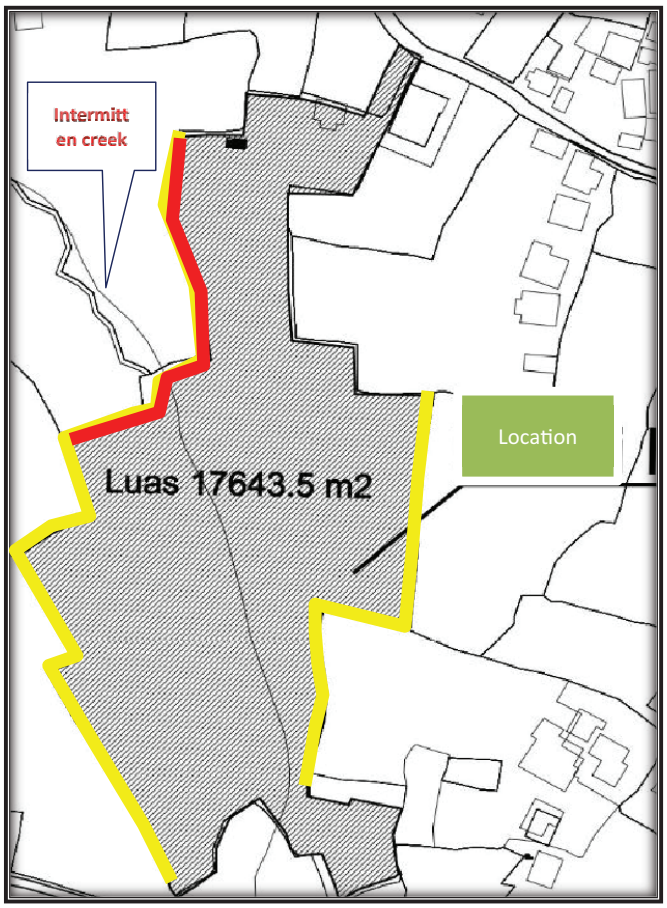

Figure 6: Supceptibility to landslide map in the prospective housing land (Pamungkas et.al., 2018; field work; October 2017).

5. Conclussion

The observation results show theoretical discussion and existing conditions in the field, and several conclusions can be made morphometry in the prospective housing plan area including the slope class is including slope classification of 8-15 percent or moderately slope category. But in the Southwest and Southeast region boundary is a classification 15-25 percent or slightly steep slope, in the Northeast to the north including the slope class> 40 percent or steep. Morphology of this area originally is two ridge hills which in the middle is an intermittent creek. The class slope in this area have the potential to landslide especially intermittent creek and not suitable with land suitability for housing area.

The soil in the location of prospective housing is from latosol soil and is the destruction of Salak Volcano eruption. Soil layer condition in the location of the potential house is profound, it is no found the main rocks for soil compiler until the depth of> 2 meters. This soil type has a clay content that could shrink in dry conditions and swelling when a wet condition. This condition affects on shallow foundation movement.

Lithology in this area is young volcano eruption products from Mount Salak. Most of the eruption products are tuff and lapilli, it is not found rocks that have lithification. So as a basis for construction generally would be susceptible to cracks, as a result of high coefficient of linear extensibility from the clay layer of the tuff. Therefore this housing area needs additional material so that the cole value becomes low.

Potential landslide in this housing, there is two categories medium and high landslide in the edge of West and East border. High soil movement is found in the intermittent creek path which has a steep slope. Recommendations for maintenance from landslide; hence it is necessary to make gravity type retaining walls and cantilever type retaining walls. The distance between the retaining wall and the housing is 15 meters. Type of foundation to be used is the foundation of spread footing.

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