Landslide Disaster Potential In Warungkiara District, Sukabumi Regency, Based On The Analysis Of Quantitative Geomorphology And Land Use Data

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Abstract. Land usage increases along with the rising population growth and development of a region. This leads to a greater potential for natural disasters caused by land degradation, especially on land with relatively steep to steep slopes. The research area is located in Warungkiara District, Sukabumi Regency, West Java Province. Geographically, Warungkiara lies between -6.910833° S – -7.000833° S and 106.712222° E – 106.802778° E. The study was conducted using primary fieldwork data and supporting secondary data. The geomorphological aspects considered in this research are the morphometric aspects supported by the land use of the research area. This research intends to assess the potential of landslide disaster based on quantitative geomorphology and land use data with hopes that it can be used as a reference for land management policies and for zoning landslide prone areas. Based on the analysis of quantitative geomorphology and land use data, areas with high likelihoods of landslide are found in research area zones 1, 5 and 6 which both have >40% grade. Areas with potential for landslides are found in zones 2 and 3 with grades of 15-25%. From our observations, areas with landslide potential have ineffective land management. It is recommended that land use in landslide prone areas should be reviewed, with a greater emphasis on land use that can reduce landslide potential. Human settlements and vital human activities should avoid areas of potential landslide disaster.

1. Introduction

Research was conducted in Warungkiara district, sukabumi regency, west java. While the geographical area of this research is located between -6.910833° S – -7.000833° S and 106.712222° E – 106.802778° E. The location of research has a significant increase in regional development which is characterized by the development of building in the research area and surroundings. The growth and development of regional are often more specific to economic growth and are always accompanied with transformation land use structures. While not all of research area and surroundings are suitable for regional development, this is viewed from a safety perspective from landslide. This can be seen from the characteristics of geomorphological units, diverse and complex landscapes in this research area that is, Moderately Steeply Structural Sedimentary Hills Geomorphology Unit, Moderately Steeply Volcanic Hills Geomorphology Unit, Steeply Volcanic Hills Geomorphology Unit, and Steeply Structural Sedimentary Hills Geomorphology Unit.

The geomorphological characteristics that provide advantages or disadvantages for the people are live in the area, hilly landscapes provide a unique challenge in land use. In make an analysis characteristics of geomorphological in the research area, information will be obtained about characteristics of geomorphological
including Geomorphological Units, Spreading and Altitude of Regions, Topography, and Geomorphological Elements.

2. Regional Geology
Geomorphic processes are transformations, either by physical or chemically, which resulted in changes of the earth’s surface [1][2]. The general process occuely is erosional process which affected by permeability, solubility and other characteristics from rocks.

Forms of the earth’s surface generally through the stages from youth stage, maturity and old age. Physiographically of Sukabumi included in West Java southern mountain range zone [3].Physiographically, [4] divide West Java in to four zones in sequence from nort to south are: Jakarta coastal plain zone, Bogor zone, Bandung zone, Shoutern mountain zone.

![Figure 1. Physiography zone, modified from [5]](image)

Bogor zone is located in south zone of Jakarta coastal plain zone and streched from west to east trough the city of Bogor, Purwakarta, go to Bumiayu in Central Java with a maximum width of about 40 kilometres. Bogor zone has a hilly morphology which is the result of strong folding of Neogen-aged layers and some intrusion[6].

The research area which includes the Bogor zone generally has a hilly morphology. The hills here generally extend from west to east around Bogor city, while in the eastern region of Purwakarta hills turn south, form a curvature around the city of Kadipaten [7].

![Figure 2. Shoutern mountain zone research Area and Area Intrusion Hills [8]](image)
Regional development is one aspect that needs to be considered in the implementation of development. Regional growth and development are often more specific to growth. In the research area centered into dry land which allows the occurrence of landslides in the area.

Landslide occurrence is caused by the following conditions:
1. Steep slope so that the ground mass can move down.
2. Sub-surface layer conditions a rather watertight soil mass and soft, which will be the launch field
3. Adequate conditions of water in the soil so that the soil mass layer is right above the waterproof layer become saturated.

According to [9][10], the factor affect landslide events consist from natural factors and human factors. These natural factors are geology and geomorphology, climate, soil properties, elevation and slope. While human factors are all human actions that can accelerate erosion and landslides, especially in land management and land use.

1. Geological and geomorphological factors
   Steep slopes that are influenced by geological structures such as faults, fractures, folds, are more prone to landslide symptoms. If the direction of rock layer is in the direction of the slope and there is an active fault. In areas prone to landslides there is usually a lot of water content, there is a river that is blocked or deflected. Other indications are irregular crop distribution patterns due to soil movements, including fallen and dead plants.
2. Land parent material
   Soil formed from rock sediments, especially claystone, calcareous claystone or marl and limestone, relatively sensitive to erosion and landslides.
3. Rain Intensity
   Rain intensity determines the size of erosion, while landslides are determined by the saturated conditions of the soil by rainwater and the friction collapse of the gliding field.
4. Elevation and slope
   Slope or slope of the land is one of the factors that occur landslides in mountainous land. Opportunity bigger landslides with increasingly steep slopes.
5. Type of Soil
   Another decisive factor landslide is resilience swipe the sliding field. Resilience friction is determined by shape particle. On shaped particles slab like clay, adding water accelerate collapse. On the contrary on granular-like particles quartz and feldspar, adding water slow down collapse.

3. Data and Method
   Geomorphological characteristics analysis based on primary data filed and secondary data. Three main aspects of geomorphology in the geomorphological unit mapping approach are morphography, morphogenetic, and morphometry.
   1. Morphography
      As a descriptive area aspect qualitatively which is done by analyzing topographic conditions in the field form of landform recognition and identification of visible patterns from the appearance of contour density on the map so it can determine hills or pedestrian. The drainage system that develops on the earth's surface is regionally controlled by slope, type and thickness of rock layers, geological structure, type and density of vegetation and natural conditions.
   2. Morphometry
      As a quantitative aspect of landform and as a determining aspect of other aspects (morphography and morphogenetic). so that the classification will be more assertive in the presence of clear quantitative data. Slope distribution is done quantitatively based on the number of percent and the angle of the slope. The technique of calculating the slope can be done using spatial analysis on a scale topographic map 1: 25.000. With this analysis, the appearance of the slope shape is chosen qualitatively first or spatial appearance and determined class estimates.
3. Morphogenetic
As an aspect of observing the origin of the formation of the earth's surface. The appearance of landforms on the face of the earth based on their causes is divided into two processes that is endogenic as a process that is influenced by the strength of the earth's crust and exogenic processes as processes that are influenced from outside the earth's crust such as climate, vegetation, and erosion.
To know the development of an area, can be done by analyzing the achievement of development outcomes through performance indicators in the economic and social fields as well as other fields using various methods of analysis. One way to find out about regional development is by scalogram analysis based on secondary data from previous research.

4. Result and Discussion
The slope tilt in the study area can be classified into several slopes with altitudes between 175 - 644 meters above sea level. Based on detailed aspects and analysis morphography, morphogenetic and morphometry, the study area can be divided into six 6 zone:

1. Zone 1
Zone 1 is a zone with hilly geomorphological features at an elevation between 262 m-325 m above sea level. Lithology of zone 1 are volcanic tuff and breccia, steep slopes ranging from 25% -55%, with a V-shaped valleys, showing that the erosion rate is getting higher. This zone occupies approximately 10% of the research area which covers the Ciawitali and surrounding areas. This zone is generally used by local residents as residential, and plantation areas.

2. Zone 2
Zone 2 is a zone with high hilly geomorphological features at an elevation between 557 m - 644 m above sea level. Lithology of zone 2 is volcanic tuff, with a rather steep slope ranging from 13% -25%, with a V-shaped valley, showing that the erosion rate is lower. This zone occupies approximately 10% of the research area which covers the Kubang Region and its surroundings. This zone is generally used by local residents as residential, plantation, and rice fields.

3. Zone 3
Zone 3 is a zone with hilly geomorphological features at an elevation between 175 m - 441 m on the surface of the sea surface. Lithologies of zone 3 are sandstone and claystone, with steep slopes ranging from 13% -25%, with a V-Shaped valley, indicating that erosion is lower. This zone is located around 20% of the research area, which covers the Sukamaju area and its surroundings. This zone is generally used by local residents as settlements, plantations and rice fields.

4. Zone 4
Zone 4 is a zone with hilly geomorphological features at an elevation between 225 m - 340 m above sea level. Lithology of zone 4 is volcanic breccia, with steep slopes ranging from 6-13% with V-shaped valleys, indicating that erosion is lower. This unit occupies around 35% of the research that covers Cimanggu Village and its surroundings. This zone is generally used by local residents as residential, plantation and rice fields.
5. Zone 5
Zone 5 is a zone with high hilly geomorphology features at an elevation between 425 m - 595 m above sea level. Lithologies of zone 5 are sandstone and claystone, with steep slopes ranging from 25% -55% with V-shaped valley, indicating that the level of erosion is higher. This zone is still around 10% from the research area that includes Margasari and surrounding areas. Zone this is generally used by local residents as regions settlements, plantations, and rice fields.

6. Zone 6
Zone 6 is a zone with hilly geomorphology features at an elevation between 325 m – 579 m above sea level. Lithologies of zone 6 are sandstone and claystone, with steep slopes ranging from 25% -55%, with V-shaped valleys, indicating that the level of erosion is higher. This unit occupies around 15% of the research area, which covers the PasirDatar area and surrounding it. Part of the land utilized by local people as a residential area, plantations and rice fields.

![Figure 4. Landslide Zonation Map](image)

5. Conclusion
From the results of geomorphological analysis which includes morphometry. Research areas that have steep to somewhat steep hilly topography in the Kubang region, sukamaju area and its surroundings have the potential for disaster in the form of landslides with landslide potential with a percentage of 15-25% which are zones 2 and 3 with residential land use, and plantations while in zones 1, 5 and 6 include Ciawitali, Margasari, Pasir Datar areas and its surroundings with residential land use, plantations, and rice fields.Whereas zone 4 covers the area Cimanggu village and its surroundings are not potentially of landslides. Based on the results of slope analysis, the zone is slightly sloped. So it is suggested that areas prone to landslides must be avoided from land use as settlements or vital human activities to prevent casualties from landslides that will occur. Landslide-prone areas must be considered more in the aspect of land use in order to minimize the potential for landslides that will occur.

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