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# A STUDY ON THE POTENTIAL VULNERABILITY OF DEBRIS FLOW HAZARD IN SUKABUMI REGENCY

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***ABSTRACT***

*Debris-flow hazards are a hydrometeorological disaster that often occurs in parts of Indonesia. The intensity of Debris-flow hazards increases Debris-flow hazards are a Debris-flow Debris-flow hazards are a hydrometeorological disaster that often occurs in parts of Indonesia. The intensity of Debris-flow hazards increases in various parts of Indonesia in line with climate change and environmental degradation. Sukabumi Regency has a diverse topography with a relatively high annual rainfall rate of 2,805 mm/year with 144 rainy days. In 2020, Sukabumi Regency was affected by Debris-flow hazards in three Districts. In a study by the National Disaster Management Agency (BNPB), Sukabumi District is prone to land movements. There has been no study of Debris-flow hazards in the Sukabumi Regency area. This study aims to determine regions of the Sukabumi Regency that have the potential for Debris-flow hazards. It is hoped that the study results will also complement the disaster studies that BNPB has made. The method used is a weighted multi-criteria analysis. The parameters used are rainfall, location of the 2020 flood, slope, land cover, altitude, and soil type. The results showed that the level of vulnerability is very prone to be located in the northern part of Sukabumi.*

***Keywords****: Debris Flow Hazard, Multicriteria, Sukabumi Regency*

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## PENDAHULUAN

Debris-flow hazard is a natural disaster due to hydrometeorological processes in Indonesia. Debris-flow hazards are inundation due to runoff from river discharge which suddenly enlarges and exceeds the flow capacity quickly (Adi, 2013) (less than six hours) in some narrow watersheds and carries debris (Kementerian Perumahan Rakyat, 2012; Sahara, Istijono and Sunaryo, 2013). The incidence increases with climate change and environmental degradation, such as in Padang City, Palu City, Wasior, and Jember (Adi, 2013). At the end of 2020, Sukabumi Regency was affected by debris-flow hazards in three sub-districts, namely Cicurug, Cidahu, and Parungkuda (Badai, 2020). The debris-flow hazard caused significant loss of life and property for residents.

Factors causing a debris-flow hazard in addition to natural processes can also be caused by the collapse of a dam or reservoir (BNPB, 2016). The elements are rough conditions, natural events, duration of rain, backflow of the main river, damming of rivers due to landslides, and human activities (Arkham *et al,* 2014; Utama and Naumar, 2015; Akbar *et al*, 2020). The occurrence is very fast with the debris being carried, requiring significant attention for the local government in providing warnings and the existing landslide studies. Moreover, Sukabumi Regency's risk of debris-flow hazard was analyzed in the Indonesian Disaster Risk Index (BNPB, 2016).

Research on debris-flow hazards in Sukabumi Regency is quite rare. The findings include implementing disaster management policies (Silmi, Nur and Purwanti, 2019) and the potential for geological disasters (Farasadina, 2017) in Sukabumi Regency. However, research on debris-flow hazards has been carried out in several areas, such as Padang City (Sahara, Istijono and Sunaryo, 2013; Utama and Naumar, 2015), Malang City (Panoto *et al.*, 2021), and Palembang City (Nisumanti *et al.*, 2013). Sukabumi district risks debris-flow hazards because it is vulnerable to ground movement. Debris-flow threats due to ground movements in Sukabumi need further studies, especially in knowing areas that have the potential for debris-flow hazards. The Debris-flow hazard study will complement the landslide study previously made by BNPB (BNPB, 2016). This disaster study aims to determine areas in Sukabumi Regency that have the potential for Debris-flow hazards. The existence of a debris-flow hazard study is expected to assist the government in mitigating debris-flow hazard disasters.

## METHOD

This study uses a descriptive spatial analysis (Masri, 2012) of the debris-flow hazard-prone area in Sukabumi. Spatial analysis is an empirical model to explain the relationship between computer-based variables and reveal interpreted and measured facts (Taher, 2017). In carrying out debris-flow hazard mapping, the multicriteria method is used with weighting (Malczewski, 1999) on the parameters used, and the parameters used are shown in Table 1.

Table 1. Data and Parameter

| No | Parameter | Data Source |
|---|---|---|
| 1 | Rainfall | BMKG |
| 2 | The location of the 2020 debris-flow hazard | BMKG |
| 3 | Geology | Geological |
| 4 | Type of soil | BIG |
| 5 | Elevation | BIG |
| 6 | Slope | BIG |
| 7 | Land Cover | BIG |

Sources: Data processing, 2021

The weighting adopts the research of Utama and Naumar (2015) with slight modifications to adjust the parameters used. The research flow of thought can be seen in Figure 1.

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Figure 1. Research Workflow

Data processing is done by scoring based on the following classification:

Table 2. Classification of Parameters

| Variable | Weight | Not vulnerable | Vulnerable | Very vulnerable |
|---|---|---|---|---|
| Rainfall | 30 | 1750 - 2000 mm/year | 2000 - 2500 mm/year | 2500 – 3000 mm/year |
| River | 10 | > 150 m | 100 - 150 m | 0 - 100 m |
| Elevation | 10 | > 2000 masl | 1000 - 2000 masl | 0 - 1000 masl |
| Slope | 10 | > 25% | 15 - 25 % | 0 - 15 % |
| Type of soil | 10 | Alluvial and river deposits; Alluvial Association; Red Yellow Mediterranean Complex, Grumusol, and Regosol; Lateritic and Podsolic Complexes; Yellow red podsolic from acid sedimentary rock | Latosol Complex, Litosol Complex, Regosol Complex, Latosol, Latosol Association, Latosol and Litosol Complex, Latosol and Regosol Association, Regosol and Litosol from igneous rocks | Andosol; Andosol and Regosol Association |
| Geology | 10 | Accretion, Plutonism | sedimentation | volcanic |
| Land Cover | 20 | Scrub Forest, Dense Forest, River/Lake, Freshwater Pond, Swamp | Imperata, Emplacement, Mixed Garden, Grassland/Savanna, Large Plantation, People's Plantation, Irrigated Rice Fields, Irrigated Rice Fields, Rainfed Rice Fields, Shrubs, Ponds, Upland/Field | The village, Housing, Barren Land, Open Land |

Source: data processing with modifications (6)

## RESULT

BMKG annual rainfall data shows that Sukabumi Regency has high intensity, especially in mountainous areas. The influence of global climate change indirectly changes the pattern of rainfall in an area. Although rainfall is relatively the same as usual conditions, rain with the characteristics of short duration but the high-intensity impacts increasing flooding (Utama and Naumar, 2015). Based on annual rainfall intensity, areas with moderate vulnerability cover more than half of Sukabumi. Meanwhile, areas with high exposure are located north and south of Sukabumi (Figure 2).

### Geology and Type of Soil

The geological distribution in the Sukabumi Regency in the southern region results from sedimentation, while volcanic materials dominate the northern part. Based on Taufik, Kurniawan and Putri (2016) the area with sedimentation material has a higher potential for flooding, so it has a high score, while the second position is volcanic material. With these geological conditions, almost the whole northern part and a little eastern part of Sukabumi have a high level of vulnerability. Most of these areas have a moderate level of exposure based on the soil type. (Figure 3).

### Flood Incident

Debris-flow hazard in September 2020 hit 12 villages in 3 sub-districts, namely Cicurug, Parungkuda, and Cidahu sub-districts Citarik-Cipeuncit river overflowed(Zakaria, 2020). The flood incident was traced to the overflowing river and then buffered for 100 and 250 m (Figure 4) to estimate the affected area.

### Topography

Sukabumi has a mountainous to coastal landscape (Figure 5). Almost all areas are categorized as moderate to steep slopes; this makes Sukabumi Regency disposed to debris-flow hazards when the rainfall intensity is relatively high in a short time.

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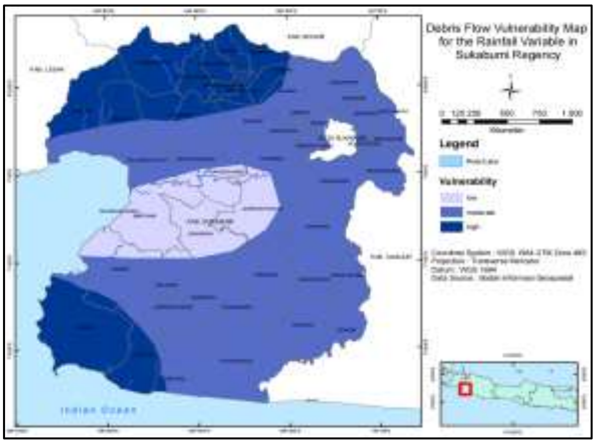


Figure 2. Rainfall Map and Debris Flow Vulnerability Map for Rainfall Variable in Sukabumi Regency

## DISCUSSION

The Sukabumi Regency area has a low, moderate, and high level of debris-flow hazard vulnerability. The distribution of highly vulnerable areas is in the northern part; the middle part is dominated by medium and low levels of exposure, while low levels dominate the southern part (Figure 7). A debris-flow hazard event map in 2020 makes the northern region very highly vulnerable, such as Parungkuda, Cicurug, Cidahu, Ciambar, Parakansalak, and Klapanunggal sub-districts.

The use of land in the form of rice fields, plantations, and settlements that dominate the northern side of Sukabumi increases the risk of a debris flow hazard. With a history of debris flow hazards in 2020, this area increasingly has a higher risk of vulnerability than other areas.

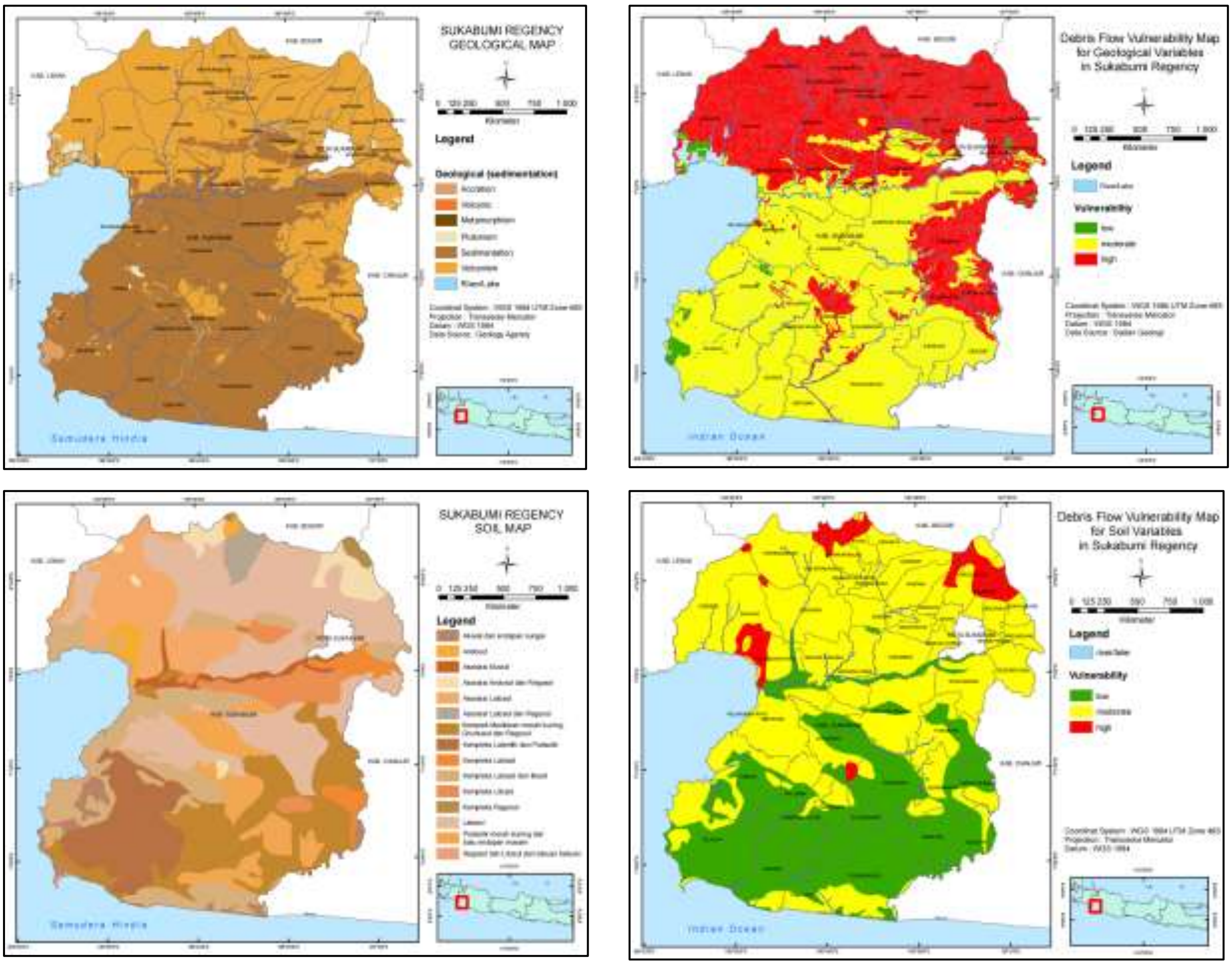


Figure 3. Debris Flow Vulnerability based on Geological and Soil Type Variables of Sukabumi Regency

### Land Cover

Plantations and rice fields dominate the land use of the Sukabumi Regency (Figure 6). Debris-flow hazards generally occur on steep slopes, and natural embankments break in the narrower part of the watershed: human activities, especially land changes, influence the collapse of natural embankments. Changes in forest land use into plantations and settlements in the highlands sometimes provide blockages such as large logs so that embankments are formed upstream (Aroengbinang and Kaswanto, 2015).

Based on a multi-criteria analysis of the vulnerability, seven sub-districts represent around 6.6% of the total area in the Sukabumi Regency. Those districts have a high vulnerability class of more than 50% of the size of each sub-district. Parung Kuda is the sub-district with the highest high level of vulnerability, where 81% of its area is in the very high vulnerable category. Both Bojong Genteng and Cicurug are sub-districts with around 75%; meanwhile, Ciambar, Cidahu, Klapanunggal, and Parakan Salak sub-districts with a very high vulnerable category, which accounts for approximately 60% of the total area of each sub-district area.

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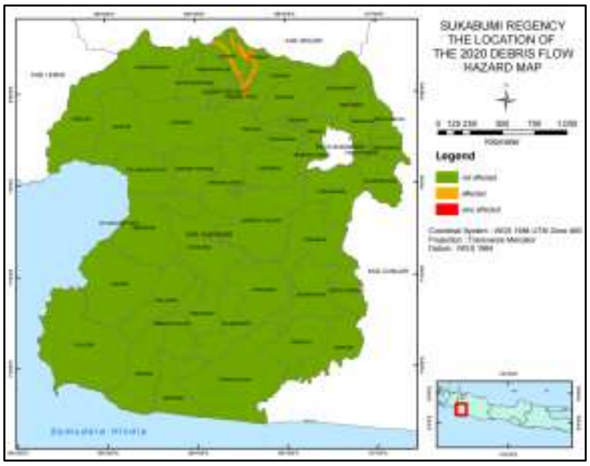


Figure 4. Debris-flow Hazard 2020

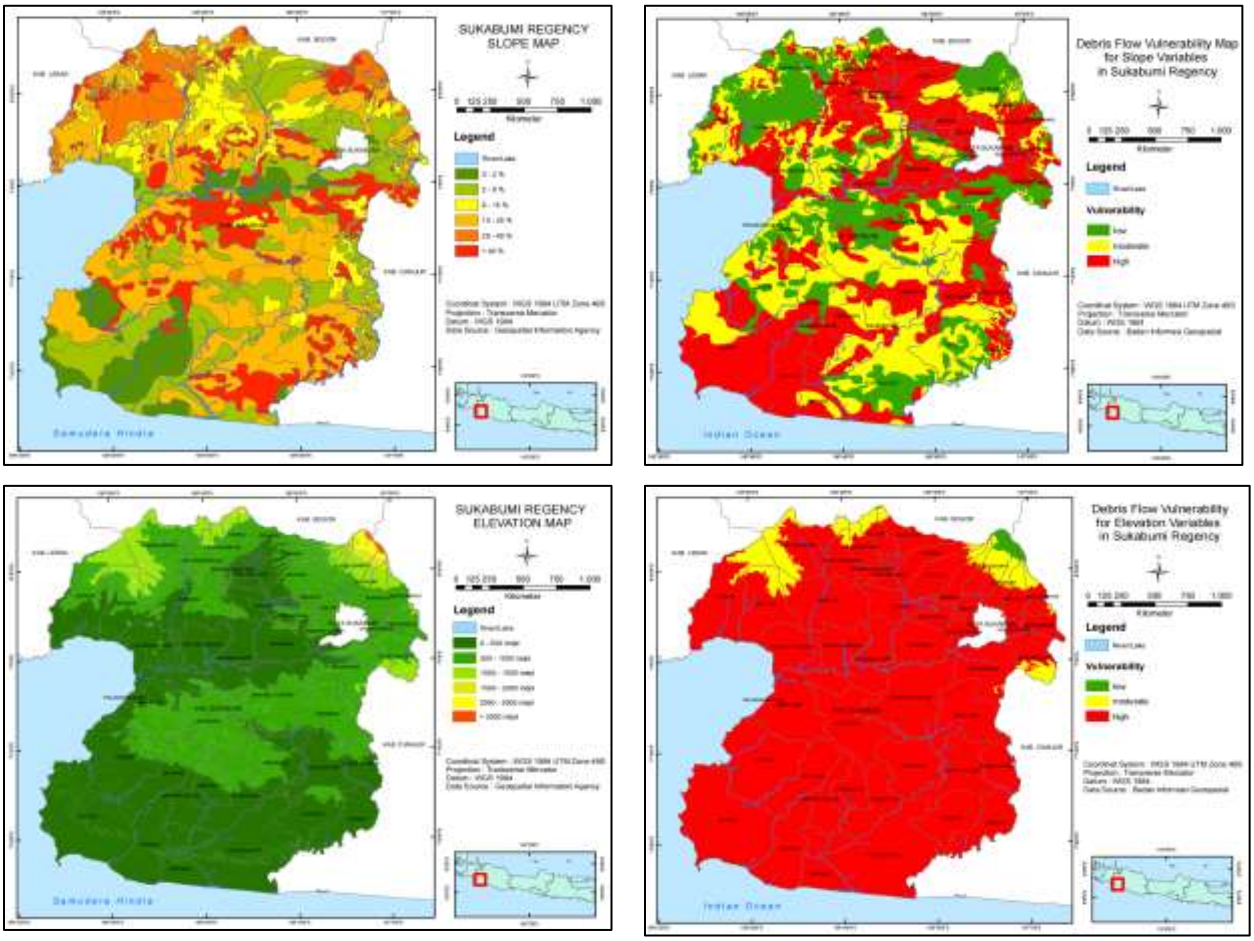


Figure 5. Debris Flow Vulnerability based on Slope and Elevation Variables

As the population grows, humans' need for land use will grow. Likewise, changes in land use from forest to agricultural land will increase. Based on geological data, the Sukabumi area has a high tendency of ground movement; this causes the site's vulnerability to increase.

This study has some limitations, such as the latest Sukabumi Regency rainfall data based on rainfall measurement stations that are unavailable. In addition, to conduct a debris flow hazard study with a larger and more detailed scale, a river density index is needed by making a convergence index (Panoto *et al.*, 2021) using DEM data. In the future, to update this study, it is hoped that the government can carry out a vulnerability and risk assessment of the debris flow hazard, which focuses on the northern area of Sukabumi, to reduce the impacts and risks that arise.

## CONCLUSION

The area with a very high vulnerability to debris-flow hazards is the Sukabumi Regency's northern part. Factors that affect the level of debris-flow hazard vulnerability are rainfall, past debris-flow hazard events, geology, soil type, slope, altitude, and land use. The critical factor for the debris-flow hazard map is the past debris-flow hazard data.

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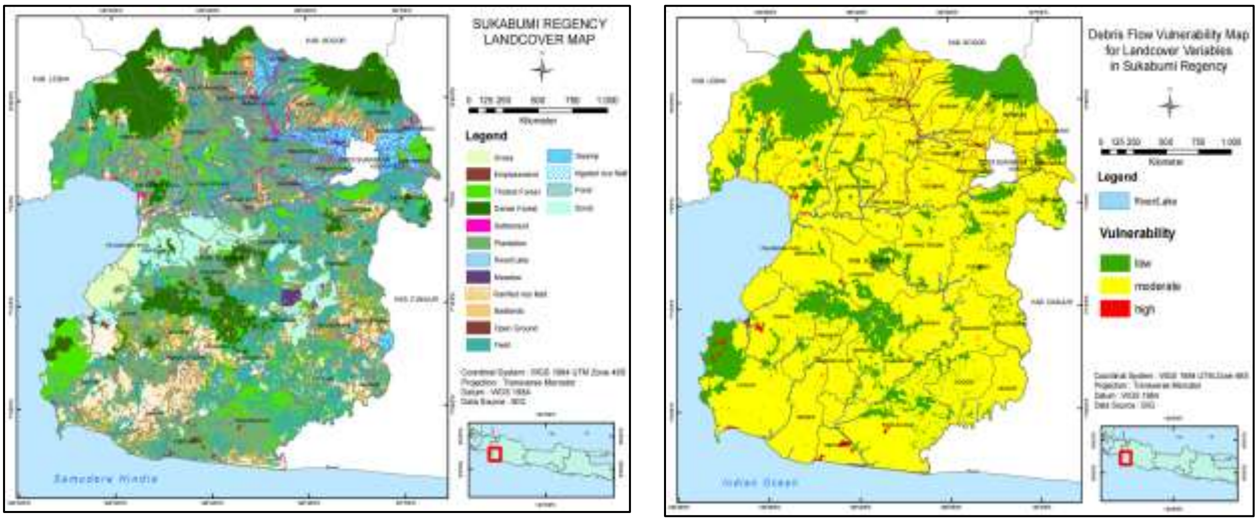


Figure 6. Debris Flow Vulnerability based on Land Use Variable

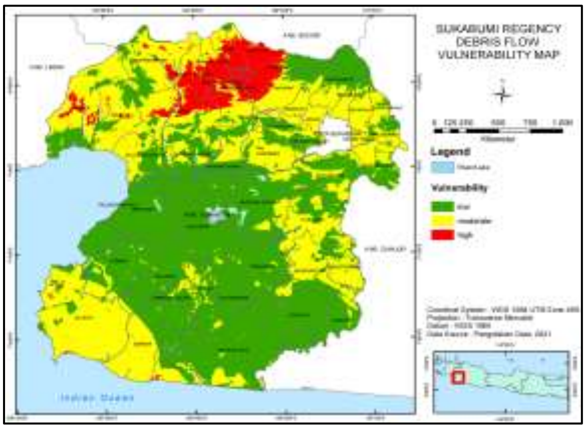


Figure 7. Debris-flow Hazard Map

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