

The Landslide Risk Level Evaluation in South Sumatra Province

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ABSTRACT

Landslides in South Sumatra Province often occur due to high rainfall, which causes unstable soil, often resulting in road closures and blocking residential areas. Therefore, an evaluation of the level of natural disaster risk for landslides needs to consider the components of hazard, vulnerability, and capacity. This is essential for producing accurate and relevant risk maps, especially for the South Sumatra Province. The results of this research show that the level of landslide risk is influenced by hazard, vulnerability, and capacity. The hazard variables include nine variables, namely: rainfall, geology, land use, slope, soil type, soil bearing capacity around bridges, safety factors, zone typology, and landslide history and frequency of occurrence around road sections. The vulnerability risk level variables include fourteen variables consisting of physical, social, economic, and environmental vulnerability. In addition, the landslide risk level variables from the capacity risk level factor consist of four variables comprising social, economic, and institutional aspects. Through this landslide risk modelling based on hazard, vulnerability, and capacity assessments, this research is expected to provide input for more effective disaster mitigation, management, and adaptation planning.

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Introduction

Landslides are events caused by greater driving forces, namely slope angle, water, load, and soil/rock density, compared to the restraining forces of rock and soil density [1]. Landslides are one of the natural disasters that frequently occur in Indonesia, especially in areas with hilly topography and high rainfall such as South Sumatra Province. South Sumatra Province has many areas that are highly vulnerable to landslides. This is because landslides occur in almost every border area in South Sumatra Province during the rainy season, making it a serious problem that must be addressed.

Landslides naturally occur due to, among other things, the decline in the stability of a slope as a result of soil/rock degradation and human activity.

Based on data from the Central Statistics Agency (BPS) in 2025, between 2018 and 2023, there were 36 natural landslide disasters in South Sumatra Province. The districts/cities that have experienced landslides include: Ogan Komering Ulu, Muara Enim, Lahat, Musi Banyuasin, Ogan Komering Ulu Selatan, Empat Lawang, Penukal Abab Lematang Ilir, Pagar Alam, and Lubuk Linggau. The district of Ogan Komering Ulu Selatan is one of the areas that has experienced the most landslides, with 12 incidents.

In disaster mitigation efforts, landslide risk modelling is a very important tool. This modelling approach is generally based on three main components [2]: hazard, vulnerability and capacity. Hazard analysis includes an assessment of the likelihood of landslides based on physical factors such as slope gradient, soil type, rainfall, and land cover. Meanwhile, vulnerability describes the potential level of damage or impact on exposed elements, such as settlements, public facilities, and

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economic activities. Capacity refers to the ability of the community and local government to cope with and reduce the impact of landslides, whether through infrastructure, preparedness, or policy.

Research conducted by [3] on landslide risk analysed hazard parameters (slope, rainfall, soil type), vulnerability (settlements, roads, population density), and capacity (evacuation facilities, warning systems). Each parameter was weighted and analysed using spatial overlay in a Geographic Information System (GIS) using a risk assessment method in accordance with National Board for Disaster Management (BNPB) Regulation No. 2 of 2012. Areas with high risk levels are dominated by areas with steep slopes, high rainfall, and low settlement density with low mitigation capacity. This resulted in a landslide risk zoning map classified into low, medium, and high risk. Meanwhile, according to [4], the disaster risk assessment framework consists of four main elements, namely hazard, disaster potential, vulnerability, and capacity.

The research by [5] on the assessment of the index and level of landslide disaster risk on road sections in Sungai Penuh City and Kerinci Regency in 2020-2021 found 13 landslide events. The parameters analysed were hazard, exposure, vulnerability, external context, and capacity. This study used scoring and weighting techniques on spatial data, which were then overlaid using GIS. The results of the study of 10 national road sections spanning 82.5 km showed that 7 sections were classified as low risk (8.72%), mostly located within the city, and 3 sections were classified as medium risk (91.28%), generally connecting roads between cities. The landslide hazard index is classified as low and moderate. Although most sections are in the moderate risk category, risk index-based mapping is crucial as a basis for decision-making on road infrastructure mitigation.

The South Sumatra National Disaster Management Agency (BNSP) (2021) analysed the risks by identifying hazard, vulnerabilities, and the capacity of the region to deal with disasters. This approach includes an assessment of 14 types of disaster hazard grouped into geological, hydrometeorological, and anthropogenic categories. The main findings are: (1) Disaster hazards: South Sumatra faces various disaster hazards, including earthquakes, floods, landslides, forest and land fires, and disease outbreaks; (2) Vulnerability: factors such as population density, socio-economic conditions, and infrastructure affect the region's vulnerability to

disasters; and (3) Capacity: the capacity of local governments and communities to deal with disasters varies, with a need to improve early warning systems, training, and supporting infrastructure.

[6] analysed the risk of road networks to landslides by considering aspects such as: hazards (geology, topography); Vulnerability (road function, road repairs, alternative routes) and Capacity (zone mapping, road repairs). The study was conducted in six counties located on the border between Sichuan and Yunnan provinces in China, an area prone to geological disasters.

Disaster risk assessment is an effort to produce information related to the level of disaster risk in an area. The level of risk is obtained from a combination of three components, namely Hazard, Vulnerability, and Capacity. The disaster risk formula is as follows:

$$\text{Risk} = \frac{\text{Hazard} \times \text{Vulnerability}}{\text{Capacity}} \quad (1)$$

These three components (hazard, vulnerability, capacity) are determined based on their respective parameters. The hazard component is determined through an analysis of probability (likelihood of occurrence) and intensity (severity of occurrence). The vulnerability component is calculated based on four parameters, namely social vulnerability (exposed population), economic vulnerability (loss of productive land), physical vulnerability (issues due to damage to houses and buildings), and environmental vulnerability (environmental damage).

Finally, the capacity component is determined using the parameter of regional resilience (government sector). The combination of these three components results in a risk that provides information about the comparison between the vulnerability and capacity of a region in facing disasters. In other words, the level of risk indicates the ability of a region to reduce the impact of losses caused by disasters.

Methods

This research was quantitative research with an explanatory and verificative approach. The aim is to explain the relationship between the cause and effect variables in the level of landslide risk in South Sumatra Province. The data collection stage aims to analyse the parameters that influence and cause landslides in the South Sumatra Province and to model the level of landslide risk. The data required

in this study are primary and secondary data. The data collection flowchart is described in Figure 1.

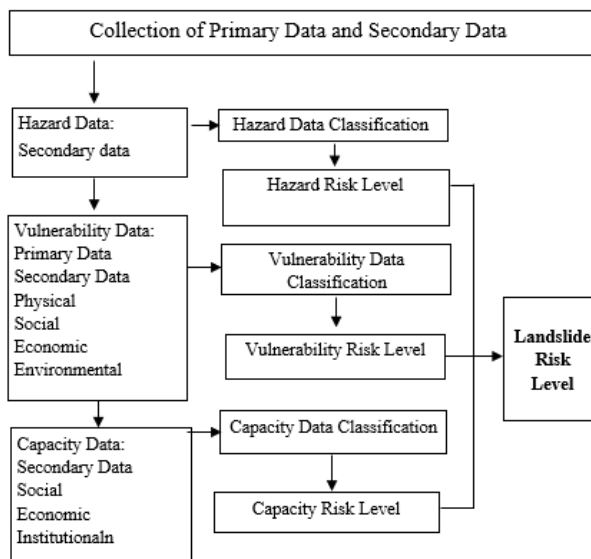


Figure 1. Research Flow Chart

Primary data includes: field surveys of geomorphological conditions, vegetation, and infrastructure; questionnaires for road users, community leaders, and authorities; soil tests covering texture, moisture, and slope inclination. Secondary data includes: geological maps, land use, slope inclination (GIS); rainfall data from the BMKG; landslide data from the South Sumatra Provincial BNPB from 2020 to 2024; and RTRW and other spatial data from relevant agencies. This research was conducted in the South Sumatra Province, focusing on the districts of South OKU, Lahat, and Muara Enim.

Results and Discussions

South Sumatra Province is located at 1° 37' 27" – 4°55' 17" South Latitude and 102° 3' 54" – 106° 13'26" East Longitude. South Sumatra Province, with its capital in Palembang has an area of 91,179,739 km². Based on its geographical position, the administrative boundaries of South Sumatra Province are as follows: North: borders Jambi Province. South: borders Lampung Province. West: borders Bengkulu Province. East: borders Bangka Belitung Province. The administrative area of South Sumatra Province consists of 13 regencies, 4 cities, 241 sub districts and 3,289 villages.

Based on Regulation of the Minister of Home Affairs of the Republic of Indonesia Number 72 of 2019, the capital and area of each regency/city in South Sumatra Province are shown in Table 1. One of the landslide locations in South Sumatra Province is shown in Figure 2.



Figure 2. Landslide on the Pagar Alam – Tanjung Sakti Road at KM 320+500

Previous research containing summaries of national and international journals and national and international proceedings related to the risk of landslide vulnerability is shown in Table 2. The results of previous research summaries are based on the level of landslide risk, which is grouped into hazards, vulnerability, and capacity.

Based on this summary, the researchers used landslide risk levels influenced by hazards, vulnerability, and capacity. The hazard variables included nine variables. The vulnerability risk level variables consist of physical, social, economic, and environmental vulnerabilities. The variables for landslide risk level from the risk capacity factor consist of: (1) social, (2) economic, and (3) institutional. Figure 3 shows the research variables used in this research.

Tsble 1. Area of Regencies/Cities in South Sumatra Province

No.	Regency / City	Capital	Wide (km ²)	Percentage of Province Area (%)
1	Banyuasin	Pangkalan Balai	1.183.299	12.92
2	Empat Lawang	Tebing Tinggi	225.644	2.46
3	Lahat	Lahat	531.174	5.80
4	Muara Enim	Muara Enim	738.390	8.06
5	Musi Banyuasin	Sekayu	1.426.626	15.58
6	Musi Rawas	Muara Beliti	635.010	6.93
7	Musi Rawas Utara	Muara Rupit	600.855	6.56
8	Ogan Ilir	Indralaya	266.609	2.91
9	Ogan Komering Ilir	Kayu Agung	1.835.904	20.04
10	Ogan Komering Ulu	Baturaja	479.706	5.24
11	OKU Selatan	Muara Dua	549.394	6.00
12	OKU Timur	Martapura	337.000	3.68
13	Penukal Abab Lematang Ilir	Talang Ubi	184.000	2.01
B City				
1	Lubuk Linggau / Pagar Alam	Lubuk Linggau	40.150	0.44
2	Pagar Alam	Pagar Alam	63.366	0.69
3	Palembang	Palembang	36.922	0.40
4	Prabumulih	Prabumulih	45.690	028
Sumatera Selatan Province		Palembang	9.179.739	100

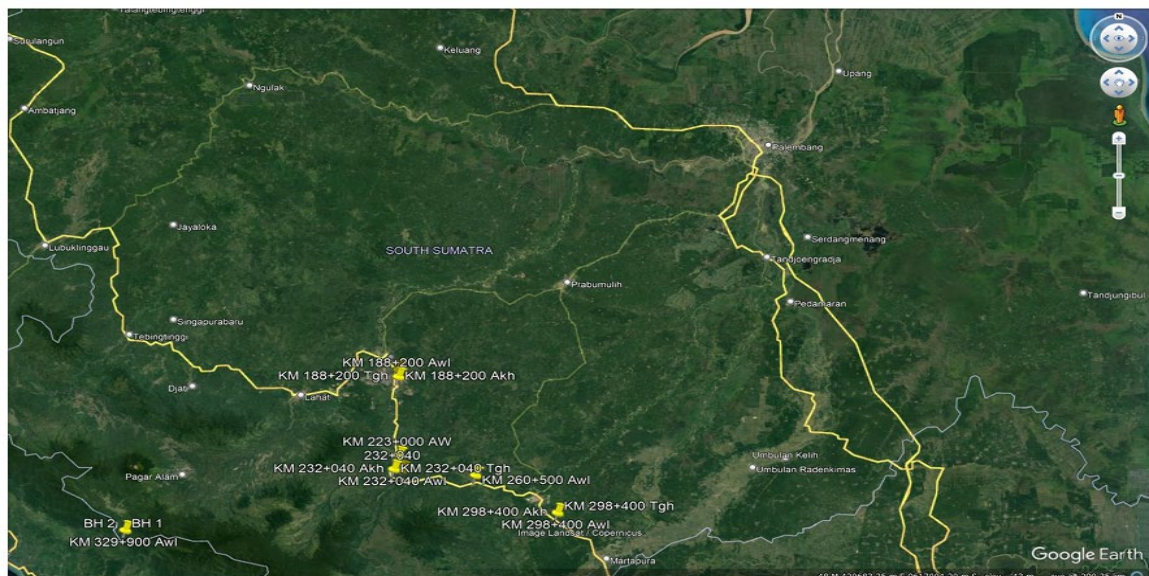
**Figure 3.** Map of Landslide Locations in 2023 in South Sumatra Province (BPPJN Report, 2023)

Table 2. Summary of Previous Research Based on Risk Level

No	Articles, Locations	Hazard	Vulnerability	Capacity
1	Alcántara-Ayala, 2025 (Africa, Americas, Asia, Europe, Oceania)	1. Natural factors 2. Human activities	1. Socio-economic aspects 2. Urbanization 3. <u>Public awareness</u>	1. Social and scientific aspects 2. Local community
2	Capobianco et al., 2025 (European Region)	1. Rainfall 2. Climate 3. <u>Land use</u>	1. Population 2. Infrastructure	1. Adaptation 2. Multi-sector approach 3. <u>Long-term planning</u>
3	Septiana, et al., 2024 (Sunda Strait)	1. Earthquake 2. Location 3. Volcanic zone 4. <u>Potential tsunami</u>	1. Topographic conditions 2. Geographical location 3. Population density	1. Geographic Information System (GIS) 2. <u>Overlay</u>
4	Zhou et al., 2024 (China)	1. Geology 2. Topography	1. Road function 2. Road repairs 3. <u>Alternative route</u>	1. Zone mapping 2. Road repairs
5	Diputra et al., 2023 (Lubuk Linggau)	1. Slope Gradient 2. Land clearing 3. <u>Fault/Fracture</u>	1. Social/Population 2. Physical 3. <u>Economy</u> 4. <u>Environment</u>	1. Region 2. Preparedness
6	Pratiwi., 2023 (Bogor)	1. Rainfall 2. Slope gradient 3. <u>Soil type</u>	1. Land slope 2. Land use 3. <u>Population density</u>	1. Soil and water conservation techniques 2. <u>Disaster mitigation</u>
7	Liu et al., 2022 (Portugal)	1. Rainfall 2. Climate	1. Settlements 2. Infrastructure 3. <u>Economy</u>	1. Early warning 2. Regulations 3. <u>Society</u>
8	Prihatin et al., 2022 (Purworejo Regency)	1. Rainfall 2. Steep topography 3. Soil type	1. Socio-economic 2. Housing density 3. <u>poverty</u>	1. Society 2. Regulations
9	Panchal and Shrivastava, 2022 (India)	1. Rainfall 2. Topography 3. <u>Land use</u> 4. <u>Geology</u>	1. National road 2. Traffic intensity	1. Intervention area 2. Road
10	Arambepola and Devkota, 2021 (Laos)	1. Rainfall 2. Geomorphological factors	1. Road infrastructure 2. Population	1. Transportation system 2. Government
11	Bahri et al., 2021 (Ngantang Regency, East Java)	1. Volcanic hazards 2. Landslide	1. Settlements 2. <u>Agricultural land</u>	1. Risk zoning mapping 2. <u>Mitigation</u>
12	Sari, et al., 2021 (Kerinci Regency and Sungai Penuh City)	1. Rainfall 2. Geology 3. <u>Frequency of landslides</u>	1. Road infrastructure 2. Drainage system 3. <u>Slope protection</u>	1. Mapping of landslide zones 2. Road construction 3. <u>Drainage system</u>
13	Wang et al., 2021 (Fengjie County China)	1. Model susceptibility 2. GeoDetector	1. Land use 2. Population density 3. <u>Economic value</u>	1. Risk map 2. Spatial data
14	Wahyudianto, 2021 (East Java)	1. Rainfall 2. Historical landslides	1. Road section 2. Maintenance	1. Road 2. <u>Mitigation</u>
15	BNPB South Sumatra Report, 2021 (South Sumatra)	1. Rainfall 2. Geological conditions 3. <u>Land use</u>	1. Population density infrastructure 2. <u>Society</u>	1. Disaster management 2. Training and socialization 3. <u>Early warning system</u>
16	Aminatun and Muntafi, 2020 (Bantul, Yogyakarta)	1. Rainfall 2. Slope gradient 3. <u>Weathered soil</u>	1. Settlements 2. Society	1. Settlement planning 2. Society
17	Madria et al., 2020 (Kota Kinabalu, Sabah, Malaysia)	1. Steep slope 2. Human activities	1. Social 2. Physical	1. Geology 2. Social 3. <u>Mitigation</u>
18	Nugroho, et al., 2020 (Kulonprogo Regency)	1. Rainfall 2. Soil conditions	1. Settlement 2. Agricultural land	1. Agroforestry techniques 2. Land conservation 3. <u>Mitigation techniques</u>
19	Hamida and Wdyasamratri, 2019 (City, Bantul Regency, Buleleng Regency)	1. Rainfall 2. Slope gradient 3. Soil type 4. Land use 5. Fault/Fracture 6. Vegetative Density	1. Social 2. Physical 3. Economy 4. Environment	1. Social 2. Physical 3. Economy 4. Institutions
20	Firmansyah, et al., 2019 (Bukittinggi City)	1. Rainfall 2. Slope gradient 3. <u>Fault activity</u>	1. Population density 2. Solid buildings 3. <u>Residential land</u>	1. Evacuation route 2. Facilities and infrastructure 3. <u>Disaster socialization</u>
21	Asteriani et al., 2019 (City of Siak Sri Indrapura)	1. Land cover 2. Land conversion 3. <u>River bank erosion</u>	1. Settlement 2. Population growth 3. <u>Land use</u>	1. Infrastructure 2. Evacuation access 3. <u>Spatial planning</u>
22	Wijaya, 2018 (Cilacap Regency)	1. Rainfall 2. Topography 3. Active seismic	1. Age 2. Level of education 3. Unemployment	1. Infrastructure 2. Mitigation system 3. Disaster education
23	Gariano and Guzzetti, 2016 (Asia, South America, and Africa)	1. Climate change 2. Landslide intensity 3. <u>Seismic</u>	1. Settlements 2. Infrastructure 3. <u>Economy</u>	1. Early warning 2. Adaptation strategy 3. <u>Policy</u>
24	Saputra and Ardhana., 2016 (Buleleng Regency)	1. Rainfall 2. Geological conditions 3. Soil conditions 4. <u>Slope gradient</u>	1. Settlement 2. Public facilities 3. Agricultural activities	1. Landslide mapping 2. Public education
25	Faizana, et al., 2015 (Semarang City)	1. Rainfall 2. Slope gradient 3. <u>Soil type</u>	1. Population density 2. Infrastructure	1. Geographic Information System (GIS) 2. <u>Mitigation</u>

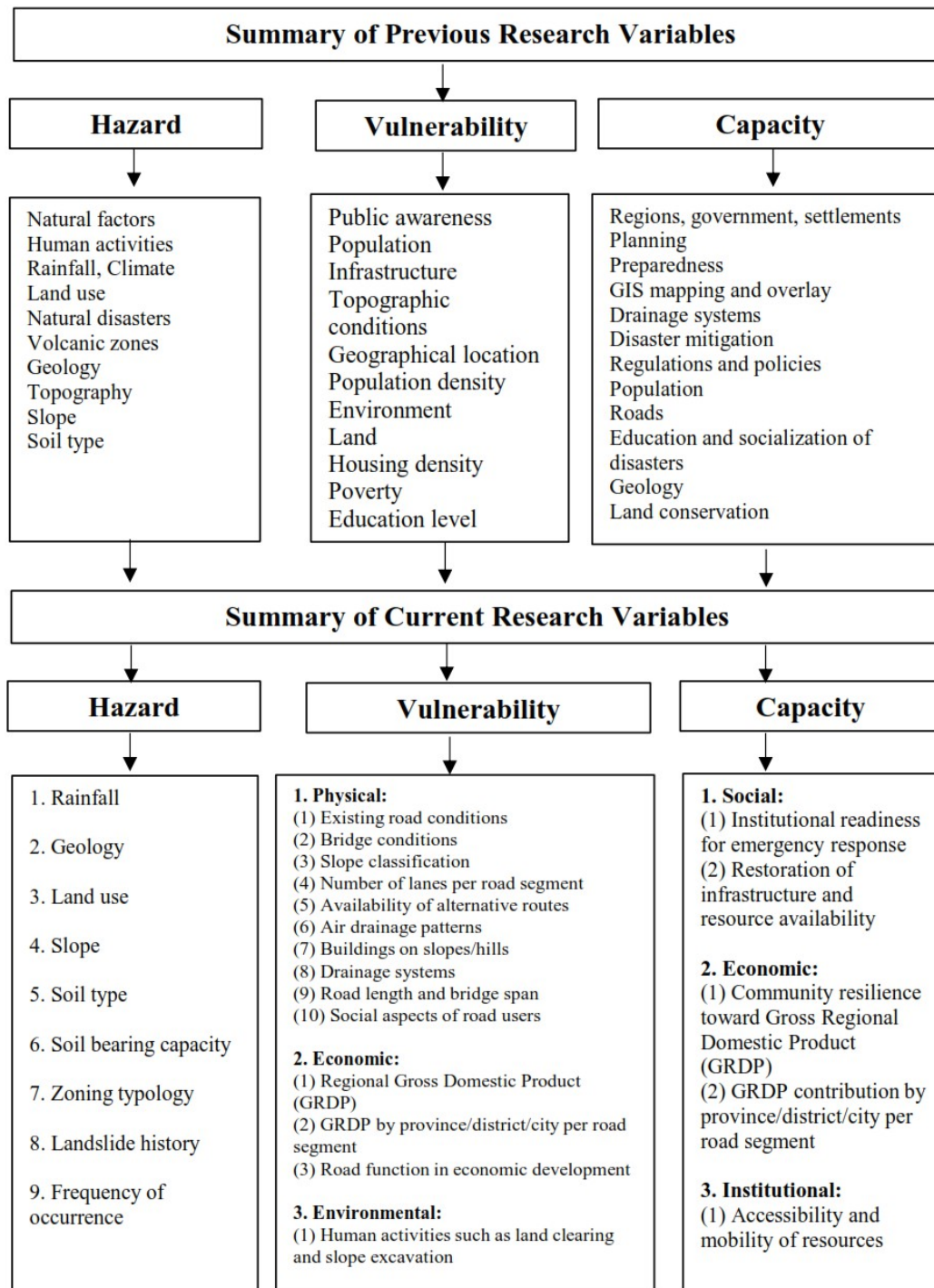


Figure 4. Research Variables Used (Researcher, 2025)

Landslide risk level variables are factors that influence the likelihood of landslides occurring and their potential impact. These variables are generally divided into three main components, namely: hazard, vulnerability, and capacity. Understanding landslide risk level variables is essential as it provides a scientific and practical basis for understanding, mapping, and controlling landslide hazards.

Knowing the variables of landslide risk level is an important step in understanding, predicting, and reducing the impact of landslides in an area. Landslides are geological disasters triggered by various factors, both natural and human-induced. Therefore, identifying influential variables such as slope inclination, soil type, rainfall, land cover, and geological conditions is the basis for assessing the level of danger in an area. Understanding these variables enables researchers and authorities to identify the main causes of landslides and map areas that are prone to similar events in the future.

In addition, knowledge of vulnerability variables such as population density, infrastructure value, and socio-economic conditions of the community is also necessary to assess the potential impact of a landslide. Meanwhile, capacity variables, such as the availability of mitigation infrastructure, early warning systems, and community preparedness levels, play an important role in determining the extent to which an area is able to cope with such hazards. By combining these three groups of variables, the level of landslide risk can be analyzed comprehensively.

Information on landslide risk level variables is crucial in compiling landslide-prone zone maps based on geographic information systems (GIS), which can be used to support spatial planning policies and sustainable development planning. Through this approach, high-risk areas can be identified more accurately so that mitigation measures, such as the construction of slope drainage systems, planting of erosion-control vegetation, and relocation of settlements, can be designed more effectively. In addition, understanding risk variables also contributes to increasing public awareness in recognizing the early signs of landslides and taking preventive action. Thus, knowledge of landslide risk variables is not only important academically, but also has strategic value in disaster risk reduction efforts and the protection of human safety and environmental assets.

Conclusions

Disaster risk assessment is an effort to produce information related to the level of disaster risk in an area. The level of risk is obtained from a combination of three components, namely hazard, vulnerability and capacity. These three components are determined based on their respective parameters.

Based on this summary, the researchers used the landslide risk level influenced by hazard, vulnerability, and capacity. The hazard variables include nine variables, namely rainfall, geology, land use, slope, soil type, soil bearing capacity around bridges, safety factors, zone typology, and landslide history and frequency of occurrence around road sections.

The vulnerability risk level variables consist of physical, social, economic, and environmental vulnerability. Physical vulnerability includes: (a) existing road conditions, (b) existing bridge conditions, (c) road terrain classification, (d) number of bridges on the road section, (e) availability of alternative routes/road sections, (f) slope drainage, (g) slope/cliff protection structures, (h) availability of drainage systems, (i) road section length, and (j) total bridge length. Social vulnerability is the population (users). Economic vulnerability is: (a) Regional Gross Domestic Product (RGDP) of the province/district/city on the road section, and (b) the function of the city in economic development. Environmental vulnerability is the result of human activities such as the creation of ponds on road slopes.

The variables for landslide risk level from the risk capacity factor consist of: (1) social, (2) economic, and (3) institutional. The landslide risk level from the social capacity factor is: (a) institutional readiness for emergency response, and (b) recovery of resource availability and completeness. The landslide risk level from economic capacity factors is: assessment of Regional Gross Domestic Product (PDRB). The landslide risk level from institutional capacity factors is access and mobility of resources. Evaluation of landslide risk levels is important for the safety of lives, property, and the environment because it helps identify hazards, assess vulnerability, and predict losses.

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