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Landslide Intensity and Potential Based on Geomorphology and Their Relationship to the Stadia Level of The Karanggayam River, Kebumen Regency, Central Java Province, Indonesia

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Abstract

Landslides are disasters, with a high incidence in the Kebumen Regency area. The Kebumen Regency Regional Disaster Management Agency (BPBD) recorded that from 2011 to 2020, there were 1,335 disaster events, 477 events (35.7%) were landslides, and most landslides occurred in Karanggayam District with a total of 43 disaster events, which is the number one landslide incident in Kebumen Regency. Landslides also occurred at several points along the Karanggayam River. The research method consists of three stages: a literature study, surface geological mapping, and field data processing. The strength and potential of landslides are connected to geomorphological conditions, which include morphology, morphogenesis, and morphoassociation. This is shown by field research results, geomorphological data analysis, and Karanggayam River stage data. The mature river stage level in the study area affects the strength and possibility of landslides caused by lateral erosion on the outer bend slopes of the river. These slopes are steep, have thick soil, less resistant rock types, and few to moderate plants.

Keywords: Landslide, Geomorphology, Stadia Level River, Karanggayam River

1. Introduction

Landslides are disasters with high incidence in the Kebumen Regency area. The Kebumen Regency Regional Disaster Management Agency (BPBD) recorded that from 2011 to 2020, there were 1,335 disaster events, 477 events (35.7%) were landslides, and most landslides occurred in Karanggayam District with a total of 43 disaster events, which is the number one landslide incident in Kebumen Regency. Landslides also occurred at several points along the Karanggayam River (Retongga, 2023). Landslide disasters can occur because of geomorphological conditions, such as landforms, slopes, rock types, weathering processes, regional discontinuities, rainfall, land use, hydrological conditions, and vegetation (Sadisun, 2005). Morphotectonic conditions with relatively high tectonic levels are susceptible to landslides with steep slopes and loose constituent materials (Wahyudi et al., 2015). Slope stability is generally controlled by a series of interrelated environmental parameters, namely lithology, structure, rock texture, soil, morphology, and surface topography (described by attributes such as slope angle and curvature) that produce shallow landslides (Bartelletti et al., 2017). Weathering is the main factor influencing the potential for surface collapse (landslides). Deep weathering produces thick soils, and rainfall intensity plays a role in landslides in tropical areas (Nagarajan et al., 2000).

The dominant actors in landslides are large or steep slopes (> 45 %), land use, and rainfall as trigger factors for areas with potential for landslides (Sunimbar and Angin, 2021). Land use is often considered a static factor in landslide hazard studies, and some studies have considered changing land use as a factor in their analysis. Changes in land cover and land use due to human activities, such as deforestation, road construction, fires, and cultivation on steep slopes, can have an important impact on landslide activity (Van Beek and Van Asch, 2004), (Van Westen et al., 2008). Vegetation is an important factor influencing slope stability and can control slope instability by changing the hydrological and mechanical properties of the slope (Saito et al., 2022), (Zhang et al., 2022). Landslide events are closely related to lithological characteristics, because different rock types have different resistance, engineering, and hydrological characteristics (Van Westen et al., 2008). Rainfall is the main trigger for landslides, and long-lasting secondary triggers include geological structures that accelerate rock weathering, the formation of clay minerals, and thick soil (Regmi et al., 2013). Landslides are caused by an increasing number of residential areas living along river borders.

This settlement, which is right on the riverbank, causes many people to throw rubbish directly into the river, causing the rubbish to pile up and become sedimented. Sedimented rivers become more sloping, water often overflows, and have the potential for sustainable flooding (Lestari, 2017). There is a moderate-to-high risk of landslides along the main river in the Karanggayam area (Retongga, 2023). Based on the explanation above, it is necessary to analyze the intensity and potential of landslides based on geomorphological conditions and their relationship with the stadia level of the Karanggayam River, Kebumen Regency, Central Java Province, Indonesia.

2. Methodology

The research method consists of three stages: literature study, surface geological mapping, and field data processing.

2.1 Literature Study

Literature from previous researchers was used as supporting data and basic references in this research in the form of scientific articles and regional geological maps of Kebumen.

2.2 Surface Geological Mapping

Surface geological mapping using topographic map materials for plotting locations, types of lithology, sampling locations, and geological structures, and tools such as geological compass, geological hammer, loupe, and clipboard for collecting lithology, strike/dip, geological structure data (joints, folds, and faults), degree of weathering, and erosion. Morphological analyses included morphology (landforms) and morphometry (differences in slope, elevation, and height). Morphological analysis includes endogenous and exogenous forces acting in the research area and their influence on passive morphostructures (lithology), active morphostructures (faults and faults), and dynamic morphostructures (level of weathering, soil thickness, erosion, transport, and landslides). Morpho-association analysis includes the relationship between the natural landscape and the environment or natural landscape, such as the relationship between the natural landscape and rocks, geological structures, soil, water, vegetation, and land use. River-stage levels are based on river bends in the field and the interpretation of topographic maps.

2.3 Field Data Processing

Field data processing of the Karanggayam River was carried out to determine the relationship between geomorphology, river stage level, landslide intensity, and landslide potential along the Karanggayam River, Karanggayam District, Kebumen Regency, Central Java Province (Figure 1).

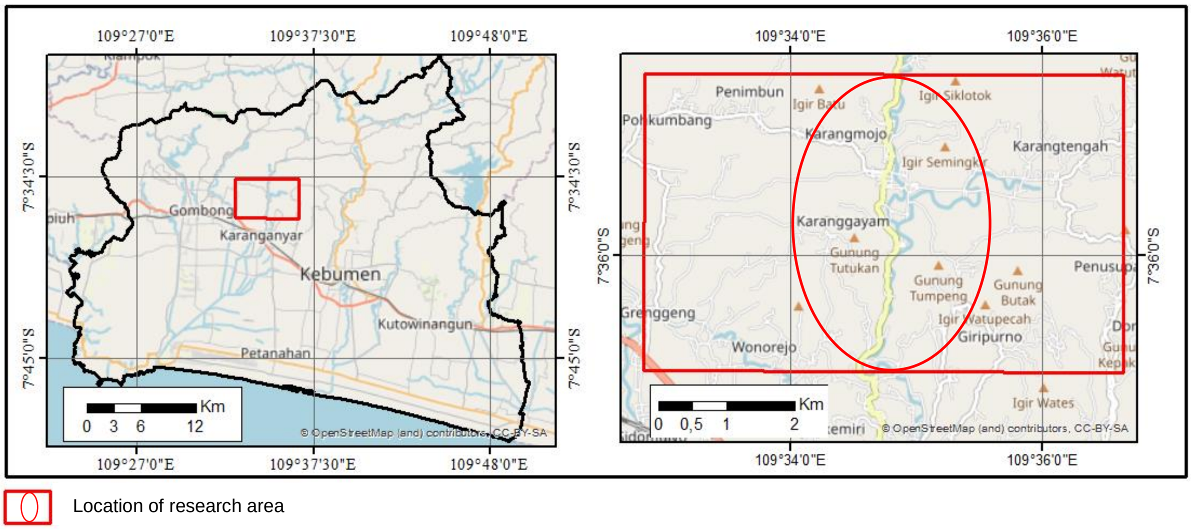

Figure 1. Location of research area

3. Result and Discusstion

The results of field observations in the area where the river body is shaped show four landslide disaster occurrence points (Figure 2) and six potential landslides (Figure 3) that occur in the river flow. Landslides and potential landslides occur only locally along the river flow and are caused by scouring or lateral erosion by river flow at the outer bend of a river with large slopes and relatively weathered rocks. The role of geomorphology in landslide disasters has been studied based on morphological, morphogenetic, and morpho-association aspects, as well as morphotectonics. Based on the morphological aspect, namely the morphography of the river body with steep slopes and morphometry with a slope value of 21°–78°, landslides occur and are prone to landslides in the morphogenesis aspect, namely passive morphostructure with limestone-sandstone, calcarenite, and tuffaceous sandstone lithology. which is a rock that is less resistant, in active morphostructures there are areas of discontinuity which accelerate rock weathering so that it will produce thick soil, in dynamic morphostructures if there is high rainfall intensity and water saturation on slopes with thick soil it can cause erosion or landslides. Based on the morpho-associative aspect of structural valley landforms, which are relatively flat in the middle, river body landforms with gentle to very steep slopes, especially at the outer bends of rivers, can cause landslides, are prone to landslides, and are supported by vegetation, land cover, and vegetation data. The lack of root reinforcement cannot increase the slope stability, whereas the land cover of occupied settlements increases the risk of landslides.

The main trigger for landslides and potential landslides along the Karanggayam River is the increase in river flow during the rainy season. The river flow continuously erodes the river slopes, particularly in the river bend area, because the river stage in the research area is mature and exists in the river. Land movement is a geomorphological process that occurs on the slopes of hills and mountains (Priyono and Sartohadi, 2011). Landslides are the process of moving a surface material by gravitational force either slowly or quickly from one place to another (Van Zuidam, 1983). Geomorphological processes that have occurred in the past are not only based on landform morphology but also on the materials that make up landforms, one of which is soil (Sartohadi, 2008). The condition of the slope is a controlling factor for ground movement (Karnawati, 2005).

A stable slope is a slope that has balance and is not prone to landslides; when there is disturbance, there is an imbalance that results in irregularities in slope conditions (Zakaria, 2010). Identifying landslides can use geological and geophysical approaches (Dzakiya et al., 2023). The mature river stage is characterized by a moderate river gradient, the river flow has started to meander somewhat or the river has meandering, there are no waterfalls or lakes, vertical erosion is balanced with lateral erosion, the valley has started to have a "U" shape, the valley is large and Deep down, the stratigraphy is already quite chaotic and the erosion process is dominant (Lobeck, 1939), so that the geomorphological conditions and river stadia play a role in the occurrence of landslides apart from looking for rainfall.

The rainfall thresholds for high-intensity landslides are 61 mm and 91 mm for effective rainfall of 1 d and 3 days, respectively; the rainfall thresholds for moderate intensity landslides are 30 mm and 64 mm for effective rainfall of 1 d and 3 days, respectively; and the rainfall threshold for landslides is the smallest intensity with a threshold value of 15 mm and 40 mm for effective rainfall of 1 d and 3 days, respectively (Yuniawan et al., 2022). Kebumen Regency is one of the southwest coastal areas of Central Java which is characterized by high rainfall in Sandy (1987); Indratmoko, et al., (2017), the average rainfall in Kebumen Regency is 3,250 mm/year (Sandy, 1996; Bappenas, 2004;Indratmoko et al., 2017), in 2010 rainfall in Kebumen Regency reached 4,100 mm/year (BPS, 2011;Indratmoko et al., 2017).

Figure 2. Landslides occurred in areas along the Karanggayam River

Figure 3. Potential for landslides in areas along the Karanggayam River

4. Conclusion

Based on the results of field research, geomorphological data analysis and Karanggayam River stage data reveal a relationship between the intensity and potential of landslides and geomorphological conditions, encompassing aspects of morphology, morphogenesis, and morphoassociation. The mature river stage level in the study area affects the strength and possibility of landslides caused by lateral erosion on the outer bend slopes of the river. These slopes are steep, have thick soil, less resistant rock types, and few to moderate plants.

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References

Badan Penanggulangan Bencana Daerah Kabupaten Kebumen. (2021). Tentang Rekapan Bencana di Kabupaten Kebumen. Kebumen: BPBD

Bartelletti, C., Giannecchini, R., D'Amato Avanzi, G., Galanti, Y., Mazzali, A., 2017. The influence of geological–morphological and land use settings on shallow landslides in the Pogliaschina T. basin (northern Apennines, Italy). J. Maps 13, 142–152.

Dzakiya, N., Laksmana, R.B., Hidayah, R.A., 2023. Identifying Probable Slip Surface in Wanurejo, Borobudur District, By Subsurface Analysis Utilizing the Dipole-Dipole Configuration of Resistivity Method. J. Appl. Geospatial Inf. 7, 739–746.

Indratmoko, S., Harmantyo, D., Kusratmoko, E., 2017. Variabilitas curah hujan di Kabupaten Kebumen. J. Geogr. Trop. Environ. 1.

Karnawati, D., 2005. Bencana alam gerakan massa tanah di Indonesia dan upaya penanggulangannya. Jur. Tek. Geol. Fak. Tek. Univ. Gadjah Mada, Yogyakarta.

Lestari, E., 2017. Sistem Drainase Aliran Bawah Tanah Untuk Daerah Rawan Longsor (Studi Kasus Sub DAS Sungai Cikapundung, Bandung), in: Forum Mekanika. pp. 1–7.

Lobeck, A.K., 1939. Geomorphology, an introduction to the study of landscapes. McGraw-Hill Book Company, inc.,.

Nagarajan, R., Roy, A., Vinod Kumar, R., Mukherjee, A., Khire, M. V, 2000. Landslide hazard susceptibility mapping based on terrain and climatic factors for tropical monsoon regions. Bull. Eng. Geol. Environ. 58, 275–287.

Priyono, K.D., Sartohadi, J., 2011. Tipologi Pedogeomorfik Longsorlahan di Pegunungan Menoreh Kabupaten Kulonprogo Daerah Istimewa Yogyakarta.

Regmi, A.D., Yoshida, K., Dhital, M.R., Devkota, K., 2013. Effect of rock weathering, clay mineralogy, and geological structures in the formation of large landslide, a case study from Dumre Besei landslide, Lesser Himalaya Nepal. Landslides 10, 1–13.

Retongga, N., 2023. Analisis Risiko Bencana Longsor Dan Banjir Berbasis Pola Pengaliran Dan Geomorfologi Di Daerah Karanggayam Kabupaten Kebumen Provinsi Jawa Tengah. Tesis. Universitas Pembangunan Nasional "Veteran" Yogyakarta.

Sadisun, I.A., 2005. Usaha Pemahaman Terhadap

Stabilitas Lereng dan Longsoran sebagai Langkah Awal dalam Mitigasi Bencana Longsor (Workshop Penanganan Bencana Gerakan Tanah). Bandung Dep. Geoligi Inst. Teknol. Bandung.

Saito, H., Uchiyama, S., Teshirogi, K., 2022. Rapid vegetation recovery at landslide scars detected by multitemporal high-resolution satellite imagery at Aso volcano, Japan. Geomorphology 398, 107989.

Sartohadi, J., 2008. The Landslide Distribution in Loano Sub-District, Purworejo District, Central Java Province, Indonesia.

Sunimbar, S., Angin, I.S., 2021. Analisis Geomorfologi Kejadian Longsor Di Kecamatan Wolotolo Kabupaten Ende. J. Geogr. 17, 14–22.

Van Beek, L.P.H., Van Asch, T.W.J., 2004. Regional assessment of the effects of land-use change on landslide hazard by means of physically based modelling. Nat. Hazards 31, 289–304.

Van Westen, C.J., Castellanos, E., Kuriakose, S.L., 2008. Spatial data for landslide susceptibility, hazard, and vulnerability assessment: An overview. Eng. Geol. 102, 112–131.

Van Zuidam, R.A., 1983. Guide to geomorphologic interpretation and mapping, section of geology and geomorphology. Copyr. Reserv. ITC Finschede Ned.

Wahyudi, D.R., Sumaryono, S., Sukiyah, E., Muslim, D., Darana, A.R., 2015. Kontrol Morfotektonik Terhadap Gerakan Tanah di Daerah Malalak, Sumatra Barat. J. Lingkung. dan Bencana Geol. 6, 229–240.

Yuniawan, R.A., Rifa'i, A., Faris, F., Subiyantoro, A., Satyaningsih, R., Hidayah, A.N., Hidayat, R., Mushthofa, A., Ridwan, B.W., Priangga, E., 2022. Revised rainfall threshold in the Indonesian landslide early warning system. Geosciences 12, 129.

Zakaria, Z., 2010. Model Starlet, suatu Usulan untuk Mitigasi Bencana Longsor dengan Pendekatan Genetika Wilayah (Studi Kasus: Longsoran Citatah, Padalarang, Jawa). J. Geol. Indones. 5, 93–112.

Zhang, J., Qiu, H., Tang, B., Yang, D., Liu, Y., Liu, Z., Ye, B., Zhou, W., Zhu, Y., 2022. Accelerating effect of vegetation on the instability of rainfall-induced shallow landslides. Remote Sens. 14, 5743.