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CASE STUDY OF SPATIAL PLANNING MISMATCH AGAINST GEOMORPHOLOGY IN KAMPAR REGENCY: LANDSLIDE SUSCEPTIBILITY ANALYSIS

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ABSTRACT: This research performs a comprehensive landslide hazard mapping in Kampar Regency by integrating Geographic Information System (GIS) technology with a weighted overlay modeling approach based on four critical physical parameters: slope gradient, rainfall intensity, soil type erodibility, and land use characteristics. Utilizing classification standards from BAPPEDA and weighting methods from Taufik Q, Firdaus et al. (2012) and BNPB Regulation No. 02 of 2012, the study identifies that the region is dominated by rainfall intensities of 2501–3000 mm/year and a significant distribution of Andosol soil types which contribute to soil instability. The spatial analysis results categorize the hazard levels into three classes—Safe, Moderately Prone, and Prone—revealing that XIII Koto Kampar Subdistrict faces the highest risk with a prone area of 88,008.48 hectares (92.36%), primarily due to steep topography and high runoff velocity, whereas Bangkinang Subdistrict is identified as the safest area with a low-risk coverage of 6,836.66 hectares (28.20%). These findings conclude that land use with high vegetation density, such as forests which cover 73,154.26 hectares, plays a vital role in reducing runoff, and the resulting hazard map serves as a crucial spatial decision-support tool for disaster mitigation and regional planning in Kampar Regency.

Keywords: Landslide Susceptibility, GIS Overlay, Spatial Modeling, Kampar Regency, Disaster Mitigation.

1. INTRODUCTION

Kampar Regency is one of the regions in Riau Province characterized by a complex geomorphological profile, consisting of undulating hills, steep slopes, alluvial plains, and areas along the Kampar River Basin. These geomorphological conditions render parts of Kampar highly vulnerable to landslide disasters, particularly in hilly terrains and areas undergoing rapid land-use changes [1].

In recent years, landslide events in Kampar have recurred in several locations, such as the districts of XIII Koto Kampar, Kuok, and Kampar Kiri Hulu, as well as along the strategic Riau–West Sumatra highway. Many of these incidents occur on road embankments, steep slopes, land-clearing areas, and degraded zones. This indicates significant pressure on the natural landscape, which should ideally be managed according to its land capability [2].

Meanwhile, the Spatial Planning document of Kampar Regency designates specific areas for residential use, plantations, cultivation, industry, and transportation infrastructure. However, in several locations, these spatial allocations do not fully account for geomorphological constraints, particularly slope steepness, soil stability, and the function of protected forest zones. Spatial utilization on land that is geomorphologically unsuitable—such as developing settlements on steep slopes, land clearing at the foot of hills, or road construction without calculating slope stability-can trigger or exacerbate landslide occurrences [3].

The mismatch between land use in the RTRW and geomorphological conditions leads to an increased risk of disasters. In the case of Kampar, recurring landslides on main transportation routes, residential areas, and cultivation lands demonstrate that the region is under pressure due to spatial utilization that is not aligned with its physical environmental capacity. Consequently, besides causing infrastructure damage, landslides also threaten public safety and hinder socio-economic activities [4].

Therefore, a study on the compatibility between the Kampar Regency RTRW and the geomorphological conditions of landslide-prone

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areas is essential. This analysis is required to assess the extent to which spatial planning has considered geomorphological vulnerability and to identify critical points that require special intervention. The results of this study are expected to provide a basis for policy recommendations in spatial planning improvement, disaster mitigation, and more sustainable environmental management [5].

2. METHODS

This research employs a quantitative approach by calculating the weights of various variables that influence landslide occurrences. These variables include slope steepness, rainfall, land use, and soil type. Weighting is applied using a specific scoring scale for each variable class, assigned according to its relative influence on landslide susceptibility. All data utilized in this analysis are geospatial based, making the use of Geographic Information Systems (GIS) fundamental throughout the stages of data collection, processing, analysis, and visualization. The data analysis is performed through map overlay techniques and the calculation of the total weight for all variables across each resulting land unit. The results of this analysis produce a landslide susceptibility map, which is classified into five distinct levels: Very Low, Low, Moderate, High and Very High [6-10].

3. RESULTS AND DISCUSSION

GIS technology can be utilized to map land potential and hazards. A landslide is a process involving the displacement or movement of soil mass in an oblique or vertical direction from its original position, resulting from driving forces. Landslides can also be defined as the movement of rock or soil masses due to the force of gravity.

The intensity of landslide occurrences and the level of hazard are heavily influenced by high and continuous rainfall, slope conditions ranging from steep to very steep, land use that is incompatible with the land's capability, thick soil layers, and varied geological rocks and structures. A landslide, often referred to as mass wasting or ground movement, is a geological event occurring due to the movement of rock or soil masses in various types and forms, such as rockfalls or large soil slumps.

One of the most frequently identified causal factors is the mismatch between spatial utilization and local geomorphological conditions. Many areas with steep slopes have been utilized for settlements, mixed gardens, plantations, and road Regency to the west, Siak Regency and Pekanbaru City to the east, Pelalawan Regency to the south, and West Sumatra Province to the south and infrastructure without considering the environment's carrying and supportive capacity. Deforestation, land clearing on slopes, and a lack of soil conservation efforts further exacerbate slope instability. The Spatial Planning of Kampar Regency has established regulations for protected areas, disaster-prone zones, and cultivation areas. However, in implementation, overlaps are frequently found between actual land use and physical geomorphological conditions.
Consequently, areas that should function as protected zones are instead utilized intensively. This discrepancy increases landslide risk and highlights the urgent need for a comprehensive evaluation of spatial planning based on the physical characteristics of the land.

Administrative Map of Kampar Regency Kampar Regency is one of the regencies in Riau Province with a vast administrative area divided into numerous sub-districts. Administratively, Kampar Regency is bordered by Rokan Hulu southwest. This administrative division serves as a fundamental basis for development planning and regional spatial management [11-17].

Fig. 1. Kampar Regency

Mapping is conducted by utilizing Geographic Information Systems (GIS) to identify disaster-prone locations through Weighted Overlay modeling. This process is based on the physical characteristics of the region, including slope steepness, land use, soil type, and rainfall. The analytical method is grounded in spatial analysis, which examines various aspects of the geographic space. The research results produce a landslide susceptibility map classified into five levels: very low, low, moderate, high, and very high. The majority of landslide locations are situated in areas with moderate to very high vulnerability. Areas with built-up land cover (buildings and infrastructure) exhibit higher vulnerability to landslide disasters compared to agricultural areas or vacant land.

Table 1. Classification and Weighting of Slope Parameters

Slope Class Parameter (%)	Weight	Total Weight	Area (Ha)
0 – 2%	4	16	322,721.29
2 – 15%	8	32	526,970.08
15 – 25%	12	48	37,093.10
25 – 40%	16	64	75,601.73
> 40%	20	80	52,149.94

Based on the slope map of Kampar Regency presented above, it is observed that the largest area is dominated by the 2–15% slope class, covering 526,970.08 hectares. Meanwhile, the smallest area is occupied by the 15–25% slope class, which accounts for 37,093.10 hectares. The rainfall parameter is analyzed based on annual rainfall data from 2018, sourced from the Dynamic Monograph records.

Table 2. Classification and Weighting of Rainfall Parameters

Rainfall Class Parameter (mm/year)	Class	Weight	Total Weight	Area (Ha)
2001 – 2500	Low	4	12	66,414.46
2501 – 3000	Moderate	8	24	752,432.97
3001 – 3500	High	12	36	185,800.16
> 3501	Very High	16	48	234.14

Based on the rainfall map of Kampar Regency presented above, the largest area is categorized under the 2501–3000 mm/year rainfall class, covering 752,432.97 hectares. In contrast, the smallest area is found within the > 3501 mm/year class, which accounts for only 234.14 hectares. The soil type parameter, specifically soil erodibility (the level of soil sensitivity to erosion), is categorized into three classes: high, moderate, and low. Soil erodibility is classified as follows: high erodibility includes Regosol and Andosol; moderate erodibility includes Andosol, Gray Humic, Mediterranean, and Podzolic; and low erodibility includes Alluvial, Latosol, and Grumusol.

Tabel 3. Soils Class

Soil Type Parameter	Class	Weight	Total Weight	Area (Ha)
Alluvial, Latosol, Grumusol	Low	4	8	2,655.02
Mediterranean	Moderate	8	16	3,717.77
Andosol	High	12	24	6,773.83

Based on the soil type map of Kampar Regency presented above, the largest area is occupied by the Andosol soil class, covering 6,773.83 hectares. Conversely, the smallest area is represented by the Alluvial class, which accounts for 2,655.02 hectares. The classification of land use types in relation to landslide hazards is categorized into six groups, which include settlements, rice fields, dry fields, moorlands, and plantations.

Table 4. Classification of Land Use Parameters

Land Use Type	Weight	Total Weight	Area (Ha)
Swamp / Fishpond	2	2	24,936.20
Forest	6	6	73,154.26
Rice Field, Dry Field, Moorland, Plantation	8	8	179.06
Shrub / Bush	4	4	7,399.43
Settlement / Built-up Area	10	10	29,092.41

Landslide Hazard

The analysis of the landslide hazard map in Kampar Regency provides several critical insights. The slope gradient is utilized to determine the volume and velocity of surface runoff; steeper slopes significantly increase the speed of surface flow. Slope steepness influences surface runoff volume, drainage, land use, and erosion rates. The assumption is that gentler slopes result in slower runoff. Conversely, on steeper slopes, surface flow is faster, allowing rainwater to be discharged immediately without ponding, which can reduce certain types of localized flooding but increase the energy for mass soil movement. Rainfall is a primary trigger for landslides. High precipitation intensity often leads to slope failure. During prolonged dry seasons, the soil dries out and forms cracks or pores. When the rainy season arrives, water infiltrates these cracks and fills the voids, increasing pore water pressure and weight, which eventually triggers soil displacement or landslides.

Soil type is closely related to the infiltration and percolation processes. Infiltration is influenced by soil texture and structure. Coarse-textured soils, potential for flooding because rainwater or river overflows struggle to soak into the ground, leading to inundation. Conversely, coarser textures generally have a lower probability of inducing certain types of saturation-related landslides compared to fine-textured soils that trap water. Land use plays a vital role in determining the amount of surface runoff generated when rainfall exceeds the infiltration rate. Areas densely populated with trees significantly reduce runoff due to the high water absorption capacity of vegetation and the physical obstruction of roots and trunks which slow down the flow. In vegetated lands, a higher volume of rainwater is infiltrated, and the travel time for runoff to reach river systems is increased, there by reducing the risk of flooding and erosion compared to non-vegetated areas. By integrating these four classifications—slope, rainfall, soil type, and land use—the landslide hazard map for Kampar Regency was successfully analyzed. The results categorize the region into three hazard levels: Low Risk (Safe), Moderate Risk (Moderately Prone), and High Risk (Prone). Based on Table 6 above, the total area in hectares (Ha) and the percentage of landslide hazard levels for each subdistrict in Kampar Regency have been identified, ranging from Safe to High Risk (Prone). The subdistrict with the highest hazard level is XIII Koto Kampar, with a high-risk (Prone) area of 88,008.48 hectares, accounting for 92.36% of its territory. Conversely, the safest subdistrict (lowest hazard level) is Bangkinang, with a safe area of 6,836.66 hectares, representing 28.20% of its total area.

4. CONCLUSION

This study utilized Geographic Information Systems (GIS) to map landslide-prone locations through overlay modeling of the region's physical characteristics, including slope, land use, soil type, and rainfall. The analysis successfully quantified the hazard levels across Kampar Regency, categorizing subdistricts into safe, moderately prone, and prone areas. The findings indicate that XIII Koto Kampar is the subdistrict with the highest hazard level, featuring a high-risk (prone) area of 88,008.48 hectares (92.36%). In contrast, Bangkinang is identified as the safest subdistrict, with a low-risk (safe) area covering 6,836.66 hectares (28.20%).

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