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Landslide susceptibility assessment using geographic information system in Aring, Gua Musang, Kelantan.

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Abstract. Aring lies in Gua Musang District, Kelantan which is prone to geological risks like rock falls and slides. In some regions, it is also prone to landslides, which can result in fatalities and property damage such as houses and vehicles. The goal of this research is to assess landslide causative factors and create a landslide susceptibility map. The Digital Elevation Model (DEM) was used to determine the causative factors: aspect, slope, elevation, and drainage density while the lithology was based on a geological map, and the lineament was calculated using satellite data. Weighted Overlay Method (WOM) analysis was used to combine these weighted causative factor maps into a Geographic Information System (GIS) The landslipe susceptibility map was divided into three categories. Low hazard is class 1, medium hazard is class 2, and high hazard is class 3. As a conclusion, the capacity to estimate landslide susceptibility leads to a greater understanding of landslide mechanisms, allowing for better prevention of the most likely failure locations within a landslide-prone area in the future.

1. Introduction

Landslides are a type of geohazard that can be classified as a natural disaster. The landslide was characterised as the material's shear strengths forming when gravitational and other sources of shear stress overwhelm the slope [1]. It can happen spontaneously, but only at a gradual pace. Landslides will occur as a result of human activities such as urbanisation, deforestation, and many others. This is due to the fact that human activities or land use alter natural land distributions [2].There are often multiple types of movement inside a single avalanche. Landslides are common in tropical nations like Malaysia [3]. Because it occurs largely in developed areas such as towns and highways, it is one of the key obstacles for development projects in the country's highlands. People, society, and infrastructure were all affected by the landslides that happened in Malaysia. According to [4,] landslides near apartments or housing zones resulted in human fatality. Aside from that, it has an impact on people's economic and social lives.

In general, large-scale landslides have occurred in Malaysia, primarily as a result of severe and sustained rainfall. Landslide losses and other ground-change impacts are growing more rigorous as land development and human activities increase fast. The development of the hilly terrain has the potential to have large permanent consequences on the immediate environment as well as the downstream environment [5]. Landslides can be classified based on the type of material involved and the flow/motion mode. Human influence is responsible for about 80% of landslides and poor slope management approaches [6].

Gua Musang is a highland town. As stated by [7], slope, aspect, soil, lithology, and precipitation quantities are all causal variables for landslides in Kelantan. He also claimed that the amount of precipitation is one of the primary elements that causes the landslide. Due to enormous levels of rainfall during the Kelantan flood of 2014, rainfall distributions are reported to be the main contributing reasons. Aside from it, land use or land cover, as well as development along slopes, have become the second most significant contributors to landslides.

Landslide susceptibility refers to the likelihood of a landfall in a certain area according to local topography characteristics [8]. Susceptibility does not take into account the size, length, width, depth area, or volume of the landslide. The susceptibility assessment, on the other hand, was able to account for landslides of various magnitude. The growing use of Geographic Information Systems (GIS) has resulted in a slew of studies, the majority of which use indirect susceptibility-mapping methodologies [9].

The main objective of this study was to prepare a landslide susceptibility map of Aring. The general methodology followed includes landslide inventory mapping, followed by preparation of a statistical hazard model based on various causative factors.

The major goal of this research was to create a map of Aring's landslide susceptibility. Landslide inventory mapping is the first step, followed by the creation of a statistical hazard model based on multiple causative elements. Finally, landslide susceptibility was calculated based on the relative influence of several causative factors and divided into three categories: high, moderate, and low.

2. Methodology

Preliminary study, data collecting and processing, data interpretation, and data analysis were all part of the process of creating a landslide susceptibility map. All of the information needed to determine landslide susceptibility was gathered from primary and secondary sources. Secondary data collection pertaining to topographical maps, satellite imageries and DEM data was part of the pre-field work. The goal of the field inquiry was to gather all relevant information on previous landslide activities in the area and to double-check the numerous causative factor maps that had been generated during the pre-field study. In this study, a WOM approach was applied. Within each causative factor map and associated parameter map classes, the densities of landslide events were calculated. In addition, a generic quantitative prediction was created to rate the causative factors that could cause landslides in similar settings. The landslide susceptibility map was created by combining the causative factor maps with the resulting weights.

2.1. Landslide inventory. A rigorous landslide inventory was carried out for this investigation. All existing landslides in the study area were thoroughly investigated, and pertinent data for hazard assessment was gathered. As a result, information on the location, dimension, and material involved in previous landslides was gathered.

2.2. Evaluation of causative factors. Six significant causative elements were evaluated for the landslide susceptibility study: (i) lithology, (ii) slope, (iii) elevation, (iv) aspect, (v) drainage density, and (vi) lineament. These causative elements were examined based on previous landslide observations and their potential role in causing slope instability in the area.

2.2.1. Lithology. Differences in lithology played a significant part in determining whether an area is prone to landslides or not. According to [10], the characteristics of the component materials of a slope, such as permeability, porosity, and strength, play a critical role in the slope's stability and are often different for different lithological units, so this factor has a significant impact on the likelihood of landslide occurrence. Limestone, sandstone, tuff, and alluvium are the four types of lithologies found in the study area. Each lithology represents the structure and formation of that particular location. All of the lithologies in this example overlap in the same formation, the Aring Formation, and alluvium is from the quaternary period (Figure 1).

2.2.2. Slope. When comparing a gentle slope to a higher slope, the steeper slope is more prone to instability. The DEM was used to extract the slope for this research area, which is shown in Figure 2. The frequency of landslides is strongly influenced by the slope aspect. The scores improve as the degree of slope increases. During the field mapping, the landslide scar was identified. A landslide frequently occurs on both a steep and a gentle slope. A slope category map for six categories was created for this study: (i) 0–5°, (ii) 5–14°, (iii) 14–25°, (iv) 25–35°, (v) 35–45°, and (vi) >45°, which refers to works by [11].

2.2.3. Elevation. The elevation in the research area was calculated using a contour obtained from Triangular Irregular Network (TIN) in the ArcGIS software. Low hill (100-200m), hill (200-500m), and high hill (500- 1500m) are the three landform classifications above sea level (Figure 3).

2.2.4. Aspect. This map was created using DEM data that was separated into eight different slope directions according to the North. The parameter is used to observe the slope's direction and displays the gravitational force dependent on the slope's orientation. It is measured from 0 degrees in the north to 360 degrees in the south. The aspect map of the research area is depicted in Figure 4.

2.2.5. Drainage density. The drainage density is calculated by dividing the entire stream and river length of the drainage basin by the total drainage basin area. Drainage variance has been influenced by climate, terrain, soil infiltration, vegetation, and flux density. It is critical to determine the fluvial network in the research area. The landslide prone area can be determined in the scope of debris flow and seepage due to rainwater penetration. The drainage density map was created using the ArcGIS DEM data. Drainage density is calculated by dividing the length of a stream by its area. Drainage density was divided into three categories: low, moderate, and high. The high drainage density indicates that there is a greater risk of landslides. This is due to the significant amount of surface runoff. The drainage pattern of the research area is depicted in Figure 5.

2.2.6. Lineament. In many situations, geological structural elements such as lineaments, which may be seen on satellite images, regulate the occurrence of landslides [12]. The negative lineament revealed streams, faults, and valleys in this research (Figure 6). Negative lineaments were usually visually compared to landslide occurrences. There could be a link between lineaments and the occurrence of landslides. As a result, lineament mapping is critical in the early stages of planning to avoid landslide hazards.

2.3. Factors triggered lanslide

The landslide could have been triggered by a number of circumstances. Rainfall intensity is identified as the key element that causes landslides to occur every year in the research area. Landslides can be caused by excessive rainfall, especially in areas with deep, worn soil. When rainfall falls heavily and fills the porosity and void in the soil, an excessive amount of water slides through the bedrocks, creating landslides [13].

2.4. Lanslide suscpetibility assessment

Before the landslide susceptibility map could be created, all of the selected parameters had to be transformed into a raster data collection. The weightage of these raster data was then reclassified.

The landslide susceptibility map was created using a GIS tool and the weightage overlay approach. The lithology, slope, elevation, aspect, drainage density, and lineament criteria for landslide causative factors were chosen. The weights were applied to the parameters, and the total of all factors was set to 100 percent using the formula:

$$S = \frac{\Sigma wisij}{\Sigma wi}$$

In order to construct the landslide susceptibility map using the weightage overlay approach, it is necessary to reclassify the data.

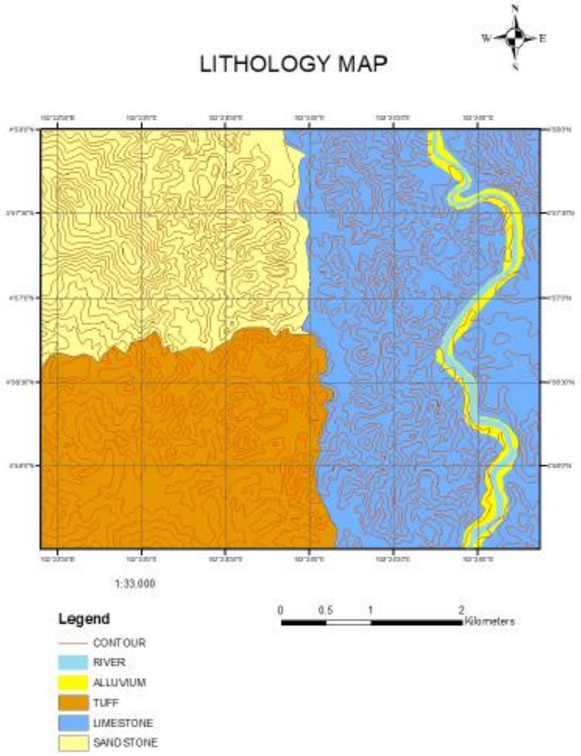

Figure 1. Lithology map

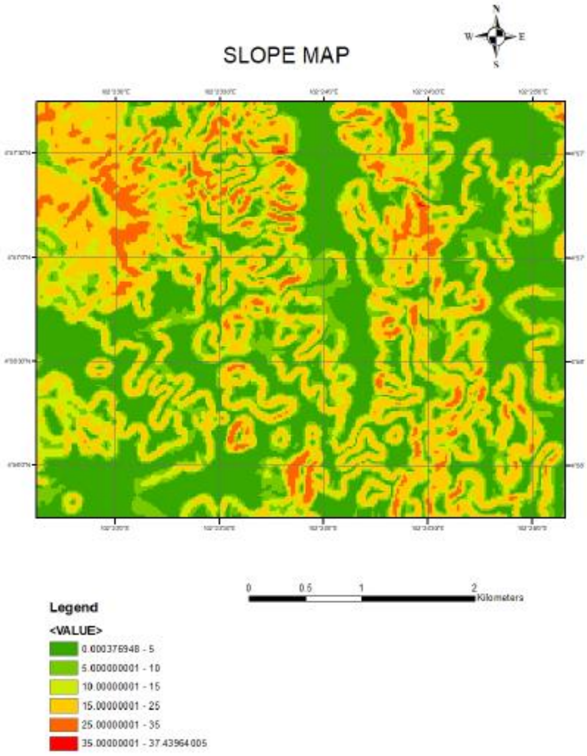

Figure 2. Slope map

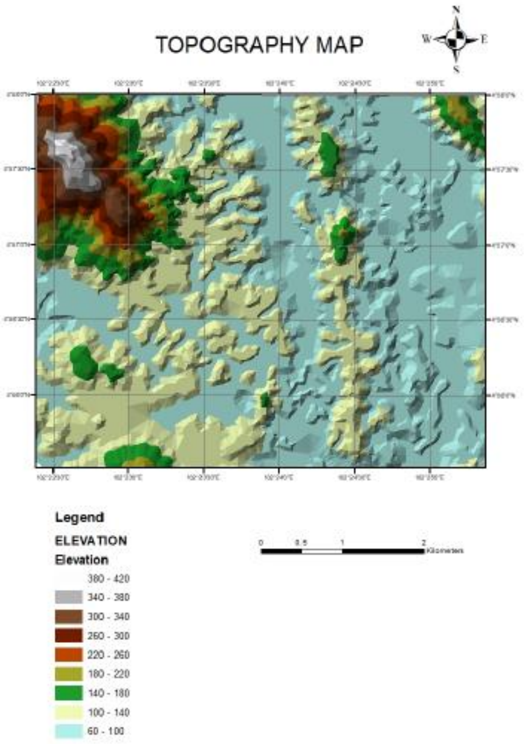

Figure 3. Elevation map

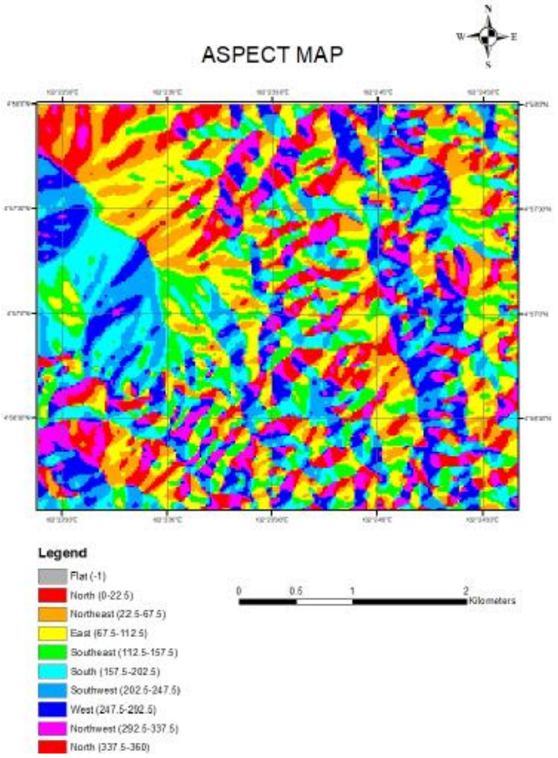

Figure 4. Aspect map

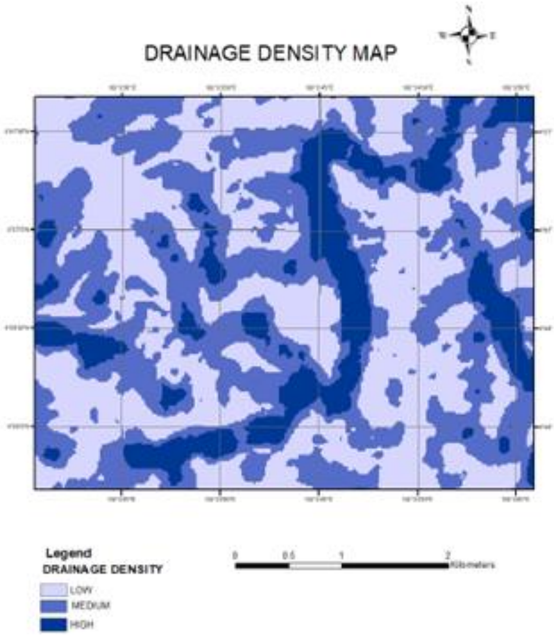

Figure 5. Drainage Density map

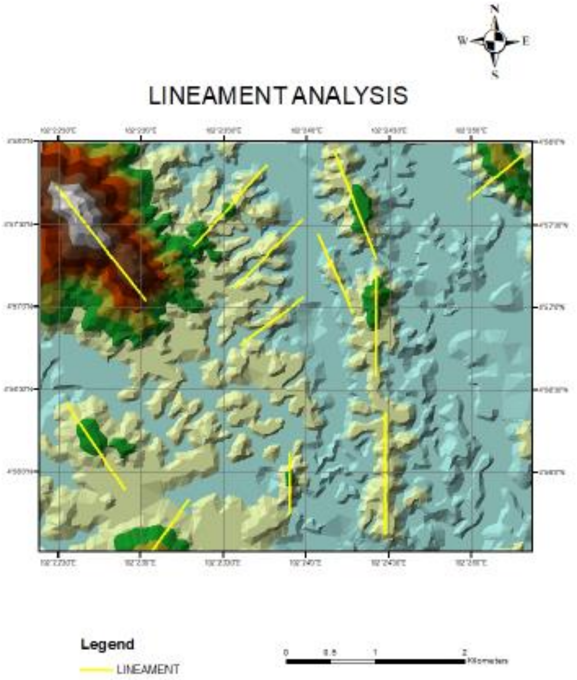

Figure 6. Lineament analysis map

3. Results and Discussion

3.1. Landslide Susceptibility Map

The landslide susceptibility map for this study found that 75% of the study area has a low hazard, 15% has a medium hazard, and 10% has a high hazard (Figure 7). Slope, lithology, and drainage density all play a part in landslide susceptibility studies and are becoming increasingly relevant characteristics. Landslides are more likely to occur on slopes with a steeper pace. Because the rock and soil that originated in the area have variable porosity and void, the lithology has an impact on the landslide. The intensity of drainage density indicates that the hydrological element can trigger landslides as most landslides occur along rivers and streams. The landslide phenomenon is moderately influenced by elevation, lineament, and aspect. However, it is also crucial in landslide analysis in the study region in terms of other metrics and factors caused. The susceptibility class for the landslide hazard in the research area is shown in Table 1.

Table 1. Susceptibility of landslide hazard in the study area

Susceptibility Class	Risk	Area Percentage (%)
Low	0 – 50%	75
Moderate	50 – 75%	15
High	> 75%	10

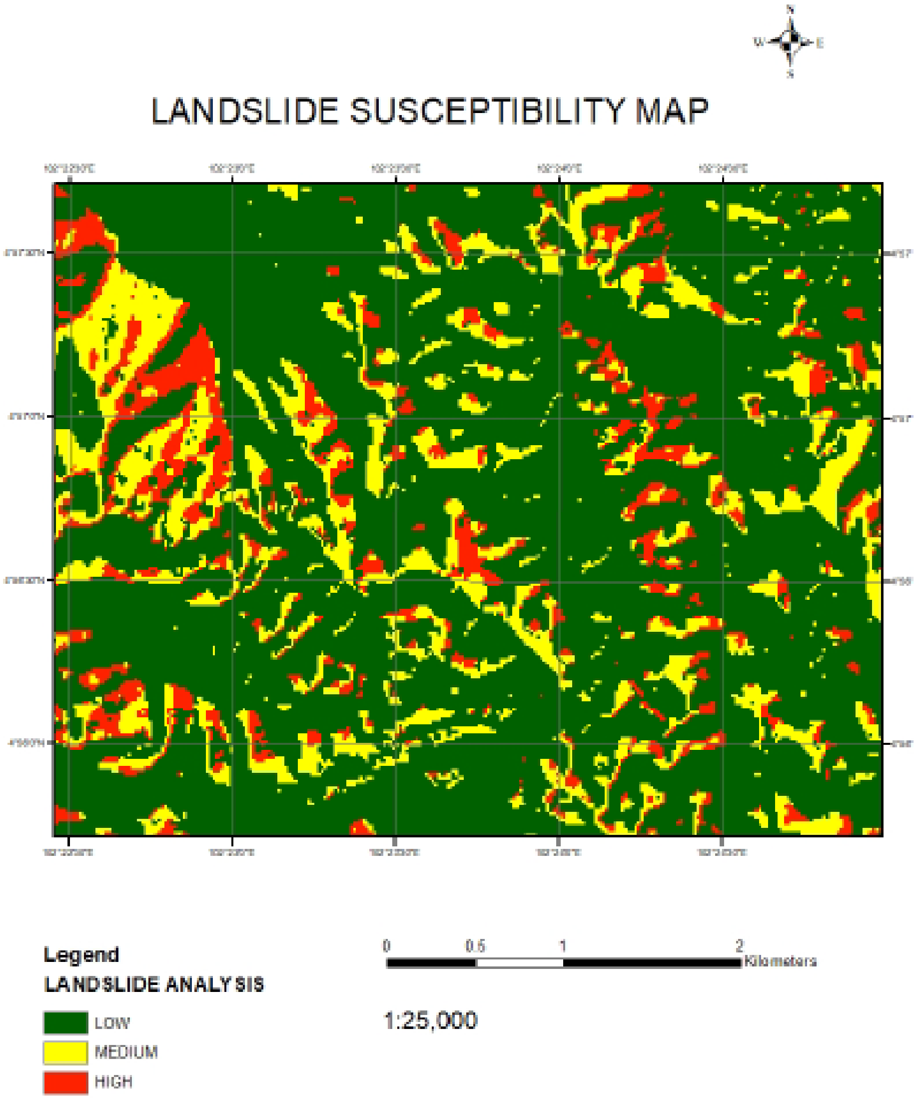

Figure 7. Landslide Susceptibility map

4. Conclusion

In conclusion, the analysis affects the possible vulnerability of Aring 6, Gua Musang Kelantan, to landfall. The landslide susceptibility map for the research area is effectively developed by identifying the landslide zoning area based on the three zoning groups of low, medium, and high.The landslide susceptibility map for the research area was created using the parameters lithology, slope, aspect, elevation, lineament and drainage density. By doing this analysis, the region's knowledge of areas with a high risk of landslides may be spread across society. According on the results of the evaluation, any preventive and new landmark estimations could be carried out. The accuracy of the map produced will aid authorities in disaster mitigation and planning in making the best decisions possible in the future.

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