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Transmission tower classification based on landslide risk map generated by Geographical Information System (GIS) at Cameron Highlands

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Abstract. Transmission tower is usually locates at remote area which is covered by hilly topography. Landslide is mainly occurring at hilly area and causing failure to the tower structure. This phenomenon subsequently will affect the national electricity supply. A landslide risk hazard map is generated using Geographical Information System (GIS). Risk classification is introduced to initiate the monitoring process along Jor-Bintang transmission line, Cameron Highland, Pahang. The classification has been divided into three categories, which are low, medium and high. This method can be applied in slope monitoring activities since all towers have been classified based on their risk level. Therefore, maintenance schedule can be planned smoothly and efficiently.

1. Introduction

Landslide is one of the world's catastrophes that affect enormous economic loss and one of the common interference nowadays. Malaysia is located at latitude 2^{o} to 7^{o} north and 100^{o} to 119^{o} east. Total area of Peninsular Malaysia is about 131,589 km^2 with 60% of the area covered by hilly topography. Every year, many landslide cases reported, either at man-made or natural slopes.

Application of new technology in prediction of slope assessment in Malaysia began in the early 1990's. As an effort to diminish landslide hazard and their consequences, government agencies and private organizations collaborated to deal with the issues. In Malaysia, existing slope assessment scale is normally conducted by dividing into two categories; large-scale and medium-to- small-scale. Lembaga Lebuhraya Malaysia (LLM) applying large-scale assessments in prioritizing slope maintenance along roads and highways. While medium-to-small-scale assessments in controlling development in hilly areas are widely use by Jabatan Kerja Raya (JKR), Jabatan Perancang Bandar dan Desa (JPPD) and Jabatan Mineral & Geossains (JMG) [1].

Slope monitoring guidelines prepared by JKR recommended standard of good practice for the maintenance of man-made slopes, disturbed terrain features and natural terrain hazard mitigation measures. The guidelines are widely used in slope engineering practice especially on new development at landslide prone area [2].

2. Landslide Risk Map Analysis using GIS

GIS is a computer system for managing spatial data. GIS is utilized to yield useful knowledge, application of colored maps and images, statistical graphics, tables, and various on-screen responses for interactive appearance. The software is made up from several interrelated and linked components with different functions. This software provides a comprehensive tool for assessing temporal environment data. A combination of GIS and Remote Sensing is useful for environmental auditing [3].

Landslide is the most common natural hazard these days that impacts the environment and human activities. Most of the occurrences are due to human factors such as extensive earth cutting, land clearing, agricultural activities, burning and uphill developments [4]. Identification of Landslide Susceptibility Zonation (LSZ) is important for safe strategic planning for future development. LSZ can be defined as the division of land surface into near-homogenous zones and rank according to the degrees of actual or potential hazard due to landslides. Methods of producing LSZ can be divided into two categories; qualitative approach and quantitative approach. Qualitative approach is integrated in generating LSZ map since a lot of subjectivity is introduced in preparing various thematic data layers. While quantitative approaches are introduced to minimize subjectivity in the weight assignment process. Common landslide causative factors such as lithology, lineament, slope, aspect, landuse and drainage are important for weights and ratings [5].

Type of approach used for this research is statistical approach (multivariate statistical analysis) because it is suitable for GIS tools and analysis. In this method, each individual thematic data layers are compared to the existing landslide distribution layers. The weight value of each category of causative factors is assigned based on landslide density. This involves overlay of landside distribution layer on each thematic data layers and calculation of respective landslide density values.

3. GIS Modelling

GIS Modelling needs various types of raw data before it comes to analysis stage. Most of the data are collected from previous researchers, government agencies and private sectors. Data sources are summarized in Table 1.

Table 1. Source of Data Collected

Description	Sources
Contour maps of Peninsular Malaysia (2004)	Department of Survey and Mapping Malaysia (JUPEM)
Soil maps	Department of Agriculture (DOA)
Land Use Map	Department of Agriculture (DOA)
Geology Maps (Peninsular Malaysia)	Minerals and Geo-Science Department (JMG)
Weightage value for Landuse Type	Literature Review
Weightage value for Lithology	Literature Review
Weightage value for Slope Category	Literature Review
Weightage value for Aspect	Literature Review
Weightage value for Elevation	Literature Review

For this research, statistical approach is used in producing landslide hazard map. This method is based on observation of relationship between each factor. Weightage values are differentiated based on types of soil, geological properties, landuse type and slope, as listed in the Table 2 [6].

Table 2 Weightage Values

LANDUSE TYPE				ASPECT		
Tin Mine	5	Wet Paddy	3	Flat	-1^{O}	1
Water Tank	5	Rubber	3	North	$0 - 22.5^{O}$	1
Pond	5	Oil Palm	3	Northeast	$22.5 - 67.5^{O}$	1
Primary Forest	5	Vegetables	3	East	$67.5 - 112.5^{O}$	2
Rifle Rang	5	Cash Crops	2	Southeast	$112.5 - 157.5^{O}$	2
Rural Building	5	Rock	2	South	$157.5 - 202.5^{O}$	3
Cemetery	5	Cocoa	2	Southwest	$202.5 - 247.5^{O}$	3
Education	5	Outcrop	2	West	$247.5 - 292.5^{O}$	4
Industrial	5	Annual Crops	2	Northwest	$292.5 - 337.5^{O}$	4

Jetty	5	Banana	2	North	337.5 – 360^{O}	1
Lake	5	Bush	2			
Major River	5	Coconut	2			
Non Tidal	5	Sand	1			
Others Building	5	Clear Land	1			
Railway Station	5	Grass	1			
SLOPE CATEGORY				LITHOLOGY		
0 – 15^{O}		1		Carboniferous		5
15 – 25^{O}		2		Permian		4
25 – 35^{O}		3		Triassic		3
35 – 45^{O}		4		Tertiary		3
45 – 90^{O}		5		Igneous Activity		2
				Silurian-Ordovician		2
				Devonian		2

4. Landslide Hazard Map and Risk Classification

Landslide Hazard Map is generated using Statistical Approach by considering weightage value for every data layer. Raw datas such as contour map, lithology map and landuse are analyzed using Model Builder application in GIS. All data must be in raster format before it can be layered to each other. The calculation for both study areas is done based on weightage value of every layer as shown in Figure 2.

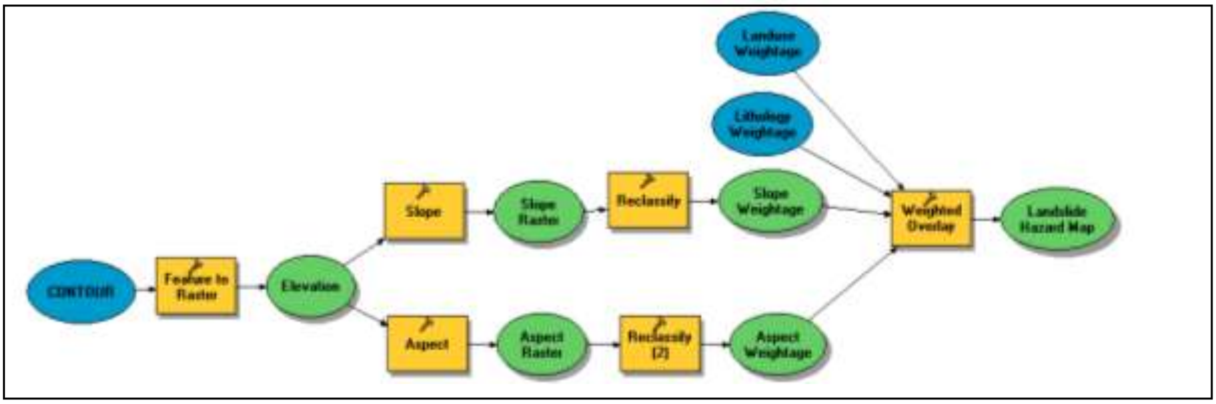

Figure 2. Weightage Overlay for Landslide Hazard Map

Classification of risk has been divided into three stages, which are low hazard (1 to 2), medium hazard (3 to 4) and high hazard (5 to 6). Figure 3 shows the detail layers in producing landslide hazard map for Jor-Bintang transmission line in Cameron Highland. After producing the erosion hazard map, all transmission towers have been arranged into their hazard class by GIS zoom scale 1:20,000. The classification is summarized in Table 3.

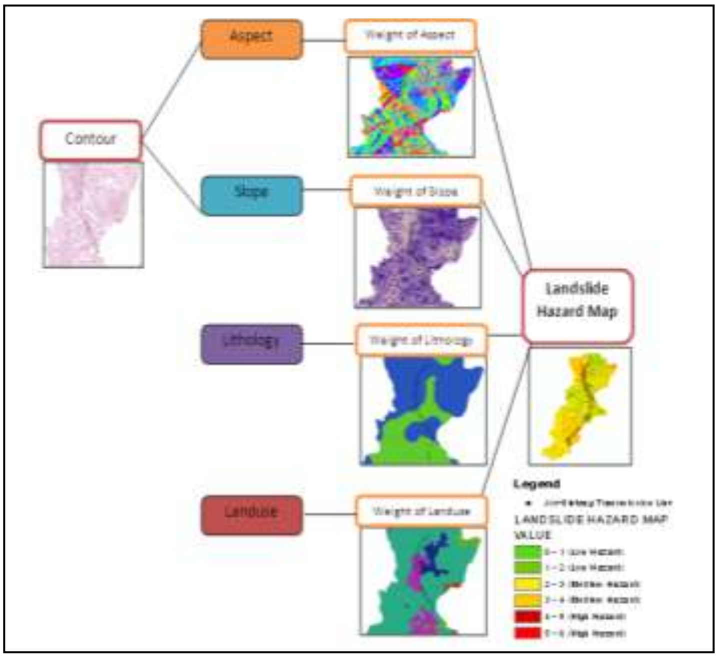

Figure 3. Landslide Risk Map

Table 3. Weightage for Lithology

Risk Level	List of Tower
Low Hazard	T2, T15, T18, T20, T22, T23, T24, T28
Medium Hazard	T5, T6, T12, T13, T3, T9, T16, T17, T19, T21, T25, T26, T29, T30, T31, T32, T33, T34, T36, T37, T38, T39, T40, T45
High Hazard	T4, T7, T8, T10, T11, T14, T27, T35, T41, T42-T44

5. Conclusion

As a conclusion, by referring to the risk level, frequency in monitoring stability of transmission tower can be planned smoothly and efficiently, especially during rainy season.

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