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

Hazwani NK, Rohayu CO, Fathoni U, Inz Baharuddin
Centre for Forensic Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.
E-mail: hazwani@uniten.edu.my

Abstract. Transmission tower is usually located 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° to 7° north and 100° to 119° east. Total area of Peninsular Malaysia is about 131,589 km² 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.

| 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].

| LANDUSE TYPE | ASPECT |
|--------------|--------|
| Tin Mine     | 5      |
| Water Tank   | 5      |
| Pond         | 5      |
| Primary Forest| 5   |
| Rifle Rang   | 5      |
| Rural Building| 5   |
| Cemetery     | 5      |
| Education    | 5      |
| Industrial   | 5      |

| Description            | Sources                                      |
|------------------------|----------------------------------------------|
| tin mine               | Literature Review                            |
| rubber                 | Literature Review                            |
| oil palm               | Literature Review                            |
| vegetables             | Literature Review                            |
| cash crops             | Literature Review                            |
| rock                   | Literature Review                            |
| cocoa                  | Literature Review                            |
| outcrop                | Literature Review                            |
| annual crops           | Literature Review                            |

| Description            | Sources                                      |
|------------------------|----------------------------------------------|
| tin mine               | Literature Review                            |
| rubber                 | Literature Review                            |
| oil palm               | Literature Review                            |
| vegetables             | Literature Review                            |
| cash crops             | Literature Review                            |
| rock                   | Literature Review                            |
| cocoa                  | Literature Review                            |
| outcrop                | Literature Review                            |
| annual crops           | Literature Review                            |
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](image)

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.
Table 3. Weightage for Lithology

| Risk Level   | List of Tower          |
|--------------|------------------------|
| Low Hazard   | T2, T15, T18, T20, T22, T23, T24, T28 |
| Medium       | 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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