Regional analysis assessment of landslide hazard and zoning map for transmission line route selection using GIS

I N Z Baharuddin¹,², R C Omar¹,², F Usman¹,², M A Mejan², M K Abd Halim² and M A Zainol⁵ and M S Zulkarnain²

¹Department of Civil Engineering, College of Engineering, UNITEN, 43000 Kajang, Malaysia
²Centre for Forensic Engineering (CeFE), College of Engineering, UNITEN, 43000, Kajang, Malaysia

E-mail: intan@uniten.edu.my

Abstract. The stability of ground as foundation for infrastructure development is always associated with geology and geomorphology aspects. Failure to carefully analyze these aspects may induce ground instability such subsidence and landslide which eventually can cause catastrophe to the infrastructure i.e. instability of transmission tower. However, in some cases such as the study area this is unavoidable. A GIS system for analysis of route was favoured to perform optimal route predictions based selection by incorporating multiple influence factors into its analysis by incorporating the Landslide Hazard Map (LHM) that was produced on basis of slope map, aspect map, land use map and geological map with the help of ArcGIS using weighted overlay method. Based on LHM it is safe to conclude that the proposed route for Ulu Jelai- Neggeri-Lebir-LILO transmission line has very low risk in term of landslides.

1. Introduction

In the territorial planning stage, analysis and identification of natural geological and geomorphological hazards (geohazards) associated with natural processes has becomes crucial aspect. Detailed assessment on this aspect is also vital and will provide better solution which emphasizes the element of optimization [1]. However, in transmission line route planning, only topography aspect is considered while geology aspect such as its formation and rock type are often overlooked. Therefore, there is a great need to develop a strategy utilizing advanced techniques of geo-informatics for route planning.

The stability of ground as foundation for infrastructure development is always associated with geology and geomorphology aspects. Failure to carefully analyze these aspects may induce ground instability such subsidence and landslide which eventually can cause catastrophe to the infrastructure i.e. instability of transmission tower. It is always been the preference of the engineers to avoid dealing with problematic ground formation such as karstic formation. However, in some cases such as the study area i.e. Ulu Jelai-Neggeri-Lebir-LILO line this is unavoidable. Therefore, analysis of geological risk factors and assessment of potential geohazards is vital in terms of rational management and sustainable of an area [2, 3, 4]. By adopting geographical information system (GIS) in transmission line route planning, geohazard aspects namely landslide hazard and karstic formation maps can be incorporated in the planning stage.
2. Development of Route Selection
The GIS based approaches for transmission route selection utilize relative rankings and weights on considering factors affecting the potential routes. Prior to the actual route design, corridor selection needs to be done. The area to which the proposed route should limit is first identified for collecting and assembling data. The base maps for the corridor selected are collected and the derived maps are generated. Once the derived maps are ready, the suitability analysis is done and a route is found abiding by the governing criteria. Figure 1 shows the schematic representation of the methodology. When a new routing process is initiated, the list of multiple variables has to be decided first and then the criteria by which these variable constraint the routing process. Factors such as land use, type of geology, elevation, infrastructures crossing, and land cost are taken into consideration and are given high priority.

A GIS system for analysis of route was favored because it can perform optimal route predictions based selection by incorporating multiple influence factors into its analysis. These influence factors are grouped into common viewpoints or perspectives addressing a common data theme or point of view such as landslide, slope, road and others. In this project, the weightage used to generate route. A higher percentage of influence factors indicate the priority of avoiding area with high percentage of influence. A weighting system has to be devised for weighing each of the map layers. The weighted layers are all summed up to form the suitability layer. This layer forms the basis of the GIS analysis. The Analytical Hierarchy Process has been used to derive weight ages for the thematic layers. The suitability layer is analyzed for the optimal route. For this study, weightage in ascending manner from 1 to 5 are assigned with 5 is considered as the least preferable.

3. Regional analysis of Ulu Jelai- Neggiri-Lebir-LILO
Regional analysis assessment is used to determine landslides hazard zoning by extracting relevant parameters from remote sensing image. Valuable parameters such as land use zone, lithology, lineament (geological structure), groundwater level, weather condition (precipitation), vegetation cover, topography and geomorphology are determined based on satellite image and secondary measured data. Each of the parameters layers will be transferred to ArcGIS to develop the layer for geohazard zoning and risk assessment especially for landslide and erosion feature. This project used the concept proposed by [5, 6] where geohazard zoning and risk maps are used to determine the site specific critical slope.
From analysis of 45 out of 674 towers are located on hilly area and risk of failure this classified into three stages; high, medium and low risk. The risk is measured by the probability and severity of loss to the element at risk which is unit area by calculation and comparison of several parameters such as; slope aspect, groundwater, runoff, erosion rate, and rainfall etc. The risk assessments based on GIS analysis are completed with the help of slope inventory database. Slope inventory database is done based on the priority knowledge that causes the landslide in that area under investigation. The parameters that involved in the slope inventory database were; general slope information; discontinuity data; geotechnical inspection; rainfall inspection; rock slopes: visual assessment; maintenance inspection; existing information for rock slope and inventory and statistical analysis of landslide.

3.1. Landslide Hazard Map (LHM)
Landslide Hazard Map (LHM) as in Figure 2 was prepared on the basis of slope map, aspect map, land use map and geological map with the help of ArcGIS using weighted overlay method. Each cell size used in this study area was 30 m. Slope and aspect map of the study area was developed from Digital Elevation Model (DEM). Landslide hazard map is generated in GIS software where it counts pixels and classify them into five classes; very high risk, high, medium, low and very low risk.

![Figure 2. Landslide Hazard Map for Ulu Jelai-Telom - Nenggiri-Lebir-LILO](image)

Route options have been generated by GIS in three areas which are LILO – Lebir, Nenggiri – Lebir and Nenggiri – Ulu Jelai with three route options for each area. For regional analysis, each area has a
minority area of very high landslide risk which makes it suitable and safe to build a transmission line or any other construction. Analysis of landslide risk in terms of percentage is summarized as in Figure 3.

![Figure 3. Summary of landslide risk for Ulu Jelai-Neggeri-Lebir-LILO transmission line](image)

4. Concluding remarks
Planning may be seen as an exercise in decision making of any development. However, the utilization of latest technology as in GIS would reduce the impact on environment, socio-economy as well as financial. Based on LHM it is safe to conclude that the proposed route for Ulu Jelai-Neggeri-Lebir-LILO transmission line has very low risk in terms of landslides.

5. Acknowledgement
The author would like to thank Tenaga Nasional Berhad (TNB) and its subsidiary Tenaga Nasional Berhad Research (TNBR) for granting this project.

References
[1] Campus S, Barbero S, Bovo S, Forlati F 2007 Evaluation and Prevention of Natural Risks *Taylor & Francis, UK* 470.
[2] Crozier M, Glade T 2010 Hazard assessment for risk analysis and risk management *Alcántara-Ayala I., Goudie A. (eds.), Geomorphological Hazards and Disaster Prevention* Cambridge Univ. Press, Cambridge, UK 221-232.
[3] Hassanzadeh N M 2000 Landslide hazard zonation in shalmanrood watershed *M. Sc. thesis, Tehran University*.
[4] Higgitt D 2010 Geomorphological hazards and sustainable development *Alcántara-Ayala I., Goudie A. (eds.), Geomorphological Hazards and Disaster Prevention* Cambridge Univ. Press, Cambridge, UK 257-268.
[5] Nagarajan R, Mukherjee A, Roy A and Khire M V 1998 Temporal remote sensing data and GIS application in landslide hazard zonation of part of western ghat, India *Int. J. Remote sensing* 19(4) 573-585.
[6] Smith K, Petley D N 2009 Environmental Hazards *Assessing Risk and Reducing Disaster. 5th edit. Routledge, New York, USA* 416.