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Landslide Hazard Map Analysis using Geospatial Technology

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Abstract **– Geospatial technology provides flexibility integrating with various information for studying spatial complex data of evaluation hazard mapping in disaster. GIS-based landslides hazard mapping in the Mukim Hulu Kelang, complimented with the Analytical Hierarchy Process (AHP). Topographical and geological data were collected, processed and constructed into a spatial database using ARC-GIS 9.3. The major outcome of this research is the landslide hazard map with five types of zones (very low risk, low risk, medium risk, high risk and very high risk). Areas with very high risk potential for landslides cover approximate 0.31% of the total area. The result of this study was verified using landslides location over a year obtained from Public Works Department (PWD).**

Keywords **– Geospatial Technology; Landslide Hazard Mapping; AHP.**

I. Introduction

A landslide causes due to internal factors and external factor. Internal factors is refer to the steeping of the slope, water content of the stratum and mineralogical composition and structural features, which are tending to reduce the shearing strength of the rocks. Whereas, external factors is a slight vibration or jerk to the mass that would be greatly add up against the frictional resistance and the mass would become unstable. For example, the heavy traffic on hill roads and unplanned construction on hilly terrain is of great contributing factors towards causing the imbalance of the masses.

Landslides have caused large numbers of casualties and huge economic losses in hilly and mountainous areas of the world. In tropical countries the annual rainfall, which can reach as high as 4500 mm, and high temperatures around the year cause intense weathering and formation of thick soil and weathered rock profile.

With these set of climate and geological conditions, combined with other causative factors, landslides are one of the most destructive natural disasters in the tropical region. Malaysia is one of the countries located in the tropical region. During the period from 1993 to 2004 a number of major landslides were reported in Malaysia, involving fill and cut of natural slopes, which also resulted in loss of live. The summary of these landslides is shown in Table 1.

Table 1. Series of Major Landslide Occurrences in Malaysia.

DATE OF OCCURENCE	LOCATION	FATALITY (NOS)
November-93	Karak Highway, Pahang	2
December-93	Ulu Klang, Selangor	48
June-95	Karak Highway, Genting Highland slip road, Pahang	22
DATE OF OCCURENCE	LOCATION	FATALITY (NOS)
January-96	Gunung Tempurung, Perak	1
August-96	Orang asli settlement, Post Dipang, Perak	44
January-99	Squatters settlement, Sandakan, Sabah	13
January-00	Vegetable farm, Cameron Highlands, Pahang	6
January-01	Simunjan, Sarawak	16
December-01	Gunung Pulai, Johor	5
November-02	Hillview, Ulu Kelang, Selangor	8
September-03	Gunung Raya Road, Langkawi	1
November-04	Taman Harmonis, Gombak, Selangor	1
December-04	Bercham, Ipoh, Perak	2
May-06	Ulu Klang, Selangor	4

II. Research Methodology

A. Study Area

Study Area Hulu Kelang is known as one of the most landslides susceptible areas in Malaysia. From 1990 to 2011, a total of 28 major landslide events had been reported in this area (Lee et al., 2013). Hulu Kelang is in Kuala Lumpur, the capital city of Malaysia and is located between latitude 101º 44′ 13" and 101º47′ 51"N and Longitude 3º 09′ 25" and 3º 13′ 45" E as presented in Figure 1.

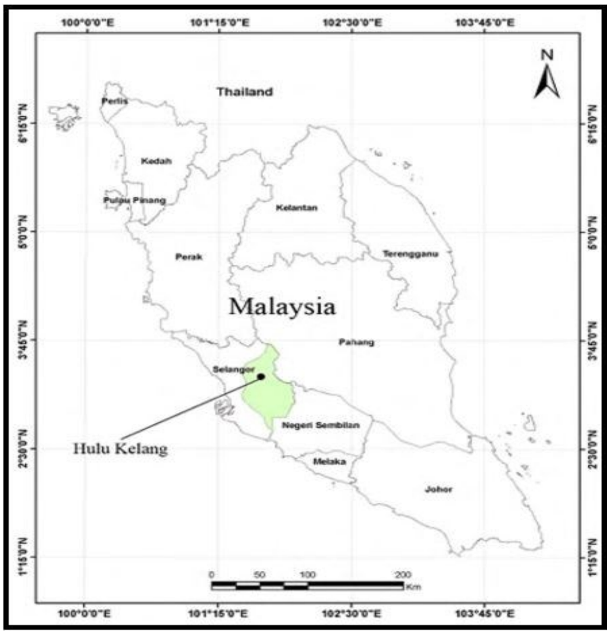

Fig. 1. The location of the study area, Hulu Kelang area, Serdang, Malaysia.

B. Research Data

The first part explained the types of data used in this study and then followed by elaborate on the processing that covers the digitized topography and geology map. Next, the final part of this chapter explained the use of the analytic hierarchy process in order to divide the case study area into four classes of risk zones (very high risk, high risk, medium risk and low risk). All data processing work was carried out in ArcGIS version 9.3. The methodology flow is shown in Figure 2.

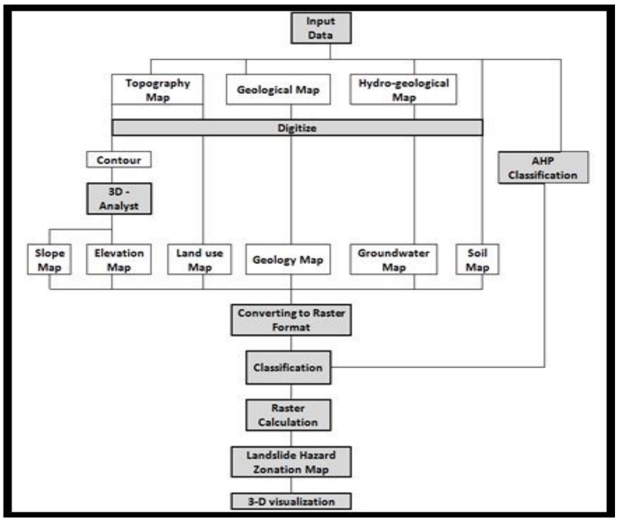

Fig. 2. Flow chart of the landslide hazard zonation map

C. Landslide Hazard Map

The weighted score (Figure 3 and Table 2) for each factor was entered in the equation of the landslides hazard model as follow.

Table 2. The weighted score for each factor

FACTORS	SUBFACTORS	WEIGHT
Slope	>35°	10
	25° - 35°	7
	15° - 25°	5
	0° - 15°	2
Elevation	>500m	9
	300m - 500m	7
	100m - 300m	5
	0m - 150m	2
Geology	Granite	8
	Phyllite & Schist	7
	Limestone	4
	Vein Quartz	1
Soil	Sand	7
	Organic	5
	Sandy Clay Loam	5
	Sandy Clay	4
Land use	Cleared land	8
	Grass	6
	Sundry Tree Cultivation	5
	Rubber	4
	Residential	4
	Industry	4
	Secondary Jungle	3
	Resort & Recreation	3
	Primary Forest	3
Groundwater	Very High	10
	Medium	5
	Low	2

Factor was entered in the equation of the landslides hazard model as follow:

$$S = W1SL + W2E + W3G + W4S + W5GW + W6L \quad (1)$$

Where:
S = Susceptibility.
Wi = 1-6 = The weights related to each factor.
S = Slope.
E = Elevation.
G = Geology.
S = Soil.
GW = Ground water.
L = Land use.

The values of the weights for every parameter are then inputted to equation above.

S = 0.457 (Slope) + 0.226 (Elevation) + 0.114 (Geology) + 0.114 (Soil) + 0.053 (Groundwater) + 0.036 (Land use).

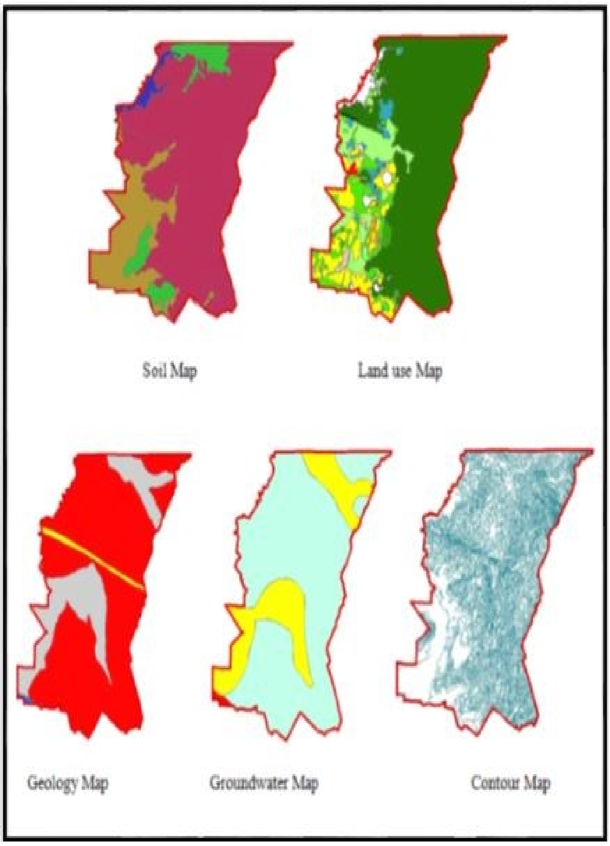

Fig. 3. The weighted score map for each landslides hazard factor

III. Result and Discussion

Figure 4 shows 2 classes of hazard which is high risk and very high risk classes this 3-D elevation map created from TIN layer by using ArcScene. This is to make attention to designs maker observe which areas must take into consideration. Figure 5 shows overlaid of simplified map and 3-D elevation map after overlaying process of each other’s. Table 3 shows the result of landslide map and the area covered. For class very low risk, the area is 24.93%, 30.68% of area studied covered by low risk. The medium risk recorded 25.73% whereas high risk and very high risk recorded 18.35% and 0.31% respectively.

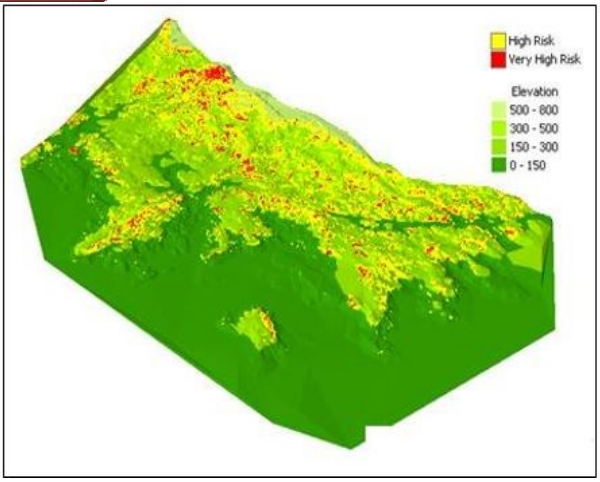

Fig. 4. Overlaid of Simplified Map with 3-D Elevation Map

Table 3. shows the result of landslide map and the area covered

Hazard Type	Area (pixel)	Percentage of Area (%)
Very Low Risk	205 817	24.93
Low Risk	253 240	30.68
Medium Risk	212 407	25.73
High Risk	151 465	18.35
Very High Risk	2 488	0.31
Total	**853 871**	**100**

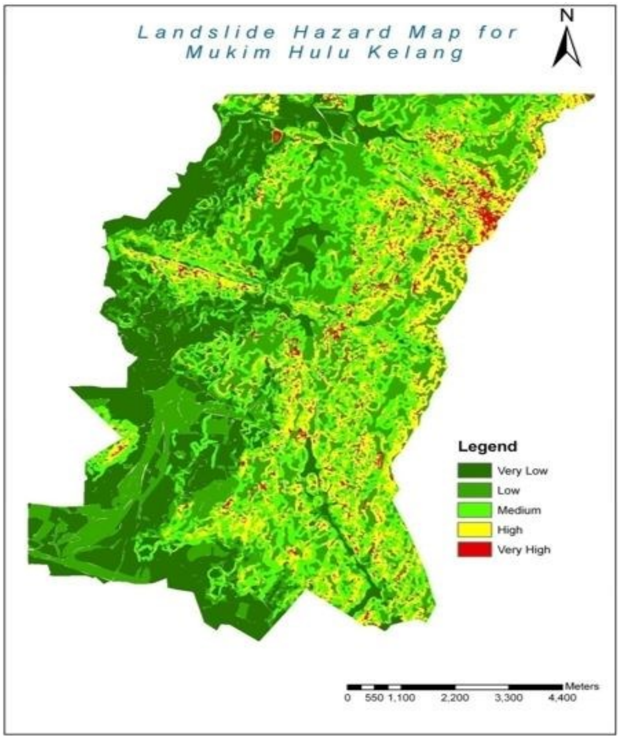

Fig. 5. Landslide Hazard Map for Mukim Hulu Kelang

A- Accuracy Assessment

Based on the landslide intersection provided by Jabatan kerja Raya (JKR) Figure 6, there are 36 point of landslide history was recorded in Mukim Hulu Kelang. From this studied, there are 28 point located from class of medium risk to very high risk which is 77.78%. I assumed that this study was in good accuracy.

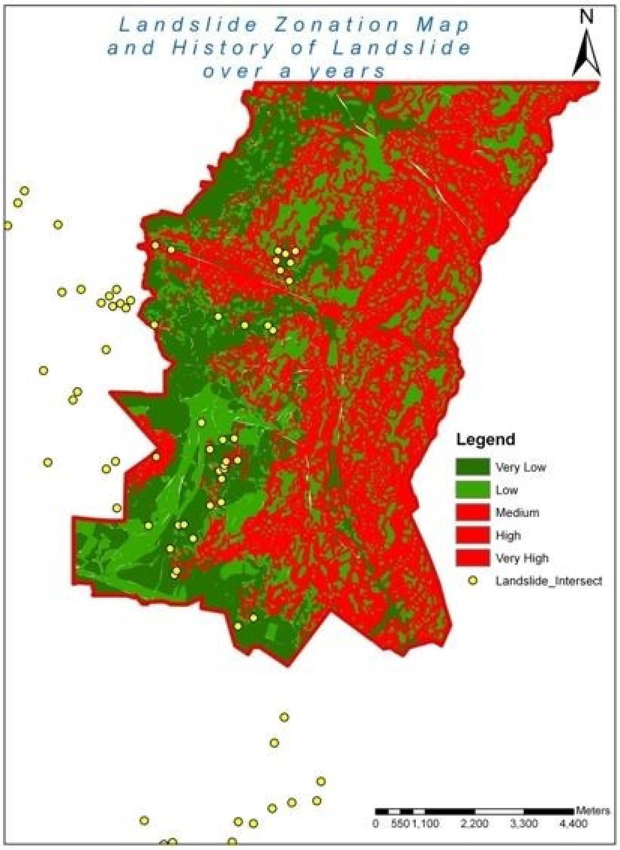

Fig. 6. Landslide History over a Year Overlaid With Landslide Hazard Map

IV. Conclusion

Landslide, is one of natural hazards like flood, earthquake and avalanche is often difficult to predict. However, landslide risk can be systematically assessed and managed by using GIS and remote sensing data. Landslide hazard or risk maps are usually is basis for attention to decision making. These decisions are usually in the form of technical countermeasures.

Landslide susceptibility maps have been constructed base on causative factors: slope, elevation, geology, soil, groundwater and land use. All of this parameter was projected using RSO meter. As preprocessing all of these parameter was given weighted by using AHP method. There are 6 parameters was took into account as stated above. All of these particular parameters have their own probability to cause a landslide as stated in Table 2. GIS techniques can play a significant role in landslide hazard mapping in Mukim Hulu Kelang area using analytical hierarchy process. The results show a landslides hazard map with different level of risk: very low risk, low risk, medium risk, high risk and very high risk.

Reference

[1] B. Pradhan, S. Lee, and M. F. Buchroithner, "Use of geospatial data and fuzzy algebraic operators to landslide-hazard mapping," Applied Geomatics, vol. 1, no. 1-2, pp. 3–15, Jan. 2009.

[2] B. Singh, "Landslide Disaster Management," Geospatial Technologies and Climate Change, Aug. 2013, pp. 53–63.

[3] C.-J. F. Chung and A.G. Fabbri, "Systematic Procedures of Landslide Hazard Mapping for Risk Assessment using Spatial Prediction Models," Landslide Hazard and Risk, Oct. 2012, pp. 139–174.

[4] "Challenges in Geospatial Technology for Water Resources Development," Geospatial Technology for Water Resource Applications, Nov. 2016, pp. 289–301.

[5] Sudiana and A. A. Arbain, "Geographic Information System (GIS)-based landslide susceptible area detection using geospatial and satellite data," TENCON 2011 - 2011 IEEE Region 10 Conference, 2011.

[6] G. Kim, S. Lee, and S. Jeon, "Landslide Vulnerability Mapping considering GCI (Geospatial Correlative Integration) and Rainfall Probability in Inje," Journal of Environmental Policy, 2013, vol. 12, no. 3, pp. 21–47.

[7] G. Konecny, "Cadastral Mapping with Earth Observation Technology," Geospatial Technology for Earth Observation, pp. 397–409, 2009.

[8] H.J. Mayer and M.R. Greenberg, "Using Integrated Geospatial Mapping and Conceptual Site Models to Guide Risk-Based Environmental Clean-Up Decisions," Risk Analysis, vol. 25, no. 2, pp. 429–446, Apr. 2005.

[9] J. Makinster and N. Trautmann, "The Nature and Design of Professional Development for using Geospatial Technologies to teach Science," Teaching Science and Investigating Environmental Issues with Geospatial Technology, Dec. 2013, pp. 323–332.

[10] M. Panizza, "Landslide Susceptibility Mapping: A Methodological Approach," Natural Disasters and Sustainable Development, 2004, pp. 183–186.

[11] M. R. M. Mokhtar, A.N. Matori, K.W. Yusof, A.M. Embong, and M.I. Jamaludin, "Assessing UAV Landslide Mapping using Unmanned Aerial Vehicle (UAV) for Landslide Mapping Activity," Applied Mechanics and Materials, vol. 567, 2014, pp. 669–674.

[12] N. Sreedevi and K. Yarrakula, "Different Techniques for Landslide Zonation Mapping and Landslide Assessment: A Review," Indian Journal of Science and Technology, 2016, vol. 9, pp.47-56.

[13] N.-D. Hoang and D.T. Bui, "GIS-Based Landslide Spatial Modeling using Batch-Training Back-propagation Artificial Neural Network: A Study of Model Parameters," Advances and Applications in Geospatial Technology and Earth Resources, pp. 239–254, Jun. 2017.

[14] N.-W. Park, "Evidential reasoning applied to GIS-based landslide susceptibility mapping with geospatial data," 2010 IEEE International Geoscience and Remote Sensing Symposium, 2010.

[15] S. Lee and C.P. Poudyal, "Landslide hazard mapping using geospatial models," Proceedings of the 2nd International Conference on Computing for Geospatial Research & Applications - COM. Geo 11, 2011.

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