CAUSATIVE PARAMETERS MAPPING OF LANDSLIDES IN WILAYAH PERSEKUTUAN KUALA LUMPUR

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Abstract - Landslide is one of the natural disasters that commonly occurs in terrestrial environments with slopes throughout the world. In addition to that, landslides also contribute to thousands of fatalities not only to human lives but also to one's economy. As Malaysia is expecting an annual average rainfall of 2000mm-2500mm due to geographical factors, landslides break rather frequently, specifically in urban areas such as Wilayah Persekutuan Kuala Lumpur. Hence, this study is conducted to identify the distribution of landslides in the area based on its parameters. The GIS-based approach has been used to generate distribution maps from the data collected. Through this study, it is determined that landslides in Wilayah Persekutuan Kuala Lumpur do not occur due to a single factor, but a combination of several.

Keywords - Distribution, GIS, Kuala Lumpur, Urban.

I. INTRODUCTION

Landslide is often defined as a geological phenomenon that involves the displacement of mass rock, debris, or earth down a slope due to the influence of gravity [1] – [3]. This phenomenon is usually followed by other natural disasters like volcanic eruptions, earthquakes, wildfires, and floods. Furthermore, a landslide is also one of the natural disasters that frequently occurred in terrestrial environments with slopes, causing thousands of fatalities concerning human lives and the economy [4], [5]. For instance, according to World Health Organization, a total of approximately 4.8 million people were affected claiming over 18,000 lives after landslide occurrences that took place between 1998 to 2017. Meanwhile, one of the most disastrous El Niño-triggered landslides ever recorded in 1983-84 obliterated a small town, Thistle, in turn costing the State of Utah over 200 million dollars total damage to its socio-economic [6]. The highest numbers of fatalities often occur in the mountains of Asia and Central and South America, as well as on steep islands in the Caribbean and Southeast Asia [7].

Because Malaysia receives an annual average rainfall of 2000mm-2500mm due to geographical factors (e.g., rainfall particularly between October to February), it has become one of the countries in Asia that experiences a frequent landslide [8] – [10]. Heavy precipitation contributes to an intense form of thick soil [11]. This, on the other hand, has affected slope stability, inducing landslides. Some of these landslides often occurred at the high-rise apartments and residential areas [12]. There are countless events were recorded in the early years indicating that several hilly areas in Malaysia are prone to landslides. An infamous collapse of Highland Tower in 1993 remains as one of the worst disasters recorded which claimed up to 48 lives. Recently, over 80 areas in Kuala Lumpur have reported landslides inundated by a continuous heavy downpour [13].

A single factor does not normally trigger a landslide but is a combination of a few other factors. Apart from rainfall, the rising events of landslides are also closely linked to the instability of slopes due to soil gestures failures. With the introduction of GIS, multiple causative parameters data of landslides can be analyzed. Therefore, a map that serves to provide information on areas that are vulnerable to landslides can be generated.

II. DETAILS OF THE STUDY

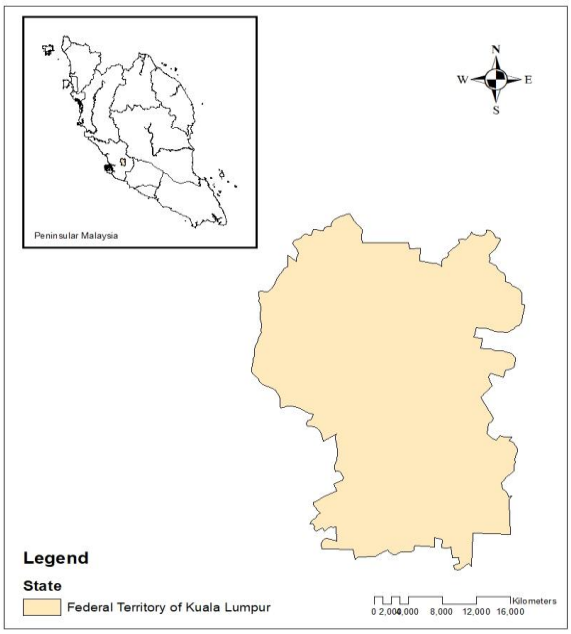


Fig.1. Map of Wilayah Persekutuan Kuala Lumpur

A. Study Area

Kuala Lumpur is the capital city of Malaysia, which is located at 3.1390 °N, 101.6869 °E, and has become a hot spot for economic activities (Fig.1.). According to the Department of Statistics Malaysia, Kuala Lumpur is the largest city in Malaysia, covering approximately

243 km2 areas. In addition, this city is covered with ranges from flat terrain to hilly regions ranging from 0 to 420m above sea level [14]. As the largest and the most developed city in Malaysia, Kuala Lumpur has undergone rapid development since the 1970s resulting in the highest number of landslide-prone areas with 19.2% of nationwide reported cases compare to other states [15].

B. Data Set

Through observation of literature data, availability of data, and field survey, this study has selected seven causative parameters of 142 landslides within the year 1975 to 2020. Landslide inventories are significant for understanding the particular landslide characteristics and clarifying the relationship between causal factors and the occurrences of landslides [16]. Landslide details were gathered from various sources, such as past studies, agencies and have been verified during the field survey. Distance to the road, distance to a river, aspects, lithology, soil series, curvature, and elevation are considered as the landslide parameters for this study.

With the provided topographic map from the Department of Survey and Mapping Malaysia (JUPEM), DEM with 10 m intervals was created. From this DEM, slopes, aspects, elevation and curvature were derived and overlayed with landslide points using GIS. In addition, the road map used in this study was retrieved from an open-source whereas a stream map was supplied by the Department of Drainage and Irrigation (DID). Using these maps, road and stream buffers were calculated. Lithology and soil series were extracted from geology maps and classified into their characteristics as shown in Table I.

III. RESULT AND DISCUSSION

For this study, seven different indicators are employed to generate distribution maps regarding landslides in the study area. The distance from the road map (Fig.2. (a)) has been classified to <2000 m, 2001-4000 m, 4001-6000 m, and >6001 m as shown in table 1. The area of 2001-4000 m has the highest percentage which represents 40.85% than the other areas indicating a high landslide event meanwhile the farthest distance records the lowest percentage of occurrences which is only 12.68%. Road construction activities in hilly areas have deliberately decreased slope steadiness, therefore, exposing prone areas to possible landslides. Meanwhile, the distance to the river map ((Fig.2. (b)) is classified into four classes, such as <300 m, 301-600 m, 601-900 m, and >901 m (Table 1).

A distance less than 300 m from the river covered to 64.08% landslide area, makes it the highest among the other three as the water flow naturally causes different types of erosion thus, increasing the vulnerability of slope angle [17]. Another parameter of landslide, elevation is considered as one of the primary parameters in landslide studies. In this study area, elevation uses a range between 0 – 320 m and is digitized through GIS ((Fig.2. (c)). It is identified that landslides largely occur in the area between 30.12 m to 67.76 m accumulating the highest number of events which covered 61.97% while the lowest is at 1.41% located between 168.16 m to 320 m area. This shows that the development projects set for Kuala Lumpur such as highways are at the low elevation but in contact with high steep slopes. For the curvature as shown in Fig.2. (d), landslides are mostly distributed on a flat which covered 42.25% of the area while concave is the least landslide occurrences with 23.94%.

Besides, [17] stated that aspect indicates the downslope direction that influences the distribution of landslides by the propagation direction of seismic waves. In terms of aspects (Fig.3. (e)); N, NE, E, SE, S, SW, W, NW, there are equally 15 cases of landslide eventuated at E, S and SW covered to 10.63% each, while landslides are less likely to occur in North with 0 occurrence number of landslide. Moreover, the majority of Kuala Lumpur is an urban land hence, the landslides covered almost 98.56% of the area while the remaining is Serdang-Kedah (Fig.3. (f)). This may have been related to the rapid development undergone in this major city. As for lithology, the geologic environment has a significant impact on the likelihood, mechanism, and classification of prospective earth movements or hazards, as well as the strength of potential rupture surfaces in rock and soil [18]. Landslides have largely occurred mainly in sandstone as 60.56% of landslide cases are in yellow areas (Fig.3. (g)) while on schist and gneiss are the least landslide events recorded over the past years.

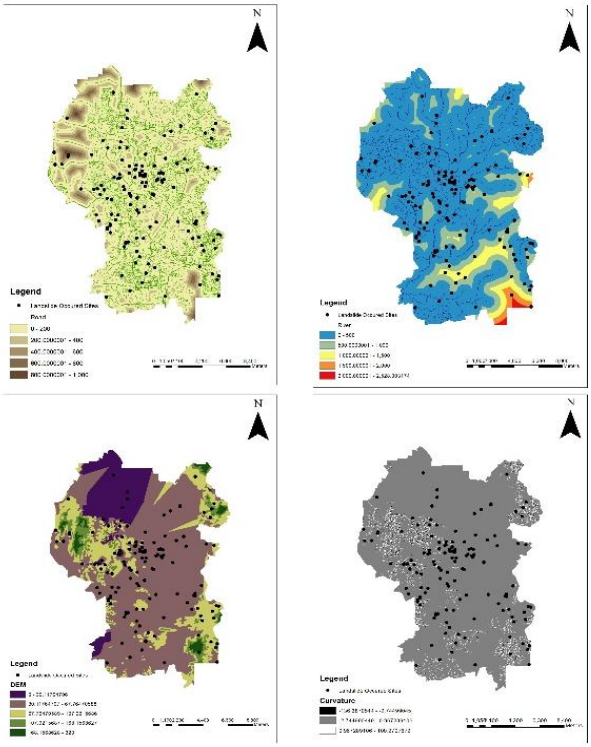


Fig.2. Landslide Parameters Distribution Map; a) Distance to Road, b) Distance to River, c) DEM and d) Curvature

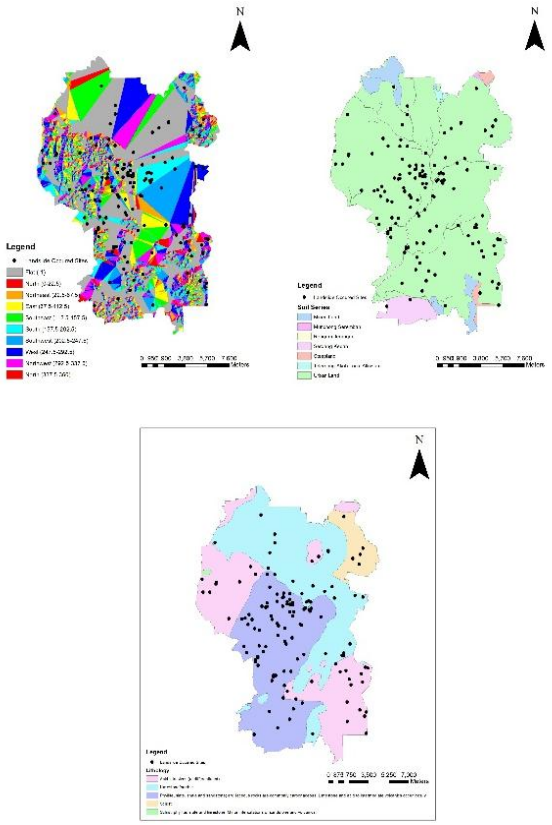


Fig.3. Landslide Parameters Distribution Map; e) Aspects, f) Soil Series, and g) Lithology

Parameters	Classes	Landslide Occurrences	Percentage (%)
Distance to road	<2000 m	46	32.39
	2001 – 4000 m	58	40.85
	4001 – 6000 m	20	14.08
	>6001 m	18	12.68
Distance to river	<300 m	91	64.08
	301 – 600 m	30	21.13
	601 – 900 m	13	9.15
	>901 m	8	5.63
Aspects	North	0	0
	Northeast	6	4.23
	East	15	10.63
	Southeast	13	9.15
	South	15	10.63
	Southwest	15	10.63
	West	9	6.34
	Northwest	10	7.04
	North	5	3.52
Lithology	Acid intrusives	31	21.83
	Limestone/Marble	18	12.68
	Mainly sandstone	86	60.56
	Schist and gneiss	7	4.93
Soil series	Urban Land	140	98.59
	Serdang-Kedah	2	1.41
Curvature	Convex	48	33.80
	Flat	60	42.25
	Concave	34	23.94
Elevation	0 – 30.11 m	12	8.45
	30.12 – 67.76 m	88	61.97
	67.77 – 107.92 m	35	24.65
	107.93 – 168.15 m	5	3.52
	168.16 – 320 m	2	1.41

Table 1: Causative Parameters of Landslide

IV. CONCLUSION

This study presents distribution maps of landslides in Kuala Lumpur. It is shown that landslides in the study areas are triggered by different causative parameters. As worrying as environmental factors, unrestrained human activities for development to sustain enormous demands of the rising population also plays a significant impact on the fragility of slopes and make them more prone to landslides. Take an example in figure 2 (f), most landslide events occurred on urban land where development is heavily carried out in those areas. The damages of landslides on properties and people can be lessened by avoiding development on steep slopes and existing landslides. Kuala Lumpur can halt forest degradation under Sustainability Development Goal 15 which stated that forests are crucial to global sustainable development. If forests are managed sustainably, soil erosion can be reduced. Even though landslides cannot be put a stop to, the impacts on the landslide can be reduced. In short, preventable landslides could be averted if humans avoid building houses near steep slopes or at the edge of hills as we see around Kuala Lumpur these days.

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REFERENCES

[1] D.M. Cruden, "The First Classification of Landslides," Geological Society of America, vol. 9, no. 3, pp. 605-608, Aug. 2003.

[2] G.L.S. Babu, and M.D. Mukesh, "Landslide analysis in Geographic Information Systems," Geospatial World, Jan. 2009.

[3] K.M.D. Hossain, H. Lateh, T.T. Lee, and A. Kamil, "Risk Factor for Landslide in Penang" Malaysian book: Landslides, Chapter: Hazard Mapping & Modelling (Chapter 3), Publisher: Japan International Cooperation Agency, Editors: Habibah Lateh, Anton Abdulbasah Kamil, pp. 115-121, Jan. 2015.

[4] H. Shahabi, and M. Hashim, "Landslide Susceptibility Mapping using GIS-based Statistical Models and Remote Sensing Data in Tropical Environment," Scientific Reports, no. 5, pp. 9899, April 2015.

[5] M.J. Froude, and D.N. Petley, "Global fatal landslide occurrence from 2004 to 2016," Nat. Hazards Earth Syst. Sci, no. 18, pp. 2161-2181, Aug. 2018.

[6] C. Martinez, E. Jorge, and M.O. Juan, "Socioeconomic and Environmental Impacts of Landslides in The Western Hemisphere," Proceedings of the Third Panamerican Symposium on Landslides, pp. 886, July-Aug. 2001.

[7] W. Joshua, "Global Toll from Landslides is Heaviest in Developing Countries," The Conversation, Jan. 2018.

[8] N. Abd Majid, R. Rainis, and W.M.M.W. Ibrahim, "Pemodelan ruangan pelbagai jenis kegagalan cerun di Pulau Pinang menggunakan Kaedah Nisbah Kekerapan," Geografi, vol. 5, no. 2, pp. 13-26, Oct. 2017.

[9] N. Abd Majid, R. Rainis, W.M.M.W. Ibrahim, "Spatial Modeling Various Types of Slope Failure Using Artificial Neural Network (Ann) In Pulau Pinang, Malaysia," Jurnal Teknologi, vol. 80, no. 4, April 2018.

[10] N. Abd Majid, and R. Rainis, "Application of Geographical Information Systems (GIS) and Discriminant Analysis in Modelling Slope Failure Incidence in Pulau Pinang, Malaysia," Sains Malaysiana, vol. 48, no. 7, pp. 1367-1381, July 2019.

[11] K. Abdullah, "Design of a laboratory model for the study of the overall slope stability in the tropics," Unpublished MSc dissertation, Heriott-Watt University, Edinburgh, 1996.
[12] J. Ab Talib, "Probabilistic landslide susceptibility analysis and verification using GIS and remote sensing data at Penang, Malaysia," Geological Society of Malaysia, Bulletin 46, pp. 173-179, May 2003.
[13] A. Ashman, "KL mayor says recent landslides mostly in older neighbourhoods like Bangsar, Taman Duta; wrong to blame overdevelopment," Retrieved from: https://www.malaymail.com/news/malaysia/2022/01/05/report-kl-mayor-says-recent-landslides-mostly-in-older-neighbourhoods-like/2033099, Jan. 2022.
[14] S. Lee, B. Pradhan, "Landslide hazard mapping at Selangor, Malaysia using frequency ratio and logistic regression models," Landslides, vol. 4, no. 1, pp. 33-41, July 2006.
[15] A.S.M. Azmi, W.A.R. Wan Mohamed Salleh, and A.H. Nawawi, "Cognitive Behaviour of Residents toward Living in Landslide Prone Area: Ulu Klang," Procedia - Social and Behavioral Sciences 101, pp. 379 – 393, 2013.
[16] J. Dou, A.P. Yunus, D. Tien Bui, M. Sahana, C.W. Chen, Z. Zhu, et al., "Evaluating GIS-Based Multiple Statistical Models and Data Mining for Earthquake and Rainfall-Induced Landslide Susceptibility Using the LiDAR DEM," Remote Sensing vol. 11, no. 6, pp. 638, March 2019.
[17] C.L. Yu, and J.P. Chen, "Landslide Susceptibility Mapping Using the Slope Unit for Southeastern Helong City, Jilin Province, China: A Comparison of ANN and SVM," Symmetry. vol. 12, pp. 1047, June 2020.
[18] I.B. Yamusa, M.S. Ismail, A. Tella, and "Geospatial Detection of Hidden Lithologies along Taiping to Ipoh Stretch of the Highway using Medium Resolution Satellite Imagery in Malaysia," Journal of Advanced Geospatial and Science Technology, vol. 1, no. 1, pp. 19-37, Aug. 2021.

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