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Procedural Effects on Controlling Natural Disasters (Landslides and Flash Floods) Based on Environmental Degradation from Development in Malaysia

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ABSTRACT

In recent years, Malaysia's growing population and accelerating economic conditions have resulted in the construction of high-rise condominiums and the expansion of settlements and lifelines across hilly areas. Natural disasters are always happening in Malaysia, with landslides and flash floods as the main problems and common natural disasters. This problem occurs annually due to rising numbers of development in Malaysia involving land clearance and rapid construction, especially in hilly areas. Under such circumstances, research was conducted on landslide and flash flood incidences in Malaysia from 2020 until 2022. The assessment in this research was done using the matrix method commonly used in Environmental Impact Assessment (EIA). The results gained by using those method shows that both landslides and flash flood naturally happen in the last quarter of a year, which are in December and January for both landslides and flash flood disaster. The highest score for landslide incidences was in Putrajaya and Kuala Lumpur with 8.4; in contrast, 9.2, the highest average score recorded for flash floods, happened in Selangor, Pahang, Kelantan, Kuala Lumpur, Melaka, Negeri Sembilan, Perak, and Terengganu. Both of these incidents occurred in December 2021. This situation shows that both natural and man-made affect the occurrence of the tragedy in Malaysia. Heavy rainfall and rapid development lead to this problem. Compliance with general guidelines from contractors, developers and agencies may reduce the number of these disasters in the future. Hence, it will help to prevent soil erosion and slope failure that frequently occurs in Malaysia.

Keywords-- Landslides, Flash Floods, Matrix Method, Environmental Degradation, Soil Erosion

I. INTRODUCTION

Several natural disasters always happen in Malaysia. Malaysia has experienced 51 natural disaster events based on the 2019 Malaysia Disaster Management Reference Handbook [1]. The most common natural disaster experienced by Malaysia is flash floods and landslides. Besides natural disasters that are always happening in Malaysia, man-made disasters are frequently encountered, such as transportation accidents, public places failures, and technological disasters.

Landslides, defined as the movement of mass rock, debris or earth down a slope [2], can be triggered by a variety of external stimuli, such as intense rainfall, earthquake shaking, water level change, storm waves or rapid stream erosion that cause a rapid increase in shear stress or decrease in shear strength of slope-forming materials. In addition, as development expands into unstable hillslope areas under the pressures of increasing population and urbanisation, human activities such as deforestation or excavation of slopes for road cuts and building sites, etc., have become essential triggers for landslide occurrence [3].

In October 2018, Cameron Highlands was hit by a landslide disaster that affected three fatalities of non-Malaysia citizens in that case. The case occurred because of the construction of a shared house constructed in an illegal area below a steep slope. According to Leh and Mokhtar [4], issues such as unlawful land exploration, the presence of illegal immigrants and weak enforcement are synonymous with Cameron Highlands, not a year or two but meant to be ingrained long ago.

The latest flash floods occurred from December 2021 until January 2022, affecting several states in Malaysia. There were 55 fatalities recorded during the disaster, resulting in significant damage to roads and infrastructure in the affected area. The climate in Malaysia is experiencing rainfall with an average of approximately 2,500 mm a year in Peninsular Malaysia, 3,000 mm a year in Sabah and 3,500 mm a year in Sarawak [5], [6], [7]. The river's water catchment flow is obstructed during the tide and cannot be entirely drained. Because of the rapid increase in river discharge, rainfall might create flooding in these circumstances. Flooding caused by human activity is most common in urban areas. This is owing to the rapid increase in urban imperviousness brought on by urbanisation and forestry operations. Due to the lack of flora and the usage of asphalt, cement, and concrete to cover the lands, urban

landscapes often have low water permeability surfaces. Water infiltration and interception were disrupted in these circumstances, causing the essential process of managing surface runoff when it rains to be disrupted.

One of the most significant impacts of flash floods in Malaysia was in Cameron Highlands. It occurred in 2016, which Ringlet had a flash flood when the water of the nearby rivers rose over the cliffs due to heavy rain. The river water then entered the residents' houses in that area, drowning most of them in a blink. After this incident occurred, according to Leh, and Mokhtar [4], to slow down the effects of flash flooding, residents of Pekan Ringlet expressed hope that authorities could expand and deepen Sungai Ringlet as soon as possible. Because the water level of the Sungai Ringlet has risen sharply due to the narrow stream and cannot cope with the overflowing water of the Sungai Bertam, especially during heavy rains, therefore, it can be concluded that the Ringlet disaster was not only due to land exploration for commercial activities, but also influenced by the natural factor that the river could not fully function because it was shallow and could not cope with the sudden eruption which could overflow the water.

II. METHODOLOGY

The methodology was adopted for this study in several stages derived based on Environmental Impact Assessment (EIA) matrix. This method began with understanding the process of degradation of the environment, significant stressor elements of the risk for environmental degradation, and the effects on the source, particularly for landslides and flash floods. This analysing data will give a stressor-source interaction matrix.

There are assigned subjective significance scores to each activity based on the subject of knowledge and practical experience of working and researching in the study area. These scores gave rise to assessing the impact of significance and the magnitude of effects required in completing the assessment. The criteria for each activity associated with stressors with an impact on the source were measured based on baseline data. However, these measures had to be converted into magnitude scores ranging from 1 to 10 using criteria explicitly set for each activity, as outlined in Table 1.

Table 1: Significance level and criteria for matrix method

Category of Impact	Significance level	Assigned Score
MINOR	Very low	1
	Moderately low	2
	Low	3
MEDIUM	Low medium	4
	Medium	5
	High medium	6
MAJOR	High	7
	Moderately high	8
	Very high	9
	Extremely high	10

The methodology used is a version of a universal matrix of risk analysis (UMRA) which is one of the methods of risk analysis proposed to enhance the transparency and sensitivity of the evaluation process. Table 2 shows the established matrix to give a detailed description of environmental degradation. The table shows activities and elements in connection with the particularly sensitive environment, especially toward the source of the risk. The designated stressors for this research are selected based on the field of this study which is landslides and flash floods.

Table 2: Stressor – Source of risk assessment

Stressor – Source of Risk	**Population**	**Climate conditions**	**Atmosphere**	**Water conditions**	**Soil**	**Flora and fauna and their biotopes**	**Landscape, structure and use of terrain, scenic aspects of the landscapes**	**The protected areas and their protective zones**	**The territorial system of ecological stability**	**The urban environment and land use**
Landslides										
Flash floods										

III. RESULTS AND DISCUSSION

The matrix method is usually used in Environmental Impact Assessment (EIA); the average score is based on the minor, medium and significant impact categories. There are ten aspects of stressor that was considered in doing this matrix method which are population, climate conditions, atmosphere, water conditions, soil, flora and fauna and their biotopes, landscape, structure and use of terrain, scenic aspects of landscapes, the protected areas and their protective zones, the territorial system of ecological stability and the urban environment and land use.

3.1 Landslides

A series of landslides usually occur in a severe condition rose annually, as shown in Table 3, providing several interpretations and perspectives related to physical, ecological, infrastructure and social connections.

Table 3: Landslides Incidences in Malaysia Sep 2020 – Mar 2022.

Date of incident	Place	No. Of death	Effects
15 Sep 2020	Batu 10 & 16 Jalan Tapah-Cameron Highlands, Batu 20 Jalan Tapah-Ringlet	-	- Affecting 2725 pupils, 190 teachers and 132 pre-schools, closure of 6 schools. - Heavy traffic
9 Nov 2020	The Banjaran Hotsprings Retreat, Tambung Perak.	2	-
3 Jan 2021	Hulu Chukai, Kemaman	-	Fourteen stall operators were ordered to stop operations after landslides occurred behind their premises.
4 Jan 2021	Gua Musang, Kelantan	-	One (1) Bangladesh worker is missing, feared buried alive.
5 Jan 2021	Kuantan, Pahang	-	Damage to two houses is believed to be triggered by soil movement caused by non-stop heavy rainfall.
11 Jan 2021	Johor Bahru, Johor	-	42 people, 12 houses need to evacuate their places
12 Jan 2021	Padawan, Sarawak	-	Affect a family after part of their house was buried under rubble in a landslide.
15 Jan 2021	Bau and Lundu, Sarawak	-	Power Failure
20 Jan 2021	Tamparuli-Ranau, Sabah	-	Severed damage on a parking area.
17 Feb 2021	Pasir Mas, Kelantan	-	97 people, 15 families affected Eight houses and one shop premise were severely damaged.
17 July 2021	Kuching, Sarawak	1	One fatality recorded.
18 Aug 2021	Gunung Jerai, Kedah	6	Six fatalities were recorded because of water column (Kepala air).
15 Sep 2021	Jalan Penampang-Tambunan, Kota Kinabalu, Sabah Forest Hill, Penampang, Sabah	2	2 fatalities recorded.
16 Sept 2021	Sungai Palas, Cameron Highland, Pahamg	1	One fatality recorded.
17 Sep 2021	Jalan Kemensah Heights, Kuala Lumpur	-	Three bungalows and 16 townhouses with 32 families were affected.
1 Oct 2021	Tanjung Bungah,Georgetown, Penang	-	-
22 Nov 2021	Tanah Rata, Pahang	-	One people affected.
2 Dec 2021	FT 185, KM 27.10 Jalan Simpang Pulai-Blue Valley, Ipoh, Perak	2	Two fatalities recorded.
15 Dec 2021	Kampung Air Sejuk, Kuaka Terengganu, Terengganu	1	1 fatality recorded.
18 Dec 2021	Kampung Sungai Merab Hulu, Putrajaya	-	-
19 Dec 2021	Jalan Pelimbayan Indah, Kampung Sungai Penchala, Kuala Lumpur	-	284 people and 94 houses were affected, with 24 of them damaged.
26 Dec 2021	International Islamic University Malaysia, Gombak	-	128 people evacuate the building.
10 Mar 2022 [8]	Taman Bukit Permai 2, Ampang	5	15 houses and ten vehicles affected - Triggered by soil movement.

Figure 1 shows the average score based on the latest landslide incidences in Malaysia from September 2020 until March 2022. The highest scores for the latest incidences happen in Putrajaya and Kuala Lumpur, with the average of 8.4. The incidents affected many people and ecological conditions. Most landslide incidences in this period are commonly due to slope failure. In Malaysia, these slope failures seem triggered mainly by heavy or non-stop rainfall that occurs more than 70 mm or over one day of an extended period of heavy rain.

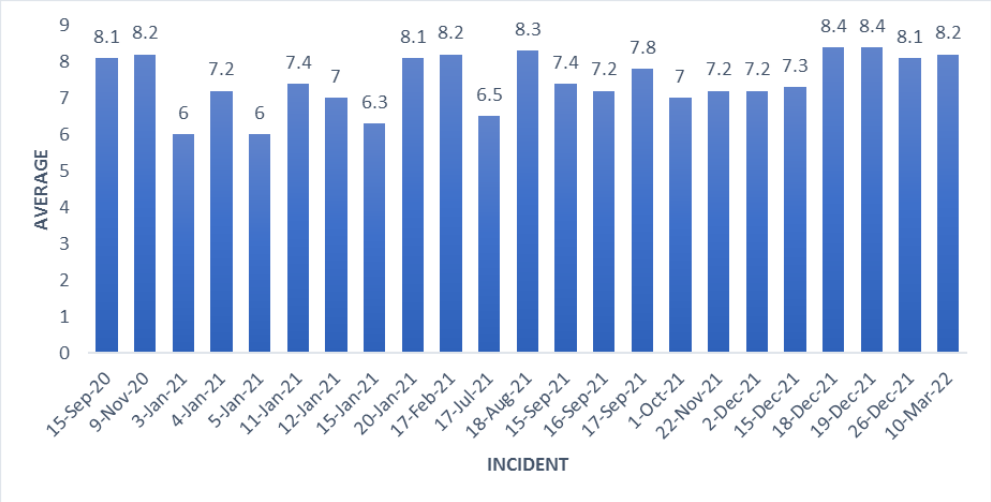

Figure 1: Average score for landslides incidences in Malaysia from Sep 2020 – Mar 2022.

Monthly-wise landslide occurrences in Malaysia are shown in Figure 2. It is demonstrated that December and January have the higher number of landslide experiences compared to the others, followed by September. Considering the climatic parameters such as rainfall and temperature, both December and January are in the rainy season in Malaysia, which may be the reason for slope failure. The other reasons why landslides occurred in Malaysia can also be interpreted as man-made or human activity. Most heavy construction in hilly areas, such as constructing a condominium with improper design without considering the risk and poor drainage system, may also lead to landslide occurrences in Malaysia.

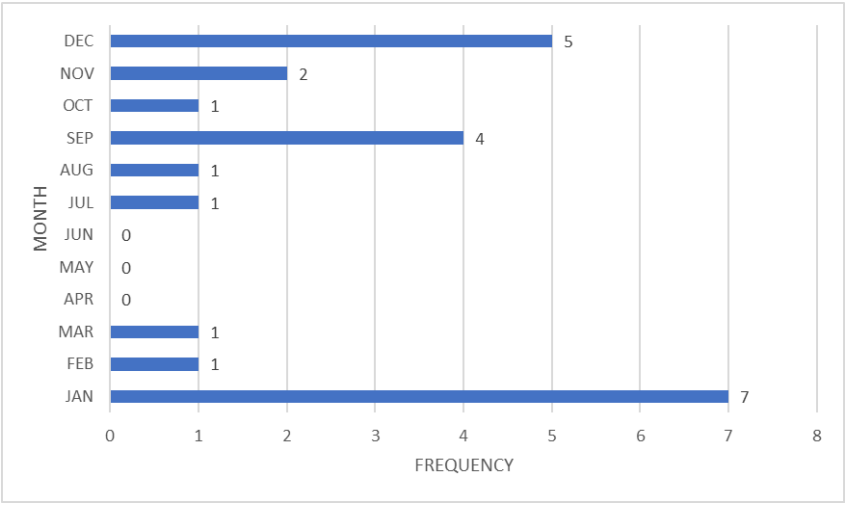

Figure 2: Monthly of wise landslides occurrences in Malaysia from Sep 2020 – Mar 2022.

3.2 Flash Floods

Annual flash floods in Malaysia are shown in Table 4, which provides several interpretations and perspectives related to physical, ecological, infrastructure and social connections. Meanwhile, Figure 3 shows the average score based on Malaysia's latest flash flood incidences from October 2020 until June 2022. The highest score for the latest incidences was in Selangor, Pahang, Kelantan, Kuala Lumpur, Melaka, Negeri Sembilan, Perak, and Terengganu, with

9.2 that occurred in December 2021, with 48 fatalities recorded during that disaster. The incidence affected many people and ecological conditions. More than 40,000 people were involved during that incident, with severe damage of vehicles and houses.

Table 4: Flash floods incidences in Malaysia Oct 2020 – June 2022

DATE OF INCIDENT	PLACE	TYPE OF PROBLEMS	NO. OF DEATH
5 Oct 2020	(Kota Kinabalu, Kota Belud, Tuaran) Sabah	Heavy rain	-
23 Nov 2020	Terengganu, Perak, Melaka, Selangor	Heavy rain > 550 mm/d	-
17 Dec 2020	Kelantan, Terengganu, Pahang	Heavy rain brought by annual monsoon season	-
Jan 2021	Johor, Pahang, Kedah, Perak, Selangor, Kelantan, Terengganu, Sabah, Sarawak	Heavy rainfall	10
May 2021	Sabah, Sarawak	Heavy rainfall	-
18 Aug 2021	Gunung Jerai, Kedah	Heavy rain > 219 mm/day	4
15 Sep 2021	Sabah	Heavy rain	3
20 Oct 2021	Selangor, Negeri Sembilan, Melaka	Overflow of water in the river due to heavy rain, clogged drainage	1
Dec 2021 [9]	Selangor, Pahang, Kelantan, Kuala Lumpur, Melaka, Negeri Sembilan, Perak, Terengganu	Heavy rainfall > 300 mm/day, climate change, low land area, high tide	48
1 Jan 2022 [10]	Melaka, Johor, Negeri Sembilan, Sabah, Pahang	Heavy rainfall	7
24 Feb 2022	Besut, Dungun, Hulu Terengganu, Jeli, Kemaman, Kota Bharu, Kuala Krai, Kuala Terengganu, Kuantan, Machang, Marang, Pasir Mas, Pasir Putih, Setiu, Tanah Merah	Heavy Rainfall	-
7 Mar 2022	Gombak, Hulu Langat, Jasin, Jelebu, Kuala Langat, Kuala Lumpur, Petaling, Sepang	Heavy Rainfall	-
14 Mar 2022	Malacca, Negeri Sembilan, Selangor	Heavy Rainfall	-
18 Mar 2022	Bentong, Pahang	Heavy Rainfall	-
25 April 2022	Kuala Lumpur	Heavy Rainfall	-
6 May 2022	Melaka	Heavy Rainfall and overflow water from a nearby river	-
11 May 2022 [11]	Janda Baik, Bentong,Pahang	Heavy Rainfall Water column with mud flood	-
24 May 2022	Seremban, Kuala Lumpur	Heavy Rainfall	-
1 June 2022	Gurun, Kedah	Heavy Rainfall	-

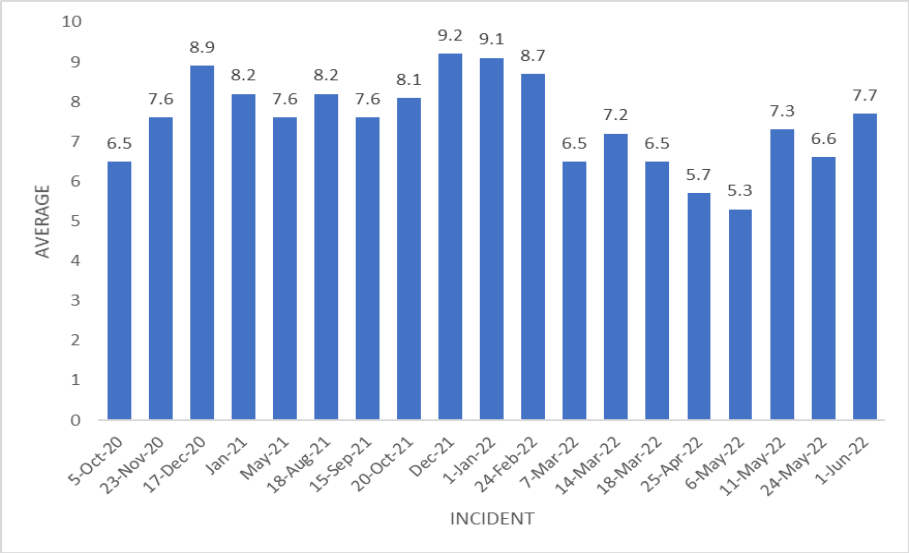

Figure 3: Average score flash flood incidences in Malaysia Oct 2020 – June 2022

3.3 Potential Causal Effect on Environmental

Environmental degradation is the breakdown of the planet or deterioration of the environment due to the depletion of resources, including soil, water, and air, the loss of ecosystems, and the extinction of wildlife. It is any alteration or aggravation to the natural world deemed harmful or unpleasant. There are two fundamental consequences which are landslides and flash floods.

3.3.1 Landslides

Previous hill slope development guidelines have been revised for stricter compliance with the developers and contractors after these incidents. Other than that, many constructions developed, especially in a hilly area with multiple slope design ranges—the steeper the hill, the higher risk of soil movement and the higher occurrence of landslides. The construction in the hilly area will face a significant risk of soil erosion and slope failure; without a proper design considering the slope, soil and water table, the higher possibility of a landslide occurring.

Soil erosion and slope failure always happen during heavy rainfalls with more than 70 mm per hour. As a tropical country, Malaysia gets 2400 mm of rain annually, adding the rainfall intensity and slope failure and erosion a perfect relationship. It will frequently trigger landslide occurrences in Malaysia, considering groundwater levels that have always been overlooked in designing the slope.

3.3.2 Flash Floods

Flash floods in Malaysia lead to high monetary losses and are always related to development. Flash floods severity in Malaysia caused significant problems, especially in the latest incident in December 2021 until January 2022. There were 48 fatalities recorded in the December 2021 flash floods incident, while seven deaths were recorded during flash floods in January 2022 that mainly affected Peninsular Malaysia and the Sabah area.

These incidents are due to heavy rainfall and improper maintenance of water basins, especially in urban areas. The severity of this incident is related to terrain conditions, amount of rain and human activities. The amount of rainfall recorded was more than 300 mm per day with the occurrence of high tide, especially in a low land area. Sediment deposition, which comes from poorly controlled construction, flows into the nearby rivers, causing the river's flow carrying capacity—besides, forest clearance with logging activities minimalises the absorption of rainwater by the forests. High rain intensity with a cleared forest area leads the rainwater 100% flows as run-off on the land into the rivers.

3.4 Mitigation Measure on Environmental Impacts

Legal instruments provided by the Department of Environment (DoE) [12] and the Department of Irrigation and Drainage Malaysia (DID) must be complied with by developers, contractors and agencies. Compliance with all guidance from related agencies can reduce upcoming landslides and flash floods disaster in Malaysia. Following the guidelines will prevent problems, especially on the soil erosion control and eliminate any possible pollution during the development of the construction area. To reduce the slope failure tragedies, the contractors must comply with a proper slope design and drainage system. Considering groundwater table also needed to be taken importantly in development that can trigger landslide according to the soil gradation that has always been overlooked in designing slope. Flood management needs to focus more on land use, uncontrolled forest clearing and development in Malaysia. The design must comply with Urban Stormwater Management Manual (MSMA) [13]. The construction of small dams and retention ponds along the river to divert some rainwater, especially during high-intensity rainfall, which could minimises flash floods disaster.

IV. CONCLUSION

The effects of environmental degradation from development in Malaysia, particularly for landslides and flash floods, can be observed by the data collected for both flash floods and landslide incidences in Malaysia. The incidence recorded for flash floods in December 2021 and January 2022 says that the incidence happened because of the improper drainage system and low maintenance of retention ponds in the affected area. This happens because of high surface runoff that can affect the situation in a particular site. High surface runoff and low impervious surface areas can prevent rainfall from infiltrating the ground, causing an excess of the local drainage capacity. To avoid further environmental risks, better legal instruments must be in place to ensure all related parties carry out all the requirements to protect the biological, physicochemical and human nearby land clearing and construction projects. Proper mitigation measures to reduce the environmental impact should be constantly improved and revised along with legal instruments such as Environmental Impact Assessment (EIA) in Malaysia. Rainfall and soil erosion needed to be taken care of, especially during construction and development, to make sure any further disasters because of landslides and flash floods could be reduced. Hence, the current legislation regarding the development in Malaysia, especially towards the environment, needs to be continuously strengthened to protect both humans and the environment from any undesired disaster.

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