Landslides Disaster in Malaysia: an Overview

Haliza Abdul Rahman[a], Jabil Mapjabil[b]

[a] *Department of Environmental & Occupational Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, MALAYSIA*

[b] *Ethnography and Development Research Unit, Faculty of Humanities, Arts and Heritage, Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, MALAYSIA*

*Corresponding Author: dr.haliza@upm.edu.my

ABSTRACT: Landslide is the movement of mass of rock, debris or earth (soil) down a slope under the influence of gravity. Although Malaysia is not a precipitous country (mountains and hills are less than 25% of the terrain), slope failures/landslides are a frequently happened. From 1993-2011, around 28 major landslides were reported in Malaysia with a total loss of more than 100 lives. Moreover, from 1973-2007, the total economic loss due to landslides in Malaysia was estimated about US $1 billion. Collapsed of the 14-storey block A of the Highland Tower in Ulu Klang, Selangor was the most tragic landslide in Malaysia with 48 deaths.The main factor that caused slopes failure/landslides at numbers site in hillside development in Malaysia are rainfall, storm water activities and poor slope management. Another cause of landslides can be due to the abuse prescriptive methods, inadequate study of past failures, design errors including insufficient site specific ground investigation. Besides, the development of highland or hilly terrain has increased developed and many hills project are in the pipe line. All this factors together contribute to landslide disaster in this country. An impact of landslides in Malaysia has given rise to some environmental and socioeconomic issues such as loss of lives, damaged of properties and infrastructures, psychological pressures among the victims, disputes on land boundaries and also land degradation. Therefore, planning, design, construction and maintenance are very critical to achieve a safe and cost-effective hill-site development.

Keywords: Landslide, Highland Tower, disaster, slope failure, rainfall, economic loss, prevention

Introduction

Landslides are a serious geologic hazard common in most countries of the world. Globally, landslides cause billions of dollars in damage and thousands of deaths and injuries each year (Bujang *et al*., 2008). There are a number of definitions of landslides, ranges from geomorphic features and processes it encompasses. Cruden (1991) defined landslide as the movement of mass of rock, debris or earth (soil) down a slope under the influence of gravity. Landslides are also explained by Keller (1999) as "mass wasting, a comprehensive term for any type of down slope movement of Earth materials".

The various types of landslides can be differentiated by the kinds of material involved and the mode of movement. According to Bujang *et al.*,(2008), landslides or slope movements can be divided into six categories namely falls, topples, slides – rotational and translational (shallow and depth), lateral spreads, flows and composites – combination of types (Table 1).

Table 1: Types of Landslides

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly coarse	Predominantly fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth Topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (deep creep)	Debris flow (soil creep)	Earth flow
COMPLEX		Combination of two or more principle types of movement		

Source: Varnes (1978)

Landslides did not occur due to a single factor (Table 2). Landslides can triggered by rainfall, earthquakes, volcanic activities, changes in groundwater, disturbances and change of slope profile by construction activities or combinations of these factors. However, more than 80 percent of landslides are at least partially related to human influence, including poor slope management practices (Seattle, 2001). This explanation is supported by Chan (1998) and Crozier (1986), landslides did not happened naturally but it was a result of human actions.

Although there are multiple types of causes of landslides, the three that cause most of the damaging landslides around the world are water, seismic activity and volcanic activity.

Table 2: Landslide Causes

Geological causes	Morphological causes	Human causes
Weak or sensitive materials	Tectonic or volcanic uplift	Excavation of slope or its toe
Weathered materials	Glacial rebound	Loading of slope or its crest
Sheared, jointed, or fissured materials	Fluvial, wave, or glacial erosion of slope toe or lateral margins	Drawdown (of reservoirs or aquifers)
Adversely oriented discontinuity (bedding, schistosity, fault, unconformity, contact, and so forth)	Subterranean erosion (solution, piping)	Deforestation
Contrast in permeability and/or stiffness of materials	Deposition loading slope or its crest	Irrigation
	Vegetation removal (by fire, drought)	Mining
		Artificial vibration
	Thawing	Water leakage from utilities
	Freeze-and-thaw weathering Shrink-and-swell weathering	

Source: The Encyclopedia of Earth (2013)

An impact of landslides has given rise to some environmental and socioeconomic issues such as loss of lives, damaged of properties and infrastructures, psychological pressures among the victims, disputes on land boundaries and also land degradation.

Landslide in Malaysia

Although Malaysia is not a precipitous country (mountains and hills are less than 25% of the terrain), slope failures/landslides are a frequent fact there (Qasim *et al.,* 2013). Generally, Malaysia did not experience strong/major earthquakes; but large-scale landslides are still existed; and they are mainly gravity-induced coupled with heavy and prolonged rainfall.

As land development and human activities grows rapidly losses from landslides and other impacts of the ground movements are increasing seriously. Due to a rapid development since the 1980s, strategic and suitable low-lying areas for development have become increasingly unavailable in Malaysia. As a result, the development of highland or hilly terrain has increased, particularly in areas adjacent to densely populated cities thereby exposing urban communities to an increased risk of landslide occurrence. Thus, many hill and their environs are already being developed and many hills project are in the pipe line. Supposedly, hill categorized as dangerous slope (20-30 degrees) and critical slope (> 30 degrees) should not be developed. According to Lim and Lee (1992), development of hill land can have serious irreversible effects on its immediate environment as well as the surrounding environment downstream. Mokhtar (2006) stressed that, main factor that caused slopes failure/landslides at numbers site in hillside development in Malaysia are rainfall and storm water activities. Lack of storm water planning and design is the main reason that the cause of landslides at Taman Zoo View / Kampung Pasir. And the same factors go to the occurrence of the Highland Tower tragedy (JKR, 1994)

Generally, there were 21,000 landslide-prone areas throughout the country out of which 16,000 or 76% are in Peninsular Malaysia while about 3,000 are in Sabah and 2,000 in Sarawak. The most common types of landslides in Malaysia are shallow slides where the slide surface is usually less than 4 m deep and occurs during or immediately after intense rainfall (Ting, 1984). Other types of landslides found are deep-seated slides, debris flow and geologically controlled failures such as wedge failure and rock fall.

In Malaysia, annual rainfall can reach as high as 4500 mm. This combined with yearlong high temperatures causes' intense chemical weathering and formation of thick residual soil profiles which in certain locations can reach 100 m in depth. With these set of climate and geological conditions, combined with other causative factors, landslides are thus one of the most destructive natural disasters in Malaysia (Bujang *et al.*, 2008) (Figure 1 and 2) (Table 3). Landslides mostly occurred during or immediately after rain.

In this country, from one aspect it seems that the frequency of slope failures is due to the monopoly of the rainfall. The question is that, is rainfall is the only issue? Most of the landslides emerge on manmade slopes and this is in essence the upshot of uncertainties related to human factors like insufficiency in design, failing in construction or wretched maintenance (Jamaluddin, 2006). One of the sectoral reports of Malaysia clearly mentioned about 49 landslides cases out of which 88% are recognized with manmade slopes (JKR, 2009a, 2009b).

Figure 1: Landslide-prone areas in Malaysia

Source: National Slope Master Plan 2009-2023 (2009)

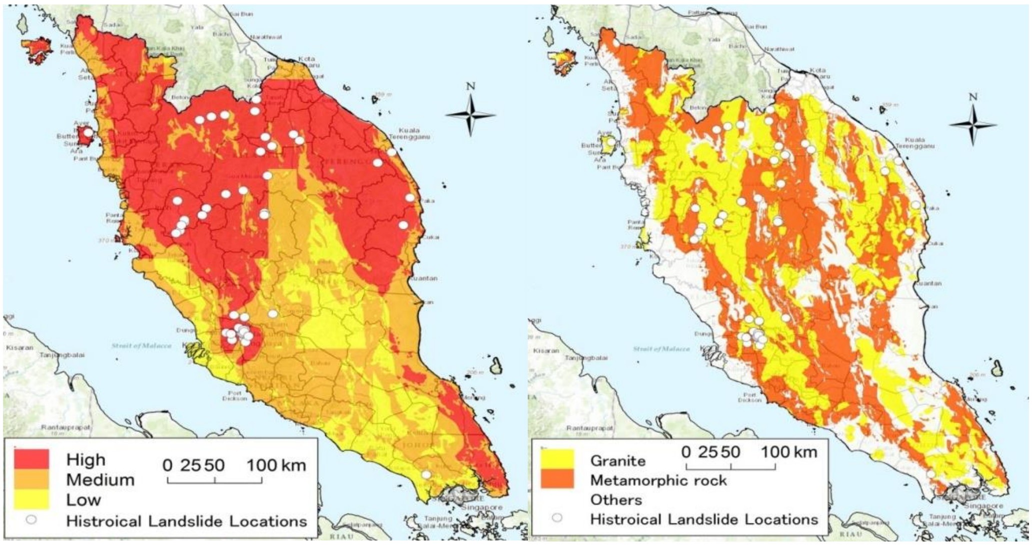

Figure 2: Landslides Hazard Map in Peninsular Malaysia

Source: National Slope Master Plan 2009-2023 (2009)

Table 3: Series of Major Landslides in Malaysia

Date	Location
1 May 1961	A landslide occurred in Ringlet, Cameron Highlands, Pahang.
21 October 1993	The man-made Pantai Remis landslide caused a new cove to be formed in the coastline
11 December 1993	48 people were killed when a block of the Highland Towers collapsed at Taman Hillview, Ulu Klang, Selangor.
30 June 1995	22 people were killed in the landslide at Genting Highlands slip road near Karak Highway.
6 January 1996	A landslide in the North-South Expressway (NSE) near Gua Tempurung, Perak. One death.
29 August 1996	A mudflow near Pos Dipang Orang Asli settlement in Kampar, Perak, 44 people were killed in this tragedy.
November 1998	Massive rockslide at Bukit Saujana, Paya Terubung, Penang.
January 1999	Shallow rotational slide. Heavy rain triggered landslide – buried a number of house/huts in squatters settlement, Sandakan, Sabah. 13 deaths.
15 May 1999	A massive landslide near Bukit Antarabangsa, Ulu Klang, Selangor. Most of the Bukit Antarabangsa civilians were trapped under the rubble. Only two victims survived - an Indonesian maid and a child.
January 2000	Debris flow from upstream landslide and erosion washed away worker squatters in vegetable farm, Cameron Highlands, Pahang. 6 deaths.
January 2001	Shallow rotational slide in Simunjan, Sarawak. Landslide occurred on vegetable farm – buried a number of houses at the toe of slope. 16 deaths.
December 2001	Debris flow in Gunung Pulai, Johor. Heavy rain triggered debris flow resulting from a number of small landslides along upstream of Sungai Pulai – washed away settlements along the river bank. 5 deaths.
20 November 2002	The bungalow of the Affin Bank chairman General (RtD) Tan Sri Ismail Omar collapsed due to an early morning landslide in Taman Hillview, Ulu Klang, Selangor, with a fatality in his family.
November 2003	A rock fall/rock debris in the New Klang Valley Expressway (NKVE) near the Bukit Lanjan interchange caused the expressway to be closed for more than six months.
November 2004	Debris flow in Taman Harmonis, Gombak, Selangor. Sliding/flowing of debris soil from uphill bungalow project-toppled the back-portion of neighbouring down slope bungalow after weeklong continuous rain. 1 death.
December 2004	Rock fall – buried back portion of illegal factory at the foot of limestone hill in Bercham, Ipoh, Perak. 2 deaths.
31 May 2006	Four persons were killed in the landslides at Kampung Pasir, Ulu Klang, Selangor. Buried 3 blocks 0f longhouses.
March 2007	Landslide at Precint 9, Putrajaya. Some 23 cars were buried under the debris.
26 December 2007	–Two villagers were buried alive in a major landslide, which destroyed nine wooden houses in Lorong 1, Kampung Baru Cina, Kapit,

Date	Location
	Sarawak.
2 February 2009	One contract worker was killed in a landslide at the construction site for a 43-storey condominium in Bukit Ceylon, Kuala Lumpur.
21 May 2011	16 people mostly 15 children and a caretaker of an orphanage were killed in a landslide caused by heavy rains at the Children's Hidayah Madrasah Al-Taqwa orphanage in FELCRA Semungkis, Hulu Langat, Selangor.
29 Dec 2012	88 residents of bungalows, shophouses and double-storey terrace houses in the Puncak Setiawangsa, Kuala Lumpur were ordered to move out because of soil movement.
4 Jan 2013	Construction at the Kingsley Hill housing project at Putra Heights has been halted temporarily following a landslide at the site that caused several vehicles to be submerged in mud
11 November 2015	A landslide occurred at km 52.4 of the Kuala Lumpur-Karak Expressway between Lentang and Bukit Tinggi, Pahang and Gombak-Bentong old roads. The Lentang-Bukit Tinggi stretch of the expressway was closed to traffic.
January 2016	A landslide has blocked all lanes in both directions on the Karak Highway, the main highway that connects the capital Kuala Lumpur to Genting Highlands and other parts of Pahang state. Four vehicles that were trapped in the landslide, but all passengers managed to escape unhurt.
February 2016	194 minor landslides and embankment failures. Puncak Borneo area, comprising mainly Bidayuh settlements and Padawan Ring Road, were most “critical”.

The statistics of landslide cases reported by Gue and Tan (2007) clearly indicates the domination of design flaws. Among 49 cases of slope failures, 29 cases are referring to design deficiencies (Table 4). Deficit design cases are not unusual but still no proper move has been taken. Design and construction deficiencies are basically of improper understanding of soil behavior, inaccurate testing of soil properties and poor management of prescriptive method. Gue and Tan (2007) also declares that along with poor designing, incompetency, casualness, raw input data are also contributing in this frequent fact of landslides.

The causes of landslides can be due to the abuse prescriptive methods, inadequate study of past failures, design errors including insufficient site specific ground investigation. However, lack of appreciation of water such as 14 underestimating existing groundwater tables and inadequate capacity of surface drainage is also one of the factors causing the landslides (National Slope Master Plan, 2009-2023).

Table 4: Reported cases of Landslides in Malaysia

Causes Of Landslides	Number of Cases	Percentage (%)
Design errors	29	60
Constructios errors	4	8
Design and Constructios errors	10	20
Geological features	3	6
Maintenance	3	6
Total	**49**	**100**

Source: Gue and Tan (2007)

From 1993-2011, around 28 major landslides were reported in Malaysia with a total loss of more than 100 lives (Table 1). From 1973-2007, the total economic loss due to landslides in Malaysia was estimated about US $1 billion (National Slope Master Plan 2009-2023).

In 1993, collapse of the 14-storey block A of the Highland Tower in Ulu Klang, Selangor was the most tragic landslide in Malaysia with 48 deaths. The total length of landslide was 120 m and width of rupture surface was about 90 m involving round about 40,000 m3 of debris. Highland Tower collapse main cause is inadequate drainage. From another aspect, design deficiencies are also found. The report has following concluded factors responsible for this landslide (Jaapar 2006): which are buckling and shearing of rail piles foundation persuade by soil movement, surface runoff due to improper drainage facility, and cut and fill slopes, rubble walls around Block I showed inadequate design (carrying safety factor <1), poorly administered construction, slope gradient is suspected to be very steep, no maintained drainage system along with leakage from pipe culvert carrying diverted flow of East stream (MPAJ 1994).

Prevention of Landslide in Malaysia

Vulnerability to landslide hazards is a function of location, type of human activity, use, and frequency of landslide events. The effects of landslides on people and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity (http://geology.com/usgs/landslides/).

In general, the hazard from landslides can be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slopes. Stability increases when groundwater is prevented from rising in the landslide mass by (1) covering the landslide with an impermeable membrane, (2) directing surface water away from the landslide, (3) draining groundwater away from the landslide, and (4) minimizing surface irrigation. Slope stability is also increased when a retaining structure and/ or the weight of a soil/rock berm are placed at the toe of the landslide or when mass is removed from the top of the slope (http://geology.com/usgs/landslides/).

As third hierarchy of government in Malaysia, local governments had exclusive power to reduce landslide effects through land-use policies and regulations in their own areas. Individuals can reduce their exposure to hazards by educating themselves on the past hazard history of a site and by making inquiries to planning and engineering departments of local governments. They can also obtain the professional services of an engineering geologist, a geotechnical engineer, or a civil engineer, who can properly evaluate the hazard potential of a site, built or unbuilt (http://geology.com/usgs/landslides/).

In Malaysia, most of the time, the existence of the large-scale landslides was only known after the areas have been developed and extensive and continuing damages to the built infrastructures. It is so unfortunate and often too late when the existences of large-scale landslides are only known after the affected areas have been developed and suffered from extensive damages/disasters. Unnecessary disasters and great economic losses could have been avoided if the large-scale landslide geohazards had been identified and assessed on the first place prior to the development. Hence, infrastructural development should be avoided when interfering with deep-seated large-scale landslides (Tajul Anuar, 2015).

Thus, prevention rather than remediation is desirable where landslides are likely to be rapid and there is a high risk of damage and injuries. Potential landslides due to these causes can be reduced in a cost-effective way by taking these actions (Bujang *et al.*, 2008):

i) Identifying landslide risk through hazard mapping and past experience, and then implementing a plan of hazard reduction on a prioritized basis.
ii) Periodic inspections of facilities which are vulnerable to landslides to observe any early signs of distress and, if appropriate, to take preventive action to avert landslide.
iii) Maintaining and improving drainage measures in areas vulnerable to landslides.

iv) Protecting lifeline facilities, buildings and other places of public access from earthquake-induced landslides.

In general, the recommended approach covers several major elements, spanning a continuum from research to the formulation and implementation of policy and mitigation. These include (Tajul Anuar, 2015):

a) Landslide hazards identification and assessments

b) Real-time monitoring

c) Loss assessment

d) Information collection, interpretation and dissemination

e) Guidelines and training

f) Public awareness and education

h) Implementation of loss reduction/mitigation measures

i) Disaster preparedness and emergency response

From governance aspect, some of the action must be taken such as restricting development in landslide-prone areas; revised land-use planning; standardizing codes for excavation, land clearing, construction and new development; and protecting existing development. Latest technology such as Geographic Information System (GIS) and remote sensing technique also apply to perform area based slope hazard assessment and mapping. In addition, National Slope Master Plan (2009-2023), is a plan provides detailed elements of a comprehensive and effective national policy, strategy and action plan for reducing risk from landslides on slopes nationwide, for 2009-2023. It also provides an assessment of the status, needs and associated costs for a national landslide hazard mitigation strategic program including activities at the national, state, and local levels, in both the public and private sectors.

Moreover, public awareness, their understanding on the hazards and risks of the landslide; understanding their socio-economic needs and capability; their perception as well as their participation in vulnerability reduction measures, albeit small, is vitally important to achieve integrated and sustainable landslide hazards management. Moreover, scientific and technical information have to be packaged and streamlined based on stakeholders' ability and capacity to address the threat and impact of the landslide hazards. Scientific, Technical and Socio-Economic inputs should be integrated as well to ensure a successful landslide hazards management (Tajul Anuar, 2015).

Furthermore, an important aspect of dealing with large-scale landslides is to understand their distribution, pattern and behavior based on geological and geomorphological features as well as from the impacted infrastructures built on them. Major landslides were easier to predict than minor ones because there would be warning signs such as widening cracks on structures in or outside homes or concentrated amounts of water overflowing onto slopes. However minor landslides can be equally dangerous because as when a car passing by at the time could be buried or pushed over a cliff. Thus, signboards to warn people not to use roads in landslide-hit areas also will be put it in major landslide areas.

Geomorphological and geological mapping focusing on large-scale landslide hazard identification should be exercised prior to any development planning and design in the hilly/mountainous terrain. Avoiding development in large-scale landslide areas should be the best option of a disaster risks pre-mitigation (prevention) measure.

The Malaysian government departments involved in landslide mitigation are the Public Works Department (PWD), Department of Mineral and Geosciences (DMG) and Centre of Remote Sensing (MACRES). PWD is the main technical department in Malaysia and is largely involved in slope remedial works (active action) as well as the development of slope assessment and management (passive action). The main contribution of the DMG and 10 MACRES is to inform the government of areas prone to land sliding. They have produced slope or terrain hazard zonation maps and these are widely used by the government agencies as a guideline in the development of hilly and mountainous areas (Suhaimi and Ahmad Nadzri 2006). The Drainage and Irrigation Department (DID) has installed rain gauges nationwide for monitoring and prediction of flood. The Malaysian Meteorological Department MMD will work closely with DID for the sharing of rainfall data to improve the data coverage and to strengthen MMD's warning capabilities on weather related hazards.

Currently, in Malaysia, since 2013, work has begun on an early warning system that can send out alerts at least two hours before a landslide occurs. People living in landslide-prone areas will be warned via TV and radio, enabling quicker evacuation as well. The Public Works Department (PWD) is in the process of creating the system, similar to the high-tech model used in landslide-prone Hong Kong. The LWS is being designed to provide warnings at least two hours ahead, compared with the three-hour benchmark set by Hong Kong. The PWD had already conducted pilot studies at two “hot spots” –which are Bukit Antarabangsa, Selangor and the Tapah-Cameron Highlands road, Perak. The PWD’s Landslide Warning System (LWS) is currently being tested at Bukit Antarabangsa.

Conclusion

In Malaysia, landslides are the most destructive disaster besides flood. Every year during the monsoon seasons, the occurrence of landslides is common in Malaysia. The occurrences mainly were in the highland areas such as Hulu Kelang, Cameron Highlands and Genting Highlands as reported by Ibrahim and Fakhrul (2006). These disasters have caused considerable numbers of death, destruction of properties loss and immerse direct and indirect economic losses. Thus, many methods are used to remedy landslide problems. Therefore, planning, design, construction and maintenance are very critical to achieve a safe and cost-effective hill-site development. However, the best solution is to avoid landslide-prone areas altogether.

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