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HISTORICAL ANALYSIS OF LANDSLIDES EVENTS IN MALAYSIA: IMPACT ON PHYSICAL AND SOCIO-ECONOMIC

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Abstract

Any earthly substance, including rock, soil, artificial fill, or debris, moving in large quantities down a slope is called a landslide. They may occur quickly or gradually over an extended length of time. A landslide occurs when the force of gravity exerted on a slope surpasses the forces that prevent it from failing. Malaysia is a tropical nation that receives a lot of rainfall and rich residual soil. Numerous landslide incidents that happened during Malaysia's rainy season are publicized in the media, and some landslides repeat themselves in the same spot over time. The aim of this research is to examine the past landslide incidents that occurred in Malaysia from 1961 to 2023 and their effects on the country's physical and socioeconomic circumstances. Data on past landslides were gathered from local news sources, earlier studies, and reports from local government agencies. There have been a significant number of fatalities, property damage, and both direct and indirect economic ramifications from the landslide tragedy. To reduce adverse environmental effects, it is advised that any development on high land areas be subject to additional restrictions. Additionally, during the planning and management phase, the public should be made aware of the risks associated with landslides. When designing, analyzing, and planning a development in a hilly area, susceptibility evaluations may also offer significant insights.

Keywords: Landslide, Slope Failure, Rainfall, Environmental Impact

Abstrak

Sebarang bahan bumi, termasuk batu, tanah, timbunan tanah tambak, atau serpihan, yang bergerak dalam kuantiti yang banyak menuruni cerun dipanggil tanah runtuh. Ia mungkin berlaku dengan cepat atau beransur-ansur dalam jangka masa yang panjang. Tanah runtuh berlaku apabila daya graviti yang dikenakan pada cerun melebihi daya yang menghalangnya daripada gagal. Malaysia adalah sebuah negara tropika yang menerima banyak hujan dan kaya dengan tanah sisa. Banyak kejadian tanah runtuh yang berlaku semasa musim hujan di Malaysia dihebahkan di media, dan beberapa kejadian tanah runtuh berulang di tempat yang sama dari semasa ke semasa. Tujuan penyelidikan ini adalah untuk mengkaji kejadian tanah runtuh yang lalu yang berlaku di Malaysia dari tahun 1961 hingga 2023 dan kesannya terhadap keadaan fizikal dan sosioekonomi negara. Data mengenai tanah runtuh yang lalu dikumpulkan daripada sumber berita tempatan, kajian terdahulu, dan laporan daripada agensi kerajaan tempatan. Terdapat sejumlah besar kematian, kerosakan harta benda, dan kesan ekonomi langsung dan tidak langsung daripada tragedi tanah runtuh itu. Untuk mengurangkan kesan buruk alam sekitar, adalah dinasihatkan bahawa sebarang pembangunan di kawasan tanah tinggi dikenakan sekatan tambahan. Di samping itu, semasa fasa perancangan dan pengurusan, orang ramai harus dimaklumkan tentang risiko yang berkaitan dengan tanah runtuh. Apabila merekabentuk, menganalisis dan merancang pembangunan di kawasan berbukit, penilaian kerentanan mungkin juga menawarkan pandangan yang ketara.

Kata kunci: Tanah runtuh, Kegagalan cerun, Hujan, impak alam sekitar

1.0 INTRODUCTION

Malaysia has a tropical climate similar to that of Southeast Asia, with significant rainfall practically year-round, especially from October to February. Particularly during these few months, Malaysia has had a number of natural catastrophes, including floods, mudslides, and landslides brought on by excessive rainfall (Abd Majid et al., 2020). There has been a rise in construction in hilly or highland terrain, especially in close proximity to heavily populated places. As a result, it puts urban neighbourhoods at higher risk of experiencing landslides (Haliza et al., 2017).

In Malaysia, landslide accidents are increasingly caused by climate change, particularly in hilly locations. Landslides have caused harm to the environment and society, including soil degradation, disputes over property boundaries, loss of life, damage to buildings and infrastructure, and social pressure on families. Major landslides and fatalities have occurred often in Malaysia (Tharshini Murthy et al., 2023). About 88% of the 49 landslide occurrences were identified as occurring on man-made slopes, according to one of Malaysia's sectoral surveys.

According to Qasim et al. (2013), human factors are physical or cognitive characteristics that affect how technological systems perform during the design process and may put pressure on structural integrity and safety. (Danish et al., 2016) further demonstrates that human error—primarily, inaccurate design or construction—as well as poor slope management are the primary causes of landslides. According to Hussien et al. (2015), a number of variables, including prolonged and strong rainfall, can saturate the soil, decreasing its stability and causing landslides.

Major geological hazards like landslides may happen anywhere in the world, including Malaysia. They are more common in hilly regions. Uneven ground and steep slopes are the most common places for landslides to occur. Every year, landslides cause billions of dollars' worth of damage and thousands of deaths and injuries worldwide (Rahman, 2017).

(Suhaimi et al., 2006) has examined the three government agencies—the Public Works Department (PWD), the Department of Mineral and Geosciences (DMG), and the Center of Remote Sensing (MACRES)—that are engaged in landslide assessment projects in Malaysia. PWD is primarily engaged in slope remediation, evaluation, and management development. Slope or terrain danger zonation maps were created by DMG and MACRES, and they must notify the government of any places that are vulnerable to landslides. The government agencies will utilize the data as a reference for developing hilly and mountainous areas. Adjacent sliding bodies interacting in a range of ways and distributions can complicate landslide failure processes. A few different failure mechanisms, including falls, topples, translational and rotational sliding, lateral spread, and flows via The Varnes, can be used to classify slope failures.

Classification of Landslide Types (Oldrich Hungr et al., 2013). The summary of the movement types and material classification are shown in Table 1. The diagram of the landslide movements is shown in Figure 1.

Table 1 Landslides and its movements (Oldrich Hungr et al., 2013).

Movement type		Material Classification		
		Bedrock	Engineering soils	
			Mainly coarse	Mainly 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 spreading		Rock spread	Debris spread	Earth spread
Flows		Rock flow	Debris flow	Earth flow

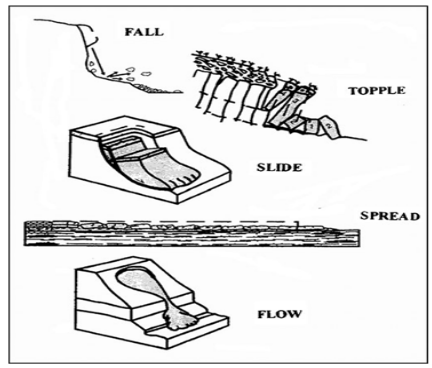

Figure 1 Types of landslide movements

The World Health Organization (WHO) estimates that between 1998 and 2017, landslides killed over 18,000 individuals and harmed 4.8 million people. According to the National Slope Master Plan (2009-2020) study, Malaysia saw its first recorded landslide in December 1919, which resulted in the deaths of 12 people. 1961 saw the first landslide occurrence in Ringlet Cameron Highlands following Independence Day 1957. A significant number of landslides were recorded in the local press starting in 1973. Figure 2 displays recorded landslides and deaths between 1973 and 2007. Since the Highland Towers catastrophe on December 11, 1993, which took 48 lives, it indicates a rise in the number of landslides and deaths.

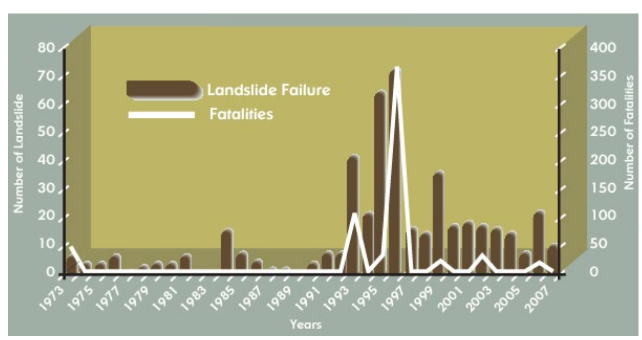

Figure 2 Reported landslides and fatalities (1973-2007)
(National Slope Master Plan (2009-2020))

2.0 LANDSLIDE EVENT FROM 1993 - 2000

Highland tower was constructed between 1976 until 1979 which consist of three (3) building blocks and 12 stories. Majority of residentiary are from upper and middle-class families. Block 1 building which located at the southeast region collapsed on the 11th December 1993 which sacrifice a total of 48 residences. Prior to tower collapsed, this place received nonstop rainy day for almost ten consecutive days. Another factor that contributes to landslide is inadequate soil testing before the construction. To make it worst, the retaining wall close to the block 1 building also collapsed due to heavy rain as seen in Figure 3. Landslide can occur anytime for example before, during or after natural disasters like floods, earthquake, or volcanic eruptions. As stated by Azuwa et al. (2023), the landslide occurred due to poor planning during construction, which involved the cut and fill technique and relied on retaining wall to stabilise the terrain. The Highland Tower development faced issues because the terrain became unstable from water buildup due to poor maintenance. The building's foundation was weak, leading to its collapse. It could not handle the horizontal pressure from the landslide. This landslide was caused by inadequate drainage systems, poor maintenance, poor city planning, low-quality construction, and a lack of technical expertise (Bray et al., 2007; Azuwa et al. (2023).

Figure 3 Highland Tower condominium collapsed

In January 6th, 1996 a cut slope at KM 303.8 of the North South Expressway which located near Gunung Tempurung, Kampar,Perak has failed (Figure 4). Debris from this landslide, including earth flow, rocks, and shotcrete materials swept a container truck off the road, killing the truck's co-driver. Besides that, another small landslide occurred at the top of the first. From the report, it can be confirmed that the area has a history of landslide, and the location of expressway was built along a highly sheared and fractured zone with natural weakness and relict structural planes. Another factor that contributes to the landslide is the site containing different types of rock which consist of granite, schists and hornfels resulting in soils with varying engineering properties. Although there was no rainfall at the time of the landslide, earlier rain had caused water to accumulate at the top of the slope.

Figure 4 Close view of Gua Tempurung Landslide at North South Expressway

Chow et al. (1996) reported that heavy rain on June 30th, 1995, caused flooding in the Karak Highway Tunnel. Traffic was redirected, and the downpour led to landslides and debris flow, sweeping away 19 vehicles. This resulted in 20 deaths, 1 missing person, and 23 injuries. An investigation revealed that the thunderstorm caused 72 additional landslides between km 1 and km 8 along the road to Genting Highland Resorts. Komoo (1997) noted that minor landslides had stopped vehicles, making them vulnerable to the debris flow, leading to the high number of deaths. Chow et al. (1996) explained that three landslides near the stream's headwaters caused debris to accumulate, eventually breaking through and creating a flow of water, mud, boulders, and trees. Komoo (1997) added that the debris flowed over about 1 km, moving an estimated 3,000 m^3 of material. Othman (1996) observed that on June 1995 was unusually wet in Genting Sempah, with 428.5 mm of rain, the highest in 20 years and 2.6 times the average. From June 25th - 30th, 207.5 mm of rain fell, making up half of the month's total and exceeding the average. This high rainfall saturated the soil before the June 30th storm, contributing to the disaster.

Komoo (1997) described a powerful debris flow in Pos Dipang, Perak, on August 30th, 1996. The powerful flow caused by heavy rains gave a massive force hit to the village, destroying almost everything in its path for over 5 km. It has uprooted trees, demolished houses, and swept away 44 people. Komoo (1997) also stated that heavy rain caused the disaster. In August 1996, 461 mm of rain fell, compared to 137 mm in 1993 and 281 mm in 1995. The excessive rain softened the ground, triggering landslides on steep slopes upstream of Sungai Dipang. This led to a massive mudflow that uprooted trees, eroded riverbanks, and created temporary dams. One of these dams, about 200 m upstream of Pos Dipang, eventually broke, releasing a huge flood of water and debris that overwhelmed the village. Figure 5 shows the aftermath of Pos Dipang after debris flow.

Figure 5 Pos Dipang debris flow

On May 15th, 1999, a large landslide occurred at Bukit Antarabangsa, Selangor, involving several smaller landslides. This forced the evacuation of nearly 1,000 residents and trapped over 10,000 people in their homes. Mahmud & Baba (2002) noted that tons of earth and granitic boulders blocked the only access road, burying a vehicle, though the driver escaped with minor injuries. The landslide was about 100 m west of the Wangsa Height condominium. Faisal (2000) estimated the landslide volume at 14,580 m³, affecting about 70 m of Wangsa 3 road. Another landslide occurred the day before, on May 14th, 1999, at around 4:30 pm near the Athenaeum at The Peak condominium. This landslide was 31 m wide and 140 m long, depositing about 13,000 m³ of debris at the slope's base, covering an area of 50 m by 100 m. Faisal (2000), Kumpulan Ikram Sdn Bhd (1999) reported an intense rainfall before the first landslide on May 14th. The second landslide occurred 13 hours later, following heavy rainfall on May 12th (80.5 mm) and a total of 308 mm of rain over the 13 days preceding the landslide.

3.0 LANDSLIDE EVENT FROM 2001 - 2014

On November 26, 2003, a huge rock slope collapse happened near KM 21.8 of the Bukit Lanjan Interchange on the New Klang Valley Expressway (NKVE), as Figure 6 illustrates. The rock slope collapse was caused by rock debris, primarily angular stones of different sizes, which eventually came to rest on the road. The collapsing materials blocked the whole roadway, forcing traffic to be stopped. The breakage occurred in Bukit Lanjan on the steepest southern cut slope of a roughly north-south oriented cut. On the failing slope, which climbed more than 65 meters above the road, were six seats. The failure surface had a wedge-like structure, with rock debris hiding the southern end and a continuous significant discontinuity (presumably a fault plane) visible along its northern border (Komo et al., 2004).

Figure 6 Bukit Lanjan rock slope failure

On May 31, 2006, landslides at Kampung Pasir, Ulu Klang, Selangor, claimed the lives of four people. Mokhtar (2006) states that in some areas of Malaysian hillside development, rainfall and storm water activities are the main causes of landslides and slope collapse. The absence of storm water planning and design is the main reason for the landslides in Taman Zoo View and Kampung Pasir. According to the research, the landslide was caused by poorly designed walls and slopes, where the unengineered walls and slopes' Factor of Safety (FOS) was less than 1.0 even without taking the existence of geological characteristics such water tables and relic joints into account. The landslide's FOS was woefully insufficient (Gue & Liong, 2007). Using a continuous monitoring technique, Akib and Aziz (2007) examined the landslide movements in Kampung Pasir, Hulu Kelang, and discovered that over the course of a 10-day monitoring period, the earth shifted from 2 mm to 17 mm.

As seen in Figure 7, a landslide happened on December 6, 2008, 1.5 km northeast of the Highland Towers, on the eastern edge of the Bukit Antarabangsa township. Four people were killed and fifteen injured when a landslide badly destroyed fourteen expensive bungalows. Ulu Klang is prone to landslides and has experienced several fatal ones. In its hilly areas, heavy rainfall, human activity, and natural topography are the main sources of instability. In 2008, the Selangor State Government identified fourteen locations on hillsides that were prone to landslides. The majority of landslide accidents, as reported by the National Slope Master Plan (NSMP) 2009–2023, happened in developed zones, mostly in the foothills of the Titiwangsa Range (Azmi et al., 2013).

A poor development plan and inadequate slope strengthening related to monitoring and maintenance may have been the major causes of this disaster. The rainfall data before to the landslide tragedy shows that there were no notable downpours, hence rainfall cannot be considered the only triggering reason. Previous studies on the 2008 Bukit Antarabangsa landslide have also identified a number of interrelated causes that led to the slope failure. Among these, human error was the most important (Chigira et al., 2011; Danish et al., 2017).

Figure 7 Bukit Antarabangsa landslide in 2008

Figure 8 illustrates the landslide that occurred on May 21, 2011, at the Children's Hidayah Madrasah Al-Taqwa orphanage in FELCRA Semungkis, Hulu Langat, Selangor, as a result of heavy rains, killing 16 persons, primarily children and an orphanage caregiver. This landslide ascribes the disaster to human action because no slope fortification or protection was provided, the vegetation was cleared, and the extremely steep slope was cut. Furthermore, the slope region had neither a buffer zone nor a maintenance zone (BBC, 2011; The Star 2011).

Figure 8 Landslide at orphanage house in Hulu Langat, Selangor.

The 2014 landslide on the Genting Sempah - Genting Highlands Highway was caused by intense rainfall. Each of the two landslides had a width of around 20 meters. Shortly after the adjacent Lembah Bertam mudslide catastrophe, which lost five lives, there was another landslide.

4.0 LANDSLIDE EVENT FROM 2015 - 2020

Due to its remote location from significant plate boundary faults, East Malaysia has a very low earthquake risk (Simons et al., 2007). However, rare earthquakes produced by active intraplate faults do happen and have resulted in large-scale destruction (Lim and Godwin, 1992). In this uncertain tectonic setting, an earthquake of a magnitude of 6.0 hit Mount Kinabalu at 23:15 on June 4, 2015, resulting in considerable damage and fatalities. The epicenter was close to Mount Kinabalu, the highest peak in Malaysia and a well-liked tourist attraction for its biodiversity. As far as Sabah province goes, it was the biggest earthquake of the previous century (Engdahl and Villasenor, 2002).

On Mount Kinabalu, the earthquake caused landslides, including one that was very destructive on the well-known Via Ferrata path for climbing. Along the climbing pathways on the high mountain face, this led to the deaths of eighteen climbers and the injuries of at least twenty-one more (Chan, 2015). With its epicenter close to Mount Kinabalu, the seismic activity was the immediate cause of the landslide. By changing the distribution of stress inside the ground, eroding rock and soil, and causing ground shaking that might cause landslides, earthquakes can cause slopes to become unstable (Wang et al., 2017).

At a depth of 10 kilometers, the earthquake occurred in the Ranau area of Sabah on Borneo Island. One of the main factors affecting Mount Kinabalu's stability is the kind of rock and soil that it has. The features of different types of rock and soil compositions, such as cohesion and permeability, influence their resistance to or vulnerability to the beginning of landslides. The ecosystem was impacted by landslides, which had an impact on Mount Kinabalu's biodiversity and scenery. In conclusion, the 2015 Mount Kinabalu landslide was caused by an earthquake, but its intensity and extent were also influenced by several geological, geomorphological, and environmental variables. Comprehending these variables is essential for evaluating the likelihood of landslides in comparable alpine areas and putting into practice efficient mitigating strategies to improve security and durability.

A notable incident that caused fatalities and property damage in 2016 was the landslide that occurred in Taman Idaman, Serendah, Selangor (Figure 9). Because of worries that the region is still unstable, local officials evacuated roughly 340 individuals from 60 residences within 600 meters of the event (Faisal and Farhana, 2016). One reason given for the collapse of a hillside and the subsequent buried of many dwellings in mud and rubble was heavy rains. Selangor State, which lies on Peninsula Malaysia's west coast, enjoys a wet tropical climate with high annual rainfall. However, there are certain seasons with higher rainfall in the winter months in the Northern Hemisphere, with November being the wettest month with an average of 260 mm of rain (Wong et al., 2016). In these kinds of places, landslides usually happen during the monsoon season, which is marked by heavy and protracted rainfall (Faisal and Farhana, 2016). The heavy downpour was identified as the main cause of the landslide as it made the steep slopes in the residential area less stable (Sardi et al., 2021). According to Nasir et al. (2018), this saturation decreased the soil's shear strength, causing dirt and debris to slide downward.

In addition to their direct effects on buildings and infrastructure, landslides can cause environmental problems such soil erosion, sedimentation in waterways, and disturbance of nearby ecosystems. The landslide brought concerns about hillside development to light, highlighting the need for improved planning and oversight to avert similar catastrophes in the future. It also brought attention to how susceptible some places are to natural disasters, particularly during heavy rainstorms.

Figure 9 The scene of the 26 November 2016 Taman Idaman landslide.

On October 19, 2018, a landslide occurred at Paya Terubong, Penang, Malaysia. The residential neighbourhood, which is steep, was devastated by the sad occurrence, which resulted in substantial damage and fatalities. The landslide that happened during a period of extreme weather was once again shown to be mostly caused by heavy rains (Arif, 2019). According to the Mineral and Geoscience Department (JMG), one of the factors that contributed to the landslide that occurred there last Friday was water flow from a creek on the mountainous Jalan Bukit Kukus, Paya Terubong nearby. Nine people were killed in the landslide, two of them were citizens of Myanmar and one of whom was a labourer from Bangladesh. The mud and debris caused several homes to be damaged or demolished, and several more people were hurt. Emergency personnel and volunteers quickly launched rescue operations to look for survivors and help impacted communities. The bedrock of Penang Island is composed mostly of granite. Granitic terrain has seen a large number of small to medium-sized landslides, which have posed a significant challenge to Penang Island's development, particularly in relation to residential and high-rise structures (Chigira et al., 2011).

According to Ahmada et al. (2016), Paya Terubong is situated in Penang Island's southeast, where the landscape is made up of microcline and medium- to coarse-grained biotite granite. According to Suzuki et al. (2002), the residual soil analyzed included around 14% gravel, 55% sand, 18% silt, and 13% clay. This mixture of particles indicated coarse-grained, highly permeable soil that is prone to landslides. The Paya Terubong tragedy brought to light the difficulties associated with steep terrain and the significance of proper disaster preparedness and mitigation techniques in susceptible regions.

In November 2019, heavy rains caused landslides in Genting Highlands, resulting in evacuations and delays for transportation in several areas surrounding the hill resort. (Figure 10) Transportation was affected, and both locals and visitors were concerned about their safety. It is thought that the landslide that occurred at Genting Highlands' Jalan Genting-Amber Court was caused by a subpar drainage system. Local authorities and emergency services reacted quickly to clear debris, assess damage, and guarantee the safety of individuals in the impacted regions as a result of the landslides. Thankfully, no injuries from these landslides were reported (Shen, 2019).

In Malaysian hillside development, inadequate drainage is a major contributing factor to landslides (Rahman et al., 2017). Slope collapses have been linked to design errors, inadequate supervision during construction, and inadequate drainage systems (Kazmi et al., 2017). Mud and debris spilled onto the road because of rainwater destabilizing the soil structure along the slope and pushing the ground downward (JMG, Shen, 2019). These events highlighted the continuous difficulties caused by the high rains and unstable terrain in the Genting Highlands. The authority also stressed that in order to lessen the effects of natural catastrophes in such high-risk locations, it is imperative to maintain ongoing surveillance, take preventative action, and implement efficient emergency response methods.

Figure 10 Landslide at Genting Highland Road

Major landslides occurred in Mount Jerai, Malaysia, in March 2020 (Figure 11), causing inconveniences and raising worries among officials and local populations. It's thought that the soil extraction operation at Gunung Jerai's base in Kedah was done without a license or approval. These actions have the potential to erode the ground's inherent stability, which might result in landslides and slope collapses. According to Cruden et al. (1996), soil excavation reduces the slope's stability by removing its natural support. There was no rain and pleasant weather at the time of the landslide disaster. The majority of the time, excavation-related landslides happen when human activity like mining, building, or excavating undermines the stability of a slope (Zhen et al., 2024).

Strict adherence to legal requirements, public awareness initiatives, and community participation in the identification and reporting of questionable operations are all necessary to stop illicit excavation. In order to stop and prohibit such actions, government authorities, law enforcement, and environmental organizations are essential.

Figure 11 Mount Jerai landslide

A landslide behind a two-story terrace house in Taman Kelab Ukay, Bukit Antarabangsa near Ampang, on May 29th, forced 40 residents of seven houses in the neighborhood to evacuate (Figure 12). It was thought that the landslide happened as a result of the area's soil shifting after persistent rain (Bryson et al., 2022). In addition to causing property damage, the landslide in Taman Kelab Ukay put the locals in danger. The significance of appropriate urban design, sufficient drainage systems, and slope stability monitoring in hilly and mountainous areas is emphasized in order to lessen the effects of natural disasters such as landslides.

Figure 12 Landslide in Taman Kelab Ukay, Bukit Antarabangsa.

Two guests at the Banjaran Hotsprings Retreat in Ipoh, Perak, have perished in a landslide that is thought to have been caused by intense rain. Since Monday, the steep region has had a lot of rain, which has loosened the ground in the resort's location. Surrounding this region are hillsides and excess dirt. A landslide may result from soft soil (Nadirah, 2021). A landslide happened at the Banjaran Hotsprings Retreat in Ipoh, Perak, Malaysia, in January 2021 (Figure 13). The resort and the surrounding surroundings sustained substantial damage as a result of this tragedy. The resort is situated in steep terrain, and the severe rains that followed caused the soil to become saturated and the slopes to become unstable, resulting in a landslide. According to Khalil et al. (2011), prolonged and heavy rainfall might cause the soil to become more saturated with water, which will decrease its stability and lead to slope collapses. The resort is located in a mountainous terrain, and during periods of heavy rain, steep slopes become more susceptible to landslides. The likelihood of landslides can be affected by soil composition and geological circumstances. The property and infrastructure destruction caused by the landslide at Banjaran Hotsprings Retreat underscores the susceptibility of mountainous areas to similar natural calamities. To reduce the hazards connected with landslides in comparable locations, it emphasizes the significance of efficient disaster preparedness and mitigation tactics, such as appropriate land use planning, slope stabilization techniques, and early warning systems.

Figure 13 Rescuers digging through the mud, found the pair within five minutes of each other at Banjaran Hotsprings Retreat in Ipoh, Perak.

In humid tropical climates, a hillside region with a high population density is frequently vulnerable to several forms of mass migration (Lari et al., 2014). The Jalan Raub-Bukit Fraser road in Malaysia was blocked in December 2020 as a result of many landslides and rockslides (Figure 14). Heavy rains caused the soil to get saturated and the hills around the road to become unstable, which resulted in large pieces of rock and debris falling onto the road, which is what triggered this closure. The previous three days have seen a lot of rain, which is what caused the rockslide. Rockfall is a common geological occurrence that mostly occurs in mountainous regions or along man-made slopes, where it can endanger people's lives, property, infrastructure, and vehicles (Roslee et al., 2018). Thus, especially mountainous regions, precise rockfall prediction is essential for both hazard assessment and mitigation design.

Figure 14 Rockslides at Jalan Raub-Bukit Fraser

5.0 LANDSLIDE EVENT FROM 2021 – 2023

In January 2021, a landslide happened at km 63 and km 73 in Pekan as a result of heavy rain that fell steadily for many hours. Although no injuries were recorded, the road construction contractor was doing immediate repairs while the road was still undergoing the latter stages of an upgrade project for the federal route from Gambang. On January 2021, a heavy downpour had caused landslides at 39 locations in Mambong including at Kampung Gerung, Jalan Puncak Borneo and Padawan, Sarawak. The landslide had crashed 37 houses, leaving more than a metre high of earth and rubble. Mambong is generally a hilly area and long heavy downpour will cause landslides. This landslides also affected houses at Kampung Sadir, Kampung Perang and Kampung Karu, while the affected roads included the ones heading to Kampung Sadir, to Kampung Kiding and to Kampung Sapit in upper Padawan. Landslides and floodwaters in southern Sarawak caused supply interruptions in several areas including Kuching, Bau, Padawan and Siburan with restoration hampered by heavy rain. In Padawan, a landslide caused a tree to fall on powerlines affecting supply to several villages along Padawan road.

A landslide had occurred on December 2021 at KM 27.10 Jalan Simpang Pulai – Blue Valley around 1.30 pm due to erosion that killed two people. Two weeks before the incident happens, the location had recorded a high amount of downpour (217 millilitres) thus leads the ground to soften and weaken causing the landslide. The debris from the landslide covered about a 100 m stretch blocking the road from both the sides. Because of the high volume of soil, the authorities took one week to clear the road and monitored the stability of the hill slope to find a long-term solution. Parts of the slope are found to be unstable thus further study need to be done to the slope.

A landslide incident at Taman Bukit Permai 2, which happened at 6 pm on March 2022 had killed four lives and one victim suffered light injuries. The landslide also damaged 15 houses and 10 vehicles. This was an embankment that was built in the 1980s where the drainage system was not properly built resulting in water stagnating. Continuous rain before the incident caused water to stagnate in large quantities and eventually caused the landslide. A total of six small landslides occurred in the area with the last incident recorded last December in the same year. Stability work include the constructing of horizontal and vertical drains and stabilisation works has been carried out on the left and right sides of the slope for the remedial measures.

On 16 December 2022 a landslide has been reported at a private campsite named Father’s Organic Farm near Batang Kali, Selangor (Figure 15). 31 people were killed and 61 were rescued, while 8 people requiring hospitalisation. The last body belonging to an 11-year-old boy was found on 24 Dec 2022. (Hashom et al., 2023). According to surveys and calculations by the Mineral and Geoscience Department (JMG), these affected areas involved a slope failure of 450,000 cubic metres of soil, across an area of 500 metres and 200 metres, with a depth of 8 metres. Experts believe saturated soil is one of the main causes of the landslide. Continuous rain for the past few days also caused the soil structure to weaken, thus making the slope in the area to become unstable.

Figure 15 Severe damage at Father’s Organic Farm, Batang Kali

On April 2023, a landslide was reported and affected 76 administrative employees of the Malaysian Anti-Corruption Academy (MACA) and Malaysian Institute of Integrity (IIM) at Persiaran Tuanku Syed Sirajuddin, Kuala Lumpur (Figure 16). The landslide occurred in front of the MACA entrance and resulted the collapsed of a command post. The area affected by the landslide is estimated around 100 x 120 sq ft. The landslide was caused by a leakage in the underground pipe and the accumulation of water after recent heavy rainfall. It was reported that the MACA building structure is 40 years old and so are the piping systems. Thus, it may have worn out over the years, causing the underground water leakage and lead to the subsequent landslide.

Figure 16 Landslide in front of MACA building, Kuala Lumpur

On May 3, 2023, a landslide at Wisma YPR in Taman Seputeh resulted in the fall of a retaining wall that was six meters high (Figure 17). Under the debris, a security guard was found buried alive. Behind Wisma YPR, a rock embankment had collapsed, allowing the earth to fall and levelling a guardhouse nearby. The area that was buried by the landslide was at least 6 by 12 meters. Although the main building's structural integrity was unaffected by the landslide, the impacted area has been roped off as a safety measure until restoration work is finished. It was thought that the occurrence was caused in part by the torrential rain that fell over most of the Klang Valley the previous evening.

Figure 17 Landslide T Wisma YPR, Taman Seputeh

A landslide was reported by the STAR news on June 2023 at Section 45 of Jalan Simpang Pulai-Blue Valley, Ipoh due to heavy rainfall (Figure 18). The incident occurred near the rock shed. The location of the incident is a slope repair site that is being carried out by the Jabatan Kerja Raya (JKR) contractor. The high amount of surface runoff caused soil to fall onto the road. The landslide had caused the road to be blocked.

Figure 18 Landslide at Jalan Simpang Pulai Valley, Ipoh

7.0 CONCLUSIONS

As a conclusion, the triggering factor of the above slope failure event in Malaysia is due to antecedent rainfall and human activities. Antecedent rainfall will increase the pore-water pressure of the saturated soil which reduced the soil shear strength and weakened the bonding between soil particles, thus led to the slope failure. Whiles, human activities disturbed the stability of the slope. As housing development and human activities growing, failures from landslides as well as other effects of soil failures will increase significantly. Landslides are dangerous disasters that cause a lot of damage in every aspect including human lives. Therefore, in the future, it is recommended to conduct more landslide susceptibility studies in Malaysia and provide more details about landslides to assess the risk, policy and framework for all future development. Susceptibility studies should be conducted to reduce the risk of landslides for proper planning and decision making. Slope maintenance and monitoring should also be conducted from time to time to monitor any unusual movements on the slopes. Lastly, awareness programs among related agencies should be conducted to highlight the risk of landslides tragedy so that proper planning can be taken to reduce the risk of landslides.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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