An Overview of Socioeconomic Impacts of Landslides

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Abstract:

Landslide is a devastating geohazard that presents a major threat to human life and economy. Landslide have claimed tens of thousands of lives in the new millennium and an estimated economic loss of $20 billion annually. This paper aims to discuss the cost of life caused by historical landslide events. In addition, economic losses and their quantification around the world will also be discussed. In addition, the paper will also analyse deeply the landslides in Malaysia and also presents a case study of one landslide in Malaysia. While data shows that losses are incurred everywhere throughout the world, the impact is much greater in the developing world. This is true especially in countries with tropical climate such as Nepal, India and China which are acutely affected by landslides due to extreme precipitation as a consequence of climate change. Unless landslide risks are reduced, the losses will continue to increase. International collaboration in landslide risk management is highly recommended to minimize losses in the developing countries.

Keywords: Landslide, Landslide socioeconomic impacts, Landslide risk management, Rainfall-induced landslide.

Introduction (Word count: 1996)

On the basis of worldwide data, landslide incur losses of around $20 billion per annum with cumulative death toll exceeding 110,000 from the beginning of the 20th century till present [1]–[5]. Considering the severity of landslide, and abundant individual case studies reported from different parts of the world, there is a need to study the distribution of landslide problems globally. Numerous literatures are reviewed with their data extracted, then tabulated and digitized into graphs to review the socioeconomic impacts in terms of casualties and economic losses.

Fatalities due to landslides

It is clear from Figure 1 that landslides hotspots mainly cluttered around developing countries with very low value of life especially across South-east China, Nepal, Phillipines and India while developed nations such as Italy and Norway have a very high value of life close to that of the USA. Tropical countries are highly susceptible to landslides disasters due to the destabilizing effect of groundwater in soil or rock slopes subjected to exceptional precipitation [6]. As mentioned by [2], [7], rainfall is the main triggering factor of landslides. A documented study by [8] states that, a total of 4862 landslide events (75% from Asia continent) occurred within year 2004 to 2016 excluding seismically triggered landslides with deaths amounted to 55,997 lives loss.

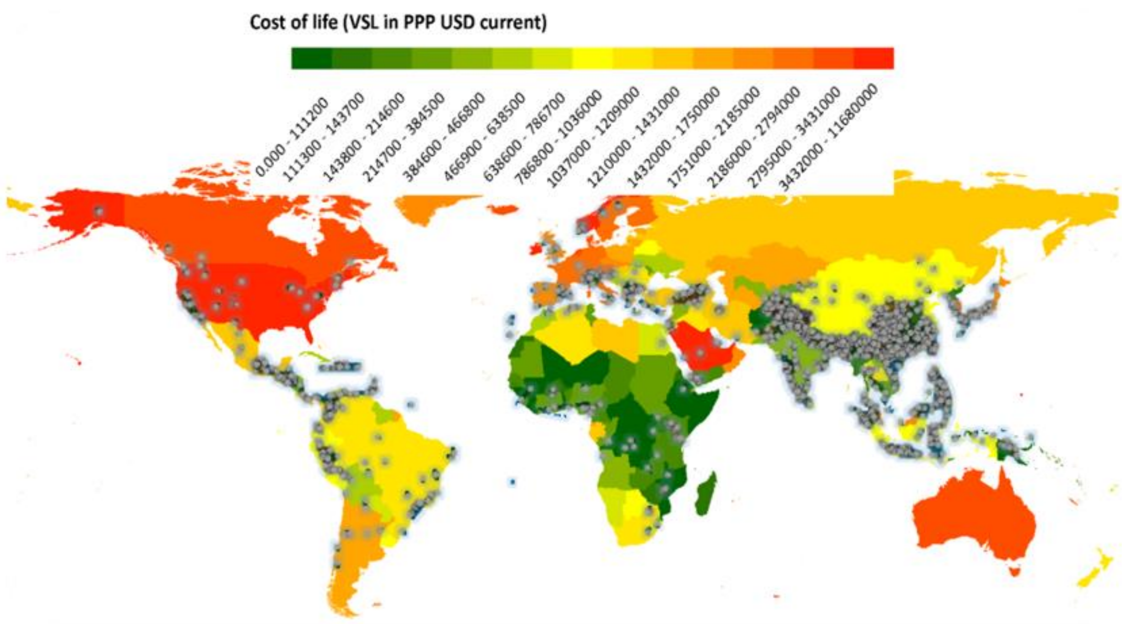

Figure 1 Global distribution of fatal landslides [9], [10] *and the value of human life by* [11]

Economic impacts of landslides

Table 1 summarizes the annual direct costs and total costs due to landslide disasters. Generally, indirect costs are not available [12], however the values of those found in studies and reports are included in the total costs. Among the developed countries, the greatest economic loss are seen in Japan and Italy. The economic costs in these mountainous regions are highly attributed to their high property values. Majority of landslides in Nepal, New Zealand and Canada occured in rural areas. Hence damage costs are comparably lower. Landslide costs in the Scandinavian regions are trivial compared to mountainous topography in the rest of European continent; the cummulative landslide costs in Italy alone is similar that of the United States. Similar scenarios are seen in [14][15].

Table 1 Estimated average annual cost of landslide of different countries

Country	**Average Annual Direct Costs (billion USD)**	**Total annual loss (billion USD)**	**Loss as percentage of GDP**	**Loss Per Capita (USD)**
United States	-	2.1-4.3	0.01-0.03	7-14
Canada	-	0.07 to 1.4	-	-
Japan	1.5	>3.0	>0.06	23
Korea	0.06	-	-	-
Italy	-	2.6 - 5	0.19	68
Spain	0.2	-	-	-
Georgia	-	0.0076-0.11	-	-
Belgium	0.00085	0.00448	-	-
Germany	-	0.3	0.01	3.7
Norway	-	~0.009	-	1.03
Sweden	-	0.015- 0.03	-	-
New Zealand	0.0196	0.053	-	-

South Africa	-	0.015	-	0.42
Brazil	0.045	0.35 – 1.25	-	-
Colombia	-	1.0		
Caribbean	-	0.022	-	1.13
Himalayas	-	1.4	-	34.7
Nepal	1.3	-	-	-
India	>1.3	2	0.11	1.7
China	0.5	>1.0	0.01	0.7
World		**~ 20**	**-**	**-**

Source: Estimates for Brazil [16], *Belgium* [17], *Germany* [4], *Canada* [15], [18], [19] *and the rest* [4], [14]–[16]. *It is difficult to compare economic losses due differences in recording criteria among nations. Nonetheless, it provides a comprehensive comparative view of the significance of landslide damage in various parts of the globe.*

Case study – Malaysia

Figure 2 shows the trend of landslide event, number of death, and cumulative number of death in Malaysia. The trend of the cumulative deaths curve takes on a 'stepped' shape, with pertinent differences in the ordinate values, in correspondence to the most intensive events in terms of recorded fatalities. The gradient of the curve was almost flat from 1961 to the beginning of the 1990s. A steeper gradient of the cumulative death coupled with frequent landslide occurrences started from the 1990s. This could be attributed to active developments on hilly terrains following rapid development in the 1980s [20]. From the late 1990s to the 2020s, the frequency of landslide event was high but not as fatal as those occurred in the early-mid 1990s. Landslide occurrence was inevitable under increasing pressures of hillside development. However, with proper landslide control measures and risk management plan enforced by the Public Works Department (JKR), Department of Mineral and Geoscience Malaysia (JMG), and local authorities, the number of fatalities per event and the probability of a massive landslide were successfully minimized.

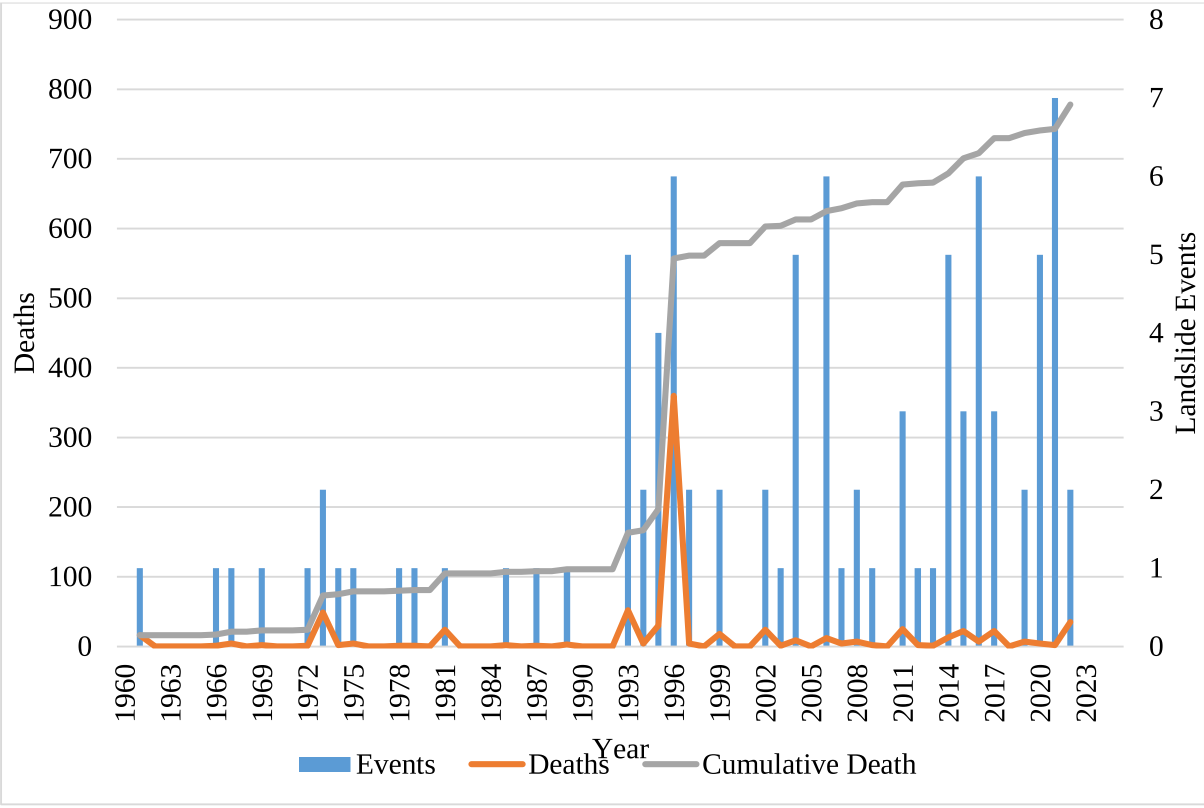

Figure 2 Fatal landslides and death trends of Malaysia. Data extracted from [21] *and newspaper sources*

Figure 3 presents the family of *F-N* curves for landslides compiled from various countries. A steeper slope signifies a higher risk aversion or in other words, a lower probability of occurrence, F for a specific number of fatality, N or lower risk.

The overall F-N curve of Malaysia was close to those of Italy, Hong Kong, Portugal, and Canada. In particular, the frequency of landslide causing 1 death for Malaysia was almost identical to Hong Kong's (slightly above F = 1). Colombia, being a tropical country that receives intense rainfall like Malaysia, shared a similar gradient and pattern of F-N curve as Malaysia albeit at higher frequencies.

From independence till present, there have been a number of major landslides in Malaysia with cumulative deaths exceeding 350 [21] and economic losses exceeding USD 1 billion [22], [23]. Malaysia's yearly rainfall could reach as much as 4500 mm, coupled with year-long high temperatures results in chemical weathering and formation of thick residual soil profiles as deep as 100 m at some locations [22]. The question to ponder is that, is extreme precipitation the only one to blame? One of the Malaysian sectoral reports stated that majority of the landslides emerges on manmade slopes [24] and statistics of landslide cases reported shows the domination of design flaws [25].

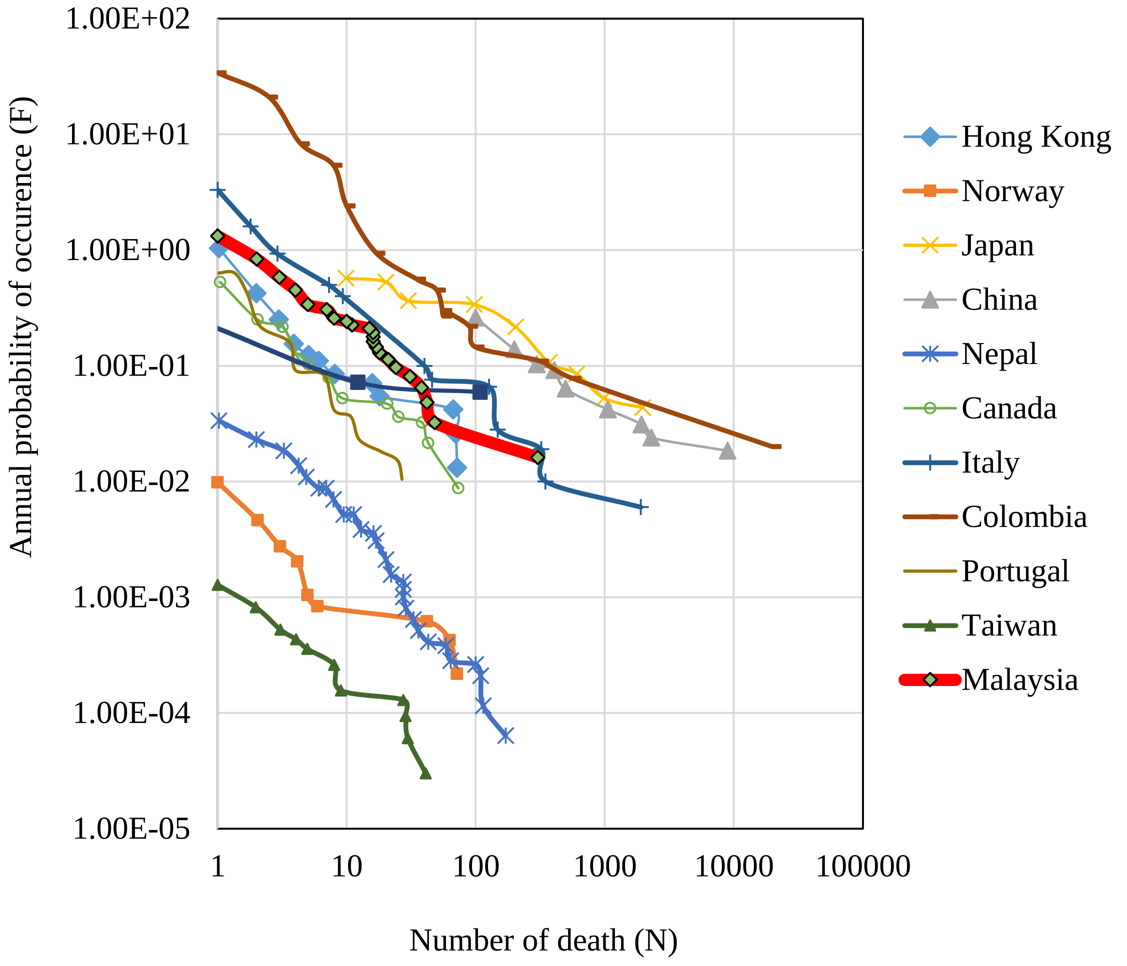

Figure 3 Global comparison of frequency (F) vs. number of deaths (N) curves [26]–[28]

Case study – Malaysia - Highland Tower collapse 1993

The Ulu Klang area has suffered major landslides since December 1993, when Block 1 of Highland Towers collapsed claiming 48 lives and economic loss of millions of Ringgits. The Highland Towers comprises three 12-storey blocks, constructed between 1975 and 1979 at the bottom of a very steep slope which was later terraced thoroughly in the beginning of 1980s. The total length of landslide was 120 m and width of rupture surface was about 90 m involving a total debris volume of about 40,000 m3. Today abandoned remains of Block 2 and Block 3 were restricted from public access, and the site have fallen from vandalism and became a haven for criminal activities. The many factors that brought about this catastrophe are extracted from various reports [22], [24], [29] and they are as follows:

- Unsuitable **construction** of building on the **edge of hill**
- **Building apartment on hillside** is against **Land Conservation Act 1960**
    - Act **prohibits development on hillsides** with **slope exceeding 18 degrees**
- Report by Ampang Jaya Town Council in 1994 **- inadequate drainage**, **design deficiencies (safety factor less than 1.0)**

- In 1991, a **new housing development project**, known as Bukit Antarabangsa Development Project, commenced construction on the hilltop behind Highland Towers. The **hill was cleared of trees and other landcovering plants**, **exposing the soil to land erosion** that lead to the catastrophe

Figure 4 Remains of Block 2 and 3 of Highland Towers [24]

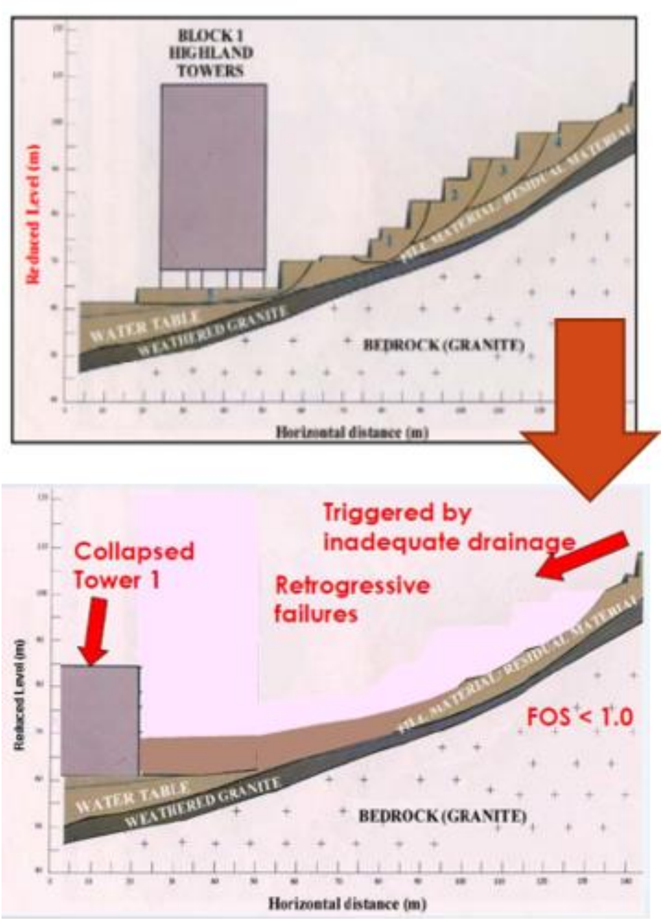

Figure 5 Schematic diagram of the collapse of Block 1 of Highland Towers [30]

Impacts – Lawsuit

On 15 October 1994, six residents filed a lawsuit against the developers of Highland Tower and other related parties, including AmBank and Ampang Jaya Municipal Council (MPAJ), for alleged negligence. The lawsuit pursued more than RM1.5million (USD 337 thousand) for property losses, damage, rental fees, and funeral expenses. The landowner, AmBank decides to compensate the 139 residents of the Highland Towers with a total sum of RM52 million (USD 11.7 million). Summary of the defendants were extracted from [31] and they are as follows:

A. The **Developer** and registered land owner
B. The **Architect**
C. The **Engineer**
D. The **Local authority** which had jurisdiction over the site and its surrounding
E. **Registered owner of bungalow** land **behind Highland Towers**
F. **Company that** carried out **clearing works** on for the land of defendant E (**behind highland towers**)
G. Registered **owner of land** located above the land **of defendant E**
H. **Provider of managemen**t services to **defendant G to** develop their land
I. **State Government** of Selangor
J. **Director of Lands and Mines** of the State of Selangor

In the end of the court case, defendants F, I and J were acquitted. The others were all found liable.

Actions taken after tragedy – New guidelines

New guidelines were implemented after the catastrophe. In addition, Environmental Impact Assessment (EIA) will be required for any development project in slopes prior to decision making [32], [33]. For example, one such guideline being prohibition of housing development on class 4 slopes i.e. gradient of above 35 degrees by authorities such as IKRAM. Interviews were conducted with landslide experts from various sectors including government, non-governmental organizations, practitioners, professional institutions, and academics to obtain more information.

The general consensus from the expert interviews is that risk management of landslides is being slowly implemented in Malaysia. However, it is still below par or in other words, ‘fragmented’, as risk is being managed in certain parts of the country by agencies such as MPAJ, DBKL, Penang Island City Council (MPPP) while in other parts it is not being well managed. Certain areas, such as Ulu Klang were given great attention as they are landslide hotspots. Owing to climate change, landslides hazards are rising in Malaysia. However, risk of deaths and slope failures for new developments is diminishing due to the implementation of stringent guidelines, i.e. appointment of auditors and checkers. Landslide hazards for existing slopes and old developments from the 1980s and 1990s still remain high due to the lack of control guidelines during that time.

An ongoing study by JMG to develop hazard and risk maps started in 2010, entitled Peta Bahaya Risiko Cerun (PBRC). In addition, the national slope master plan was carried out by the JKR between 2007 and 2009 but unfortunately the main focus was towards highways. JMG have improved the maps and handover to local authorities but alas, the PBRC only captures large scale landslide hazards. As a consequence, a landslide occurred in Bukit Permai which resulted in 5 fatalities caused a shock within JMG, as that affected region was not recorded in the hazards maps itself. The current measures could have been better implemented, as they were not prevention-based measures but more to event-based measures which are akin to “putting out the fire” instead of “avoiding the fire”. More attention should be given to monitoring and responding to slope issues preventatively.

Conclusion

From all the data gathered it can be concluded that landslides pose a much grander risk to life in the developing world as they are not able to devote the essential resources to protect their population from landslides to the same extent as developed nations which in a way reflects on the people's value of life. Nations with weaker socioeconomic standing (GNI and GDP) consistently had more dreadful landslides fatalities.

Due to climate change, increase in population density and vulnerability, the frequency of landslide occurrence rises. As stated by [7] landslides are indeed catastrophies resulting from social vulnerability. It is both an economic and social obligation to strengthen resilience and to lower the consequences of landslides. This precariousness calls for increased in focus and measures to deliver preventive measures such as systematic landslide risk management. As a way forward, cooperation and support from agencies of developed countries such as the United States Agency for International Development (USAID), the UK's Department for International Development (DFID), the Australian Agency for International Development (AusAID), the Canadian International Development Agency (CIDA), and the Japan International Cooperation Agency (JICA) will be highly desirable in providing their technical and financial aids to mitigate landslide hazards in the least developed countries.

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