ESTABLISHMENT OF A RELATIONSHIP BETWEEN LANDSLIDE SUSCEPTIBILITY ZONATION AND THRESHOLD RAINFALL INTENSITIES

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Landslides induced by heavy rainfall pose a common geotechnical hazard in Sri Lanka. Sloping grounds in Sri Lanka are made of rocks at different levels of weathering, residual and colluvial soils. The parent rock's mineralogical composition influences the heterogeneous nature of these weathering profiles. Slopes in the region have deep groundwater tables and unsaturated soil profiles with high matric suction during dry periods. However, prolonged rainfall leads to slope instability due to the loss of matric suction and the potential formation of a perched water table or the rise of the groundwater table.

National Building Research Organisation (NBRO) has developed the landslide hazard zonation maps of Sri Lanka at 1:50000 and 1:10000 for districts where landslide risk is high based on the overall hazard rating (score) determined by terrain factors. The terrain factors are bedrock geology and geological structures, type and natural soil cover and thickness, slope range and category, hydrology and drainage, land use and management and landform. In landslide hazard zonation maps, sloping grounds are divided into regions of different hazard levels: Safe slope, landslide not likely to occur, a modest level of landslide hazard and landslides are to be expected.

To supplement that zonation, it is essential to identify the threshold rainfall intensities causing a disastrous situation in zones of different landslide susceptibility. Currently, the threshold rainfall values are determined by previous experience.

Researchers have developed different empirical statistical relationships to identify threshold intensities that vary with local landslide factors and site-specific. Given the significant material variations in Sri Lankan slopes, relying solely on statistical approaches is inappropriate. Landslide susceptibility level-specific thresholds based on numerical studies would be necessary to make reliable decisions regarding early warning and remedial measures. In this research, landslides where the triggering rainfall data is available are back analysed to establish a relationship between landslide susceptibility zonation and threshold rainfall intensities.

The SEEP/W 2018 software was used to model rainwater infiltration and the consequent changes in the pore water pressure. The results of the above seepage analysis were then transferred to SLOPE/W software to analyse the slope stability. Initially, recent landslides (Pinnawala landslide and Kithulgala landslide) where rainfall records are available was back analysed and threshold rainfall values for these two slopes was established. The level of hazard of these two landslide areas was identified using the landslide hazard zonation maps of Sri Lanka that developed by National Building Research Organisation (NBRO). A relationship between landslide susceptibility zonation and threshold rainfall intensities can be established by doing this analysis on several landslides that rainfall data was available.

Keywords: Landslides; Rainfall Threshold; Groundwater Table; Unsaturated; Matric Suction; Infiltration

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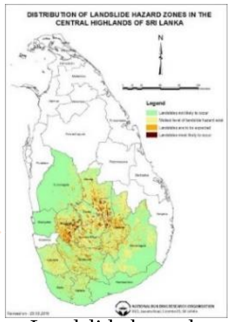
How Rainfall Causes Landslides???

The landslide hazard zonation maps of Sri Lanka at the scale of 1:50000 and 1:10000 for districts where the risk of the landslide was developed by NBRO based on terrain factors.

But, threshold limits currently used in Sri Lanka are empirical based on past experiences.

To issue more reliable early warnings it is important to develop threshold rainfall values on a mechanistic basis.



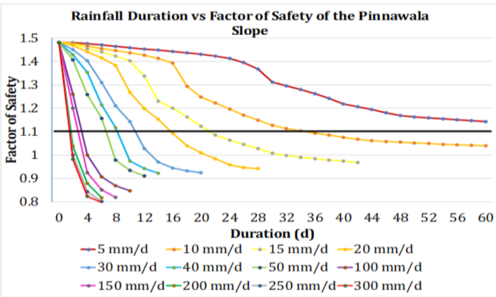
Landslide hazard zonation map (1:50000)

Back Analysis of Landslides Where Rainfall Records Are Available

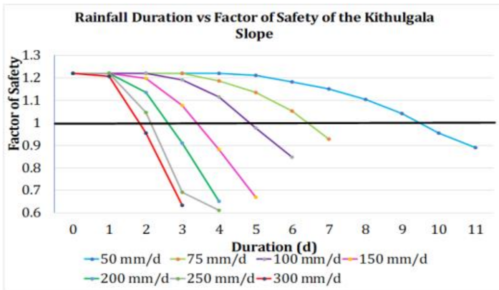
Infiltration of Rainwater → **Reduction of Matric Suction/increase of pwp** → **Loss of Shear Strength** → **Instability**

The Pinnawala and Kithulgala landslides were back analysed and both landslide areas are on a modest level of landslide hazard zonation in the landslide hazard zonation map.

Pinnawala Landslide Analysis

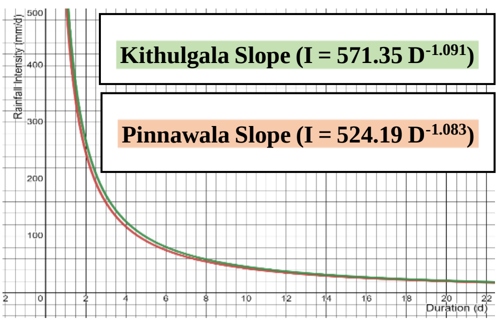


Kithulgala Landslide Analysis



Conclusion and Recommendations

By analysing the data, the rainfall threshold for the **modest level of landslide hazard zonation** is determined to be described by the equation. **I = (524.19 to 571.35) D** $^{(-1.083 \text{ to } -1.093)}$ where **I** represents rainfall in mm per day, and **D** represents the duration in days.



Threshold rainfall intensities for both Pinnawala and Kithulgala Landslides

Suggested appropriate threshold rainfall intensities for different levels of warnings for areas that landslide risk of modest level.

Threshold Rainfall Value	Warning
120 mm	Be on alert on the possibility of landslides.
160 mm	Danger of landslides and cut slope failure exists.
250 mm	Evacuate a safe place.

Similar analysis should be performed on all reported landslides where rainfall records are available. Then the more reliable threshold rainfall intensity values for each hazard level can be determined.