Determination of localized Rain Fall Thresholds for Landslide: A Case Study in Kaluthara District

RMSAK Rathnayake
Landslide Research & Risk Management Division, National Building Research Organisation, Sri Lanka.

ABSTRACT: Rainfall-initiated landslides, slope failures and cutting failures are a common hazard in mountainous terrain covering Badulla, Nuwara Eliya, Hambantota, Kaluthara, Rathnapura, Matale, Kegalle, Galle and Matara districts of Sri Lanka. Even with the enormous efforts taken by the NBRO in the recent past such as landslide hazard zonation, landslide risk assessment prior to new building or project approval, mitigation of identified landslides, awareness and education programs and issuing landslide early warnings using regional scale rainfall threshold, every year, huge human and economic losses are still recorded and damages are on the rise throughout the island. This is as a result of rapid expansion of human activities into more susceptible hill slopes and un defined localize rainfall threshold. This study analyses landslide events ,daily cumulative rainfall and 3 day cumulative rainfall with multivariate analysis the daily rainfall or 3 day cumulative rainfall which cause landslides are Identified and the local scale daily rainfall threshold varies from 60 mm to 85 mm and 3 day cumulative rainfall varies from 155 mm to 180 mm. The obtained results show considerable variations. Therefore the local scale rainfall threshold values fine tune the early warning process. This study develops methodology which can be utilized to identify well organized high accuracy local scale rainfall threshold values of landslide prone areas of Sri Lanka.

1 INTRODUCTION

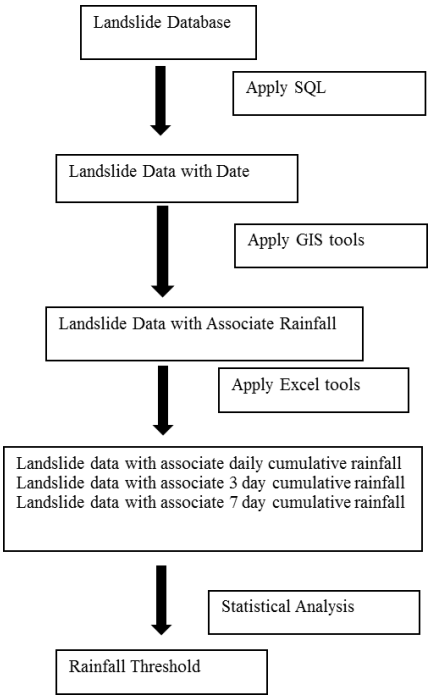
Rainfall triggers landslides, slope and cutting failures. Rainfall thresholds can be defined on physical (process-based, conceptual) or empirical (historical, statistical) basis. Empirical rainfall thresholds are defined by analyzing landslide events with associated rain fall. The thresholds are usually obtained by drawing lower-bound lines to the rainfall situations that resulted landslides plotted in Cartesian, semi-logarithmic, or logarithmic coordinates. Most commonly, the thresholds are drawn visually, i.e., without any rigorous mathematical, statistical, or physical criterion. Where information on rainfall conditions that did not result in slope failures is available, thresholds are defined as the best separators of rainfall conditions that resulted and did not result in slope instability. Empirical rainfall thresholds for the initiation of landslides have been proposed at the global (world-wide), regional, and local scales.

In Sri Lanka, regional rainfall thresholds are defined based on statistical analysis of past landslides and associated rainfall data analysis coupled with past experience.

2 SCOPE OF THE PROJECT

The scope of the project is to develop local scale rainfall threshold models for divisional secretariat divisions with a view to increase the accuracy of predictions. Under this phase, three divisional secretariat divisions in Kaluthara district was selected. The data of past landslide locations, and the associated 24 h cumulative rainfall, three consecutive days and seven consecutive days cumulative rainfall prior to the event were collected.

Due to the lack of recorded historical landslide events and associated rain fall data within the study area, the model was simulated only for a rainfall scenario during the month of May 1984 and from 2003 to 2013.



2.1 *Landslide Data Base*

Landslide data in the study area were obtained from the National Building Research Organisation and the associated rainfall data were obtained from Department of Meteorology. Landslide database was developed to analyze the landslide data with the associated rainfalls.

2.2 *GIS analysis*

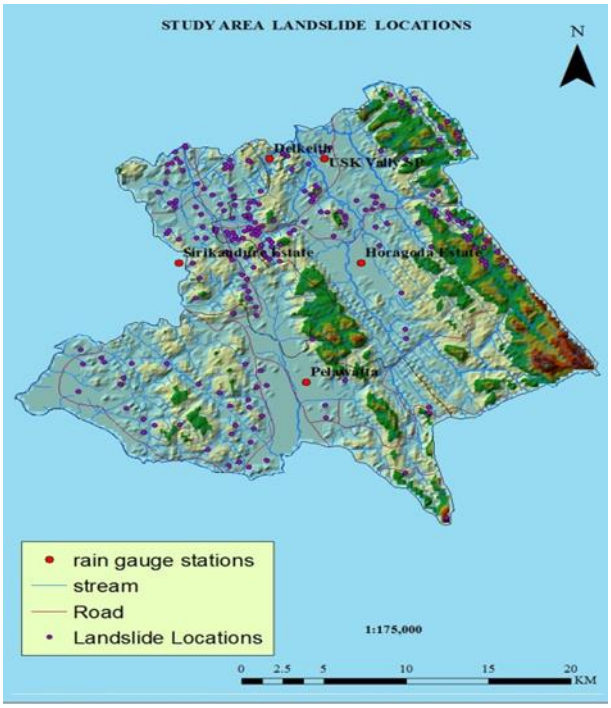


Figure 1: Map of the study area showing locations of rain gauges and landslides

Rain gauge location map and landslide location map were prepared in ArcGIS 10.1 platform. Basin map of the area was overlaid on the above maps. Landslides and the rain gauges within each basin were selected and the associated rainfall was taken from the closest rain gauge within each basin using proximity analysis.

2.3 *Statistical Analysis*

The landslide of study area were analyzed with the associated daily rainfall using Excel 2010 and further calculated 3 day cumulated rainfall and 7 day cumulated rainfall and prepared an Excel sheet with associated rainfall. Scatter plot diagram of 3 day and 7 day cumulative rainfall with days was prepared.

Further to that apply combined analysis was applied using landslide events, daily cumulative rainfall with 3 day cumulative rainfall for each DSD separately.

3 RESULTS AND DISCUSSION

The following results were obtained under the statistical analysis to calculate rainfall threshold values.

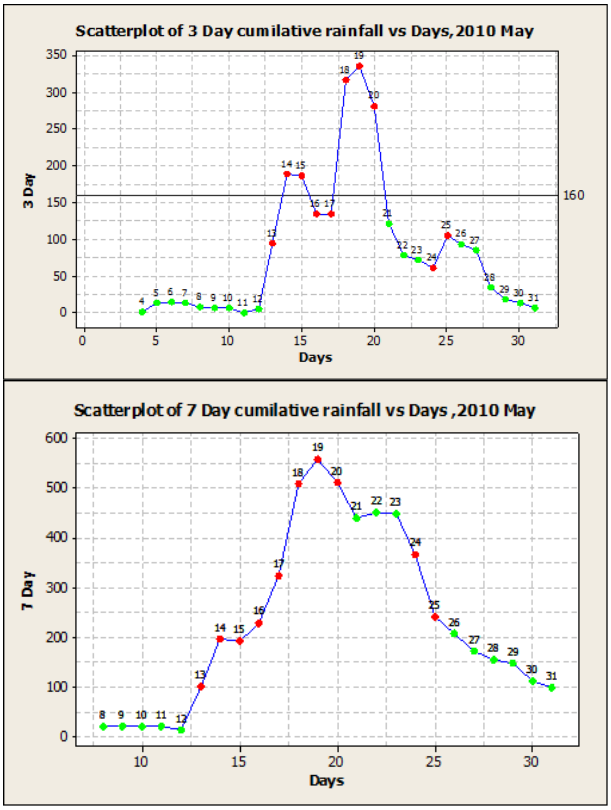


Figure 2: Scatterplot diagrams of 3 day cumulative rainfall vs. date of incident

Above result's shows that which hasn't been separated date's with landslide and date without landslide. This methodology hasn't been obtained rainfall threshold values. Therefore multivariate combined analysis was used to calculate the rainfall threshold values and the following results were obtained for Palindanuwara , Walallawita , Agalawatta district secretariat divisions separately.

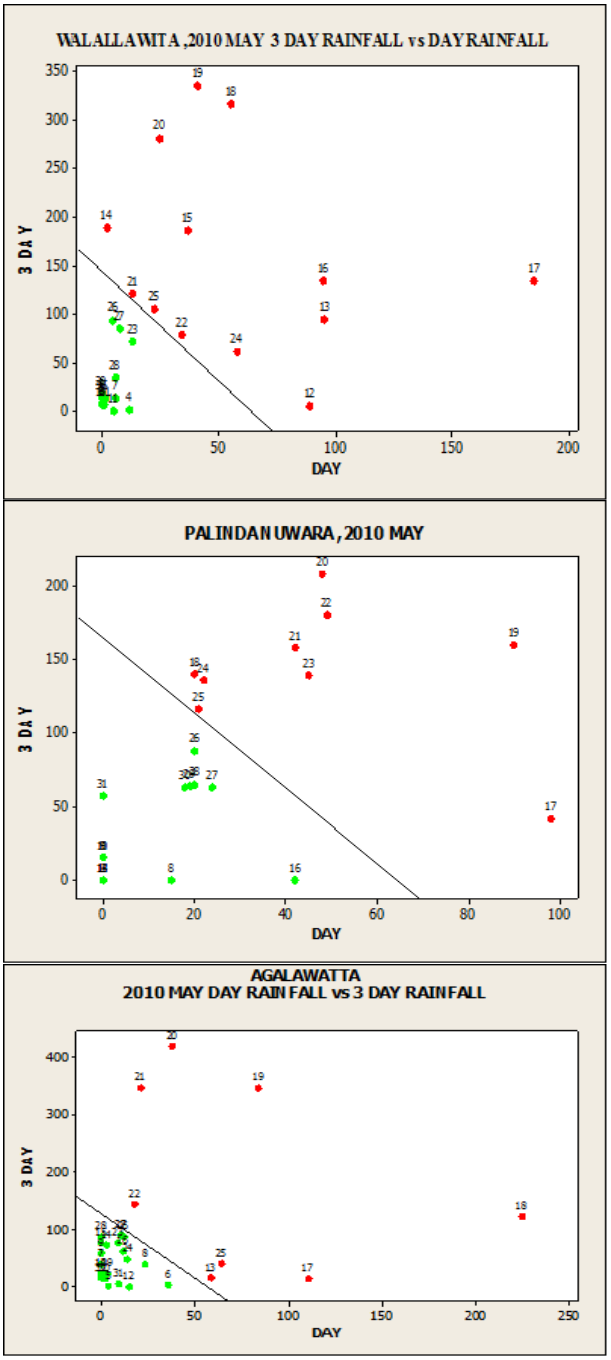


Figure 3 : Scatterplot of Palinda Nuwara, Agalawatta,Walallawita 2010 ,May antecedent rainfall vs Day rainfall with date of failure.

Location	Daily Rainfall (mm)	3 Day Rainfall (mm)
Palindanuwara	65	170
Walallawita	70	155
Agalawatta	60	175

Figure 4 : Summary of identified daily and 3 day cumulative rainfall threshold of Palinda Nuwara, Agalawatta, Walallawita 2010 ,May antecedent rainfall vs Day rainfall with date of failure.

According to the above results this methodology well separated date's with landslides and date without landslide. The rainfall threshold values could be determined using this methodology.

4 CONCLUSIONS AND RECOMMENDATIONS

This study determined rainfall threshold values that varied with other causative factors. Therefore local scale landslide initiates different amount of cumulative rainfalls. However, the statistical analysis shows most failures occurred around 160mm of minimum 3 day cumulative rainfall and around 60 mm of minimum daily rainfall intensity.

Therefore, this method is recommended to apply to determine rainfall threshold value for the landslide susceptible areas in Sri Lanka. However it is an essential task to maintain an up to date landslide and rainfall data base with well organised automated rain gauge network to develop the local scale rain fall threshold values.

5 REFERENCES

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