Effects of climate change on landslide frequencies in landslide prone districts in Sri Lanka; Overview

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Abstract

Recently antecedent rainfalls and short term high intense rainfalls have become a general weather condition in Sri Lanka. Most of the recently occurred landslides could have some possible relationship with this unusual weather condition. Unpredictable variability of climate could probably be due to climate change where many environmental changes are happening around the world due to the climate change or global warming. This paper discusses the effect of climate change on landslide frequency in landslide prone districts in Sri Lanka. Several factors, such as rainfall and temperature variation in the last decade are analyzed to assess their significance. Analysis confirms that these changes have a possible effect on landslide frequency in Sri Lanka. Based on these results, possible trend patterns due to climate change during last decade are identified.

1. Introduction[1]

Landslides related to heavy rainfall cause widespread property damage and occasional loss of lives. During the last ten years it has become evident that the most devastating landslide events tend to occur as a result of comparatively short duration, high intense rainfall compared to the previously had lower intense prolonged rainfalls in Sri Lanka.

Global climate change is possibly impacting the frequency of landslides in the world and will continue to do so in the future [2]. An independent review of more than one and a half billion temperature records from fifteen sources over more than a century clearly shows that the planet is warming [5].

Climatic conditions predicted from worldwide global warming involve new precipitation and wind conditions. These will significantly affect the amount and type of vegetation, groundwater levels and surface water levels. All these factors will affect the stability of certain natural slopes due to losses of soil suction, higher groundwater tables, increase in seepage velocities, frequent

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occurrences of rapid drawdown conditions, losses of soil reinforcement contributed by roots and losses of stabilizing materials through erosion from flooding [2].

Considering the above facts, possible correlations between extreme rainfall conditions, temperature conditions and landslide frequencies were studied in landslide prone districts of Sri Lanka. The information gathered from local administrators and engineering geology consultants, as well as from interviews with inhabitants, could suggest that starting from the second half of the 2001, there has been an increase in landslide activity in many urban and peri-urban areas in Sri Lanka [1].

This research paper explores the variation of extreme rainfall conditions and temperature variations with respect to spatial distribution of landslides in Sri Lanka over the span of last ten years.

2. Methodology

The interrelationship between the rainfall data and the global warming effect was identified using three different methods, such as identification of annual rainfall variation throughout the year, identification of average daily rainfall variation and the studying of the rainfall variation of the year in the wettest and driest months. The other factor studied was the temperature variation in selected landslide prone district considering annual average maximum temperature variation and annual average minimum temperature variation. Overall objective has been identified using three different objectives such as identification of the effect of global warming on the rainfall, identification of the effect of global warming on the temperature and the identification of effect of global warming on landslide frequencies. The following information was collected from Department of Meteorology Sri Lanka and National Building Research Organization Sri Lanka (NBRO).

1. Monthly rainfall data
2. Maximum temperature data
3. Minimum temperature data
4. Landslide data

Known landslide events considered in this paper were analyzed with respect to the associated rainfall and temperature data.

3. Results and Discussion

Overall, the amount of landslide events per year has been increased over the period of 34 years. Moreover, it is clear that there was a sudden increase in the occurrence of landslides during the period from 2002 to 2008. Landslides were previously considered as a minor type of disaster and not a common occurrence in Sri Lanka. Until the year 2002, the annual average number of landslide records did not exceed 50 [3]. Figure 1 shows the time series distribution of landslides in Sri Lanka during last 34 year period.

Figure 1 clearly concluded that the trend pattern has a 3.651 annual increment in the landslide frequency in Sri Lanka during the period from 1974 to 2008.

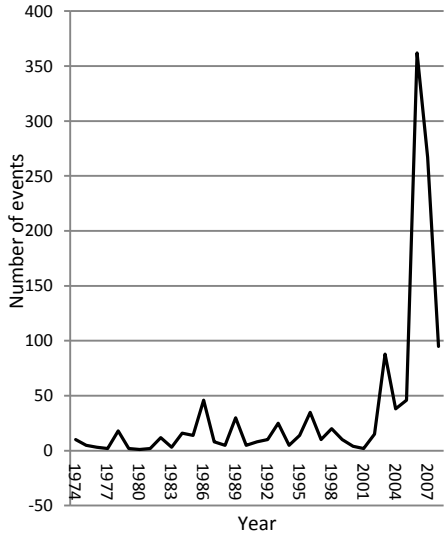

Figure 1: Annual total time series distribution of landslides in Sri Lanka during last decade [3]

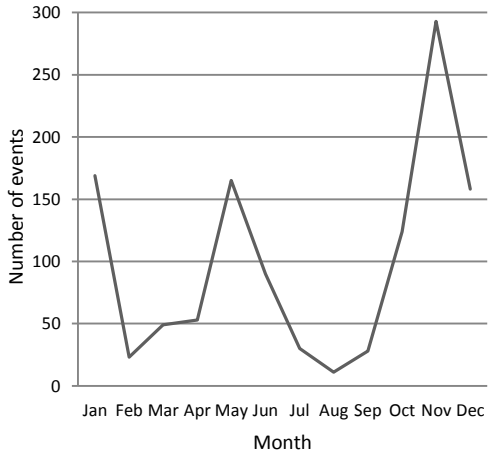

Figure 2: Seasonal Distributions of Landslides in Sri Lanka from 1974 to 2008[3]

Mainly six trend patterns were developed to get the effect of global warming in selected landslide prone area in Sri Lanka. Annual rainfall variations in selected landslide prone districts in Sri Lanka are shown in Table 1. Annual rainfall data was calculated by using monthly rainfall data which was collected from the department of Meteorology Sri Lanka.

Identification of the trend pattern of the annual rainfall was done considering last 10 years period.

Table 1: Observed changes in annual rainfall in landslide prone district in Sri Lanka during last decade

District	Observed trend pattern
Rathnapura	Increase of 26.02 mm per year
Kandy	Increase of 49.35 mm per year
Nuwara Eliya	Increase of 29.54 mm per year
Galle	Increase of 105.7 mm per year
Badulla	Increase of 40.22 mm per year

Since the annual average rainfall trend patterns clearly show increments, the effect of the wettest month rainfall patterns and the driest month rainfall patterns were also studied to find out further conclusions.

Table 2 clearly shows the trend patterns of the wettest month rainfall in selected landslide prone districts in Sri Lanka Where the trend patterns show an increments of the monthly rainfall in Ratnapura, Nuwara Eliya, Kandy and Galle where Badulla district shows some deviation from the other selected districts.

The trend patterns also clarified that the wettest month in each districts have experienced more rain during the past 10 years and it will be continuing.

Table 2: Observed changes in wettest month monthly rainfall in landslide prone district in Sri Lanka during last decade.

District	Observed trend pattern
Rathnapura	Increase of 2.131 mm per month
Kandy	Increase of 22.17 mm per month
Nuwara Eliya	Increase of 4.946 mm per month
Galle	Increase of 37.4 mm per month
Badulla	Decrease of 5.746 mm per month

Then the concentration was given to the driest month rainfall variation where the trend patterns show decrements of the monthly rainfalls, except Badulla district.

Table 3: Observed changes in driest month monthly rainfall in landslide prone district in Sri Lanka during last decade.

District	Observed trend pattern
Rathnapura	Decrease of 9.323 mm per month
Kandy	Decrease of 7.432 mm per month
Nuwara Eliya	Decrease of 7.907 mm per month
Galle	Decrease of 2.241 mm per month
Badulla	Increase of 0.846 mm per month

Temperature changes can affect the landslide in several ways. Firstly, changes in temperature can cause changes in vegetation cover, for example previously healthy vegetation can die. Secondly, temperature also affects groundwater. Due to that the groundwater body would experience thermal expansion. This thermal expansion could lead to a rise in groundwater level. Therefore, a significant temperature rise will reduce the stability of natural slopes and can cause devastating landslides. Thirdly increasing the temperature can desiccate the soil. Whereas in some cases the lower moisture content will increase soil strength parameters and beneficial soil suction, it can conversely result in losses of soil cohesion, for example as a result of fissuring of a clay deposit. These fissures or cracks also accelerate infiltration into the slope with the associated loss of FOS. This will also accelerate the occurrence of the landslides in natural slopes [4].

Since the temperature variation acts an important role on landslide frequency, the concentration was given to identify the possible trend of temperature variation in landslide prone districts in Sri Lanka, considering the three different variations, such as annual maximum temperature, annual minimum temperature and the annual mean temperature.

Table 3: Observed changes in annual maximum temperature in landslide prone districts in Sri Lanka during last decade.

District	Observed trend pattern
Rathnapura	Increase of 0.064 ^{0}C per year
Kandy	Decrease of 0.021 ^{0}C per year
Nuwara Eliya	Decrease of 0.03 ^{0}C per year
Galle	Decrease of 0.074 ^{0}C per year
Badulla	Decrease of 0.156 ^{0}C per year

Table 4: Observed changes in annual minimum temperature in landslide prone districts in Sri Lanka during last decade.

District	Observed trend pattern
Rathnapura	Decrease of 0.001 ^{0}C per year
Kandy	Increase of 0.041 ^{0}C per year
Nuwara Eliya	Decrease of 0.04 ^{0}C per year
Galle	Decrease of 0.3 ^{0}C per year
Badulla	Decrease of 0.062 ^{0}C per year

Considering the above facts, separate analysis was carried out to study the possible trend in each landslide prone districts during the last decade.

Table 5: Observed changes in annual distribution of landslides in Sri Lanka during last decade.

District	Observed trend pattern
Rathnapura	Increase of 0.666 event per year
Badulla	Increase of 12.82 event per year
Nuwara Eliya	Increase of 24.89 event per year

4.0 Conclusion

At a time when climate change and global warming issues are considered as hot topics, a research on "Effect of Climate change on landslide frequencies" could be treated as a timely research. This study looks at extreme rain conditions in the context of climate change in landslide prone districts in Sri Lanka. During the last ten years it has become clear that the most devastating landslide events tend to occur as a result of comparatively short duration, high intense rainfall compared to the previously had lower intense prolonged rainfalls. Since the both rainfall and the temperature trend pattern have shown a positive trend on the global warming effect, these types of studies could conclude that there is a direct relationship between climate change and the frequency of landslide occurrences in landslide prone districts in Sri Lanka.

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The Journal of Transdisciplinary Environmental Studies, vol. 9, no.1.