IMPACT OF ANTECEDENT RAINFALL ON SHALLOW LANDSLIDES

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INTRODUCTION

Rainfall is one of the major landslide triggering factors worldwide and Slovenia is no exception in this regard. It is well known that diverse morphology and the influence of various weather types reflect in various rainfall occurrences with different rainfall periods. In recent years, intense short and long duration rainfall have triggered numerous shallow landslides and caused considerable economic losses. In this paper we focus on the rainfall threshold defined on an empirical basis. Presented is the analysis of the relationship between shallow landslides and different rainfall patterns at different time scales, and defined the threshold above which a significant number of landslides have occurred. For the purpose of validation of the proposed method, the Škofjeloško Cerkljansko area was selected because of due to its diverse morphology and numerous historical landslide records, which also include the including the dates of landslide occurrences and daily rainfall data from four rain gauge stations.

METHDOLOGY

Using the threshold approach two major thresholds can be defined, the minimum threshold and the maximum threshold, which identify the lower and upper boundaries of the threshold's probability range (White et al. 1996; Glade et al. 2000). The minimum threshold is defined as the rainfall value below which there has been no recorded landslide activity, whereas the maximum threshold is defined as the rainfall value above which landslides have always been activated. The fundamental input data for the threshold model is a time series of daily rainfall R(t), expressed in mm h-1 or mm day-1. The basic assumption is that there is a function of $R_D(t)$ which is related to the a landslide occurrence:

$$R(t) = f[R_D(t),\ \ R_{AD}(t)] \qquad (1)$$

The daily rainfall must exceed a threshold, which is a function of the total rainfall R(t) in a period and of the amount of the antecedent rainfall R_{AD} (t), where t is time, R(t) is the amount of rainfall in a given period (e.g. hourly, daily, monthly or n-day cumulated rainfall) in mm, and R_{AD} (t) is the antecedent rainfall in mm.

RESULTS AND DISSCUSION

For the purpose of determining rainfall thresholds, 6 rainfall events were investigated which were known to have triggered landslides in the period from 1990 to 2007. Within this period, about 450 landslides have been identified. Slightly higher numbers of landslides were documented in the Davča and Železniki zone (Upper Triassic claystone, sandstone and clastic limestone; slope inclination varies between 14°-38°) due to the mechanical properties of the rock mass, which are better in steep slopes and poorer in gentler terrain. Likewise, the formations containing claystone (Poljane zone; slope angle varies between 7°-31°) retained more water than the clastic limestone, which fails rapidly in rainy conditions. Rainfall data were collected from 4 rainfall gauges and cumulative 5-day antecedent rainfall was used to determine R_T in a scatter plot form. The envelope curve is drawn for each day of the year with a rainfall event that triggered shallow landslides. The line presents the linear mathematical equation adapted by Crozier (1999) and Chleborad (2000) in which the horizontal axis

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represents a 5-day cumulative antecedent rainfall while the vertical axis represents a total rainfall in a day (Fig. 1). R_T was calculated for all rainfall events in the years 1990, 1992, 1998, 2000, 2007. A general threshold for the entire period was also determined (Fig. 1). For the area under investigation the minimum threshold to initiate a slope failure is around 150mm of 5-day antecedent rainfall

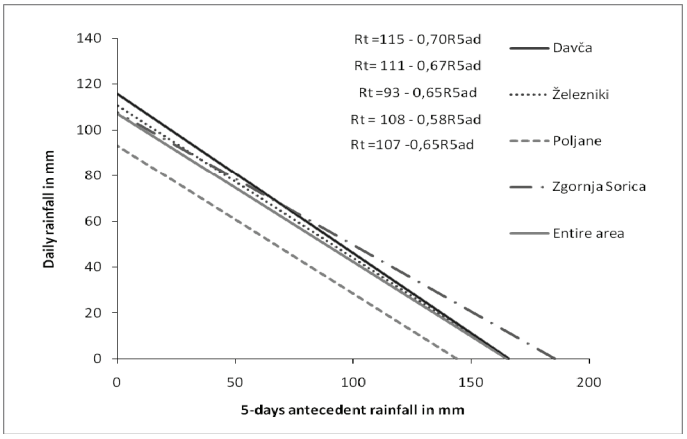

Fig. 1 Envelope curves for landslides around the rain gauge stations. Rt is the rainfall threshold and R_{5ad} the antecedent rainfall.

CONCLUSION

In the research area, landslides were triggered when the rainfall threshold exceeded 5-day antecedent rainfall. Our analyses showed that the required amount of rainfall for triggering landslides ranged from 115 to 160mm. The proposed threshold model can be used for the rainfall induced landslides but can not be compared with other thresholds due to specific rainfall conditions in each region. Therefore, one of the important future tasks for the institutions dealing with prevention against slope failures is to determine the rainfall threshold, characterise significant differences between the observed areas and identify areas with higher or lower susceptibility to landslides. Furthermore, it can serve as an appropriate input for the application of a landslide early warning system.

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