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A method to develop the rainfall-based criteria for debris-flow warning for the area lacking data

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The abundant loose soils, the steep slope, and the large amount of water are three basic conditions for debris-flow occurrence. Among three conditions, the heavy rainfall is usually regarded as most active condition to trigger the debris flow. Therefore, Jan (2004) has proposed a rainfall-based debris-flow warning model based on the rainfall triggering index (RI) which is defined as the product of the rainfall intensity I (mm/hr) and the effective accumulated rainfall Rt (mm). Jan's model has been adopted by Taiwan Government. The RI -values of historical rainfall events were analyzed to set up the rainfall-based warning criteria of the area with many debris-flow occurrence records. However, this method is hard to apply on the area where lack events records and have occurrence potential of debris-flow which can not determine the criteria line of occurrence. Therefore, this study proposes a composite warning index rainfall and geological conditions (RGI) to estimate the rainfall-based criteria of the area where lack debris-flow records. For estimating the physiographical condition, various physiographical factors which had been used to assess the debris-flow potential are collected. After tested by statistic methods, the physiographical factors that are highly related to debris-flow occurrence are selected which are effective watershed area, average gully's slope, collapse rate and rock formation. The first factor concerns the hydrological conditions of watershed. Note that the effective watershed area is defined as the watershed area of gully's slope above 15o. The second factor concerns morphological characteristics of watershed. Average gully's slope represents the average slope declination of the stream. The third factor considers the production of debris materials. Collapse rate is defined as the total collapse area divided into watershed area. The last factor concerns lithological property. Rock formation is referred to the distribution of different rock types. The fuzzy statistic method is used to evaluate the membership functions of these physiographical factors, and then the Analytic Hierarchy Process (A.H.P.) method is used to calculate the weight of these physiographical factors. A physiographical potential index of debris-flow occurrence (GI) is established by a method of linear-addition. In this paper we used 180 debris flow gully in 7 townships to analyze the relationship between rainfall triggering index and GI , and the relation has been estimated. Therefore, if a specified gully or area lacks debris-flow triggered record, but the physiographical condition is known, then one can be estimated the rainfall-based criteria for debris-flow warning by physiographical potential index of debris-flow occurrence (GI). In this study, we also compared the estimated warning criteria with the rainfall-based debris-flow criteria based on the method proposed by Jan (2004), and the results show the deviation is about 7%, which means the method we purposed could apply to estimate the debris-flow warning criteria for the area of lacking debris-flow records.

Keywords: debris flow, rainfall-based criteria, physiographical potential index