Rainfall Conditions Causing Concentrated Deep-seated Landslides: Analysis of Rainfall by Typhoon Talas

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INTRODUCTION

Typhoon Talas in September, 2011 brought about massive rainfall exceeding 1,000 mm and caused many deep-seated landslides in Wakayama Prefecture and the southern part of Nara Prefecture, Southwest Japan. Huge amounts of collapsed materials (soil) not only created natural dams but also inflicted substantial damage to some of the affected areas.

There have not been many studies exploring the relationship between deep-seated landslides and rainfall. This study examined the relationship between the scale of deep-seated landslides and rainfall indices based on actual rainfall data at the time of a disaster, targeting the southern part of Nara Prefecture where a number of deep-seated landslides occurred due to Typhoon Talas. In addition to the one hour rainfall, total rainfall, etc., probable excess rainfall indices are also considered because of the possibility that deep-seated landslides are affected by rainfall events in the past and climate characteristics rather than the level of the affected rainfall itself.

DATA USED FOR THE STUDY

In this study, a deep-seated landslide is defined as a landslide with a slope failure area of 10,000 m^2 or larger among landslides extracted by interpretation of aerial photograph taken around the time of Typhoon Talas. The evaluation unit for the occurrence or non-occurrence of a deep-seated landslide is a 1 km mesh. In the study area, there is a total of 1,575 meshes of which 99, including actual sites of deep-seated landslides, are classified as occurrence meshes and the rest as non-occurrence meshes. Sites of deep-seated landslides are concentrated in the western side of the southern part of Nara Prefecture (Totsukawa Region). From the geological point of view, the western side is similar to the eastern side (Yoshino Region with alternate layers of sandstone and mudstone and other features). In regard to rainfall data, C band radar rainfall data (1 km mesh) released by the Japan Meteorological Agency was used. Six rainfall indices were selected. These were 1, 12, 24, 36 and 48 hour rainfall and total rainfall. The maximum value of each index in a continuous rain period was used for the analysis.

ANALYSIS METHOD AND FINDINGS

The relationship between the occurrence of deep-seated landslides and each rainfall index was analyzed based on a histogram (10 categories) for each rainfall index, in turn prepared by classifying the occurrence method into three patterns of slope failure area, i.e. 10,000 to 50,000 m^2, 50,0001 to 100,000 m^2 and larger than 100,000 m^2. For the correlation yardstick, the slope of the occurrence rate (number of occurrence meshes in one category to the total number of meshes in the same category) was given special attention.

Fig. 2 shows a histogram of the total rainfall as an example. Although the occurrence rate rapidly increases when the total rainfall exceeds 930 mm, the occurrence rate is generally proportional to the number of actual landslides, simply indicating a natural outcome in that the number of deep-seated landslides is high in those categories where the ratio of occurrence meshes is high. As such, there is no confirmation of a clear correlation between any of the rainfall indices and deep-seated landslide occurrences.

Meanwhile, the examination of histograms charting individual probable excess rainfall indices and deep-seated landslides confirmed a correlation between the probable excess of the long-term rainfall index such as 24 hour rainfall or total rainfall and deep-seated landslides. **Fig. 3** shows a histogram of the probable excess total rainfall as an example. **Fig. 1** shows the distribution of the probable excess rainfall and sites of deep-seated landslides. The distribution of the probable excess rainfall as shown in **Fig. 1** was calculated using rainfall data for the last 36 years observed by AMeDas Observation Stations in and around the study area. In **Fig. 3**, the larger the probable excess is (meaning fewer rainfall events in the past), the higher the occurrence rate. There is also a tendency for the probably excess to become larger in a pattern where the slope failure area is larger.

Based on the above, it has been established that the probable excess for a long-term rainfall index is proportional to the number and scale of deep-seated landslides.

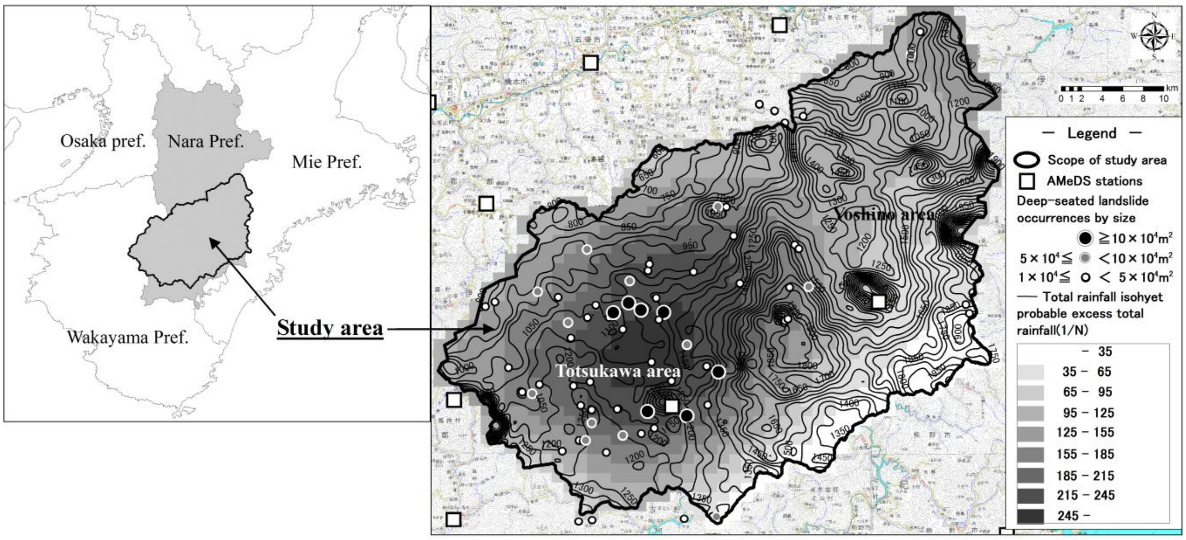

Fig. 1 Scope of study area , Relationships among total rainfall distribution, probable excess rainfall distribution , and the occurrence of deep-seated landslides meshes by size

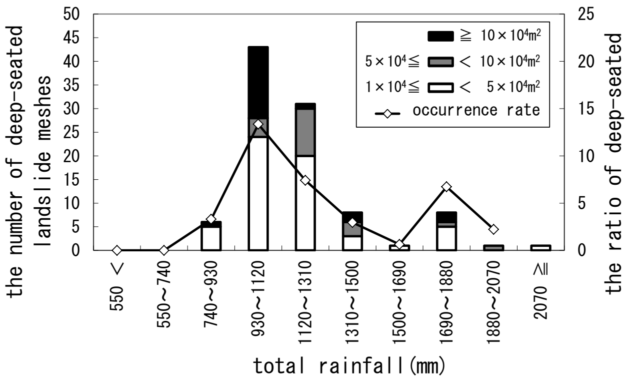

Fig. 2 Relationship between total rainfall and the number of deep-seated landslide meshes by size

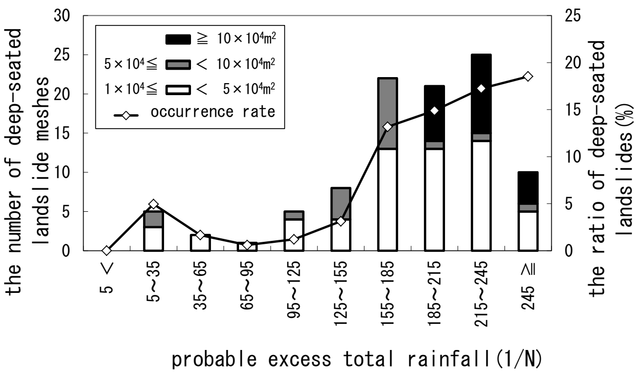

Fig. 3 Relationship between probable excess total rainfall and the number of deep-seated landslide meshes by size

Keywords: deep-seated landslide, probable excess rainfall