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Prediction of Deep-Seated Landslide Area in Kii Peninsula based on The Geographical Characteristics

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INTRODUCTION

Kii Peninsula was severely damaged by Typhoon Talas in September 2011, with about 4000 houses destroyed, 82 victims and more than 400 people injured. The typhoon caused total precipitation about 1,800 mm in Kamikitayama, Nara, 1,600 mm in Miyagawa, Mie, and while in other area, it caused more than 1,000 mm of total precipitation (National Institute of Informatics, 2012). During three days of the typhoon, the total precipitation reached about half of the annual precipitation in Kii Peninsula, which is 3,000 mm. This heavy rainfall caused landslides in 3,000 locations, deep-seated landslides in 72 locations and landslide dams in 17 locations, with total sediment amount of those landslides approximately 100 million m^3 (Hayashi, 2013).

In 1889, Kii Peninsula was also severely damaged by typhoon which leads to many deep-seated landslide disasters and landslide dams. The typhoon brought rainfall over 1000 mm between 19 and 20 August 1889 and caused more than 33 landslide dams. Most of the dams were collapsed and caused more severe damages (Inoue, 2012).

Taking these two catastrophes into account, Kii Peninsula seems very prone to deep-seated landslide disasters (Fujita, 2012). Thus, this research aims to find a method to predict of the area of deep-seated landslide in Kii Peninsula so that appropriate countermeasures can be applied in order to avoid severe disasters in the future.

METHODOLOGY

The characteristics of deep-seated landslides which divided into three types (landslide dam, debris flow, other) based on its material movement were already studied in prior researches. Kikuchi (2013) analysed DEM data obtained from Geospatial Information Authority of Japan (GSI) and aerial photographs of Kii Peninsula, and found the geographical characteristics of these deep-seated landslides. Kharismalatri (2013) continued this research and found typical relationship between streambed gradient and confluence angle for deep-seated landslides.

Based on Kikuchi (2013) and Kharismalatri (2013), factors that affecting deep-seated landslides and material movement type are average slope inclination, distance to valley, stream order, streambed gradient, and confluence angle. On this research, characteristics of the deep-seated landslides were observed further and the prediction of deep-seated landslide area was investigated through multiple regression analysis.

However, factors used in this research are average slope inclination (x_1), stream order (x_2), streambed gradient (x_5), upstream watershed area (x_6), and slope height (x_7). Considering that the aim of this research is to predict the deep-seated landslide area, while the distance to valley and confluence angle factors can be calculated if the landslide area known beforehand.

RESULT AND DISCUSSION

Total of deep-seated landslide case used in this research were 34, where it were classified into landslide dam, debris flow and other based on the material type movement. Multiple regression analysis was done on each type of deep-seated landslide and also on general condition, where all the deep-seated landslides considered as one general type without classifying it into three types.

The results of multiple regression analysis are showed below. The comparison between observed and calculated deep-seated landslide area is shown in Figure 1 below. The result equations show that there is not much difference between three types of landslide regarding the landslide areas and factors influencing the occurrence. The types of movement (at flowing down area) may be strongly influenced by the confluence angle and distance to valley which were not used in this analysis. The types are not decided at the time when the landslides occur, but decided by the process of movement, namely topography of downstream which is important for material's travel distance. It is difficult to estimate the types of landslides by the landslide areas, thus only equation (4) can be used for estimating landslide areas.

$$y = 1161.3x_1 - 2622.5x_2 - 3760.6x_5 + 0.2x_6 + 164.9x_7 - 51446.5 \quad \text{(debris flow)} \quad (1)$$

($R^2 = 0.77$, significance F = 0.03)

$$y = -6630.6x_1 + 66362.9x_2 + 16917.2x_5 - 0.001x_6 + 525.2x_7 - 97267.9 \quad \text{(landslide dam)} \quad (2)$$

($R^2 = 0.64$, significance F = 0.19)

$$y = 9719x_1 + 39365.7x_2 - 3432x_5 - 0.0002x_6 + 380.9x_7 - 461935.7 \quad \text{(other)} \quad (3)$$

($R^2 = 0.71$, significance F = 0.41)

$$y = 4837.5x_1 + 10493.2x_2 - 721.1x_5 - 0.0001x_6 + 367.5x_7 - 212175.8 \quad \text{(general condition)} \quad (4)$$

($R^2 = 0.46$, significance F = 0.003)

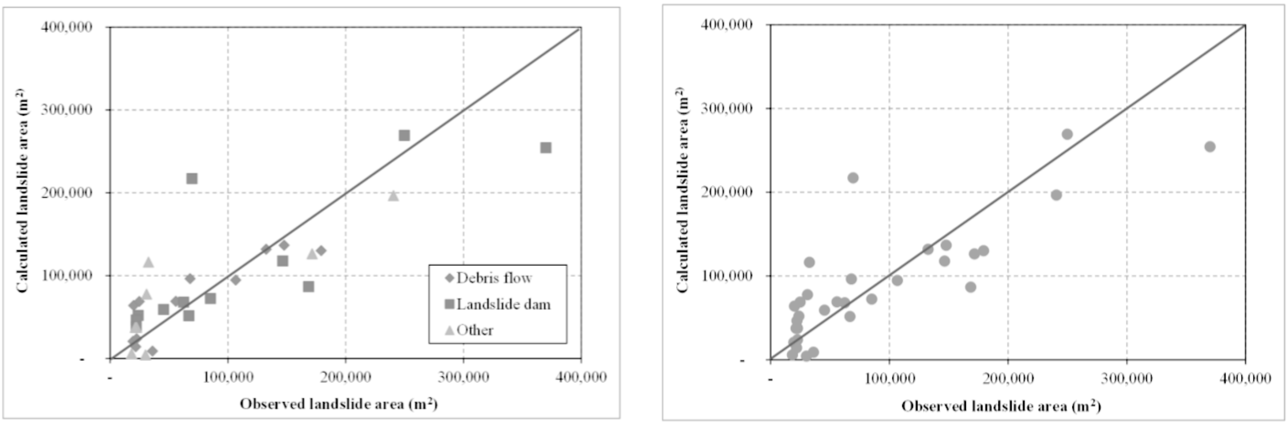

Figure 1. Comparison between observed and calculated deep-seated landslide area, by type (left) and general condition (right)

Equations (2) and (3) are having significance F (p-value) greater than 0.05, while equations (1) and (4) having p-value less than it. This difference is strongly affected by the number of the data. The number of data on landslide dam and others are too small comparing with the number of debris flows and general.

Equation (4) shows pretty good result based on the regression model output and comparison between observed and calculated landslide area (Figure 1). However, deeper study on multiple regression analysis and consideration of more landslide cases or other slope might be necessary.

CONCLUSIONS

The results of the analysis must be used for estimation of landslides area, not for separation of the types of landslides. The application of the results must be confined to estimation of landslide area in general condition. The equations are still need improvement for better prediction of deep-seated landslide area.

Keywords: Kii Peninsula, area prediction, deep-seated landslide, geographical characteristics.

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