Effects of geomorphological properties on the surface failure occurred by a heavy rainfall in Hiroshima city in 2014 by using machine

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1. Introduction

Prediction methods for surface failure can be classified into heuristic, deterministic and statistical methods. Studies using statistical method have been increasing rapidly because of development of airborne-scanning LiDAR, remote sensing technology and machine-learning technique. This study examines geomorphological properties of surface failures occurred by a heavy rainfall in Hiroshima city in 2014 statistically by using Random Forest (RF) prediction model (Breiman , 2001).

2. Study area and Methods

Study area is Mt. Abu and Mt. Takamatsu in Hiroshima city. This study focused on surface failure in granite area to apply RF method. 5 m mesh digital elevation model (DEM) released by Geospatial Information Authority of Japan (GSI) was used. The DEM for study area was made in 2008. Thus we can analyze the terrain before the landslide in 2014. Map of 2014 landslide areas was published by GSI. Using DEM we calculated geomorphological properties such as slope angle, flow accumulation, topographical convergence Index (TCI), profile curvature, tangential curvature by GRASS GIS 7.0.1. Statistical analysis was carried out by R language 3.2.3.

This study defined three geomorphic units with different spacial scales; 1) failure head, 2) first-order basins and 3) large basins. Failure head is represented by the highest cell within each surface failure. In failure head scale, water lines were set to investigate geomorphological characteristics of water line. Neighbor of the failure head is defined as the following 5 cells; both the upper 2 cells and lower 2 cells from the failure head, and the failure head cell itself. First-order basins were extracted after making stream order map. This study sets the large basins whose outlets locate the foot of the mountains because to evaluate risk of sediment disaster at each outlets of valley is valuable for disaster prevention.

3. Results and Discussion

Failure heads are located within 125 m from the mountain ridge and at around the steepest slope point along each waterline. RF model suggested critical slope angles (32 to 39 degree) for occurring surface failure. When profile curvature changes concave shape to straight shape and tangential curvature changes straight or ridge shape to straight or valley shape from upper of failure heads to under of them, RF model classified the points as high potential of occurring failure.

RF model for first order basin has the highest miss classification rate among the three. This suggests that geomorphological differences between the failured and non-failured first order basins are relatively small. RF model suggested that lowest elevation of the basins was most important parameter for classification. When the lowest elevation of the first order basins is higher than 143 m., such basin is classified as failure basin, which tends to locate near the main ridge.

RF model applied for large basins suggested that failured large catchments have relatively higher value of TCI and flow accumulation. It means large basins which have long wetness duration on rainfall tend to failure. It is naturally conceivable that failure can occurred in large scale basins on a heavy rainfall. However, the suggestion by RF model is important for disaster prevention because it may strongly correlated to frequency of hit of debris flow.

This study focused surface failure in granite area. As geomorphological condition of surface failure is changeable by geology and region, the same statistical examine should be tried to other geological areas and regions.

References

Breiman L (2001) Random forests. Machine learning, 45:5-32.

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