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学 位 論 文 内 容 の 要 旨

博士 (環境科学)

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Studies on land-use/land-cover change and forest fragmentation with the implications
for landslide occurrence in the Garhwal Himalaya, India

(インド、ガルワール・ヒマラヤにおける土地利用・土地被覆変化
および地すべり発生と関連した森林の分断化に関する研究)

The Garhwal Himalaya is believed to have experienced extensive deforestation and forest fragmentation due to anthropogenic and natural drivers, but data and documentation detailing this transformation are limited. Previous studies have examined forest fragmentation and landslide occurrence separately, and forest fragmentation has been believed to cause landslides. However, there is no study to understand the correlation between forest fragmentation and landslide occurrence. Therefore, understanding the link between forest fragmentation and landslide occurrence is important in the mountains such as the Himalaya.

Remote sensing satellite data are suitable for poorly researched area with less data availability, and can provide detailed assessment. This study, therefore, used satellite remote sensing and geographic information system (GIS) to create a spatial inventory of land-use and land-cover (LULC), and to examine forest fragmentation and landslides in the Garhwal Himalaya. Then, an evaluation on how potential change of forest fragmentation would result in changes of landslide susceptibility and vice versa. Three images from Landsat 2 Multispectral Scanner System (MSS), Landsat 5 Thematic Mapper (TM), and Landsat 8 Operational Land Imager (OLI) were used to extract land cover. A cross-tabulation detection method in a GIS module was used to detect land cover changes during the 1st period (1976–1998) and 2nd period (1998–2014). The landscape fragmentation tool LFT v2.0 was used to prepare a forest fragmentation map and to analyze the patterns and changes of the forest fragmentation during the 1st period (1976–1998) and 2nd period (1998–2014). Using the weight-of-evidence (WOE) model, the relationship between the forest fragmentation and the landslide occurrence was established to identify the potential change of forest fragmentation and landslide susceptibility in the study area.

The results of this research showed that the overall annual rate of decreasing change in the forest cover was 0.22% and 0.27% in the 1st period (1976–1998) and 2nd period (1998–2014), respectively. Non-forest area, i.e., agriculture land, built-up area, scrub land and barren land, had increased in both periods of time. An increase in the areas of scrub land and barren land also contributed to the accumulation of wasteland in the area. The forest fragmentation analysis showed that a large core forest has decreased throughout the study period. The results of forest fragmentation showed that the increased non-forest and perforated areas were the main cause of the decline in the large core forest. The total area of the forest patches also increased during the study period (1976–2014).

The result of the weighted contrast value showed that the forest fragmentation probability was primarily observed near built-up area (less than 500 m), agriculture land (less than 500 m), roads (less than 1000 m), and streams (less than 500 m) with very gentle and gentle slopes (less than 25 degree) at the lower to middle altitude zone (less than 2000 m). The probability map of the forest fragmentation showed that medium to high probabilities are primarily concentrated near the roads and agriculture land area on very gentle to gentle slopes at the lower altitudes. The probability map of the forest fragmentation also showed that the role of higher altitude zone (more than 2000 m) is less significant, and that factors such as distance to roads, distance to agriculture land, distance to built-up area and slopes are more important. The analysis of the forest fragmentation probability suggested that the area would experience more forest fragmentation in the future due to the increased area of patch forests and perforated forests, meaning the increase in the forest degradation. Regarding the landslide susceptibility, the result clearly showed that medium to high landslide susceptibilities had occurred mainly in the non-forest area. The result of the weighted contrast value showed that most of the medium to high landslide susceptibilities are primarily concentrated in the areas adjacent to higher altitudes, steep slopes, and the non-forest area such as scrub land, barren land, and pasture land. Regarding potential changes in the forest fragmentation probability and the landslide susceptibility, the result demonstrated that the forest fragmentation probability was observed in the areas where landslides are less likely to occur. The probability of landslides would not give a major influence on forest fragmentation and vice versa, which was suggested for the first time by the approach with the combination of both forest fragmentation and landslide occurrence.