Topic: "Risk Analysis of Large-scale landslides"

Associative Relationship Of Land Cover And Topographic Dynamics On Landslide Events Using Remote Sensing, Spatial Autocorrelation And Ground Survey Techniques

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Abstract

This paper discusses the contribution of land cover and topographic changes over time to landslide events. In particular, we are looking at Milenyo (International Name: Rammasun) that occurred in 2006 as a baseline in the assessment. We analyzed Remote Sensing images to investigate anthropogenic-induced spectral changes in vegetation at the landslide points (before and after the landslide). These were compared at several time periods to infer on the changes that occurred. The hypothesis is that the vegetation will be different in structure (eg. age) and composition (eg emergents, species) for landslide areas in a natural vegetation. In an altered vegetation i.e. agroforestry, we infer that the vegetation shall have been the same as the people will just replant the same species as before. Results reveal that landslide occurrences gravitate around altered landscapes (eg settlements and farmlands).

Key words: land use/land cover, digital elevation model (DEM), remote sensing, change analysis

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1. Introduction

In 2006, a devastating Super Typhoon Milenyo (International Name: Rammasun) destoyed many parts of the Philippines along its path. In particular, the infrastructure, settlements and the natural landscape of Mount Makiling and its environs were significantly affected destroying houses, buildings and farmlands, and damaging many parts of the forest. The towns and cities on its slopes experienced floods and portions of the mountainsides had landslides. In Los Banos alone, almost 4,000 houses were either totally or partially destroyed with several casualties.

Our analysis revealed that based on rainfall alone, the landslides were very likely. But, combined with high antecedent soil moisture, the landslides were imminent all the more exacerbated by unprecedented strong winds. The combination of loose soil, heavy rainfall, strong winds, debris, boulders made worse by the bursting of the temporary dam caused the tragedy.

This paper focuses on two landslide factors, namely: land use/land cover and topography. The objective is to determine if there is a congruence or association between land use/land cover change and topographic change that trigger a landslide event. The hypothesis is that land use/land cover change is not a sole indicator of vulnerability to landslide. In combination with topographic change over time, active landslides may be identified. This evaluation is part of the analysis being undertaken under the aegis of the project "Heavy Rain Monitoring and Forecasting in Mountainous Areas and Early Warning for Landslides" of the research program "Improvement of Forecast Capability on Weather, Marine Meteorology and Short Range Climate". This program is funded by DOST-PCIEERD under the Manila Economic and Cultural Office – Taipei Economic and Cultural Office collaborative research for Volcanoes, Oceans, Typhoons and Earthquake (VOTE).

2. Materials and Methods

After Super Typhoon Milenyo, at least 25 landslide occurrences were observed (Figure 1). These were concentrated on the steep slopes and higher elevations of Mt Makiling.

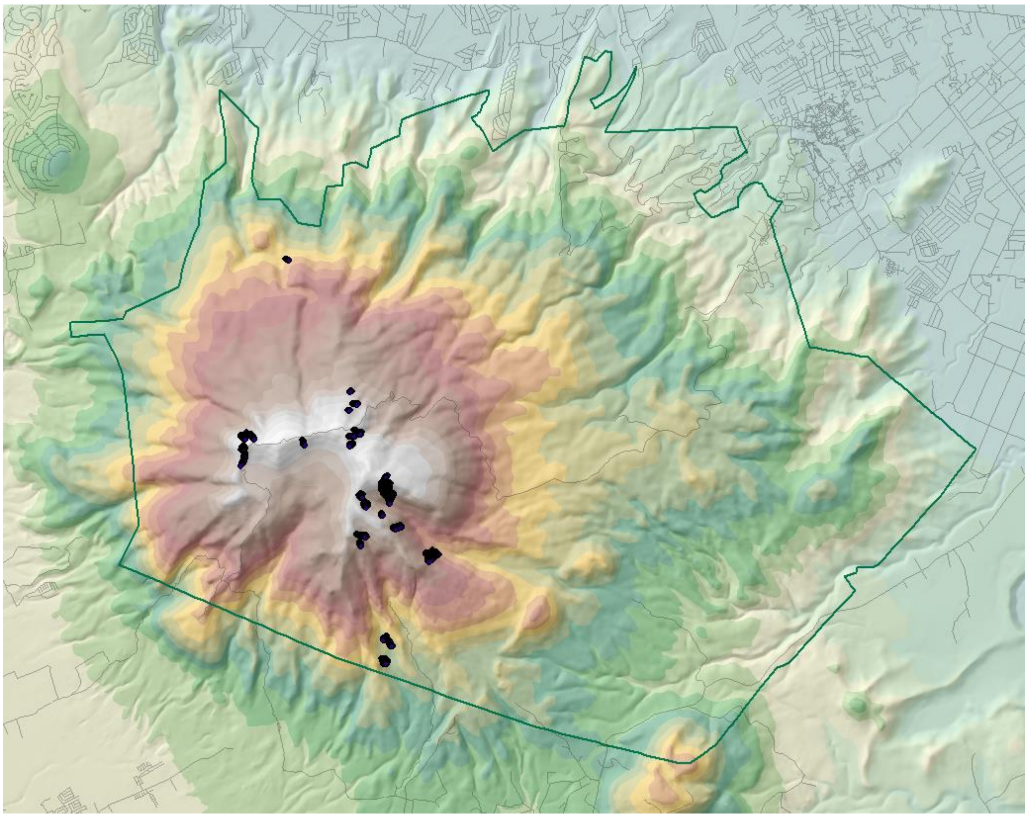

Figure 1. Location of landslides due to Super Typhoon Milenyo in 2006.

2.1 Comparison of elevation models from various sources

This paper compares two sources of topographic data in Mount Makiling. These are the 1:10,000 topographic map with its 20-meter contour lines digitized and Interferometric Synthetic Aperture Radar (IFSAR) at 5 meters resolution. All data were sourced from NAMRIA (National Mapping and Resources Information Authority).

2.2 Comparison of Land use/land cover change

Land cover change on Mount Makiling and its neighboring areas in two different time periods (2010 and 2015) was evaluated. Different land cover types were used in the classification, namely: forest, shrubs, grassland, perennial crop, annual crop, built-up, open/barren, inland water, and fishpond. Using the barangay (or village) as unit of analysis, spatial autocorrelation was implemented using the application LISA (local indicators of spatial association).

3. Results and Discussion

For the NAMRIA topographic map, contour data was transformed into DEM by first generating a triangulated irregular network (TIN) thereby transforming line data into a surface. The TIN was transformed into a raster with a ground resolution of 10m/pixel. Likewise, the IFSAR dataset was translated to the same resolution.

Land use/land cover change assessment results show that large areas of annual crops of agricultural areas were converted to other land cover types in 2015. In the same manner, shrub areas declined significantly. Interestingly, there is an apparent increase in forest.

When super typhoon Milenyo passed over Mount Makiling, widespread damage was most notable at the upland community of Bagong Silang. This same area figured significantly in the land use/land cover analysis. For instance, the Barangay Bitin showed a High-High (HH) LISA result indicating high clustering of high forest decline. Two other barangays in the same area, namely Barangay Tranca and Barangay Sta Cruz show LH value or low cluster of high forest decline.

However, several other uninhabited locations were damaged where landslides were noted to occur causing loss of vegetation. Field data was supplemented with high resolution imagery to delineate the expanse of these observed landslide areas. One of the observed landslides occurred in Bagong Silang community at an area adjacent to a road. The same area experienced a landslide in 2017 when a rainfall event of very high precipitation occurred (Figure 2).

Figure 2.Active landslide in two time periods (2a – 2006; and 2b – 2017)

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