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GIS-based logistic regression method for susceptibility assessment of earthquake-triggered landslides: A case study from Fogo Volcano (S. Miguel, Azores)

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Landslides are responsible worldwide for significant socioeconomic losses and, since far historical times, have a prominent position in the list of natural hazards affecting the Azores archipelago. More than 250 landslides, triggered by two earthquakes on the 20th and 21st September 2005(ML=4.1 and ML=4.3 respectively), were identified in a study area of about 169 km2 located in the Fogo Volcano (S. Miguel Island, Azores). These two earthquakes were the strongest events of a seismic crisis that started on May 2005. More than 46000 earthquakes were registered until the end of December 2005, in Fogo-Congro seismogenic region (S. Miguel Island, Azores) by the SIVISA (Azores Seismological Surveillance System).

Most of the landslides were located on the deep gullies steep slopes, which dissect the Fogo Volcano flanks, composed of unconsolidated pyroclastic materials (pumice lapilli and ash) produced during recent explosive eruptions that occurred on the volcano. The landslides were mainly debris flows and shallow soil slips, which usually evolved downslope into debris flows. Some rural roads were temporarily closed and natural dams were formed due to landslides deposits.

In the present work, it was made the landslide susceptibility assessment at the regional scale, using logistic regression (multivariate statistical method). Assessment of landslide susceptibility was based on the assumption that future landslides can be predicted by statistical relationships between past landslides and the spatial data sets of relevant predisposing factors. Considered variables include: landslide distribution, slope angle, slope aspect, lithology and distance to earthquake epicenter. Data integration of vari-

ables was made with a GIS, overlaying the considered thematic layers which allowed the definition of susceptibility scores for each variable case, and the computation of favorability values (susceptibility indicators) for each pixel of the study area. Results of the statistically based landslide susceptibility assessment were validated through an independent cross-validation technique. The original landslide data set was split in two comparable groups using a random criterion. The first sub-set (landslide estimation group) was used to obtain a prediction map, and the second sub-set (landslide validation group) was compared with the prediction results for validation through the computation of prediction-rate curves.

The output earthquake-landslide susceptibility map showed that, 96.3% of landslides from the validation group are located in the 1.6% of the area classified as more susceptible to slope instability by the logistic model. The lithologic homogeneity of the affected area and the high selectivity of the triggering mechanism, namely in what concerns distance to epicenter and slope angle helped to explain the high accuracy of the conceived susceptibility map algorithm.

This type of approach, by the modeling process dynamism and predictive accuracy, revealed to be a very powerful and useful tool to predict earthquake-triggered landslides at the regional scale, and can be integrated as an important tool for land use and emergency planning.