



ICG2022-543

<https://doi.org/10.5194/icg2022-543>

10th International Conference on Geomorphology

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Predicting earthquake-induced landslides by using a stochastic modeling approach which combines preparatory and triggering factors: a case study of the co-seismic landslides occurred on January 2001 in El Salvador (CA)

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On January 13th, 2001, El Salvador was hit by an earthquake of magnitude 7.7 which triggered thousands of landslides, causing 1259 fatalities and extensive damage to infrastructures. The analysis of aerial images provided by the CNR (Centro Nacional de Registros de El Salvador), which were taken a few days after the event, allowed us to map 1005 seismically-induced landslides that occurred in a study area extended for 92 km². The objective of this experiment was to verify whether it is possible to predict the spatial distribution of these landslides through a stochastic approach that combines a rainfall-induced landslide susceptibility (SUSC) model, which is based on preparatory factors, and an earthquake-triggered landslide predictive (TRIGGER) model, which is based on seismic parameters such as peak ground acceleration (*PGA*) and distance to the epicenter (*ED*). The SUSC model was calibrated by using an inventory of 5609 landslides that occurred in November 2009 in the area of the San Vicente volcano, due to the simultaneous action of low-pressure system 96E and Hurricane Ida. The TRIGGER model was instead trained with the 20% of the earthquake-triggered landslides, whereas the remaining 80% was used to validate both the SUSC and TRIGGER models, as well as an ensemble model obtained by using as predictors *PGA*, *ED* and the landslide probability calculated by the SUSC model. In order to evaluate the robustness of the results, ten calibration and validation samples were randomly extracted from the 2001 landslide inventory. Multivariate adaptive regression splines (MARS) was used as modelling technique. The predictive performance of the models was evaluated by using receiver operating characteristics (ROC) curves and the area under the ROC curve (AUC).

The validation results revealed a slightly better performance of the SUSC model (average AUC = 0.719; AUC st.dev. = 0.008) with respect to the TRIGGER model (average AUC = 0.707; AUC st.dev. = 0.009). Moreover, the analysis highlighted that the best predictive ability is achieved by the ensemble model (average AUC = 0.743; AUC st.dev. = 0.006). These results suggest that, in the event that only some of the landslides triggered by an earthquake are known, as usually happens shortly after the event, it is possible to use the approach proposed in this study to identify those sites where the other landslides are more likely to have occurred.

This work is a part of the CASTES project, which is funded by the Italian Agency for Development Cooperation (AICS) and focuses on promoting research and training activities in the field of earth

sciences in El Salvador (CA).