



A preliminary regional assessment of earthquake-induced landslide susceptibility for Vrancea Seismic Region

Mihai Micu (1), Dan Balteanu (1), Constantin Ionescu (2), Hans Havenith (3), Mircea Radulian (2), Cees van Westen (4), Michiel Damen (4), and Marta Jurchescu (1)

(1) Romanian Academy, Institute of Geography, Bucharest, Romania (mikkutu@yahoo.com), (2) National Institute for Earth Physics, Magurele, Romania, (3) Liege University, Liege, Belgium, (4) University of Twente, ITC Enschede, Netherlands

In seismically-active regions, earthquakes may trigger landslides enhancing the short-to-long term slope denudation and sediment delivery and conditioning the general landscape evolution. Co-seismic slope failures present in general a low frequency - high magnitude pattern which should be addressed accordingly by landslide hazard assessment, with respect to the generally more frequent precipitation-triggered landslides. The Vrancea Seismic Region, corresponding to the curvature sector of the Eastern Romanian Carpathians, represents the most active sub-crustal (focal depth > 50 km) earthquake province of Europe. It represents the main seismic energy source throughout Romania with significant transboundary effects recorded as far as Ukraine and Bulgaria. During the last 300 years, the region featured 14 earthquakes with $M > 7$, among which seven events with magnitude above 7.5 and three between 7.7 and 7.9. Apart from the direct damages, the Vrancea earthquakes are also responsible for causing numerous other geohazards, such as ground fracturing, groundwater level disturbances and possible deep-seated landslide occurrences (rock slumps, rock-block slides, rock falls, rock avalanches). The older deep-seated landslides (assumed to have been) triggered by earthquakes usually affect the entire slope profile. They often formed landslide dams strongly influencing the river morphology and representing potential threats (through flash-floods) in case of lake outburst. Despite the large potential of this research issue, the correlation between the region's seismotectonic context and landslide predisposing factors has not yet been entirely understood. Presently, there is a lack of information provided by the geohazards databases of Vrancea that does not allow us to outline the seismic influence on the triggering of slope failures in this region. We only know that the morphology of numerous large, deep-seated and dormant landslides (which can possibly be reactivated in future) with head scarps near mountain tops and close to faults is similar to the one of large mass movements for which a seismic origin is proved (such as in the Tien Shan, Pamir, Longmenshan, etc.). Thus, correlations between landslide occurrence and combined seismotectonic and climatic factors are needed to support a regional multi-hazard risk assessment. The purpose of this paper is to harmonize for the first time at a regional scale the landslide predisposing factors and seismotectonic triggers and to present a first qualitative insight into the earthquake-induced landslide susceptibility for the Vrancea Seismic Region in terms of a GIS-based analysis of Newmark displacement (ND). In this way, it aims at better defining spatial and temporal distribution patterns of earthquake-triggered landslides. Arias Intensity calculation involved in the assessment considers both regional seismic hazard aspects and singular earthquake scenarios (adjusted by topography amplification factors). The known distribution of landslides mapped through digital stereographic interpretation of high-resolution aerial photos is compared with digital active fault maps and the computed ND maps to statistically outline the seismotectonic influence on slope stability in the study area. The importance of this approach resides in two main outputs. The first one, of a fundamental nature, by providing the first regional insight into the seismic landslides triggering framework, is allowing us to understand if deep-focus earthquakes may trigger massive slope failures in an area with a relatively smooth relief (compared to the high mountain regions in Central Asia, the Himalayas), considering possible geologic and topographic site effects. The second one, more applied, will allow a better accelerometer instrumentation and monitoring of slopes and also will provide a first correlation of different levels of seismic shaking with precipitation recurrences, an important relationship within a multi-hazard risk preparedness and prevention framework.