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Landslide hazard assessment and mapping for Malawi (Southeastern Africa): from susceptibility to hazard by integration of temporal exceedance probabilities related to tropical meteorological events

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Landslide are ubiquitous phenomena affecting many countries around the world. In recent years, in the context of landslide risk reduction and management an increasing number of landslide susceptibility or hazard maps were carried out at the national scale. These analyses are generally based on: (1) an existing inventory (national database or compilation of work carried out individually); (2) empirical indirect or data-driven methods. However, it appears that few studies, at this scale of work, take into account the temporality of events and/or the triggering factors to tend towards hazard assessment. This statement is often due to a lack of information, especially for emerging countries, where a lack of spatial and temporal information on events and on triggering factors subsist. Thus, if landslide inventories provide the first information to assess the susceptibility, at this scale of work, it is also necessary to identify and analyze the components inducing hazard in order to assesses properly the associated risks (i.e. the annual frequency of events). This identification can be carried out by several ways with: (1) direct approaches based on the analysis of temporal data of past landslides (e.g. computations of the exceedance probability of landslide occurrence estimated by Poisson or binomial distributions); or (2) by indirect approaches based on the analysis of triggering factors (e.g. rainfalls volume, intensity and duration).

This contribution focus on the methodology adopted during the GEMMAP[i] project to assess landslide hazard at national scale (i.e. 1:250,000) for Malawi, a landlocked country in southeastern Africa. This country is characterized by its topography composed of mountains crossed by the Great Rift Valley and the Malawi Lake. It is experiencing many slope instabilities principally due to intense rainfalls from tropical cyclones to depressions. The methodology is based on an approach quantifying the different failure probabilities at the spatial and temporal levels following the JTC-1 guidelines. Thus, after having improved the landslide inventory by visual remote sensing and field surveys, integrated information on their type, activity, and triggering periods; susceptibility

analyses to different types of landslides were carried out by a data driven method. Then temporal analyses of the events were performed, taking into account: (1) the recurrence time for different phenomena (i.e. debris-flows, debris-slides and slides for the period 1946–2019) and (2) the rainfall periods induced by several and different tropical meteorological events (World Meteorological Organization). This analysis has led to compute the exceedance probability (i.e. based on Poisson distribution) of landslide reactivation for six return periods from 1 to 100 years following different typical meteorological events. The computations were performed for each susceptibility class associated to each type of landslide. Finally, the methodology allows elaborating different landslide hazard scenarios at national scale for the near or more distant future.

[i] The "Geological Mapping and Mineral Assessment of Malawi" project is led by the BRGM, with international partners: GTK (Geological Survey of Finland), and CGS (Geological Survey of South Africa) for the Government of Malawi through the Geological Survey Department (GSD).