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Landslide inventory mapping at 1:50,000 scale in the fourteen northern provinces of Vietnam: Achievements and difficulties

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Three fourths of the territory of Vietnam comprises hilly and mountainous regions that are often threatened by landslides. The incorporation of landslide susceptibility mapping into regional and local land-use planning is an important measure to reduce the impact of landslides. However, most projects on landslide mapping in Vietnam have been independently conducted in separated areas by different organizations/individuals for their own purposes, resulting in qualitative zonation that are not yet integrated into one unified database. The country needs a national program to systematically assess landslide susceptibility, hazard and risk for all landslide prone areas. That is principal aim of the State-Funded Landslide Project (SFLP), namely "Investigation, assessment and warning zonation for landslides in the mountainous regions of Vietnam". Under this SFSP, a landslide inventory mapping at 1:50,000 scale has been carried out since 2012. This paper gives an overview of the results as well as the major drawbacks of the mapping activities in the first phase of the SFLP, and points out some feasible solutions to improve the mapping results in the second phase of the SFLP.

In the first phase (2012-2014), the mapping was implemented over the whole mountainous areas of fourteen northern provinces: Lai Chau, Dien Bien, Son La, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Cao Bang, Bac Kan, Bac Giang, Quang Ninh, Hoa Binh, Thanh Hoa and Nghe An. More than 500 staff of 15 organizations were involved. They followed the same procedures of landslide inventory using a guidelines developed by SFLP's key staff with the aid of international experts (from the Netherlands, Norway, Japan). As to the achievements, 10,148 historic landslides were mapped by field surveys. Those surveyed landslides are mostly found in accessible areas (along roads and inside/nearby residential areas); with small dimensions (from small to moderate volumes); partly as a consequence of the slope cuts; with high losses in terms of economic values. In addition, 8,988 locations with landslide signs were delineated by interpretation of airphotos (captured in 2000) and analysis of 3D relief (interpolated from 1:10,000 topographic maps that were built in 2000). Those interpreted landslides are mostly found in inaccessible areas (remote areas/high mountains); with large dimensions (from moderate to very large volumes); little involved in activities of slope excavation; probably with high numbers of deaths (for those with field-checks). About 4% of the interpreted landslides were verified in the field with an accuracy of approximately 65%. The achieved inventory maps have also been handed over to the above-mentioned provinces and involved organizations in order to inform the local authorities and communities about real situations, and improve the effectiveness of disaster prevention and mitigation in the investigated areas.

The major drawbacks of the work in the first phase are: (1) The unavailability of multi-date airphotos; (2) The lack of human resources with enough experience in image interpretation; (3) The difficulties of verifying the interpreted landslides, especially for the inaccessible sites; (4) Few or no sources of historic information due to the isolated sites or little memory of insignificant events; (5) No updates of surveyors after they finished their tasks. Such drawbacks can lead to the insufficiency of adequate data on the

types, sizes and characteristics of the slope failures, especially the exact dates of occurrences. Therefore, it would be difficult to correlate the landslide with a triggering event as different landslides have different meteorological triggers. To overcome the above-mentioned obstacles in the second phase, some of solutions are recommended such as: (1) Making the most advantage of available Google Earth, satellite and radar images; (2) Sending staff to training courses for image processing and interpretation as well as improving their capacity of inventory mapping; (3) Inviting local communities in field surveys; (4) Developing and maintaining the online spatial database - WebGIS on landslides, and training the local authorities and people to use the WebGIS for validating inventoried landslides as well as updating the historic and recent landslides.