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Integrated multi-disciplinary approach for landslide Early Warning Systems: a collaborative framework in Georgia

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We present a collaborative research initiative involving Politecnico di Torino (Italy), Ilia State University (Georgia), and Telavi State University (Georgia) aimed at developing and implementing customized Early Warning Systems (EWS) for landslide risk mitigation. The research is carried out at strategic pilot sites in Georgia, a region characterized by high geological complexity and significant susceptibility to slope instability. Two Georgian pilot sites are located in the Kakheti Region, within the Gombori Range of the Alazani River basin (eastern Georgia), and in the Vere River basin, a right-bank tributary of the Kura River, southwest of the capital city, Tbilisi.

A first phase focuses on site characterization based on integrated geological, geophysical, geotechnical, and geomatics surveys. This phase aims to define lithological sequences, material properties, and slope geomorphological features to identify the dominant failure mechanisms. The geomatics methodology involves the use of GPS devices, photogrammetric analysis and drone-based LiDAR surveys. The adopted geophysical methods mainly combine electrical resistivity tomography (ERT) and seismic refraction and surface wave analyses. Geological characterization and modeling further include lithological and structural analyses, identification and mapping of existing landslide and debris-flow bodies using photogrammetry and satellite image analyses, estimation of the approximate volume of mobilized sediments in different catchments within the study area, and the collection of geological information required to model the potential distribution of landslide-related debris flows.

The second phase addresses the EWS design for the development of a monitoring framework primarily based on geophysical and geomatics methodologies. Attention is also given to the monitoring of the landslide-induced microseismicity associated with fracture processes and slope movements. The EWS is customized with sensor configuration and threshold parameters specifically designed for the types of landslide phenomena identified during the first phase. The overall goal is to develop a methodology for protecting infrastructures and local communities from landslide triggering; by integrating multi-sensor data fusion with site-specific geological and hydogeological models, the project aims to establish a robust framework for real-time monitoring and early warning, providing a scalable approach to landslide risk management.