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Operationalizing Early Warning Systems (EWSs) for Hydrologically Induced Landslides in West Nepal: Challenges and Opportunities

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Landslides are a frequent phenomenon across the mid hills and siwaliks of Nepal; however, very little is understood about the governing processes, and forecasting is still at a nascent stage. The underlying complexities in hydrogeological processes and difficulties associated with continuous monitoring have made landslide-prone areas data-scarce. Landslides are localized in nature; generating site-specific information with local buy-in, and linking it to local and regional risk governance structures, is very challenging. Looking at some case studies of landslide early warning systems (LEWSs) at a local scale, we discuss some of the key constraints of operationalizing LEWSs in the remote mountainous terrain of Nepal. We then describe ongoing research on setting up a citizen science-based approach to address landslide risk reduction, and link it to resilience-building initiatives.

LEWSs at a regional scale rely on using rainfall thresholds and landslide susceptibility mapping, which usually generate general warning information that provides first-order estimates of the possibility of landslide occurrences in predefined hazard zones when rainfall exceeds certain threshold levels. However, this requires a dense network of rain gauges and landslide susceptibility models, which Nepal currently lacks. Although there have been some initiatives to install hydrological and geological sensors to monitor pore-water pressure and slope movement at a local scale, they have not been upscaled to operational LEWSs. Notwithstanding numerous incidences of false alarms, in EWSs that are solely based on rainfall thresholds, making communities, local stakeholders and the government aware of the uncertainties associated with threshold probabilities in landslide early warning is critical in designing effective citizen-oriented systems. The dynamics of disaster risk governance also needs to be well understood in a socio-economic context, as it determines the speed at which expert judgement is required to deliver early warning information in an efficient manner, which would lead to early action being taken.

We are co-designing and will deliver a citizen science-oriented system for landslide risk reduction, as well as investigating ways in which landslide early warning can be integrated within a multi-hazard framework. Using cost-effective sensor technologies, we will implement simple precipitation and river flow monitoring systems alongside soil moisture and slope monitoring. Using these data, meteorological extremes, and their impact on spatiotemporal patterns of landslide risk across the Karnali River basin in West Nepal, will be analysed. Combining community-sourced rainfall data merged with satellite precipitation products, we will develop high-resolution maps for extreme precipitation and river flow triggers to issue generalized warnings for hydrologically induced landslides based on the probability of occurrences. Based on community based mapping of landslide risks and vulnerabilities and geological monitoring complemented by near-real-time satellite rainfall estimates, we are also developing community based LEWS, and will quantify the uncertainties associated with communicating probabilistic risk information in an appropriate format to local and national stakeholders.