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Nature-based solutions to mitigate the risk of shallow landslides: a global analysis

Udo Nehren^{1,2} and Teresa Arce Mojica^{1,2}

¹TH Köln - University of Applied Sciences, Institute for Technology and Resources Management in the Tropics and Subtropics, Köln, Germany (udo.nehren@th-koeln.de)

²University of Passau, Department of Geography, Passau, Germany

Landslides claim many lives and cause high financial losses in mountainous regions around the world every year. Especially in high mountain regions, the landslide risk is likely to increase further in the coming years due to the thawing of permafrost soils and the associated activation of slope dynamics. However, a higher landslide risk is also expected regionally in tropical and subtropical mountainous regions, namely where an increase in extreme weather events is projected and at the same time, there is a higher socio-ecological vulnerability and exposure due to population growth, land use pressure and other factors.

To mitigate the risk to people and their assets, various hard and soft infrastructure measures are available. Especially in the European Alps, the concept of protection forests (*German: Schutzwälder*) in combination with hard infrastructure has been used for years as an ecosystem-based or hybrid measure. Based on a systematic global literature review (275 papers), we investigated which Nature-based Solutions (NbS) to mitigate the risk of shallow landslides are in place worldwide, in which countries and regions they were implemented, and which approaches under the NbS umbrella concept were applied (e.g. Green Infrastructure, Ecological Engineering, Eco-DRR, etc.).

As a result of this comprehensive analysis, we present a portfolio of measures to mitigate the risk of shallow landslides that are being applied in various (eco)regions and cultural contexts around the world and discuss the success of these measures as well as potential risks, uncertainties, and failures. We also emphasize the need for further research particularly on the effectiveness of ecosystem-based landslide risk reduction in different mountain ecosystems, as well as the cost-effectiveness of NbS compared to hard infrastructure. We conclude that despite a successful implementation in the Alps and few other mountain regions, the protection forest concept has hardly been applied so far, especially in the Global South. In addition, we emphasize the particular challenge of establishing protection forests due to the rapid climatic and ecological changes and related geomorphological process dynamics in mountain regions in the course of global climate change.