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## **Ecosystem-based solutions for gravitational natural hazard mitigation: a review on the use of protection forests for disaster risk reduction in mountain areas**

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Mountain regions are affected by various natural hazards, of which gravitational mass movements are some of the most important ones. Due to the accumulation of settlements and intense economic activities in exposed areas, mountain regions such as the Alps constitute a risk hot-spot. The threat posed by gravitational natural hazards to human activities affirms the strong need for risk management, particularly for prevention. Structural measures are increasingly applied in combination with land use planning and ecosystem-based solutions. In particular, ecosystem-based solutions not only prevent the initiation of the processes but also act as a protective barrier. These green measures have been gaining an increasing attention also due to their adaptability to respond to the challenges posed by global change. Systematic reviews on how ecosystems can be used for disaster risk reduction have been carried out; however, their focus is on urban and coastal environments or on specific natural hazards such as shallow landslides. Up to now, there is no systematic review which addresses the role of ecosystems in disaster risk reduction regarding multiple gravitational natural hazards in mountain areas.

This contribution provides such a systematic review aimed at filling this knowledge gap to give a direction for future research. The review is composed of two main parts: a quantitative bibliometric analysis followed by a qualitative review. The quantitative part, based on the Scopus peer-reviewed database, aimed to investigate the publication trend on the ecosystem-based solutions for gravitational natural hazard mitigation by comparing it with the general trend of published scientific documents. The bibliometric analysis also served as a basis to select most relevant articles on which to conduct the subsequent qualitative analysis. The content of the so selected publications was analysed qualitatively the following predefined criteria: the natural hazards addressed, the features of the ecosystem (i.e. forest species composition, management activities, effectiveness in risk mitigation), the development of alternative scenarios to test different hypothesis, the degree of stakeholder involvement, and the monetary evaluation of the measures (i.e. comparing them to structural measures). Results show a sharp increase in the number of publications on the topic from 1980 to 2018 compared to the overall number of documents published on Scopus. Although the overall topic is gaining more attention in scientific

literature, the in-depth qualitative analysis revealed that research still pays little attention to stakeholder involvement and an economic evaluation of measures. We conclude that filling this research gap might help to foster a wider adoption of ecosystem-based solutions for disaster risk reduction across mountain areas.