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An expert-based framework for susceptibility analysis for tsunamigenic landslides in Indonesia

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Landslides can induce extremely high tsunami waves, reaching several tens of meters. These tsunamis typically impact only localized areas within about 100 km of the landslide. The most significant impact is generated in the immediate proximity to the landslide. Due to the short time between wave initiation and reaching the coast, early warning systems for these events have not yet been developed. This study aims to assess the exposure of particular regions to this specific form of tsunami with a focus on the Indonesian coastline. The approach not only evaluates the potential for the occurrence of landslides but also assesses whether there is a potential for the formation of particularly high tsunami waves, e.g. due to reflection or superposition of waves.

The limited number of known landslides that have triggered tsunamis in the past is not sufficient to enable a data-driven analysis. Hence, a heuristic approach is adopted in this study. It consists of the following 4 steps.

(1) Orientation workshop: A group of international scientists working on landslides and tsunamis discusses and selects parameters that might be relevant for the analysis.

(2) Online survey: The parameters selected in step (1) are ranked by a larger group of scientists.

(3) Result workshop: The survey results are discussed in another workshop.

(4) Susceptibility analysis: The parameter ratings from the online survey are transformed into a model for tsunamigenic landslide susceptibility evaluation and a susceptibility analysis for a pilot area in Indonesia is conducted.

During the orientation workshop, 37 parameters were selected to be considered for the susceptibility analysis. As part of the online survey, these were evaluated by a total of 25 scientists working on landslides and tsunamis. For landslide susceptibility in Indonesia, subaerial and submarine slope angle, presence of oversteeped slopes, landform, lithology, presence of lowly consolidated sediments, distance to active tectonic faults, depth and magnitude of historic earthquakes, precipitation, and pore water pressures were voted as crucial parameters. The work on this study is still ongoing and step (4) is planned to be conducted in the future.

The results of tsunamigenic landslide susceptibility mapping can aid local officials in elaborating

mitigation measures for this type of tsunami. Even minor earthquakes in these areas could trigger landslides, creating waves despite not typically causing seismic tsunamis. Hence, it might be necessary to adapt land-use and evacuation plans in at-risk regions to account for both seismic and landslide-induced tsunamis. The limited availability of high-resolution data representing the submarine environment is the main obstacle, which hampers a deeper analysis of submarine landslide susceptibility and the potential for tsunami wave generation. Future efforts must be made to close this data gap and enable effective protection of coastal populations from landslide-induced tsunamis.