



## **Roads at risk – the impact of debris flows on road network reliability and vulnerability in southern Norway**

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Norwegian's road network is frequently affected by debris flows. Both damage repair and traffic interruption generate high economic losses and necessitate a rigorous assessment of where losses are expected to be high and where preventive measures should be focused on. In recent studies, we have developed susceptibility and trigger probability maps that serve as input into a hazard calculation at the scale of first-order watersheds. Here we combine these results with graph theory to assess the impact of debris flows on the road network of southern Norway. Susceptibility and trigger probability are aggregated for individual road sections to form a reliability index that relates to the failure probability of a link that connects two network vertices, e.g., road junctions.

We define link vulnerability as a function of traffic volume and additional link failure distance. Additional link failure distance is the extra length of the alternative path connecting the two associated link vertices in case the network link fails and is calculated by a shortest-path algorithm. The product of network reliability and vulnerability indices represent the risk index. High risk indices identify critical links for the Norwegian road network and are investigated in more detail.

Scenarios demonstrating the impact of single or multiple debris flow events are run for the most important routes between seven large cities in southern Norway. First results show that the reliability of the road network is lowest in the central and north-western part of the study area. Road network vulnerability is highest in the mountainous regions in central southern Norway where the road density is low and in the vicinity of cities where the traffic volume is large. The scenarios indicate that city connections that have their shortest path via routes crossing the central part of the study area have the highest risk of route failure.