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Mapping rivers with a potential danger of damage by flash flooding and debris flows

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Landforms associated with past debris flows such as alluvial fans are typical locations for settlements in Norway. Flash floods with associated debris flows in small and steep river catchments cause a great deal of damage to infrastructure and housing located on alluvial fans. The Norwegian Water Resources and Energy Resources Directorate (NVE) is the national authority responsible for flood and landslide hazard management in Norway. Mapping areas with a risk of damage from flooding and landslides coupled with advice on land use planning, results in better land use practices and an increased awareness of the potential hazard among local authorities and citizens. Methods for mapping floodplain inundation for large rivers are well developed. This is not the case for rivers with small and steep catchments with a potential for high rates of erosion and sediment transport. A method for identifying and mapping rivers with a potential danger of flash flooding and associated debris flows is currently being developed at NVE. The resultant maps will assist local authorities in the first step in land use planning where they are required to identify if there is a potential hazard in the area. The method makes use of spatial data available for the whole country and is based on a 25*25 m terrain model. The method is based on two simple assumptions adapted to the available data:

i) Under normal hydraulic conditions there is a balance between processes of erosion and sedimentation. A debris flow will first occur when this balance is disturbed. This is quantified by the relative difference between the discharge of an extreme flood and floods that occur more frequently, ie. if the difference is large the probability of a debris flow occurring is greater and vice versa.
ii) Steep rivers with a large difference in height between cells have more energy available for erosion and sediment transport and therefore a larger potential for erosion and sediment transport than less steep rivers.

Regional flood equations (Sælthun, 1997) have been developed for the whole country and are used to find the relative difference between an extreme flood and a mean flood. The regional flood equations require effective lake percentage and mean runoff as input. The terrain model is used to compute the effective lake percentage for each grid cell. The same terrain model is used together with maps of mean runoff in a 1*1 km grid to find the mean runoff for each grid cell. These parameters are then utilised in the regional flood equations to find Q1000 and Q2 for each grid cell and the relative difference between the two floods is found. The results from this analysis are combined with the difference in height along the river reach for each grid cell. A preliminarily test of the method has been made comparing results of the analysis with 10 actual events in the west of Norway. In all cases both the relative difference between an extreme and mean flood and the difference in height are large for these rivers. These would therefore be mapped as having a large potential for damage by a flash flood/ debris flow. This shows that the method does identify rivers where such events occur. The small amount of events tested, are however, far too few to validate the results of the analysis. Further comparison with a much larger amount of actual events over the whole country is necessary. Separate analysis of the difference in height and difference in floods is also necessary to determine the sensitivity for both parameters. So far the method only identifies river reaches where a flash flood/ debris flow event is triggered. Further development is required so as to identify which areas downstream are at risk of damage. The preliminary results are however promising and further development and validation of the method is ongoing.
Reference: Sælthun, N.R. 1997: Regional flomfrekvensanalyse for norske vassdrag (Regional flood frequency analysis for Norwegian rivers). Rapport 14-97, NVE.