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Outbursts of landslide dammed lakes — mapping their potential across the Himalaya

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Lake formation as a result of river damming by landslides is frequently observed in the Himalayas. Historic records are riddled with sudden failures of debris dams that culminated in catastrophic outburst floods and debris flows with far-reaching devastating consequences for downstream communities and infrastructure. In addition, it has been argued that the formation of large orogens is tightly coupled with the damming of these lakes as they trap sediments and abate river incision.

The severity of outburst floods of landslide dammed lakes is directly related to the impounded water volume and downstream channel morphology both of which are controlled by topography. Prime insights into the spatial patterns of hazards generated by landslide dammed lakes can thus be inferred from digital elevation models (DEMs) that are available at sufficient detail at even the remotest localities.

Here we quantify from topographic constraints the physically possible size range of catastrophic outburst events at the mountain-belt scale. By manipulating digital topographic, climatic, and river discharge data we estimate to first order the potential peak discharge arising from failure of hypothetical dams occurring anywhere throughout the Himalayan drainage network. Thus modelled peak discharges encompass four to six orders of magnitude, with the most extreme events surpassing the largest documented monsoon floods by a factor of >100. For a range of pre-defined breach rates, the heavy-tailed size distribution of peak discharge stretches with increasing dam height.

Our simulation predicts the highest peak discharge for dam breaks outside of the Higher Himalaya, i.e. along the margins of the Tibetan Plateau, and the large orogen-parallel rivers of the Sub-Himalaya. Many of the bedrock rivers slicing through the Higher Himalaya are simply too steep to allow for trapping large quantities of water behind natural dams. This regional consistent pattern underscores the notion that high transient stream power associated with episodic natural dam breaks may play a dominant role in enhancing fluvial bedrock incision in the Higher Himalayas. From a hazard management perspective our data provide a promising and proactive tool for rapidly assessing the likely impacts of outburst events anywhere in the Himalayas.