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Predicting geomorphically-induced flood risk for the Nepalese Terai communities

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Rivers sourced from the Himalaya irrigate the Indo-Gangetic Plain via major river networks that support $\sim$ 10% of the global population. However, many of these rivers are also the source of devastating floods. During the 2014 Karnali River floods in west Nepal, the Karnali rose to around 16 m at Chisapani (where it enters the Indo-Gangetic Plain), 1 m higher than the previous record in 1983; the return interval for this event was estimated to be 1000 years. Flood risk may currently be underestimated in this region, primarily because changes to the channel bed are not included when identifying areas at risk of flooding from events of varying recurrence intervals.

Our observations in the field, corroborated by satellite imagery, show that river beds are highly mobile and constantly evolve through each monsoon. Increased bed levels due to sediment aggradation decreases the capacity of the river, increasing significantly the risk of devastating flood events; we refer to these as 'geomorphically-induced floods'. Major, short-lived episodes of sediment accumulation in channels are caused by stochastic variability in sediment flux generated by storms, earthquakes and glacial outburst floods from upstream parts of the catchment. Here, we generate a field-calibrated, geomorphic flood risk model for varying upstream scenarios, and predict changing flood risk for the Karnali River. A numerical model is used to carry out a sensitivity analysis of changes in channel geometry (particularly aggradation or degradation) based on realistic flood scenarios. In these scenarios, water and sediment discharge are varied within a range of plausible values, up to extreme sediment and water fluxes caused by widespread landsliding and/or intense monsoon precipitation based on existing records. The results of this sensitivity analysis will be used to inform flood hazard maps of the Karnali River floodplain and assess the vulnerability of the populations in the region.