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Modelling the sensitivity of changes in sediment flux and grainsize distributions on flooding in the Kathmandu basin, Nepal

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Abstract: Climate change and land-use change impact the sediment flux and grainsize delivered to rivers which influences channel morphologies and hence modifies flood risk; this is particularly the case where channels are fed by high mountain catchments. Here, We studied the Nakkhu River which is the largest southern tributary of the Kathmandu basin, Nepal. The mobility of the channel is well documented in response to bank erosion, down-cutting, and accumulation of bar forms; these processes are particularly important during extreme flood events. Comparing satellite images from 2003 to 2020, the river course, which has a medium channel width of 15 m, has migrated laterally up to 130m. Bank erosion and down-cutting reduce the inundation and water storage upstream, whereas aggradation of river bar forms downstream reduces the channel's conveyance capacity. These vertical and lateral geomorphological alterations result in significant impact on flood risk downstream.

In this research, we investigate how changes in sediment supply, and grain size affect river morphology and flood inundation in the Nakkhu River. We use the landscape evolution model, CAESAR-Lisflood, combined with a newly generated (2019) 10 m digital elevation model, field-derived grainsize data and 20 years (2001 to 2020) of daily discharge data, to simulate erosion and deposition along a 14 km reach of the river. In a set of experiments, we compare river bed cross-sections, flood extent, and water depths for 15 model scenarios where we vary sediment supply and grain size from fine sand to coarse gravel dominated distributions assessing the geomorphic uncertainty of observation of sediment data.

The model results show that channel morphologies are sensitive to changes in sediment grainsize distribution. The study suggests that lack of consideration of sediment impact in flood hazard mapping could lead to increased flood risk. In addition, this study highlights some of the challenges regarding the significance of grain size parameter and uncertainty to the landscape evolution model that need to be addressed in current research.

Keywords: River morphology, sediment flux, grainsize, flood modelling, Nepal