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Linking hydrology and sediment connectivity in a large Himalayan river basin

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The geomorphic and climatic settings strongly influence the hydrology and sediment transport characteristics of a large river system. The mode, efficiency, and scale of sediment transfer in a catchment are controlled by the degree of linkages between the different landscape components (i.e. sediment connectivity). Therefore, the spatial analysis and cross-correlation of hydrology, and sediment connectivity are essential in order to develop effective sediment management strategies and to mitigate the associated hazards in large-sized catchments (10^3-10^4 km^2), where systematic field investigations are not feasible. The upper Kosi basin covers an area of ~52,731 km^2 draining through Tibet and Nepal. Seven major tributaries namely, the Indrawati, Bhote Kosi, Tama Kosi, Dudh Kosi, Sun Kosi, Arun, and Tamor join at different points and the combined annual water and sediment discharge at Chatara is measured as 1546 m^3/s and 101 million tonnes respectively before it debouches into the plains of north Bihar, India. The rainfall in upper Kosi basin has large regional and temporal variations due to considerable orographic contrast and the basin average rainfall at Chatara is 898 mm/yr. Observed discharge and sediment load data for ~30 years were analyzed and compared with the spatial sediment connectivity results derived from a topographic based index. This comparison helps to understand the spatio-temporal variability in sediment dynamics and its implications for flood hazard.

The overall response of the Kosi basin towards sediment connectivity shows significant spatial contrasts among the sub-basins, and this is governed by several factors such as landuse/landcover, slope and size of the basin. Our study reveals that out of ~101 million tonnes of annual sediment load at Chatara ~40% is being transported from western tributaries (Bhote, Indravati and Tama Kosi) and this confirms the that Bhote Kosi and Tama Kosi are among the most dynamic and well-connected system. In contrast, the Tamor, a moderately connected system, contributes only ~16% of the total sediment load at Chatara. The remaining ~44% is transported by other tributaries upstream of Chatara, the most important being the Arun (moderately connected), Dudh Kosi (highly connected) for which no independent estimates are available. Exceptionally high sediment flux is one of the most serious problems in the Kosi basin that is linked to several river-related hazards and sediment connectivity analysis can be extremely useful to understand sediment dynamics in such large river basins.