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Controls on river morphology in the Ganga Plain

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The Ganga Plain represents a large proportion of the current foreland basin to the Himalaya. The Himalayan-sourced waters irrigate the Plain via major river networks that support ~7% of the global population. However, some of these rivers are also the source of devastating floods. The tendency for some of these rivers to flood is directly linked to their large scale morphology. Systematic variations in the large scale morphology of the river systems are recognised across the extent of the Ganga foreland basin. In general, the rivers that drain the east Ganga Plain have channels that are perched at a higher elevation relative to their floodplain, leading to more frequent channel avulsion and flooding. In contrast, those further west have channels that are incised into the floodplain and are historically less prone to flooding. Understanding the controls on these contrasting river forms is fundamental to determining the sensitivity of these systems to projected climate change and the growing water resource demands across the Plain.

Here, we present a new basin scale approach to quantifying floodplain and channel topography that identifies the degree to which channels are super-elevated or entrenched relative to their adjacent floodplain. We explore the probable controls on these observations through an analysis of basin subsidence rates, sediment grain size data and sediment supply from the main river systems that traverse the Plain (Yamuna, Ganga, Karnali, Gandak and Kosi rivers). Subsidence rates are approximated by combining basement profiles derived from seismic data with known convergence velocities; results suggest a more slowly subsiding basin in the west than the east. Grain size fining rates are also used as a proxy of relative subsidence rates along the strike of the basin; the results also indicate higher fining rates (and hence subsidence rates for given sediment supply) in the east.

By integrating these observations, we propose that higher subsidence rates are responsible for a deeper basin in the east with perched, low gradient river systems that are insensitive to climatically driven changes in base-level. In contrast, the lower subsidence rates in the west are associated with a higher elevation basin topography, and entrenched river systems recording climatically induced lowering of river base-levels during the Holocene.