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Controls on valley-floor width across the Himalayan orogen

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Himalayan rivers transport approximately 10^3 Mt of sediment annually from their source in the steep topography of the High Himalaya to ocean basins. However, the journey from source to sink is not necessarily a smooth one: on the way, sediment can become trapped in montane storage systems, such as river valleys or floodplains. While sediment is stored in valleys, climate and erosional signals that we may wish to read from the final sedimentary record can be modified or even destroyed. We therefore need to understand the spatial distribution, volume and longevity of these valley fills. However, controls on Himalayan valley location and geometry are unknown, and sediment volume estimates are based on relatively untested assumptions of valley widening processes.

In this work we use a new method of automatically detecting valley floors to extract 1,644,215 valley-floor width measurements across the Himalayan orogen. We use this dataset to explore the dominant controls on valley-floor morphology, and to test models of valley widening processes. We use random forest regression to estimate the importance of potential controlling variables, and find that channel steepness, a proxy for rock uplift, is a first-order control on valley-floor width. We also analyse a newly compiled dataset of 1,797 exhumation rates across the orogen and find that valley-floor width decreases as exhumation rate increases. We therefore suggest that valley-floor width is adjusted to long-term exhumation, controlled by tectonics, rather than being controlled by water discharge or bedrock erodibility. We also hypothesise that valley widening predominantly results from sediment deposition along low-gradient valley floors, controlled by the ratio of sediment to water discharge, rather than lateral bedrock erosion.