Landscape Transience in Himalayan Syntaxial Catchments: Drainage Reorganization, Extreme Event Responses, and Numerical Modelling

Abstract

This thesis investigates how nonlinear interactions among tectonic uplift, climate, and surface processes operating across multiple temporal and spatial scales govern the evolution of Himalayan syntaxial landscapes. Focusing on the western Himalayan syntaxis traversed by the Upper Indus River and the eastern syntaxis traversed by the Yarlung–Siang River, the study addresses why these tectonic terminations sustain extreme relief, rapid exhumation, and persistent geomorphic disequilibrium. Using an integrated framework that combines quantitative geomorphic analysis, event-scale hydrological reconstruction, and numerical landscape evolution modeling, the research explicitly links discrete geomorphic events with long-term tectonic and climatic forcing. Geomorphic and stratigraphic reconstructions demonstrate that large-scale drainage reorganization, driven by differential uplift and crustal doming, produces long-lived landscape transience expressed through divide instability, knickzone persistence, and reconfigured sediment routing. Analysis of extreme floods in the Upper Indus shows that short-lived, high-magnitude events generated by interaction between the Indian Summer Monsoon and Western Disturbances exceed incision thresholds by orders of magnitude, causing rare events to dominate long-term erosion and challenging steady-state interpretations of channel metrics. Numerical modeling further reveals that focused uplift alone cannot reproduce observed syntaxial relief; only when coupled with transient, event-driven erosional efficiency and orographic precipitation gradients do models generate deeply incised gorges, asymmetric drainage networks, and extreme local relief. Collectively, the results demonstrate that Himalayan syntaxial landscapes emerge from nonlinear feedbacks among drainage reorganization, stochastic geomorphic perturbations, and coupled tectonic-climatic forcing, establishing a transferable process-based framework for understanding the evolution of high-relief orogenic systems.

Keywords: Drainage Reorganization: Extreme Events: Himalayan Syntaxial Catchment: Landscape Evolution.