Quantifying geomorphic change and forecasting channel shifts in the Kosi River Basin using integrated GIS and ARIMA-ETS-Prophet modelling

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The present study quantifies three decades of geomorphic change in the Kosi River Basin (1990–2024) and forecasts channel dynamics to 2050 using integrated geographic information systems (GIS) and time-series models: auto-regressive integrated moving average (ARIMA), exponential smoothing state space (ETS), and Prophet. Multi-temporal Landsat–Sentinel datasets across 43 cross-sections reveal progressive stabilisation, marked by declining sinuosity and confined migration. Of the three-modelling methods, Prophet achieved the lowest RMSE, accurately capturing non-linear channel evolution. Forecasts indicate reduced lateral activity (approx. 0.15 km yr^{-1}) and a 12%–18% decline in channel-width variability by 2050. The results demonstrate a transition toward a semi-confined, quasi-equilibrium regime and establish a replicable geomorphic forecasting framework for flood-prone alluvial systems.

Keywords: ARIMA model, exponential smoothing (ETS), geographic information system (GIS), Kosi River Basin, Prophet model, remote sensing

such as ARIMA and ETS are well established in hydrology and environmental sciences[8,9], yet their application to river morphodynamics has been limited. Prophet, a forecasting tool developed by Facebook, offers robustness against irregular trends and structural breaks[9] but has rarely been applied in fluvial geomorphology. Integrating multi-temporal GIS metrics with such statistical models presents a critical opportunity to predict channel shifts in data-sparse, avulsion-prone rivers like the Kosi.

The present study, therefore, focuses on a 189–212 km reach between Birpur and Kursela, characterised by high sediment flux, frequent avulsions, and dense floodplain settlements[10,11]. Using Landsat and Sentinel imagery[12], combined with gauge records, we derive morphometric indicators channel width, centreline migration, sinuosity index, meander ratio, and tortuosity across 43 fixed cross-sections between 1990 and 2024. These datasets are then used to evaluate ARIMA, ETS, and Prophet models for forecasting channel evolution up to 2050.

The research contributes in two ways: (i) it demonstrates the novelty of applying Prophet to forecast geomorphic change and channel migration in a Himalayan foreland river, and (ii) it generates bend-specific migration envelopes that provide actionable insights for adaptive embankment planning and dynamic floodplain zoning.