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Morphodynamical Behavior of the Ghaghara River (Bahraich–Tanda Reach), Central Ganga Plain, Northern India

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Abstract

The Ghaghara River, a major Himalayan tributary of the Ganga River, exhibits pronounced morphodynamical variability within its alluvial reaches of the Central Ganga Plain, Northern India. This study examines the morphodynamic behavior of the middle reaches of the Ghaghara River, specifically between Bahraich and Tanda, using remote sensing and field observations. Multi-temporal Landsat satellite imagery spanning 1975–2022, integrated with GIS-based analyses and detailed field observations were employed to quantify planform evolution, bankline shifting, and reach-wise morphodynamic responses. Quantitative bankline analysis indicates that left-bank migration ranges from 3.12 km to 4.22 km. In contrast, right-bank migration ranges from 3.37 km to 7.91 km, reflecting contrasting erosion and accretion patterns under changing hydrological conditions. The highest degree of channel instability is observed around the Rudauli–Goshainganj reach, where active meander expansion, cut-bank erosion, and point-bar accretion are dominant geomorphic processes. Sinuosity index range from 1.07 to 1.27 in Reach-A (Bahraich-Colonelganj), 1.10 to 1.24 in Reach-B (Colonelganj–Rudauli), 1.21 to 1.37 in Reach-C (Rudauli–Goshainganj), and 1.14 to 1.31 in Reach-D (Goshainganj-Tanda), with peak sinuosity generally recorded during the 1990–2020 period. Variations in channel length further indicate progressive meander development and localized cut-off events, particularly in Reach B (Colonelganj–Rudauli) and Reach C (Rudauli–Goshainganj).

Keywords: Ghaghara River, Channel migration, Channel sinuosity, Central Ganga Plain, India

Introduction

River migration across floodplains is a natural geomorphic process influenced by both natural anthropogenic factors, and this phenomenon is particularly characteristic of meandering and braided river systems, where channels undergo spatial and temporal shifts (Leopold *et al*., 1964; Yang, 1971; Randle, 2006; Pati *et al*., 2008; Chakraborty and Mukhopadhyay, 2015; Manjare, 2017; Manjunatha *et al.,* 2017; Kamble *et al.,* 2019; Kale and Deshmukh, 2020; Gupta *et al.,* 2020; Tiwari *et al.,* 2025). Such variations may involve two-dimensional changes, such as adjustments in channel planform, as well as one-dimensional changes in parameters like channel depth, width, and thalweg length (Wallick *et al*., 2006). In cases where river channels are incised, as in many rivers of the Central Ganga Plain, their migration is confined to their valleys (Shukla et al., 2012; Singh et al., 2019; Singh *et al.,* 2022; Yadav *et al.,* 2025). Channel migration is of particular significance to communities residing in or near floodplains, as well as to government agencies responsible for infrastructure development and management in these areas (Philip *et al*., 1989; Philip *et al*., 1991; Petropoulos *et al*., 2015). The fluvial architecture and channel patterns serve as sensitive indicators of migration dynamics, responding to variations in sediment load, hydrological regimes, and active tectonic processes (Goswami *et al*., 1999; Schumm *et al*., 2000; Pati *et al*., 2008; Singh and Awasthi, 2011; Shukla *et al*., 2012; Kanhaiya *et al*., 2019). Lateral migration of river banks often leads to asymmetrical channel positioning within the valley, driven by changes in sediment-water discharge (Yang *et al*., 1999; Schumm *et al*., 2000; Thakur *et al*., 2012). Such migration involves variations in channel width, sinuosity, and braiding intensity (Parua, 2002). These processes can cause extensive bank erosion, floodplain inundation, and displacement of populations residing near riverbanks (Singh, 1996; Shukla *et al*., 2001; Srivastava and Shukla, 2009; Prakash *et al*., 2019).

Particularly in India, numerous studies have documented the spatiotemporal dynamics of riverbank migration across various river systems (Srivastava and Singh, 1999; Mani *et al*., 2003; Swamee *et al*., 2003; Kotoky *et al*., 2005; Pati *et al*., 2008; Singh and Awasthi, 2011; Thakur *et al*., 2012; Chakraborty and Mukhopadhyay, 2015; Prakash *et al*., 2016; Debnath *et al*., 2017; Kanhaiya *et al.,* 2019; Arya and Singh, 2021; Gautam *et al*., 2024). In light of previous studies, this work focuses on analyzing channel

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