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Investigation on Behavior of *i*ntermittent Rivers and its Distinct Impact on landforms in Kalakankar Region of Uttar Pradesh, India

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ABSTRACT

The Kalakankar region is part of Ganga plain located in Pratapgarh district of Uttar Pradesh, India experiences a drastic and distinct geomorphic changes in landforms driven by the seasonal activity of intermittent streams. There are numerous streams mainly actives during the monsoon months and originated from nearby uplands and flow temporarily across the landscape, leaving behind noticeable landform changes such as erosion, sediment deposition, channel incision, and landform changes such as erosion, sediment deposition, channel incision, and landform incision, and landform modification. This study aims to investigate the localized geomorphic impacts of these seasonal streams using field-based methods. An intensive field survey have been conducted in order to identify geomorphic features such as rills, gullies, sheet erosion zones, depositional fans, and temporary channels were identified. In addition, soil sampling was undertaken across active streambeds and depositional zones to assess sediment type, grain size, and depth of deposition. Preliminary findings indicate that seasonal streams play a significant impact in the landscape of Kalakankar region and there is drastic change in topography along the intermittent streams

within short period of time features such as ephemeral gullies and silt-laden fans were commonly observed after heavy rainfall events, often cutting across village roads and farmland. Local interactions revealed that these geomorphic changes also influence land-use decisions, crop patterns, and infrastructure planning. This study indicates that short-lived seasonal water flows can perform geomorphic changes and play a dominant role in changing the shape of micro-landforms in low-gradient floodplain environments. It underlines the value of integrating field observation in order to suggest better land management planning and hazard mitigation strategies at micro level scale.

INTRODUCTION

Rivers show different flow characteristics depending on climate, relief, geology, and groundwater conditions. Based on flow continuity, rivers are generally classified as perennial, intermittent, and ephemeral. Among these types, intermittent rivers are those that do not flow throughout the year and remain active only during certain seasons. An intermittent river usually flows during the rainy season when rainfall and groundwater levels are sufficient, and it remains dry during long dry periods.

Several geographers have explained the concept of intermittent rivers. Strahler (1952) defined intermittent streams as those that flow only during wet seasons when the water table rises above the channel bed. Stamp (1961) described intermittent rivers as rivers that flow for part of the year, mainly during the rainy season, and remain dry during the dry season. Chorley, Schumm, and Sugden (1984) explained that intermittent rivers carry surface flow only at certain times depending on rainfall and seasonal hydrological conditions. According to Savindra Singh, intermittent rivers are seasonal rivers whose flow is mainly controlled by rainfall and limited groundwater contribution.

Intermittent rivers occupy a middle position between perennial rivers, which flow throughout the year, and ephemeral streams, which flow only for a short time after rainfall. Even though intermittent rivers do not flow continuously, they can perform significant geomorphic work during their active phases. Sudden monsoon flows often have enough energy to erode channel beds and banks, transport sediments, and deposit them over nearby floodplains.

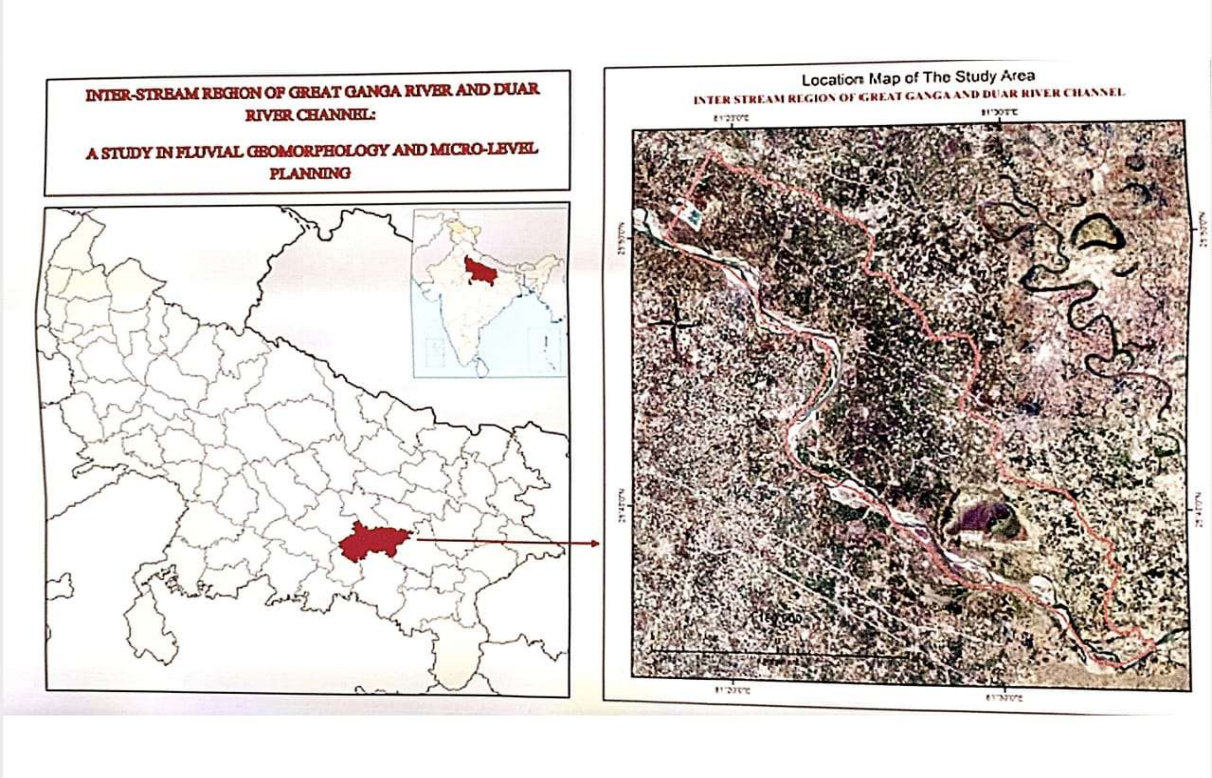
In India, intermittent rivers are widely distributed, especially in the Indo-Gangetic Plain where rainfall is highly seasonal. The Pratapgarh district of Uttar Pradesh lies in the Ganga Plain and is drained by several

rivers and seasonal streams. The Kalakankar region is influenced by rivers such as the Sai, Bakulahi, Duar, Chamraura, Loni, Sakarni, Naiya, and Paraiya. Except for the Sai River, which is largely perennial, most rivers in the region show intermittent flow behaviour and remain dry for a major part of the year.

For the present study, the Duar River has been selected. The Duar River is an intermittent river of the Kalakankar region and shows clear seasonal variation in flow. During the monsoon season, the river becomes active and causes erosion and sediment deposition, while during the dry season the channel remains inactive. The study aims to examine the behaviour of the Duar River and understand its role in shaping floodplain landforms in the Kalakankar region.

ABOUT THE REGION

The 'inter-river area of Ganga and Duar is mainly spread in Pratapgarh district of Uttar Pradesh state, whose latitudinal and longitudinal extension is from 25°35'8" North to 25°53'18" North and 81°19'15" East to 81°35'25" East respectively. The boundaries of this region are determined by the Ganga and Duar rivers and the water divide. Generally this area is a plain area but on the banks of Ganga and Duar rivers, rilles, gullies and badland topography can be seen. Generally this area is plain and lies within the upper Ganga plain but the flow of these rivers has given rise to various types of topographies. This arc is unclearly an independent entity on which no research has yet been done.



METHODOLOGY

The present study is based on an integrated approach using cartographic analysis, remote sensing, and field investigation. Topographical sheets obtained from the Survey of India were used to delineate the drainage network, basin boundary, and elevation characteristics of the Duar River basin. Satellite images supported the analysis of channel pattern, land use conditions, and floodplain features. Morphometric analysis was carried out using standard geomorphological methods to calculate linear, areal, and relief parameters of the basin. Field surveys were conducted twice, once before the monsoon season and again after the monsoon, to observe seasonal changes in channel form and sediment behaviour. Direct field observation was used to record channel width, bank profiles, sediment characteristics, rills, gullies, and depositional features. Cross-sectional analysis of the river was carried out at selected locations in the upper, middle, and lower reaches to understand variations in channel geometry. The combined use of maps, satellite data, and field observations ensured reliable interpretation of the intermittent behaviour of the Duar River and its associated landforms.

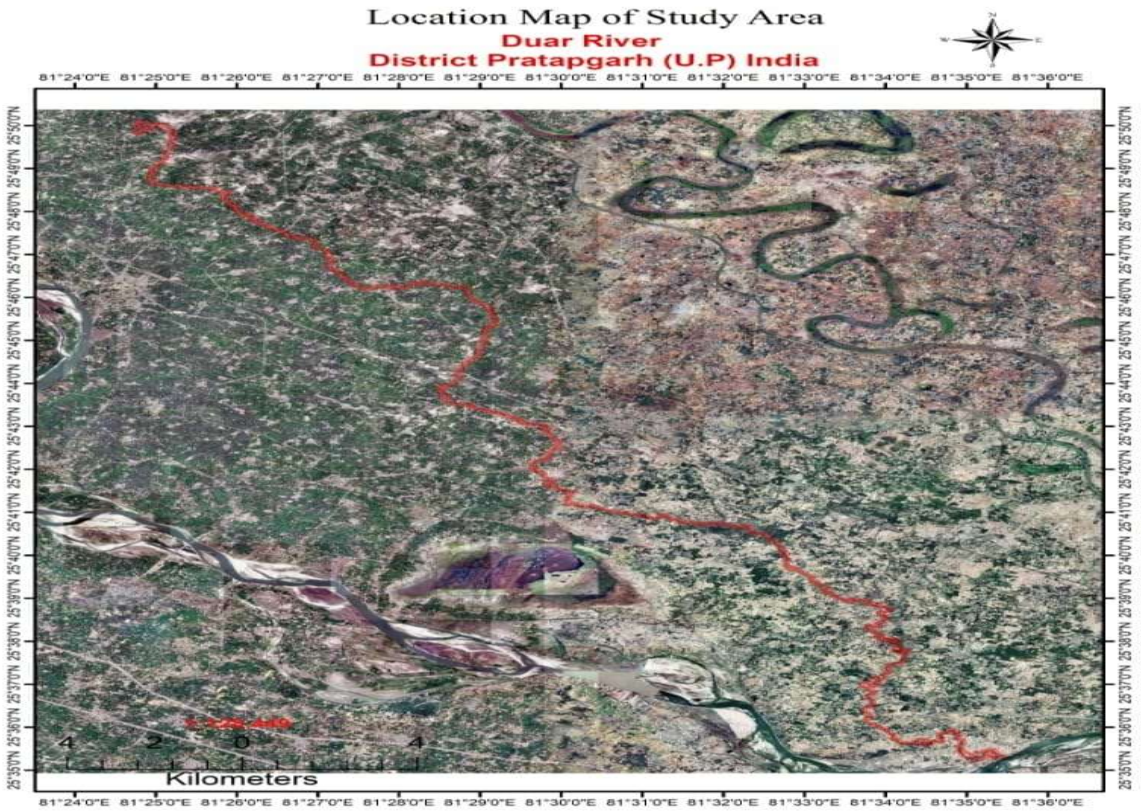
THE DUAR RIVER

The only tributary of the Ganga in this district is the Duar. It takes its origin in Reoli Tal and runs tortuously in a south-easterly direction nearly parallel to the Ganga, joining that river amid a network of ravines at the southern extremity of the district near Jahanabad. Between the Duar and the Ganga is a strip of upland bounded by the ravines which lead down to the river. These stretches are flat with crumbling edges and grow the characteristic crops of the loam tracts of the district. The Duar River is an important intermittent stream of the Kalakankar region in Pratapgarh district of Uttar Pradesh and forms a part of the middle Ganga plain drainage system. The river has a total length of about 55.2 km and drains a small but geomorphically active basin covering approximately 1.601 square kilometers. The channel width of the Duar River shows noticeable variation along its course, reflecting changes in discharge, slope, and sediment load. Near Reoli Tal, the river channel is relatively narrow, with an average width of about 10 meters, indicating limited flow conditions during most of the year. Downstream near Kunda, the channel widens to around 25 meters, suggesting increased runoff contribution and lateral erosion during the monsoon season. Close to its confluence with the Ganga River, the channel width is observed to be about 60 meters, while the average channel width of the river reach is approximately 32.8 meters, indicating localized widening caused by seasonal flooding and bank instability. Elevation data further highlight the downstream gradient of the river, with mean sea level values of about 124 meters near Riali, 110 meters near Kunda, and 107 meters near the Ganga confluence. This gradual decrease in elevation controls the intermittent flow behaviour of the river and plays a significant role in shaping erosional and depositional landforms along its course. The

Duar River ultimately contributes its seasonal discharge to the Ganga, influencing local floodplain dynamics and sediment redistribution in the lower reaches.

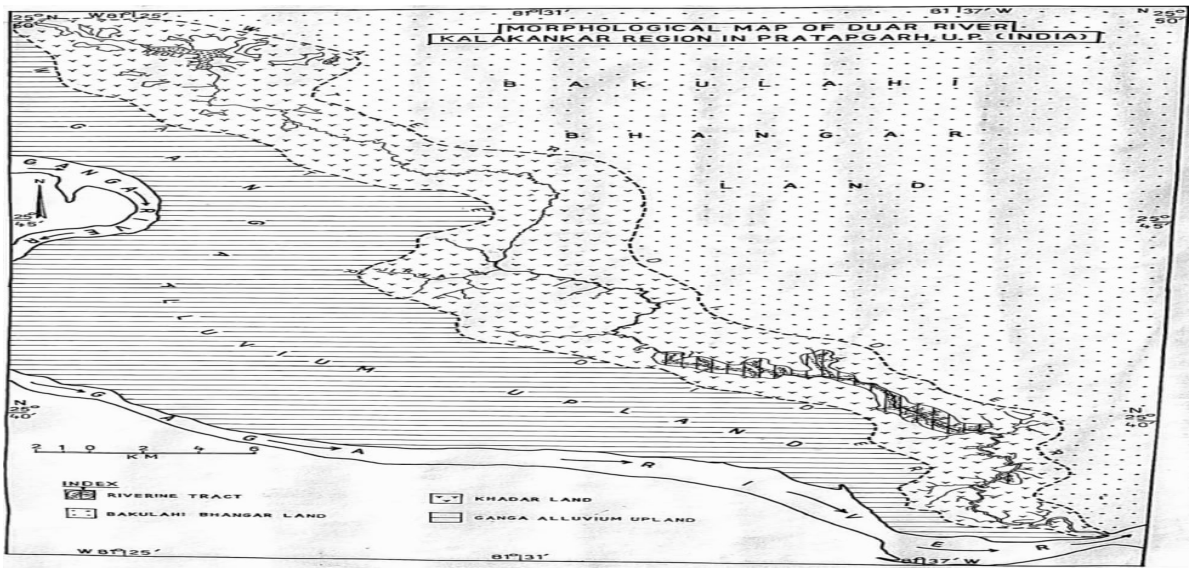
Table: Physical characteristics of the Duar River

Parameter	Location/Reach	Value
River length	Entire course	55.2 km
Drainage area	Duar River	1.601 km square
Channel width	Near Reoli Tal (upper reach)	10 m
	Near Kunda (middle reach)	25 m
	Near Ganga confluence (lower reach) Average channel width	60 m 32.8 m
Elevation(Mean Sea Level)	Near Reoli tal Near Kunda Near Ganga confluence	124m 110m 107m



MORPHOMETRIC ANALYSIS OF THE DUAR RIVER BASIN

Morphometric analysis of the Duar River basin was carried out to understand the drainage characteristics and basin behaviour of this intermittent river system. The analysis is based on Survey of India topographical sheets and manually prepared morphometric maps derived from detailed map interpretation and field verification. Standard morphometric parameters related to drainage network, basin geometry, relief, and drainage texture were calculated following established geomorphological methods. The results of the



morphometric analysis help in explaining the nature of surface runoff, degree of dissection, and the seasonal flow behaviour of the Duar River basin.

Morphometrical map of Duar river Kalakankar region in Pratapgarh ,U.P. (India)

Interpretation and Findings of Morphometric Analysis

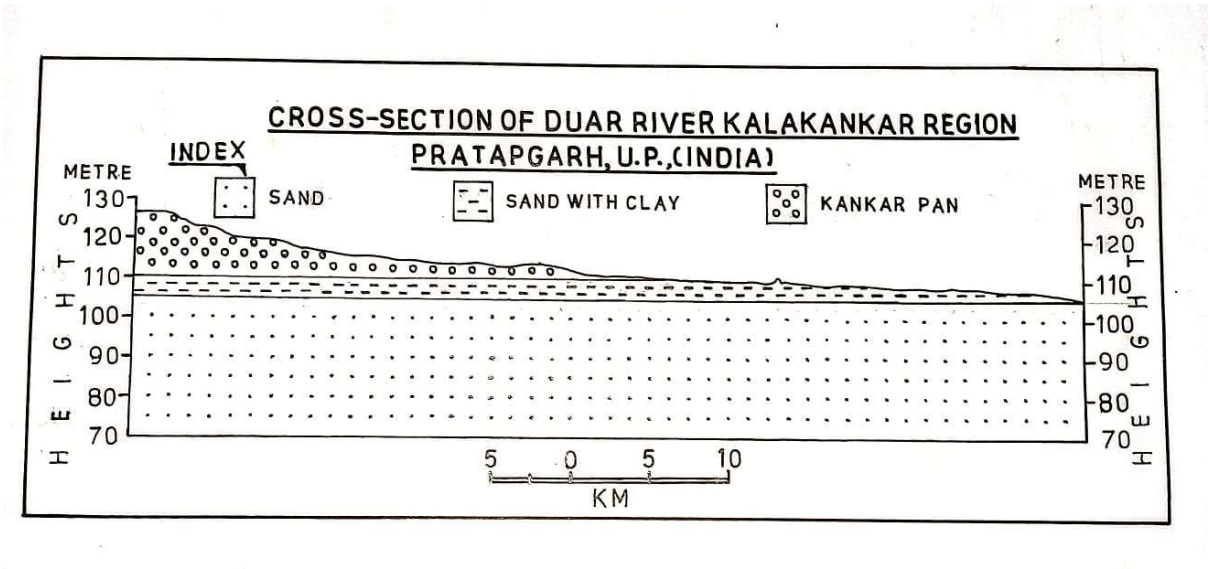
The morphometric parameters of the Duar River basin indicate that it is a low-order drainage system developed over a gently sloping alluvial surface. The third-order stream development and low total number of streams reflect limited drainage integration, which is typical of intermittent river basins. The bifurcation ratio value suggests that the drainage network is mainly controlled by natural surface conditions rather than strong structural disturbances.The basin geometry parameters show a moderately elongated basin shape with a moderate form factor, indicating delayed runoff response and lower peak discharge conditions. Very low drainage density and stream frequency values suggest high infiltration capacity and dominance of subsurface flow, which explains the seasonal nature of the Duar River. Relief parameters further confirm

low vertical erosion and dominance of lateral processes. Overall, the morphometric characteristics support the Duar River's intermittent behaviour and its limited but effective role in shaping local landforms.

CROSS- SECTION OF THE DUAR RIVER BASIN

Cross-sectional analysis of the Duar River was carried out at three representative locations: the upper reach near Reoli, the middle reach near Kunda, and the lower reach near the Ganga confluence. The upper reach exhibits a narrow, shallow channel with gently sloping sand banks and minor rills, reflecting limited vertical erosion and episodic monsoon flows. The middle reach shows a wider, deeper channel with asymmetrical banks and layered sediments, including sand, sand-clay mixtures, and kankar pans, indicating repeated deposition and lateral erosion. The lower reach features a broader floodplain with reduced depth, suggesting extensive sediment accumulation and slower flows. Overall, cross-section analysis demonstrates that the Duar River primarily undergoes lateral adjustment, sediment deposition, and floodplain development, consistent with its intermittent flow regime and role in shaping local landforms.

Cross- section of Duar river Kalakankar region Pratapgarh, U.P. (India)



Cross-sectional characteristics of the Duar river basin

Reach	Channel width (m)	Channel Depth (m)	Bank slope	Sediment type	Obeservation/ notes
Upper (reoli tal)	10	1.0-1.5	gentle	Loose sand	Narrow,shallow miner erosion
Middle (Kunda)	25	1.6-2.0	Moderate, asymmetrical	Sand with clay, kankar patches	Wider, lateral erosion dominant, layered sediments

Lower (Near Ganga)	16	2.0-2.5	Gentle, broad floodplain	Sand, silt	Reduced depth with floodplain, deposit dominant

The cross-sectional profiles indicate that the Duar River experiences limited vertical erosion but significant lateral adjustment. In the upper reach, the narrow and shallow channel shows minor rill development, while the middle reach exhibits lateral erosion with layered sediment deposition. The lower reach near the Ganga has a broader floodplain and reduced depth, reflecting sediment accumulation and backwater effects. These patterns confirm the intermittent flow regime and the river's role in shaping local landforms through seasonal sediment transport and bank modification.

DEVELOPMENTS OF LANDFORMS ALONG DUAR RIVER

The landforms associated with the Duar River develop in a distinct sequence that reflects the intermittent nature of the river and the seasonal rhythm of the monsoon. Although the river remains dry for a major part of the year, the geomorphic imprint left by short-duration monsoon flows is clearly visible across its valley and floodplain. The development of landforms can be understood as a series of interconnected events beginning in the upper reaches and ending at the confluence with the Ganga River.

Pre monsoon picture

Post monsoon picture

Initiation of Surface Erosion: Rills and Minor Gullies

The first geomorphic response to monsoon rainfall in the Duar basin is the development of rills on upland slopes and cultivated fields in the upper valley. These rills form due to concentrated surface runoff over bare or sparsely vegetated surfaces. Initially shallow and discontinuous, the rills gradually deepen and extend downslope as rainfall intensity increases.With repeated rainfall events, several rills merge to form minor gullies. These gullies act as efficient pathways for runoff and sediment transfer toward the main channel. Field observations show that rill and gully development is more pronounced in areas where natural vegetation has been reduced due to agricultural activity.

Rills formation by river

Soil Profiles on Banks and Exposure of Subsurface Materials

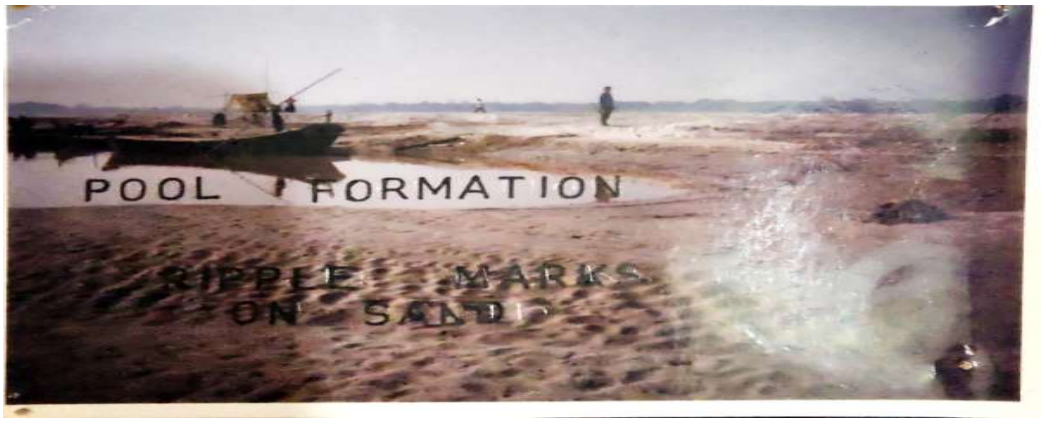
As runoff and channel flow intensify, lateral erosion along the river banks leads to the exposure of distinct soil profiles. These profiles commonly show layered alluvial deposits consisting of fine sand, silt, and clay. In several locations, erosion has exposed compact layers of gravels and kankar pan, indicating older depositional phases of the floodplain

Soil profile of duar river

The presence of kankar layers influences local erosion patterns by increasing resistance to vertical erosion while promoting lateral erosion. This contrast in material strength contributes to irregular bank morphology and uneven channel widening.

Pool Formation and Channel Bed Modification

During peak monsoon flow, the Duar River develops a series of shallow pools along its channel bed. These pools form mainly in widened or slightly deeper sections where flow velocity decreases. Pool formation plays an important role in temporary water storage and sediment trapping during active flow periods.



Pool formation by Duar river

As discharge declines after rainfall events, fine sediments settle within these pools, while coarser materials remain exposed. In the dry season, many of these pools become isolated or completely dry, leaving behind sediment patches that are reworked during the next monsoon.

Parallel Retreat and Slope Replacement along Valley Sides

One of the noticeable geomorphic processes along the Duar River is parallel retreat of valley sides. Continuous bank erosion and mass wasting cause the valley slopes to retreat laterally rather than deepen vertically. Over time, steep banks are replaced by gentler slopes through slope replacement processes.

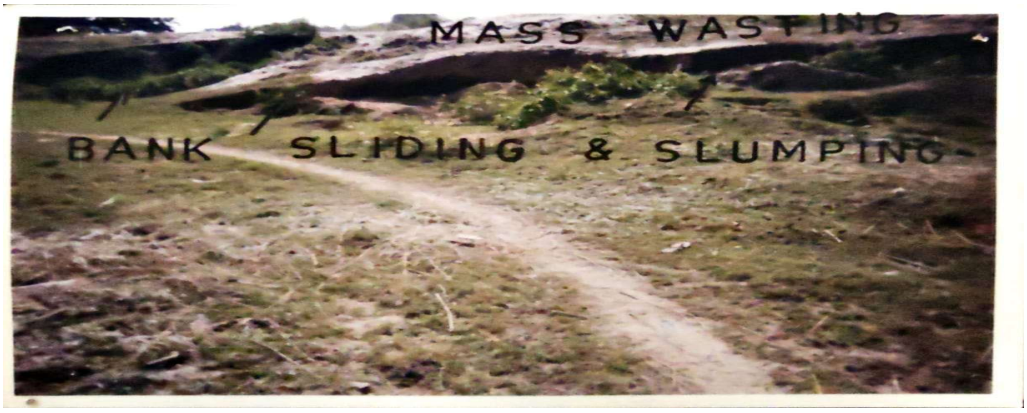
Parallel retreat and slope replacrment

This gradual widening of the valley floor results in the expansion of floodplain surfaces and increased accommodation space for sediment deposition. Parallel retreat is particularly evident in middle reaches where bank materials are loose and vegetation cover is limited.

Mass Wasting: Bank Sliding and Slumping

Mass wasting processes such as bank sliding and slumping are commonly observed along the Duar River, especially after heavy rainfall. Saturation of bank materials reduces cohesion and triggers sudden failure of bank sections. Slumping occurs where thick alluvial deposits overlie weaker layers, leading to rotational movement of soil blocks into the channel.

These mass wasting events supply large volumes of sediment to the river in a short time and contribute significantly to channel widening and instability. Field observations indicate that slumping is more frequent near bends and in areas affected by human disturbance.



Bank slinding and slumping

Sedimentation Sites and Floodplain Deposition

As the Duar River moves downstream, flow energy decreases and sediment load is deposited over floodplain surfaces. Sedimentation sites are commonly observed in the form of silt fans, floodouts, and overbank deposits. These features develop when the channel loses confinement and spreads across low-gradient floodplain areas.

Fine sediments carried from upper reaches are deposited over agricultural fields and low-lying areas, often altering micro-topography. While these deposits enhance soil fertility in some areas, they also create management challenges for local communities.

Vegetation Recovery and Seasonal Stability

After the monsoon season, vegetation gradually recolonizes abandoned channels, banks, and depositional surfaces. Grasses and seasonal crops help stabilize loose sediments and reduce erosion during minor rainfall events. However, this stability remains temporary, as the next monsoon cycle reactivates erosion and

sediment transport.Vegetation thus plays a seasonal role in controlling geomorphic processes, contributing to the cyclic nature of landform development along the Duar River. Type equation here.

Vegetation of the area

Downstream Integration and Confluence with the Ganga River

In its lower course, the Duar River gradually loses its individual channel identity and becomes integrated into the broader floodplain of the Ganga River. Reduced gradient and declining flow energy lead to extensive sediment deposition before confluence. During the monsoon, the Duar River acts as an important sediment-carrying tributary, discharging its seasonal flow and sediment load into the Ganga.

The Duar and Ganga river confluence

This confluence represents the final stage of geomorphic adjustment, where materials eroded from the upper and middle reaches are transferred to the main river system. The Duar River, despite its intermittent nature, thus plays a significant role in connecting local geomorphic processes of the Kalakankar region with the larger fluvial dynamics of the Ganga basin.

Discussion

The findings of the study reveal that the Duar River, as an intermittent stream in the Kalakankar region, exhibits a clear seasonal variation in flow and a strong influence on local landform development. Morphometric analysis indicates a low-order drainage system with limited stream segments, low drainage density, and gentle basin slope, which collectively control the flow dynamics and sediment transport of the river. The river's channel width and cross-sectional profiles vary along its course, reflecting differential erosion and deposition; narrower channels in the upper reaches indicate limited runoff, while wider sections near Kunda show enhanced lateral erosion and sediment redistribution during the monsoon. Observed landforms, including rills, gullies, pool formation, bank slumping, sedimentation sites, and vegetation-controlled micro-channels, highlight the dynamic interplay between hydrology, sediment supply, and channel morphology. The seasonal high-energy flows during the monsoon promote lateral channel adjustment, bank retreat, and sediment deposition, while dry-season inactivity leads to temporary stabilization of floodplain surfaces. The river ultimately integrates with the Ganga, transferring its sediment and water, demonstrating that even short-lived intermittent flows significantly shape floodplain morphology and contribute to the geomorphic evolution of the middle Ganga plain.

Conclusion

The study of the Duar River demonstrates how even short-lived, intermittent streams can play a major role in shaping local landscapes. Despite its limited flow duration, the river actively influences floodplain morphology by controlling sediment redistribution, bank dynamics, and channel patterns. The morphometric characteristics of the basin—low drainage density, gentle slope, and small catchment area—explain why flow is seasonal and why lateral erosion predominates over vertical incision. Field observations and cross-sectional analyses reveal that natural processes like pool formation, rill and gully development, and bank slumping combine with monsoon-driven flows to gradually modify the valley and floodplain. Furthermore, the Duar River's contribution to the Ganga highlights the interconnectedness of small tributaries and major river systems in sustaining sediment balance and floodplain evolution. Overall, the study emphasizes the importance of understanding intermittent rivers for geomorphic assessment, flood management, and sustainable land-use planning in the Ganga plain.

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