IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402, p- ISSN: 2319-2399.Volume 19, Issue 4 Ser. 1 (April 2025), PP 15-25
www.iosrjournals.org

Channel Morphology And Human Interventions: A Decadal Study Of The Noai River, West Bengal

Pritam Sarkar, Chandan Surabhi Das, Ratna Khoso
Department Of Geography, West Bengal State University, Barasat, India
Department Of Geography, Darjeeling Govt. College, Darjeeling, India

Abstract
This study investigates the morphological evolution of the Noai River, West Bengal (2015–2024), studying the interplay between natural processes and human interventions. Methodologically, cross-sectional surveys at nine sites were undertaken using theodolite tacheometry, supplemented by geographic distribution analysis of channel width, depth, and width-depth ratios to characterize morphological diversity. Results reveal spatially heterogeneous adjustments: active erosion dominated upstream reaches, evidenced by channel widening and localized deepening (up to 1.8 m), whereas mid-reaches suffered aggradation (exceeding 1.5 m) due to flow stagnation and trash dumping. Downstream, silt extraction and bank collapse drove extensive widening (up to 3 m). Human activities appeared as significant drivers—dredging deepened thalwegs by 0.7–2 m at regulated sites, whereas waste dumping and urbanization enhanced sedimentation and bank instability. Notably, bank concretization at Deara Pole alleviated alterations, showing the usefulness of structural reforms. The data indicates that width-depth ratio trends correlate substantially with anthropogenic stresses, particularly around metropolitan hubs. Spatial approaches proved useful in separating human impacts (e.g., rubbish dumping, sediment mining) from natural erosional-depositional cycles. Discussion highlights that unrestrained urbanization and resource extraction have eclipsed fluvial dynamics as key change factors. The report calls for adaptive management measures, including targeted dredging, waste restriction, and restoration of hydrologically vulnerable zones. These findings provide a framework for reconciling anthropogenic pressures with fluvial sustainability in subtropical river basins.

Keywords: *Noai River, Channel Morphology Anthropogenic Impacts, Urbanization, Erosion and Sedimentation*

Date of Submission: 25-03-2025 Date of Acceptance: 05-04-2025

I. Introduction

In recent years, rivers have gained more attention due to rising water scarcity and anthropogenic activities, including agriculture, urban development, and industrial operations, are becoming the dominant contributors to change the river morphology [2, 25]. In regions such as West Bengal, rivers are not only essential for sustaining daily livelihoods [14] but also serve as vital sources of water for agriculture and industry (Central Pollution Control Board [CPCB], 2020). River Noai is one of the major River north 24 parganas [7], but currently the river is facing a lot of challenges for survival due to rapid urbanization and industrialization alongside of its banks [6]. The river started from Borti bill near Barrachpore and ends up to its confluence with Bidyadhari river near Haroa tidal creek. The length of Noai from its source Borti bill to its confluence with Bidyadhari is 28.95 km (Figure 1). Through the journey of its source to its confluence Noai crosses 5 major municipal areas, which causing a threat to its ecosystem and overall health because of the untreated waste dumping and excavation of alluvium for brick making [23]. Since the problem under investigation is related to dumping of solid wastes into the river and the impact of human intervention on channel morphology [19], studious works on this river have referred. Bhadra et al [1] stated that rivers like Noai, Suti, Icchamati etc are getting detached from its source and most of the rivers are in danger of anthropogenic activities, because most these river's courses have been transformed into agricultural fields and encroached by fisheries in their lower reaches. Kalyan Rudra (2014) [12] stated that the natural flow regimes of the Noai, Sunti, and Bidyadhari rivers have been frequently disrupted by human activities [4], with riverbeds being encroached upon in several areas [23]. This has resulted in scattered stagnant water pools, causing waterlogging, particularly during the monsoon season [27].

The channel of river Noai under consideration represents a case of channel disturbance with response to human interventions [5]. The human intervention in terms of transforming river banks into agricultural lands, dumping solid wastes directly into the river [41] and alluvium excavation for brick making activities have occurring at a decent scale in some areas of lower part along River Noai [11]. Recently humans have emerged as a very important geomorphic agent and is capable of changing the earth's surface, much faster than many of the natural processes [2]. Human activities have significantly stressed global systems, driving major landscape transformations, particularly in fluvial and coastal areas impacted by settlements and mineral extraction [19]. Loss of alluvial terrace and flood-plain deposits has an adverse effect on agriculture and other riparian-zone-land uses [24]. In the study area, hydraulic geometry and cross-sectional characteristics of the river Noai is influenced by natural processes of fluvial systems and human interventions too. This intervention would be viewed positively as well as negatively. Plantation of thick vegetation alongside of channel, possibly to protect agriculture land, may cause a slow shift to the opposite side causing erosion on the other side of the channel bank leading to change in cross section. Therefore, it is necessary to study the variation in cross sections and morphological characteristics of the channel in response to human intervention [25]. Therefore, the present study aims to analyses the effect of human interventions on channel morphology, channel behaviour and cross sections.

II. Materials And Methods

Study Area

The Noai river basin in North 24 Parganas district spans latitudes 22^0 47’54’’N to 22^0 37’41’’N and longitudes 88^0 25’34’’E to 88^0 32’35’’E. The river is approximately 31.7 km long and acts as a spill channel for the Hooghly River, receiving water from the Ichapur canal. It originates at Bartirbeel and flows south through Sahapur, Nilganj, Taldharia, and Madhyamgram, before reaching the Haroa tidal creek.

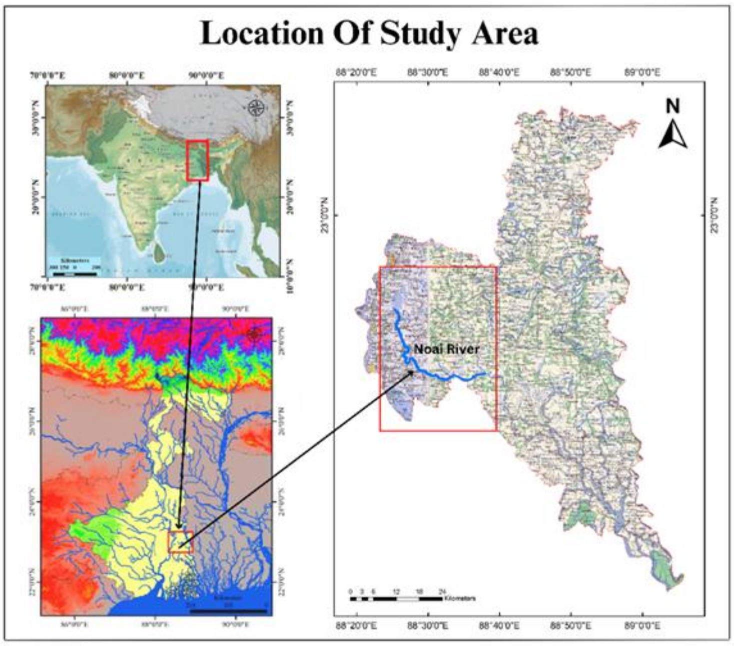


Figure 1. *Location Map of Noai River.*

Data Collection and Cross-sectional Analysis

Nine cross-sectional sites were chosen on the Noai River (Figure 2), with all locations positioned along the river's main channel. The area surrounding these stations had different land use trends. A complete description of each site, together with the coordinates of the sample collection spots, is presented in Table 1.

Table 1. *Showing Location Details and Site Description.*

Sampling station	Coordinate of the sampling station		Site description
	Latitude	Longitude	
S1 (Sahapur)	22° 46' 28"	88° 25' 33"	Located in the upstream near Bortir bil, mainly consisting of agricultural areas and swamps
S2 (Nilganj)	22° 45' 25"	88° 25' 48"	Located near market area surrounding by small residential zones
S3 (Taldharia)	22° 42' 31"	88° 26' 15"	Located in an industrial area, mainly dyeing industry discharging effluents directly into the river
S4 (Madh-yamgram)	22° 41' 34"	88° 27' 04"	Located in an urban area, most populated and, active untreated municipal sewage dumping in the river
S5 (Ganganagar)	22° 40' 19"	88° 27' 19"	Located in an urban area, most populated and, active untreated municipal sewage dumping in the river
S6 (Motir Pole)	22° 40' 05"	88° 27' 31"	Located in a urban area, most populated and, active untreated municipal sewage dumping in the river

Sampling station	Coordinate of the sampling station		Site description
	Latitude	Longitude	
S7 (Deara Pole)	22° 38' 12"	88° 29' 17"	Located in a peri-urban area, slaughter house located, active untreated municipal sewage dumping in the river
S8 (Langolpota)	22° 37' 38"	88° 30' 37"	Located in a village area, less populated but active solid waste dumping spotted.
S9 (Kharibari)	22° 37' 24"	88° 33' 54"	Located near confluence zone, very less population.

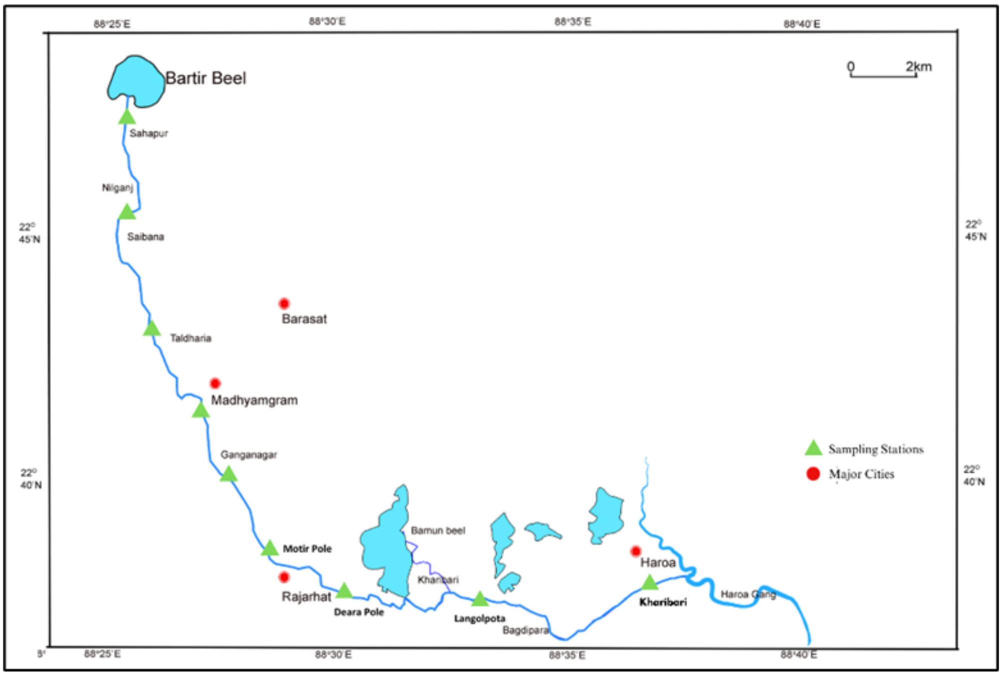


Figure 2. *Showing 9 cross-sectional Sites Along the Noai River.*

Theodolite Tacheometry
Instrumentation

To measure the cross-sectional dimensions of the Noai River, a theodolite and measuring staffs were employed [20]. This choice of instrumentation was driven by the unique characteristics of the Noai River and the specific requirements for precise and reliable data collection. The Noai River, being a small peri-urban river with dynamic flow regimes and irregular cross-sectional morphology, presented significant challenges for conventional survey instruments like Total station. The river's narrow channel width, variable depth, and irregular bed profile and presence of water hyacinth in the water required a tool capable of handling fine-scale measurements with a high degree of precision [39]. The theodolite is renowned for its exceptional accuracy in angular measurements, making it ideal for capturing both horizontal and vertical angles needed for cross-sectional surveys. Unlike modern electronic distance measurement (EDM) tools or total stations [36, 37] the theodolite's ability to operate without reliance on uninterrupted laser sightlines or GPS signals was crucial in a riverine environment with frequent obstructions such as vegetation and tidal influences. Also, the tacheometry picked over current Total Station systems due to site-specific logistical restrictions. While Total Stations offer higher precision (±2–5 mm accuracy) via EDM, their utility was restricted in this investigation by the vertical range of the reflector prism (1.5 m maximum height). In contrast, theodolite tacheometry employs stadia rod readings, enabling vertical measurements up to 6 m using a graded staff. This capacity was crucial for surveying steep, unstable banks (e.g., at Langolpota and Haroa) where reflector deployment at higher altitudes (>1.5 m) was problematic due to unstable terrain or extensive riparian vegetation. Importantly, unbroken laser sightlines a need for Total Stations were damaged at several sites (e.g., Nilganj, Taldharia) by rubbish dumping and urban expansion. Theodolite tacheometry's dependence on direct stadia rod sightings avoided these impediments. While admitting the trade-off in precision, the methodology prioritized vertical reach, adaptability to occluded sightlines, and operational feasibility in logistically complex locations. By combining the theodolite's precision with the practicality of measuring staffs, this methodology effectively addressed the challenges posed by the Noai River's unique characteristics [10]. This approach ensured that even small-scale variations in the river's morphology were accurately captured, contributing to the robustness of the analysis.

Data Collection Procedure

The data collection procedure was meticulously designed to ensure accurate and reliable measurements of the

Noai River's cross-sectional dimensions. This involved careful site selection, precise station setup, and methodical measurement processes as described below. Cross-sectional surveys were conducted along nine systematically selected sites, each defined as a transect perpendicular to the river's dominant flow direction, verified using a GPS data. Sites were separated at approximately 1.5 km to 2 km intervals, favouring locations with visible historical morphological changes (identified via 2015–2024 satellite imagery), proximity to anthropogenic activities (e.g., waste dumping, dredging zones), and hydraulic diversity (e.g., changing channel geometry). To maintain uniformity, cross-sections were orientated perpendicular to flow by setting the theodolite's horizontal circle to 90° from a 30 m baseline built parallel to the river. Staff positions were spaced at 2 m intervals, tightened to 1 m at important features (e.g., bank margins, thalweg, undulations) pre-identified through walkover survey. Undulations, were identified with GPS coordinates and reflective stakes during preliminary field survey. Horizontal angles were measured relative to a north-aligned baseline, corrected for local magnetic declination, while vertical angles were calibrated daily against a set benchmark. Discrepancies exceeding 0.15 m in elevation triggered resurveys. This procedure ensured replicability while balancing resolution and fieldwork efficiency, complying to ASTM D5613-20 criteria for dynamic river systems. This structured approach to data collection allowed for high-resolution and reliable cross-sectional profiles of the Noai River, forming a robust dataset for tacheometric analysis. This approach ensured that the cross-sectional data captured the heterogeneity of the river system. The structured approach to data collection allowed for high-resolution and reliable cross-sectional profiles of the Noai River, forming a robust dataset for tacheometric analysis.

Data Calculation Using Tacheometry

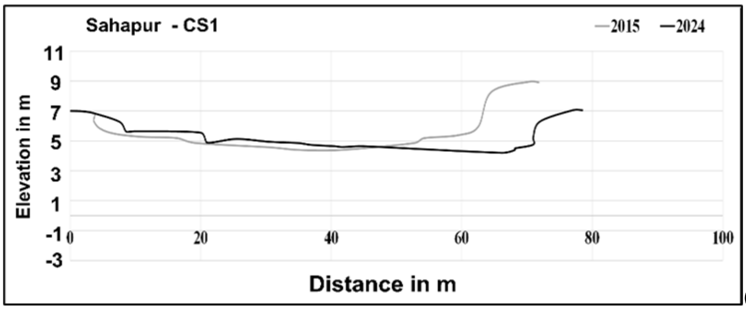
The data collected from the field was processed using tacheometric principles to calculate horizontal distances, vertical elevations, and cross-sectional profiles of the Noai River [6]. The calculated horizontal distances (D) and corrected vertical elevations (V) were used to plot cross-sectional profiles for each site. These profiles depicted the relative heights and spatial arrangement of the riverbanks, riverbed, and any intermediate features. The resulting diagrams highlighted variations in bank slope, bed morphology, and channel geometry. This detailed representation allowed for an in-depth analysis of the Noai River's physical characteristics, providing essential data for understanding its cross-sectional changes. Cross-sectional elevations were referenced to a fixed vertical datum to guarantee consistency across all sites. The datum elevation was defined as the mean sea level (MSL) benchmark established by the Survey of India (Toposheet No. 78B/12), with a known elevation of 12.45 meters above MSL at the Ganganagar reference station. At each survey site, a temporary benchmark (TBM) was created on stable ground (e.g., concrete embankments or bedrock outcrops) and connected to this primary datum using differential leveling. All elevation values (e.g., riverbed depth, bank height) were recorded as real elevations relative to MSL, with "zero elevation" in cross-sectional profiles matching to the riverbed's lowest position at each location during the 2015 baseline survey. This approach ensured temporal comparability, as later assessments (2024) measured aggradation or degradation compared to the 2015 reference [35]. Horizontal coordinates were georeferenced using, whereas vertical altitudes were estimated with theodolite tacheometry, calibrated daily against the TBM to avoid instrumental drift. Elevation uncertainties (±0.12 m) were assessed through repeated measurements at control positions and validated against RTK-GPS data (Trimble R8, ±0.02 m vertical accuracy) at three sites. This stringent elevation framework enables exact detection of meter-scale morphological changes while retaining compliance with regional hydrographic norms.

III. Results

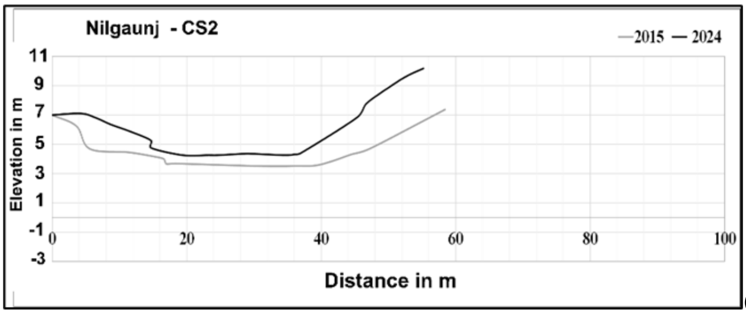
Cross-sectional Characteristics of Noai River

The comparative analysis of the nine cross-sectional profiles of the Noai River, obtained in 2015 and 2024, indicates considerable changes in the channel's shape throughout this period. A total of 18 cross sections have been taken. All 18 cross-sections have been drawn for each of the surveys and these have been superimposed to detect the changes in the cross-sectional features of the channel. On average, these cross sections are taken at an interval of 2000 m. However, they are not necessarily equi-spaced. Each location displays significant changes in channel depth, width, and bank stability. Cross sections were taken in locations with considerable changes.

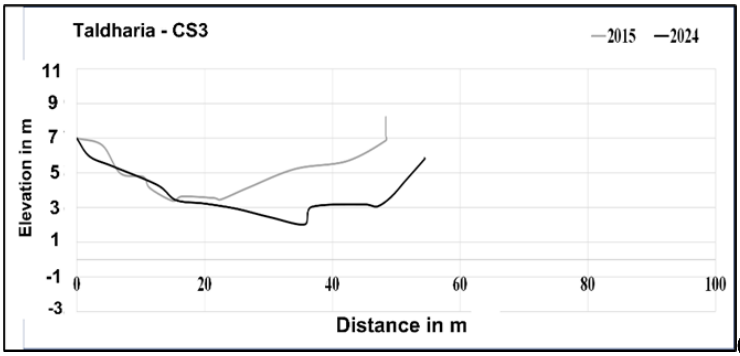
At Sahapur (CS1), the cross-section suggests an expansion of the river channel, accompanied by a noticeable deepening near the right bank (Figure 3a). In 2015, the channel had a rather consistent depth profile, but by 2024, the right bank had shown signs of erosion, leading to an asymmetrical profile. The depth near the right bank increased by roughly 0.8 meters (Table 2). The profile at Nilganj (CS2) displays major alterations, particularly along the right bank, where erosion has steepened the slope considerably. In contrast, the left bank has remained reasonably steady, with some modest deposition recorded. The overall channel depth fell by around 0.25 meters in the middle section, while the depth declined near 1.2 meters. The breadth of the channel remains more or less the same. Taldharia (CS3) displays one of the most substantial modifications across all locations. The central segment of the channel has deepened by roughly 1.5 meters (Figure 4c), and the overall width has expanded by approximately 6 meters. The left bank indicates depositional activity, while the right bank reveals substantial erosion. The cross-section at Madhyamgram (CS4) reveals a unique pattern of aggradation in the center area of the channel, where bed elevation has grown by roughly 0.9 meters since 2015 (Figure 4d). This is the narrowest part of the river, with an average width of roughly 40 meters. The width has stayed unaltered due to the presence of the Madhyamgram railway bridge. However, the right bank has experienced considerable deposition, increasing the height of the right bank by nearly 2 meters (Table 2). At Ganganagar (CS5), the river channel displays mild modifications, with a slight increase in both width (about 2 meters) and depth (0.7 meters) (Figure 4e). The left bank is essentially untouched, whilst the right bank indicates evidence of erosion. Motiprole (CS6) reveals considerable modifications, with the channel deepening by almost 1.8 meters and broadening by around 5 meters. The right bank has degraded dramatically, while the left bank remains stable. Deara Pole (CS7) shows little modifications, with steady channel width and a slight 0.3-meter aggradation along the left bank. Langalpota (CS8) displays considerable alterations, with the right bank facing extensive erosion, resulting to a steepened profile. The central segment of the channel has deepened by roughly 1.4 meters (Figure 4h), and the overall width has risen by nearly 5 meters. Deposition along the left bank has caused a more uneven cross-section compared to 2015. At Kharibari (CS9), the channel has deepened by about 1.6 meters and widened by nearly 7 meters. Erosion is severe on the right bank, whereas the left bank exhibits silt accumulation.



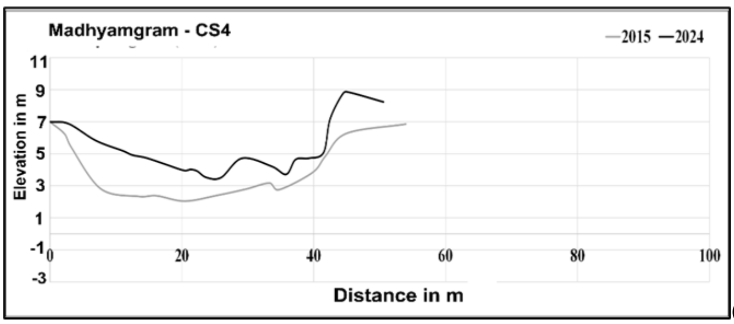
(a)



(b)



(c)



(d)

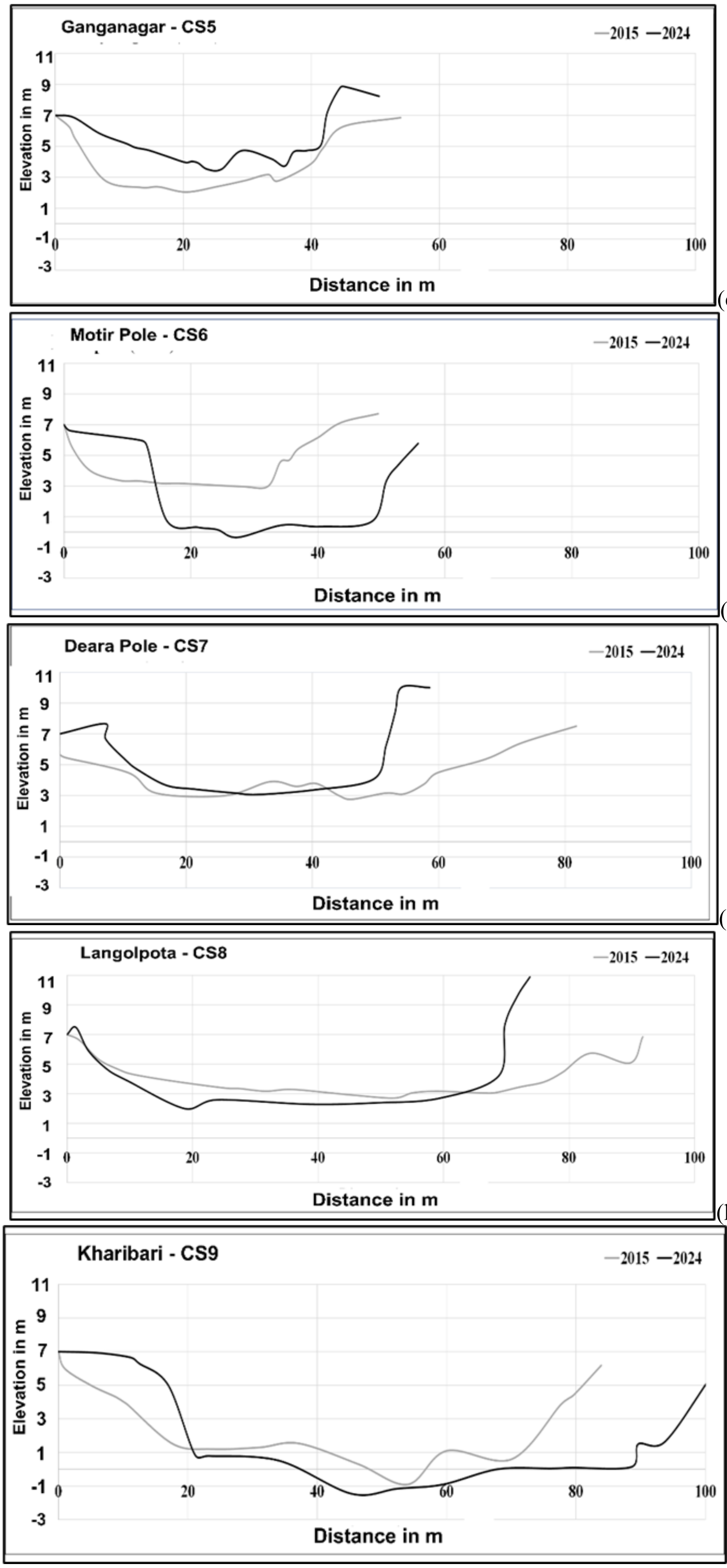


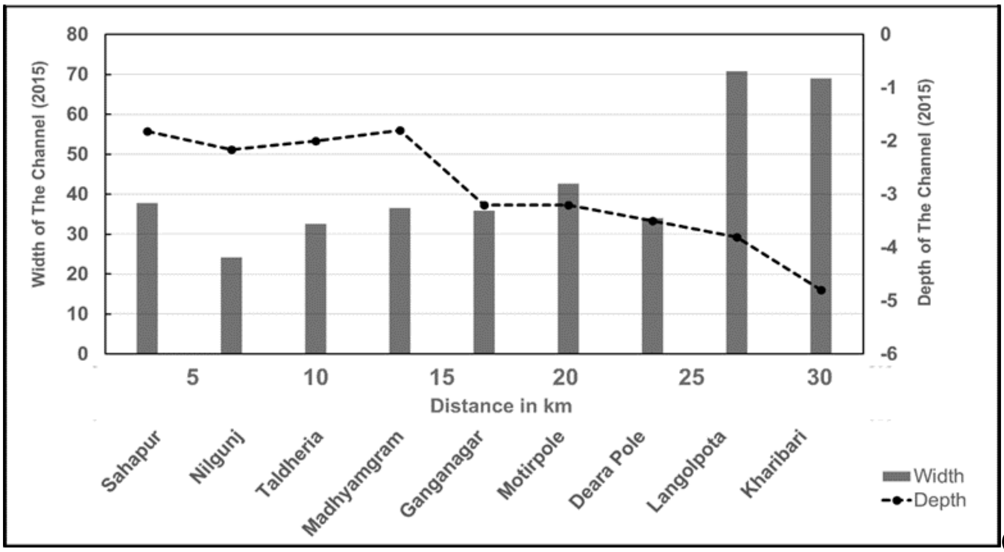
Figure 3. *Showing cross sectional changes between 2015-2024 of Noai river.*

Table 2. *The cross-sectional changes of Noai river between 2015 – 2024.*

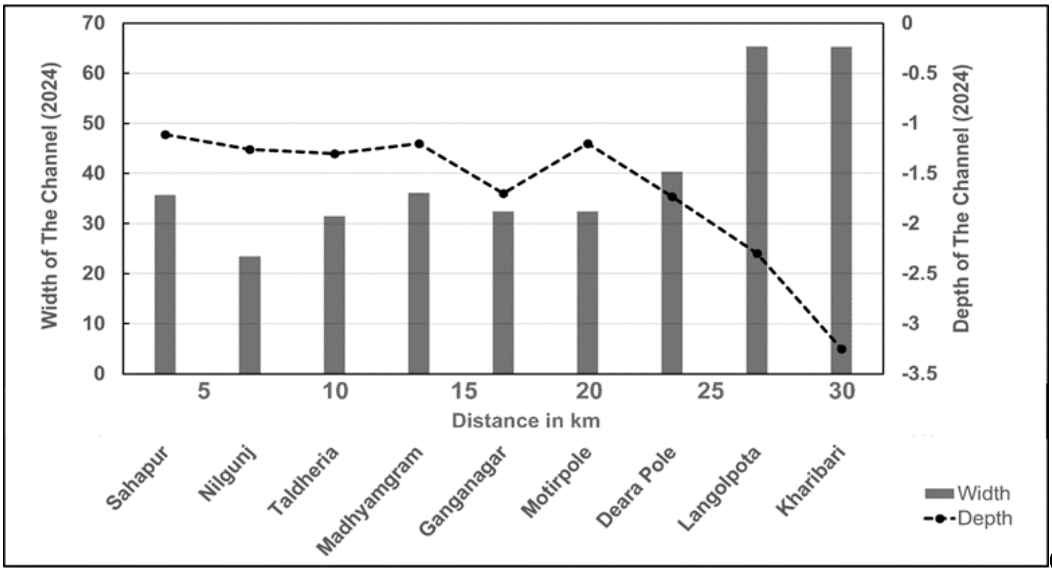
Station name	Cross-section	Bed of slope (s)	Depth of channel (D)		Bed width of channel (B)		Cross-sectional area (A)		Wetted perimeter (P)		Hydraulic mean depth (R)	
			2015	2024	2015	2024	2015	2024	2015	2024	2015	2024
Sahapur	1	0.0003	0.82	0.78	37.81	38	20.84	21.45	38.64	41.03	0.54	0.63
Nilgunj	2	0.0003	0.16	1	24.25	24.46	2.31	19.83	24.39	25.75	0.09	0.77
Taldheria	3	0.0003	1.6	1.4	15.59	31.49	7.02	16.53	15.74	32.22	0.45	0.51
Madhyamgram	4	0.0003	2	1.2	36.56	26.76	90.51	13.26	40.65	28.66	2.23	0.46
Ganganagar	5	0.0003	3.2	1.7	25.88	32.42	62.31	24.81	27.86	33.73	2.24	0.74
Motirpole	6	0.0003	3.2	1.2	32.68	32.38	232.58	20.92	54.45	32.5	4.27	0.64
Deara Pole	7	0.0003	2.7	2.26	58.74	39.31	105.79	62.72	61.52	41.7	1.72	1.5
Langalpota	8	0.0003	2	2.3	70.79	65.35	90.56	190.19	72.39	69.96	1.25	2.72
Kharibari	9	0.0003	4	2.25	68.95	65.26	983.83	77.19	111.02	66.22	8.86	1.17

Spatial Distribution of Channel Width and Depth in the Noai River

The Noai River exhibits significant spatial variations in 2015 (Figure 4a) in its channel width and depth across different stations. Upstream, at Sahapur, the width is around 37.8 m with a depth of -1.82 m, while at Nilgunj, the width narrows to 24.25 m and the depth decreases to -1.26 m, indicating sediment deposition. Midstream, at Madhyamgram and Ganganagar, the widths are relatively stable at 36.16 m and 35.88 m, with depths of -1.2 m and -1.7 m, reflecting moderate flow conditions. Downstream, the channel widens significantly, particularly at Langalpota (width 70.79 m, depth -2.3 m) and Kharibari (width 68.95 m, depth -4.8 m). These trends indicate that downstream sections experience both lateral erosion and scouring, with Kharibari showing the deepest channel due to concentrated flow. Overall, the widening and deepening patterns reflect the interplay of sediment deposition upstream and increased flow velocity downstream, influenced by both natural processes and anthropogenic factors [33]. In 2024 (figure 4b), the width and depth of the Noai River show distinct variations across the surveyed stations. The channel width is narrowest at Nilgunj, measuring approximately 24.25 m, followed by Taldharia at 33.21 m, while stations like Madhyamgram and Ganganagar have moderate widths of 41.35 m and 42.63 m, respectively. Further downstream, the width slightly increases at Motipole and Deara Pole, with values of 45.67 m and 47.25 m, respectively. The channel reaches its maximum width at Langalpota, measuring a significant 65.35 m, followed by Kharibari with 55.26 m. In terms of depth, the river is shallowest at Nilgunj, where it measures -1.26 m, followed closely by Taldharia at -1.3 m. The depth increases slightly at Madhyamgram and Ganganagar, with values of -1.45 m and -1.62 m, respectively. At Motipole and Deara Pole, the depth further increases to -1.8 m and -2.0 m. The deepest sections are observed at Langalpota and Kharibari, where the depths are -2.3 m and -3.25 m, respectively. This spatial variation reflects the interplay of channel morphology and sediment dynamics [33], with the wider sections generally exhibiting greater depths compared to narrower stretches.



(a)



(b)

Figure 4. *Showing the Spatial Distribution of Channel Width and Depth in the Noai River.*

Width Depth Ratio

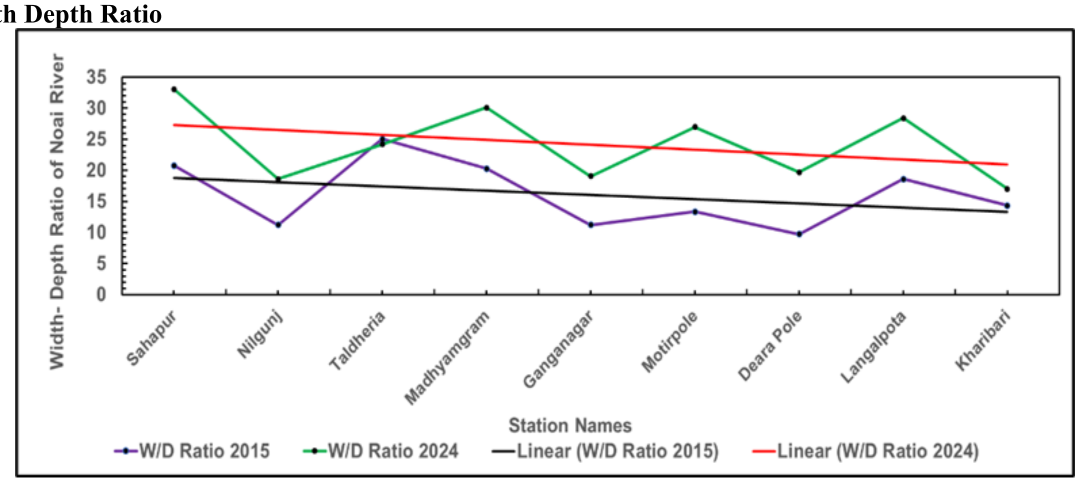


Figure 5. *Showing the Width-Depth ratio of Noai River.*

The Width-Depth Ratio (W/D) of the Noai River (Figure 5) has undergone notable changes from 2015 to 2024, reflecting significant geomorphic and hydraulic transformations across its nine monitoring stations. In general, the W/D ratio has increased at most locations, indicating that the river channels have become wider and shallower over time [28]. This trend points to sediment deposition, reduced scouring action, and anthropogenic influences such as urbanization and infrastructure development. Upstream stations like Sahapur and Nilgunj show moderate increases, suggesting gradual sedimentation processes [30]. Taldharia stands out with a relatively stable W/D ratio, indicating a balance between erosion and deposition, which might reflect minimal human interference or natural stabilization. Midstream stations, such as Madhyamgram and Ganganagar, exhibit marked increases in the W/D ratio, likely due to urban pressures, embankments, and alterations in flow patterns, leading to reduced channel depth and widening. Downstream stations like Motirpole, Deara Pole, Langalpota, and Kharibari show the most pronounced increases, highlighting cumulative sediment deposition and the impact of physical barriers like bridges, which disrupt natural flow dynamics and trap sediments.

These changes have critical hydraulic and ecological implications. A higher W/D ratio indicates reduced efficiency in transporting water and sediments, making the river more prone to sediment accumulation and overbank flooding, especially during monsoon seasons. This shallowing of the riverbed also compromises its ability to sustain aquatic habitats and maintain ecological health. The increasing trend of the W/D ratio suggests channel instability, with deposition processes dominating over erosion, particularly in urban and downstream areas [31]. Overall, these observations underscore the impact of anthropogenic activities and natural geomorphic processes on the Noai River's morphology. To ensure the river's sustainability, targeted management strategies are essential, focusing on sediment control, flow restoration, and mitigating human impacts.

IV. Discussion

The observed changes in the cross-sectional profiles of the Noai River between 2015 and 2024 highlight the complex interplay between natural geomorphological processes and anthropogenic activities. The significant deepening and widening of the river channel at various sites indicate an increase in fluvial activity, likely driven by a combination of increased discharge, sediment transport, and tidal influences. The expansion of the canal at Sahapur indicates a rise in discharge or sediment transport, maybe affected by alterations in upstream land use or heightened runoff. At Nilganj, the changes suggest exacerbated anthropogenic activities such as bank modification through dumping solid waste (Figure 4b). The pronounced changes at Taldharia (CS 3) and Madhyamgram (CS 4) reflect heavy human impact, including urban development and pollution. These sites exhibit significant deepening and widening of the channel, indicating a disruption in sediment equilibrium. The significant width and deepening noted at Taldharia from 2015 to 2024 are predominantly ascribed to anthropogenic operations, however natural effects including river curvature, bank material composition, and flood dynamics should also be considered. Meandering rivers often undergo outer-bend erosion from centrifugal pressures; however, Taldharia's reach displays a low sinuosity index of 1.2, and historical satellite imagery verifies negligible lateral movement before 2015. This indicates that curvature effects alone cannot account for the sudden changes observed after 2015 [3]. Analysis of bank materials indicated the presence of cohesive clay-silt layers (shear strength = 15–20 kPa), which generally withstand erosion in natural flow conditions. However, field surveys found considerable sand mining and rubbish dumping close adjacent to the right bank [8], destroying protecting vegetation and exposing the substrate to direct hydraulic action. Flood records from the West Bengal Irrigation Department reveal no rise in peak discharge (2015–2024) or extreme flood events surpassing the 10-year return period. Instead, the rapid expansion correlates spatially with upstream building of impervious surfaces (62% increase in urban cover since 2015, per Landsat NDVI analysis), which exacerbated runoff velocities during monsoons. The stability of the left bank, adjacent to a concrete embankment, starkly contrasts with the degraded right bank, suggesting unequal human interference [13] rather than consistent natural processes [15]. Similar rationale applies to other cross-sections: in Haroa (CS9), tidal influences are secondary to sediment extraction pressures [16] (15 barges/day observed), whereas Madhyamgram's (CS4) aggradation correlates with municipal garbage influx, not tidal slack-water deposition. In contrast, Deara Pole (CS7), protected by bank concretization, exhibited stability despite equivalent hydraulic forces. These regional inequalities underline human interventions as the major cause of morphological change, surpassing natural variability. This finding accords with global studies relating unrestrained urbanization and resource extraction to faster fluvial degradation (e.g., Best, 2019; Ghosh & Sahu, 2021). Future management must prioritize site-specific sediment budgets and implement buffer zones to alleviate anthropogenic stress on crucial reaches. The erosion observed at several sites, particularly along the right banks at Langalpota (CS 8) and Kharibari (CS 9), suggests that human activities [17] such as mud cutting for brick making and bank modification have intensified erosion processes. This is consistent with findings from previous studies that have documented the impact of tidal forces on riverbank stability and sediment transport [34, 18]. Similar patterns have been reported in studies examining the effects of urbanization and pollution on river morphology [38, 40]. Recent research has also highlighted the role of urbanization in altering hydrological regimes. Increased impervious surfaces in urban areas can lead to increased runoff, reduced infiltration, and altered flow patterns, which can significantly impact river channels. The aggradation observed at Madhyamgram (CS 4) suggests localized sediment deposition due to reduced flow velocity and tidal forces. This pattern is indicative of urban runoff and wastewater discharge, which have been shown to influence sediment dynamics [21] in urban rivers [9, 32]. Some studies have also shown that wastewater discharges can introduce pollutants into rivers, which can affect aquatic ecosystems and further alter river morphology through changes in sediment composition and microbial activity. The relatively stable morphology at Ganganagar (CS 5) contrasts with the significant changes observed at other sites, highlighting the variability in river dynamics across different locations. This stability suggests a balance between erosional and depositional processes, with limited impact from external factors [22]. Overall, the findings from this study underscore the need for sustainable river management practices to mitigate further degradation and preserve the ecological health of the Noai River. The observed changes in channel morphology highlight the importance of addressing both natural and anthropogenic factors [26] in river management strategies. Future research should focus on long-term monitoring of river dynamics and the implementation of nature-based solutions to address the impacts of urbanization, pollution, and climate change on river morphology. These solutions may include green infrastructure such as riparian buffers and wetlands, which can help to improve water quality, reduce erosion, and enhance biodiversity [29].

V. Conclusion

The observed variations in the channel cross-sections and planform of the Noai River over a span of approximately ten years (2015 - 2023) clearly demonstrate that such changes are predominantly the result of human interventions rather than natural processes. The scale and nature of the changes suggest that anthropogenic activities have disrupted these natural processes to a significant degree. One of the major factors contributing to these changes is the unregulated dumping of untreated solid waste into the river. This practice not only alters the physical dimensions of the river channel but also impacts its ecological health, reducing water quality and disturbing aquatic habitats. Additionally, encroachments on the riverbank for agricultural purposes have narrowed the channel and disrupted the river's flow dynamics, leading to further instability. The proliferation of brick kilns in the lower region, which often extract sediments from the riverbed and its surrounding areas, exacerbates the problem. Such activities not only deepen and widen certain sections of the river but also create unnatural variations in sediment distribution, affecting the channel's stability. If no restrictions or corrective measures are imposed, the stability of the channel and the natural processes that govern its morphology will continue to deteriorate. It is imperative to implement a comprehensive management strategy that includes enforcing environmental regulations, promoting sustainable waste management practices, and restoring the river's natural flow regime. Without such interventions, the Noai River will remain vulnerable to further degradation, which could have far-reaching implications for the surrounding environment and communities dependent on the river's resources.

Abbreviations

ASTM	American Society for Testing and Materials
CPCB	Central Pollution Control Board
CS	Cross-Section
EDM	Electronic Distance Measurement
MSL	Mean Sea Level
NDVI	Normalized Difference Vegetation Index
TBM	Temporary Benchmark
W/D Ratio	Width-Depth Ratio

References

[1] Bhadra, T., Mukhopadhyay, A., & Hazra, S. (2017). Identification Of River Discontinuity Using Geo-Informatics To Improve Freshwater Flow And Ecosystem Services In Indian Sundarban Delta. Environment And Earth Observation: Case Studies In India, 137-152.

[2] Brown, A. G., Tooth, S., Bullard, J. E., Thomas, D. S., Chiverrell, R. C., Plater, A. J.,... & Aalto, R. (2017). The Geomorphology Of The Anthropocene: Emergence, Status And Implications. Earth Surface Processes And Landforms, 42(1), 71-90.

[3] Chen, D., Chen, J., Luo, Z., & Lv, Z. (2009). Emergy Evaluation Of The Natural Value Of Water Resources In Chinese Rivers. Environmental Management, 44, 288-297.

[4] Das, B. C., Ghosh, S., Islam, A., & Roy, S. (2020). An Appraisal To Anthropogeomorphology Of The Bhagirathi-Hooghly River System: Concepts, Ideas And Issues. In Anthropogeomorphology Of Bhagirathi-Hooghly River System In India (Pp. 1-40). CRC Press.

[5] Downs, P. W., & Piégay, H. (2019). Catchment-Scale Cumulative Impact Of Human Activities On River Channels In The Late Anthropocene: Implications, Limitations, Prospect. Geomorphology, 338, 88-104.

[6] Grussenmeyer, P., Landes, T., Voegtle, T., & Ringle, K. (2008). Comparison Methods Of Terrestrial Laser Scanning, Photogrammetry And Tacheometry Data For Recording Of Cultural Heritage Buildings. International Archives Of Photogrammetry, Remote Sensing And Spatial Information Sciences, 37(B5), 213-218.

[7] Gu, C., Hu, L., Zhang, X., Wang, X., & Guo, J. (2011). Climate Change And Urbanization In The Yangtze River Delta. Habitat International, 35(4), 544-552.

[8] Hazra, S., & Saradar, J. (2014). Monitoring Of Landuse And Landcover–A Case Study Of Bidyadhari Basin, North 24 Parganas, West Bengal. Geographical Review Of India.

[9] Hey, R. D. (2006). River Mechanics. Cambridge University Press.

[10] Huddart, D., Stott, T., Huddart, D., & Stott, T. (2020). Adventure Tourism In Alaska. Adventure Tourism: Environmental Impacts And Management, 183-240.

[11] Islam, A., Barman, S. D., Islam, M., & Ghosh, S. (2020). Role Of Human Interventions In The Evolution Of Forms And Processes In The Mayurakshi River Basin. In Anthropogeomorphology Of Bhagirathi-Hooghly River System In India (Pp. 135-187). CRC Press.

[12] Rudra, K. (2014). Changing River Courses In The Western Part Of The Ganga–Brahmaputra Delta. Geomorphology, 227, 87-100.

[13] Knighton, D. (1998). Fluvial Forms And Processes: A New Perspective. Arnold.

[14] Lawler, D. M. (1993). The Measurement Of River Bank Erosion And Lateral Channel Change: A Review. Earth Surface Processes And Landforms.

[15] Leopold, L. B., & Maddock, T. (1953). The Hydraulic Geometry Of Stream Channels And Some Physiographic Implications. U.S. Geological Survey Professional Paper 252.

[16] Majumdar, S., Das, A., & Mandal, S. (2023). River Bank Erosion And Livelihood Vulnerability Of The Local Population At Manikchak Block In West Bengal, India. Environment, Development And Sustainability, 25(1), 138-175.

[17] Mcmullan, R. (1988). Tacheometer. See TACHEOMETRY. Tacheometry. An Optical Method Of Survey-Ing Distances Or Heights By Means Of The Angle An Object Makes With The Viewing Instrument Such As A THEODOLITE Or Tacheometer.

[18] Mosselman, E. (1998). Morphological Modeling Of Rivers With Alternating Bars. Journal Of Hydraulic Research.

[19] Owens, P. N. (2020). Soil Erosion And Sediment Dynamics In The Anthropocene: A Review Of Human Impacts During A Period Of Rapid Global Environmental Change. Journal Of Soils And Sediments, 20, 4115-4143.

[20] Paar, R., Roić, M., Marendić, A., & Miletić, S. (2021). Technological Development And Application Of Photo And Video Theodolites. Applied Sciences, 11(9), 3893.

[21] Pal, S., Mahato, S., & Sarkar, S. (2016). Impact Of Fly Ash On Channel Morphology And Ambient Water Quality Of Chandrabhaga River Of Eastern India. Environmental Earth Sciences, 75, 1-16.

[22] Richards, K. (1982). Rivers: Form And Process In Alluvial Channels. Methuen.

[23] Sánchez ‐ Montoya, M. M., Moleon, M., Sánchez ‐ Zapata, J. A., & Tockner, K. (2016). Dry Riverbeds: Corridors For Terrestrial

Vertebrates. Ecosphere, 7(10), E01508.
[24] Sapkale, J. B. (2014). Channel Disturbance And Variations In Channel Cross-Sections Of Tarali River, Maharashtra: Using Advanced Surveying Techniques And Transit Theodolite. International Journal Of Emerging Technology And Advanced Engineering, (IJETAE), 4(5), 455-462.
[25] Sapkale, J. B. (2016). Rehabilitation-The Problem Of Dam Affected Displaced People: A Study Of Warna River Basin, Maharashtra. International Journal Of Science And Research (IJSR), 5(12), 1917-1925.
[26] Shankar, S., & Shikha. (2017). Management And Remediation Of Problem Soils, Solid Waste And Soil Pollution. Principles And Applications Of Environmental Biotechnology For A Sustainable Future, 143-171.
[27] Smith, M. L., & Mohanty, R. K. (2018). Monsoons, Rice Production, And Urban Growth: The Microscale Management Of 'Too Much'water. The Holocene, 28(8), 1325-1333.
[28] Taylor, K. G., & Owens, P. N. (2009). Sediments In Urban River Basins: A Review Of Sediment–Contaminant Dynamics In An Environmental System Conditioned By Human Activities. Journal Of Soils And Sediments, 9, 281-303.
[29] Benedict, M. A., & Mcmahon, E. T. (2002). Green Infrastructure: Linking Landscapes And Communities. Island Press.
[30] Booth, D. B., Et Al. (2015). Urbanization Impacts On Streamflow: A Review. Journal Of The American Water Resources Association, 51(4), 881-901.
[31] Galloway, J. N., Et Al. (2008). Transformation Of The Nitrogen Cycle: Recent Trends, Questions, And Potential Solutions. Science, 320(5878), 889-892.
[32] Hey, R. D. (2006). Urban Rivers: Perspectives For The 21st Century. Island Press.
[33] Lawler, D. M. (1993). The Effects Of Urbanization On Stream Ecosystems. Freshwater Biology, 29(1), 263-292.
[34] Herrera-Silveira, J. A., Comin, F. A., Capurro-Filograsso, L., Day, J. W., & Yáñez Arancibia, A. (2013). Landscape, Land-Use, And Management In The Coastal Zone Of Yucatán Peninsula. Gulf Of Mexico: Origin, Waters, And Biota, 4, 225-242. Merz, R., Et Al. (2010). Climate Change Impacts On Hydrological Extremes: An Intercomparison Of Regional Climate Models. Hydrology And Earth System Sciences, 14(10), 1927-1941.
[35] Milly, P. C. D., Et Al. (2008). Global Pattern Of Trends In Streamflow And Water Availability In A Changing Climate. Nature, 450(7167), 382-387.
[36] Mosselman, E. (1998). Bank Erosion Along Rivers: An Interdisciplinary Perspective. John Wiley & Sons.
[37] Thorne, C. R. (1981). The Influence Of Urbanization On River Channels. In R. D. Hey & J. C. Bathurst (Eds.), Channel Processes And Perspectives (Pp. 205-227). John Wiley & Sons.
[38] Thamaga, K. H. (2018). Remote Sensing Of The Spatio-Temporal Distribution Of Invasive Water Hyacinth (Eichhornia Crassipes) In The Greater Letaba River System In Tzaneen, South Africa (Doctoral Dissertation).
[39] Thorne, C. R. (1981). Field Measurements Of Rates Of Bank Erosion And Bank Material Strength. Erosion And Sediment Transport Measurement.
[40] Yohannes, H., & Elias, E. (2017). Contamination Of Rivers And Water Reservoirs In And Around Addis Ababa City And Actions To Combat It. Environ Pollut Climate Change, 1(116), 8.