

Spatio-Temporal Change and Anthropogenic Effect for the Decline of the Saraswati River, Lower Ganga Delta: Integrating Historical Cartography, Hydraulic Morphometry, and Land Use Land Cover Change (1776–2025)

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Abstract

Over time, natural processes and growing anthropogenic interventions have enhanced the degradation of distributary channels in the lower Ganga Delta. The Saraswati River, which was a distributary of the Bhagirathi system of the Hooghly system at one time, has had a great decline in its morphological and hydrological conditions. This paper studies the Spatio-temporal change of the river through the combination of historical cartography, hydraulic morphometry, and Land Use and Land Cover (LULC) dynamics between 1776 and 2025. Georeferences of archival sources, such as the Bengal Atlas, were used to reconstitute the channel patterns in the past, and multi-temporal Landsat (1990, 2005, and 2025) images were interpreted by applying supervised classification methods. Several stations were chosen for this study. Findings show that the downstream channel depth (previously 1.23 m) and discharge (previously 23.70 m³/s) decreased significantly and the width-depth ratio increased (> 45), a sign of widening channels and declining hydraulic efficiency. The LULC analysis shows that the built-up areas are growing at a rapid rate, and fallow land and vegetation are decreasing, which means that the pressure of people in the river corridor increases. This is further indicated by the historical evidence that diversion of the canals and massive interventions, especially under the Damodar Valley Corporation (DVC), have greatly changed the natural flow regimes. It shows a close connection between channel degradation and land use change, and it is necessary to implement an approach to managing rivers and sustainable planning to recover ecological stability in the deltaic river systems.

Keywords: River dynamics, Channel morphology, Land Use and Land Cover (LULC), Hydraulic characteristics, Flow dynamics.

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1. Introduction

India is a peninsular nation that lies along the Bay of Bengal, Arabian Sea and Indian Ocean with a long and vibrant river system, with the Himalayas at the north being the main source of water. Significant rivers like the Ganga River, Brahmaputra River and Indus River are important to support agriculture, human settlements and economic activities throughout the subcontinent. Of special interest among them is the Ganga basin, which sustains almost one-third of the Indian population (Census of India, 2011). Besides water supply, the river system enhances the fertility of soils through alluvial deposition and supports the industrial and urban development (Singh & Kumar, 2017). Regardless of their significance, river systems in India are becoming more stressed as a result of the rapid urbanisation, industrialisation process and uncontrolled anthropogenic intervention. Other rivers like the West Bengal have been seriously degraded in terms of their abatement, pollution and morphological instability. Research has pointed out that unless action is taken, some of the rivers might take the course of other channels that are highly degraded, like the Saraswati River (Dey, 2021).

Previously, rivers defined the landscapes, maintained biodiversity, and contributed to socio-economic growth, but today they are experiencing an increased degradation under the cumulative pressure of natural and human activities (Misra & Roy, 2019). Saraswati River of the Hooghly district in West Bengal is one of the important instances of distributary channels degradation in the lower Ganga Delta. It was historically a distributary of the Bhagirathi system, a branch of the Hooghly river system, with its source towards the south near Tribeni, and its outlet near Sankrail, on the Bhagirathi. The river was once a significant trade route and a route of navigation, connecting the inland areas with the ancient port of Tamrapal-Lipto (Chakraborty et al., 2016). In the long run, however, the river has experienced significant changes through siltation, diminished flow, building of embankments and encroachment. Currently, a vast expanse of the river has been transformed into shallow, disjointed and low-flow channels, most of which are stagnant and polluted. The impacts of such degradation are environmental and socio-economic. Deteriorating water quality has had negative impacts on aquatic habitats and contributed to groundwater pollution, creating a threat to human health (Ghosh & Jana, 2018).

Moreover, the river has been a source of livelihood, particularly fishing and small-scale trade, which have been affected economically by the river. An extensive literature on the various aspects of river degradation, especially the degradation of water quality, has been explored. According to research by (Hazra et al., 2018) and (Bhowmik et al., 2019), industrial discharge and untreated sewage have a negative impact on water quality. On the same note, Das et al. (2020) put emphasis on the interaction of urbanisation, industrial growth, and climate variability on river systems. Deforestation and the degradation of catchment have also been noted to be decisive factors affecting hydrological processes, decreasing infiltration and base flow (Mukherjee et al., 2015). The problems are further enhanced by climate change, which changes the pattern of precipitation and enhances the hydrological variability (Sultana et al., 2019).

Besides environmental forces, anthropogenic activities, including embankment construction, sand mining, and channelisation, have also had a major impact on the morphology and flow

patterns of rivers. The high heavy metal contamination reported by (Saha et al., 2021) also signifies the high level of ecological stress. Socio-economic effects are also reflected, as a drop in fish productivity and related livelihood issues were reported in the Saraswati and other river basins (Panigrahi & Pattnaik, 2020). Intercomparable insights on the changes in river systems can be found in global studies. As an example, (Murray et al., 2000) revealed the effects of land-use change and dam construction on the sediment processes in the Ord River estuary, and (Shi et al., 2004) emphasised the importance of the alterations in sediment load and slope in the degradation of the lower Yellow River. In India, (Mandal, 2018) has reported comparable trends in the channel contraction and ecological degradation of the Adi Ganga River with urban encroachment and pollution. Morphometric analysis is not a new methodology in studying characteristics of drainage and fluvial processes (Horton, 1945; Schumm, 1956; Strahler, 1957). Modern studies combine these methods with geospatial and statistical methods, such as regression models, artificial neural networks, and spatial analysis, to study the relationship between land use and river dynamics (Chen et al., 2023; Li et al., 2018; Tao et al., 2019).

Nevertheless, even with the large body of research, a majority of the work on the Saraswati River is still fragmented, with the majority concentrating on water quality or discrete elements of environmental degradation. There are no integrated studies done on historical channel reconstruction, morphometric analysis or land use dynamics. Moreover, historical accounts of the river, based on colonial sources and literature like the “*Manasamangal Kavya*”, are mostly subjective and cannot be verified using current geospatial methods.

This paper fills these gaps by taking a multi-temporal approach to the Saraswati River and its transformation. It seeks to (i) recreate the historic palaeo-channel based on the archival cartographic data, such as the Bengal Atlas; (ii) measure the multi-decadal variation of LULC based on satellite-derived data; and (iii) understand the correlation between channel degradation and the anthropogenic pressure. Through integrating historical, geomorphological, and geospatial studies, the research aims to bring a holistic picture of the process of transformation of rivers in deltaic settings.

2. Study Area

The current research is concerned with the Saraswati River and the neighbouring region of the Hooghly district in West Bengal, which is a constituent of the lower Ganga Delta. This area is defined by lowlands, rich alluvial soils, and a highly developed system of distributaries and channels (Mukherjee et al., 2015). The Saraswati River starts at Tribeni near Bandel and flows southwards and joins the Bhagirathi River at Sankrail. It was a powerful distributary channel in the past, but much of its route is lost and silted with a mixture of natural processes and human intervention (Chakraborty et al., 2016).

The study region covers several important observation sites along the river, such as Tribeni, Gajghanta, Bandel, Chinsurah, Khalisani and Khosalpur (Fig. 1). These locations have been chosen to represent spatial differences in the morphology of the channels, the hydraulic characteristics, and land use patterns in various parts of the river. The geomorphological position of the area is that of a deltaic plain, which has a very low slope in the southeastern

direction. The area is mainly made up of recent alluvial deposits, which render the soil very conducive to agricultural practice (Singh & Kumar, 2017).

Its climate is tropical monsoon, hot and humid in summer, there is a specific period of rainy season between June and September, and winters are mild. Rainfall patterns are also affected by the southwest monsoon, and it has an impact on seasonal river flow and water availability (Sultana et al., 2019). Human activities have significantly changed the drainage system of the region. Massive projects, especially those that are being implemented by the Damodar Valley Corporation (DVC), have altered natural flow regimes by building barrages, canals, and diversion structures. These activities have decreased the interconnectedness of distributary channels and have led to decreased flow in the rivers like the Saraswati (Das et al., 2020).

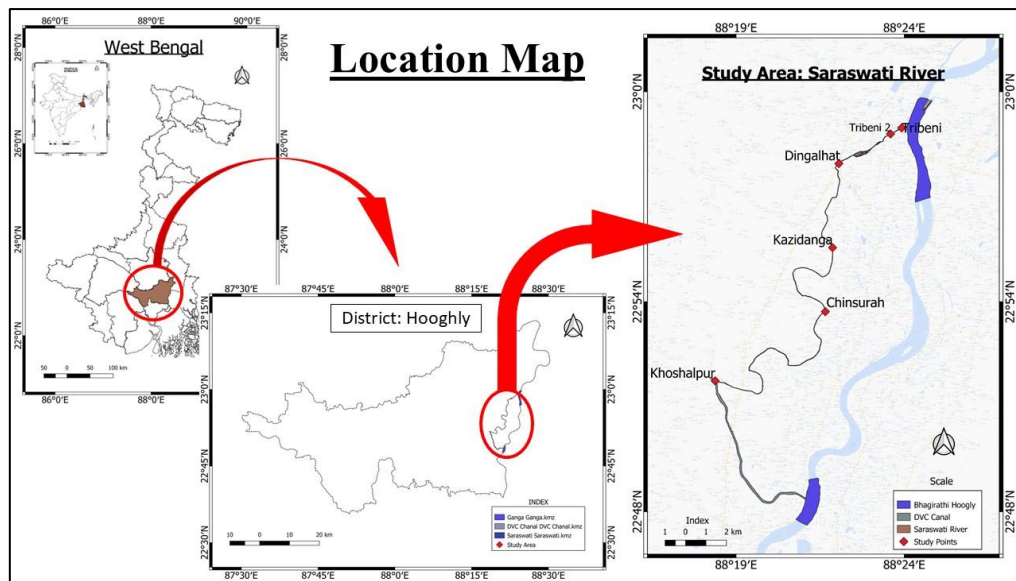


Fig.1: location map of the Saraswati River, showing the major observation stations (Tribeni, Dingalhat, Kazidanga, Chinsurah, and Khoshalpur)

Moreover, the study area has undergone a high rate of urbanisation over the past few decades, mainly because of its closeness to the Kolkata Metropolitan Area. There is a growing trend toward agricultural lands becoming residential, industrial and infrastructural developments, which puts a strong burden on land and water resources (Hazra et al., 2018). This has led to the intrusion of river channels, the rise of waste discharge, and interference with natural hydrological processes (Bhowmik et al., 2019).

Overall, the study area is a delicate and dynamic fluvial environment, where natural geomorphic processes come into contact with strong anthropogenic forces. Knowledge of these interactions is vital in evaluating the degradation of rivers as well as developing sustainable management plans (Dey, 2021).

3. Methodology

The proposed study is an integrated geospatial and field study as it seeks to examine the spatio-temporal change of the Saraswati River and how it interacts with Land Use and Land Cover (LULC) dynamics. The methodology is designed to be divided into three large stages: (i)

preparation and pre-field data, (ii) field-based data, and (iii) post-field data processing and analysis.

3.1. Pre-Field Data Preparation

The first phase entailed the development of research objectives and an extensive literature survey of previous studies on river morphometry, geomorphology and land use dynamics. The theoretical basis of the channel characteristics analysis was classical morphometric principles that were developed by (Horton, 1945), (Strahler, 1957) and (Schumm, 1956) Other sources on drainage basin analysis and geospatial methods were also referred to (Dhiman et al., 2018; Rana et al., 2017; Singh & Kumar, 2017). To re-create the historical course and palaeochannel arrangement of the river, historical cartographic data, such as the Bengal Atlas by Major (Brice, 1964) and early Survey of India toposheets, were gathered. These maps were scanned, georeferenced and digitised to provide a temporal baseline with which to detect long-term change. Multi-temporal satellite data were obtained to examine the LULC changes in the study area. The benchmark years (1990, 2005 and 2025) of Landsat imagery were selected because of their uniform coverage over time and applicability to the analysis of the regions. Additional spatial information, such as base maps by OpenStreetMap (OSM), was also added to enhance spatial referencing and mapping accuracy. A survey tour was held to locate appropriate observation points along the river as well as to familiarise oneself with field conditions, accessibility, and other important geomorphological features.

3.2. Field Data Collection

The main data was collected in the form of a systematic field survey at the selected exits of the river, such as Tribeni, Gajaghanta, Dingalhat, Bandel, Chinsurah, Khalisani and Khosalpur. These points were selected to be upstream, middle stream, and downstream points, so that one can measure spatial variability in the channel characteristics. Standard field procedures were used to measure the cross-sectional profiles of the river channel at each station. Channel width and depth were measured at fixed time intervals along transects to measure changes in channel geometry. The basic float-based methods were used in measuring the flow velocity, which made it possible to estimate surface velocity when the field conditions were used. These measurements were then manipulated to achieve some important hydraulic parameters in accordance with the standard hydraulic principles (Chen et al., 2020). GPS devices were used to take observation points in geographic coordinates to enable integration and spatial mapping with geospatial datasets. Along with quantitative measurements, qualitative observations concerned with channel condition, sediment deposition, vegetation growth and anthropogenic activities (e.g., waste disposal, encroachment and agricultural runoff) were recorded to assist in the interpretation of results.

3.3 Post-Field Data Processing and Analysis

3.3.1. LULC Classification and Change Detection

Geographic Information System (GIS) and remote sensing methods were employed to process satellite images in order to classify the categories of land use and land cover. An authorised classification strategy was embraced, dividing the landscape into water bodies, constructed

areas, agricultural land, vegetation, wetlands, and fallow land, as per common land classification plans (Anderson, 1976). The classified images of various years were compared to create a change detection matrix, which allowed identifying time trends in land use change. Spatial overlays were undertaken to study the association between the changes in LULC and the dynamics of river channels.

3.3.2. Morphometric and Hydraulic Analysis

Field data and well-established geomorphological techniques were used to calculate morphometric parameters of the river. The main parameters were channel width, depth, cross-sectional area, wetted perimeter and width-depth ratio (Zhao et al., 2021). These measures are critical to the explanation of the channel form, stability, and flow properties (Horton, 1945; Strahler, 1952). The standard equations were used to determine hydraulic parameters like hydraulic radius, velocity head, and discharge (Te Chow, 1959). The product of the cross-sectional area and flow velocity was taken as discharge, the ratio of cross-sectional area to wetted perimeter as the hydraulic radius. These parameters give an understanding of the efficiency of the flow, the capacity of sediment transportation and channel resistance. The bed slope or hydraulic gradient was computed as the difference between the elevations and the horizontal distance between the points of observation, which made it possible to evaluate the conditions of the flow of energy on the river course.

3.3.3. Spatial Analysis and Integration

To measure the relationship between the dynamics of rivers and human pressure, past river alignments were superimposed on modern LULC maps. This facilitated the detection of encroaching areas and channel-shrinking areas. They analysed the relationship between built-up areas expansion and the reduction of channel dimensions by using spatial analysis techniques. A combination of historical, geomorphological, and LULC data allowed a clear vision of the spatio-temporal change in the river system. This multi-dimensional method enabled the discovery of the most significant agents of river degradation and the evaluation of their overall effect in the long term.

Overall, the methodological approach includes historical reconstruction, field-based hydraulic analysis, and geospatial analysis to deliver an integrated analysis of river change. The combination of several datasets and methods of analysis allows the study to be considered strong and reproducible to evaluate the factors contributing to the degradation of the Saraswati River.

4. Results and Discussion

4.1. Spatio-Temporal Channel Transformation

The morphological changes of the Saraswati River, which have been reconstituted using historical cartography (e.g, Bengal Atlas) and contemporary geospatial analysis, show a distinct pattern of evolution of the river from a distributary channel to a disaggregated and degraded one (Fig.2).

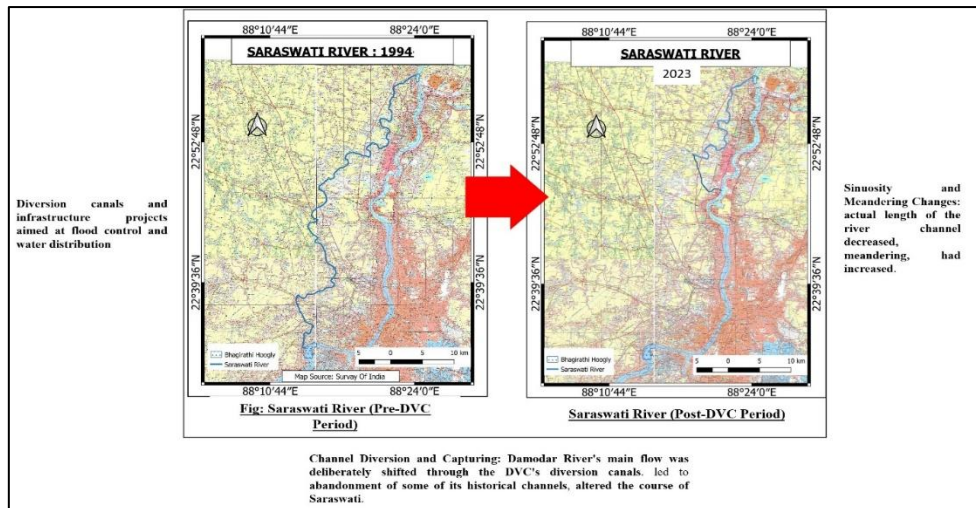


Fig. 2: A spatio-temporal transformation of the Saraswati River (1994-2023) on the basis of satellite images. The map indicates localised bending and channel shifting laterally, and displacement of the river course over thirty years, with significant changes occurring in the middle and lower reaches.

During the pre-DVC period, the river was a definite and continuous course in the Bhagirathi-Hooghly network. Nevertheless, comparative analysis of satellite images taken in 1994 and 2023 demonstrates that the channels have become progressively narrower, are laterally unstable, and have lost connectivity, especially in the middle and lower reaches (Fig.3).

The channel shift map (Fig.2) suggests that there was some apparent lateral movement of the river course within the last 30 years. The river maintained a fairly constant course in 1994, yet in 2023, multiple parts of it, in particular in the middle reach, display strong, localised bending and channel displacement. A part of the previously active channel has been abandoned and traces of old channels can still be seen, and the river has changed its course because of deposition of sediment, erosion and human activity, including land encroachment and construction.

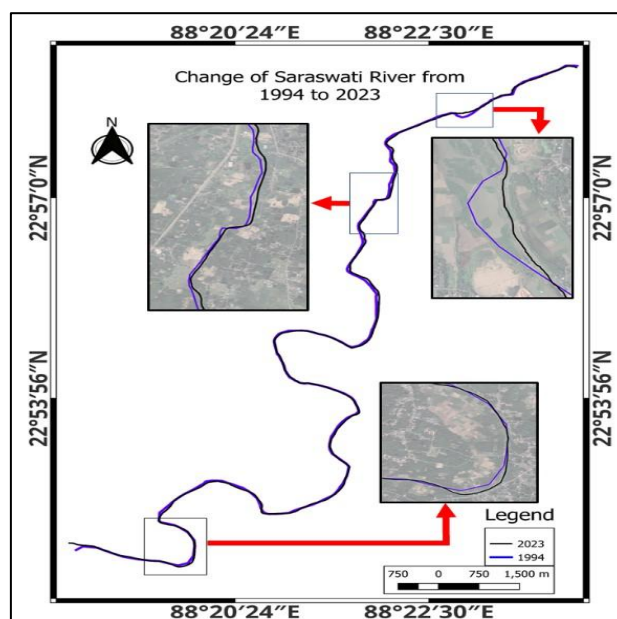


Fig. 3: Channel diversion and capturing in the Saraswati River system in the pre-DVC and post-DVC periods. The diversion flow of the main body of the Damodar River by diversion canals of the DVC resulted in the desertion of ancient routes and a change in the direction of the Saraswati River with variations in sinuosity and meandering.

The most radical change is, however, associated with the massive anthropogenic interventions in the post-DVC period (Fig.3). The intentional diversion of the main channel of the river Damodar by the use of the DVC canals resulted in the abandonment of several historical channels. Some of the deserted channels (e.g., Beulah, Kantul, Ghala, Julki) were then taken by the Saraswati as tributaries, but this was not enough to re-establish its old flow regime. Also, the sinuosity and meandering patterns of the river have changed, and the real length of the active channel has been decreasing over time. Areas that had been active flow channels are now stagnant water bodies or are fully covered by the developed areas.

This is due to progressive fragmentation and instability of channels, which is a consequence of the overall pressure of naturally deposited sediment and human actions such as land reclamation, construction of embankments, and diversion of flows. The results are consistent with other degraded river systems, where decreased discharge and amplified sediment load bring channel instability and eventual fragmentation (Mandal, 2018; Shi et al., 2004).

4.2. Hydraulic and Morphometric Characteristics

Hydraulic and morphometric analysis of the Saraswati River indicates that there is a great deal of spatial variation in channel geometry and flow characteristics along its longitudinal profile. The calculated parameters, such as average depth, channel width, width-depth ratio, hydraulic radius, wetted parameters, as well as velocity of the flow, all point to a progressive downstream deterioration of channel efficiency.

The mean channel depth (Fig. 4a) has a significant decrease in upstream to downstream segments, with a decrease in depth between 1.23m at Tribeni and 1.11m at Gajaghata to less than 0.50m at downstream positions like Bandel (0.42m), Chinsurah (0.47m), and Khalsani (0.38m). The lowering of this depth suggests sedimentation and aggradation of the channel, both typical of low-energy fluvial systems. However, channel width (Fig.4b) shows an overall downstream trend, with a peak at Bandel (23.18m) and a slight decrease further downstream. This negative correlation width and depth is also indicated in the width to depth ratio (Fig. 4c), where the ratio rises rapidly at Tribeni and reaches values above 45m at downstream sections, especially at Bandel (47.57) and Khalsani (46.19). These large ratios imply expansion of lateral channels in situations of lower discharge and decreased vertical erosion capacity.

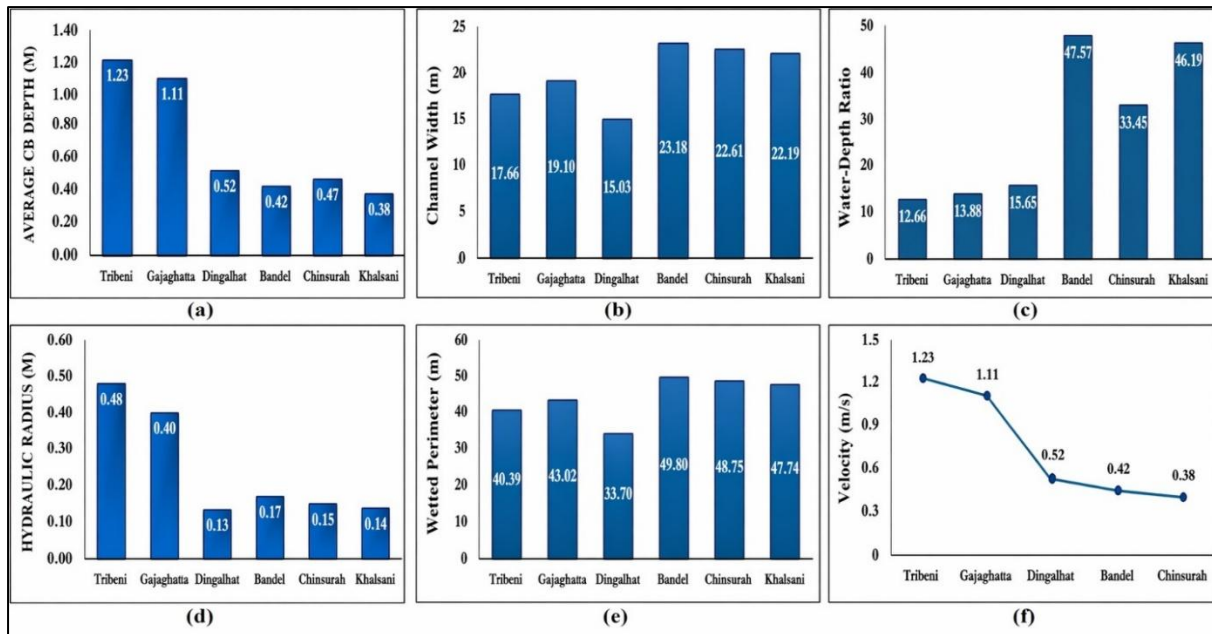


Fig.4. Hydraulic and morphometric data of the Saraswati river at the chosen station: (a) Mean depth, (b) Channel width, (c) Width-depth ratio, (d) Hydraulic radius, (e) Wetted parameters, and (f) Flow velocity.

The hydraulic radius (Fig.4d), which is a major indicator of flow efficiency, also reduces quite considerably downstream, with values of 0.48m at Tribeni and down to about 0.13-0.17m in lower reaches. Such a decrease indicates a high frictional resistance and low flow competence and restricts the capacity of the river to effectively move sediment. Likewise, the wetted parameter (Fig. 4e) is greater in broader downstream sections, almost 50m at Bandel, further adding to energy loss and decreased hydraulic efficiency. Flow velocity (Fig. 4f) also shows a similar downward trend as it slows down to 0.38m/s at Chinsurah as compared to 1.23m/s at Tribeni. The velocity decrease is indicative of less energy in the flow and contributes to the noted trend in the deposition of sediments and infilling of channels. The loss in velocity and the loss in the hydraulic radius occur together to mean that there is a shift in the flow regime to slow and low-energy flow.

All these morphometric and hydraulic properties are indicative of the fact that the Saraswati River is in transition between an active fluvial system and a degraded channel that is characterised by sedimentation and subsequent instabilities. Such changes are predictive of decreased discharge and different dynamics of flow as defined by accepted morphometric principles (Horton, 1945; Schumm, 1956; Strahler, 1952). The same trend of increasing the width of channels, decreasing the depth, and decreasing hydraulic efficiency has been observed in other degraded river systems that were impacted by urbanisation and anthropogenic pressure (Mandal, 2018).

Overall, the observed patterns demonstrate the loss of channel competence and geomorphic instability that is gaining momentum, which are the key signs of river degradation. These results support the rationale to take into account hydraulic parameters and land use dynamics to evaluate river health and design restoration plans.

4.3. Land Use and Land Cover (LULC) Dynamics

The comparison of the Land Use and Land Cover (LULC) in the Saraswati River area on the basis of the data obtained in about 1994, 2011, and 2023 (Fig. 5) indicates a radical alteration of the landscape under the impact of anthropogenic pressure. The most obvious commonality in all the observation posts, which are Tribeni, Gajaghanta, Bandel, Chinsurah and Khalisani, is the rapid and sustained growth of built-in areas. This urbanisation has always taken place at the cost of fallow land, farmland and natural vegetation, meaning that there is a systematic process of changing pervious surfaces into impervious settlements.

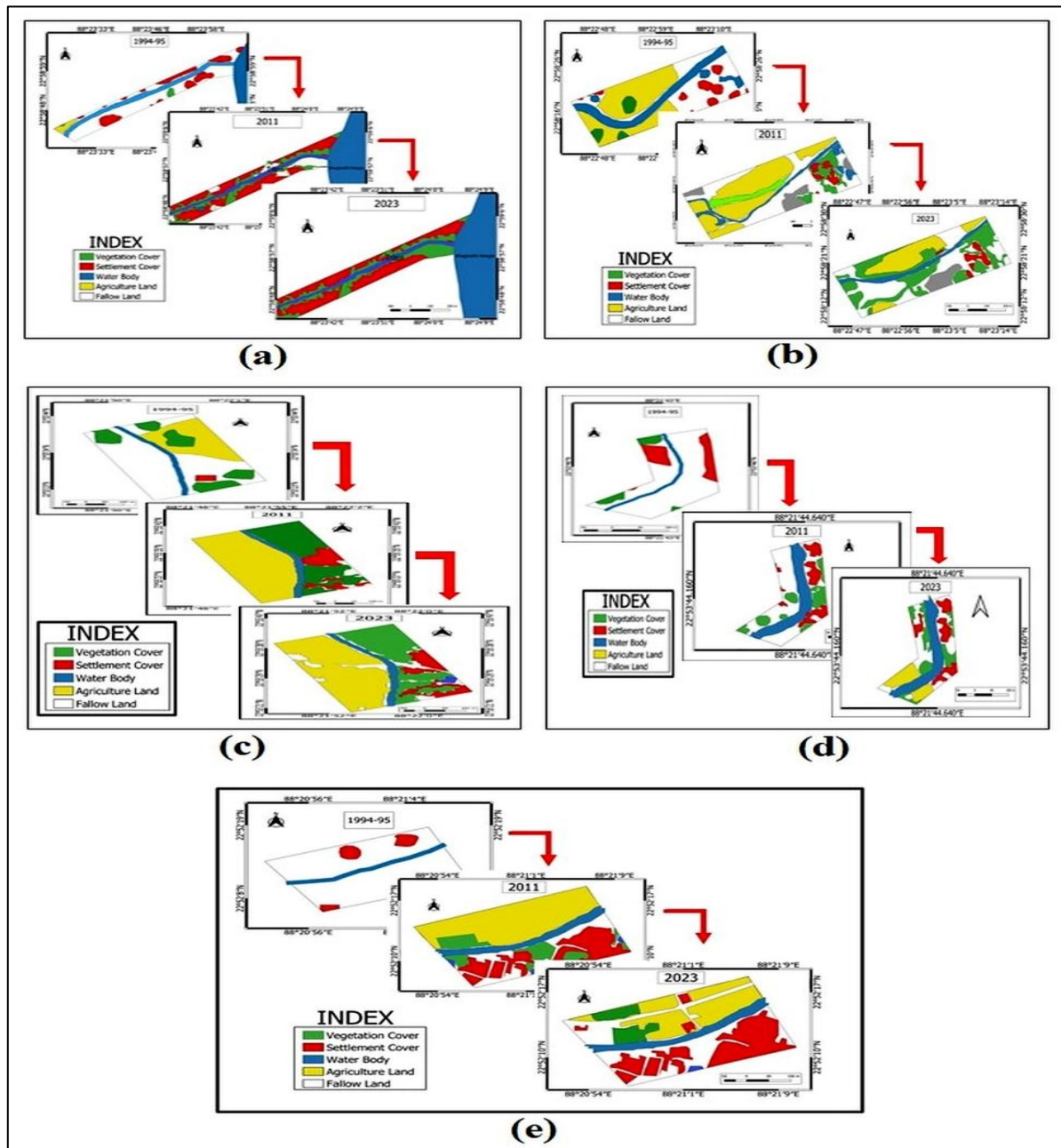


Fig.5: LULC dynamics in the Saraswati River at a chosen station showing rapid urban expansion at a loss of agriculture, vegetation, and fallow land. (a) Tribeni (b) Gajaghata (c) Bandel (d) Chinsurah, and (e) Khalisani.

In Tribeni (Fig. 5a), the effects of urbanisation are brutal. The number of settlement areas increased about four times in 2023. This dramatic growth was accompanied by an almost complete conversion of fallow land, which dropped by about 10 % in the same years. The trend in natural vegetation, which slightly rose between 1994 and 2011, also indicated a negative trend by 2023, indicating that even what were once stable green areas are now at risk. The dramatic and sudden rise in water bodies in 2023 is unusual and can be attributed to local flooding or river enlargement through channel realignment, or a better data point than a true ecological restoration.

The same trend of progressive land conversion can be observed in Gajaghanta (Fig. 5b). Fallow land was virtually killed out, decreasing from 1994 to 2023. At the same time, there were steady drops in agricultural land and natural vegetation, as vegetation cover reduced to 2023 compared to 1994. Conversely, settlement areas were developed vigorously, increasing in the following years. The comparative stability of water bodies in this station is a notable exception, which implies that there is local resilience or alternative hydrological management. The Bandel (Fig. 5c) LULC dynamics indicate a complicated interaction between urbanisation and agriculture.

Although there was a significant decrease in fallow land, agricultural land showed a steep recovery in 2023 following a major drop in 2011. The rebound indicates that there might be a backlash towards farming or agricultural intensification in the regions that are not yet consumed by urban sprawl. However, the natural vegetation was still decreasing, and the number of settlements increased almost seven times, which shows that the environmental stress remained. The dominance of anthropogenic dominance is strengthened by Chinsurah (Fig. 5d) and Khalisani (Fig. 5e). The loss of fallow land to settlements in Chinsurah is also indicative of new, planned or semi-planned urban development. Natural vegetation experienced an increase followed by a decline as of 2023. Although agricultural land and natural vegetation revealed some slight changes in Khalisani, the most pronounced tendency in this area is the gradual increase in settlements that grew in 2023, occupying even more space along the riverbed.

Overall, the LULC analysis indicates that the Saraswati River corridor has experienced a fundamental change in the form of a landscape of agriculture and fallow land to a landscape of more and more impervious built-up surfaces (Fig. 5). This high rate of urbanization has had a direct impact on decreasing natural vegetation cover and also changing the size of water bodies resulting in the breakage of the natural drainage patterns and the decrease of hydrological connectivity. This urban development also increases impervious surfaces that increase surface runoff and reduce infiltration, which worsens the transportation of sediments and the siltation of channels (Das et al., 2020; Mukherjee et al., 2015). These results agree with the previously measured reduction in the hydraulic efficiency of the river and are a good indication that the anthropogenic pressure is a key contributor to the degradation of the Saraswati River.

4.4. Pressure and Degradation of Channels by Humans

When the historical channel alignments are overlaid with the current LULC maps, it is clear that a significant amount of encroachment occurred along the previous river channel. Constructed growth, especially in fast-growing areas, has greatly narrowed the active channel,

and in a few instances, has completely blocked the natural flow patterns. River degradation has also been aggravated by industrial discharge and untreated sewage. These factors have been determined by the previous research as the key contributors to the deterioration of the water quality in the Saraswati River (Bhowmik et al., 2019; Hazra et al., 2018). The presence of high concentrations of pollutants, such as heavy metals, implies a significant ecological load and threat to both aquatic ecosystems and human health (Saha et al., 2021).

Moreover, structural interventions, including embankments and canal diversions, have changed the natural flow regimes, decreasing discharge and sediment transportation capacity. The redistribution of the waters, which is due to large-scale projects, such as those of the Damodar Valley Corporation, has further reduced the flow into the distributary channels. These factors combined have led to the replacement of a dynamic fluvial system by a low-energy channel that is degraded. Other river systems to which humans have allowed intervention have shown similar trends with channel alteration and pollution resulting in an ecological deterioration over time (Mandal, 2018; Murray et al., 2000).

4.5. Comprehensive Study and Implications for River Changes

The combination of historical, hydraulic, and LULC studies indicates that there is a close correlation between channel degradation and anthropogenic pressure. Regions of high rates in urban development are associated with regions of great channel narrowing and decreased flow capacities. The Saraswati River degradation can hence be perceived as a multi-dimensional process that is initiated by: Decline in the supply of upstream flow. Heightened sedimentation and aggradation of the channels. Land use conversion and encroachment. Environmental pollution and degradation. This multi-factor interplay indicates the necessity of the combined river basin management strategies that would deal with both geomorphological and human activities. The results support the thesis that the degradation of rivers is not only a natural process but an uncontrolled anthropogenic intervention that speeds it up to a much higher rate (Misra & Roy, 2019).

The trends observed show that unless something is done, the Saraswati River might keep on degrading and losing its identity as a living fluvial system. The restoration activities should aim at enhancing the connectivity of flows, managing pollution, and managing land use in the river corridor. The morphometric and geospatial procedures that have been used in this paper present a solid framework for monitoring river health and making management decisions. The combination of such strategies and policy interventions can aid in reducing further deterioration and enable the sustainable management of rivers within the deltaic setting.

5. Conclusions

Saraswati River, which was once of cultural and economic significance, has been radically changed by the natural processes as well as anthropogenic activities. Being an important distributary that supported trading routes involving in the ancient period, the river has gradually lost its functional integrity. The course of the canal excavations in the colonial era was to divert the flow to the Hooghly River, and subsequent interventions by the DVC caused additional control of discharge by dams and barrages, considerably cutting down the water and sediment supply.

Field observations at various stations (Tribeni, Gajaghanta, Dingalhat, Bandel, Chinsurah and Khalisani) indicate a downstream efficiency decrease in channels. Increased depth and velocity of flow are found in upstream sections and shallow, expanded, and slow channels are found in downstream reaches, signifying a decreased ability to transport and an increased ability to deposit sediment. The reduced flow in a few portions has hampered the self-cleaning capacity of the river, which has caused the buildup of pollution and degradation of the environment.

At the same time, urbanization, and the construction of infrastructure, has added pressure to the river system. The run-off of agricultural fertilizers has facilitated excessive growth of aquatic weeds and lowered the concentration of dissolved oxygen and endangered the biodiversity. Generally, the research shows that increased human activity has increased the rate at which channels have deteriorated resulting in the river being a low-energy, contaminated system. The river will be in danger of losing its ecological and functional identity without effective management.

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