National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development & Ganga Rejuvenation
Government of India

Geomorphological Mapping in Krishna River Basin

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National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

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Centres for Krishna River Basin Management Studies (cKrishna)

The Centres for Krishna River Basin Management Studies (cKrishna) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by NIT Warangal and NIT Surathkal, under the supervision of cGanga at IIT Kanpur, the centre serves as a knowledge wing of the National River Conservation Directorate (NRCD). cKrishna is committed to restoring and conserving the Krishna River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

www.ckrishna.org

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cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this, it is also responsible for introducing new technologies, innovations, and solutions into India.

www.cganga.org

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by NIT Warangal (Lead Institute) and NIT Surathkal (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRCD) in 2024. We gratefully acknowledge the individuals who provided information and photographs for this report.

Disclaimer

This report is a preliminary version prepared as part of the ongoing Condition Assessment and Management Plan (CAMP) project. The analyses, interpretations and data presented in the report are subject to further validation and revision. Certain datasets or assessments may contain provisional or incomplete information, which will be updated and refined in the final version of the report after comprehensive review and verification.

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Preface

In an era of unprecedented environmental change, understanding our rivers and their ecosystems has never been more critical. This report aims to provide a comprehensive overview of our rivers, highlighting their importance, current health, and the challenges they face. As we explore the various facets of river systems, we aim to equip readers with the knowledge necessary to appreciate and protect these vital waterways.

Throughout the following pages, you will find an in-depth analysis of the principles and practices that support healthy river ecosystems. Our team of experts has meticulously compiled data, case studies, and testimonials to illustrate the significant impact of rivers on both natural environments and human communities. By sharing these insights, we hope to inspire and empower our readers to engage in river conservation efforts.

This report is not merely a collection of statistics and theories; it is a call to action. We urge all stakeholders to recognize the value of our rivers and to take proactive steps to ensure their preservation. Whether you are an environmental professional, a policy maker, or simply someone who cares about our planet, this guide is designed to support you in your efforts to protect our rivers.

We extend our heartfelt gratitude to the numerous contributors who have generously shared their stories and expertise. Their invaluable input has enriched this report, making it a beacon of knowledge and a practical resource for all who read it. It is our hope that this report will serve as a catalyst for positive environmental action, fostering a culture of stewardship that benefits both current and future generations.

As you delve into this overview of our rivers, we invite you to embrace the opportunities and challenges that lie ahead. Together, we can ensure that our rivers continue to thrive and sustain life for generations to come.

Centres for Krishna River Basin
Management and Studies (cKrishna)
NIT Warangal (Lead Institute), NIT Surathkal (Fellow Institute)

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Abbreviations and Acronyms

Abbreviation/Acronym	**Full Form**
AOI	Area of Interest
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
DEM	Digital Elevation Model
GIS	Geographic Information System
GEP	Google Earth Pro
KRB	Krishna River Basin
SAR	Synthetic Aperture Radar
SRTM	Shuttle Radar Topography Mission
RS	Remote Sensing
GoI	Government of India
m	meter
km	kilometer
km^2	square kilometer

1. Introduction

Geomorphology is the scientific study of landforms, their origin, evolution, and the processes that shape the Earth's surface. Rivers play an important role in sculpting landscapes through erosion, transportation, and deposition of sediments. The Krishna River Basin, one of the major river basins of peninsular India, offers a diverse range of geomorphic features due to its variation in climate, lithology, elevation, and hydrological regimes. The Krishna River originates in the Western Ghats near Mahabaleshwar in Maharashtra at an elevation of around 1337 meters above sea level and flows eastward across Karnataka, Telangana, and Andhra Pradesh before draining into the Bay of Bengal. The basin covers a large geographical area with varied terrain, including plateaus, escarpments, valleys, and river floodplains.

Geomorphic mapping in the Krishna Basin helps in understanding landform evolution, river channel patterns, sedimentation, groundwater occurrence, ecological systems, and water resource planning. Remote sensing and GIS techniques have strengthened the ability to delineate geomorphic units and analyse spatial variation across the basin. Key controlling factors of geomorphology in the basin includes, Lithology: Basalts in the upstream Western Ghats; granites and gneisses across central basin; alluvium in the deltaic plains. Structural control: Faults and fractures influence drainage patterns. Climatic variability: High rainfall in the Western Ghats and semi-arid conditions in interior regions. Fluvial processes: Rivers, tributaries, and distributaries shape valleys, terraces, and alluvial plains.

The geomorphology of the Krishna Basin reflects a dynamic interaction of erosional and depositional forces over time. These landforms result from a complex interplay of geological processes, climatic influences, and human activities over time. This report provides an overview of the geomorphic classes identified within the basin, highlighting their spatial distribution, characteristics, and significance.

2. Geomorphic Classes

Spatial variation of different geomorphic classes present in Krishna River Basin are represented in Figure 1. Geomorphic Classes in the Krishna River Basin were:

(i) Highly Dissected Denundational Hills and Valleys: These regions are characterized by steep slopes and rugged terrain. They result from intensive weathering and erosion processes acting on hard rock formations. These areas play a crucial role in influencing drainage patterns and water flow within the basin.

(ii) Highly Dissected Structural Hills and Valleys: Formed by tectonic and structural processes, these landforms exhibit distinct linear ridges and valleys. The structural control on erosion in these areas is evident, leading to the formation of complex drainage networks.

(iii) Low Dissected Denudational Hills and Valleys: These features are characterized by gentler slopes compared to highly dissected terrains. They represent areas where erosional processes are less intense, often supporting sparse vegetation and localized agricultural activities.

(iv) Moderately Dissected Denudational Hills and Valleys: Intermediate between highly and low dissected terrains, these areas exhibit moderate slopes and an intricate network of streams. They are significant for their role in water retention and soil conservation.

(v) Coastal Plain: The coastal plain of the Krishna River Basin is marked by flat to gently sloping land, influenced by marine processes. These regions are vital for agriculture and fisheries due to their fertile soils and proximity to water resources.

(vi) Deltaic Plain: Located near the river's mouth, the deltaic plain is a highly fertile region formed by the deposition of sediments carried by the Krishna River. This area supports extensive agricultural activities and is prone to flooding during monsoons.

(vii) Alluvial Plain: Composed of sediments deposited by rivers, these plains are widespread in the basin. Their rich soils make them highly productive for cultivation, while their flat terrain facilitates irrigation development.

(viii) Pediment-Pediplain Landform: These are gently sloping erosional surfaces found at the base of hills. They result from long-term weathering and erosion and often serve as transition zones between highlands and plains.

(ix) Quarry and Mine Dumps: Human activities, such as mining and quarrying, have led to the formation of artificial landforms like mine dumps. These areas are often associated with environmental challenges, including soil degradation and water pollution.

(x) Flood Plain: Flood plains are flat, low-lying areas adjacent to rivers, formed by periodic flooding and sediment deposition. These regions are highly fertile but require effective flood management strategies to mitigate risks.

(xi) Aeolian Landform: Aeolian landforms, shaped by wind activity, are relatively rare in the Krishna River Basin. They include sand dunes and other wind-modified features, primarily found in localized arid regions.

(xii) Anthropogenic Terrain: These areas reflect human-modified landscapes, including urban settlements, industrial zones, and infrastructure developments. The rapid expansion of these terrains has significant implications for the basin's hydrology and ecology.

(xiii) Bajada: Bajadas are broad, gently sloping depositional features formed by the coalescence of multiple alluvial fans. They occur along the base of hills and are significant for groundwater recharge.

(xiv) Waterbodies: Waterbodies, including reservoirs, lakes, and ponds, are scattered across the basin. They are essential for irrigation, drinking water supply, and biodiversity conservation.

(xv) Rivers: The Krishna River and its tributaries form the lifeline of the basin. They are vital for transportation, agriculture, and supporting the region's ecosystems.

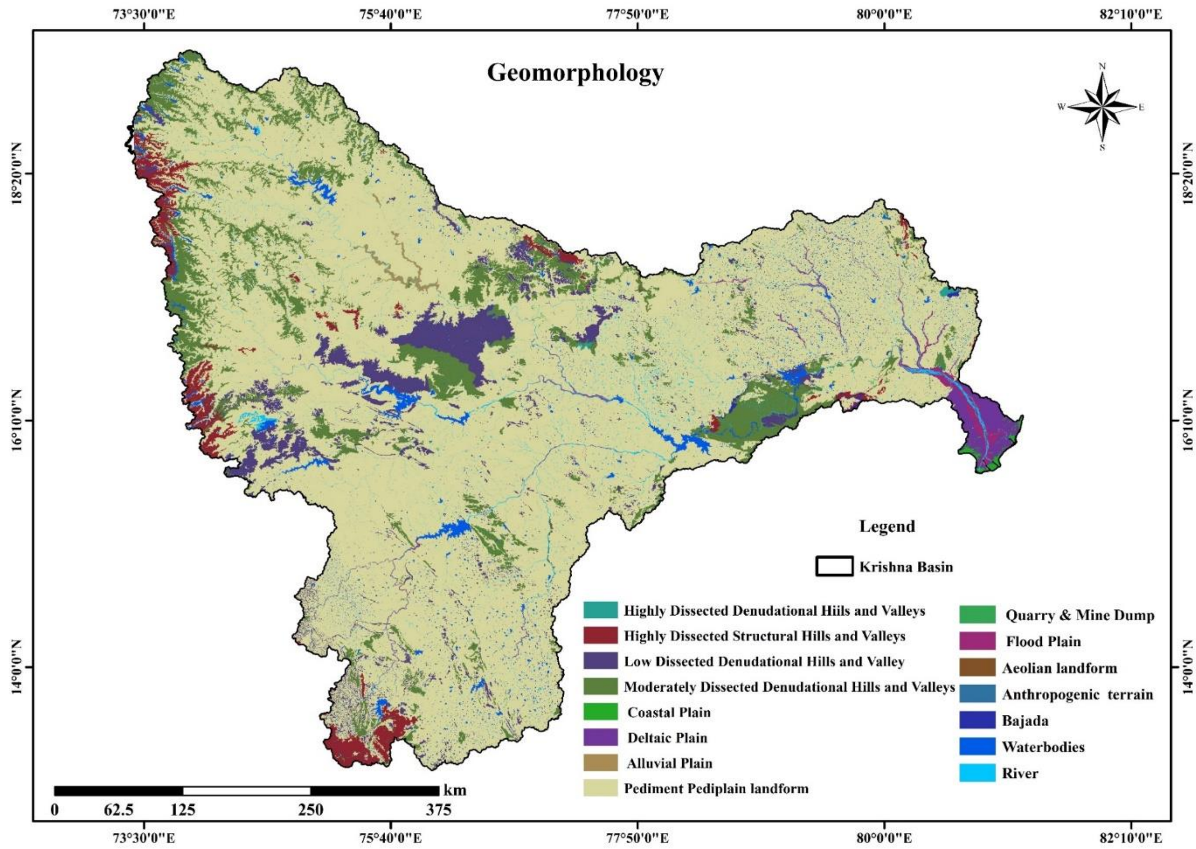

Figure 2. 1 Spatial variation of different geomorphic classes present in Krishna River Basin

3. Floodplain Mapping in the Krishna River Basin

The floodplain extent of the Krishna River Basin (KRB) was mapped using multi-temporal Sentinel-1 SAR imagery combined with CHIRPS rainfall data. The resulting spatial floodplain map shows that major tributaries such as the Bhima, Ghataprabha, Malaprabha, Munneru, Musi, and Tungabhadra contribute significantly to flooding across the basin. The upper basin tributaries show localized flooding mainly influenced by reservoir releases and monsoon rainfall, while eastern tributaries like Musi and Munneru increase flood risks in Telangana and Andhra Pradesh. The Tungabhadra displays extensive floodplain spread due to its large catchment and regulated flows. The Krishna delta shows the highest vulnerability because of both riverine and tidal influences.

Reach-based floodplain assessment for major tributaries shows that floodplain width and inundation vary considerably along river stretches due to differences in channel morphology, topography, and settlement proximity. The Bhima, Ghataprabha, Malaprabha, Munneru, Musi, and Tungabhadra rivers all show segments where floodplains widen near meandering zones and settlements, indicating higher flood risk. Several villages and towns located near these corridors are exposed to seasonal flooding. This reach-wise floodplain characterization provides essential information for flood hazard zoning, settlement planning, land-use regulation, and sustainable flood risk management across the Krishna River Basin. Spatial distribution of flood-prone areas across the Krishna River Basin were represented in the Figure 3.1.

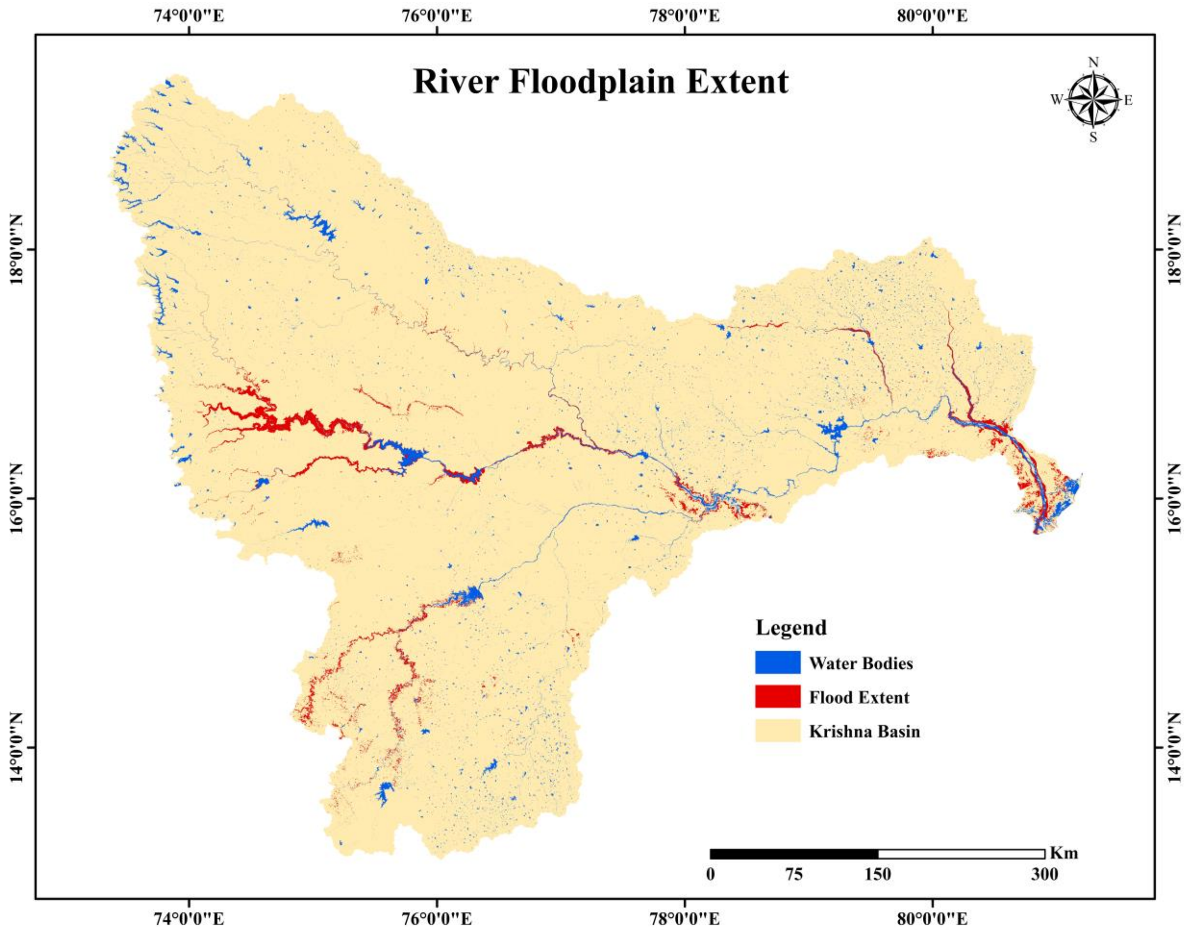

Figure 3. 1 Spatial distribution of flood-prone areas across the Krishna River Basin

4. River and Valley Margin

River and valley margin delineation is a fundamental aspect of fluvial geomorphology that helps in understanding the spatial relationship between rivers, their floodplains, and the surrounding terrain. In this study, Google Earth Pro software was used to delineate the river and valley margins of the Krishna River and its major tributaries including the Bhima, Tungabhadra, Munneru, Musi, Malaprabha and Ghataprabha rivers. Using high-resolution satellite imagery and digital elevation data, polygon data were created to mark the river margins, clearly defining the active channel boundaries and identifying areas influenced by fluvial processes. The Krishna basin covers an area of nearly 258,948 square kilometers, supporting diverse landscapes ranging from steep valleys in the upper catchments to wide alluvial plains in the lower reaches. These variations make it an ideal case for valley confinement analysis.

4.1 Methodology Using Google Earth Pro

After mapping the river margins, a floodplain layer was overlaid to delineate zones of periodic inundation and sediment deposition. This overlay helped visualize the extent of floodplain connectivity and flood dynamics. To analyze valley morphology in detail, cross-sections were drawn at 5 km intervals along the entire river course and selected tributaries. Each cross-section provided elevation profiles, revealing valley slopes, floodplain widths, and channel confinement. From these profiles, each reach was categorized into one of three geomorphological confinement classes: confined, partly confined, and laterally unconfined. This classification followed field-based geomorphic principles but was implemented entirely through remote sensing and digital elevation data, demonstrating the power of Google Earth Pro as an accessible, cost-effective analytical tool.

4.2 Classification of River Valley Confinement

The classification of river valley confinement helps in understanding how the surrounding topography influences the shape, behaviour and floodplain development of a river. Valley confinement determines the degree to which a river can migrate laterally and form floodplains, impacting channel morphology, sediment transport, and flood dynamics. By categorizing valleys based on their degree of confinement, it becomes possible to assess flood hazards, identify river corridor stability, and plan sustainable land-use practices along riverbanks. This classification provides a useful framework for interpreting river behaviour within different geomorphic settings.

4.2.1 Confined Reaches

Confined reaches are those where the river channel is tightly enclosed between valley walls or bedrock slopes, leaving little to no space for floodplain development. The channel is typically steep, straight, and narrow, with a high stream power and limited lateral movement. These reaches are mostly found in the upper Krishna basin and Middle Krishna, particularly in the Western Ghats and hilly regions of nallamala forest, where valley incision dominates. Mapping confined reaches helps identify stable, erosion-resistant zones where channel migration is minimal. These areas are significant for understanding sediment transport efficiency and for assessing potential zones of landslides or gorge development. Confined river and valley margin in middle Krishna sub-basin is represented in Figure 4.1.

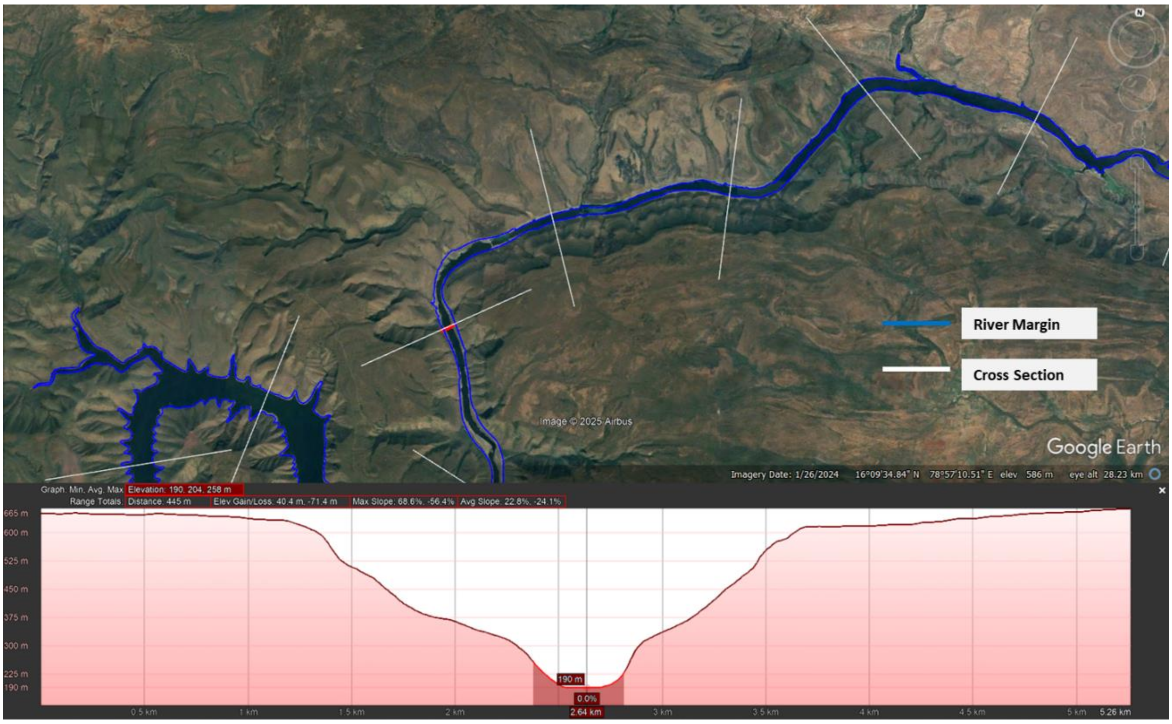

Figure 4. 1 Confined River and Valley Margin in Middle Krishna Sub-basin

4.2.2 Partly Confined Reaches

Partly confined river segments occur where the channel is bounded by valley walls or terraces on one side, but the other side is open to limited floodplain development. These reaches typically occur in the middle Krishna basin, notably in parts of northern Karnataka and southern Telangana. Here, the river displays alternating confined and unconfined patterns due to variations in valley width and slope. The floodplain is moderately developed, containing terraces, side channels, or small islands. These reaches are geomorphologically active, with moderate channel migration, localized sediment deposition, and a balance between vertical incision and lateral expansion. Partially confined river and valley margin in middle Krishna sub-basin is represented in Figure 4.2.

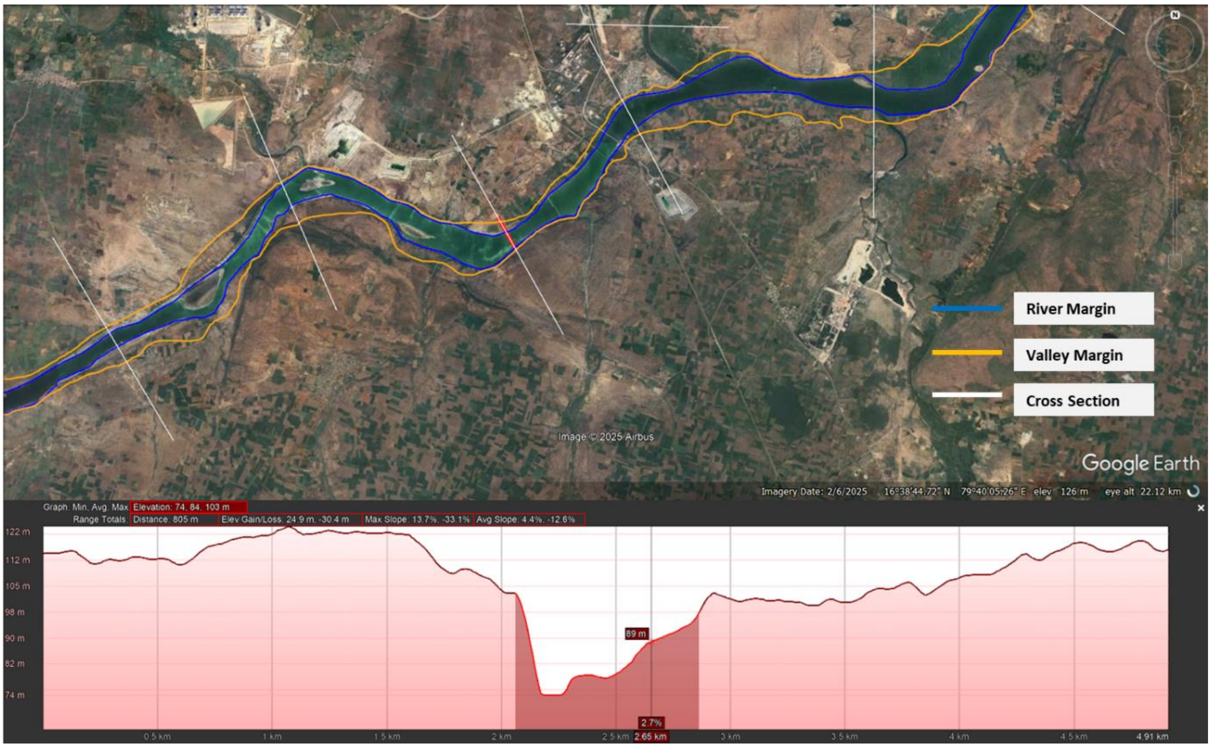

Figure 4. 2 Partially confined River and Valley Margin in Lower Krishna Sub-basin

4.2.3 Laterally Unconfined Reaches

Laterally unconfined reaches are found primarily in the lower Krishna basin, especially in Andhra Pradesh, where the river flows through broad alluvial plains before reaching the delta. These sections are characterized by wide floodplains, gentle slopes, and dynamic channel behavior, such as meandering and anabranching. The river has the freedom to migrate laterally, deposit sediments, and form oxbow lakes and levees. Such reaches are critical for flood management, agricultural planning, and wetland conservation, as they represent the most fertile and hydrologically dynamic parts of the river system. Laterally unconfined river and valley margin in middle Krishna sub-basin is represented in Figure 4.3.

4.2.4 Purpose and Significance of the Study

The primary purpose of delineating river and valley margins is to enhance understanding of river confinement, morphology, and floodplain dynamics. The Krishna River's varying confinement patterns reflect its geomorphic evolution—from steep, confined mountain channels to wide, unconfined alluvial plains. This classification helps identify erosion-prone areas, potential flood zones, and stable valley segments, which are vital for river basin management, flood risk assessment, and sustainable development. It also supports hydrological modeling and watershed planning, providing a scientific basis for restoration and conservation efforts. Moreover, the use of Google Earth Pro demonstrates how freely available geospatial tools can produce high-quality geomorphic mapping results. The ability to extract elevation profiles, visualize terrain in 3D, and overlay multiple spatial datasets makes it an invaluable resource for researchers and planners. By applying this method to the Krishna River system, this study contributes to a deeper understanding of fluvial landscape dynamics across climatic, topographic, and geological gradients. It establishes a framework that can be replicated for other major river basins in India to promote integrated river management and resilience against flooding and environmental change.

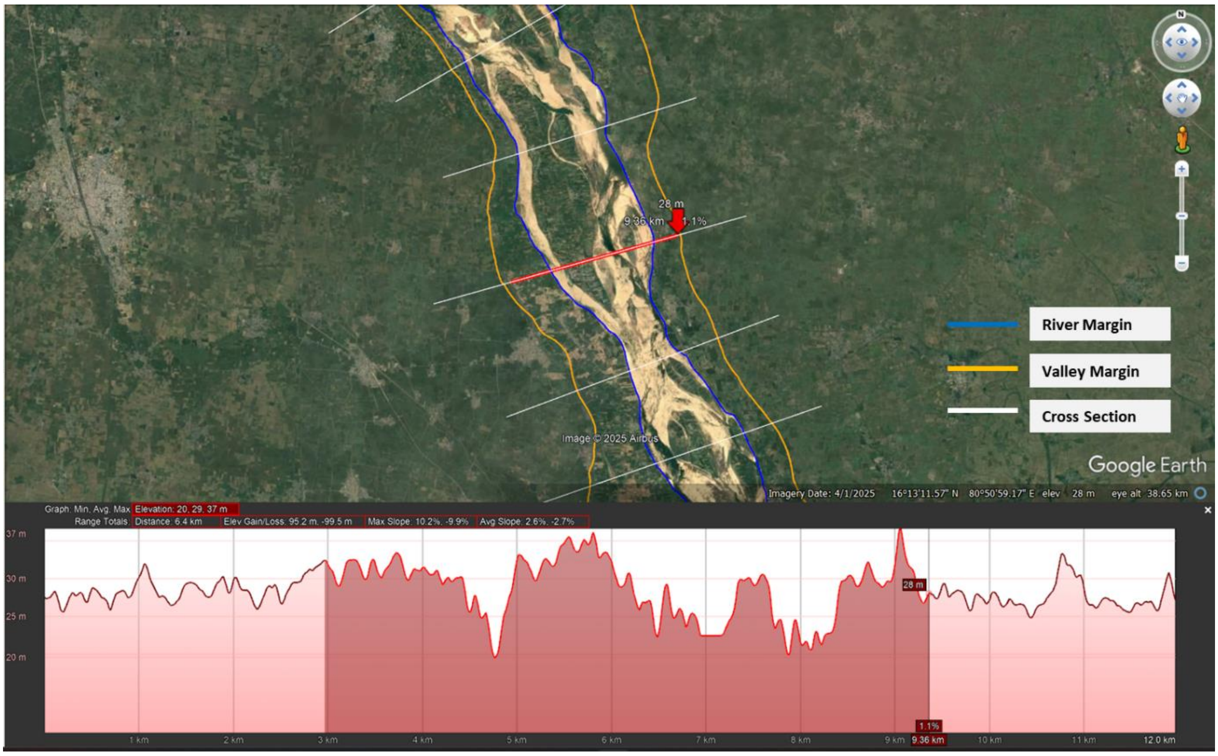

Figure 4. 3 Laterally Unconfined River and Valley Margin in Lower Krishna Sub-basin

5. River Island

Figure 5.1 illustrates the spatial distribution of river islands (locally known as donkas or donnas) observed along selected reaches of the Krishna River Basin. The islands are mainly concentrated in the middle and lower courses of the river, particularly between Pulichintala, Vijayawada, and the Krishna Delta region. These islands are formed through fluvial depositional processes, where sediment accumulation occurs due to reduced flow velocity and channel bifurcation.

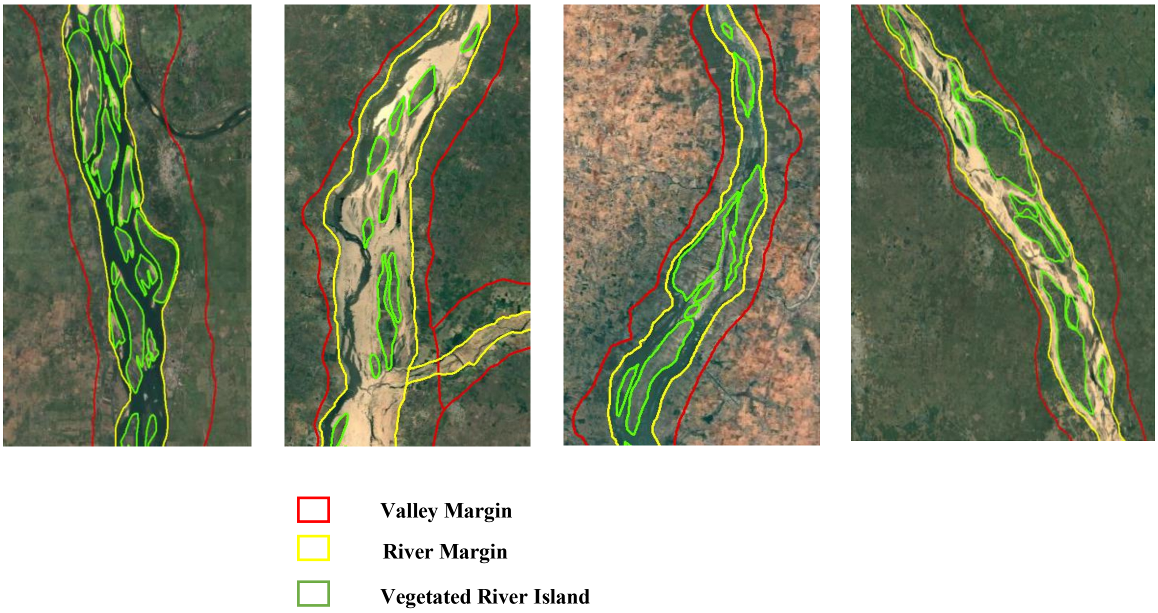

Figure 5. 1 Representation of River Islands Present in Some Stretches of the Krishna River Basin

A total of 122 river islands have been identified along various stretches of the Krishna River Basin, primarily concentrated in the middle and lower reaches of the river. These islands vary significantly in size, shape, and stability, reflecting the dynamic fluvial processes operating within the basin. The largest island covers an area of 15.48 square kilometers, while the smallest island measures only 0.176 square kilometers. The average island area is approximately 2.43 square kilometers, and together they occupy a cumulative area of around 297 square kilometers. Most of these islands are located between Pulichintala, Vijayawada, and the Krishna Delta, where the river gradient decreases and sediment deposition becomes prominent. The islands are generally elongated or oval-shaped, formed by mid-channel sedimentation due to variations in discharge and flow velocity. Some of the larger islands have developed stable surfaces that support vegetation and are even used for seasonal agriculture, while smaller ones appear as temporary sandbars that emerge and disappear with changes in river flow. The occurrence and morphology of these river islands reveal the sediment transport dynamics and channel migration patterns within the Krishna River system. Their distribution is influenced by a combination of factors such as hydrological regime, sediment supply, channel slope, and human interventions like dam construction and sand mining. Overall, these islands serve as important geomorphic indicators of active depositional environments, playing a key role in shaping the fluvial landscape and ecological balance of the Krishna River Basin.

6. Geomorphic Mapping in Krishna River Basin

Geomorphic mapping of river corridors helps in understanding the physical features and sedimentary forms that shape the river channel and its floodplain. Rivers continuously adjust their course and channel pattern due to variations in water flow, sediment supply, and valley confinement. These adjustments create distinct geomorphic units such as sandbars, point bars, lateral bars, mid-channel bars, and scroll bars. Sandbars and mid-channel bars often form within the active channel due to sediment deposition during low-flow conditions. Point bars and lateral bars develop along the inner bends of meandering channels, reflecting channel migration over time. Scroll bars represent older meander features preserved on the floodplain, marking the historical shifting of the river course. Mapping these geomorphic features provides valuable insights into river dynamics, flood risk zones, sediment processes, and long-term channel evolution. The Figure 6.1 illustrates the geomorphic characteristics of the Bhima River between Reach 33 and Reach 36. The active river channel (blue) is bordered by varying widths of floodplain deposits (yellow), indicating zones prone to periodic inundation. The valley margins (grey) define the lateral extent within which the river migrates. Several geomorphic units are identified along the river corridor, including river islands (green), lateral bars (pink), mid-channel bars (light yellow), sand sheets, and scroll bars, which reflect the dynamic sediment transport and channel adjustment processes occurring in this segment of the basin. Settlements such as Narube, Hunsihal, Sunatti, Tangadgi, Yadgiri, Kesler, and Jagpri lie close to the floodplain, highlighting regions where seasonal flooding poses potential risks. The geomorphic variability across these reaches demonstrates the influence of local topography, hydrology, and channel morphology on floodplain development and river behaviour.

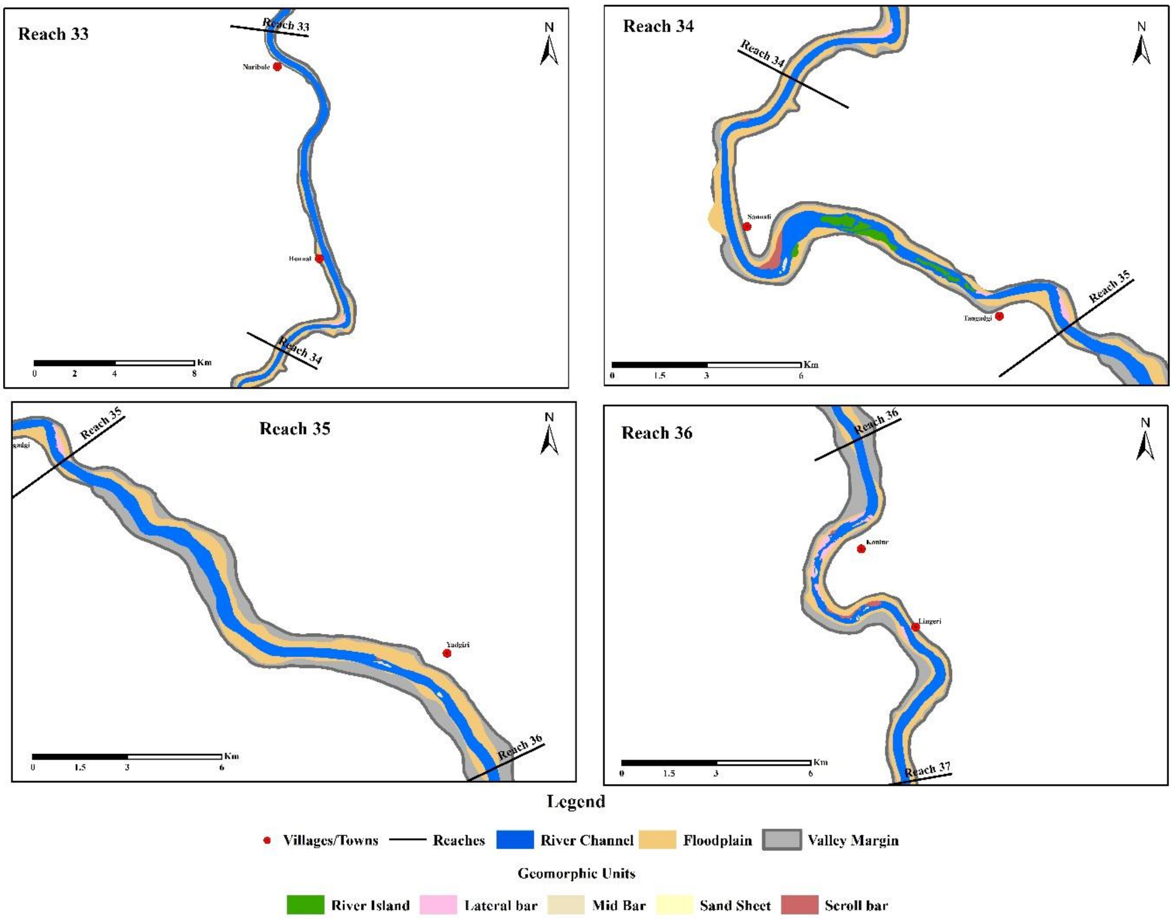

Figure 6. 1 Geomorphic mapping of the Bhima River from Reach 33 to Reach 36

The Figure 6.2 represents the spatial arrangement of geomorphic features along the Munneru River between Reach 5 and Reach 8. The active river channel (blue) is bordered by extensive floodplain areas (yellow), indicating zones that are frequently inundated during seasonal high flows. The valley margins (grey) outline the lateral limits of river migration within this section of the basin. A variety of geomorphic units are mapped within the channel corridor. River islands (green) and mid-channel bars (light yellow) indicate active sediment deposition zones influenced by variable flow conditions. Lateral bars and sand sheets form along channel margins, reflecting ongoing bank erosion and sediment transport. Scroll bars (pink) mark remnants of past meander loops preserved on the floodplain, providing evidence of historical channel migration. Settlements such as Pratap Singaram, Bacharam, Pillipalli, Rednavelly, Peddaravulapalle, Indriyala, Sangam, Gokaram, Vellipenda, Nagaram, Shobanadripuram, Vemulakonda, and Dugopally are located close to the floodplain, indicating areas with heightened flood susceptibility. The geomorphic variability observed across reaches highlights dynamic river behavior influenced by channel morphology, floodplain width, and local topographic controls.

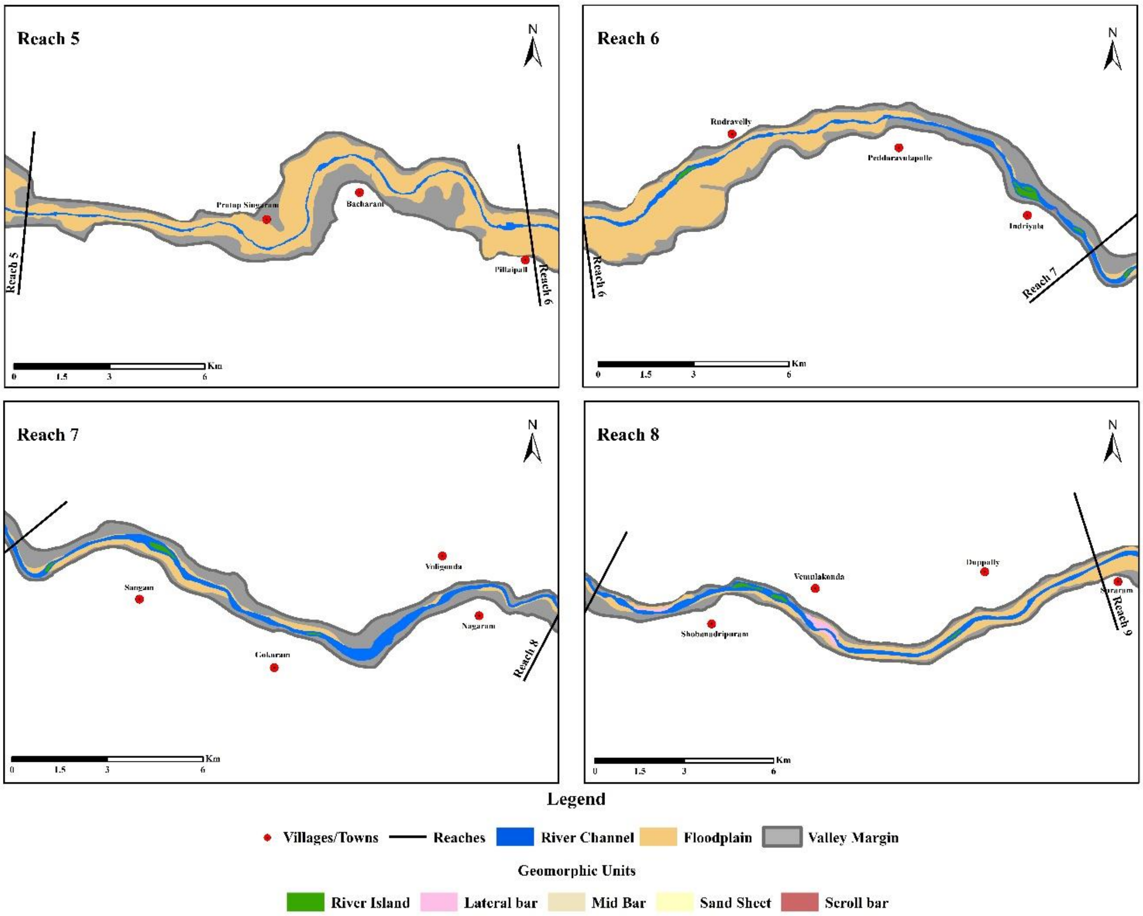

Figure 6. 2 Geomorphic mapping of the Musi River from Reach 5 to Reach 8

The Figure 6.3 illustrates the geomorphic characteristics of the Munneru River between Reach 5 and Reach 8. The active channel (blue) is bordered by broad floodplain areas (yellow), indicating zones of frequent inundation during high-flow conditions. The valley margins (grey) show the lateral extent of the river corridor and help define the degree of valley confinement. A variety of geomorphic units are present in these reaches. River islands (green) and mid-channel bars form within the main channel, reflecting active sedimentation and channel adjustment processes. Lateral bars and sand sheets develop along the channel margins, indicating ongoing erosion and deposition influenced by changes in Stream Energy. Occasional scroll bars (pink) mark former channel positions and record historical river migration on the floodplain surface. Settlements such as Dornakal (Reach 5), Khammam (Reach 6), Gandhari and Palampalle (Reach 7), and Penuganchiprolu (Reach 8) lie close to the floodplain and therefore face flood exposure during high discharge events. The spatial variability across the four reaches highlights the influence of local channel morphology, floodplain width, and human settlement distribution on flood risk and river dynamics.

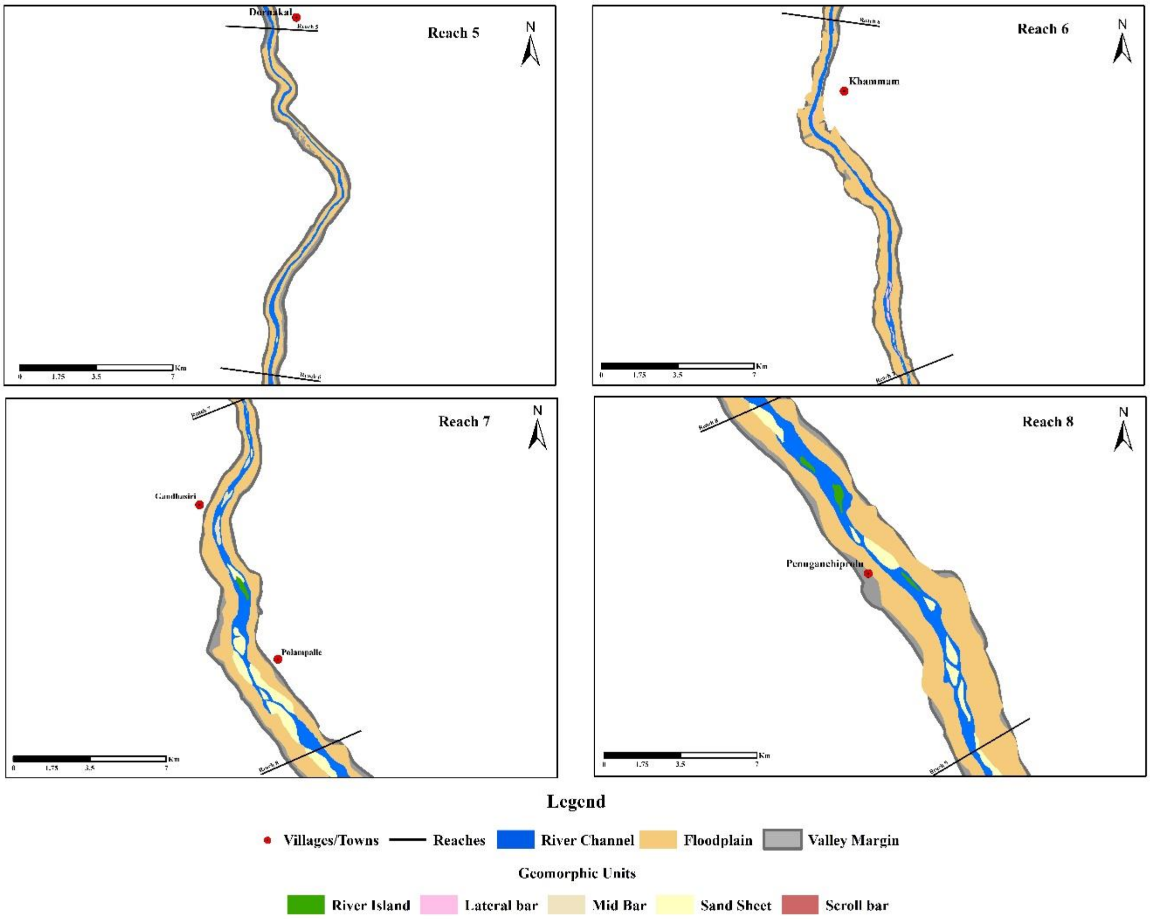

Figure 6. 3 Geomorphic mapping of the Munneru River from Reach 5 to Reach 8

The Figure 6.4 presents the geomorphic configuration of the Krishna River from Reach 45 to Reach 48 in the Lower Krishna sub-basin. In Reach 45, the river widens significantly due to the presence of the Pulichintala Reservoir, where channel form is controlled by impounded water and reduced flow velocities. Downstream from the reservoir, in Reach 46 through Reach 48, the river transitions back into a free-flowing state, marked by active channel migration and complex sediment deposition patterns. A variety of geomorphic units are evident in the downstream reaches. River islands (green) and mid-channel bars (yellow) indicate zones of dynamic sediment redistribution within the active channel. Lateral bars (pink) and sand sheets form along channel margins, reflecting alternating erosion and deposition driven by seasonal flow variations. Scroll bars (red) preserved on the floodplain surface mark older meander loops and document the historical shifting of the river course. Settlements such as Vajjimudipadu, Tadepalli, Koteru, Amaravalli, and Kotikalapudi are situated close to the floodplain and may experience seasonal flood impacts depending on reservoir releases and monsoon flows. The geomorphic variability in these reaches reflects the combined influence of reservoir control, sediment supply, valley width, and channel adjustments, making this section critical for flood management and land-use planning in the lower basin.

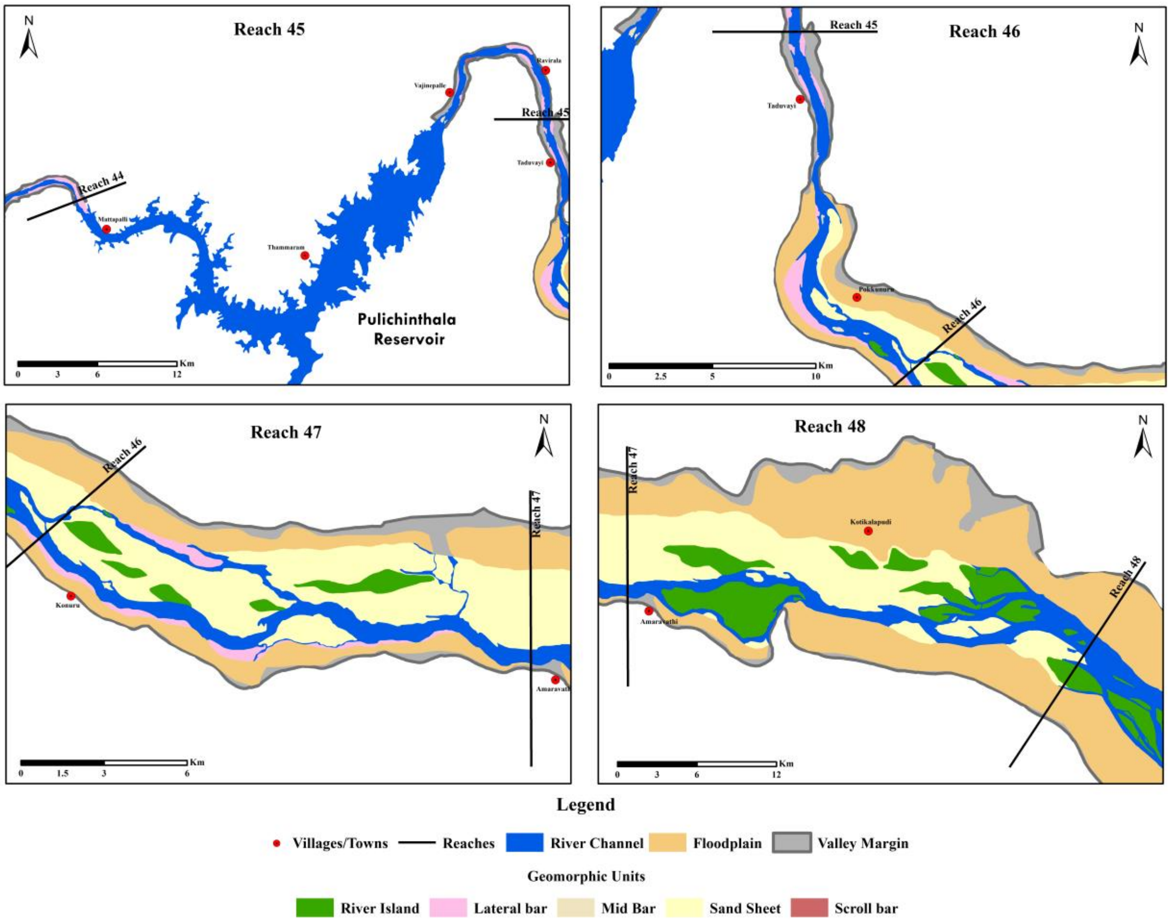

Figure 6. 4 Geomorphic mapping of the Krishna River from Reach 45 to Reach 48

7. River Style

A river style refers to the distinctive geomorphological characteristics of a river, including its channel pattern, sediment transport processes, and floodplain dynamics. The Krishna River Basin, spanning Maharashtra, Karnataka, and Andhra Pradesh, exhibits diverse river styles influenced by geology, climate, and human interventions. Understanding these styles helps in flood management, water resource planning, and ecological conservation. River Styles framework explains the mutual linkages between the river forms and the geomorphic processes within a specific zone in the river. It consists of attributes at different scales that provide a platform to distinguish different types of rivers. The River Styles framework provides a physical basis to describe and explain within a catchment distribution of river forms and processes, and predict future river behaviour. Within a catchment, River Style framework gives a holistic framework for data collection and organization and provides a framework to interpret its behaviour and the adjustment potential over time.

Scale is very important to define the hierarchical River Style framework. The nested hierarchical River Styles framework consists of five scales: catchment, landscape, reach, geomorphic and hydraulic. Catchment scale explains the geological setting and climatic condition over the entire catchment. Similarly, the landscape setting defines the large-scale landforms that directly impact the processes operative in different reaches. River reaches are stretches over which the basic riverine processes are more or less uniform. River Styles are identified and interpreted at the reach scale using valley setting and assemblage of geomorphic units. Geomorphic units and their sedimentology is defined for both the channel and the floodplain of the river. Within the geomorphic units, homogeneous sets of flow type and substrate define the hydraulic units that are used to interpret aquatic habitat patches along the river. River Styles classification is accomplished in different steps. For the identification of distinct River Styles three parameters namely, valley setting, geomorphic units and bed material texture are necessary. Each parameter plays a major role in defining one style. For an example, channel plan form of an alluvial river shows distinct behaviour between different valley settings whereas the bed material texture is important in defining the processes operative in a particular river reach. Sedimentological composition and the mutual association of channel planform and channel geometry with the geomorphic units provide the distinct attributes for the different River Styles. Sinuosity and braid channel ratio are important from channel morphometry point of view. Field investigation assists the River Style framework by providing some necessary data. Bed material texture can be interpreted from the field data. In general terms, bed material size and texture reflects regional geology, flow energy and sediment flux from upstream. Confined valley settings are dominated by bed rock with coarse textured geomorphic units. In Partly confined valley settings bed rock may or may not be present and bed materials are of variable sizes. Fine-grained suspended deposits are encountered in the floodplain pockets. Unconfined valley settings comprise all kinds of textures with locally significant bedrock. Bed material textures and its relation to the bank composition translate to the river character and behaviour. The Krishna River basin has significant diversity in terms of landscape setting, valley setting, valley morphology, geomorphic features; morphometric parameters that will be reflected in the River Style based classification. Additionally, River Style is a hierarchical approach, which includes geomorphic characteristics at different scales. The large-scale attributes for the Krishna River include landscape setting, valley setting, valley morphology, valley confinement and the small scale (reach scale) attributes consist of bar area, bar percentage, sinuosity, braid channel ratio etc. The Krishna River exhibits multiple river styles, each shaped by natural and human-induced factors. A proper understanding of these styles is crucial for sustainable river basin management, flood control, and ecosystem conservation. From the application point of view, River Styles framework will provide a present base line to evaluate the physical status of a river with respect to the geomorphic character, its present-day condition in terms of geomorphology, flow characteristics and biota and allow us to develop a framework for comparison with the past condition and future trends of the river. On the basis of characterization of the river following the River Style framework approach we propose to approach the work of river restoration and management.

7.1 Data used

The key geomorphic units that have been mapped for the river Krishna are valley margin, active floodplain and river margin; each characterized by several geomorphic features. Landsat imagery, SRTM generated DEM along with Google Earth images were used to prepare these maps. The geomorphic maps were also used to calculate different parameters such as sinuosity, braid channel ratio, the bar area, etc and has been used for characterizing the River Styles.

7.2 Field Observation

While characterizing a river reach, several parameters are needed such as bed material character, types of riparian vegetation; these were recorded during field visits to key points along the river. Field trip was organized in February 2025 and March 2025 to study these parameters.

7.3 DEM (SRTM)

The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) provides high-resolution topographic data for understanding terrain variations. It is widely used in hydrological modeling, floodplain mapping, and watershed analysis. The Krishna River Basin, covering Maharashtra, Karnataka, and Andhra Pradesh, has diverse topography ranging from Western Ghats (high elevations) to the Krishna Delta (low elevations), making SRTM DEM data essential for river basin studies. 30m SRTM DEM (1-arc second) is ideal for detailed river channel and floodplain studies. High-resolution DEM (30m): Captures small streams, riverbanks, and flood-prone areas more accurately.

7.4 Methodology

In order to characterize the stretches of Krishna River and divide it into geomorphologically significant and distinctive portions, the guidelines outlined in the River Style framework (Brierly et al., 2005) have been used which is represented in Figure 7.1. However, as Krishna is a much larger and complex system as compared to smaller drainages of Australia studied by Brierly and others, we have designed a set of parameters and criteria that can be applied in the present scenario to document geomorphic diversity and function of the Krishna River. This has formed the basis for differentiating the Krishna River into distinct River Styles.

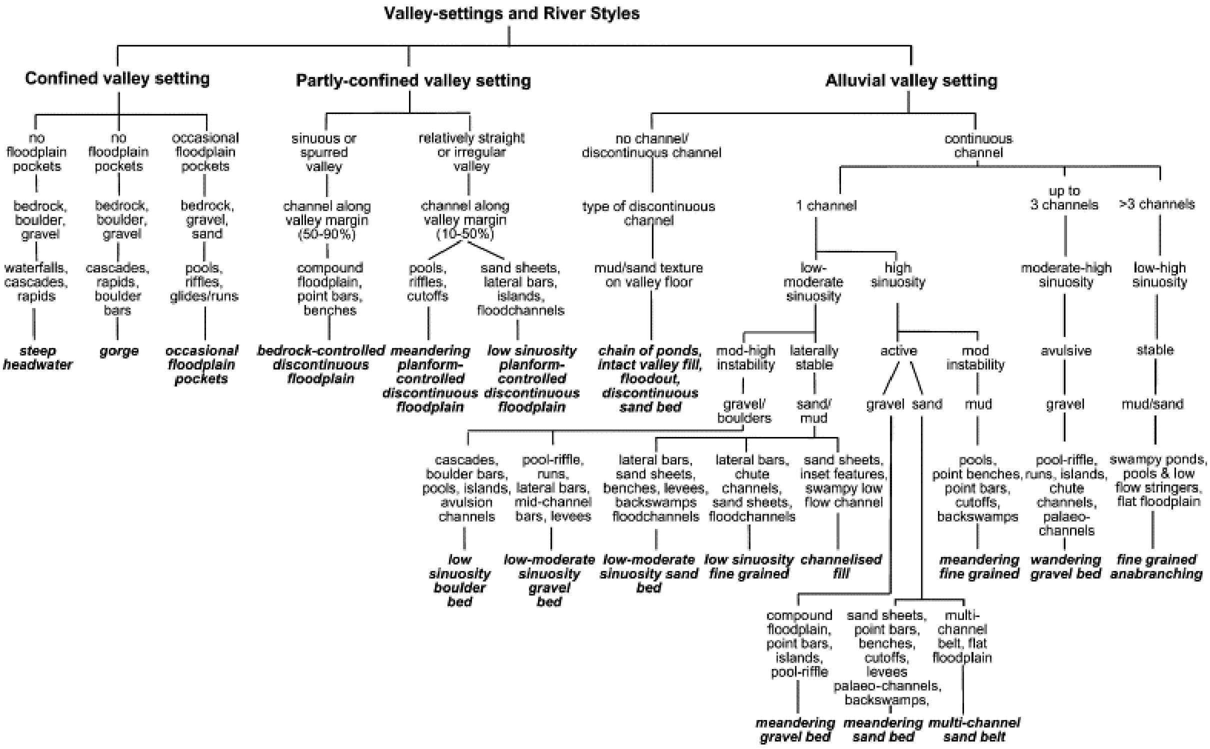

Figure 7. 1 Procedures used to name River Styles (Source: Brierly et al., 2005)

7.5 River Styles in Krishna River Basin

The following section describes the different river styles present in Krishna River Basin.

7.5.1 Laterally unconfined, continuous channel, anabranching, sand bed

This reach of the Krishna River in the Lower Krishna sub-basin exhibits a laterally unconfined channel pattern, where the river has ample room to migrate across a broad valley floor. The channel displays an anabranching form, with multiple interconnected flow paths that split and rejoin around mid-channel bars and islands. The riverbed is predominantly composed of sand, indicating active sediment transport and frequent channel adjustments during high flows. Such a geomorphic setting supports wide floodplain development and reflects dynamic hydrological conditions influenced by seasonal discharge variability and sediment supply. This river type is highly responsive to changes in flow regime, making it important for floodplain management and river corridor planning. Figure 7.2 represents the laterally unconfined, continuous anabranching sand-bed channel in the Lower Krishna sub-basin along the Krishna River.

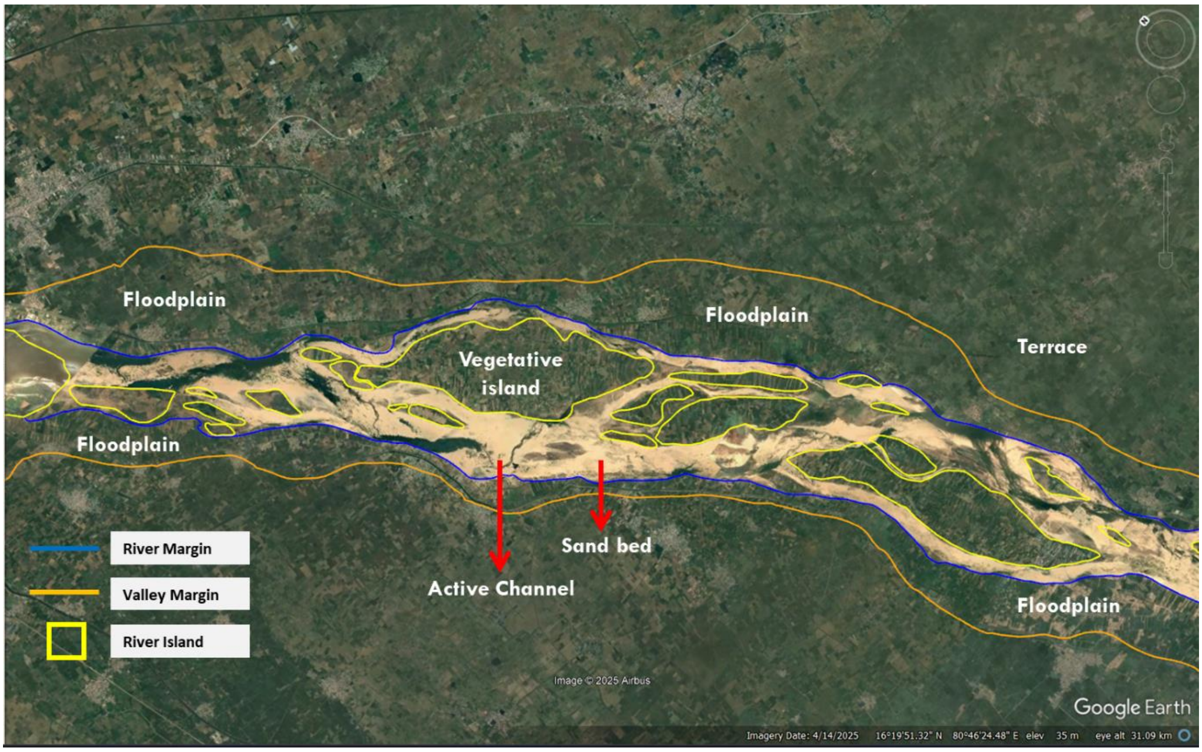

Figure 7. 2 Laterally unconfined, continuous anabranching sand-bed channel in the Lower Krishna sub-basin along the Krishna River

7.5.2 Partly Confined, Bedrock-Controlled Channel, Discontinuous Floodplain, Low Sinuosity, Sand-Bed

This reach of the Krishna River in the Lower Krishna sub-basin exhibits a partly confined valley setting, where the river corridor is bounded intermittently by bedrock hills on one or both sides. These bedrock margins restrict the lateral migration of the channel, resulting in a narrow to moderately developed floodplain that is discontinuous along the valley. The channel form is low sinuous, reflecting limited freedom for lateral movement due to valley confinement and structural controls. The riverbed is primarily sand-dominated, indicating active sediment transport under seasonal discharge variations. However, unlike laterally unconfined reaches, the presence of bedrock margins limits the formation of large mid-channel bars. Instead, point bars and small lateral bars develop along inner bends where velocity decreases flow. These bar forms represent localized sediment deposition and gradual channel adjustment within available space. The interaction between bedrock control, limited floodplain width, and sand-bed channel processes results in a geomorphic configuration where channel migration is restricted, discontinuous, and controlled by valley topography rather than solely by sediment supply or flow regime. This reach is therefore sensitive to changes in discharge magnitude, particularly during high-flow events when floodplain inundation occurs only in the wider unconfined pockets. Figure 7.3 illustrates the partly confined, bedrock-controlled, low-sinuosity sand-bed channel with discontinuous floodplain in the Lower Krishna sub-basin.

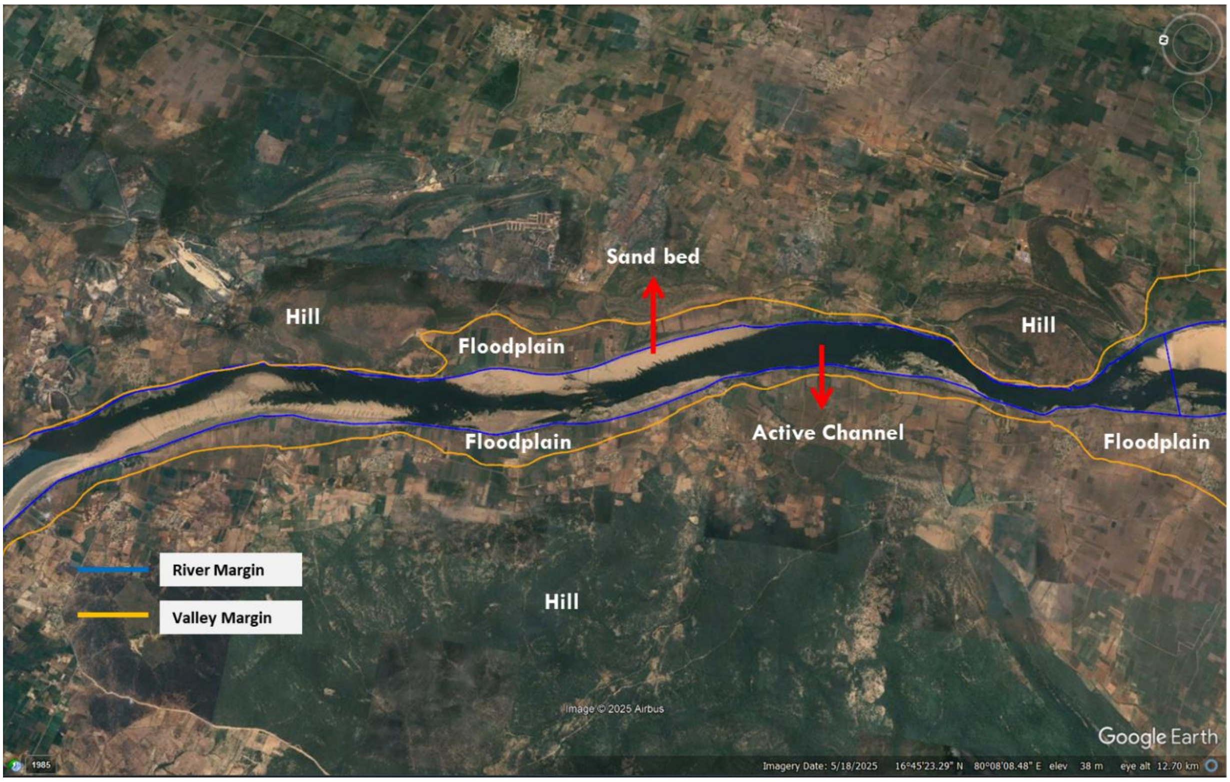

Figure 7. 3 Partly confined, bedrock-controlled, low-sinuosity sand-bed channel with discontinuous floodplain in the Lower Krishna sub-basin

7.5.2 Partly Confined, Terrace-Margin Controlled, Discontinuous Floodplain, Gravel Bed

This reach of the Krishna River within the Lower Krishna sub-basin is characterized by a partly confined valley setting, where the active river channel is bounded on one or both sides by terrace margins and hilly terrain. The confinement restricts lateral channel migration, resulting in a discontinuous floodplain that appears in isolated patches along the valley floor. The gravel-dominated riverbed indicates a relatively high-energy fluvial environment, reflecting coarse sediment transport and reduced overbank deposition. The presence of terrace margins suggests historical incision and adjustments of the river course through time, often influenced by tectonic activity and variations in discharge. The active channel is well-defined, bordered by narrow floodplains that widen locally where valley confinement decreases. This geomorphic configuration signifies a transitional setting between confined bedrock reaches and unconfined alluvial plains, emphasizing the role of structural control and sediment dynamics in shaping the river morphology. Figure 7.4 represents the partly confined, terrace-margin controlled, discontinuous floodplain with a gravel-bed channel in the Lower Krishna sub-basin along the Krishna River.

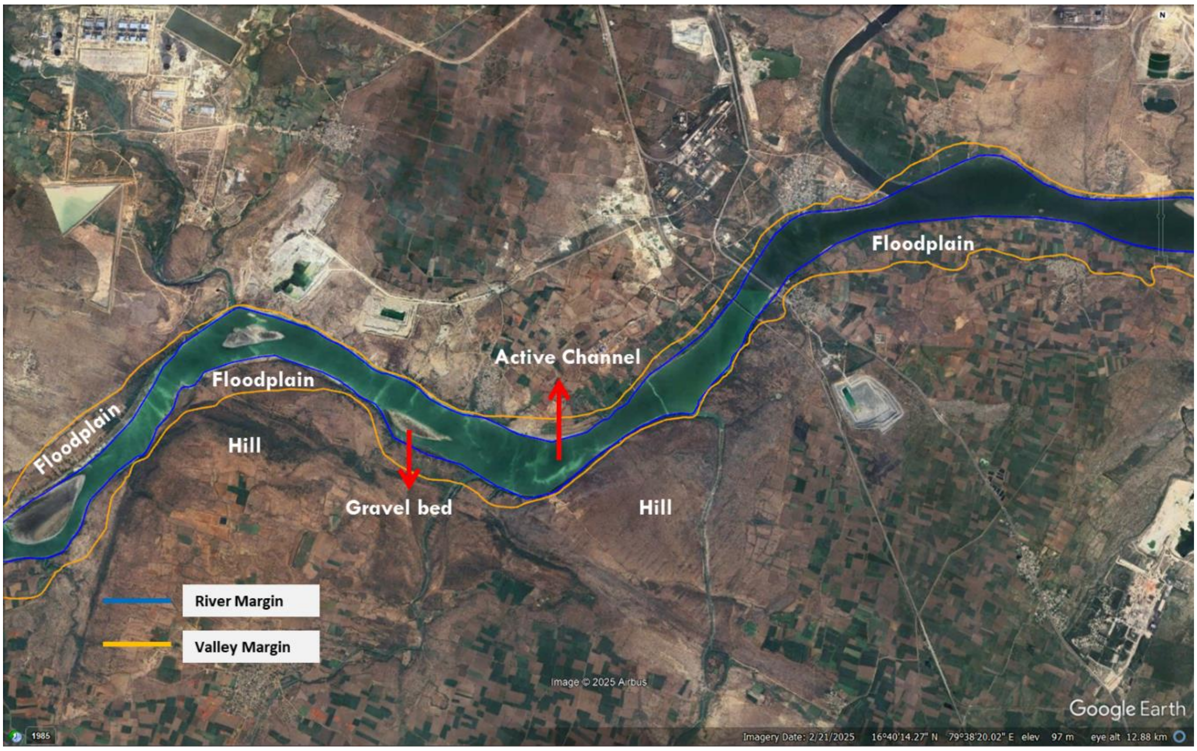

Figure 7. 4 Partly confined, terrace-margin controlled, discontinuous floodplain with a gravel-bed channel in the Lower Krishna sub-basin

7.5.4 Confined, Bedrock-Controlled, Continuous Channels, Lateral Bars, Boulder Bed

This reach of the Krishna River within the Middle Krishna sub-basin represents a confined, bedrock-controlled channel system, where the river flows through a narrow valley bordered by steep hills and resistant lithological formations. The confinement limits lateral channel migration, resulting in a continuous, linear river corridor that follows the structural alignment of the bedrock terrain. The riverbed is primarily composed of coarse boulders and cobbles, reflecting high stream power and limited sediment deposition. Lateral bars composed of boulder and gravel material are observed along the channel margins, formed during variations in discharge and localized sediment supply. The absence of a well-developed floodplain highlights the dominance of vertical incision over lateral erosion. This geomorphic configuration typifies a bedrock-dominated fluvial environment, where channel morphology and sediment characteristics are strongly governed by structural and lithological controls. Such reaches play a key role in regulating downstream sediment dynamics and influence the overall hydrological connectivity of the basin. Figure 7.5 represents the confined, bedrock-controlled, continuous channel with lateral boulder bars in the Middle Krishna sub-basin along the Krishna River.

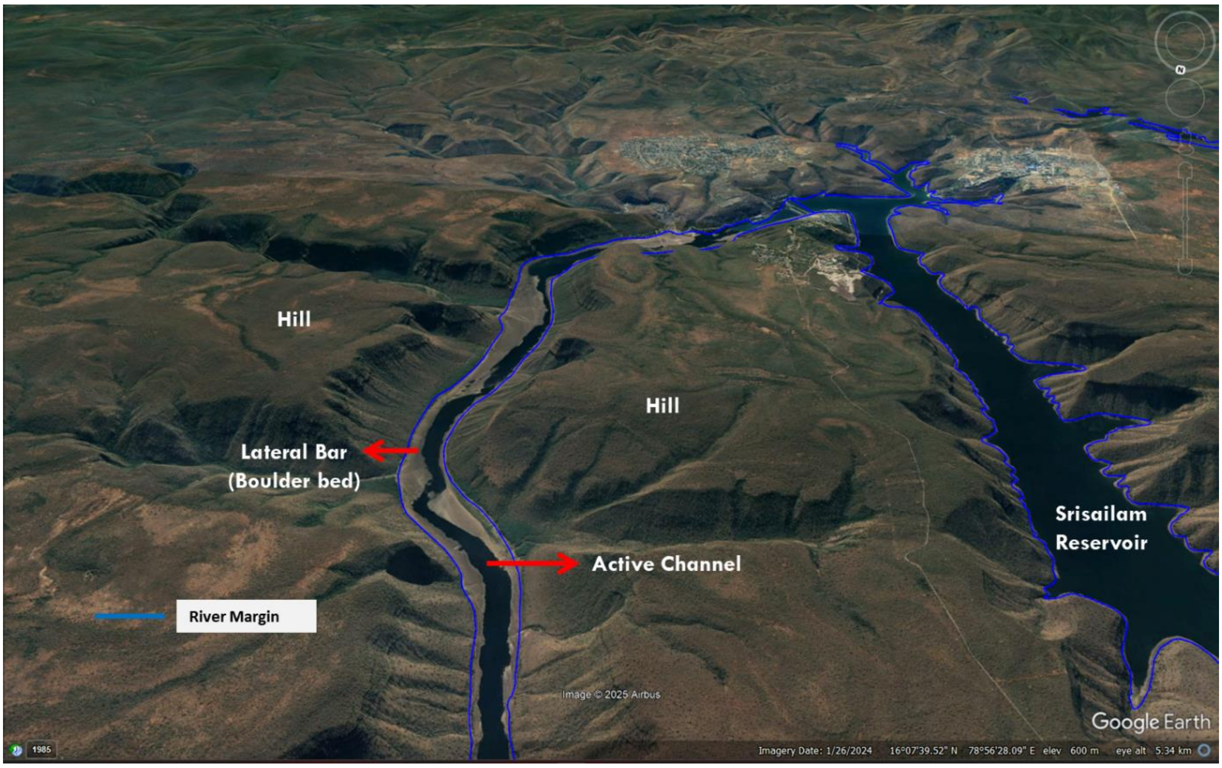

Figure 7. 5 Confined, bedrock-controlled, continuous channel with lateral boulder bars in the Middle Krishna sub-basin

7.5.5 Partly Confined, Terrace-Margin Controlled, Discontinuous Floodplain, Boulder Bed

This reach of the Krishna River within the Middle Krishna sub-basin exhibits a partly confined channel morphology, where the river is flanked by terrace margins and gentle valley slopes. The confinement restricts lateral migration, resulting in discontinuous floodplain patches that alternate along the channel margins. The boulder-dominated riverbed reflects high Stream Energy and coarse sediment transport, indicative of strong flows during monsoonal periods. The channel contains vegetative islands and mid-channel bars, formed through partial sediment deposition and stabilization by riparian vegetation. Terraces on either side of the channel mark former floodplain levels, representing stages of river incision and floodplain abandonment due to hydrological or tectonic influences. The active channel is moderately sinuous, flowing between exposed terraces and limited floodplain areas, suggesting partial structural control and sediment supply variability. This geomorphic setup highlights the transitional nature of the Middle Krishna, bridging the confined bedrock reaches upstream with the more open floodplain systems downstream. Figure 7.6 represents the partly confined, terrace-margin controlled, discontinuous floodplain with a boulder-bed channel in the Middle Krishna sub-basin along the Krishna River.

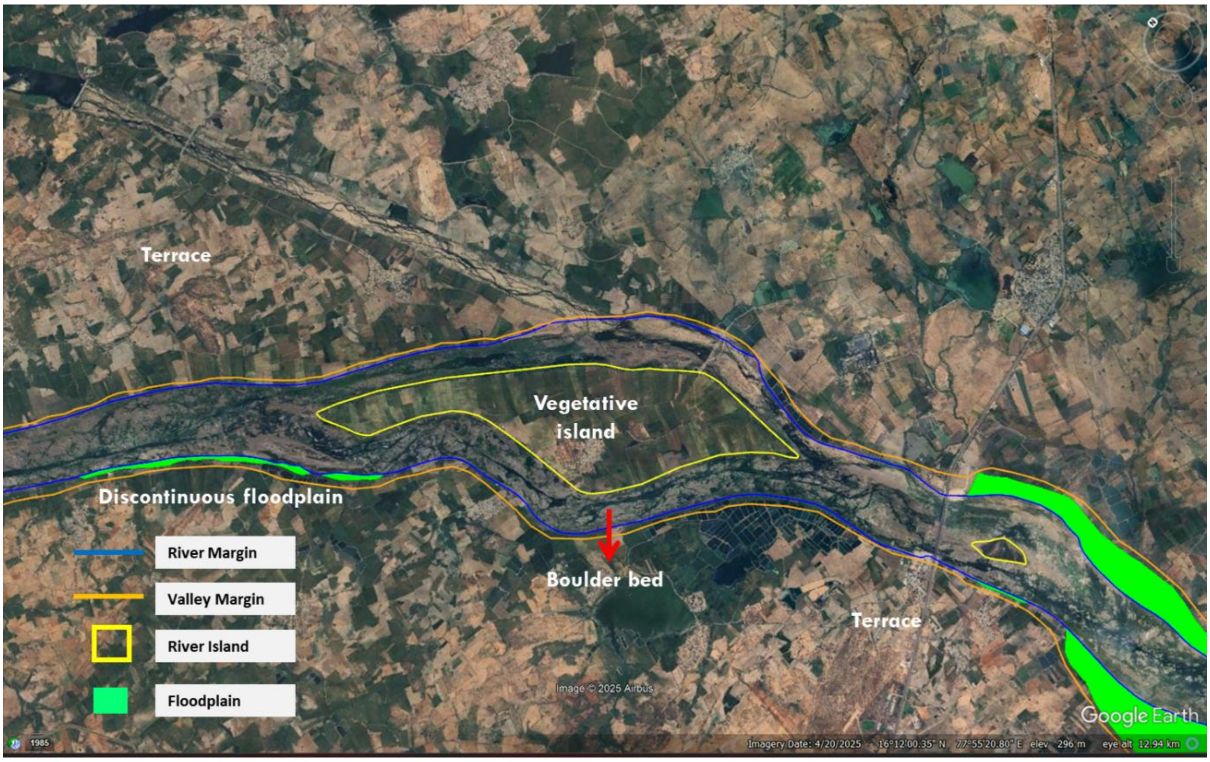

Figure 7. 6 Partly confined, terrace-margin controlled, discontinuous floodplain with a boulder-bed channel in the Middle Krishna sub-basin

7.5.6 Laterally Unconfined, Continuous Channel, Anabranching, Low Sinuosity, Boulder Bed

This reach of the Krishna River within the Middle Krishna sub-basin exhibits a laterally unconfined channel pattern, where the river occupies a broad valley floor with minimal structural or topographic constraints. The river displays a continuous anabranching form, characterized by multiple interconnected channels separated by vegetated islands and bars. The presence of a boulder-dominated bed indicates a high-energy fluvial system capable of transporting coarse sediment, particularly during peak discharge periods. The channel's low sinuosity suggests a predominance of straight to gently curving flow paths, reflecting a balance between sediment load, discharge, and valley gradient. Extensive floodplain zones flank both sides of the active channel, signifying lateral channel mobility during monsoonal flooding. The vegetative islands within the active channel promote channel stability and sediment trapping, contributing to the anabranching morphology. Overall, this geomorphic setting represents a transitional fluvial environment where strong hydrodynamic forces and sediment supply maintain a complex, multi-threaded channel system. Figure 7.7 represents the laterally unconfined, continuous anabranching low-sinuosity boulder-bed channel in the Middle Krishna sub-basin along the Krishna River.

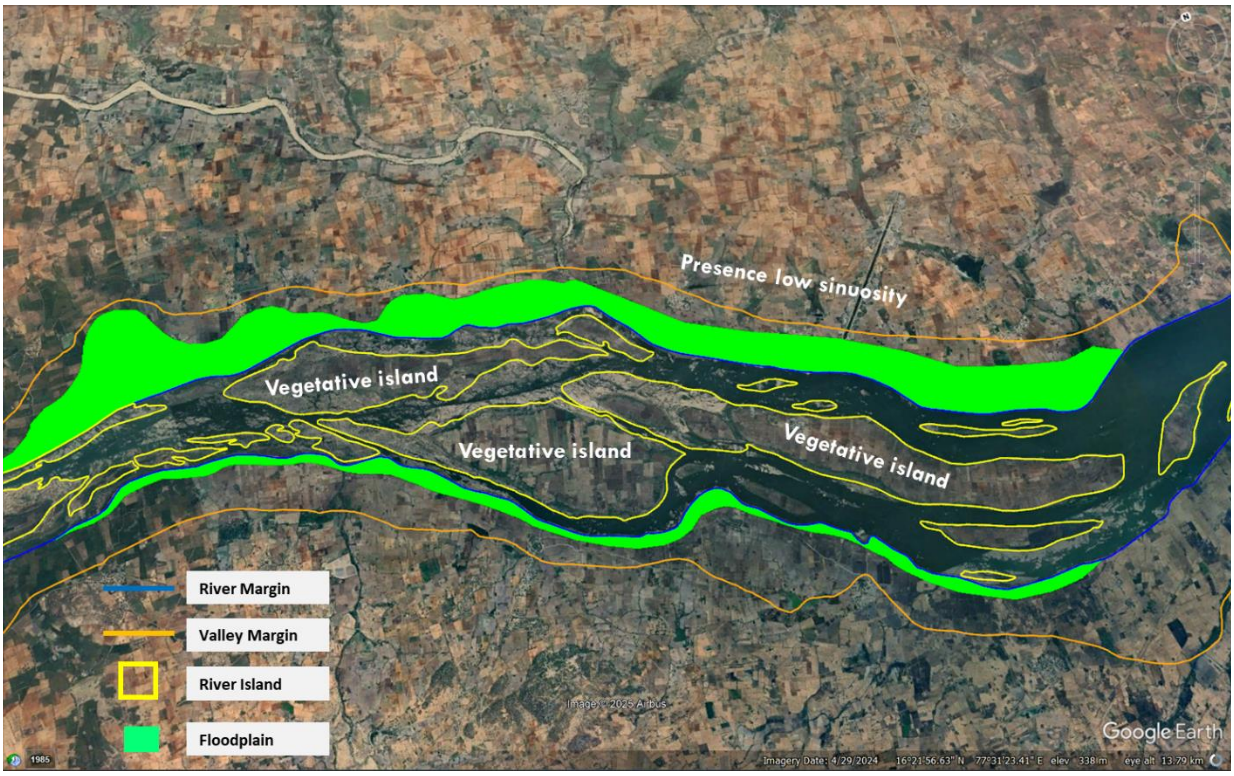

Figure 7. 7 Laterally unconfined, continuous channel, anabranching, low sinuosity, boulder bed in the Middle Krishna sub-basin

7.5.7 Partly Confined, Planform Controlled, Discontinuous Floodplain, High Sinuosity, Sand Bed

This reach of the Bhima River within the Lower Bhima sub-basin exhibits a partly confined channel morphology, where the active channel is bounded by subtle valley margins that locally restrict lateral expansion. The river displays a highly sinuous planform, characterized by well-developed meander bends and point bar formations along the inner banks. The sand-dominated riverbed indicates an alluvial system with active sediment transport and frequent channel migration during high-flow events. The floodplain is discontinuous, appearing intermittently along the outer margins of meanders, reflecting localized overbank deposition and lateral confinement due to valley morphology. The active channel alternates between wide meandering loops and narrow sections, showing a dynamic equilibrium between flow energy and sediment load. This type of geomorphic setting is typical of transitional alluvial plains, where variations in valley width, slope, and sediment supply govern channel behavior. The high sinuosity and sand-bed composition highlight the fluvial dynamism of this reach, emphasizing its sensitivity to hydrological changes and anthropogenic influences. Figure 7.8 represents the partly confined, planform-controlled, discontinuous floodplain with a high-sinuosity sand-bed channel in the Lower Bhima sub-basin along the Bhima River.

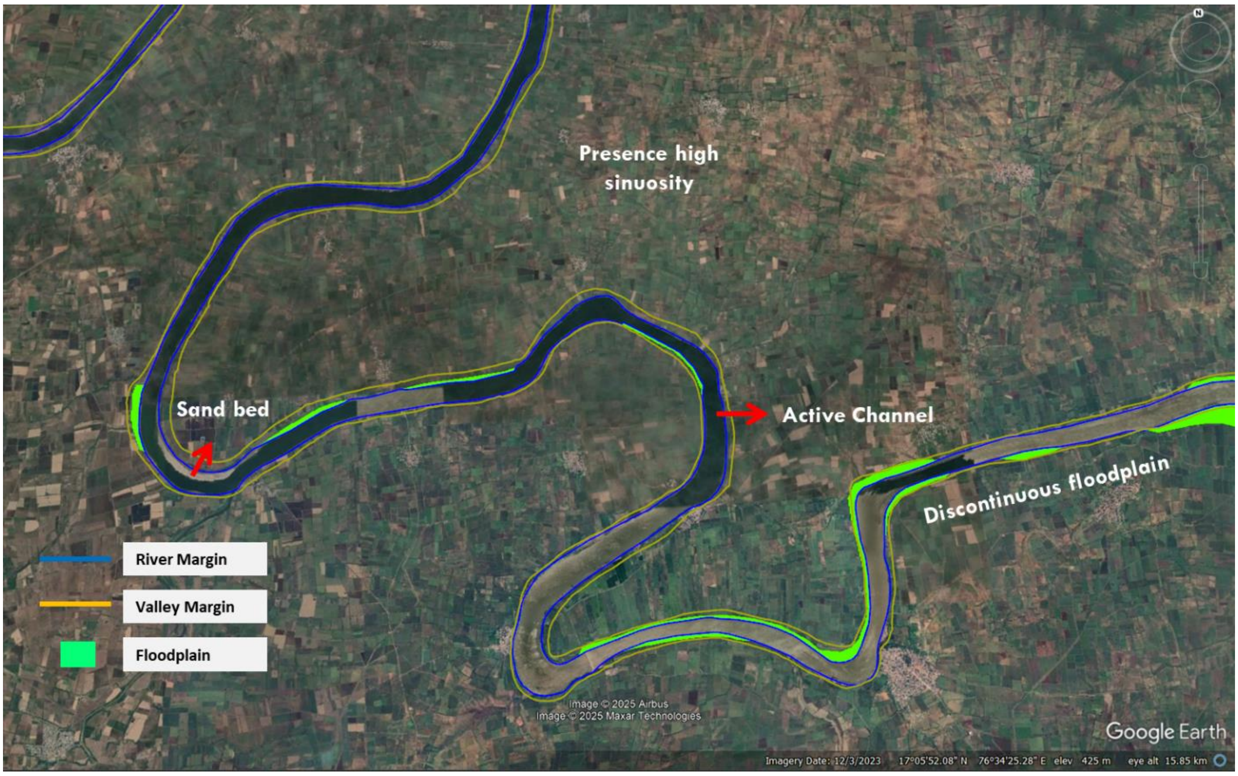

Figure 7. 8 Partly confined, planform-controlled, discontinuous floodplain with a high-sinuosity sand-bed channel in the Lower Bhima sub-basin

7.5.8 Confined, Bedrock-Controlled Margin, No Floodplain, Boulder Bed

This reach of the Bhima River within the Lower Bhima sub-basin represents a highly confined, bedrock-controlled valley segment, where the river flows through steep and narrow gorges carved into resistant lithological formations. The channel is tightly constrained by hills and valley walls, allowing minimal lateral movement or floodplain development. The absence of floodplains indicates dominant vertical incision rather than lateral erosion, typical of bedrock rivers in high-relief terrains. The riverbed is composed predominantly of boulders and cobbles, reflecting a coarse sediment load and high stream power associated with steep gradients. The active channel is narrow and entrenched, with flow energy focused on eroding and transporting large clasts rather than depositing finer sediments. This geomorphic configuration signifies a structurally and lithologically influenced fluvial system, where tectonic uplift, rock resistance, and valley confinement govern channel morphology and sediment dynamics. Figure 7.9 represents the confined, bedrock-controlled, no-floodplain boulder-bed channel in the Lower Bhima sub-basin along the Bhima River.

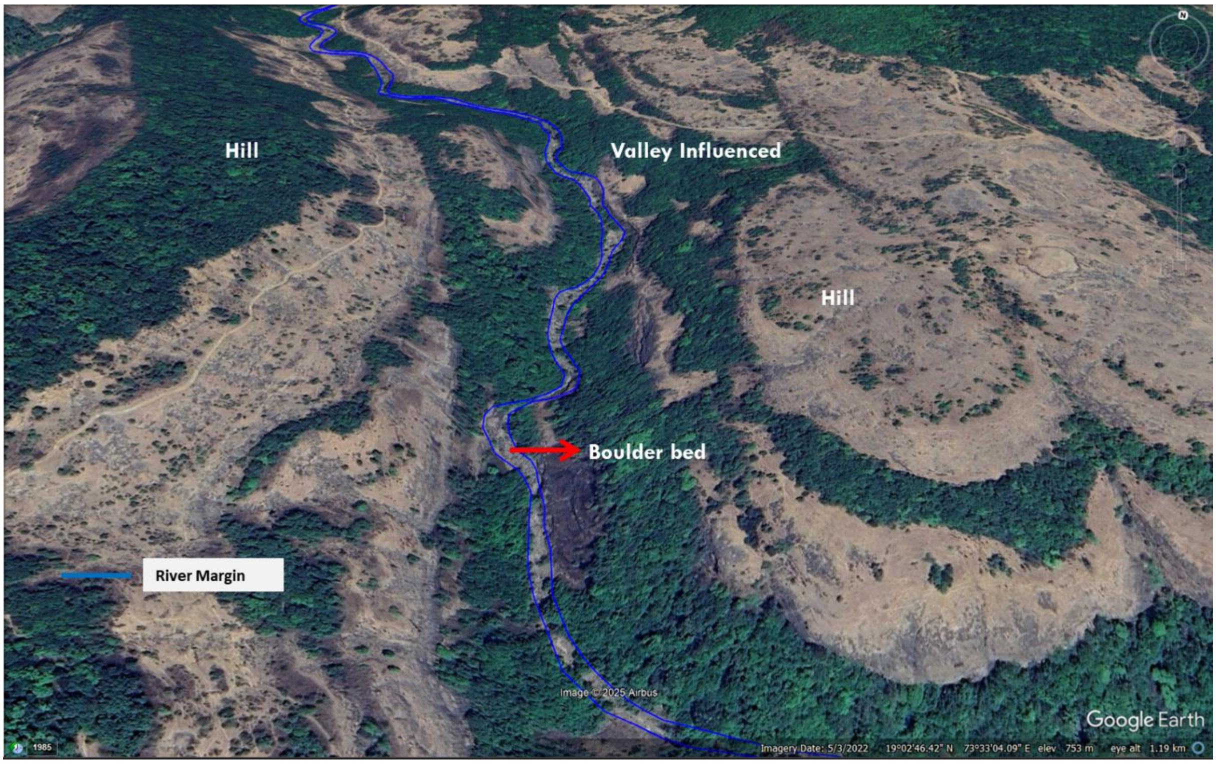

Figure 7. 9 Confined, bedrock-controlled, no-floodplain boulder-bed channel in the Lower Bhima sub-basin

7.5.9 Partly Confined, Terrace-Margin Controlled, Discontinuous Floodplain, Low Sinuosity, Boulder Bed

This reach of the Krishna River within the Lower Krishna sub-basin displays a partly confined channel system, where the river course is bordered by terrace margins and valley slopes that locally constrain lateral expansion. The channel exhibits low sinuosity, following a relatively straight to gently curving course across the valley floor. The boulder-dominated bed reflects high-energy flow conditions, capable of transporting coarse sediments during intense discharge events. The floodplain is discontinuous, occurring as narrow, isolated patches adjacent to the channel, primarily in zones where confinement relaxes. The terraces flanking the channel represent older floodplain levels, indicating stages of vertical incision and channel adjustment through time. The active channel alternates between wider depositional sections with exposed boulder beds and narrower confined segments controlled by terrace and valley morphology. This geomorphic configuration suggests a transitional environment between confined bedrock reaches and downstream unconfined alluvial plains, shaped by structural control, sediment supply, and periodic high-flow events. Figure 7.10 represents the partly confined, terrace-margin controlled, discontinuous floodplain with low sinuosity and a boulder-bed channel in the Lower Krishna sub-basin along the Krishna River.

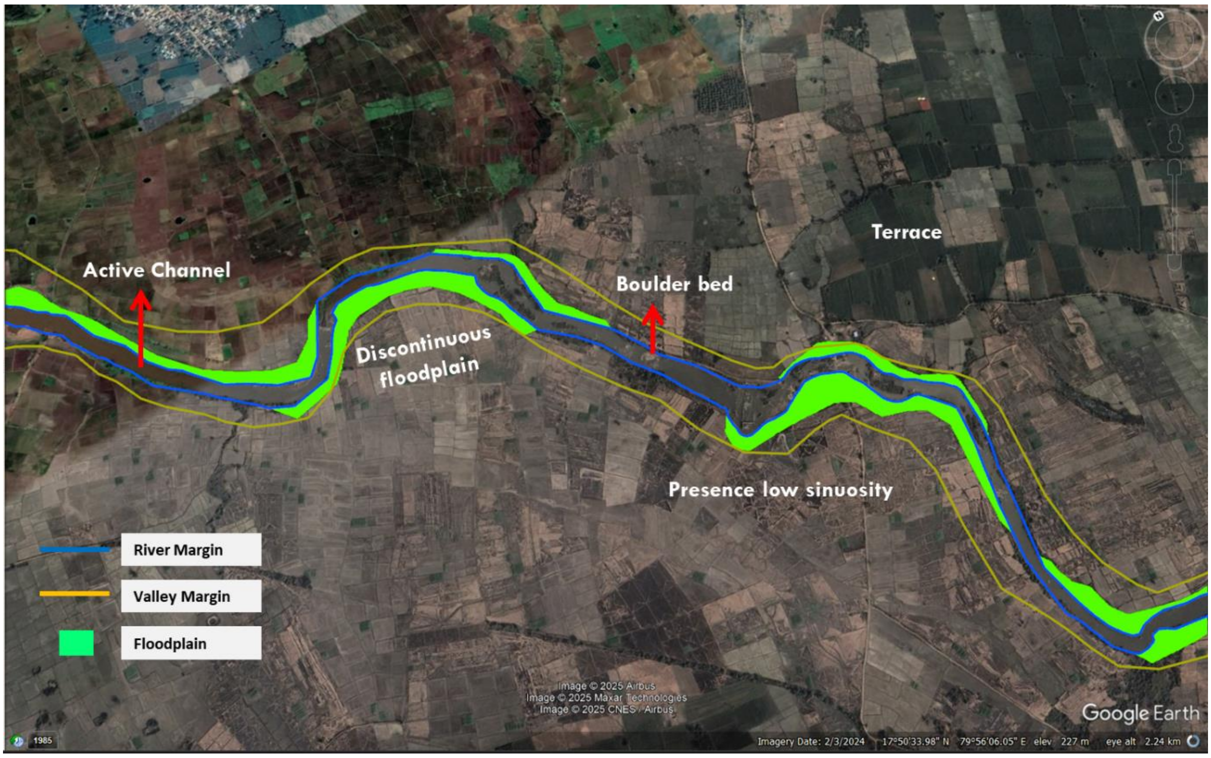

Figure 7. 10 Confined, terrace-margin controlled, discontinuous floodplain with low sinuosity and a boulder-bed channel in the Lower Krishna sub-basin

7.5.10 Laterally Unconfined, Continuous Channels, Braided, Mid-Channel Bars, Sand Bed

This reach of the Krishna River within the Lower Krishna sub-basin exhibits a laterally unconfined braided channel system, where the river spreads across a wide alluvial valley with minimal topographic or structural constraints. The channel network consists of multiple interconnected flow threads that divide and rejoin around mid-channel bars and sand islands, forming a classic braided pattern. The sand-dominated riverbed indicates high sediment supply and active bedload transport under variable flow conditions. Such morphology develops where Stream Energy fluctuates seasonally, allowing for alternate phases of bar formation, migration, and channel shifting. The floodplains on either side of the active channel are extensive and low-lying, reflecting frequent overbank inundation during monsoon floods. The braided nature of the river signifies high discharge variability and strong fluvial dynamics, characteristic of downstream alluvial reaches influenced by large sediment loads. This geomorphic setting highlights the dynamic equilibrium between flow energy, sediment transport, and channel morphology, crucial for floodplain management and channel stability analysis. Figure 7.11 represents the laterally unconfined, continuous braided channel with mid-channel bars and a sand-bed in the Lower Krishna sub-basin along the Krishna River.

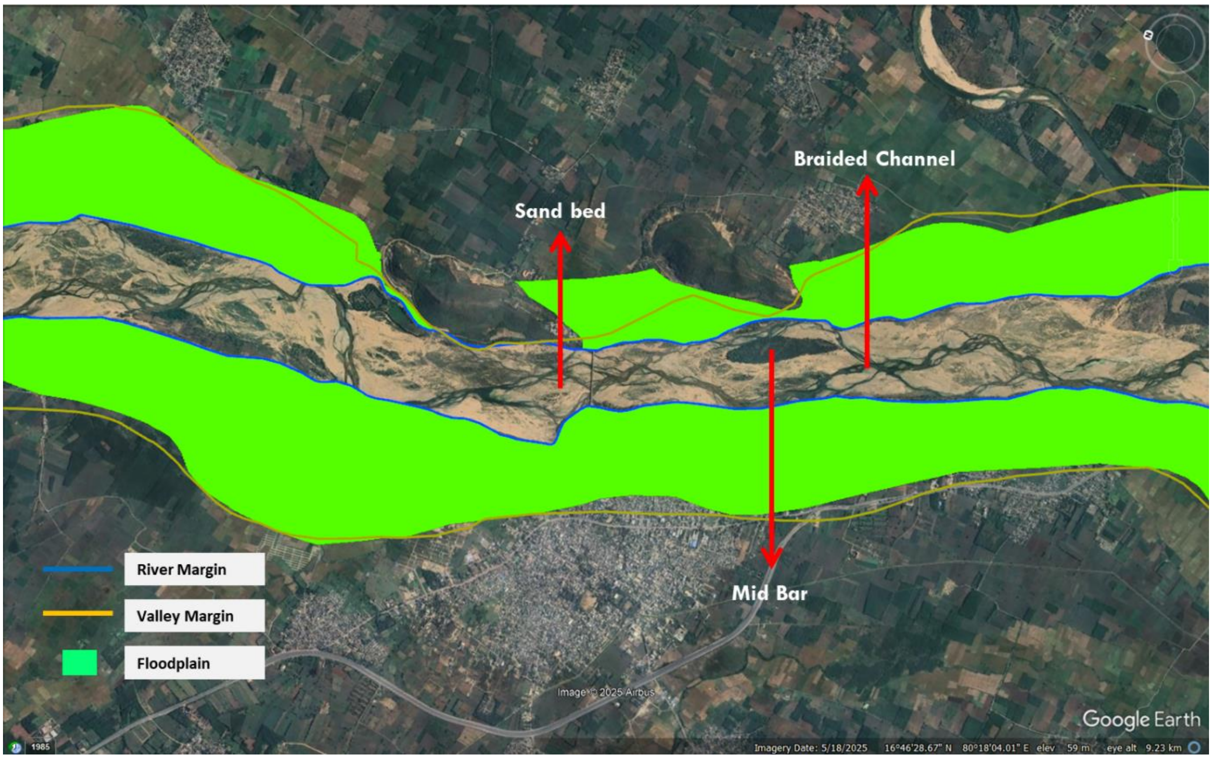

Figure 7. 11 Laterally unconfined, continuous braided channel with mid-channel bars and a sand-bed in the Lower Krishna sub-basin

7.5.11 Partly Confined, Terrace-Margin Controlled, Discontinuous Floodplain, Low Sinuosity, Boulder Bed

This reach of the Krishna River within the Lower Krishna sub-basin demonstrates a partly confined channel morphology, where the river flows through a moderately narrow valley bordered by terrace margins on either side. The confinement by terraces restricts lateral channel migration, leading to the development of a discontinuous floodplain that appears as isolated patches adjacent to the active channel. The low sinuosity of the river indicates a relatively straight channel form with limited meandering, typical of structurally influenced reaches in gently sloping terrains. The boulder-dominated riverbed reflects high Stream Energy and strong flow competence, capable of transporting coarse sediments during monsoonal floods. The active channel maintains a consistent width and flows between alternating narrow and slightly wider sections where terrace confinement relaxes. These characteristics suggest a transitional fluvial environment, where vertical incision dominates over lateral erosion, resulting in limited floodplain development and terrace preservation. Overall, this geomorphic setup highlights the influence of structural control, terrace evolution, and hydrological variability in shaping the channel morphology of the Lower Krishna. Figure 7.12 represents the partly confined, terrace-margin controlled, discontinuous floodplain with low sinuosity and a boulder-bed channel in the Lower Krishna sub-basin along the Krishna River.

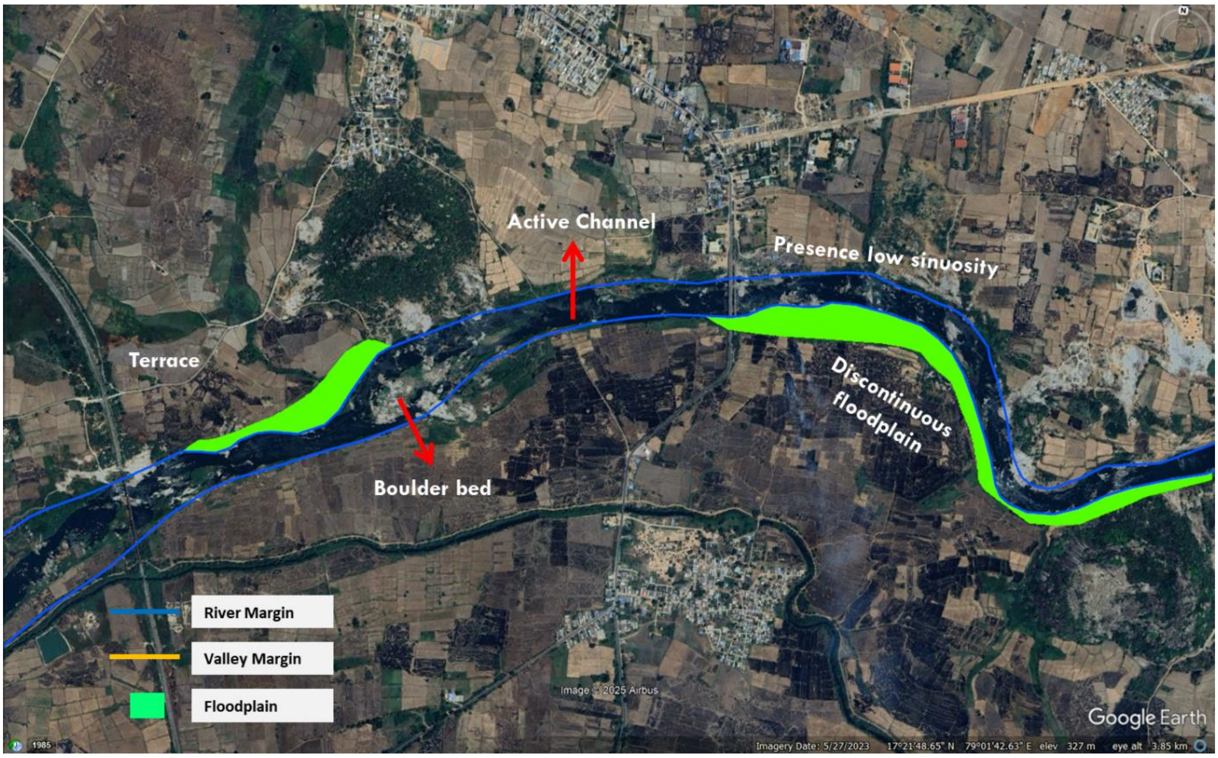

Figure 7. 12 Partly confined, terrace-margin controlled, discontinuous floodplain with low sinuosity and a boulder-bed channel in the Lower Krishna

7.5.12 Laterally Unconfined, Continuous Channel, Low Sinuosity, Boulder Bed

This reach of the Krishna River within the Lower Krishna sub-basin is characterized by a laterally unconfined channel system, where the river occupies a wide alluvial valley with minimal structural or topographic restrictions. The channel exhibits a continuous, low-sinuosity form, indicating a straight to gently meandering flow path with limited lateral deviation. The boulder-dominated riverbed signifies a high-energy fluvial environment capable of transporting coarse sediments during high discharge conditions, reflecting the strong hydrodynamic regime typical of monsoonal flows. The floodplain is continuous and well-developed on both sides of the channel, suggesting periodic overbank deposition and lateral sediment accretion. The presence of terrace features along the margins indicates previous floodplain levels, representing phases of incision and channel migration through time. This geomorphic setting reflects a stable, laterally extensive fluvial corridor, shaped by consistent flow energy and sediment supply, where coarse-grained material contributes to channel stability while maintaining dynamic flow characteristics. Figure 7.13 represents the laterally unconfined, continuous channel with low sinuosity and a boulder-bed channel in the Lower Krishna sub-basin along the Krishna River.

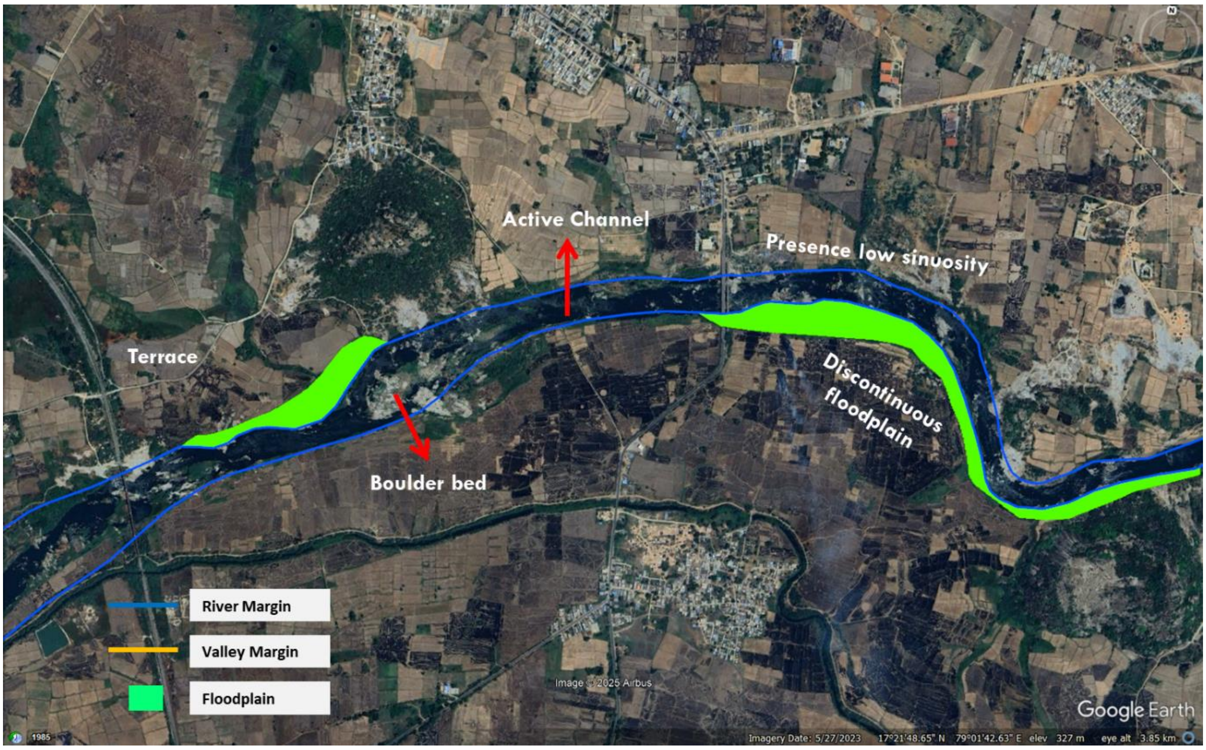

Figure 7. 13 Laterally unconfined, continuous channel with low sinuosity and a boulder-bed channel in the Lower Krishna sub-basin

7.5.13 Confined, Bedrock-Confinement with Discontinuous Terrace Control, Canyons, High Sinuosity, Boulder Bed

This reach of the Krishna River within the Upper Krishna sub-basin is characterized by a deeply confined bedrock-controlled channel, where the river flows through narrow canyons and gorges incised into resistant lithological formations. The confinement severely limits lateral migration, resulting in steep valley walls and restricted floodplain development. The terraces along the margins are discontinuous, occurring as isolated remnants formed during earlier fluvial stages of incision and sediment deposition. The channel displays high sinuosity, indicating pronounced meandering despite the structural confinement, a feature influenced by local lithological heterogeneity and tectonic adjustments. The boulder-dominated riverbed reflects the high stream power required to transport coarse sediment through confined reaches with steep gradients. The presence of multiple river islands within the active channel and narrow floodplain corridors suggests dynamic sediment redistribution and localized deposition.

Overall, this geomorphic setting represents a structurally influenced confined fluvial system, where incision, lithologic control, and variable discharge conditions have shaped a rugged canyon landscape. Figure 7.14 represents the confined, bedrock-constrained channel with discontinuous terrace control, canyons, high sinuosity, and a boulder-bed channel in the Upper Krishna sub-basin along the Krishna River.

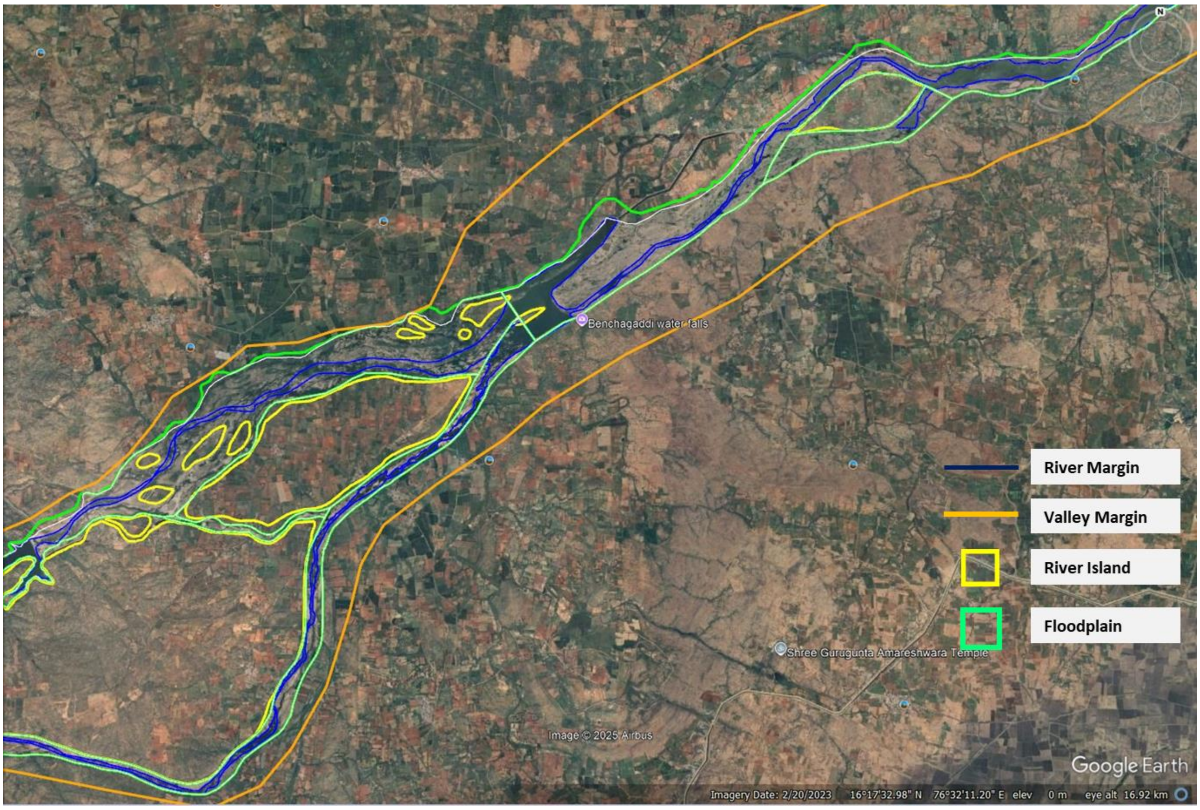

Figure 7. 14 Confined, bedrock-constrained channel with discontinuous terrace control, canyons, high sinuosity, and a boulder-bed channel in the Upper Krishna sub-basin

7.5.14 Confined, Discontinuous Stop-Bank–Margin Controlled, Highly Sinuous, Sand-Bed

This reach of the Krishna River in the Upper Krishna sub-basin exhibits a confined fluvial setting, where the river corridor is restricted by artificial and natural stop-bank margins rather than bedrock or terrace confinement. These stop-banks limit lateral channel migration and create a controlled pathway for river flow, resulting in a narrow and regulated floodplain zone. Despite the confinement, the river displays a highly sinuous planform, forming prominent meander loops that reflect active lateral erosion and deposition within the restricted corridor. The channel is underlain by a sand dominated bed, indicating active sediment transport and point-bar development along meander bends. Floodplains occur as discontinuous narrow strips, confined between the meandering channel and the stop-bank margins, highlighting frequent overbank deposition during peak flows. Localized river islands and bank-attached bars further reflect ongoing channel adjustments. This geomorphic setting represents a hybrid human-influenced confined river system, where anthropogenic stop-banks, historical flood control structures, and natural valley forms collectively govern channel behaviour. The combination of high sinuosity, sand-bed morphology, and discontinuous floodplain pockets underscores the dynamic nature of this regulated reach. Figure 7.15 illustrates the confined, discontinuous stop-bank–controlled, highly sinuous sand-bed channel within the Upper Krishna sub-basin along the Krishna River.

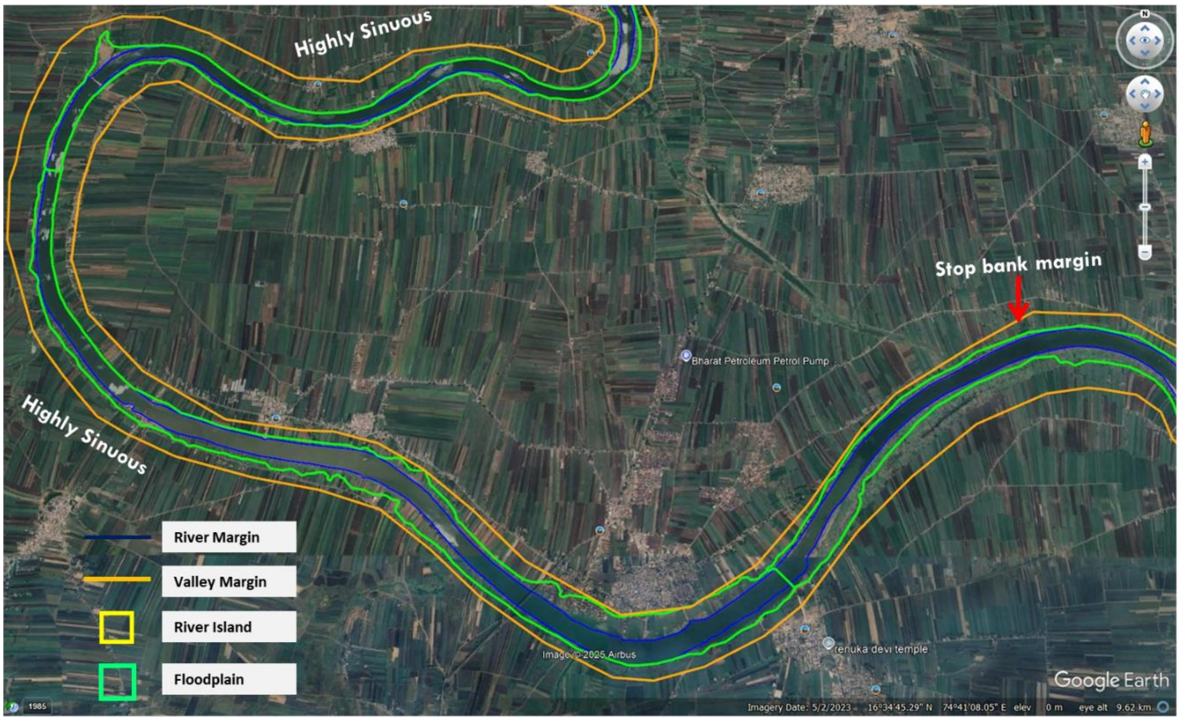

Figure 7. 15 Confined, discontinuous stop-bank–controlled, highly sinuous sand-bed channel within the Upper Krishna sub-basin

7.5.15 Confined, Discontinuous Stop-Bank Margin Controlled, Highly Sinuous, Sand-Bed Channel

This reach of the Malaprabha River in the Upper Krishna sub-basin represents a confined, stop-bank margin controlled fluvial system, where the river course is restricted by man-made embankments (stop banks) and adjacent valley margins. These discontinuous stop banks limit lateral channel migration, resulting in a narrow but highly sinuous river corridor. The channel displays pronounced meandering, with tightly looping bends formed due to hydraulic forcing within a confined zone. The sand-dominated riverbed indicates an alluvial system governed by moderate to high sediment supply, where point bars and inner-bend accretion surfaces develop within the meander loops. The floodplain is discontinuous, emerging mainly where the confinement from stop banks relaxes. The presence of artificial embankments strongly influences channel behavior, modifying natural meander migration, sediment deposition, and overbank flooding patterns. This geomorphic setting reflects a human-modified river environment, where structural controls (stop banks) interact with natural fluvial processes, resulting in enhanced sinuosity despite confinement. Such reaches are particularly sensitive to bank erosion, local flooding, and rapid bar development due to altered flow pathways. Figure 7.16 represents the confined, discontinuous stop-bank controlled, highly sinuous sand-bed channel in the Upper Krishna sub-basin along the Malaprabha River.

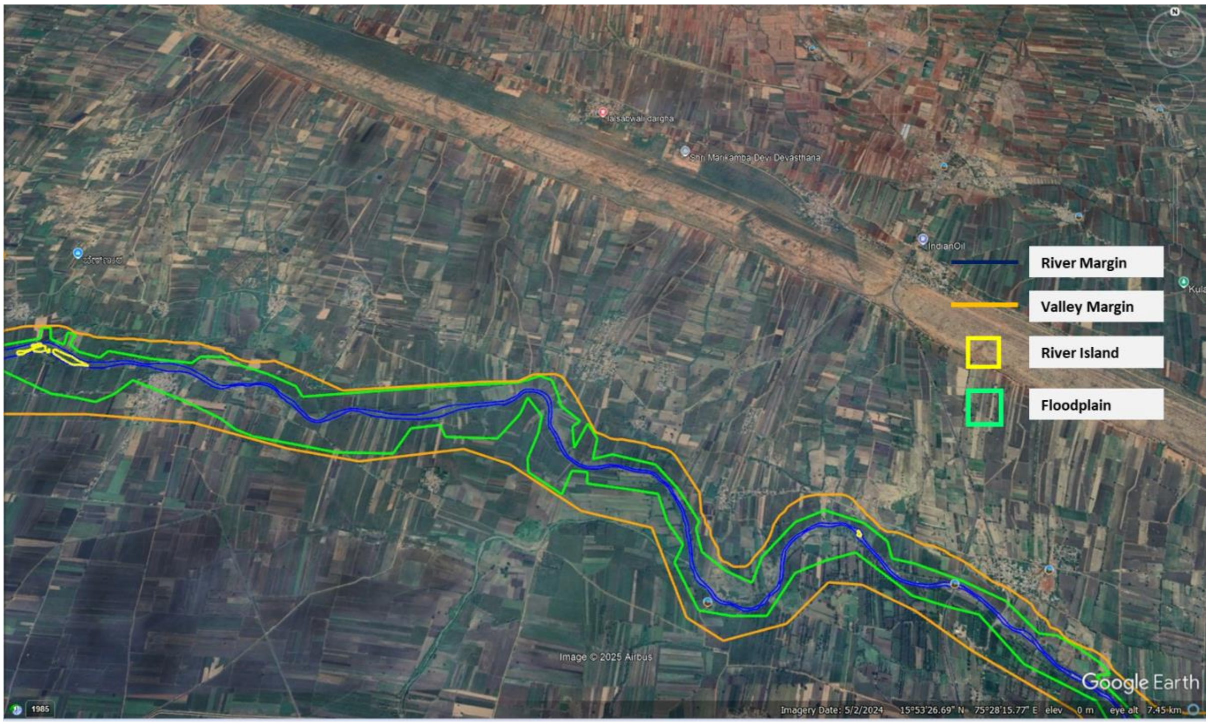

Figure 7. 16 Confined, discontinuous stop-bank controlled, highly sinuous sand-bed channel in the Upper Krishna sub-basin

7.5.16 Partly Confined, Discontinuous Bedrock & Floodplain, Gorge, Boulder Bed

This reach of the Krishna River within the Upper Krishna sub-basin is characterized by a partly confined channel system, where the river alternates between bedrock-controlled gorges and short stretches of limited floodplain development. The confinement results from steep valley walls, rugged topography, and exposed bedrock surfaces, which restrict the lateral mobility of the channel. As the river passes through these narrow gorges, it exhibits a boulder-dominated bed, indicating high stream power, strong incision, and the ability to transport coarse sediment during peak flows. Floodplains are discontinuous, appearing only in wider pockets where the valley briefly opens. These isolated floodplain patches reflect localized deposition under reduced confinement. The channel exhibits moderate sinuosity but remains largely controlled by structural and lithologic constraints of the surrounding hills and ridges. The presence of gorge-like segments, combined with alternating bedrock and alluvial patches, highlights a transition between fully confined bedrock reaches and partially unconfined alluvial sections downstream. Overall, this geomorphic environment represents a tectonically and lithologically influenced river corridor, where steep gradients, bedrock exposure, and coarse sediment loads dominate channel processes. Figure 7.17 represents the partly confined, discontinuous bedrock–floodplain system with gorge sections and a boulder-bed channel in the Upper Krishna sub-basin along the Ghataprabha River.

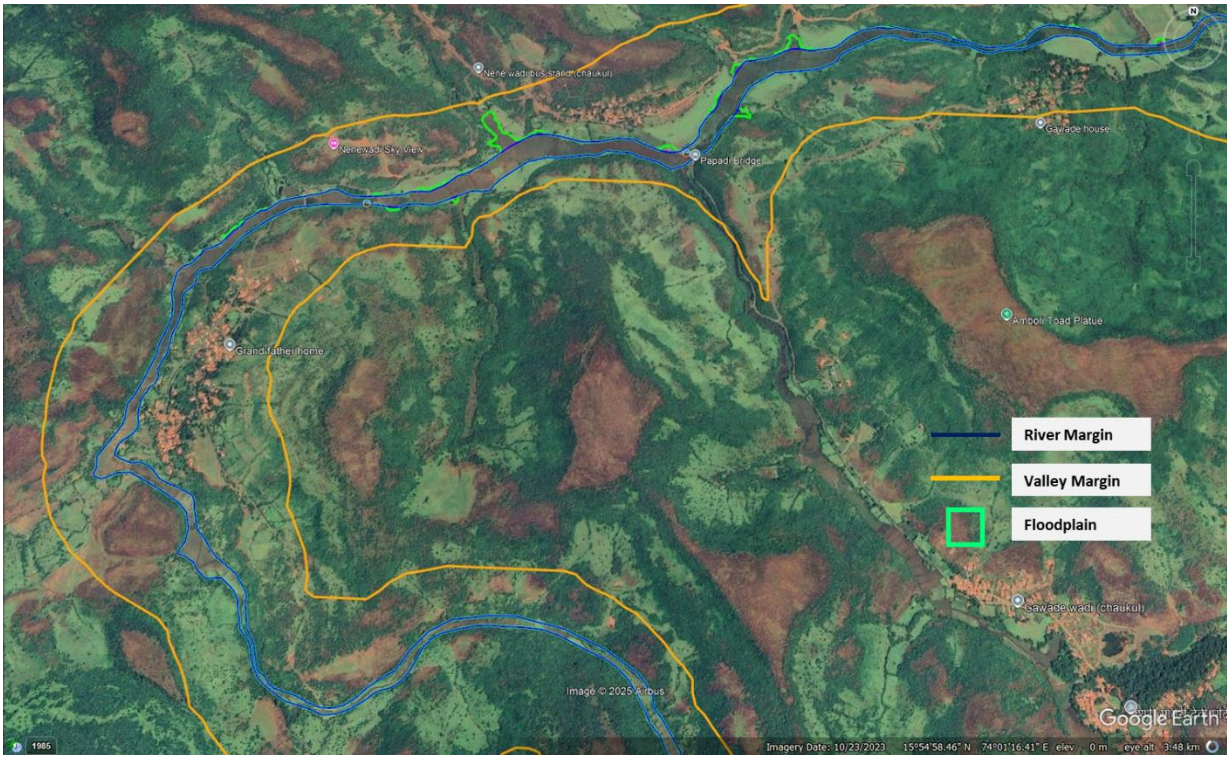

Figure 7. 17 Partly confined, discontinuous bedrock–floodplain system with gorge sections and a boulder-bed channel in the Upper Krishna

7.5.17 Laterally Unconfined, Continuous Channel, Low Sinuosity, Gravel-Bed

This reach of the Krishna River in the Upper Krishna sub-basin represents a laterally unconfined fluvial setting, where the channel flows across a broad valley floor with minimal structural or topographic constraints. The river exhibits a continuous, low-sinuosity channel pattern, characterized by generally straight to gently curving segments that reflect a relatively uniform valley gradient and steady flow conditions. The gravel-dominated riverbed indicates a moderate- to high-energy flow regime capable of transporting coarse sediments, particularly during monsoonal discharge peaks. The presence of both mid-channel bars and lateral bars highlights active sediment sorting and bar-building processes within the channel. These features also signify periodic channel adjustments and local flow divergence. The adjacent floodplain is continuous, particularly along the wider portions of the valley floor, supporting overbank deposition during high-flow events. Low sinuosity combined with a gravel bed suggests a transitional fluvial environment where sediment supply, valley width, and flow competence collectively shape channel behavior. Overall, this geomorphic configuration reflects a stable yet dynamic alluvial system within the Upper Krishna basin, providing important insights for sediment management, ecological connectivity, and hydrological assessments. Figure 7.18 represents the laterally unconfined, continuous low-sinuosity gravel-bed channel in the Upper Krishna sub-basin along the Ghataprabha River.

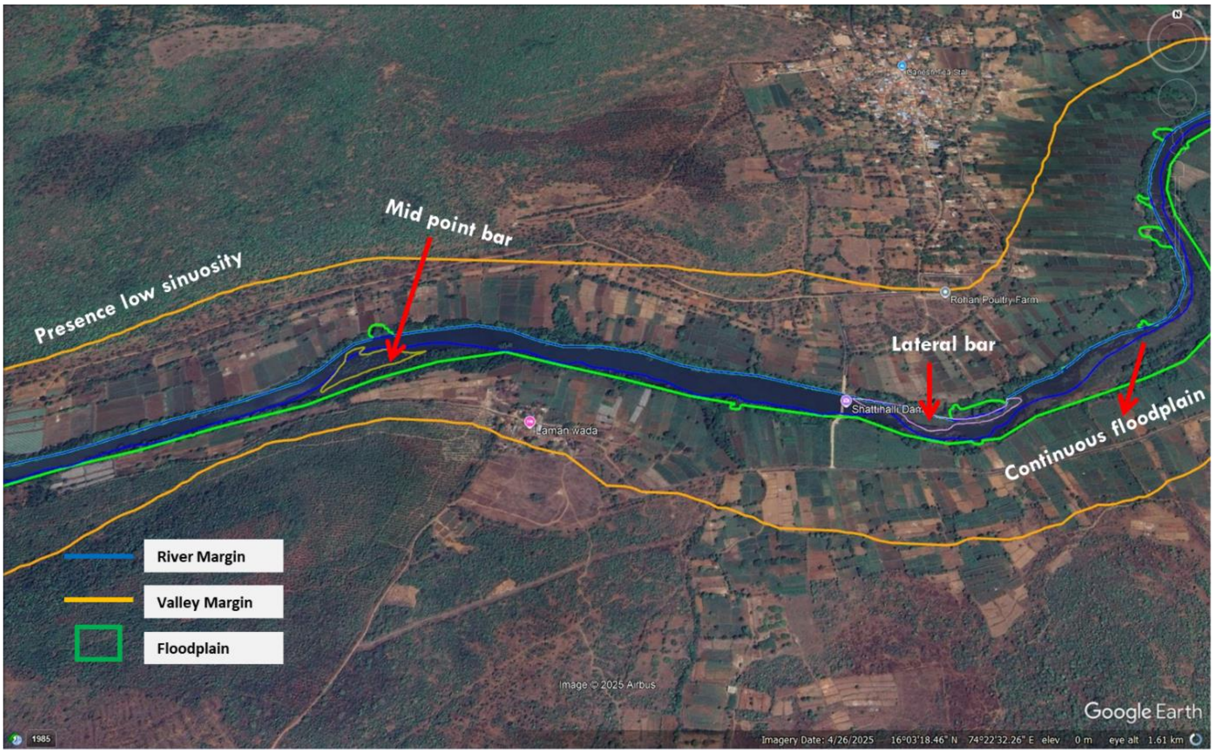

Figure 7. 18 Laterally unconfined, continuous low-sinuosity gravel-bed channel in the Upper Krishna sub-basin

7.5.18 Laterally Unconfined, Wide Valley, Medium Sinuosity, Gravel Bed

This reach of the Krishna River within the Upper Krishna sub-basin flows through a laterally unconfined, wide alluvial valley, allowing the channel to migrate freely across the valley floor. The river exhibits medium sinuosity, forming broad meander loops that reflect moderate lateral mobility under alluvial conditions. The gravel-dominated riverbed indicates a relatively high-energy fluvial environment with active bedload transport during seasonal high flows. Multiple mid-channel and lateral bars are present, demonstrating frequent sediment reworking and deposition. The presence of an extensive continuous floodplain along both margins highlights the role of overbank flooding and lateral sediment accretion in shaping valley morphology. This geomorphic setting represents a transitional river type where valley width, sediment load, and hydrological regime collectively produce a dynamic yet moderately sinuous gravel-bed channel system. Figure 7.19 represents the laterally unconfined, wide-valley, medium-sinuosity gravel-bed channel in the Upper Krishna sub-basin along the Malaprabha River.

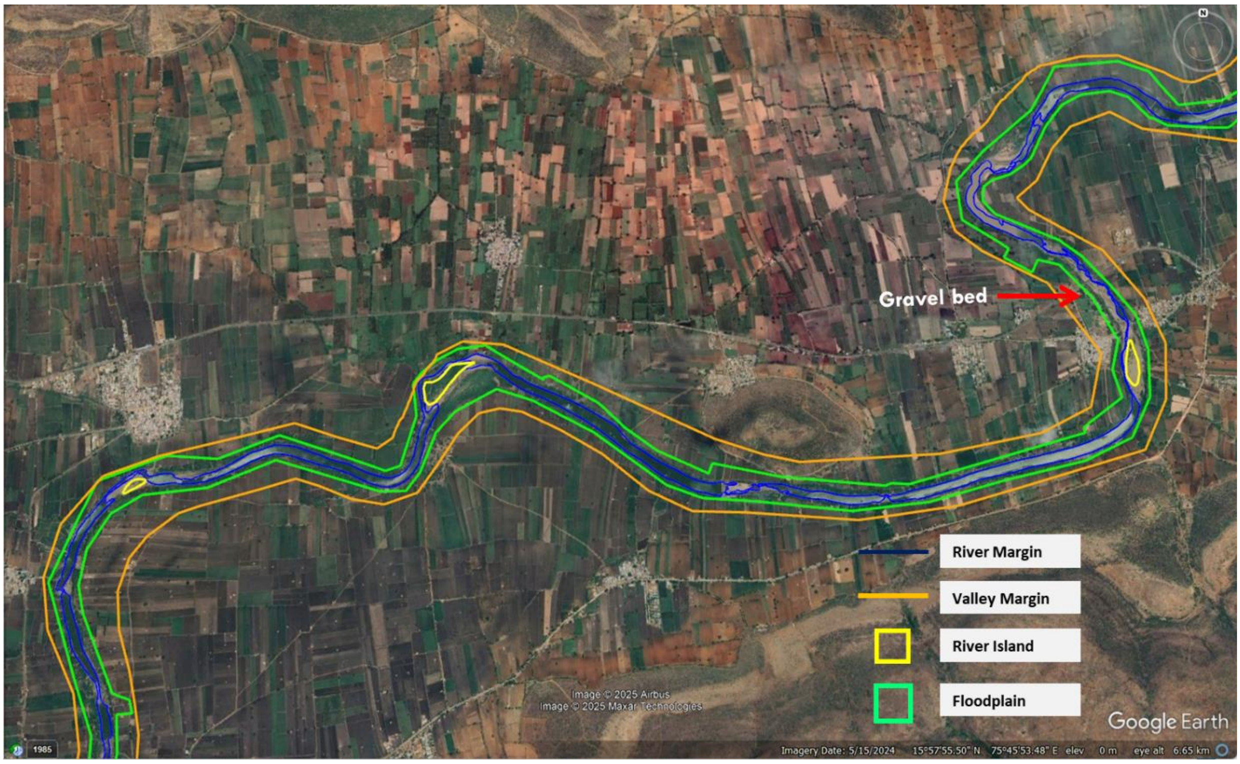

Figure 7. 19 Laterally unconfined, wide-valley, medium-sinuosity gravel-bed channel in the Upper Krishna sub-basin

7.5.19 Partly Confined, Terrace-Controlled, High Sinuosity, Sand-Bed

This reach of the Tungabhadra River in the Upper Tungabhadra sub-basin exhibits a partly confined channel morphology, where the river flows within a moderately narrow valley bordered by terrace margins. These terraces restrict lateral migration in certain segments, producing a channel that alternates between confined bends and slightly open sections. The river shows high sinuosity, with well-developed meander bends indicating a dynamic alluvial system that continues to adjust its planform over time. The presence of a sand-dominated bed reflects active sediment transport and frequent reworking of channel bars, especially during monsoonal flows. Despite partial confinement, the river maintains a broad meander belt where the channel migrates laterally, producing point bars, cutbanks, and local overbank deposits. Valley margins shape the planform, limiting floodplain width in some locations while allowing local expansion in others. The active channel displays strong curvature, with long, sweeping bends that highlight the influence of both hydrology and valley structure. Overall, this geomorphic configuration represents a hybrid alluvial-terrace controlled system, where terrace confinement, high sinuosity, and abundant sand supply interact to produce an actively adjusting meandering channel. Figure 7.20 represents the partly confined, terrace-controlled, highly sinuous, sand-bed channel in the Upper Tungabhadra sub-basin along the Tungabhadra River.

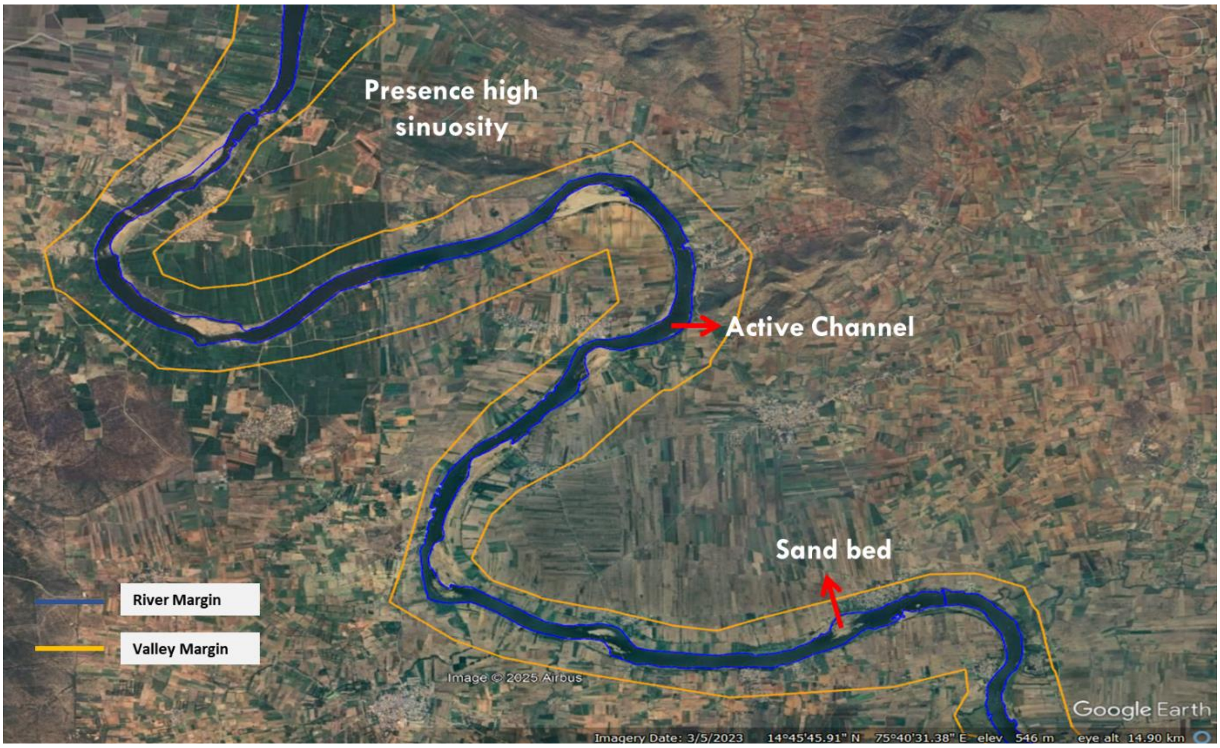

Figure 7. 20 Partly confined, terrace-controlled, highly sinuous, sand-bed channel in the Upper Tungabhadra sub-basin

7.5.20 Confined, High Sinuosity, Sand-Bed with Bedrock Influence

This reach of the Tungabhadra River in the Upper Tungabhadra sub-basin exhibits a distinctly confined channel morphology, shaped predominantly by the surrounding bedrock-controlled valley walls. The river flows within a narrow, steep-sided valley where lateral movement is highly restricted, resulting in minimal or absent floodplain development. Despite the confinement, the channel displays high sinuosity, forming pronounced meander bends as it adjusts to local lithological variations and structural controls within the bedrock terrain. The sand-bed nature of this reach indicates zones of active sediment deposition, primarily along inner bend margins and wider valley pockets, where flow velocity decreases. However, the presence of exposed bedrock within the channel corridor—particularly near sharp bends—reveals strong bedrock influence and high flow energy capable of scouring underlying substrates. The active channel is well defined, with alternating deep pools and shallower sediment-laden bars marking zones of erosion and deposition. Overall, this geomorphic setting represents a high-energy confined meandering system, where bedrock exerts primary control over channel form and alignment, while sand deposition occurs in locally widened pockets. Figure 7.21 illustrates the confined, high-sinuosity, sand-bed reach with bedrock influence in the Upper Tungabhadra sub-basin along the Tungabhadra River.

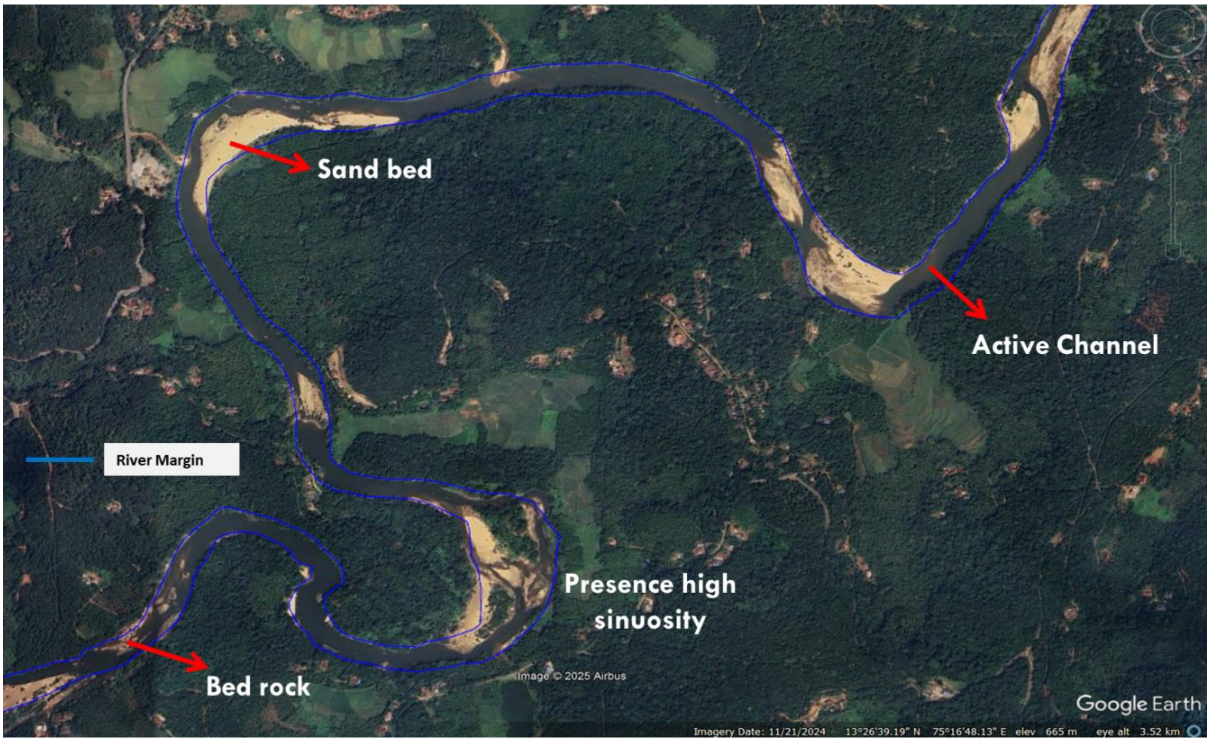

Figure 7. 21 Confined, high-sinuosity, sand-bed reach with bedrock influence in the Upper Tungabhadra sub-basin

7.5.21 Partly Confined, Terrace-Controlled, High Sinuosity, Gravel–Sand Bed

This reach of the Tungabhadra River in the Upper Tungabhadra sub-basin exhibits a partly confined geomorphic setting, where the channel is bounded by terrace margins that locally restrict its lateral mobility. Despite this confinement, the river maintains high sinuosity, forming large meander loops shaped by variations in valley width, slope, and sediment supply. The presence of both gravel and sand beds reflects a mixed-energy fluvial environment, gravel deposition in high-energy bends and coarse riffles, and sand accumulation in lower-energy zones such as point bars and inner meander banks. The active channel shifts dynamically within the confined valley floor, with gravel bars, sand patches, and vegetated islands indicating ongoing sediment transport and deposition. Terraces on either side of the channel represent abandoned floodplain surfaces created during earlier stages of incision. The floodplain is moderately developed, occurring in pockets where valley confinement lessens, allowing wider overbank deposition. This geomorphic configuration signifies a transition from upland confined reaches to broader alluvial plains, influenced by valley structure, hydrological variability, and sediment dynamics. Figure 7.15 represents the partly confined, terrace-controlled, high-sinuosity gravel–sand bed channel in the Upper Tungabhadra sub-basin.

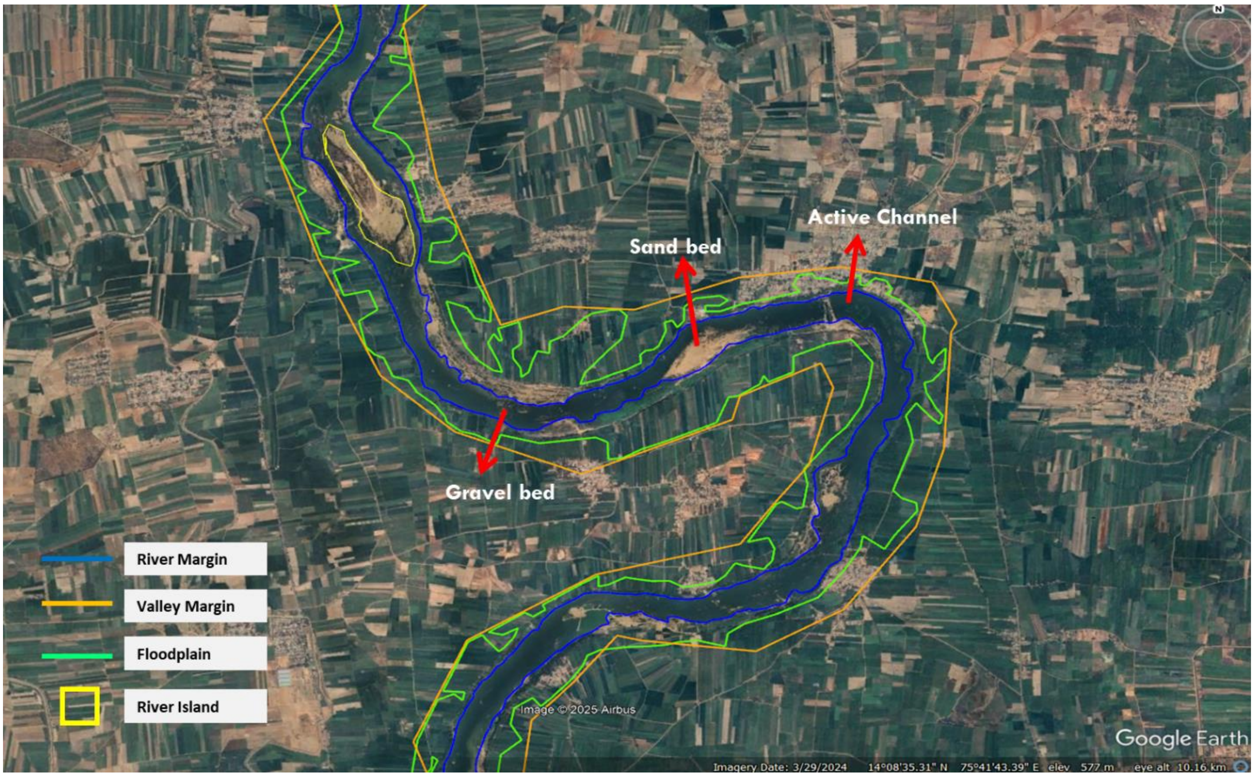

Figure 7. 22 Partly confined, terrace-controlled, high-sinuosity gravel–sand bed channel in the Upper Tungabhadra sub-basin

7.5.22 Confined, Bedrock-Controlled, Low Sinuosity, Multi-Channel, Bedrock Channel

This reach of the Tungabhadra River within the Lower Tungabhadra sub-basin exhibits a strongly confined, bedrock-controlled channel system, where the river flows through a narrow and structurally restricted valley. The channel margins are dominated by exposed bedrock, which significantly limits lateral movement and inhibits the development of wide floodplains. As a result of this structural confinement, the river maintains low sinuosity, reflecting a relatively straight to gently curved course dictated by lithological controls rather than fluvial processes. A distinctive attribute of this reach is the presence of a multi-channel structure, where several narrow threads of flow are divided by zones of exposed bedrock and limited sediment deposits. These multi-thread segments are not formed by alluvial bar development but by bedrock protrusions, ridge alignments, and differential erosion patterns controlling channel division. Sediment storage is minimal, and the channel floor is predominantly bedrock, indicating high stream power and limited opportunities for bar formation or deposition of finer materials. The adjoining valley margins are steep and rocky, with only very narrow and discontinuous floodplain patches occurring where short breaks in confinement allow limited sediment deposition. Overall, this geomorphic setting represents a highly constrained, structurally governed fluvial corridor where valley geology, tectonic framework, and resistant lithological units primarily dictate channel form and dynamics, rather than sediment supply or hydraulic variability. Figure 7.23 represents the confined, bedrock-controlled, low-sinuosity, multi-channel river segment of the Tungabhadra River in the Lower Tungabhadra sub-basin.

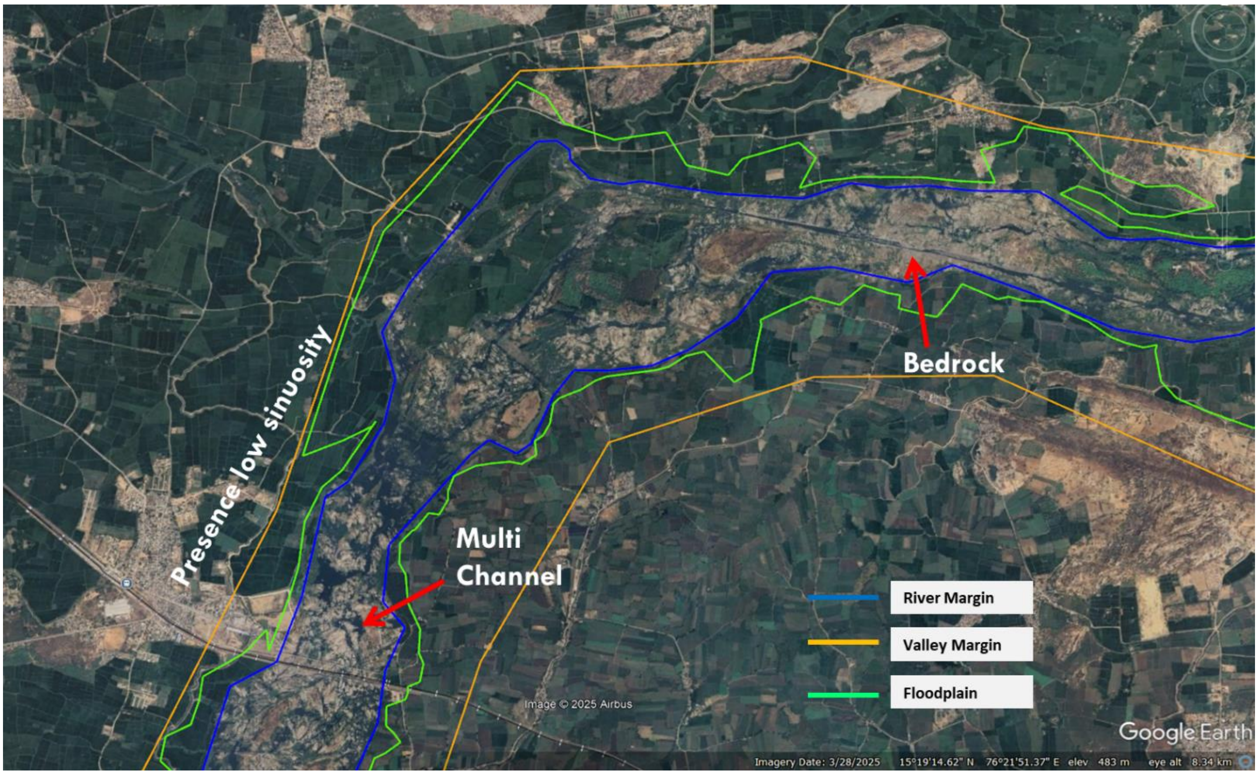

Figure 7. 23 Confined, bedrock-controlled, low-sinuosity, multi-channel river segment of the Tungabhadra River in the Lower Tungabhadra sub-basin.

7.5.23 Partly Confined, Terrace-Controlled, Low-Sinuosity, Gravel & Bedrock Channel

This reach of the Tungabhadra River in the Lower Tungabhadra sub-basin displays a partly confined valley setting, where the channel is restricted intermittently by terrace margins and bedrock outcrops. The confinement varies along the course, producing alternating wider and narrower valley sections. The river shows low sinuosity, with gentle bends that reflect limited lateral migration due to the structural and topographic controls of terraces and exposed bedrock surfaces. The channel bed consists of a combination of gravel patches and bedrock exposures, indicating moderate to high stream power capable of transporting coarse sediments and maintaining shallow alluvial cover. Floodplain development is discontinuous, occurring only in locally widened valley pockets where confinement relaxes. The bedrock-controlled segments reduce overbank deposition, restrict lateral bar formation, and maintain a relatively fixed channel position. Such river types typically respond slowly to hydrological changes but are highly sensitive to structural controls and sediment supply variations. Figure 7.24 represents partly confined, terrace-controlled, low-sinuosity Tungabhadra River reach showing gravel-bed and bedrock exposures in the Lower Tungabhadra sub-basin.

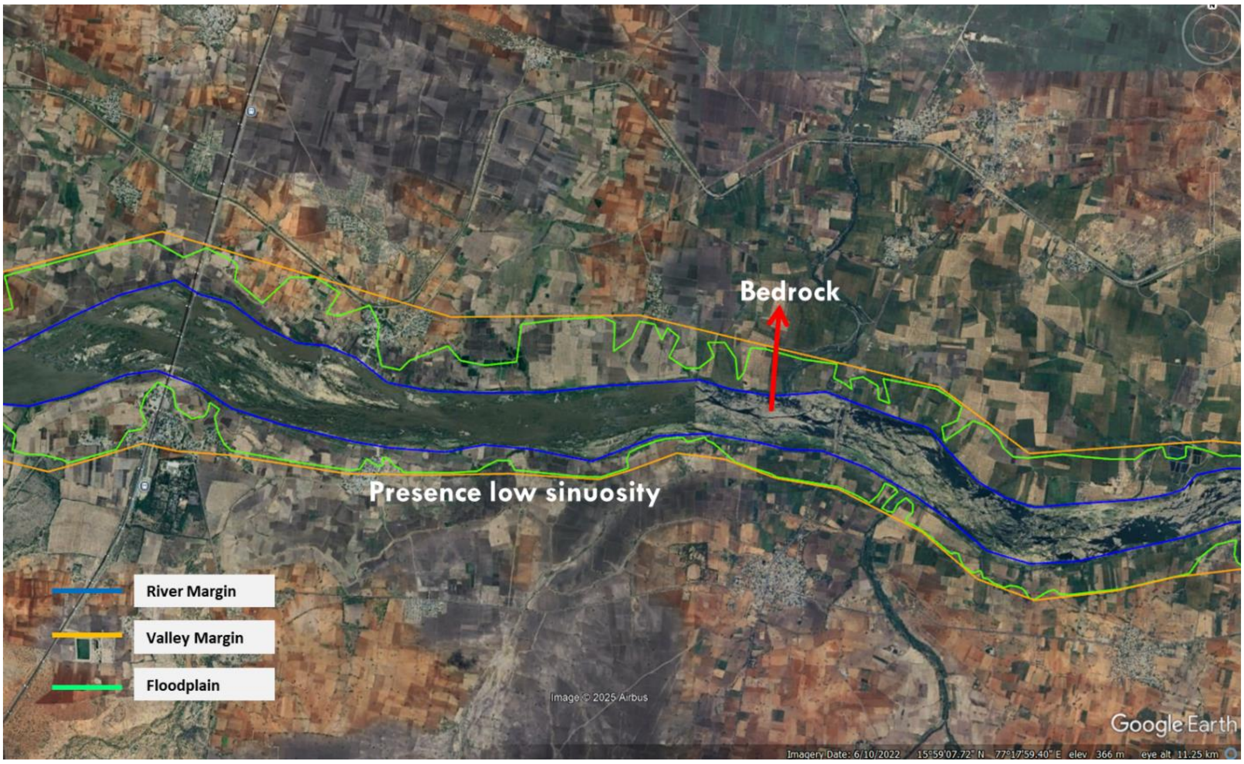

Figure 7. 24 Partly confined, terrace-controlled, low-sinuosity Tungabhadra River reach showing gravel-bed and bedrock exposures in the Lower Tungabhadra sub-basin.

7.5.24 Partly Confined, Terrace-Margin Controlled, Low-Sinuosity, Sand–Gravel Bed Reach

This reach of the Tungabhadra River exhibits a partly confined channel morphology, where the channel is laterally restricted by terrace margins on both sides. The confinement limits large-scale channel migration, but localized adjustments are still evident. The planform shows low sinuosity, indicating relatively gentle meandering with broad bends and stable outer banks. The channel displays alternating sand-bed and gravel-bed patches, reflecting variable energy conditions and sediment supply. Sand bars occur in relatively wider sections, while gravel deposition appears in narrower, higher-energy reaches. A narrow but recognizable floodplain is present intermittently along the valley margins, showing areas of periodic overbank deposition. Overall, this geomorphic setting represents a transition zone between confined bedrock-influenced reaches upstream and more unconfined alluvial sections downstream. The combination of terrace confinement, mixed sediment bed, and low sinuosity provides important insights for river behaviour, sediment transport, and floodplain evolution in the Lower Tungabhadra sub-basin. changes but are highly sensitive to structural controls and sediment supply variations. Figure 7.25 represents partly confined, confinement-controlled, terrace, low-sinuosity Tungabhadra River reach showing sand and gravel-bed and exposures in the Lower Tungabhadra sub-basin.

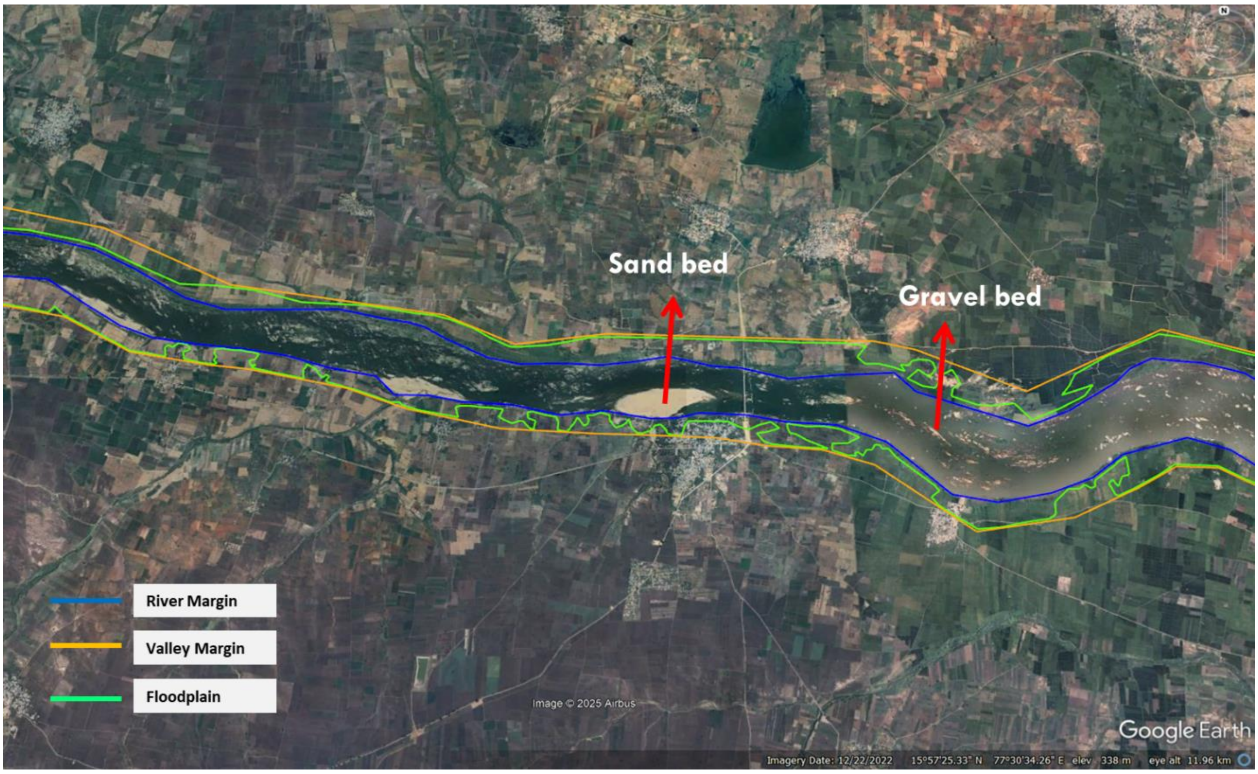

Figure 7. 25 Partly confined, confinement-controlled, terrace, low-sinuosity Tungabhadra River reach showing sand and gravel-bed exposure in the Lower Tungabhadra sub-basin.

The Figure 7.26 illustrates the spatial distribution of river styles within the Krishna River Basin, highlighting variations in channel morphology along the main river and its tributaries. Different coloured river segments represent distinct river styles, reflecting changes in geomorphology and flow characteristics across the basin, while major reservoirs are shown in blue. The classification captures upstream–downstream transitions influenced by topography, geology, and hydrological controls. Overall, the map supports basin-scale understanding of river processes relevant to river management and restoration planning.

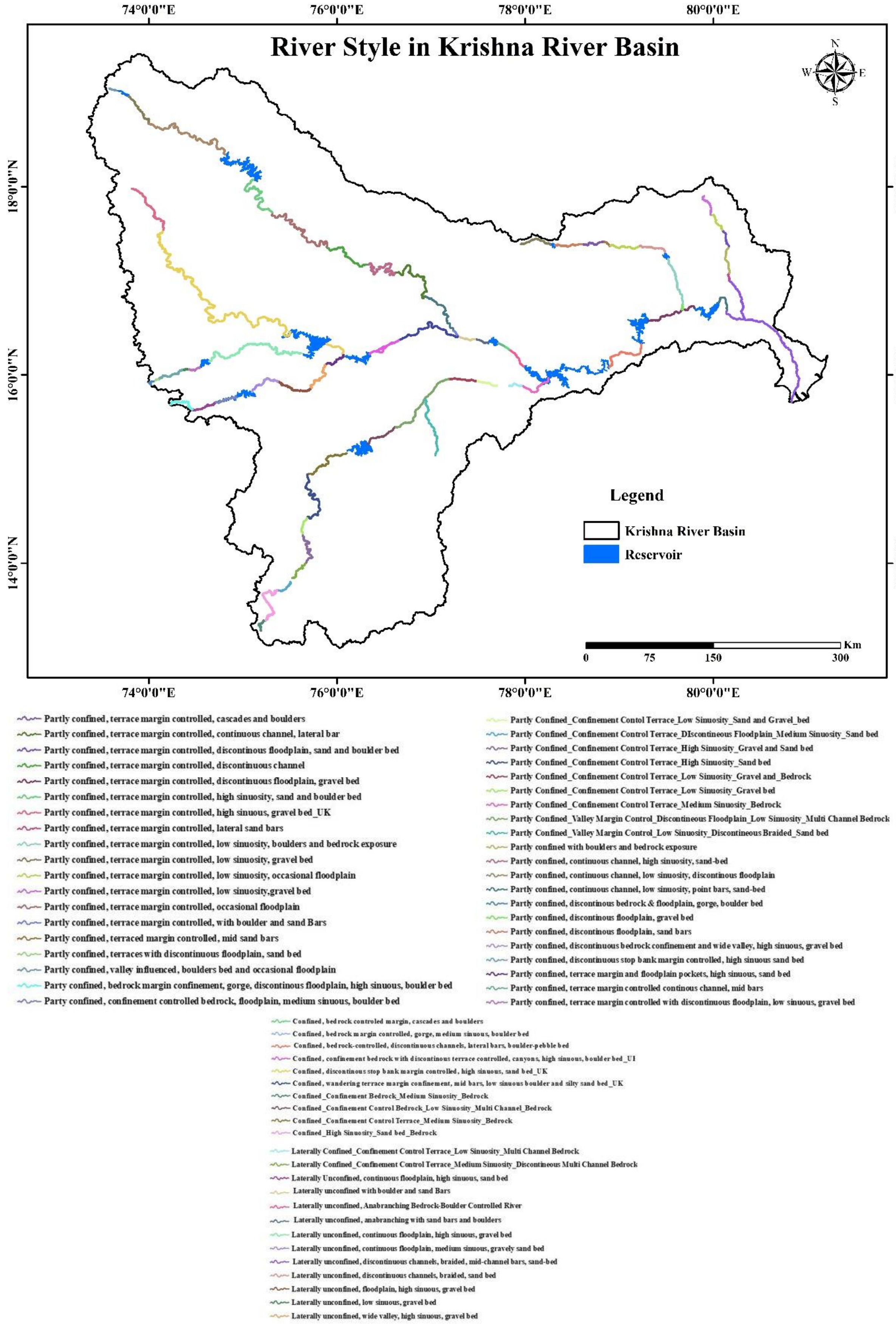

Figure 7. 26 River Styles present in the Krishna River Basin

8. Visual Records from Field Investigations in the Krishna River Basin

During the field visits along the Krishna River Basin, detailed observations were carried out across the main river and its major tributaries, including the Musi, Munneru, Ghataprabha, Malaprabha, and Tungabhadra rivers. These visits captured spatial variations in river morphology, flow conditions, bank characteristics, and human interventions such as reservoirs, barrages, urban encroachments, and irrigation infrastructure. Photographs taken during field visit along the Upper Krishna River Basin at various locations are illustrated in Figure 8.1. Similarly, Figure 8.2 represents the visual records along the Tungabhadra River Basin. Figure 8.3 represents the photos taken during field visit along the Musi River at various locations and Figure 8.4 elucidates the photographs taken during field visit along the Munneru River Figure 8.5 at various locations.

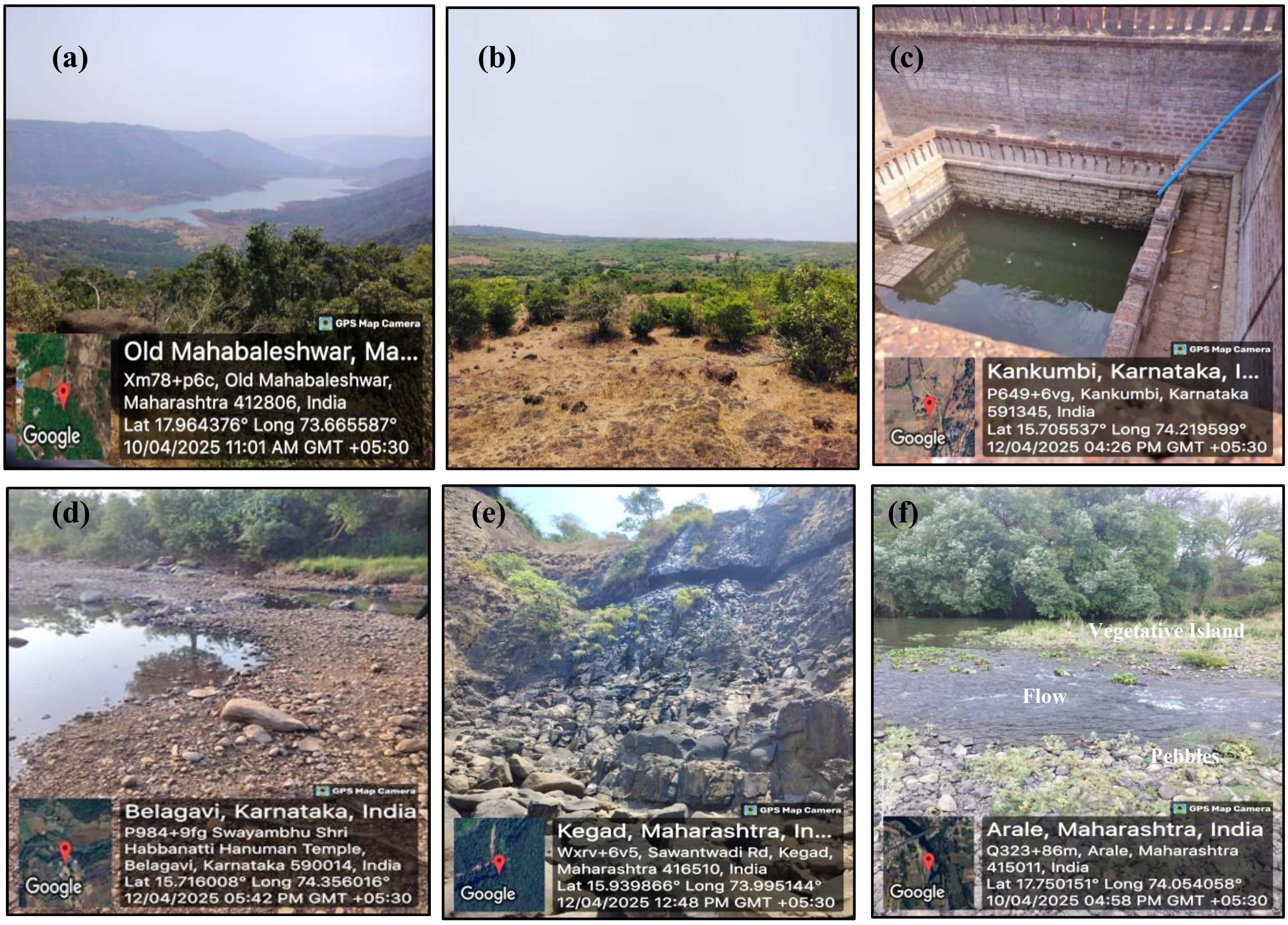

Figure 8. 1 Photographs taken during field visit along the Upper Krishna River Basin at various locations (a) Origin of River Krishna (b) Chaukal Hill, Origin of River Ghataprabha (c) Origin of River Malaprabha (d) Malaprabha at Habbanahatti (e) Amboli Waterfalls, Kegad (f) Krishna at Arale

Figure 8. 2 Photographs taken during field visit along the Tungabhadra River Basin at various locations (a) Gangamoola Hills, Origin of River Tunga (b) Tungabhadra Dam at Hosapete (c) Vanivilas Sagara Dam (d) Confluence of Rivers Tunga and Bhadra (e) Mantralayam (f) Mantralayam (g) River Vedavathi (h) River Vedavathi, Vanivilas Sagara Dam (i) River

Tunga, Sringeri Shaaradapeetam (j) Confluence of Krishna and Tungabhadra (k) Confluence of Krishna and Tungabhadra (l) Sheerlu

Figure 8. 3 Photographs taken during field visit along the Musi River at various locations (a) Chillapally (b) Origin of Musi River (c) Musi River at Hyderabad (d) Vangamarthy (e) Tekumatla, Suryapet (f) Valigonda

Figure 8. 4 Photographs taken during field visit along the Krishna River at various locations (a) Jurala Project (b) Nagarjuna Sagar (c) Srisailam Canyon (d) Srisailam Dam (e) Bed Rock exposure (f) Sand Bar

Figure 8. 5 Photographs taken during field visit along the Munneru River at various locations (a) Nandigama (b) Polisettigudem Bridge (c) Khammam (d) Mahabubabad Bridge (e) Penuganchiprolu (f) Bayyaram Village

9. CONCLUSIONS

The geomorphological mapping of the Krishna River Basin provides a comprehensive understanding of the spatial distribution, characteristics, and controlling processes of landforms across one of India's major river systems. The basin exhibits pronounced geomorphic diversity, ranging from highly dissected denudational and structural hills in the upper reaches to extensive alluvial plains, floodplains, and deltaic environments in the lower basin. This diversity reflects the combined influence of lithology, tectonic controls, climatic variability, and fluvial processes operating at different spatial and temporal scales. The integration of remote sensing, GIS techniques, Digital Elevation Model (SRTM), and high-resolution satellite imagery enabled systematic delineation of geomorphic units, river corridors, floodplains, river islands, and valley confinement classes. The classification of river reaches into confined, partly confined, and laterally unconfined settings highlights the strong control of valley morphology on channel behavior, sediment transport, and floodplain development. Confined reaches in the upper basin are dominated by bedrock-controlled channels with limited floodplain development, while partly confined reaches show transitional characteristics with discontinuous floodplains and terrace control. In contrast, laterally unconfined reaches in the lower basin are characterized by wide alluvial valleys, active channel migration, and extensive floodplains, making them highly dynamic and flood-prone. The application of the River Styles framework further enhanced the understanding of reach-scale geomorphic variability by linking valley setting, channel planform, bed material texture, and assemblages of geomorphic units. The identification of multiple river styles across the Krishna River and its major tributaries demonstrates the complexity of fluvial adjustment processes and provides a robust physical basis for interpreting present-day river behavior and potential future changes. Mapping of geomorphic units such as bars, islands, terraces, and floodplain features offers valuable insights into sediment dynamics, channel stability, and historical river evolution. Overall, this geomorphological assessment establishes a scientifically sound baseline for the Krishna River Basin, supporting informed decision-making in river basin management, flood risk assessment, ecological conservation, and river restoration planning. The results underscore the importance of integrating geomorphological understanding into water resources planning and sustainable development strategies. The methodology and framework adopted in this study are replicable for other large river basins in India, contributing to improved river management practices and long-term resilience of fluvial systems under changing climatic and anthropogenic pressures.

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Appendix

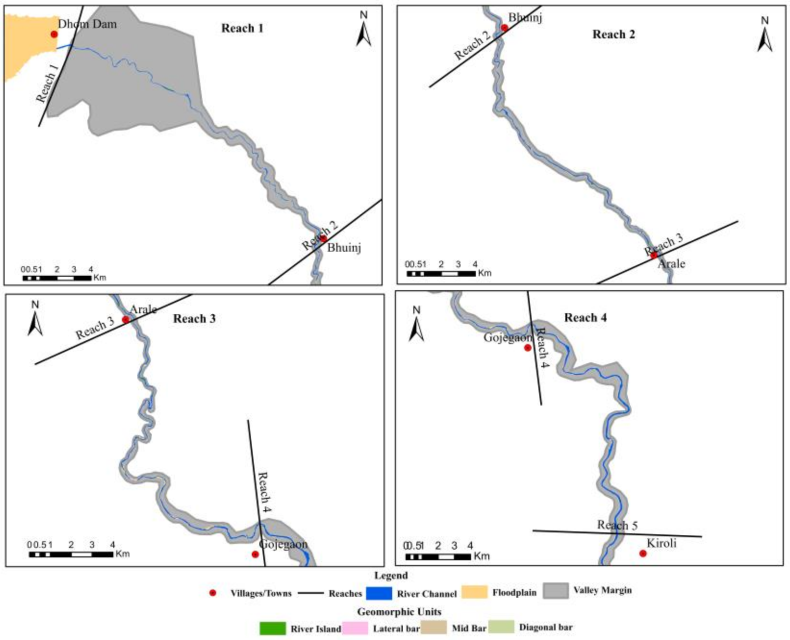

Figure A1. Geomorphic Units of the Krishna River from Reach 1 to Reach 4.

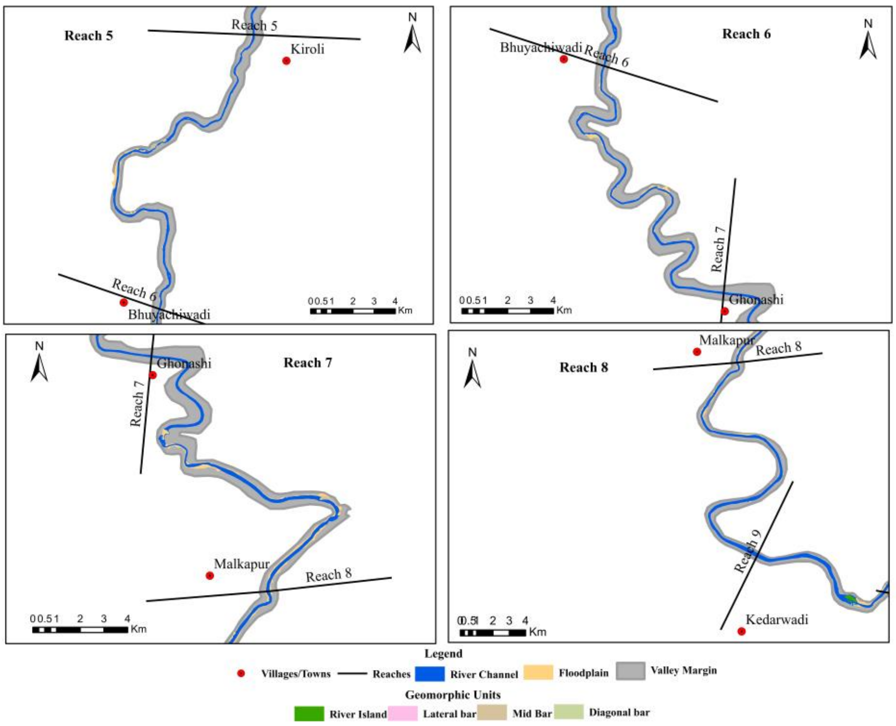

Figure A2. Geomorphic Units of the River Krishna River from Reach 5 to Reach 8.

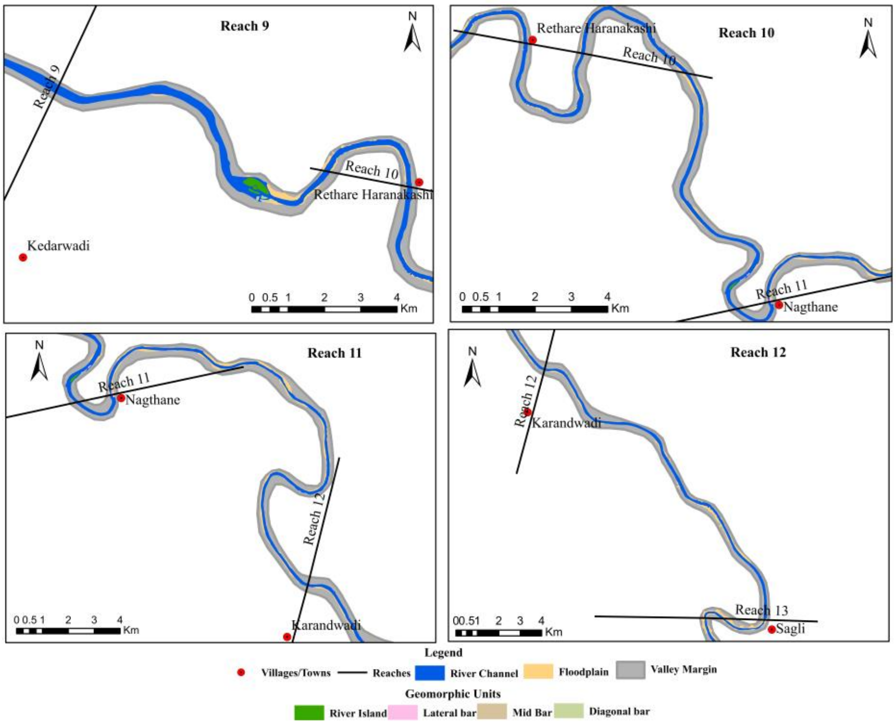

Figure A3. Geomorphic Units of the River Krishna River from Reach 9 to Reach 12.

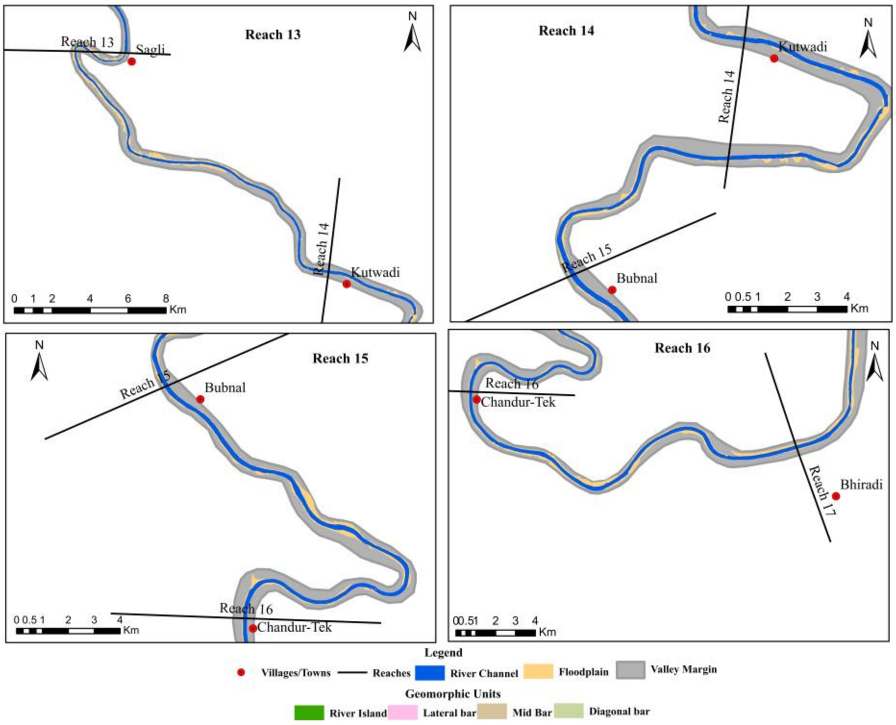

Figure A4. Geomorphic Units of the River Krishna River from Reach 13 to Reach 16.

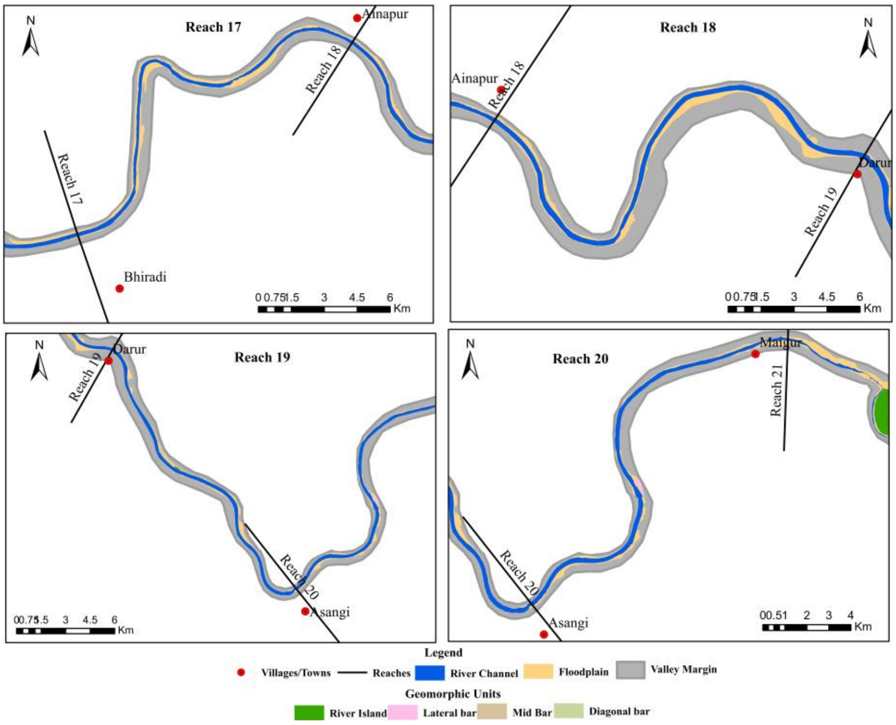

Figure A5. Geomorphic Units of the Krishna River from Reach 17 to Reach 20.

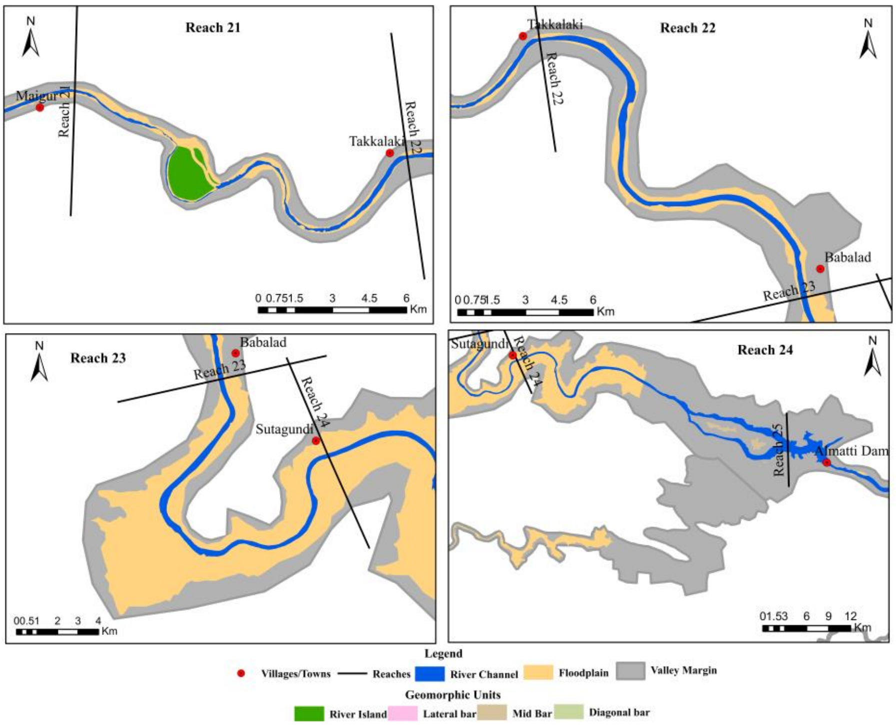

Figure A6. Geomorphic Units of the Krishna River from Reach 21 to Reach 24.

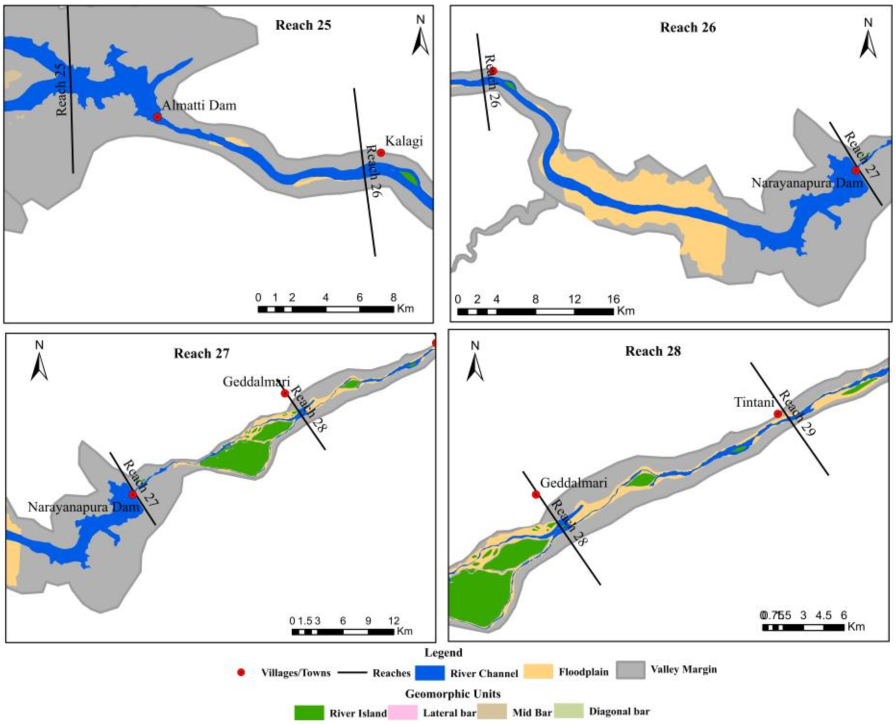

Figure A7. Geomorphic Units of the Krishna River from Reach 25 to Reach 28.

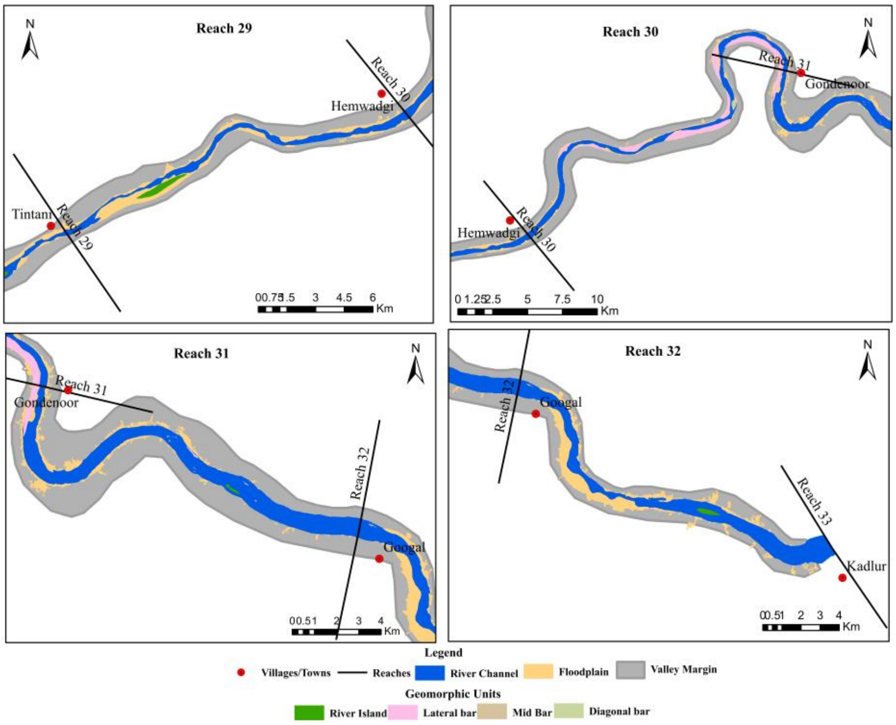

Figure A8. Geomorphic Units of the Krishna River from Reach 29 to Reach 31.

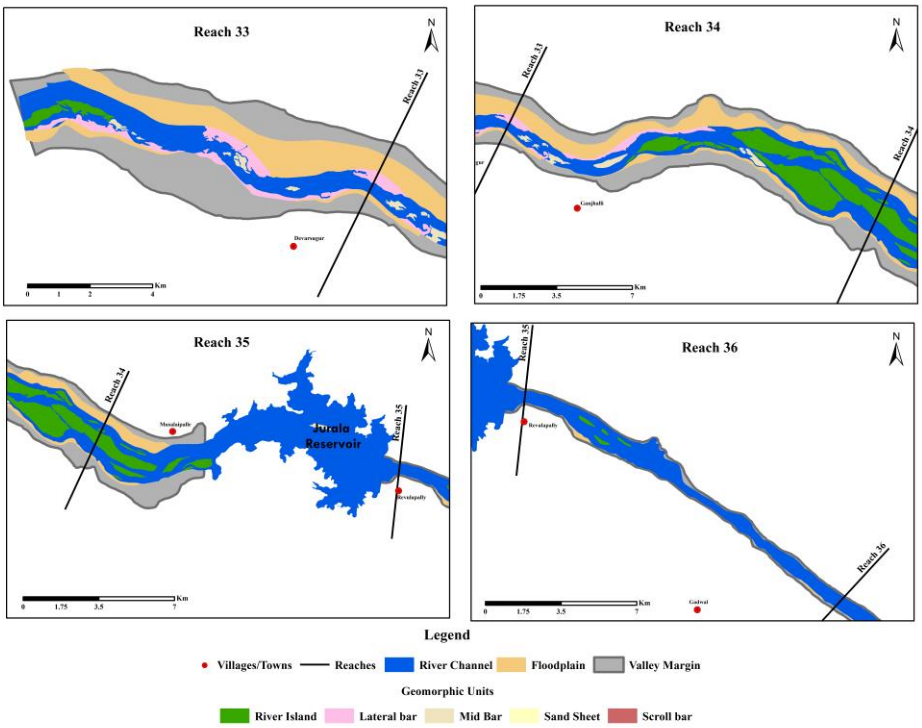

Figure A9. Geomorphic Units of the Krishna River from Reach 33 to Reach 36.

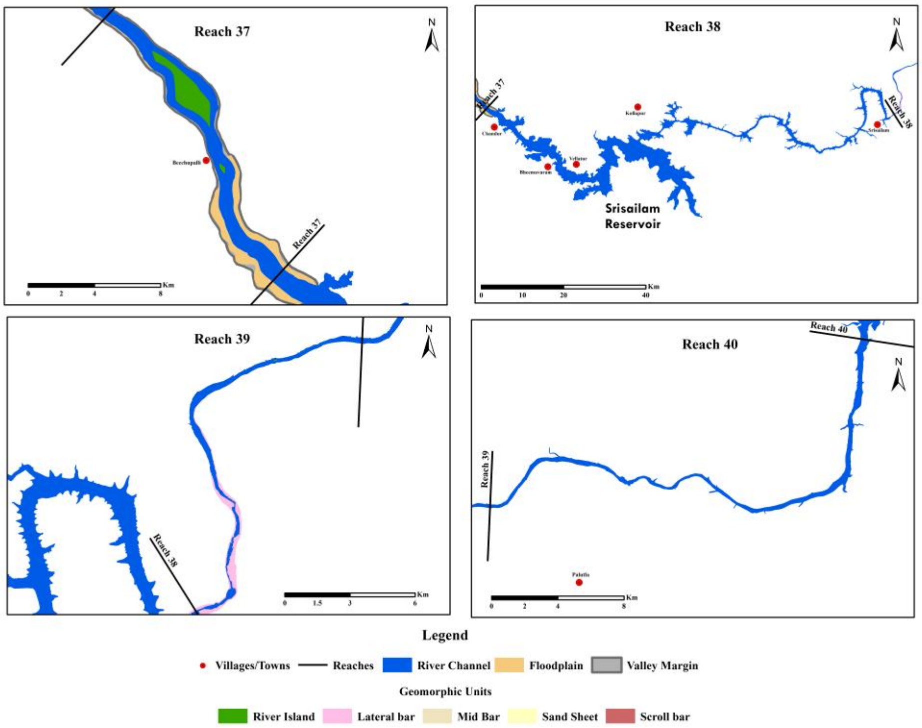

Figure A10. Geomorphic Units of the Krishna River from Reach 37 to Reach 40.

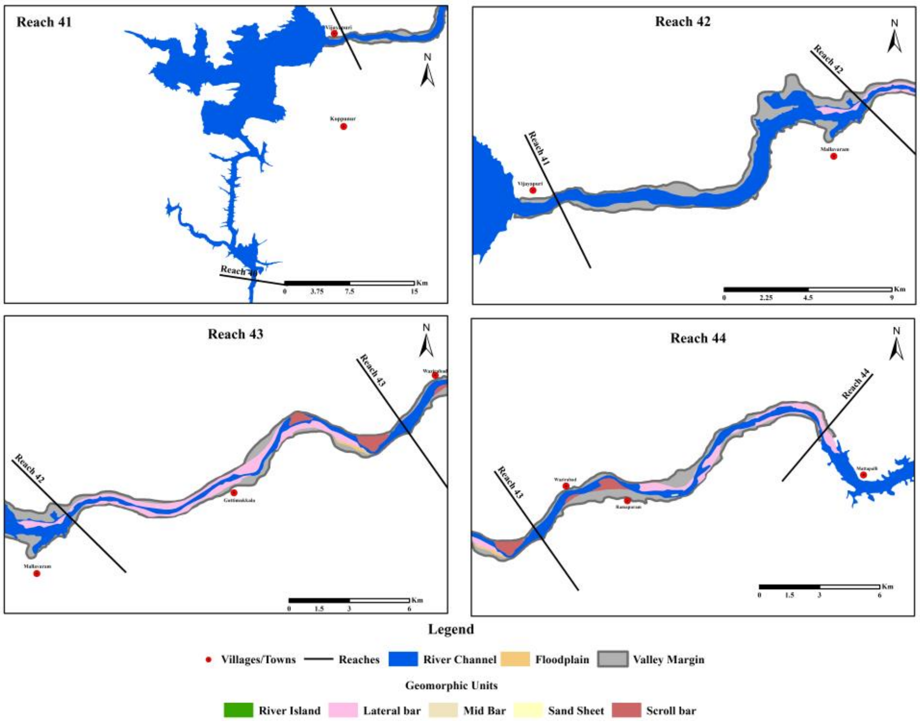

Figure A11. Geomorphic Units of the Krishna River from Reach 41 to Reach 44.

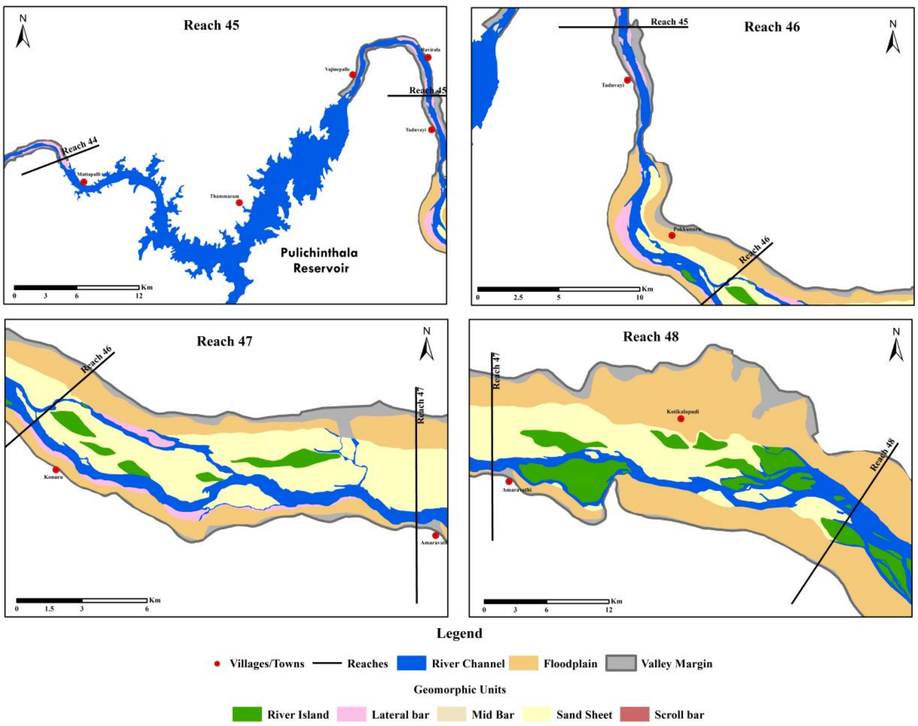

Figure A12. Geomorphic Units of the Krishna River from Reach 45 to Reach 48.

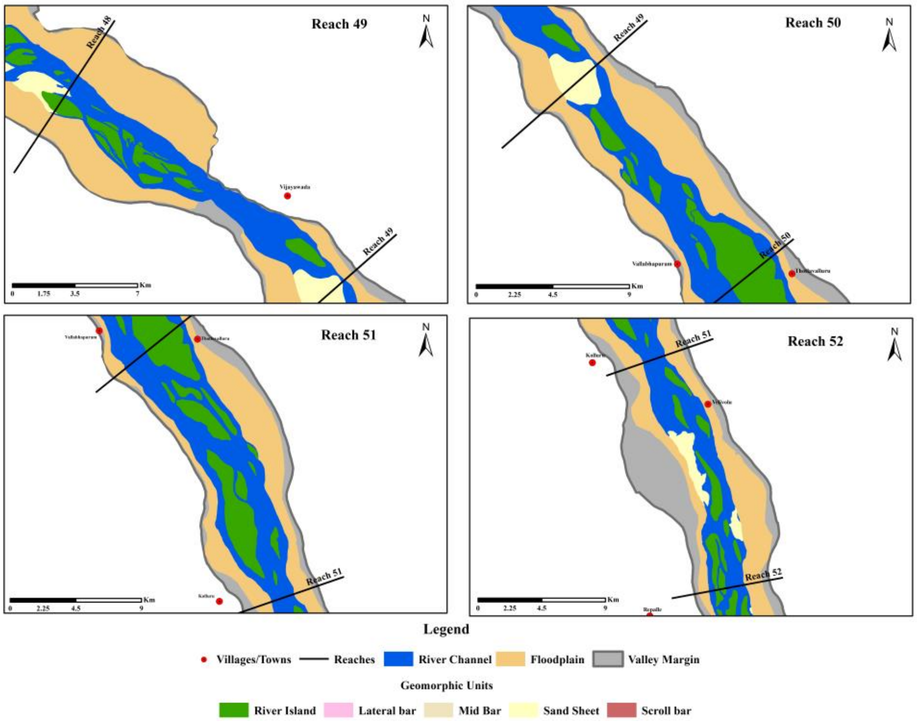

Figure A13. Geomorphic Units of the Krishna River from Reach 49 to Reach 52.

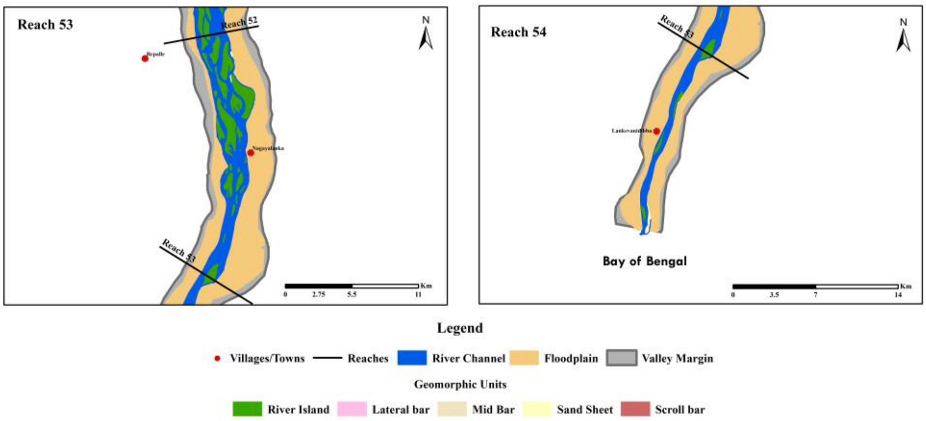

Figure A14. Geomorphic Units of the Krishna River from Reach 53 to Reach 54.

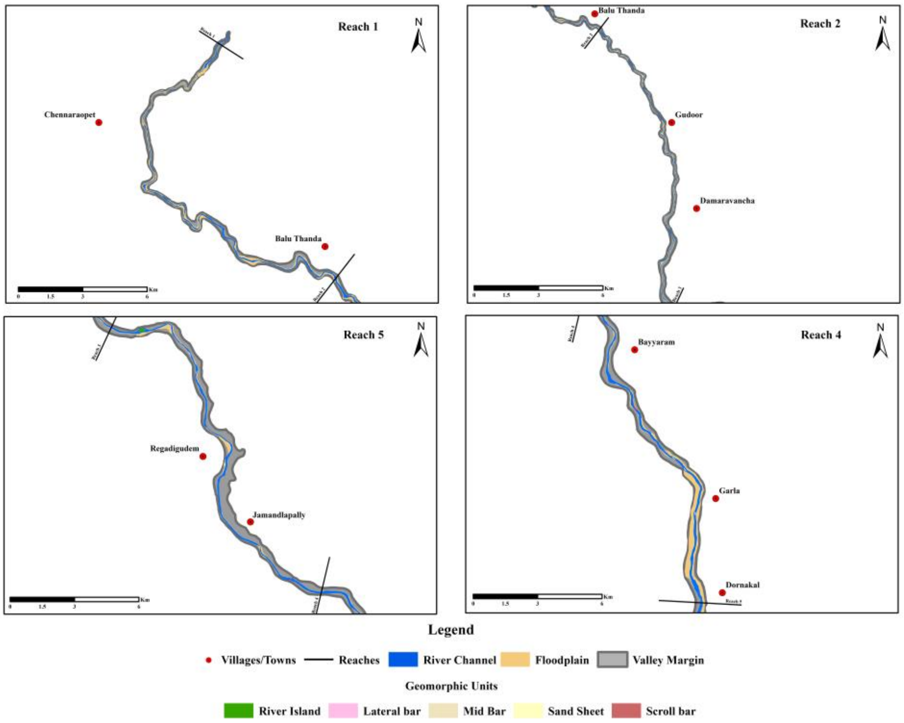

Figure A15. Geomorphic Units of the Munneru River from Reach 1 to Reach 4.

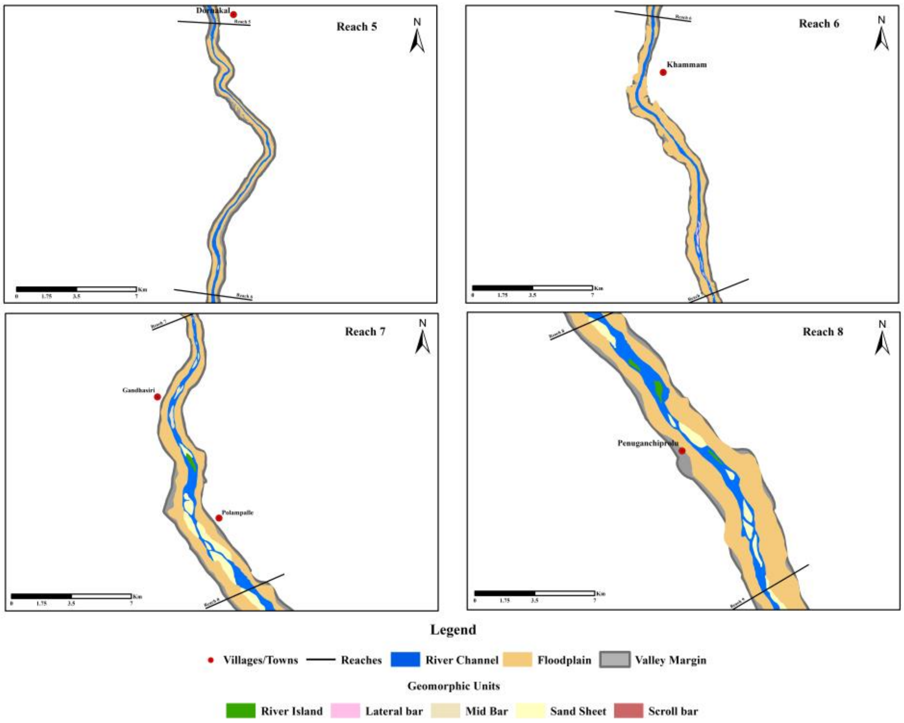

Figure A16. Geomorphic Units of the Munneru River from Reach 5 to Reach 8.

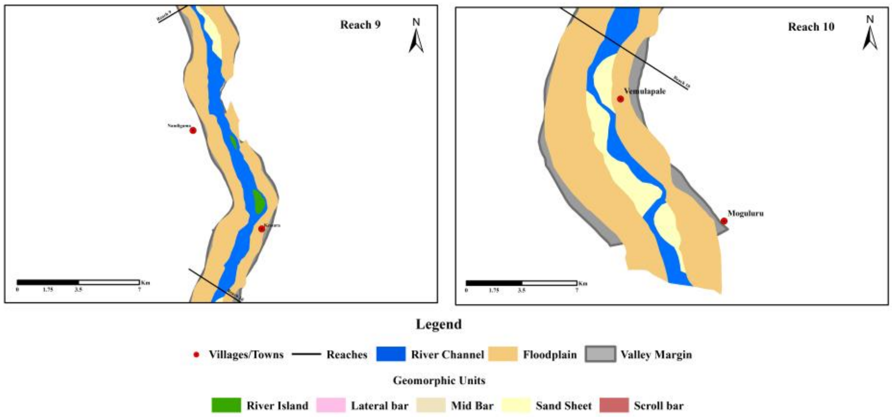

Figure A17. Geomorphic Units of the Munneru River from Reach 9 to Reach 10.

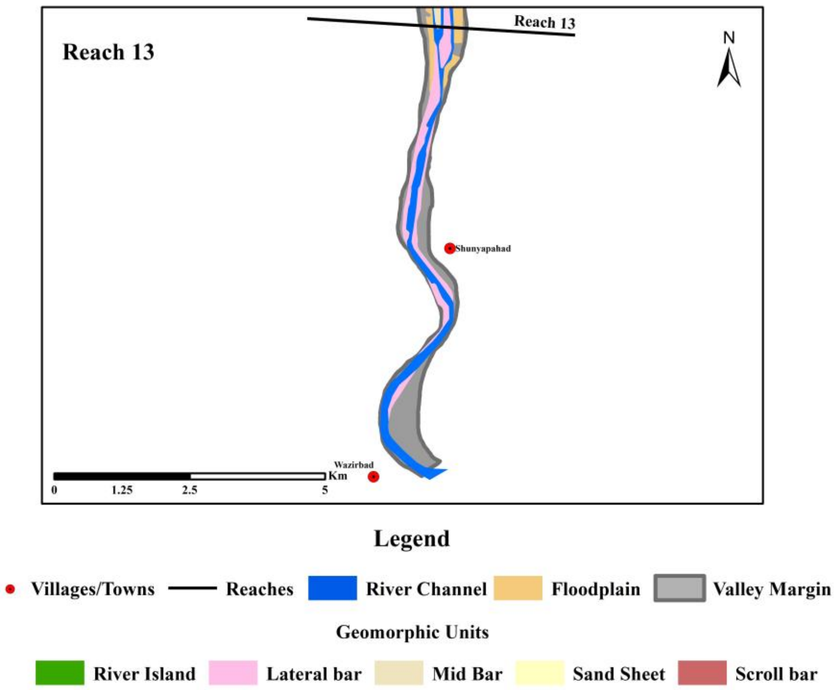

Figure A18. Geomorphic Units of the Musi River from Reach 13.

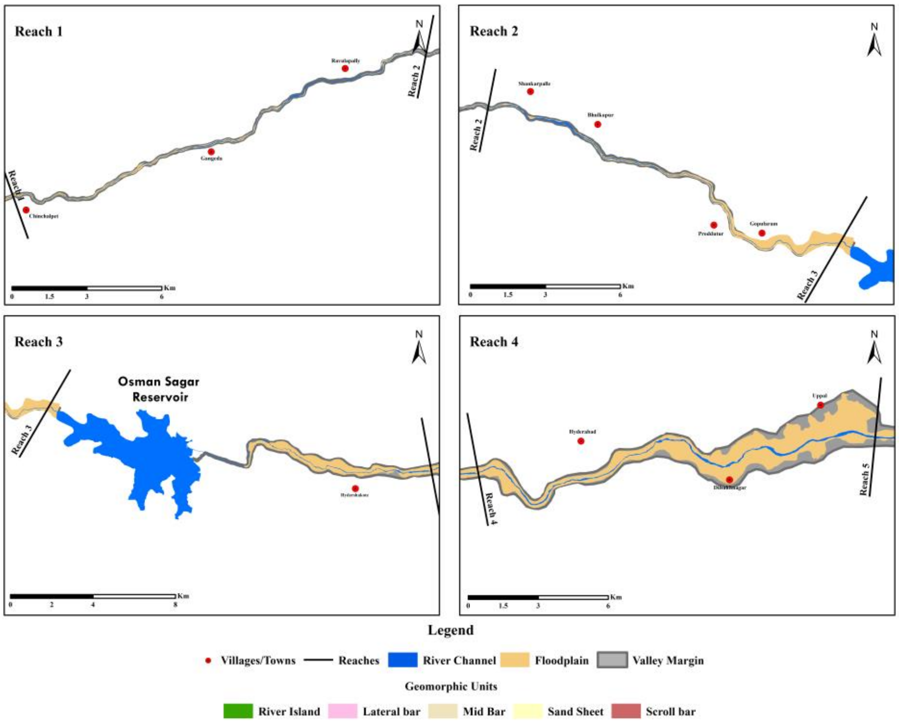

Figure A19. Geomorphic Units of the Musi River from Reach 1 to Reach 4.

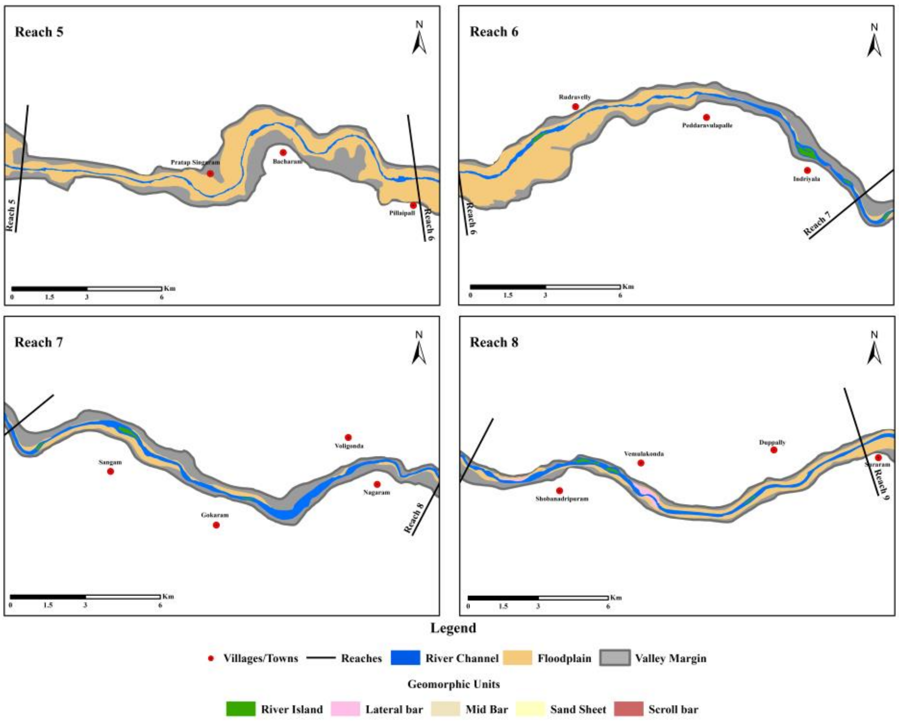

Figure A20. Geomorphic Units of the Musi River from Reach 5 to Reach 8.

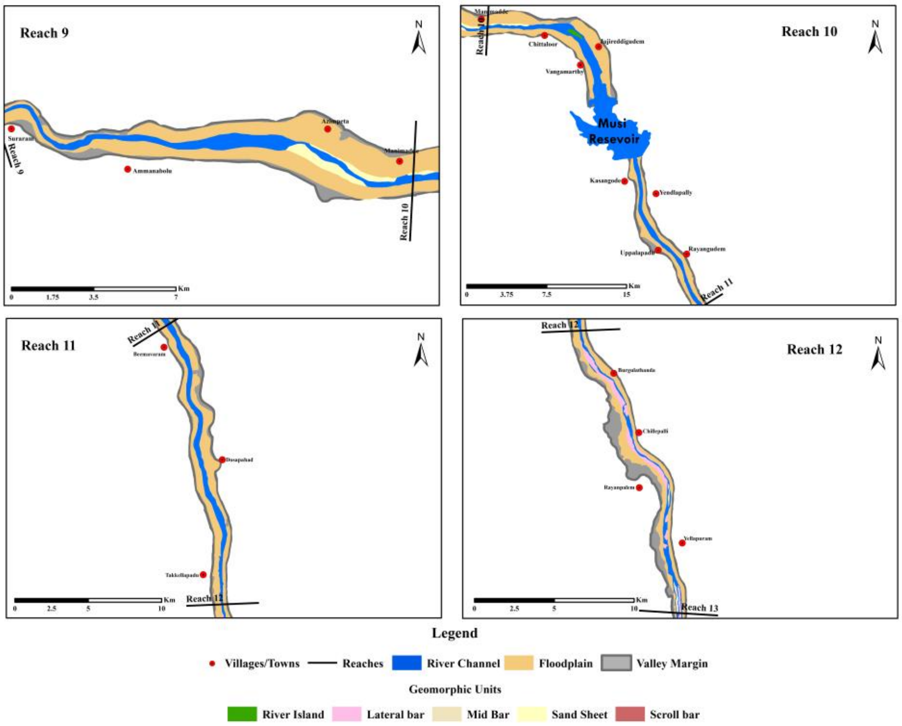

Figure A21. Geomorphic Units of the Musi River from Reach 9 to Reach 12.

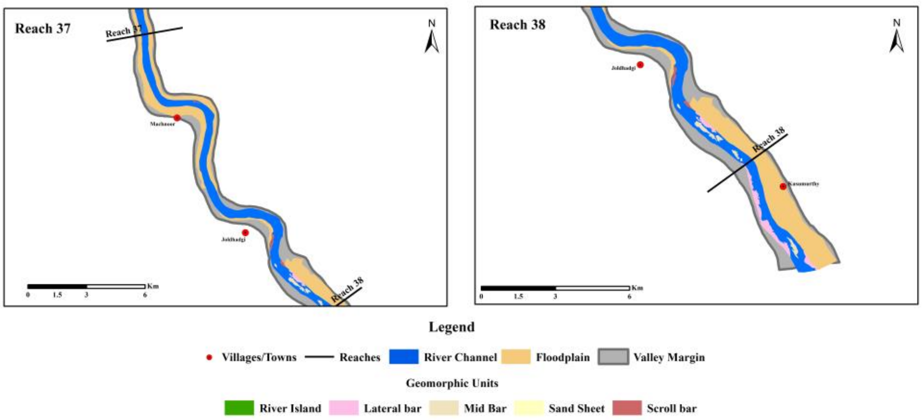

Figure A22. Geomorphic Units of the Bhima River from Reach 37 to Reach 38.

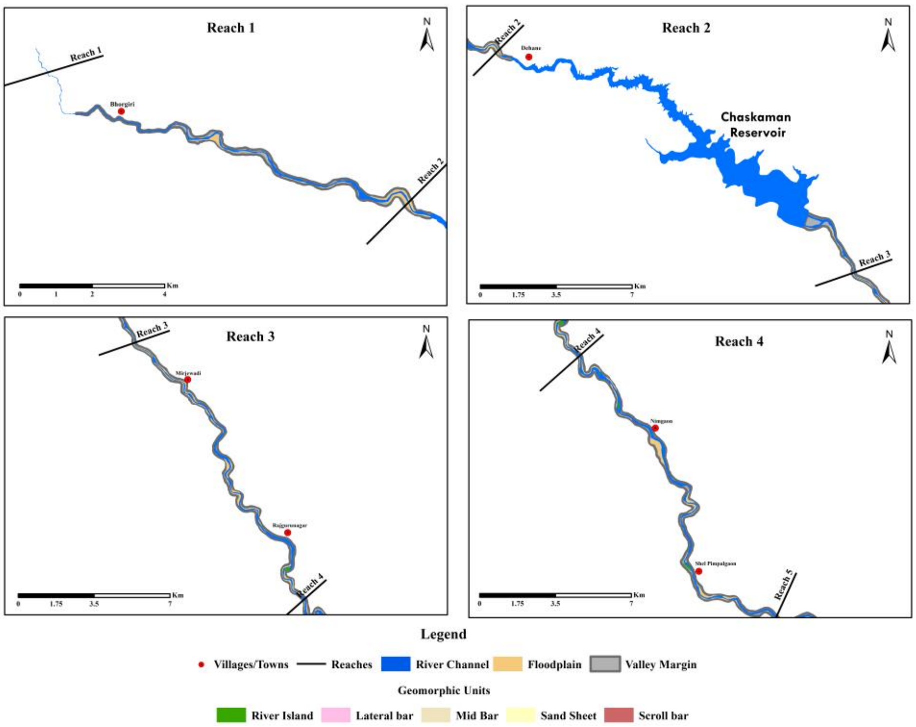

Figure A23. Geomorphic Units of the Bhima River from Reach 1 to Reach 4.

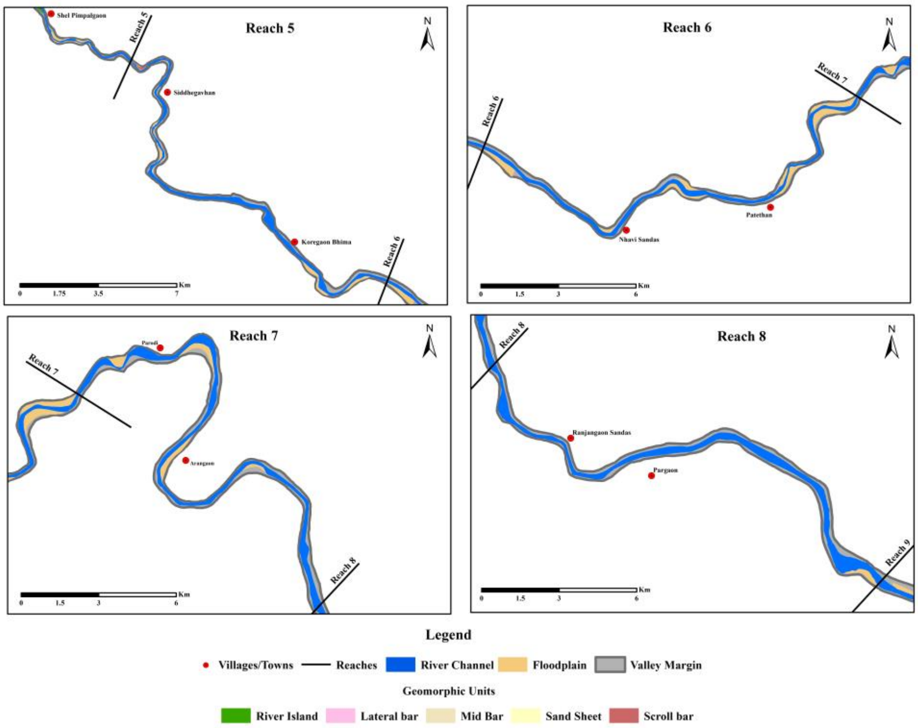

Figure A24. Geomorphic Units of the Bhima River from Reach 5 to Reach 8.

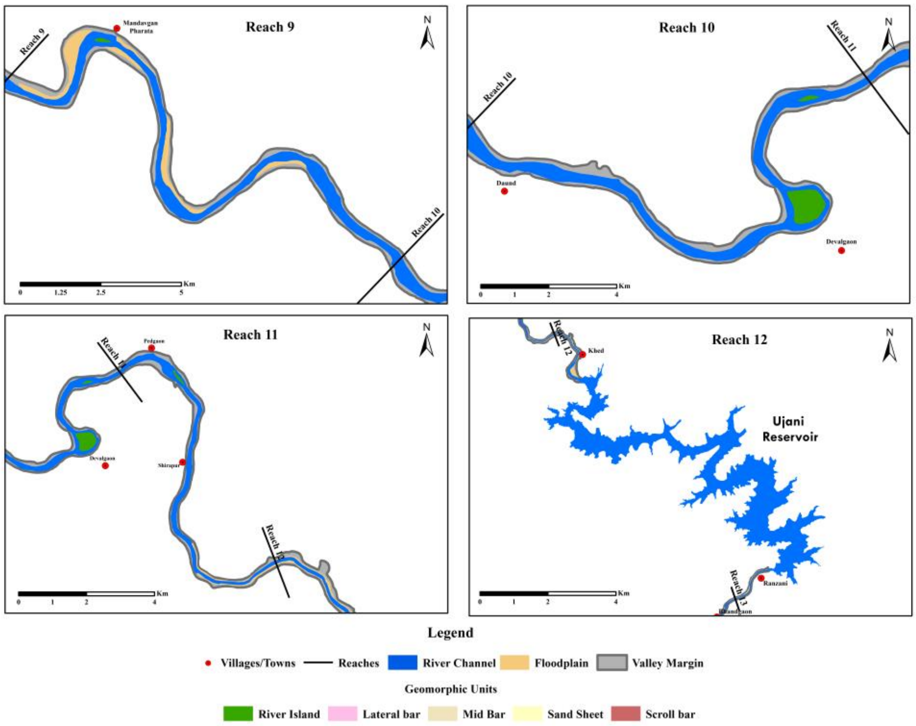

Figure A25. Geomorphic Units of the Bhima River from Reach 9 to Reach 12.

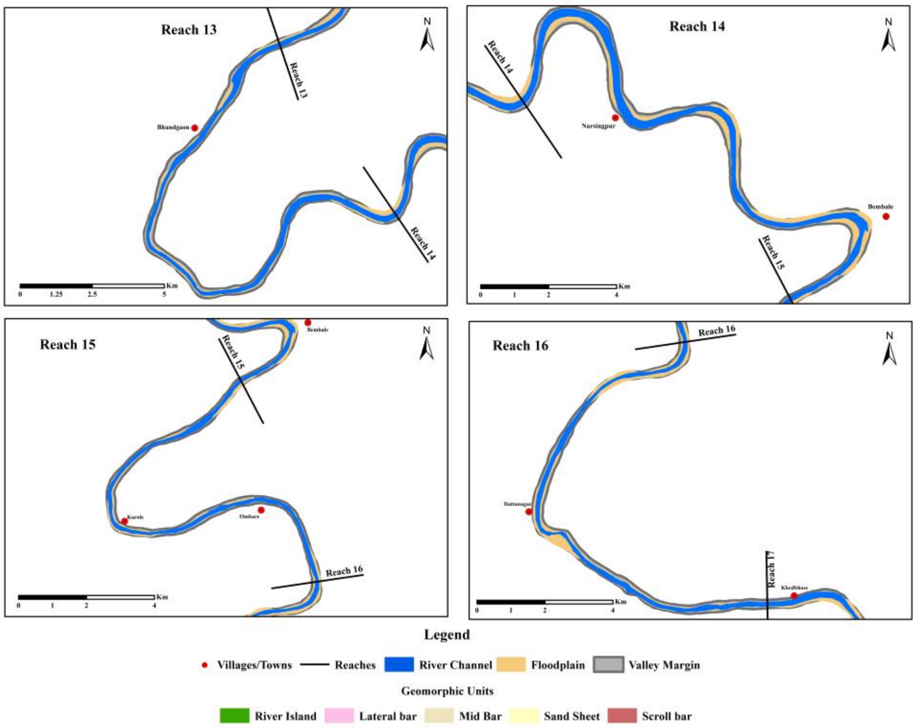

Figure A26. Geomorphic Units of the Bhima River from Reach 13 to Reach 16.

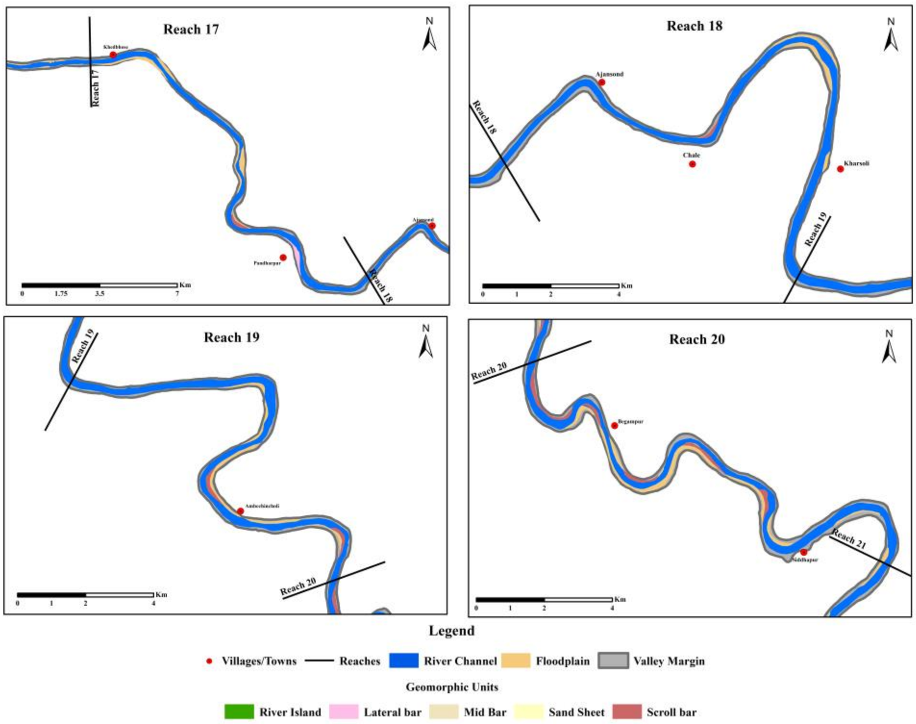

Figure A27. Geomorphic Units of the Bhima River from Reach 17 to Reach 20.

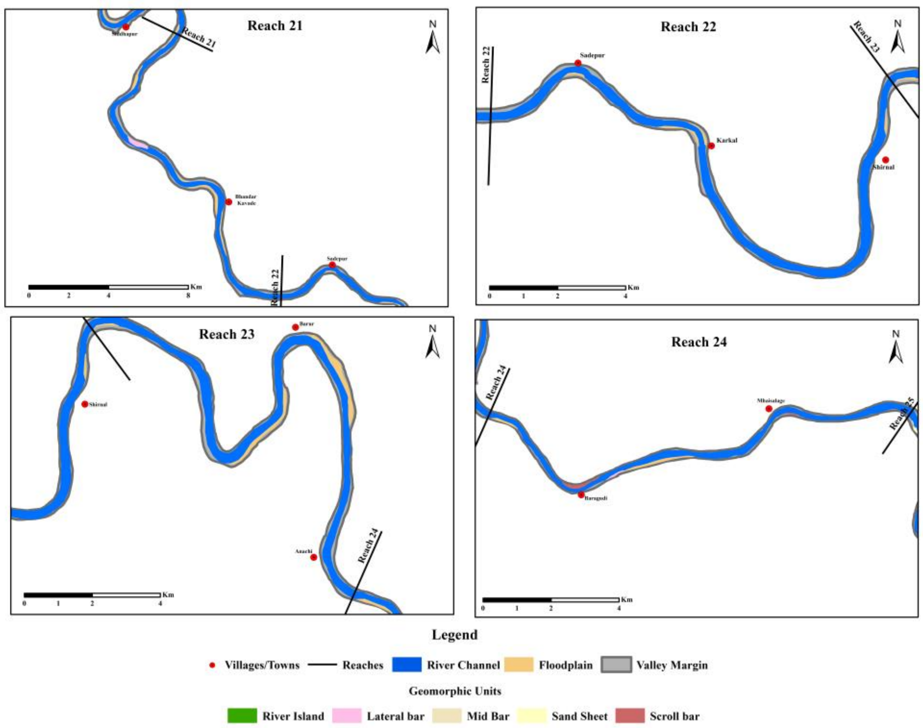

Figure A28. Geomorphic Units of the Bhima River from Reach 21 to Reach 24.

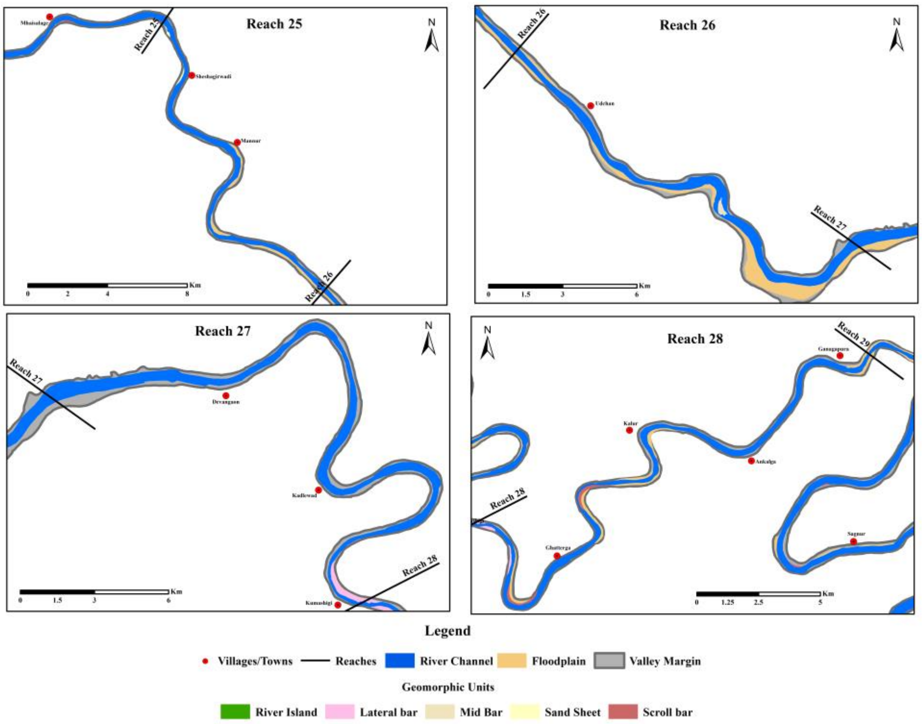

Figure A29. Geomorphic Units of the Bhima River from Reach 25 to Reach 28.

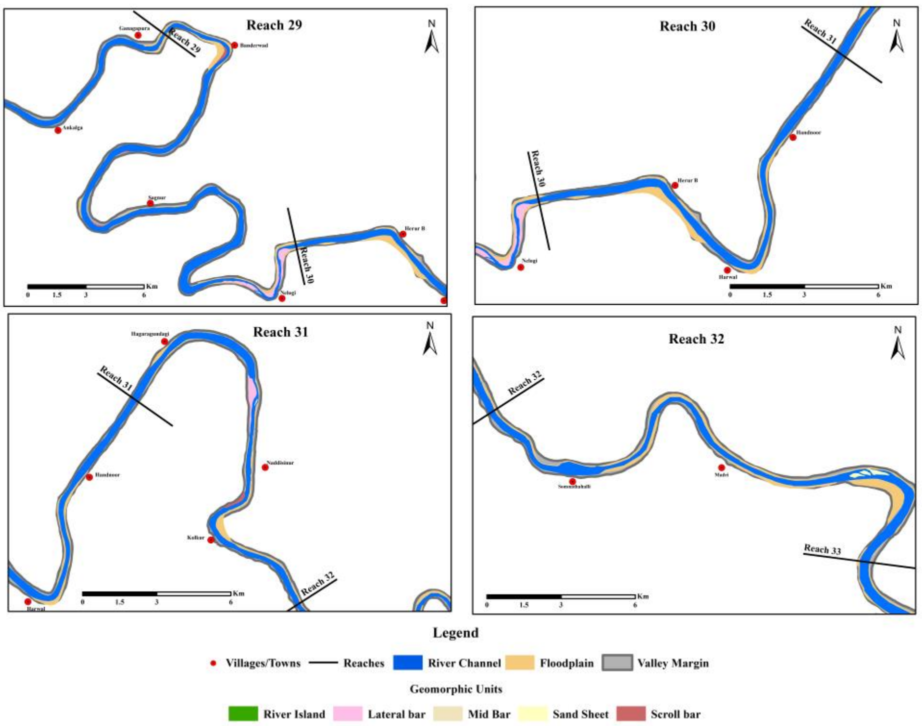

Figure A30. Geomorphic Units of the Bhima River from Reach 29 to Reach 32.

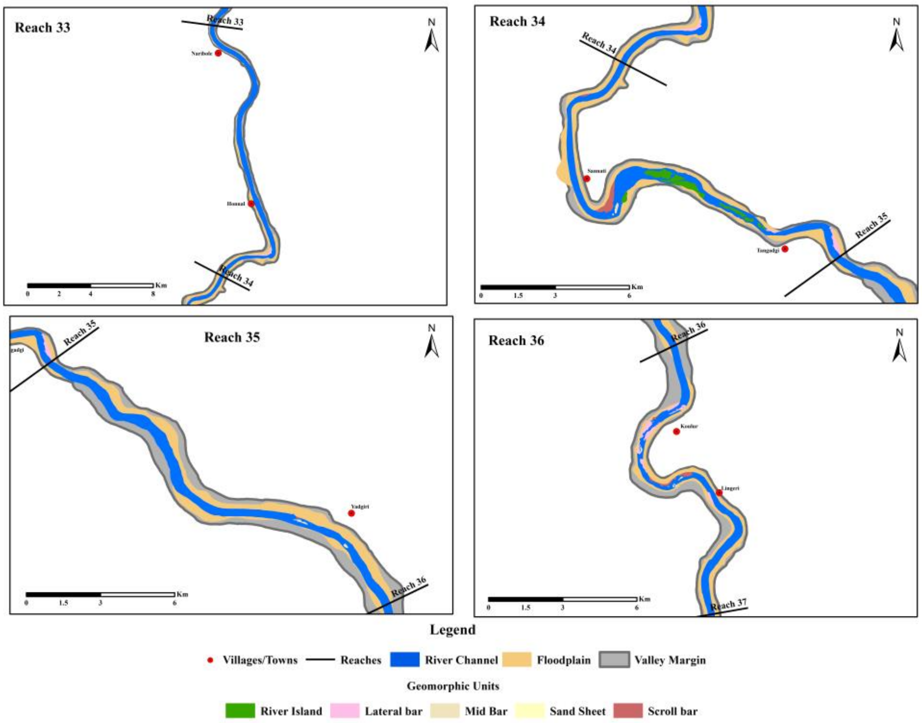

Figure A31. Geomorphic Units of the Bhima River from Reach 33 to Reach 36.

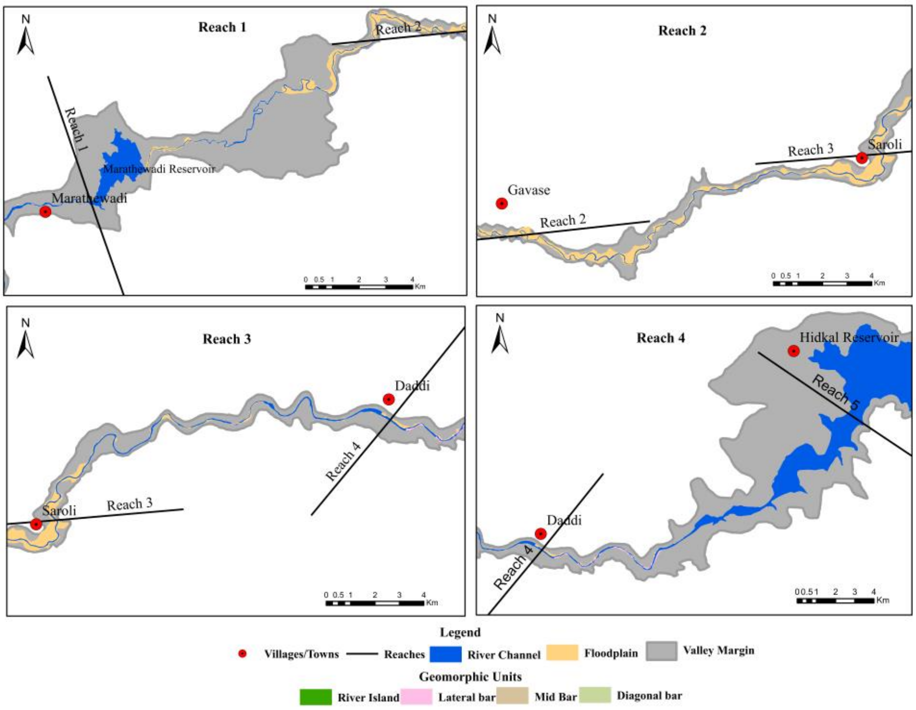

Figure A32. Geomorphic Units of the Ghataprabha River from Reach 1 to Reach 4.

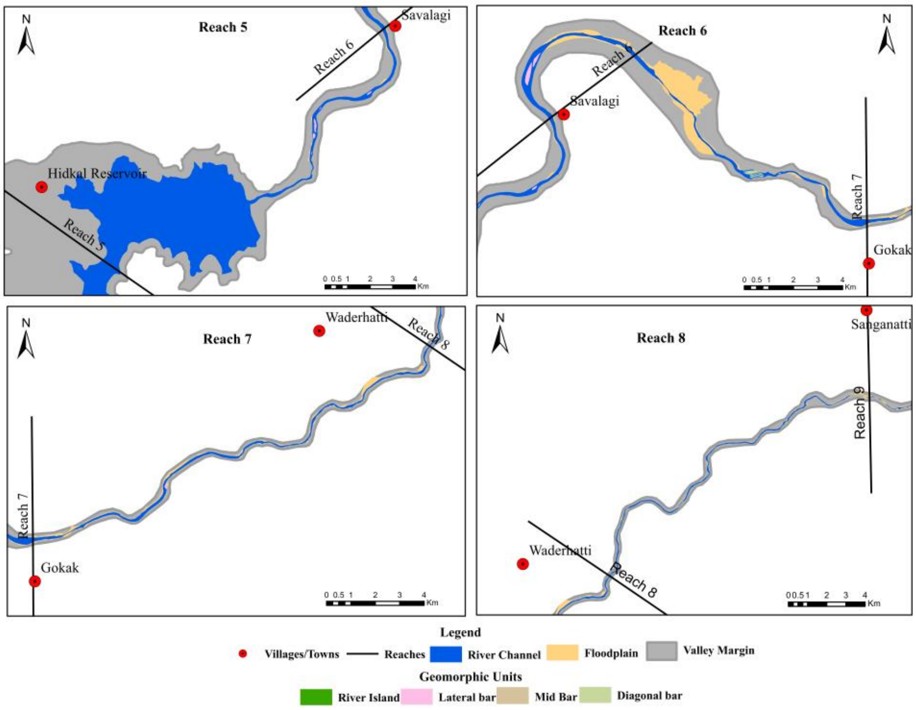

Figure A33. Geomorphic Units of the Ghataprabha River from Reach 5 to Reach 8.

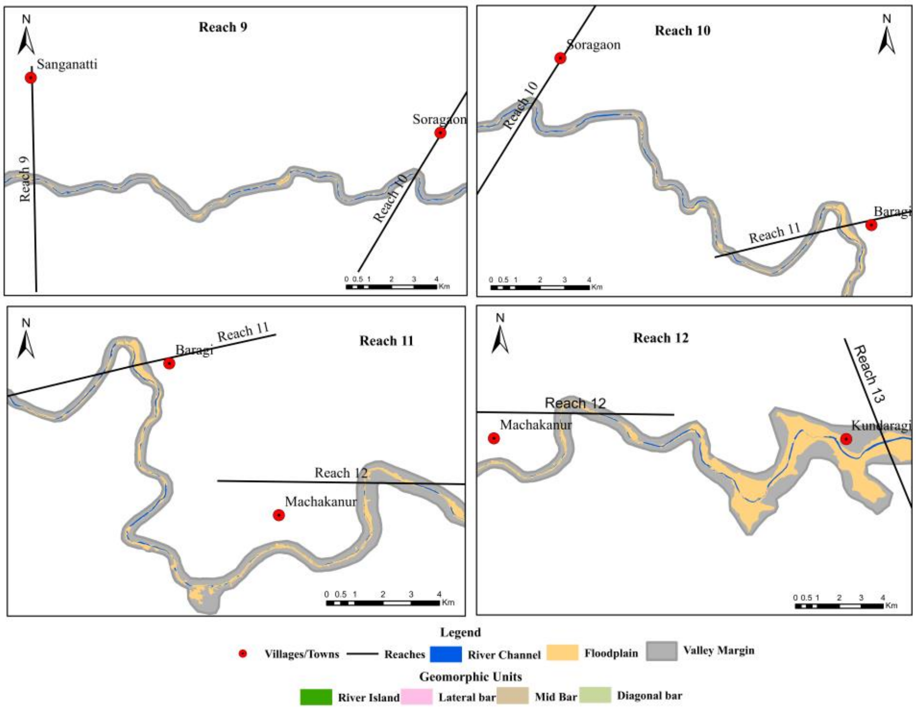

Figure A34. Geomorphic Units of the Ghataprabha River from Reach 9 to Reach 12.

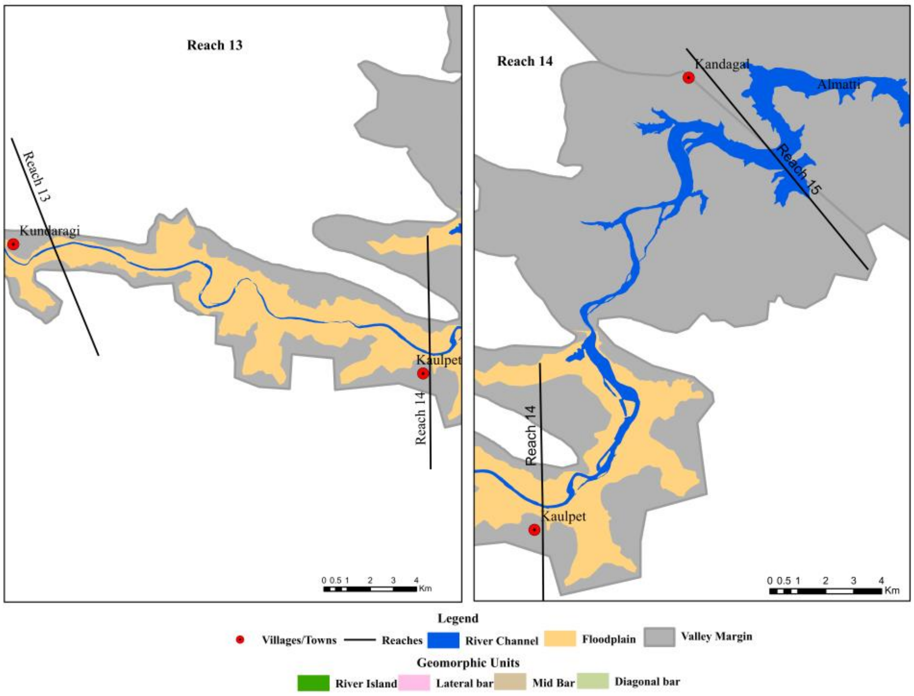

Figure A35. Geomorphic Units of the Ghataprabha River from Reach 13 to Reach 14.

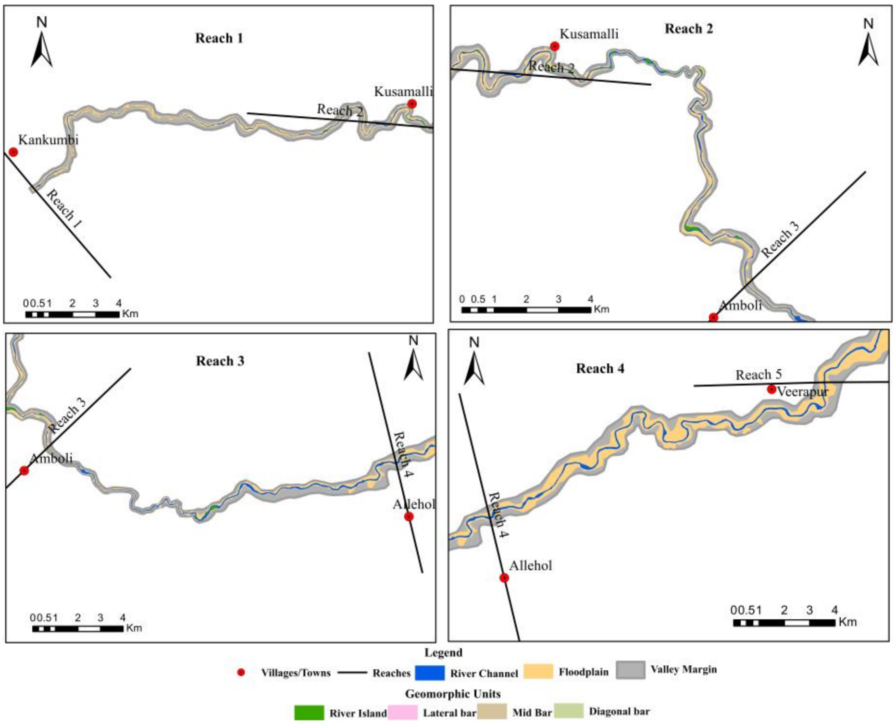

Figure A36. Geomorphic Units of the Malaprabha River from Reach 1 to Reach 4.

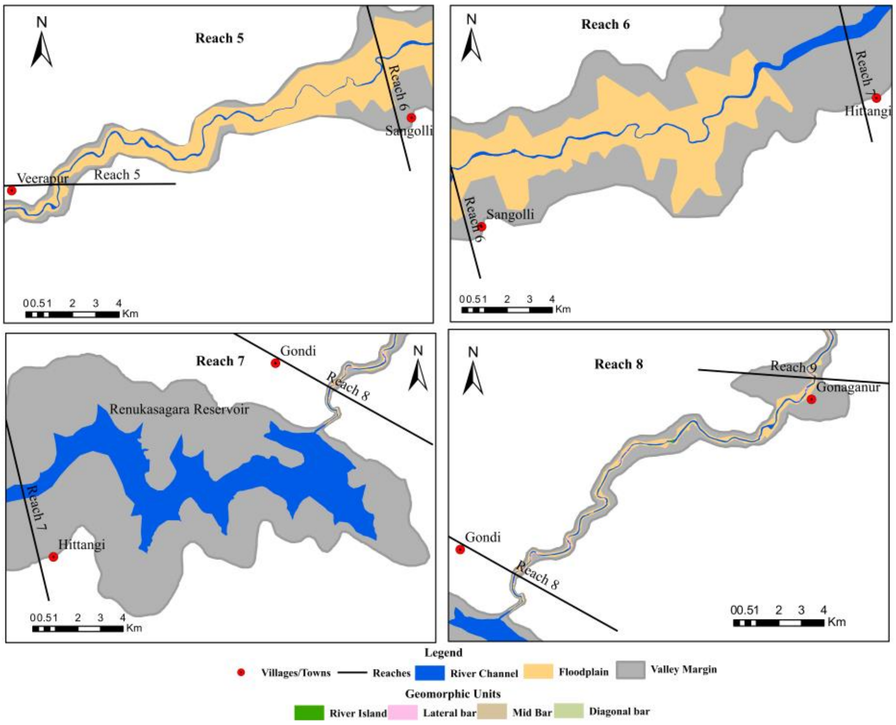

Figure A37. Geomorphic Units of the Malaprabha River from Reach 5 to Reach 8.

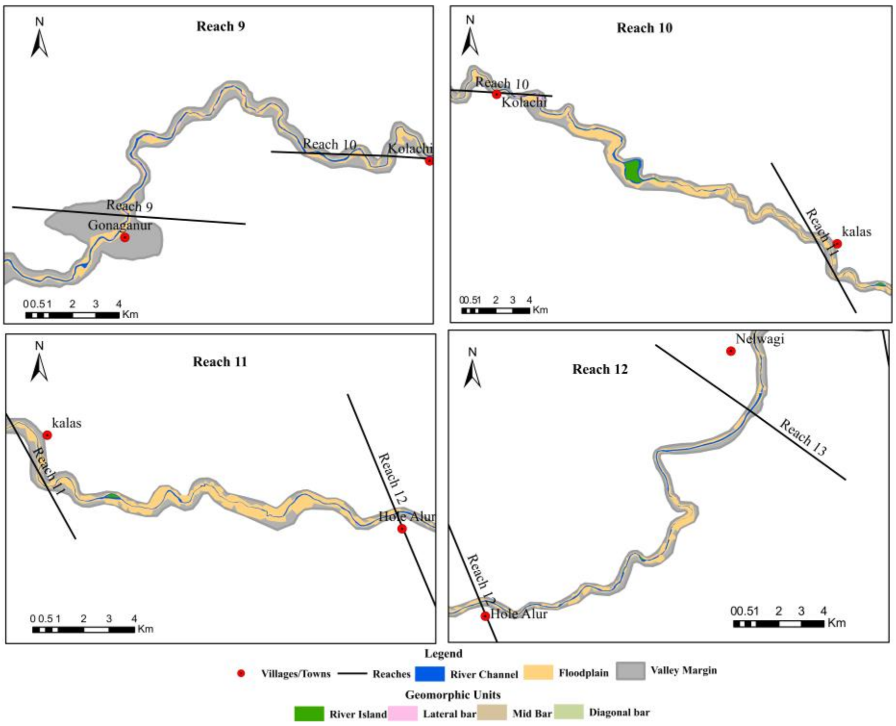

Figure A38. Geomorphic Units of the Malaprabha River from Reach 9 to Reach 12.

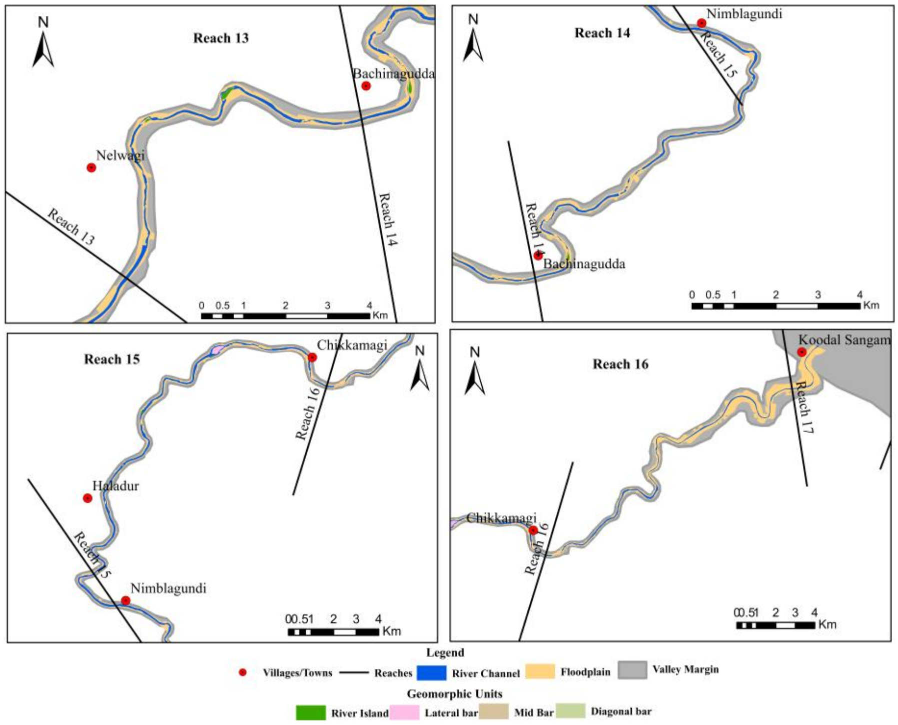

Figure A39. Geomorphic Units of the Malaprabha River from Reach 13 to Reach 16.

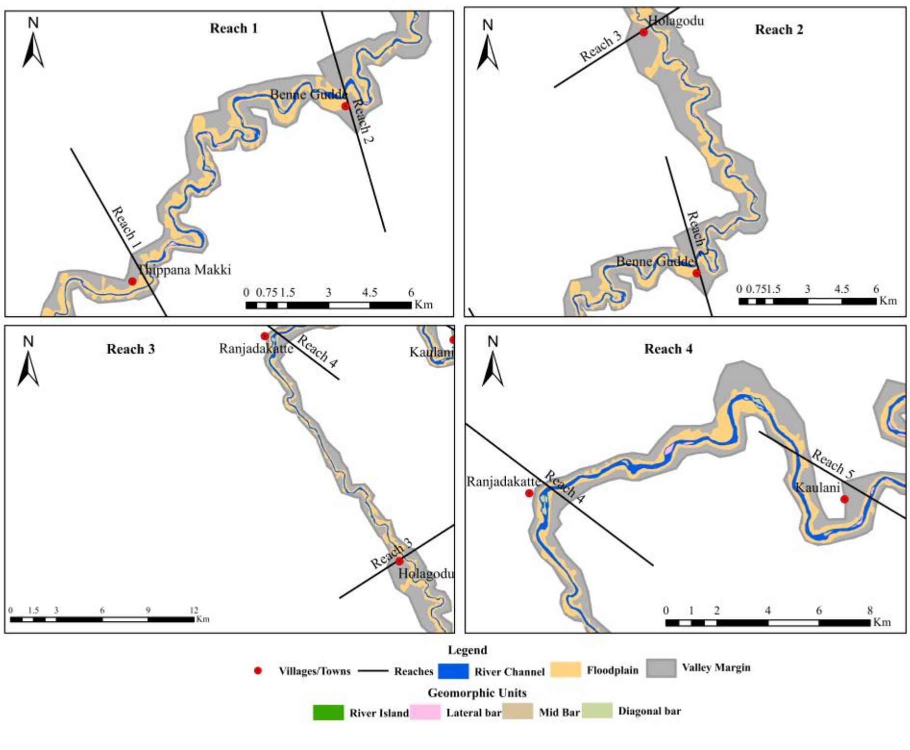

Figure A40. Geomorphic Units of the Tungabhadra River from Reach 1 to Reach 4.

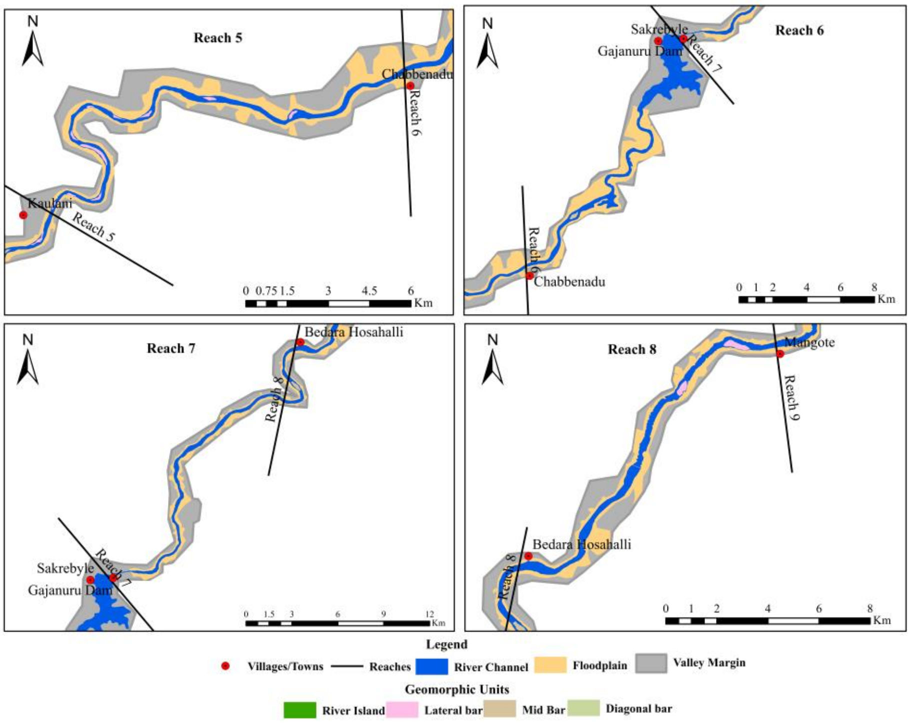

Figure A41. Geomorphic Units of the Tungabhadra River from Reach 5 to Reach 8.

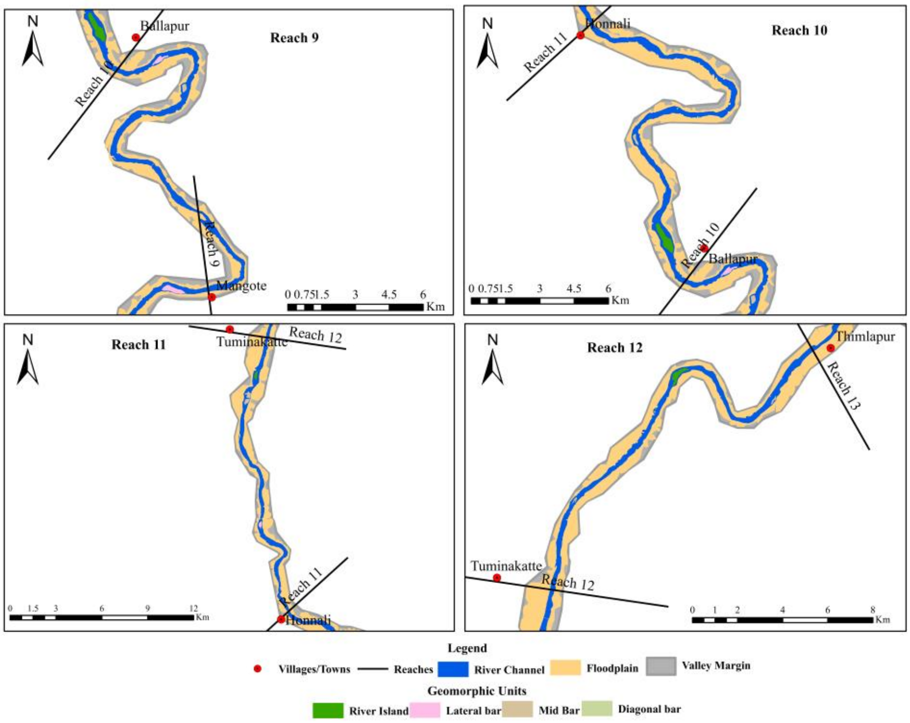

Figure A42. Geomorphic Units of the Tungabhadra River from Reach 9 to Reach 12.

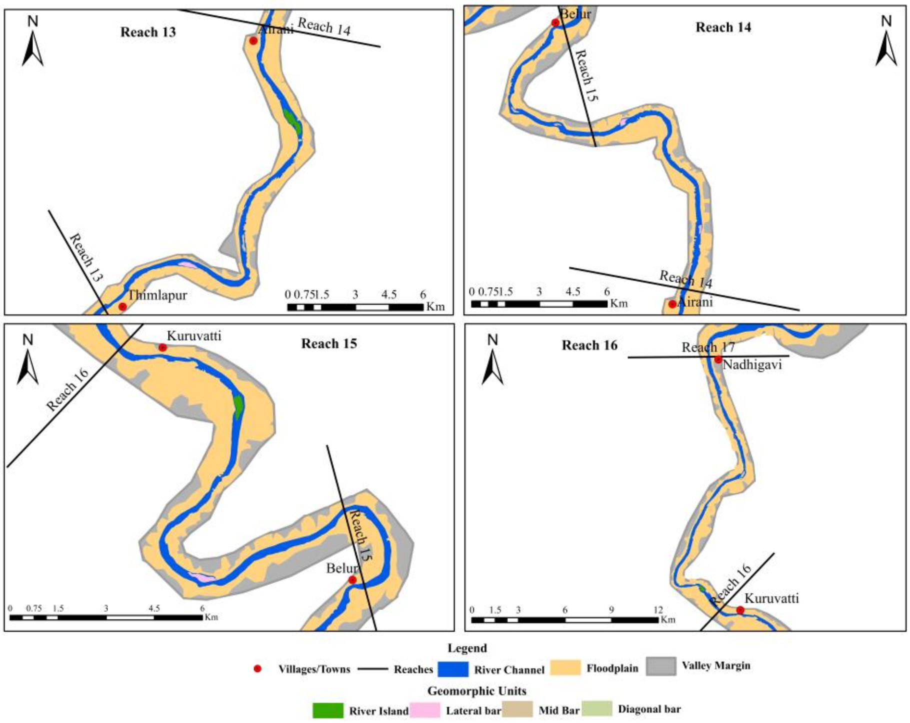

Figure A43. Geomorphic Units of the Tungabhadra River from Reach 13 to Reach 16.

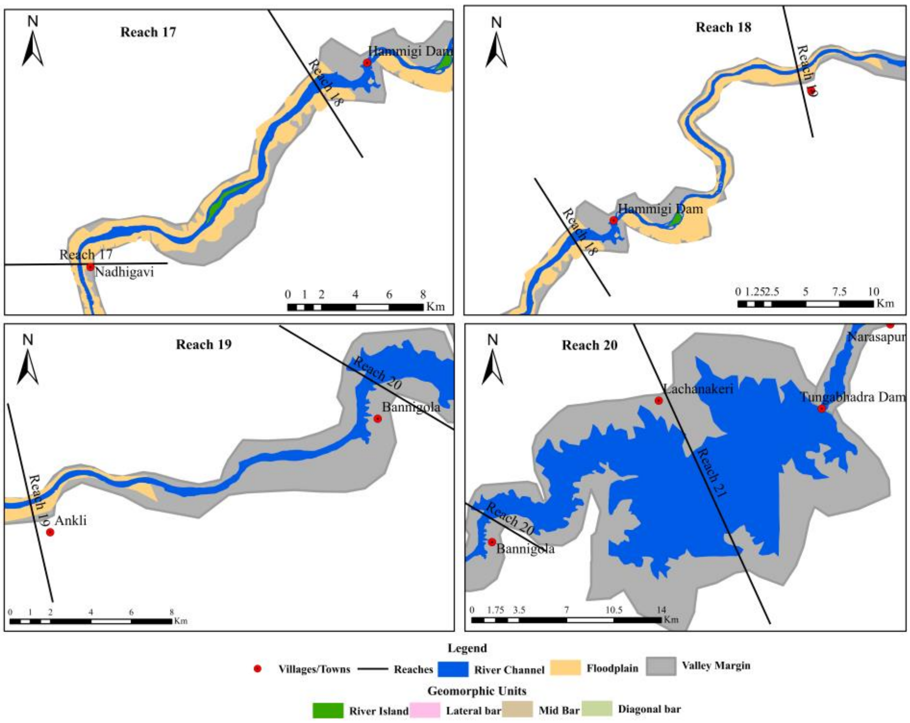

Figure A44. Geomorphic Units of the Tungabhadra River from Reach 17 to Reach 20.

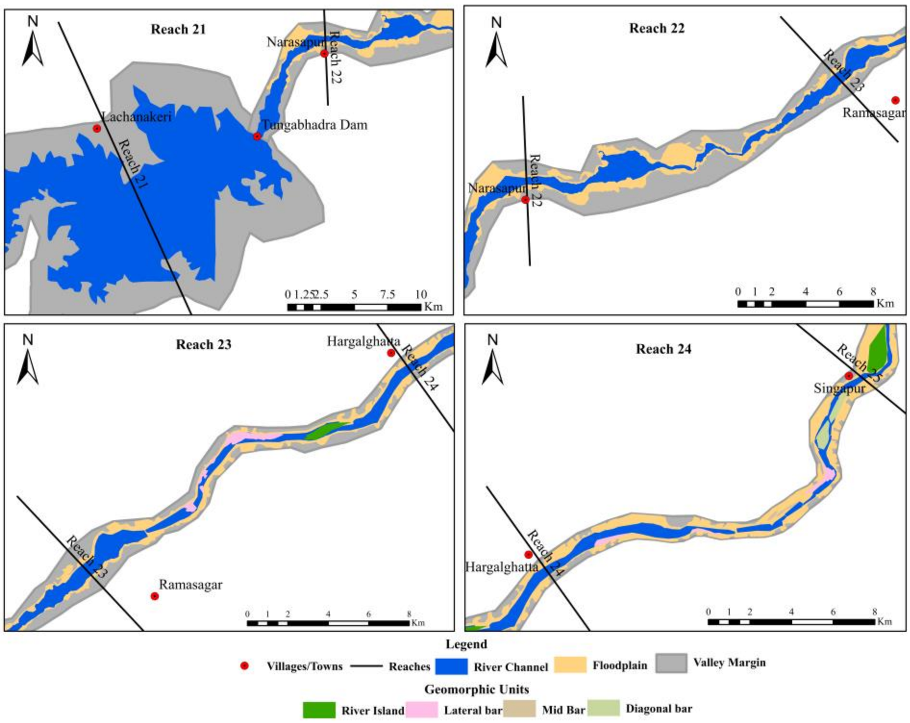

Figure A45. Geomorphic Units of the Tungabhadra River from Reach 21 to Reach 24.

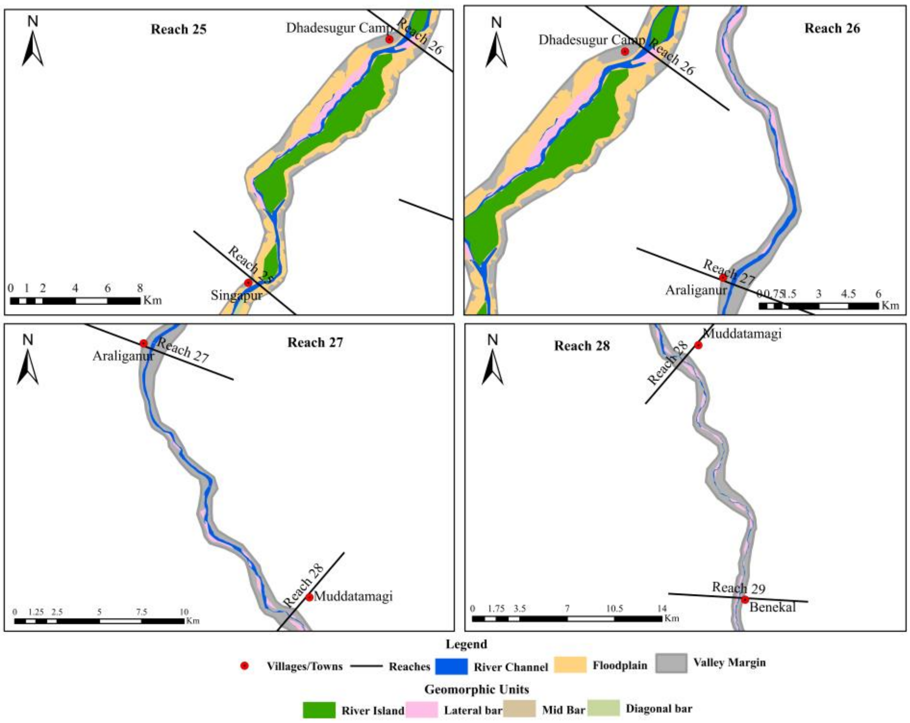

Figure A46. Geomorphic Units of the Tungabhadra River from Reach 25 to Reach 28.

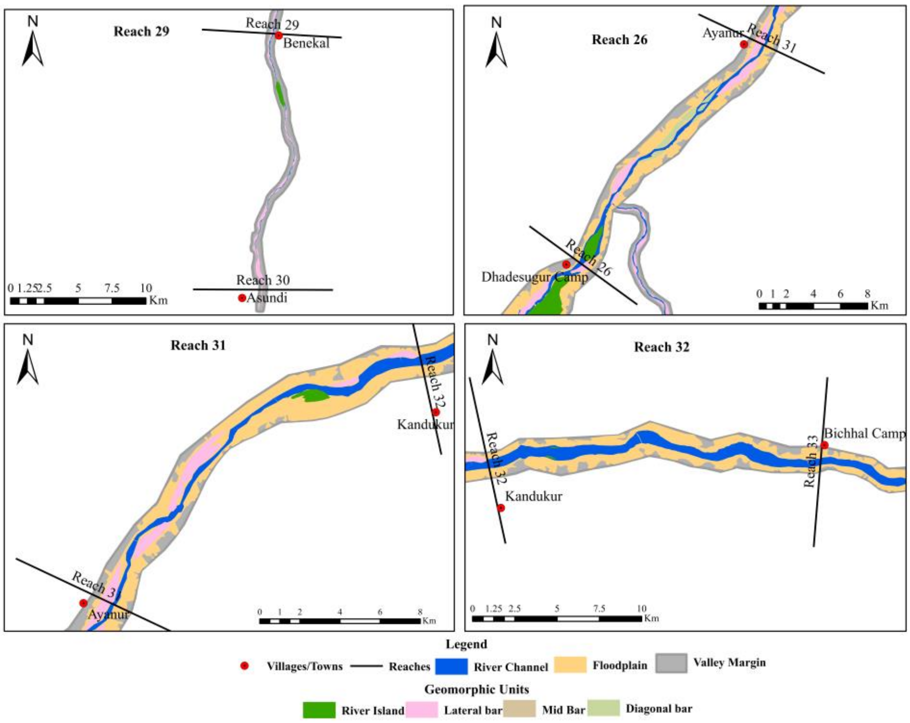

Figure A47. Geomorphic Units of the Tungabhadra River from Reach 29 to Reach 32.

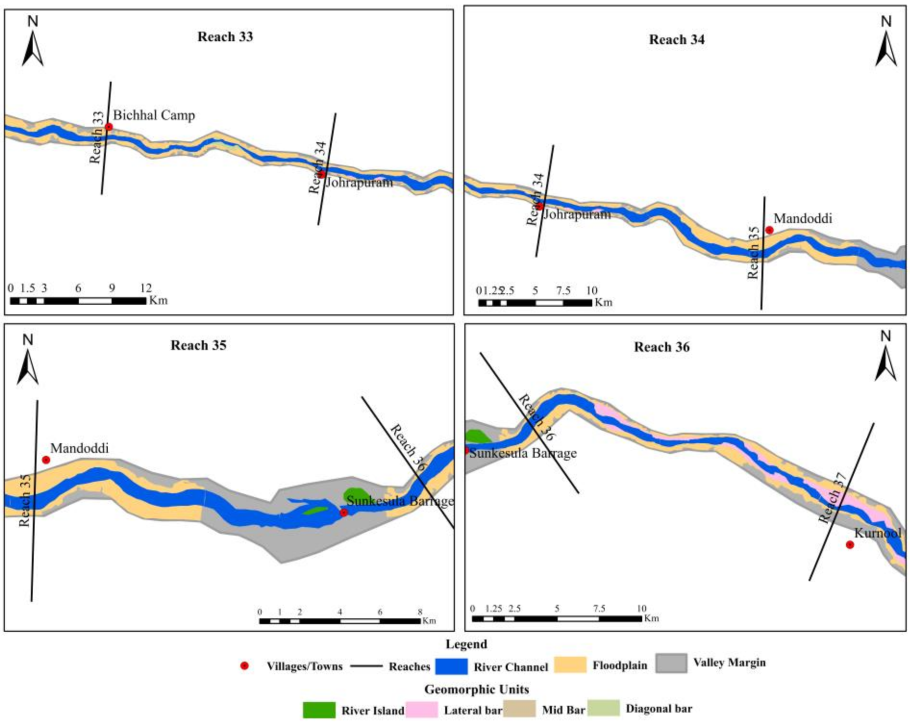

Figure A48. Geomorphic Units of the Tungabhadra River from Reach 33 to Reach 36.

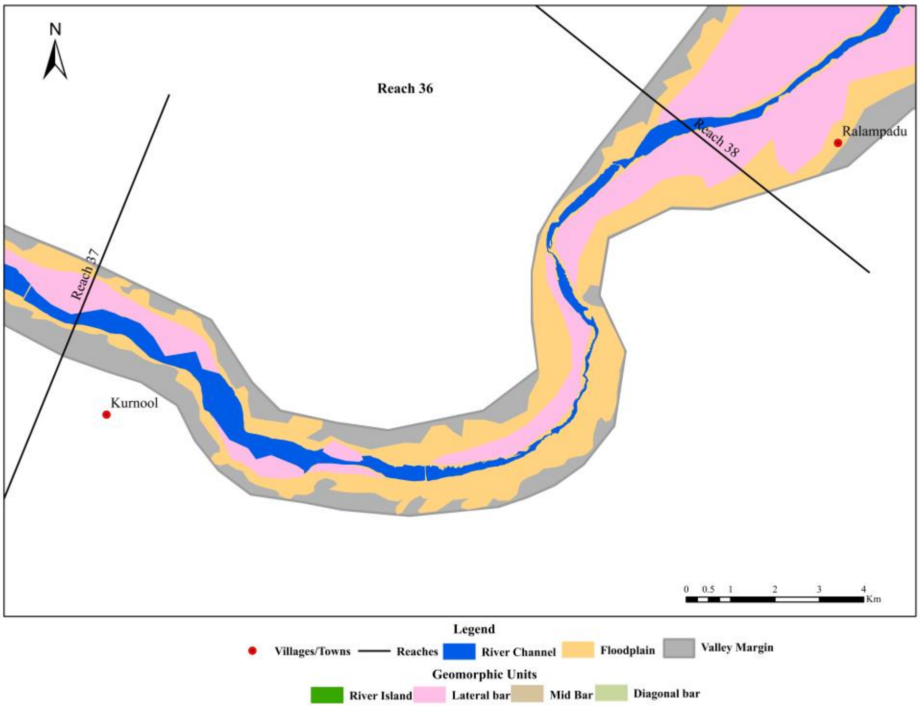

Figure A49. Geomorphic Units of the Tungabhadra River from Reach 37.