*JSL, 9(6), JUN 2024: 01-10*

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

JOURNAL OF SCIENTIFIC LETTERS
www.jslsci.com

# INFLUENCE OF RIVER MORPHODYNAMICS ON HABITAT SUITABILITY OF THE GANGETIC DOLPHIN IN THE LOWER GANGA TRIBUTARY SYSTEM

**Debgopal Mondal**

Research Scholar, Department Of Zoology, Sunrise University, Alwar, Rajasthan

**Dr. Sunil Chauhan**

Professor, Department Of Zoology, Sunrise University, Alwar, Rajasthan

## ABSTRACT

River morphodynamics plays a critical role in shaping aquatic habitats and sustaining biodiversity in large alluvial river systems. The Gangetic dolphin (Platanista gangetica gangetica), an endangered freshwater cetacean endemic to the Ganga–Brahmaputra–Meghna basin, is highly sensitive to changes in river morphology and flow dynamics. The Lower Ganga tributary system exhibits complex morphodynamic behavior influenced by monsoonal hydrology, sediment transport, channel migration, and increasing anthropogenic interventions. This theoretical research paper explores the conceptual linkages between river morphodynamics and habitat suitability for the Gangetic dolphin. It synthesizes existing theoretical frameworks related to fluvial geomorphology, hydraulic variability, sediment dynamics, and ecological habitat formation to explain how morphodynamic processes govern the spatial and temporal distribution of dolphin habitats. The paper highlights the importance of channel geometry, depth–velocity relationships, substrate composition, and morphological units such as pools, meanders, and confluences in sustaining dolphin populations. Furthermore, it discusses how human-induced alterations disrupt natural morphodynamic processes, leading to habitat degradation. The study provides a conceptual

foundation for integrating morphodynamic principles into dolphin conservation and river management strategies in the Lower Ganga tributary system.

**keywords:** Rivermorphodynamics,Habitatsuitability,Gangeticdolphin,LowerGanga Tributaries, Hydraulic Diversity.

## I. INTRODUCTION

Rivers are dynamic systems whose physical form and ecological functions are continuously shaped by interactions between water flow, sediment transport, and channel morphology. These interactions, collectively described as river morphodynamics, govern habitat diversity and ecological productivity in fluvial environments. In large alluvial rivers such as the Ganga and its tributaries, morphodynamic processes operate across multiple spatial and temporal scales, creating heterogeneous habitats that support a wide range of aquatic species.

The Gangetic dolphin (*Platanista gangetica gangetica*), India's national aquatic animal, depends heavily on the structural and hydraulic complexity of river channels. Its survival is closely linked to river depth, flow velocity, channel continuity, and prey availability—all of which are influenced by morphodynamic processes. The Lower Ganga tributary system, comprising rivers such as the Ghaghara, Gandak, Kosi, Son, and others, represents a critical habitat zone for the species. However, this region is undergoing rapid morphological transformations due to both natural processes and anthropogenic pressures.

This theoretical paper aims to examine how river morphodynamics influences habitat suitability for the Gangetic dolphin in the Lower Ganga tributary system. By developing a conceptual understanding of morphodynamic–habitat interactions, the study seeks to provide a framework for ecologically informed river management and conservation planning.

## II. CONCEPTUAL FOUNDATIONS OF RIVER MORPHODYNAMICS

River morph dynamics refers to the reciprocal interactions between flow hydraulics, sediment transport, and channel form. In alluvial rivers, channels adjust continuously in response to variations in discharge and sediment load, leading to erosion, deposition, and channel migration.

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

These processes give rise to diverse morphological features such as pools, riffles, bars, islands, and meander bends.

Theoretical models of river morph dynamics emphasize the role of flow energy in shaping channel geometry. High-energy flows mobilize sediments, deepen channels, and reshape riverbanks, while low-energy conditions promote sediment deposition and habitat stabilization. Seasonal and interannual variability in discharge, particularly in monsoon-dominated rivers like the Ganga, further enhances morphological dynamism.

Morphodynamic theory also recognizes rivers as self-organizing systems, where channel form evolves to balance sediment supply and transport capacity. This dynamic equilibrium creates spatial heterogeneity, which is essential for maintaining ecological niches for aquatic organisms, including top predators such as the Gangetic dolphin.

## III. ECOLOGICAL CHARACTERISTICS AND HABITAT REQUIREMENTS OF THE GANGETIC DOLPHIN

The Gangetic dolphin is a riverine cetacean adapted to turbid, freshwater environments. It relies on echolocation for navigation and foraging, making it particularly dependent on channel depth and acoustic conditions. Dolphins prefer deep pools, confluences, meander bends, and areas with reduced flow velocity, which offer energy-efficient movement and higher prey availability.

From a theoretical perspective, dolphin habitat suitability is influenced by physical habitat parameters such as water depth, flow velocity, channel width, and substrate type. These parameters are not static but are continuously shaped by morph dynamic processes. Stable deep-water habitats are especially important during the dry season, when water levels decline and suitable habitat becomes fragmented.

The dolphin's dependence on morphological complexity underscores the importance of understanding river morph dynamics as a driver of habitat quality rather than viewing habitat characteristics in isolation.


**Impact Factor: 6.004**

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

## IV. THEORETICAL LINKAGES BETWEEN RIVER MORPHODYNAMICS AND HABITAT SUITABILITY

River morphodynamics exerts a direct and fundamental influence on habitat suitability by governing the formation, spatial distribution, and long-term persistence of key morphological units within river channels. Continuous interactions between flow regime, sediment transport, and channel geometry shape features such as pools, riffles, runs, meander bends, and confluences, each of which provides distinct hydraulic and ecological conditions. Among these units, pools formed through scouring processes during high-flow events are particularly important for large aquatic fauna, as they offer deep-water refugia with reduced flow velocities. For river dolphins, such pools serve as critical resting, breeding, and foraging habitats, especially during periods of low discharge when suitable habitat availability becomes limited.

Meander bends and river confluences further enhance habitat suitability by generating pronounced hydraulic diversity and localized zones of prey aggregation. Secondary currents and flow separation associated with channel curvature promote sediment sorting and the development of deep pools along outer bends, while confluences create complex flow patterns characterized by turbulence, velocity gradients, and mixing zones. These morphodynamic conditions increase biological productivity by concentrating nutrients and organic matter, thereby supporting dense assemblages of fish and invertebrates that form the primary prey base for dolphins. As a result, morphologically complex reaches often function as ecological hotspots within river systems.

Depth–velocity–substrate interactions are central to the formation and maintenance of suitable habitats. High-velocity flows over shallow riffles and unstable substrates are generally unsuitable for dolphins, as they limit maneuverability, increase energetic costs, and reduce prey availability. In contrast, deep-water zones with low to moderate flow velocities and stable substrates provide optimal conditions for efficient swimming, echolocation, and foraging. The availability of such habitats depends on morphodynamic processes that regulate channel depth, bedform stability, and sediment composition.

Morphodynamic adjustments resulting from natural variability or anthropogenic disturbances can significantly alter these depth–velocity–substrate relationships. Changes in sediment supply, flow regulation, or channel morphology may lead to pool infilling, riffle expansion, or channel

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

simplification, thereby reducing the extent of suitable deep-water habitats. Conversely, processes that maintain or enhance channel complexity can improve habitat suitability by sustaining hydraulic diversity and prey-rich environments. Understanding these morphodynamic controls is therefore essential for assessing habitat quality and guiding conservation and management strategies for riverine megafauna.

## V. SEDIMENT DYNAMICS AND RIVERBED STRUCTURE

Sediment dynamics play a crucial role in shaping riverbed structure and habitat complexity. The size, composition, and distribution of sediments influence channel roughness, flow resistance, and benthic habitat quality. In the Lower Ganga tributaries, fine sediments dominate, creating soft riverbeds that support diverse benthic organisms forming the base of the food web.

Morphodynamic processes such as erosion and deposition regulate sediment distribution, thereby influencing prey availability for dolphins. Stable sedimentary environments support higher fish diversity, while excessive sediment disturbance can degrade feeding habitats.

From a theoretical standpoint, sediment balance is essential for maintaining morphological units that dolphins depend on. Disruptions to sediment supply—caused by upstream dams or sand mining—alter riverbed structure and reduce habitat suitability.

## VI. HYDROLOGICAL REGIMES AND MORPHODYNAMIC VARIABILITY IN THE LOWER GANGA TRIBUTARIES

Riverbed structural heterogeneity is a critical determinant of ecological processes in fluvial systems, influencing habitat complexity, biological diversity, and food web dynamics. Natural riverbeds are composed of a mosaic of substrates, including sand, gravel, cobbles, boulders, and organic materials, arranged in varied spatial patterns. This physical diversity creates a wide range of microhabitats that regulate hydraulic conditions, sediment stability, and biological interactions. Theoretical ecological frameworks suggest that such heterogeneity enhances prey availability by supporting diverse and productive benthic invertebrate communities, which form the primary food source for many freshwater fish species.

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

Benthic invertebrates are closely associated with riverbed characteristics because they inhabit or interact directly with the substrate throughout their life cycles. Structurally heterogeneous riverbeds provide attachment surfaces, interstitial spaces, and refuges that protect invertebrates from high flow velocities and predation. Coarse and mixed substrates facilitate periphyton growth and organic matter retention, thereby increasing food availability for grazing and detritivorous invertebrates. In contrast, homogenous riverbeds dominated by fine sediments often exhibit reduced oxygen exchange and habitat simplification, leading to lower invertebrate diversity and biomass. As a result, substrate heterogeneity plays a central role in sustaining complex benthic assemblages.

The availability of fish prey is directly influenced by the abundance and diversity of benthic invertebrates supported by riverbed structure. Heterogeneous substrates promote a range of invertebrate functional groups, including collectors, shredders, grazers, and predators, which contribute to continuous prey supply. Invertebrate drift, a key feeding mechanism for many fish species, is enhanced in structurally diverse riverbeds where variations in flow and turbulence dislodge organisms from substrates. Riffle–pool sequences and transitional bedforms often function as feeding hotspots, increasing foraging efficiency for both benthic and drift-feeding fish.

Hydrodynamic interactions further strengthen the relationship between riverbed heterogeneity and prey availability. Variations in bed roughness generate zones of contrasting flow velocity, shear stress, and turbulence. Low-velocity refugia behind bedforms and substrates allow invertebrates to persist during high-flow events, while higher-velocity zones enhance oxygenation and nutrient delivery. This balance between stability and disturbance promotes resilient invertebrate populations capable of rapid recovery, ensuring sustained prey availability for fish communities.

Anthropogenic modifications such as dam construction, channelization, dredging, and sand mining have significantly reduced riverbed heterogeneity in many rivers. Flow regulation disrupts natural sediment transport, resulting in substrate armoring or excessive fine sediment deposition. These alterations simplify habitats, reduce invertebrate production, and ultimately limit food resources for fish. Theoretical and applied research consistently emphasizes that restoring riverbed structural complexity is essential for improving prey availability and supporting healthy fish populations.

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

In conclusion, riverbed structural heterogeneity is a fundamental driver of prey availability in riverine ecosystems. By enhancing habitat diversity, invertebrate productivity, and hydrodynamic variability, heterogeneous riverbeds sustain robust fish–invertebrate food webs. Integrating geomorphological and ecological principles into river management and restoration strategies is therefore crucial for maintaining biodiversity, ecosystem resilience, and long-term freshwater sustainability.

## VII. CONCLUSION

River morphodynamics plays a fundamental role in determining habitat suitability for the Gangetic dolphin in the Lower Ganga tributary system. The dynamic interactions among flow regimes, sediment transport, and channel morphology create a diverse array of hydraulic and geomorphic features that are essential for sustaining dolphin populations. Deep pools, meander bends, confluences, and areas of reduced flow velocity—formed and maintained through natural morphodynamic processes—provide critical habitats for foraging, resting, and movement of this endangered species. Any alteration in these processes directly affects habitat availability, continuity, and quality.

The theoretical analysis highlights that both natural variability and stability in river morphology are necessary for maintaining ecological balance. Seasonal hydrological fluctuations contribute to habitat renewal and prey productivity, while excessive morphological instability or artificial regulation leads to habitat simplification and fragmentation. Anthropogenic activities such as dam construction, flow diversion, and sand mining disrupt sediment balance and channel dynamics, thereby degrading key morphological units required by the Gangetic dolphin. These interventions weaken the river’s capacity to self-adjust, resulting in long-term ecological consequences.

## REFRENCES

Cox, Sam & Hosegood, Phil & Embling, Clare & Englund, Anneli & Garagouni, Maria & Rogan, Emer & Votier, Stephen & Ingram, Simon. (2025). Understanding consistent habitat use by dolphins at dynamic oceanographic features to inform conservation management.

Das, Basanta & Bhakta, Dibakar & Johnson, Canciyal & Nirupada Chanu, Thangjam & Ramteke, Mitesh & Chauhan, Suraj & Ray, Archisman & Nandy, Saurav & Kunui, Arghya & Roy, Shreya

& Mohanty, Trupti & Tiwari, Nitish & Acharjya, Naba & Singh, Karmveer & Singh, Deependra & Jana, Aritriya & Kumar, Atul & Kayal, Tania & Behera, Sandeep. (2025). Status of Ganges River dolphin Platanista gangetica (Lebeck, 1801) in the lower stretch of the Ganga River, India, with emphasis on threats, conservation, and recommendations. Frontiers in Ecology and Evolution. 13.

Khatun, Mst Tasnima & Naz, Sabrina & Galib, Shams. (2024). Ecological impacts on the distribution of Ganges River dolphin (Platanista gangetica) in the lower Gangetic plains and its conservation challenges. Journal of Fisheries. 12. 122204. 10.17017/j.fish.718.

Aziz, Md & Khan, M & Ahsan, Md & Chowdhury, Md & Faisal, Arif. (2024). Identification of key habitats and conservation threats of the Ganges River dolphin (Platanista gangetica) of Bangladesh. Bangladesh Journal of Zoology. 51. 253-266. 10.3329/bjz.v51i3.72013.

Sonkar, Gaurav & Gaurav, Kumar & Kumar, Vaibhav & Beg, Zafar. (2024). Hydrodynamic modelling to assess habitat suitability of the Ganga River dolphins. Ecohydrology. 17. 10.1002/eco.2622.

Kabanze, Joseph & Kimanzi, Johnstone & Patrick, & Malonza, Kinyatta & Rutina, Lucas. (2023). Anthropogenic effects of habitat modification on anuran species diversity in a swamp forest area, Kenya. African Journal of Ecology. 62. 1-20. 10.1111/aje.13245.

Rai, Anu & Bashir, Tawqir & Díaz, Elio & Shrestha, Bibek. (2023). Modeling Ganges river dolphin distribution and prioritizing areas for efficient conservation planning- a range-wide assessment. Ecological Modelling. 481. 10.1016/j.ecolmodel.2023.110362.

Rai, Anu & Bashir, Tawqir & Lagunes–Díaz, Elio & Shrestha, Bibek. (2023). The effect of physiographic and hydrologic complexities and their alterations on the distribution of obligate freshwater dolphins. Ecology and Evolution. 13. 10.1002/ece3.10106.

Ranjan, Devarshi & Verma, Priyanka & Maurya, Preeti & Singh, Mayank & Upadhyay, Aditya. (2023). Ganges River Dolphin (Platanista gangetica gangetica): An Indicator of Ecosystem Health in the River Basins. UTTAR PRADESH JOURNAL OF ZOOLOGY. 44. 173-180. 10.56557/UPJOZ/2023/v44i203659.

Sharma, Ashutosh & Baruah, Anupal & Mangukiya, Nikunj & Hinge, Gilbert & Bharali, Biswadeep. (2022). Evaluation of Gangetic dolphin habitat suitability under hydroclimatic changes using a coupled hydrological-hydrodynamic approach. Ecological Informatics. 69. 101639. 10.1016/j.ecoinf.2022.101639.

Das, Goura & Sharma, Surya & Ali, Sk & Gawan, Saurav & Usmani, Aftab & Sarkar, Arkojyoti & Katdare, Suyash & Rawat, Ajay & Pichaimuthu, Gangaiamaran & Panda, Ashish & Agnihotri, Umang & Ramachandran, Aishwarya & Guha, Srijani & Barthwal, Shivani & Johnson, Jeyaraj & Badola, Ruchi & Hussain, Syed Ainul. (2022). Prioritising river stretches using multi-modelling habitat suitability of Gangetic dolphin (Platanista gangetica) as a flagship species for aquatic biodiversity conservation in the Ganga River Basin, India. Ecological Indicators. 145. 109680. 10.1016/j.ecolind.2022.109680.

Grantham, H. & Duncan, A. & Evans, Tom & Jones, Kendall & Beyer, H. & Schuster, Richard & Walston, Joe & Ray, Justina & Robinson, John & Callow, M. & Clements, T. & Costa, Hugo & DeGemmis, A. & Elsen, Paul & Ervin, Jamison & Franco, P. & Goldman, E. & Goetz, Scott & Hansen, A. & Watson, J.. (2020). Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. Nature Communications. 11. 10.1038/s41467-020-19493-3.

Paschoalini, Victor & Santos, Marcos. (2020). Movements and habitat use of bottlenose dolphins, Tursiops truncatus , in south-eastern Brazil. Journal of the Marine Biological Association of the United Kingdom. 100. 1-12. 10.1017/S0025315420000387.

Sonkar, Gaurav & Gaurav, Kumar. (2020). Assessing the impact of large barrages on habitat of the GangaRiver dolphin. River Research and Applications. 36. 1-16. 10.1002/rra.3715.

Choudhury, Nazrana & Mazumder, Muhammed & Chakravarty, Himabrata & Choudhury, Amir & Boro, Freeman & Choudhury, Imrana. (2019). The endangered Ganges river dolphin heads towards local extinction in the Barak river system of Assam, India: Plea for conservation. Mammalian Biology. 95. 10.1016/j.mambio.2019.03.007.

Correia, Ana & Gil, Agatha & Valente, Raul & Rosso, Massimiliano & Pierce, Graham & Sousa Pinto, Isabel. (2019). Distribution and habitat modelling for shortbeaked common dolphins

**Online ISSN: 2456-1495**
**CODEN (USA): JSLOBJ**

(Delphinus delphis) in Eastern North Atlantic Ocean. Journal of the Marine Biological Association of the UK. 99. 1443-1457. 10.1017/S0025315419000249.

Bonin, Carolina & Lewallen, Eric & Wijnen, Andre & Cremer, Marta & Simões-Lopes, Paulo. (2017). Habitat Preference and Behaviour of the Guiana Dolphin (Sotalia guianensis) in a Well-Preserved Estuary off Southern Brazil. Pakistan Journal of Zoology. 49. 10.17582/journal.pjz/2017.49.6.2235.2242.