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

Biological Profile of

Mahanadi River Basin

July 2026

cMahanadi

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Seventh Quarter Consolidated Report on cMahanadi

Biological Profile of the Basin

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 Mahanadi River Basin Management and Studies (cMahanadi)

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

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www.cganga.org

Acknowledgment

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Team Members

NIT Raipur

Dr. Samir Bajpai, Coordinator & Head

Dr. A. V. Ahirwar, Project Investigator

Dr. Kshitij Upadhyay, Sr. Project Scientist

NIT Rourkela

Dr. Kishanjit Kumar Khatua, Coordinator & Head

Dr. Surajit Das, cMahanadi, NIT Rourkela

Dr. Binod Bihari Sahu, cMahanadi, NIT Rourkela

Pupun Senapati, cMahanadi, NIT Rourkela

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.

Centre for Mahanadi River Basin
Management and Studies (cMahanadi)
NIT Raipur & NIT Rourkela

Executive summary

The Mahanadi River Basin (MRB) supports a rich diversity of freshwater, riparian, floodplain, and estuarine ecosystems, making it one of India's ecologically significant river basins. This report presents a comprehensive biological profile of the basin by synthesising published literature, ecological records, and available biodiversity information to document the biological characteristics of the main river and its major tributaries.

The assessment covers the Upper, Middle, and Lower Mahanadi main-stem sub-basins and the eight principal tributary sub-basins. It provides an overview of river origin and course, channel characteristics, tributary networks, biogeography, river connectivity, riverspace, river zonation, and the distribution of major biological communities, including phytoplankton, periphyton, macrophytes, zooplankton, zoobenthos, fishes, amphibians, reptiles, birds, and mammals.

The report highlights the basin's exceptional biodiversity, which ranges from forested headwater streams to the productive Mahanadi delta and estuarine ecosystems. Several ecologically important habitats support threatened and endemic species, while the river system also provides critical ecosystem services that sustain millions of people across Chhattisgarh and Odisha.

At the same time, the biological integrity of the basin is increasingly threatened by river regulation, habitat fragmentation, altered flow regimes, urbanisation, industrial development, mining, agricultural expansion, pollution, sand mining, and floodplain encroachment. These pressures have affected river connectivity, habitat quality, and aquatic biodiversity across many parts of the basin.

This biological profile establishes a baseline understanding of the ecological characteristics of the Mahanadi River Basin and identifies key conservation priorities. It provides a scientific foundation for river basin management, biodiversity conservation, ecological restoration, and evidence-based decision-making to support the long-term sustainability of the Mahanadi River ecosystem.

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Abbreviations and Acronyms

Abbreviation	Full Form
AMD	Acid Mine Drainage
APRF	Ashoka Plant Research Foundation
BCM	Billion Cubic Metres
CAMP	Condition Assessment and Management Plan
CIFA	Central Institute of Freshwater Aquaculture
CIFRI	Central Inland Fisheries Research Institute
cGanga	Centre for Ganga River Basin Management and Studies
cMahanadi	Centre for Mahanadi River Basin Management and Studies
CWC	Central Water Commission
DEM	Digital Elevation Model
EPT	Ephemeroptera, Plecoptera and Trichoptera
GRBMP	Ganga River Basin Management Plan
ICAR	Indian Council of Agricultural Research
ISCA	International Science Community Association
ISBN	International Standard Book Number
ISSN	International Standard Serial Number
IJCSPUB	International Journal of Creative Research Thoughts / IJCSPUB
IUCN	International Union for Conservation of Nature
MRB	Mahanadi River Basin
NMCG	National Mission for Clean Ganga
NRCD	National River Conservation Directorate
NRCP	National River Conservation Plan
PCCF	Principal Chief Conservator of Forests
SRTM	Shuttle Radar Topography Mission
UID	Unique Identification Code
WII	Wildlife Institute of India
WISA	Wetlands International South Asia

1. Introduction

1.1 Brief Overview of the Mahanadi River Basin

The Mahanadi River is one of the major river systems of peninsular India, renowned for its ecological significance, hydrological richness, and the diverse biological communities it sustains. Understanding the biological status of river systems and their potentially perennial streams is fundamental to effective river basin management, conservation planning, and ensuring the long-term ecological health of freshwater ecosystems.

This report presents a comprehensive assessment of the biological status of the Mahanadi River Basin (MRB) and its potentially perennial river streams. The Mahanadi River originates from the Sihawa Hills in the Dhamtari district of Chhattisgarh at approximately 442 metres above sea level. It traverses a significant portion of central and eastern India before emptying into the Bay of Bengal, covering a total length of approximately 909 kilometres and draining an expansive basin area of over 1,41,589 square kilometres.

The basin encompasses parts of Chhattisgarh (52.42%), Odisha (47.14%), Maharashtra (0.23%), and Madhya Pradesh, spanning across 56 districts, 372 sub-districts, 294 blocks, and 38,094 villages. This vast geographic extent translates into an enormous diversity of habitats, including headwater streams, mid-elevation tributary networks, large floodplain rivers, and a complex delta system that ultimately connects to the Bay of Bengal.

The biological assessment of river systems encompasses multiple dimensions: the diversity and abundance of aquatic biota (fishes, macroinvertebrates, periphyton, and macrophytes), the quality and extent of riparian vegetation, habitat integrity, and the connectivity of river reaches. These biological attributes are fundamentally shaped by the hydrological, geomorphological, and physicochemical characteristics of the river and its catchment. Perennial flow is a critical prerequisite for maintaining most forms of aquatic biodiversity, as it ensures habitat continuity, year-round feeding and breeding opportunities, and uninterrupted ecological processes.

The Mahanadi River Basin harbours a significant proportion of India's freshwater biodiversity. In its initial course, the river flows through Chhattisgarh, where it is joined by prominent tributaries such as the Seonath, Hasdeo, Mand, and Jonk. As the river flows into Odisha, it

receives additional tributaries, including the Ib, Ong, and Tel, each contributing unique biological assemblages shaped by distinct geological substrates, vegetation cover, and land-use patterns. The delta region of the Mahanadi is a globally recognised wetland, supporting numerous migratory birds, aquatic species, and unique mangrove ecosystems.

However, the biological integrity of the Mahanadi River Basin faces mounting pressures from anthropogenic activities. Proliferation of dams and barrages in the basin, which hosts 282 dams, 17 barrages, and 13 weirs, has dramatically altered flow regimes, sediment transport, and aquatic connectivity. Agricultural intensification, urbanisation around cities such as Raipur, Bilaspur, Dhamtari, Cuttack, Sambalpur, and Bhubaneswar, industrial activities in coal-rich Korba and steel-producing Rourkela areas, and encroachment into riparian zones collectively pose severe threats to the biological status of rivers across the basin.

This report is structured to provide a systematic account of the salient features of the Mahanadi River and its major tributaries, followed by a detailed biological assessment that integrates field observations, spatial analyses, and secondary data from published literature and government sources. The scope covers the three major main-stem sub-basins (Upper, Middle, and Lower Mahanadi) and eight major tributary sub-basins (Seonath, Tel, Ib, Hasdeo, Mand, Ong, Jonk, and Pairi).

The assessment framework employed in this report draws upon established river classification and bioassessment methodologies adapted for Indian peninsular rivers. Key parameters evaluated include river origin and course characteristics, channel morphology, tributary networks, biogeographic context, river connectivity and fragmentation indices, riverspace delineation, and river zonation patterns, all of which collectively determine the biological potential and current ecological condition of river reaches.

The primary objectives of this assessment are: (i) to characterise the physical and hydrological attributes of major river systems in the Mahanadi Basin; (ii) to assess the biological status of potentially perennial streams; (iii) to identify critical stretches from the perspective of aquatic biodiversity; (iv) to evaluate the degree of connectivity and fragmentation in the river network; and (v) to provide a scientific foundation for targeted conservation and restoration interventions.

2. Salient Features of the River

This chapter presents the salient features of the Mahanadi River and its major sub-basins, covering the physical, hydrological, biological, and ecological characteristics that define the

river system. The features are organised under the main river, followed by individual sections for each tributary sub-basin and main-stem sub-basin.

2.1 Mahanadi River

The Mahanadi River is the principal river of the basin bearing its name. Ranked among the major peninsular rivers of India, it flows through geologically ancient Precambrian and Gondwana formations, supporting extraordinary biodiversity and serving as the lifeline for millions of people in Chhattisgarh and Odisha.

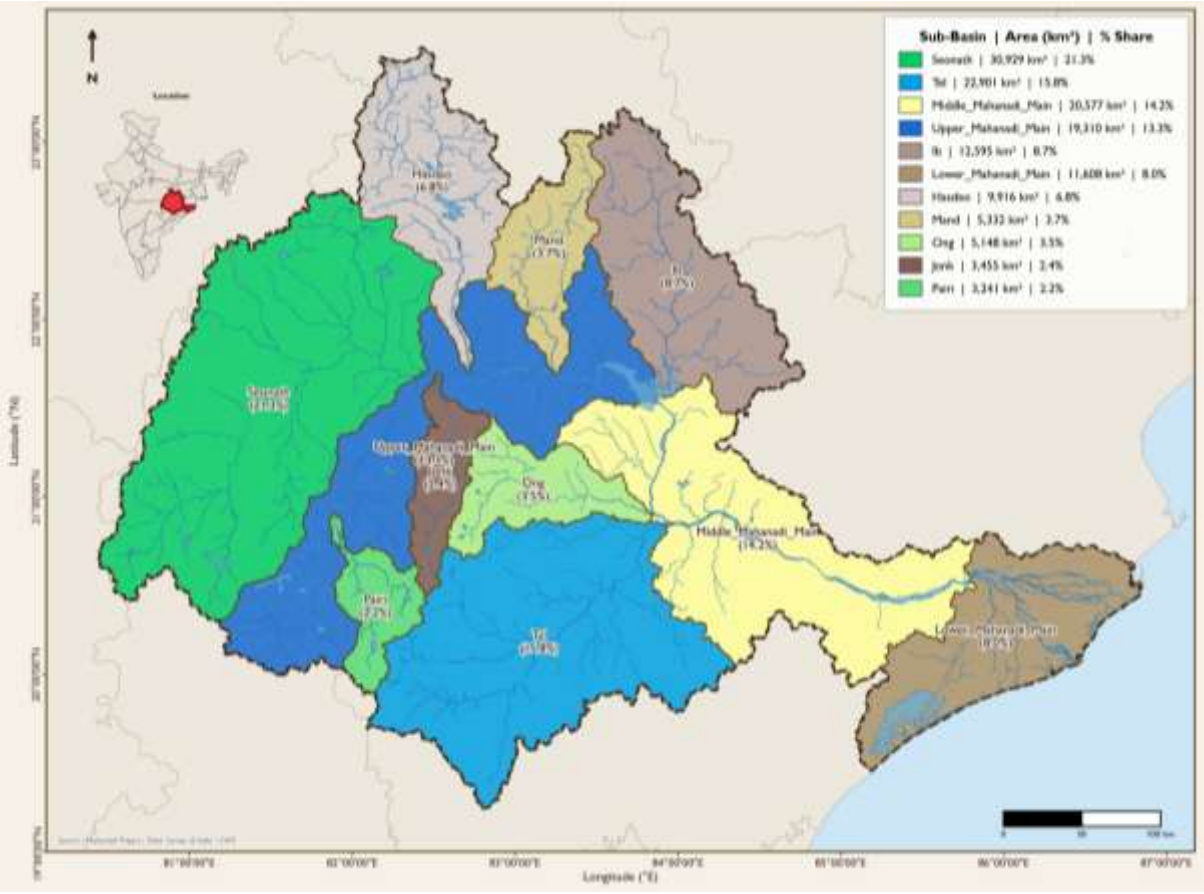


Figure 1 Mahanadi River Basin & Its Sub-Basin Boundaries

Table 1 Salient Features of MRB

S.No.	Feature	Description
1	Basin Extent	80° 28' to 86° 43' E, 19° 8' to 23° 32' N
2	Area (sq km)	1,41,589
3	States in the Basin	Chhattisgarh (52.42%), Odisha (47.14%), Maharashtra (0.23%), Madhya Pradesh

4	Districts	56
5	Sub Districts	372
6	Blocks	294
7	Villages (Census 2001)	38,094
8	Mean Annual Rainfall (mm)	1,291.92
9	Mean Max Temperature (°C)	39.56
10	Mean Min Temperature (°C)	20.01
11	Total Population (Census 2001)	2,83,22,294
12	Highest Elevation (m)	1321 (SRTM DEM)
13	Avg Annual Water Potential (BCM)	66.9
14	Utilizable Surface Water (BCM)	50
15	Number of Sub-basins	3
16	Number of Watersheds	227
17	Number of Water Resources Structures	Dams (282), Barrages (17), Weir (13), Lifts (4), Power Houses (6)
18	Highest Dam	Minimata (Hasdeo) Bango Dam (87 m)
19	Longest Dam	Hirakud Dam (4800 m)
20	Number of Irrigation Projects (Major)	24
21	Avg Annual Water Potential (BCM)	66.9

2.1.1 Origin and Course

The Mahanadi originates from the Sihawa Hills in the Dhamtari district of Chhattisgarh, at an elevation of approximately 442 metres above mean sea level (amsl) at coordinates approximately 19°58'N, 82°05'E. The headwaters emerge from a series of springs and seasonal streams in the Dandakaranya plateau, a landscape dominated by mixed deciduous forests and dissected terrain characteristic of the Eastern Satpura ranges.

From its source, the river initially flows in a northerly and then north-easterly direction through the upland region of Chhattisgarh, passing through major settlements including

Dhamtari and Rajim before converging with the Seonath River near Shivrinarayan at approximately 287 km from the origin. The river continues eastward through the Mahanadi plains, receiving the Hasdeo tributary near Shivrinarayan-Champa stretch, the Mand near Raigarh, and the Jonk further downstream.

Figure 2 Flow Diagram of the Mahanadi River with Major Dam/Reservoir

After crossing into Odisha, the Mahanadi enters the Hirakud reservoir formed by the iconic Hirakud Dam near Sambalpur, which at 4800 metres is the longest earthen dam in India. Downstream of Hirakud, the river transitions through the Sambalpur plains and receives the Ib River before passing through Sonepur, where it is joined by the Tel River. The lower reaches of the Mahanadi form an extensive delta system, bifurcating into multiple distributary channels, including the Birupa, Chitrotpala, Paika, Kushabhadra, Devi, and Daya rivers, before finally discharging into the Bay of Bengal near Paradeep and False Point. The total length of the main river is approximately 909 km.

2.1.2 Channel Characteristics

The Mahanadi exhibits three broad morphological zones that correspond to its upper, middle, and lower reaches. In the upper reaches (source to Hirakud, approximately 442 km), the channel is characterised by a narrow, moderately steep gradient with rocky and gravelly substrates. The river flows through a series of gorges interspersed with broader valley sections,

with an average gradient of approximately 1.0–1.5 m/km. Channel widths range from 30–100 m in constricted reaches to 200–400 m in alluvial plains sections. The upper reach hosts seasonal and perennial pools separated by riffle and run habitats, which are critical for fish spawning and macroinvertebrate production.

In the middle reach (Hirakud to Naraj Barrage, approximately 335 km), the channel character changes substantially. Regulated by the Hirakud Dam, the natural flow regime is significantly altered. The riverbed widens considerably, reaching 500–1500 m in places, with extensive sand bars and mid-Channel Islands (called 'diaras') during the dry season. The substrate transitions from coarse gravels to mixed sand-gravel-silt, supporting a different community of benthic organisms. The gradient reduces to approximately 0.3–0.5 m/km.

The lower reach (Naraj Barrage to sea, approximately 132 km) is characterised by the deltaic morphology. The channel is wide, low-gradient, and dominated by fine silt and clay substrates. Extensive floodplains are inundated during the monsoon, creating seasonally productive wetland habitats. The distributary network creates a mosaic of riverine and estuarine habitats of exceptional ecological value. The Chilika Lake, connected to the Mahanadi delta system, is Asia's largest brackish water lagoon and a Ramsar Wetland of International Importance.

The Mahanadi Basin has a total of 282 dams, 17 barrages, and 13 weirs, with a total canal network length of 17,128 km serving a command area of 32,94,761 hectares. The average annual water potential of the basin is 66.9 BCM, of which 50 BCM is usable surface water.

2.1.3 Tributaries

The Mahanadi River has a rich and complex tributary network comprising both major rivers and thousands of small streams. The basin contains 1,709 named rivers with a total named river length of 34,378.59 km. The eight major tributaries that define the basin's hydrology are: The Seonath (385.77 km), Tel (310.94 km), Ib (274.49 km), Hasdeo (337.06 km), Mand (265.40 km), Ong (219.40 km), Jonk (192.94 km), and Pairi (128.69 km).

In its Chhattisgarh phase, the Mahanadi is predominantly augmented by left-bank tributaries draining the Maikal-Satpura ranges (Seonath, Hasdeo, Mand) and right-bank tributaries from the Gondwana uplands. In its Odisha phase, important additions come from the south via the Eastern Ghats-derived Tel River and the north via the Ib, which originates in the Jharkhand highlands. The tributary network exhibits strong dendritic drainage patterns in the upper

basin, transitioning to more parallel and sub-parallel patterns in the lower basin, where structural controls are prominent.

2.1.4 Biogeography

The Mahanadi River Basin spans two major biogeographic zones of India: The Deccan Plateau and the Eastern Ghats-Northern Circars, with a small extension into the Central Highlands. This biogeographic diversity translates into a rich mosaic of ecosystems ranging from moist deciduous forests in the upper catchments, dry deciduous forests and scrublands in the mid-basin, to the productive delta wetlands and mangrove forests at the coast.

The upper catchment of the Mahanadi in Chhattisgarh lies within the Deccan Plateau biogeographic zone and is characterised by the Dandakaranya forests, one of the largest contiguous forest patches in peninsular India. These forests are dominated by sal (Shorea robusta) and mixed deciduous species, and support populations of tiger, elephant, sloth bear, and an array of smaller mammals. The riparian corridors of the upper Mahanadi and its tributaries serve as critical wildlife corridors.

The fish fauna of the Mahanadi Basin is exceptionally diverse, estimated at over 90 species, including numerous endemics and several commercially important species. Key fish groups include mahseer (Tor species), several species of catfish (Bagridae, Sisoridae), carps (Labeo, Cirrhinus, Catla), minor carps, and hill-stream fishes (Balitoridae, Cyprinidae). The basin supports globally significant populations of gharial (Gavialis gangeticus) and mugger crocodile (Crocodylus palustris) in suitable reaches, particularly the Seonath, Tel, and Jonk.

Macroinvertebrate communities in the upper Mahanadi and its tributaries are typical of peninsular Indian highland rivers, with Ephemeroptera, Plecoptera, and Trichoptera (EPT) being important indicators of good water quality. The lower reaches and delta support a distinct assemblage of molluscs, crustaceans, and soft-sediment organisms. Riparian and aquatic macrophytes form important habitat components throughout the basin.

2.1.5 River Connectivity, Fragmentation and Dam Density

The Mahanadi Basin is heavily fragmented by water infrastructure. With 282 dams, 17 barrages, and 13 weirs documented within the basin, the degree of hydrological fragmentation is substantial. The Hirakud Dam (commissioned 1957) is the most significant structure, creating a reservoir of 746 sq km surface area that blocks fish migration between the upper and lower Mahanadi, traps sediment, and dramatically alters the natural flow regime downstream.

Other major dams include the Ravishankar Sagar Dam (Gangrel Dam) on the upper Mahanadi near Dhamtari, the Minimata (Hasdeo) Bango Dam on the Hasdeo tributary, and the Sondur Dam, each creating significant barriers to longitudinal connectivity. The total length of canals in the basin reaches 17,128 km, further fragmenting the landscape and affecting lateral connectivity between the river channel and its floodplains.

Dam density analysis reveals that the Seonath Sub-basin has the highest density of water storage structures relative to its size, reflecting intensive agricultural development in the Chhattisgarh plains. The Tel Sub-basin in Odisha also has significant fragmentation. The Ib Sub-basin, with its coal mining area, presents additional stressors beyond dam fragmentation. Reaches with minimal dam influence notably portions of the Jonk, Pairi, and upper Hasdeo retain higher biological integrity.

River connectivity encompasses longitudinal (upstream-downstream), lateral (floodplain-channel), vertical (hyporheic zone), and temporal dimensions. In the Mahanadi Basin, all four dimensions of connectivity have been adversely affected. Upstream-downstream connectivity for migratory fish has been largely disrupted. Lateral connectivity is compromised by embankments built to protect agricultural land, particularly in the lower reach. The hyporheic zone function is affected by groundwater extraction in many reaches.

2.1.6 Riverspace

Riverspace refers to the total geomorphic and ecological space that a river system requires to function, encompassing the active channel, seasonally wetted bars and banks, floodplain, riparian corridor, and the hyporheic zone. The Mahanadi River's riverspace varies considerably along its course.

In the upper reaches, the riverspace is relatively well-preserved where the river flows through forested terrain in national parks and wildlife sanctuaries. The Sitanadi-Udanti Tiger Reserve and Barnawapara Wildlife Sanctuary in Chhattisgarh, and the Satkosia Tiger Reserve in Odisha (through which the Mahanadi flows for approximately 22 km through one of the deepest gorges), represent areas where riverspace integrity is comparatively maintained.

However, in agricultural plains sections, particularly in the Chhattisgarh ricelands and the Mahanadi delta of Odisha, the riverspace has been dramatically reduced by encroachment, embankment construction, and conversion of floodplains to agriculture. The lower Mahanadi delta has experienced extensive riverspace loss due to urbanisation around Cuttack and agricultural intensification. The total riverspace required for ecological functioning of the

Mahanadi system is estimated at several thousand square kilometres, far exceeding the currently protected or managed river corridor.

2.1.7 River Zonation

River zonation in the context of the Mahanadi follows the classic ritronal-potamal continuum concept adapted for Indian peninsular rivers. The basin can be divided into five broad ecological zones based on altitude, gradient, substrate, flow characteristics, and biotic assemblages.

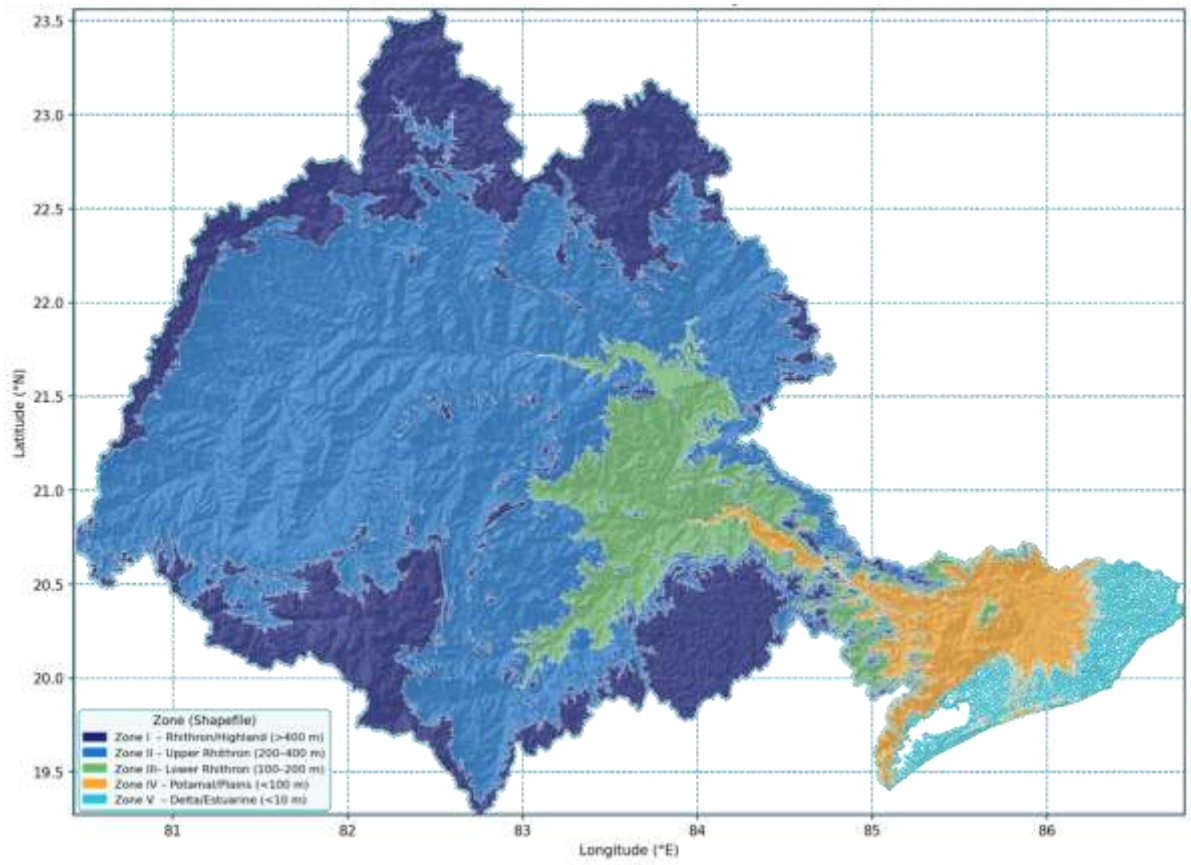


Figure 3 Classification of the Mahanadi River Basin in Five Broad Ecological Zones

Zone I (Rhithron / Highland Streams, >400 m amsl): The uppermost headwater streams above 400 m elevation, typically within forested catchments. These streams are characterised by turbulent flow, clean cobble and boulder substrates, high dissolved oxygen, low temperatures, and EPT-dominated macroinvertebrate communities. Hill-stream fish species (Balitoridae, Garra, Crossocheilus) predominate. These reaches are found in the uppermost Mahanadi headwaters, Hasdeo headwaters (Koriya district), Ib headwaters (Jashpur), and Mand headwaters (Raigarh).

Zone II (Upper Rhithron / Foothill Streams, 200–400 m amsl): Transitional highland-lowland streams with moderate gradient, mixed substrate of gravel-cobble-sand, higher temperatures than Zone I, and mixed fish communities including mahseer (Tor) and rheophilic carps. Moderate EPT diversity with increasing Diptera and Odonata.

Zone III (Lower Rhithron / Upper Plains Rivers, 100–200 m amsl): Rivers with gentle gradient, predominantly sandy substrates with occasional gravel beds. Important spawning grounds for carp and catfish. Fish diversity peaks in this zone with over 40–60 species expected in well-preserved reaches. Macroinvertebrate communities are dominated by Diptera, Odonata, and Hemiptera. Large sections of the Seonath, Tel, and Jonk fall in this zone.

Zone IV (Potamal / Major Plains Rivers, <100 m amsl): Large, low-gradient rivers with sand-silt substrates, turbid waters during monsoon, and well-developed floodplain ecosystems. The main Mahanadi channel from Sambalpur to Naraj falls in this category, as do the lower reaches of Tel and Seonath. Fish communities are dominated by large-bodied carps and catfish; gharial and crocodile may occur in suitable reaches.

Zone V (Delta / Estuarine Zone): The tidal-influenced lower delta, including distributary channels, Chilika Lake, and the estuarine mouth. This zone supports a unique brackish-freshwater transition community including hilsa (Tenualosa ilisha), estuarine catfishes, prawns, crabs, and migratory birds. The Mahanadi delta and Chilika Lake together form one of the most productive and biodiversity-rich ecosystems on the eastern coast of India.

2.2 Tributaries and Sub-Basins

This section provides detailed salient features for each of the three Major Main-Stem Sub-Basins and eight Major Tributary Sub-Basins of the Mahanadi River Basin. For each sub-basin, the origin and course, channel characteristics, tributaries, biogeography, river connectivity, riverspace, and river zonation are described.

2.2.1 Upper Mahanadi Main Sub-Basin

Table 2 Attributes of Upper Mahanadi Main Sub – Basin

Parameter	Value
UID Code	08CG377R44727301
Main River Length (km)	442.02

Basin Area (sq km)	19,311.48
Number of Named Rivers	205
Length of Named Rivers (km)	4,302.72
Major Rivers	Kelo, Son, Lath, Borai, and Sukha

2.2.1.1 Origin and Course

The Upper Mahanadi Main Sub-Basin encompasses the river from its origin at Sihawa Hills in Dhamtari district, Chhattisgarh (elevation ~442 m amsl) to the site of the Hirakud Reservoir near Sambalpur. Over this reach of approximately 442 km, the Mahanadi drains an area of 19,311 sq km through the heart of Chhattisgarh. The river initially flows northwards through Dhamtari, passes the Ravishankar Sagar (Gangrel) Dam, continues through Rajim (a sacred confluence with the Seonath and Pairi), and then flows eastward through the Mahanadi plains of Raipur Division. Key milestones include Rudri Barrage and Dhamtari at ~108 km from the origin, Rajim at ~164 km, Sirpur at ~220 km, and Shivrinarayan at ~287 km. Major dams in this stretch include the Ravishankar Sagar Dam (31.57 m height, 1246 m length) on the Mahanadi and the Dudhawa Dam on the Kelo tributary.

2.2.1.2 Channel Characteristics

In the upper sub-basin, the Mahanadi transitions from a rocky, shallow hill-stream character near its Sihawa headwaters to a broad alluvial plains river by the time it reaches Shivrinarayan. The gradient decreases from approximately 2–3 m/km in the uppermost reaches to less than 0.5 m/km in the plains. Channel width increases from 20–50 m near the source to 200–500 m in the alluvial sections. Substrates range from bedrock outcrops and boulders in the upper gorge sections to gravel-cobble in transitional reaches, and sandy to sandy-silt in the plains. The Ravishankar Sagar Reservoir (surface area ~82 sq km) creates a significant impoundment within this sub-basin. Below the dam, the channel narrows, and the flow regime is highly regulated, with ecological releases being insufficient to maintain the natural hydrograph in many years.

2.2.1.3 Tributaries

The Upper Mahanadi sub-basin receives 205 named rivers draining 4,302 km collectively. Major tributaries joining in this stretch include the Pairi River (right bank, ~128 km), Seonath River (left bank, ~385 km) at Shivrinarayan, Jonk River (right bank, ~193 km), Hasdeo River (left bank, ~337 km), Mand River (left bank, ~265 km), Kelo River (left bank, ~47 km), and Chhote Kelo River. Each of these tributaries brings distinct hydrological and biological

contributions. The Pairi drains the southern forested highlands near Gariyaband, while the Seonath drains the extensive agricultural plains of central Chhattisgarh.

2.2.1.4 Biogeography

The upper sub-basin catchment is predominantly forested in its headwater areas, with sal forests of Dandakaranya giving way to mixed deciduous forests and then agricultural landscapes in the plains. Wildlife corridors in the Gariyaband, Dhamtari, and Mahasamund forests support elephants, tigers, leopards, gaurs, and a rich avifauna. The riparian forests along the upper Mahanadi and Pairi are important roosting and foraging habitats for the endangered Indian skimmer (Rynchops albicollis). Aquatic biodiversity in this sub-basin includes mahseer (Tor tor, T. khudree), several species of Labeo, Cirrhinus, Catla, and diverse catfishes. Mugger crocodile and Indian softshell turtle populations are documented. The lower-gradient alluvial sections support gharial in limited numbers.

2.2.1.5 River Connectivity, Fragmentation and Dam Density

The Upper Mahanadi sub-basin has significant hydrological fragmentation. The Ravishankar Sagar Dam is the principal barrier, effectively splitting the sub-basin's longitudinal connectivity. Below the dam, the Rudri Barrage and Dhamtari Barrage further impede connectivity. Despite these structures, some seasonal connectivity is maintained during high flood periods when fish can navigate over or around these structures. The Gangrel Reservoir constitutes a physical barrier of approximately 37 km, beyond which upstream fish migration is impossible. Dam density in this sub-basin is moderate, with smaller check dams and weirs in the Pairi and upper Mahanadi catchments.

2.2.1.6 Riverspace

The riverspace in the upper sub-basin is best preserved in the forested headwater areas of the Dhamtari-Gariyaband landscape. The Satkosia-Mahanadi corridor in the adjacent reach, and the forests of Udanti-Sitanadi Tiger Reserve (through which the Pairi and Mahanadi flow) represent areas of reasonable riverspace integrity. In the agricultural plains around Raipur and Mahasamund districts, the riverspace has been severely reduced by embankments, agricultural encroachments, and infrastructure development. The Rajim floodplain, a cultural-ecological heritage site, retains some floodplain character but is increasingly stressed by encroachment and sand mining.

2.2.1.7. River Zonation

The Upper Mahanadi sub-basin spans Zones I through III of the river zonation framework. The Sihawa headwaters and associated streams above 400 m represent Zone I (Highland

Streams) with typical hill-stream biota, including hill-stream loaches, Garra species, and EPT-dominated invertebrates. The intermediate elevations (200–400 m) in the Dhamtari-Gariyaband foothills constitute Zone II with mixed assemblages. The extensive plains section from below the Gangrel Dam to Shivrinarayan is Zone III character, with sandy-substrate fish communities and high carp diversity.

2.2.2 Middle Mahanadi Main Sub-Basin

Table 3 Attributes of Middle Mahanadi Main Sub-Basin

Parameter	Value
UID Code	08CG377R44727301
Main River Length (km)	334.83
Basin Area (sq km)	20,525.72
Number of Named Rivers	207
Length of Named Rivers (km)	4,440.42
Major Rivers	Salki, Bagh, Jira, Harihar Jor, Burtanga, Kali Jor, Malti Jhor, Ranj Jhor

2.2.2.1 Origin and Course

The Middle Mahanadi Main Sub-Basin covers the river from the site of the Hirakud Reservoir (at approximately 419 km from origin) to the Naraj Barrage near Cuttack (at approximately 756 km from origin), spanning a river length of 334.83 km through Odisha. Key landmarks in this reach include Sambalpur (421 km), Sonepur at ~521 km, where the Tel River joins from the right bank, Boudh at ~563 km, and Banki at ~724 km. The Ib River joins the Mahanadi from the left bank at approximately 419 km (Hirakud outflow zone), and the Ong River joins from the right bank at ~505 km. This sub-basin drains an area of 20,525 sq km predominantly in the northern and central districts of Odisha.

2.2.2.2 Channel Characteristics

Below Hirakud Dam, the Mahanadi's channel is dominated by the regulated flow regime. The channel widens from approximately 300 m near Sambalpur to over 1 km in the sandy braided reaches downstream. The middle reach is characterised by large sand bars and mid-Channel Islands that are exposed during the dry season and submerged during the monsoon. The substrate is predominantly medium to coarse sand with occasional gravel deposits in the upper portion. The river's natural meandering tendency has been constrained by embankments in many agricultural areas. The gradient in this reach is approximately 0.3–0.5 m/km. Near Bodh and Sonepur, the river exhibits broad floodplain sections that are seasonally

inundated, forming productive wetland habitats. The Naraj Barrage near Cuttack marks the transition to the lower delta reach.

2.2.2.3 Tributaries

The Middle Mahanadi sub-basin receives 207 named rivers. Major tributaries include the Ib River (left bank, ~274 km, near Hirakud outflow), Ong River (right bank, ~219 km, at Sonepur), Tel River (right bank, ~311 km, at Sonepur), the Salki River (left bank), Bagh River, Jira River (right bank), and Harihar Jor. The Salki River (Salki Nadi B, ~139 km) is a significant left-bank tributary draining the Kandhamal highlands of Odisha. The Bagh Nadi (~120 km) drains the eastern slopes of the Eastern Ghats.

2.2.2.4 Biogeography

The middle sub-basin catchment in Odisha includes portions of the Eastern Ghats biodiversity hotspot on the right bank and transitional plateau forests on the left bank. This region is known for the Satkosia Tiger Reserve, through which the Mahanadi flows in a spectacular 22-km gorge, one of the deepest river gorges in Odisha. The Satkosia gorge is a critical habitat for gharial (Gavialis gangeticus), one of the last remaining viable populations of this critically endangered species in India. Mugger crocodile, smooth-coated otter, and Indian skimmer are among the other flagship species of this reach. The fish fauna of the middle Mahanadi is diverse, with high-value mahseer (Tor tor), large-bodied catfishes (Bagarius bagarius), and numerous carps. The Hirakud Reservoir itself supports important inland fisheries employing thousands of fisher families.

2.2.2.5 River Connectivity, Fragmentation and Dam Density

The Hirakud Dam is the dominant connectivity barrier in the middle sub-basin. Below Hirakud, the Naraj Barrage (at 756 km) presents another major barrier. Intermediate structures include weirs and check dams on tributaries like Ong, Jira, and Burtanga. The Hirakud Reservoir occupies approximately 746 sq km of surface area, completely blocking fish migration between the upper and middle Mahanadi. Attempts to install fish passes at Hirakud have been unsuccessful due to the height (60.96 m) and design of the dam. The overall connectivity index for the middle Mahanadi is low, reflecting severe fragmentation by multiple large-scale structures.

2.2.2.6 Riverspace

The riverspace in the Satkosia gorge section is among the best-preserved in the entire Mahanadi Basin, protected by the Satkosia Tiger Reserve designation. However, in the agricultural plains of Sambalpur, Bargarh, Baudh, and Subarnapur districts, the riverspace has

been significantly compressed. The Hirakud Reservoir has inundated approximately 266 villages and extensive tracts of riparian forest, permanently transforming the pre-dam riverscape. Downstream of Hirakud, sand extraction is a major pressure in many river sections, degrading riverbed structure and reducing the available habitat complexity.

2.2.2.7 River Zonation

The middle sub-basin primarily represents Zone III (Lower Rhithron / Upper Plains Rivers) and Zone IV (Potamal / Major Plains Rivers). The Satkosia gorge section, with faster flow over rocky substrates and specialised biota including gharial and hill-stream fishes, exhibits some Zone II characteristics despite its relatively low elevation. The extensive sand-bed sections from Sambalpur to Naraj are typical Zone IV potamal environments with characteristic planktonic algae, soft-sediment invertebrates, and large carp-catfish fish communities.

2.2.3 Lower Mahanadi Main Sub-Basin

Table 4 Attributes of Lower Mahanadi Main Sub-Basin

Parameter	Value
UID Code	08CG377R44727301
Main River Length (km)	121.91
Basin Area (sq km)	11,542.08
Number of Named Rivers	127
Length of Named Rivers (km)	2,945.74
Major Rivers	Gobari, Marka, Bhargabi, Hansua, Kushabhadra, Devi, Chitrotpala, Ratanchira, Daya

2.2.3.1 Origin and Course

The Lower Mahanadi Main Sub-Basin spans from the Naraj Barrage (approximately 756 km from the origin) to the river's discharge into the Bay of Bengal at Paradeep (approximately 866 km). This 121.91 km reach encompasses the entire Mahanadi delta, one of the most extensive and ecologically significant deltas on India's east coast. The sub-basin covers an area of 11,542 sq km, including the distributary network, Chilika Lake, and coastal wetlands. The city of Cuttack lies at the apex of the delta at approximately 776 km. The distributary system bifurcates at Naraj Barrage into the main Mahanadi channel and the Kathajhori River, which

flows through Cuttack. Further downstream, major bifurcations give rise to the Chitrotpala, Paika, Devi, Gobari, Kushabhadra, Bhargabi, and Daya distributaries.

2.2.3.2 Channel Characteristics

The Lower Mahanadi sub-basin has the character of a low-gradient alluvial delta with very gentle slopes (< 0.1 m/km) and fine-textured silt and clay substrates. Channel widths in the main distributaries range from 100–400 m, while secondary and tertiary channels may be 20–100 m wide. The delta surface is flat to slightly undulating with a complex network of inter-distributary areas including productive rice-growing lowlands, seasonally flooded marshes, and tidal creeks. The major distributaries are navigable and serve as important transportation routes. Tidal influence extends approximately 50–80 km upstream in some channels during the dry season. The substrate in the lower delta is dominated by silts and clays with organic-rich deposits supporting abundant benthic invertebrate communities.

2.2.3.3 Tributaries

The lower sub-basin has 127 named rivers, mostly distributary channels rather than tributaries in the traditional sense. Major distributaries include the Kathajhori River (34 km), Birupa Nadi (23 km, reaches Chilika Lake), Chitrotpala Nadi (66 km), Paika River (49 km), Kushabhadra River, Devi River, Gobari Nadi (~117 km), Bhargabi River, Hansua Nadi, and Daya River (which flows through Bhubaneswar and drains into Chilika). The Chilika Lake, connected to the delta system via the Daya and other channels, is itself a vast waterbody of 1,100 sq km.

2.2.3.4 Biogeography

The Lower Mahanadi delta is a globally recognised biodiversity hotspot. Chilika Lake is designated as a Ramsar Wetland of International Importance and hosts over 230 bird species, including large flocks of migratory waterfowl (flamingos, bar-headed geese, spotted billed pelicans, etc.). The lake and delta support the only breeding population of Irrawaddy dolphins (Orcaella brevirostris) in India. The delta's mangrove forests, while much reduced from historic extent, still harbour significant biodiversity, including mudskippers, fiddler crabs, and various estuarine fish. The aquatic biodiversity of the lower sub-basin includes hilsa (Tenualosa ilisha), the most commercially important fish, estuarine catfishes, mullets, and a diverse prawn fauna. The lower Mahanadi also supports fishing communities numbering in the tens of thousands, and fish production from Chilika Lake alone exceeds 10,000 tonnes annually.

2.2.3.5 River Connectivity, Fragmentation and Dam Density

The Naraj Barrage is the primary connectivity barrier at the entry to the lower sub-basin. Although fish can pass during high-flood periods, migration is severely curtailed during the dry season. Within the delta, the extensive canal network and road embankments have fragmented lateral connectivity between channels. The Chilika Lagoon's connection to the sea through a tidal inlet at Satapada is periodically managed through artificial interventions. Sand bar formation at the sea mouth has historically led to the opening of a new mouth near Satapada, altering the hydrology of the entire delta system. The overall connectivity in the lower sub-basin is complex: while longitudinal connectivity along individual distributaries exists, connectivity between the Mahanadi main channel and Chilika Lake has been reduced by anthropogenic modifications.

2.2.3.6 Riverspace

The riverspace of the Lower Mahanadi delta is under severe pressure from multiple directions: urbanisation around Cuttack (population ~600,000) and Bhubaneswar (Odisha's capital city), extensive rice cultivation in the inter-distributary lowlands, prawn aquaculture in coastal areas, sand and soil extraction, and industrial development along the coast near Paradeep. The mangrove ecosystem, which forms a critical component of the delta's riverspace, has been reduced to fragmented patches. Despite these pressures, the Bhitarkanika National Park and Mangrove Wildlife Sanctuary at the Brahmani-Baitarni delta (adjacent to the eastern Mahanadi delta) represents a conservation success in the broader region. Within the Mahanadi delta proper, riverspace conservation is critically needed along the Devi River and the eastern distributary channels.

2.2.3.7 River Zonation

The Lower Mahanadi sub-basin represents Zone IV (Potamal) in its upper section near Cuttack, transitioning to Zone V (Delta / Estuarine) in the middle and lower sections. The estuarine zone is characterised by the classic salinity gradient from freshwater to brackish to marine conditions over relatively short distances. Biological communities shift from freshwater cyprinids in the upper delta to euryhaline species (mullets, gobies, prawns) in the middle delta and fully estuarine and marine species in the tidal creeks and Chilika Lake. The tidal influence creates unique ecological conditions for biological productivity, making the lower sub-basin the most productive part of the Mahanadi system in terms of fisheries yield per unit area.

2.2.4 Major Tributary Sub-Basins

2.2.4.1 Seonath Sub-Basin

Table 5 Attributes of Seonath Sub-Basin

Parameter	Value
UID Code	08MH475R53885901
Main River Length (km)	385.77
Basin Area (sq km)	30949.68
Number of Named Rivers	296
Length of Named Rivers (km)	7,501.88
Major Rivers	Kharun, Maniari, Hanp, Agar, Arpa, Rahan, Liagar, Sakri, Tandula, Phonk

2.2.4.2 Origin and Course

The Seonath River is the longest tributary of the Mahanadi, originating from the Maikal Hills in Maharashtra near the Chhattisgarh border at approximately 20°33'N, 80°35'E. It initially flows in a south-easterly direction through the hilly terrain of Rajnandgaon and Kabirdham districts before entering the alluvial plains of Durg, Bemetara, and Raipur districts. The Seonath joins the Mahanadi at Shivrinarayan (approximately 287 km on the Mahanadi) from the left bank after a total journey of 385.77 km. Key landmarks along the Seonath include the Mongra Dam at ~44.5 km, Durg city at ~148 km, and Simga at ~255.6 km. The Seonath drains the largest sub-basin of any Mahanadi tributary at 30,949 sq km, encompassing parts of Maharashtra, Madhya Pradesh, and predominantly Chhattisgarh.

2.2.4.3 Channel Characteristics

The Seonath transitions from a hill-stream character in its upper reaches (Rajnandgaon-Kabirdham hills) to a broad, sandy alluvial river in the plains of Durg, Bemetara, and Raipur districts. Channel width increases from 20–40 m in the upper reaches to 200–400 m in the plains. Substrate changes from cobble-gravel to sand-silt in the lower reaches. The gradient is approximately 0.5–1.0 m/km in the upper portion and < 0.3 m/km in the lower plains. Flow in the Seonath is strongly seasonal, with high flows during June–October and very low to near-zero flows during March–May in many stretches due to the combination of low rainfall, high evapotranspiration, and excessive groundwater extraction for agriculture.

2.2.4.4 Tributaries

The Seonath sub-basin is the most hydrologically complex tributary sub-basin with 296 named rivers covering 7,501 km, the highest in the basin. Major tributaries include the Kharun River (173.64 km), Maniari River (172.88 km), Hanp River (168.07 km), Agar River (156.29 km), Arpa River (150.38 km), Rahan (147.75 km), Liagar Nadi (130 km), Sakri Nadi (113.67 km), Tandula River (106.78 km), and Phonk Nadi (104.61 km). The Kharun River flows through Raipur city (the capital of Chhattisgarh) and is significantly polluted by urban runoff. The Arpa River flows through Bilaspur. The Tandula River has a major irrigation reservoir (Tandula Reservoir) serving the Durg-Rajnandgaon irrigation area.

2.2.4.5 Biogeography

The Seonath sub-basin spans a significant biogeographic gradient from the Maikal Hills part of the Central Highlands to the agricultural plains of central Chhattisgarh. The headwaters in Rajnandgaon and Kabirdham districts originate within forested landscapes supporting diverse wildlife. The Achanakmar-Amarkantak Biosphere Reserve, a UNESCO-recognised biosphere, is adjacent to the headwaters of several Seonath sub-tributaries. The plains section of the Seonath, however, flows through one of the most intensively cultivated landscapes in central India, where the river provides water for two crop seasons. Fish diversity in the Seonath includes approximately 60–70 species; notable species include Tor tor (mahseer), various Labeo species, catfishes, and small cyprinids. The river is a critical habitat for the Indian softshell turtle and mugger crocodile in some reaches.

2.2.4.6 River Connectivity, Fragmentation and Dam Density

The Seonath sub-basin has a high dam density with multiple structures, including the Mongra Barrage (Rajnandgaon), the Mudhiparha Reservoir, the Tandula Reservoir (Durg), Kharkhara Dam (on Kharkhara tributary), and numerous smaller check dams. The proliferation of check dams for groundwater recharge and minor irrigation has significantly fragmented the smaller tributaries. In the plains section, large-scale groundwater extraction for rice cultivation has contributed to flow depletion in many streams. The Seonath itself becomes near-dry in some reaches between February and May, compromising the perennial status that is fundamental to maintaining aquatic biodiversity.

2.2.4.7 Riverspace

The riverspace of the Seonath is severely compromised in the plains section. Agricultural fields extend to the riverbank in most stretches from Durg to the Mahanadi confluence. The riparian buffer strips have been cleared in most urban reaches, notably along the Kharun through

Raipur and along the Seonath through Durg. Sand mining is reported as a major pressure throughout the Seonath plains, altering channel morphology and reducing habitat diversity. The better-preserved riverspace sections are restricted to the headwater forests in Rajnandgaon and Kabirdham districts.

2.2.4.8 River Zonation

The Seonath sub-basin spans Zones I to III of the river zonation framework. Zone I (above 400 m) exists in the Maikal Hills headwaters, particularly on the Maharashtra-Chhattisgarh border. Zone II (200–400 m) occupies the Rajnandgaon foothills. Zone III (100–200 m) characterises most of the Seonath plains reach, while the lowermost section near the Mahanadi confluence transitions towards Zone IV character. The Maniari, Hanp, and Agar tributaries, originating from forested hills, exhibit better-preserved zonation characteristics than the plains-dominated Kharun and lower Seonath.

2.2.5 Tel Sub-Basin

Table 6 Attributes of Tel Sub-Basin

Parameter	Value
UID Code	08OD366R42731401
Main River Length (km)	310.94
Basin Area (sq km)	22,890.25
Number of Named Rivers	274
Length of Named Rivers (km)	5,029.48
Major Rivers	Sukhtel, Raul, Kharag, Lant, Udanti, Utai, Ret, Hatti, Sunda

2.2.5.1 Origin and Course

The Tel River is the second-longest tributary of the Mahanadi and the principal drainage system of southern Odisha's undivided Kalahandi-Nuapada-Bolangir region. The Tel originates near Phurlijharan in Nabarangpur district, Odisha, at approximately 19°45'N, 82°14'E at an elevation of about 700 m amsl. It flows in a generally north-easterly direction, passing through Dharamgarh (~105 km), Kesinga (~179 km), and joining the Mahanadi at Sonepur from the right bank after a total length of 310.94 km. The Tel drains a vast basin of 22,890 sq

km encompassing parts of Odisha and Chhattisgarh, the largest tributary sub-basin in Odisha. Its catchment covers some of the most ecologically significant landscapes in the Eastern Ghats biodiversity hotspot.

2.2.5.2 Channel Characteristics

The Tel River is a pool-riffle-run system in its upper reaches, where it flows over the Eastern Ghats terrain with gradients of 1–3 m/km and substrates ranging from bedrock and boulders to cobble-gravel. In the middle reaches around Dharamgarh and Kesinga, the channel widens to 100–300 m with sandy-gravel substrates and a moderate gradient (~0.5 m/km). The lower reach from Kesinga to Sonepur is a broad alluvial channel with predominantly sandy substrate, channel widths of 300–600 m, and a gentle gradient (~0.2 m/km). Flow in the Tel is moderately seasonal, with some perennial reaches maintained by groundwater contributions from the Eastern Ghats aquifers. The Lower Indra Dam (also known as the Lower Suktel Dam) near Nuapada is a major water storage structure in this sub-basin.

2.2.5.3 Tributaries

The Tel sub-basin has 274 named rivers covering 5,029 km. Major tributaries include Sukhtel River (right bank, ~140 km, one of the major tributaries of the Tel in the upper basin), Raul River (right bank, ~122 km), Kharag River (~122 km), Lant Nadi (~119 km), Udanti Nadi (~118 km, which drains the Udanti Wildlife Sanctuary famous for wild buffaloes), Utai Nadi (~100 km), Ret Nadi (~92 km), Hatti River (important in Kalahandi), and Sunda River. The Udanti River is particularly significant for conservation as it flows through the Udanti-Sitanadi Tiger Reserve.

2.2.5.4 Biogeography

The Tel sub-basin lies at the transition between the Eastern Ghats biodiversity hotspot and the Deccan Plateau biogeographic zones. The upper catchment forests, including the Udanti Wildlife Sanctuary and Sitanadi Wildlife Sanctuary, support globally important populations of the Indian wild buffalo (Bubalus arnee), one of the most endangered large mammals in India, as well as tigers, leopards, elephants, and wild dogs. The riparian forests of the Tel and its major tributaries harbour unique plant communities adapted to the seasonally dry Eastern Ghats conditions. Fish diversity in the Tel sub-basin is notable, with mahseer, murrel (Channa species), catfishes, and numerous small hill-stream cyprinids documented. The river provides critical dry-season refuges (deep pools) for aquatic fauna across a landscape experiencing rapid forest loss.

2.2.5.5 River Connectivity, Fragmentation and Dam Density

The Tel sub-basin has multiple water storage and diversion structures. The Lower Indra Dam on the Utai/Indra tributary (3780 m length, 22 m height) is a major barrier. Other structures include the Muran Barrage and several smaller check dams. The Sukhtel Dam project, proposed for the Sukhtel River, represents a planned addition with significant implications for connectivity in the upper sub-basin. Despite the presence of these structures, some reaches of the Tel and its tributaries in the upper Eastern Ghats terrain retain reasonable longitudinal connectivity due to the sparsity of large infrastructure. The Udanti and Ret rivers, in particular, have relatively fewer connectivity barriers and are ecologically significant.

2.2.5.6 Riverspace

The riverspace in the Tel sub-basin is best preserved in the upper reaches within the Udanti-Sitanadi Tiger Reserve and the forested landscapes of Kalahandi, Nabarangpur, and Nuapada districts. These areas maintain extensive riparian forest cover, natural channel morphology, and undisturbed floodplain connections. The middle reaches around Dharamgarh and Kesinga have experienced agricultural encroachment and some forest clearing. The lower reach near Sonepur, in the irrigated agricultural plains of Bolangir and Subarnapur districts, has experienced significant riverspace reduction. Sand and gravel mining in the middle and lower Tel is a growing pressure affecting channel stability.

2.2.5.7 River Zonation

The Tel sub-basin spans Zones I through III of the river zonation. The upper Eastern Ghats headwaters above 500 m represent Zone I with hill-stream character and EPT-dominated invertebrates. The mid-elevation transition zone (200–500 m) represents Zone II with mixed substrate and biotic assemblages. The plains section from Kesinga to Sonepur is Zone III character with sandy substrate, carps, catfishes, and murrels dominating the fish community. The exceptional fish diversity of the Eastern Ghats tributaries of the Tel, particularly in streams draining laterite-capped plateaus with clear, well-oxygenated water, represents some of the highest-quality aquatic habitats in the entire Mahanadi Basin.

2.2.6 Ib Sub-Basin

Table 7 Attributes of Ib Sub-Basin

Parameter	Value
UID Code	08CG377R44727301
Main River Length (km)	274.49

Basin Area (sq km)	12,574.95
Number of Named Rivers	147
Length of Named Rivers (km)	2,769.65
Major Rivers	Bhedan, Maini, Dorki

2.2.6.1 Origin and Course

The Ib River originates from the Chhattisgarh-Jharkhand border region in the Jashpur district of Chhattisgarh, near the Ranchi Plateau escarpment at approximately 23°10'N, 83°44'E at an elevation of over 900 m amsl. The river flows in a broadly southward direction through Jashpur and Surguja districts of Chhattisgarh before entering the Rourkela urban agglomeration of Odisha and ultimately joining the Mahanadi at the Hirakud Reservoir zone from the left bank at approximately 419 km. The total length of the Ib is 274.49 km, draining a basin area of 12,574 sq km. Key urban centres along the Ib include Sundergarh and Jharsuguda (in Odisha) and the industrial city of Rourkela at the confluence of the Ib and Brahmani rivers.

2.2.6.2 Channel Characteristics

The Ib River exhibits a steep, rocky character in its upper reaches in the Jashpur Plateau at gradients of 3–5 m/km, flowing over granite-gneiss bedrock with extensive rapids and waterfalls. The river transitions to a more moderate gradient in Sundergarh district (~1–2 m/km) and becomes a moderately broad alluvial channel near Jharsuguda and Rourkela (gradient ~0.3–0.5 m/km, width 100–300 m). The substrate transitions from bedrock and large boulders in the upper reaches to cobble-gravel in the middle section and sandy-silt in the lower reach. The Ib River's catchment encompasses the coal-bearing Ib Valley Coalfield, one of the most productive coalfields in India, and major thermal power stations are located along the river, contributing thermal and fly-ash pollution.

2.2.6.3 Tributaries

The Ib sub-basin has 147 named rivers totalling 2,769 km. Major tributaries include the Bhedan River (~127 km), Maini River (~102 km), Dorki Nadi (~59 km), Sapal River (~36 km), and Basundhara Nadi. The Bhedan River drains the Jharsuguda-Rourkela area and is significantly impacted by coal mining activities. The Maini River originates in the Chhattisgarh-Jharkhand hills and is an important perennial tributary with relatively better

ecological status in its upper reaches. Several small tributaries originate from the Ib Valley Coalfield area and carry coal mine drainage and effluents.

2.2.6.4 Biogeography

The Ib sub-basin occupies a unique biogeographic position at the junction of the Chhattisgarh Plateau, the Jharkhand highlands, and the Odisha plateau. The upper Ib catchment in Jashpur district contains some of the finest sal forests in Chhattisgarh, with rich wildlife including elephants, gaurs, leopards, and diverse bird fauna. The Jashpur Plateau is notable for its diverse tribal communities and forest-based livelihoods closely linked to the Ib River system. Fish diversity in the upper Ib is significant, with hill-stream species including Garra species, Balitorid loaches, and mahseer. The lower Ib, particularly near Rourkela, Jharsuguda, and the coal mining areas, experiences severe water quality degradation from industrial effluents, coal mine drainage (AMD), fly-ash leachate, and urban sewage. The biological community in affected reaches is severely impoverished.

2.2.6.5 River Connectivity, Fragmentation and Dam Density

The Ib sub-basin has moderate dam density. The primary structure is the Rengali Dam on the Brahmani River (which the Ib joins before entering the Mahanadi), affecting lower Ib hydrology. Within the Ib catchment itself, there are smaller structures. However, the dominant connectivity and habitat quality issues in the lower Ib are associated with industrial pollution rather than dam fragmentation. Coal mine drainage creates severe chemical connectivity barriers in some reaches near the Ib Valley Coalfield, where metal-rich acidic water effectively excludes sensitive aquatic species. The upper Ib in Jashpur and Surguja retains reasonable longitudinal connectivity, given the absence of major dams.

2.2.6.6 Riverspace

The riverspace of the upper Ib in Jashpur district is relatively well-preserved within forested catchment areas. The Barnawapara Wildlife Sanctuary and adjacent forest reserves provide some riverspace protection in the headwater region. However, the middle and lower Ib in the coal mining and industrial zone (Korba-Jharsuguda-Rourkela triangle) has experienced dramatic riverspace degradation: overburden dumping from open-cast mines has encroached directly on river banks; fly-ash disposal sites are located in the floodplain; and industrial land use has replaced riparian forest in many reaches. These represent some of the most severely degraded riverspace conditions in the entire Mahanadi Basin.

2.2.6.7 River Zonation

The Ib sub-basin spans Zones I to IV. Zone I (above 700–900 m) represents the rocky, fast-flowing headwaters of the Jashpur Plateau with hill-stream biota. Zone II (400–700 m) covers the mid-elevation transition in Sundergarh district. Zone III (100–400 m) represents the moderately sloped middle reaches. Zone IV is represented by the lower Ib near Jharsuguda and the confluence with the Brahmani. The biological integrity of zones in the lower Ib is severely compromised by pollution, placing this sub-basin among those requiring urgent remediation for ecological restoration.

2.2.7 Hasdeo Sub-Basin

Table 8 Attributes of Hasdeo Sub-Basin

Parameter	Value
UID Code	08CG384F32330205
Main River Length (km)	337.06
Basin Area (sq km)	9,918.09
Number of Named Rivers	201
Length of Named Rivers (km)	3,135.01
Major Rivers	Gej, Bamni, Tan, Atem, Aharan, Jhink

2.2.7.1 Origin and Course

The Hasdeo River originates from the dense forests of the Chhattisgarh hills in the Koriya district at approximately 23°28'N, 82°35'E, at an elevation exceeding 1,000 m amsl in the Son-Hasdeo divide area. It flows southward through Koriya, Manendragarh, Surajpur, and Korba districts before joining the Mahanadi near Champa in Janjgir-Champa district from the left bank, at approximately 305 km from the Mahanadi's origin. The total length is 337.06 km. The Minimata (Hasdeo) Bango Dam near Katghora (22.61°N, 82.60°E) is the major structure, creating the Hasdeo Bango Reservoir, the highest dam (87 m) in the Mahanadi Basin.

2.2.7.2 Channel Characteristics

The Hasdeo exhibits a pronounced highland character in its upper reaches through Koriya and Surajpur districts, with fast-flowing rocky channels over Gondwana sandstone and granite-gneiss terrain, gradients of 2–4 m/km, and cobble-boulder substrates. Below the Hasdeo Bango Dam, the river transitions to a regulated flow regime with significantly altered temperature, sediment, and flow characteristics. The post-dam reach through the Korba industrial area (a major coal and thermal power hub) flows through heavily impacted terrain.

Further downstream in Janjgir-Champa district, the Hasdeo becomes a broader alluvial channel with sandy substrate. The reservoir formed by the Bango Dam extends approximately 118 km upstream, inundating a vast forested valley.

2.2.7.3 Tributaries

The Hasdeo sub-basin contains 201 named rivers covering 3,135 km. Major tributaries include the Gej Nala/Nadi (~105 km), Bamni Nadi (~78 km), Tan Nadi (~75 km), Aharan Nadi (~52 km), Atem Nadi (originating in Surajpur), and Jhink Nala. The Gej River, with its 105 km length, is a significant perennial tributary draining the southern Korba forests. The Hasdeo sub-basin's upper tributaries are critical for the ecological water budget of the Bango Reservoir, which is the primary source of drinking and industrial water for Korba.

2.2.7.4 Biogeography

The Hasdeo sub-basin encompasses the ecologically extraordinary Hasdeo Arand forests of Koriya, Korba, and Surajpur districts, a contiguous block of approximately 1,70,000 ha of moist deciduous sal forest recognised as one of the most biodiverse forest landscapes in central India. These forests support elephants (a critical elephant corridor), tigers, leopards, wild dogs, four-horned antelope, and an exceptional diversity of birds. The Hasdeo Arand forests are currently under significant threat from large-scale coal mining, with several blocks having been allocated to coal companies. The aquatic biodiversity of the upper Hasdeo includes endemic hill-stream species, mahseer, and diverse catfishes adapted to the clear, cold, fast-flowing streams. However, the lower Hasdeo through the Korba industrial belt experiences severe water quality degradation from thermal power plant effluents, coal washery discharges, and urban wastewater.

2.2.7.5 River Connectivity, Fragmentation and Dam Density

The Hasdeo Bango Dam is the dominant connectivity barrier, creating an impoundment that completely blocks upstream-downstream migration. Below the dam, the Hasdeo Barrage (at Janjgir-Champa, 22.07°N, 82.63°E; height 17.15 m, length 283.76 m) constitutes another major barrier. Industrial effluents from Korba's thermal power plants, coal washeries, and aluminium plants create chemical barriers in some reaches, effectively preventing fish movement even in the absence of physical structures. The dam density in the upper Hasdeo is low, and the headwater streams in Koriya and Surajpur retain some connectivity.

2.2.7.6 Riverspace

The upper Hasdeo riverspace is partially protected within the Hasdeo Arand forests, which, despite mining pressure, maintain significant forest cover over the catchment. The Bango

Reservoir has inundated approximately 14,000 ha of forest area, representing a major riverspace loss. In the Korba industrial zone, the riverspace has been dramatically reduced by industrial establishments, thermal power plant ash ponds, and urban development. The lower Hasdeo through Janjgir-Champa plains has lost most of its riparian vegetation to agriculture. The headwater streams in Koriya and Surajpur districts, particularly those within Guru Ghasidas National Park, retain the most intact riverspace in this sub-basin.

2.2.7.7 River Zonation

The Hasdeo sub-basin spans Zones I to IV. The upper Koriya headwaters above 700–1000 m (Zone I) support pristine hill-stream communities in some reaches. The mid-elevation forests of Surajpur and northern Korba represent Zone II. The Bango Reservoir has disrupted the natural zonation continuum in the middle portion. The post-dam Korba industrial reach is severely degraded ecologically despite being in a Zone III position altitudinally. The lower Hasdeo in Janjgir-Champa is a Zone IV system. The Hasdeo is unique in the basin for exhibiting the most extreme contrast between pristine upper-basin biology and severely degraded middle-lower-basin conditions.

2.2.8 Mand Sub-Basin

Table 9 Attributes of Mand Sub-Basin

Parameter	Value
UID Code	08CG377R44727301
Main River Length (km)	265.40
Basin Area (sq km)	5,328.52
Number of Named Rivers	87
Length of Named Rivers (km)	1,473.25
Major Rivers	Kurket, Koerga

2.2.8.1 Origin and Course

The Mand River originates in the forested highlands of the Jashpur district in Chhattisgarh at approximately 22°58'N, 83°43'E at an elevation of approximately 950–1100 m amsl near the Chhattisgarh-Jharkhand border. It flows in a broadly southerly direction through Jashpur, Korba, Raigarh, and Sakti districts of Chhattisgarh, eventually joining the Mahanadi at

approximately 359 km from the origin (near Sarangarh). The total river length is 265.40 km, draining a compact basin of 5,328 sq km. The Mand is notable for passing through the eastern Chhattisgarh highlands and receiving tributaries from both the Chhattisgarh plateau and the lower Gondwana hills.

2.2.8.2 Channel Characteristics

The Mand River has a notably steep gradient in its upper reaches (3–5 m/km) where it flows through the Jashpur highland forests over crystalline basement rocks. The Gersa Dam site near the upper Mand (at 2.2 km from the origin) is a small hydropower structure. Through the Korba district, the Mand becomes a moderate-gradient river (1–2 m/km) with mixed cobble-gravel-sand substrate. The middle and lower reaches in Raigarh and Sakti districts show a broader alluvial character with sandy substrate and moderate gradient (~0.3–0.5 m/km). Channel width increases from 15–30 m in the upper reaches to 100–200 m in the lower alluvial sections. The Mand flows through the Dharamjaigarh forest division, an area with significant coal reserves and some mining activity.

2.2.8.3 Tributaries

The Mand sub-basin has 87 named rivers covering 1,473 km. Major tributaries include the Kurket River/Nadi (~88 km, a significant right-bank tributary in the middle Mand) and Koerga Nadi (~52 km). Other notable streams include Sangul Nadi, Sariya Nala, Chindai Nala, and Pawasi Nala. The sub-basin is relatively compact with a dendritic drainage pattern in the upper Jashpur hills transitioning to a more angular pattern in the coal-bearing lower portions.

2.2.8.4 Biogeography

The Mand sub-basin's upper catchment in Jashpur district is one of the ecologically richest parts of Chhattisgarh. The forests here are contiguous with the Jharkhand highlands and form part of the Central Indian Highlands biodiversity hotspot. Elephants, gaurs, leopards, and diverse bird species use the Mand riparian corridor as part of their range. The river supports populations of hill-stream fish species in the Jashpur headwaters, transitioning to a more diverse plains fish community in the lower reaches. The coal-bearing middle portion of the Mand catchment in Korba district is under pressure from mining activities, though the extent of ecological impact is less severe than that of the Ib and Hasdeo.

2.2.8.5 River Connectivity, Fragmentation and Dam Density

The Mand sub-basin has relatively low dam density compared to other Mahanadi tributaries. The Gersa Dam in the upper Mand is a small structure. There are no large reservoirs comparable to those on the Hasdeo or Seonath within this sub-basin, making the Mand one of

the more hydrologically intact tributary systems. However, coal mining activities and associated infrastructure in the middle Mand catchment pose emerging threats to connectivity through chemical contamination and habitat modification. The absence of major dams means that the Mand retains reasonable longitudinal connectivity compared to most other Mahanadi tributaries.

2.2.8.6 Riverspace

The riverspace of the upper Mand in the Jashpur forests is in relatively good condition, with forest cover maintained over much of the catchment. The Korba-area middle reaches are subject to mining-related land use changes. The lower Mand in Raigarh and Sakti districts flows through agricultural plains where riparian vegetation has been cleared and riverspace reduced. Overall, the Mand sub-basin has intermediate riverspace integrity better than the Seonath plains and significantly better than the Ib, reflecting its position in a moderately forested landscape with lower agricultural intensity.

2.2.8.7 River Zonation

The Mand sub-basin spans Zones I to III. The upper Jashpur highlands (Zone I, above 700 m) support hill-stream communities. The mid-elevation transition zone in southern Jashpur and Korba (Zone II, 300–700 m) hosts mixed assemblages. The lower Mand in Raigarh-Sakti districts (Zone III, 100–300 m) has sandy-substrate fish communities with carps and catfish dominant. The biological integrity of the Mand decreases progressively from upper to lower reaches, a pattern influenced primarily by mining activities in the middle basin and agricultural intensification in the lower basin.

2.2.9 Ong Sub-Basin

Table 10 Attributes of Ong Sub-Basin

Parameter	Value
UID Code	08OD345F31450102
Main River Length (km)	219.40
Basin Area (sq km)	5,145.60
Number of Named Rivers	45
Length of Named Rivers (km)	1,015.70
Major Rivers	Ghensnali Jhor, Utali Jhor

2.2.9.1 Origin and Course

The Ong River originates from the Bargarh Plateau in the Bargarh district of Odisha, at approximately 21°30'N, 83°00'E at an elevation of approximately 500–600 m amsl. The river flows predominantly eastward through Bargarh, Subarnapur, and Balangir districts of Odisha before joining the Mahanadi near Sonepur from the right bank at approximately 505 km from the Mahanadi's origin. The Ong's total length is 219.40 km, draining a basin of 5,145 sq km. The river passes through Paikamal (~197 km) and Padmapur (~162 km) along its course.

2.2.9.2 Channel Characteristics

The Ong River is a moderately graded stream in the upper reaches near Bargarh, transitioning to a low-gradient plains river in its lower course. In the upper reaches, the channel has cobble-gravel substrates and gradients of approximately 1–2 m/km. The middle and lower reaches are characterised by sandy alluvial channels with widths of 50–150 m and gradients of 0.2–0.4 m/km. Flow in the Ong is strongly seasonal, with the river becoming very shallow or near-dry in the pre-monsoon period in many stretches. The lower Ong near Sonepur flows through rice-growing plains and is subject to water diversion for irrigation.

2.2.9.3 Tributaries

The Ong sub-basin has the smallest number of named rivers (45) among the major Mahanadi tributary sub-basins, with a total named river length of 1,015 km. Major tributaries include Ghensnali Jhor (~43 km), Utali Jhor (~42 km), Kulari Jhor, Surangi Nala (~49 km), and Chirar Nala. The relatively low number of named rivers reflects the sub-basin's compact drainage area and dominantly agricultural landscape in the lower portion.

2.2.9.4 Biogeography

The Ong sub-basin catchment includes some forested areas in the Bargarh plateau section (upper Ong) that provide ecological services, including water yield and stream habitat maintenance. The lower Ong flows through the rice-growing plains of Subarnapur and Bolangir districts, which are characterised by intensive agriculture and seasonal waterlogging. Fish diversity in the Ong includes murrels (Channa species), carps, catfishes, and small cyprinids typical of Odisha plains rivers. The river supports artisanal inland fisheries in its lower reaches. The ecological condition of the Ong is intermediate, better than the Ib but more impacted than the Tel upper reaches.

2.2.9.5 River Connectivity, Fragmentation and Dam Density

The Ong sub-basin has moderate fragmentation. The primary barriers are minor check dams and barrages in the upper-middle reaches for irrigation purposes. There are no major dams

within the Ong sub-basin comparable to those on the Hasdeo, Tel, or Seonath. However, the numerous minor irrigation structures collectively fragment the river during the dry season, affecting fish migration between seasonal habitats. The Ong's longitudinal connectivity is moderate in the monsoon period but highly compromised in the dry season due to flow depletion from diversion and groundwater extraction.

2.2.9.6 Riverspace

The riverspace of the Ong sub-basin is moderately preserved in the upper Bargarh plateau section, where some forest cover is maintained. In the middle and lower reaches through the Subarnapur and Bolangir plains, the riverspace has been substantially reduced by agricultural encroachment and settlement expansion. The Ong does not pass through any protected area, which limits institutional mechanisms for riverspace conservation. Overall, the Ong riverspace is under moderate pressure and requires conservation attention to prevent further degradation.

2.2.9.7 River Zonation

The Ong sub-basin spans Zones II to IV. The upper Bargarh plateau section (Zone II, 300–500 m) has moderately fast-flowing streams with mixed biota. The middle reaches (Zone III, 150–300 m) host sandy-substrate fish communities. The lower reach near Sonepur (Zone IV, ~100 m) has characteristics of the major plains river zone. The biological integrity across all zones is moderate to low, limited by flow seasonality, agricultural runoff, and minor irrigation-related fragmentation.

2.2.10 Jonk Sub-Basin

Table 11 Attributes of Jonk Sub-Basin

Parameter	Value
UID Code	08OD368F31550106
Main River Length (km)	192.94
Basin Area (sq km)	3,455.47
Number of Named Rivers	55
Length of Named Rivers (km)	813.91
Major Rivers	Karmel, Kantra

2.2.10.1 Origin and Course

The Jonk River originates from the forested Nuapada-Kalahandi uplands in Odisha (and some sources in adjacent Chhattisgarh) at approximately 20°27'N, 82°25'E at an elevation of approximately 700–800 m amsl. The river flows in a broadly northward and then northwestward direction through Nuapada, Bolangir, and Bargarh districts before joining the Mahanadi from the right bank at approximately 286 km from the origin (near Bargarh in Chhattisgarh). After a journey of 192.94 km, the Jonk drains a basin of 3,455 sq km. Key reference points along the Jonk include the Patora Dam (~44 km), Khariar Road (~70 km), and Sankra (~126 km).

2.2.10.2 Channel Characteristics

The Jonk River has a mixed character: rocky and moderately fast-flowing in its upper Eastern Ghats headwaters, transitioning to a meandering sandy channel in the plains. In the upper reaches (above 300 m), the river has cobble-gravel substrates and gradients of 1.5–3 m/km. Below the Patora Dam, the channel becomes sandier with a lower gradient (~0.4–0.8 m/km). Channel widths range from 20–40 m in the upper reaches to 80–150 m in the lower alluvial section. The Jonk is known for its relatively better ecological condition compared to many other Mahanadi tributaries, partly owing to its forested upper catchment and lower agricultural intensity in the middle reaches.

2.2.10.3 Tributaries

The Jonk sub-basin contains 55 named rivers covering 813 km. Major tributaries include Karmel Nala (~43 km, a significant right-bank tributary in the middle Jonk), Kantra Nala (~32 km), and various smaller streams. The dendritic drainage pattern in the upper Jonk reflects the rocky Eastern Ghats terrain, while the lower catchment shows more parallel drainage on softer alluvium. The Jonk's tributaries from the Nuapada-Kalahandi highlands bring clear, relatively unpolluted water to the main channel.

2.2.10.4 Biogeography

The Jonk sub-basin occupies the northern Eastern Ghats biogeographic zone and is notable for its relatively intact forest catchment in the upper reaches. The forests of Nuapada and Kalahandi districts in the upper Jonk catchment are part of the broader Eastern Ghats forest corridor. These forests support leopards, deer (sambar, spotted deer), sloth bears, and diverse reptiles and amphibians. The aquatic fauna of the Jonk is relatively well-preserved in the upper reaches, with reported populations of mahseer (Tor species), hill-stream loaches (Balitoridae), and several endemic small cyprinids of the Eastern Ghats. The river is also

documented as a habitat for the Indian softshell turtle and mugger crocodile in appropriate reaches. The Jonk is regarded as one of the ecologically higher-value tributaries of the middle Mahanadi.

2.2.10.5 River Connectivity, Fragmentation and Dam Density

The Jonk sub-basin has low dam density. The Patora Dam (a small structure at 44 km) is the principal water storage structure. There are a few major dams in the Jonk sub-basin, making it one of the less fragmented tributary systems in the Mahanadi Basin. This low fragmentation contributes significantly to the relatively better biological integrity of the river. The absence of large impoundments allows reasonably continuous fish migration between habitats and maintains the natural seasonal hydrograph with regular dry-season base flows supported by forest-derived groundwater recharge.

2.2.10.6 Riverspace

The riverspace of the Jonk sub-basin is in relatively good condition, particularly in the upper and middle reaches, where forest cover provides natural riparian buffering. The upper Jonk in Nuapada-Kalahandi forests retains floodplain connectivity and natural channel morphology. The lower Jonk near Bargarh experiences increased agricultural pressure on the riverspace. Overall, the Jonk sub-basin has one of the better riverspace integrity indices among the eastern Mahanadi tributaries, owing to its forested catchment and relatively lower agricultural development intensity compared to the Seonath or lower Tel.

2.2.10.7 River Zonation

The Jonk sub-basin spans Zones I to III. The upper Eastern Ghats headwaters (Zone I, above 500 m) support hill-stream fish communities, including loaches and small cyprinids. The mid-elevation forested section (Zone II, 200–500 m) has mixed assemblages with increasing diversity. The lower alluvial plains section (Zone III, 100–200 m) hosts sandy-substrate fish communities with carps, catfishes, and murrels. The Jonk is notable for having a relatively continuous zonation gradient less disrupted by dams compared to other sub-basins, making it particularly valuable as a reference system for understanding natural biological zonation in this part of the Mahanadi Basin.

2.2.11 Pairi Sub-Basin

Table 12 Attributes of Pairi Sub Basin

Parameter	Value

UID Code	08CG645R44539901
Main River Length (km)	128.69
Basin Area (sq km)	3,242.60
Number of Named Rivers	70
Length of Named Rivers (km)	949.07
Major Rivers	Sondur, Lilanj, Kajal, Ninar

2.2.11.1 Origin and Course

The Pairi River is a right-bank tributary of the Mahanadi, originating from the Gariyaband uplands in Chhattisgarh at approximately 20°15'N, 82°22'E at an elevation of approximately 600–700 m amsl. The Pairi flows in a broadly northward and northwestward direction through Dhamtari and Gariyaband districts before joining the Mahanadi at Rajim (approximately 164 km from the Mahanadi origin, the sacred Triveni Sangam of the Mahanadi, Seonath, and Pairi rivers). The Pairi's total length is 128.69 km, making it a compact but ecologically significant sub-basin of 3,242 sq km. Key landmarks include the Sikasar Dam (~40 km from the origin) and Gariyaband/Kochwai (~79 km).

2.2.11.2 Channel Characteristics

The Pairi River has a rocky, fast-flowing character in its upper reaches through the Gariyaband forests, with gradients of 2–4 m/km and cobble-boulder substrates. Below the Sikasar Dam (Sondur tributary), the mainstream and its tributaries show a transitional character. The middle reaches through Gariyaband district have mixed cobble-sand substrates and moderate gradients (~0.8–1.5 m/km). The lower reach from Gariyaband to Rajim is a broader alluvial channel with predominantly sandy substrate and a gentle gradient (~0.3 m/km). Channel width increases from 15–30 m in the upper reaches to 80–120 m near Rajim.

2.2.11.3 Tributaries

The Pairi sub-basin has 70 named rivers covering 949 km. The most significant tributary is the Sondur River (Sondur Nadi, approximately 83–98 km), which has its own Sondur Dam (3177 m length, 24.26 m height, in Dhamtari district). Other notable tributaries include Lilanj Nadi, Kajal Nadi, and Ninar Nadi. The Sondur sub-tributary drains the forested hills of the Udanti buffer zone. Several small streams originate from the Udanti Wildlife Sanctuary forest blocks and join the Pairi.

2.2.11.4 Biogeography

The Pairi sub-basin is situated within one of the ecologically richest landscapes of Chhattisgarh. The Gariyaband district, through which much of the Pairi flows, contains protected forest areas adjacent to the Udanti-Sitanadi Tiger Reserve. The river basin supports elephant corridors, tiger populations (though at low densities), leopards, wild boars, and diverse herpetofauna. The aquatic fauna of the Pairi is considered ecologically significant. The river is one of the better-documented habitats for golden mahseer (Tor tor) in Chhattisgarh, and also supports mugger crocodile, Indian softshell turtle, and Indian skimmer. The Rajim Triveni Sangam, where the Pairi joins the Mahanadi, is a sacred site of major cultural importance and hosts significant seasonal fish concentrations during the Rajim Mela.

2.2.11.5 River Connectivity, Fragmentation and Dam Density

The Pairi sub-basin has moderate fragmentation. The Sondur Dam (on the Sondur tributary) is the primary major structure. The Sikasar Dam is a smaller structure. These dams, while limiting connectivity in the upper sub-basin, have a more localised impact compared to the giant dams on the Hasdeo or Hirakud on the main Mahanadi. The Pairi main channel itself has relatively few barriers in its middle reaches through the Gariyaband forests, allowing seasonal fish migration. The connectivity status of the Pairi is intermediate, better than heavily dammed systems, but with some limitations from the Sondur Dam and water diversion structures.

2.2.11.6 Riverspace

The Pairi sub-basin riverspace is in notably good condition in the Gariyaband forest area, which provides continuous riparian forest cover along the middle Pairi and several tributaries. The Udanti-Sitanadi Tiger Reserve forest blocks (though outside the Pairi basin boundary proper) provide additional landscape context for the upper basin. The Gariyaband-Pairi forest corridor is among the better-preserved riverspace examples in the Mahanadi Basin. The lower Pairi near Rajim in Raipur district has experienced some degradation from agricultural encroachment and tourism-related activities at the Rajim pilgrimage site. Sand mining along the lower Pairi is an emerging concern.

2.2.11.7 River Zonation

The Pairi sub-basin spans Zones I to III. The upper forested headwaters above 400 m in Gariyaband (Zone I/II) support diverse hill-stream biota, including loaches, Garra species, and fast-water cyprinids. The middle Pairi through the Gariyaband forests (Zone II, 200–400 m) hosts a diverse assemblage including mahseer, catfishes, and forest-associated species. The

lower Pairi near Rajim (Zone III, ~100–150 m) has sandy-substrate fish communities dominated by carps and catfishes. The Pairi is considered a reference-quality stream for its upper and middle zones within the Mahanadi Basin, offering a valuable benchmark for biological integrity assessment in the broader Chhattisgarh upland river landscape.

3. Biological diversity of the river

Although the Mahanadi River is considered a non-perennial river, it still supports rich species diversity, including that of its tributaries. Despite being relatively less explored, studies of the river basin reveal a wide range of biological organisms that complete their life cycles within their respective niches, making the river biologically active throughout the year. However, anthropogenic activities have impacted key species of the river over time. These impacts need to be addressed and mitigated through scientific solutions in the future to ensure the river's overall sustainability and the well-being of its inhabitants.

3.1 Mahanadi River

The Mahanadi River basin supports diverse biological communities that play an important role in maintaining the structure, productivity, and ecological balance of the aquatic ecosystem. Water quality parameters such as dissolved oxygen, nutrients, temperature, and flow significantly influence the distribution and diversity of aquatic organisms in the river. Planktonic communities, including phytoplankton and zooplankton, contribute to primary productivity and form the base of the aquatic food chain, while benthic organisms regulate nutrient cycling and organic matter decomposition. These organisms are closely linked to environmental conditions and often respond quickly to changes in water quality. The presence of tolerant and adaptable species reflects the ecological status of the river and helps in understanding the functioning and health of the Mahanadi River ecosystem.

This report depicts the overall status of aquatic, riparian, and terrestrial organisms associated with the Mahanadi River basin. The entire basin was divided into three stretches: (1) Upper Stretch (Sihawa Hills in Chhattisgarh to Hirakud Reservoir in Odisha), (2) Middle Stretch (Chipilima to Kantilo) and (3) Lower Stretch (Baideswar to Paradeep). The data presented in this report are completely based on secondary sources. The collected data were stratified according to distinct river stretches, and graphical representations were standardised to enable comparative analysis across sites.

3.2 Flora

The flora of the Mahanadi River basin includes diverse plant communities occurring in aquatic, riparian, and floodplain habitats. Aquatic vegetation consists of submerged, floating, and emergent macrophytes that contribute to primary productivity and provide habitat for aquatic organisms. Riparian vegetation, including grasses, shrubs, and trees along riverbanks, helps stabilise soil, prevent erosion, and regulate nutrient inputs into the river. Floodplain vegetation develops in seasonally inundated areas and supports high biodiversity and nutrient-rich soils. Microscopic plant communities such as phytoplankton and periphyton also play a key role in ecosystem functioning, forming the base of the aquatic food web.

3.2.1. Phytoplankton

Phytoplankton forms the base of the aquatic food chain. It is the primary factor of productivity in aquatic systems, on which all aquatic organisms depend. Several studies have examined the status of phytoplankton communities in the Mahanadi River. The entire river stretch from the Reservoir to the estuary has been studied several times over the years. The Central Inland Fisheries Research Institute had published two reports between 1995 and 1997 covering the entire basin as an exploratory survey. The first survey in 1995 showed higher abundance of Bacillariophyceae (42%), followed by Chlorophyceae (20%) and Cyanophyceae (15%) families in the middle stretch of the basin, whereas the lower stretch showed higher abundance of Chlorophyceae (50%), followed by Cyanophyceae (22%) and Bacillariophyceae (14%). Anabaena sp., Aphanocapsa sp., and Chroococcus species of the Cyanophyceae family, *Amphora* sp., *Anomoeneis* sp., *Asterionella* sp., and *Bacilluria* species of the Bacillariophyceae family, *Ankistrodesmus* sp., *Binuclearia* sp., *Botryococcus* sp., *Chaetophora* sp., and *Chlamydomonas* sp. of the Chlorophyceae family were recorded to be of high abundance at that time. Other species such as *Closterium* sp., *Euglena* sp. and *Ceratium* sp. under Desmidiaceae, Euglenophyceae, and Dianophyceae families, respectively, contributed majorly to the phytoplankton biomass. The second survey included seasonal variation of phytoplankton presence in the entire basin, which reported higher density during post-monsoon in the upper (228 u/l) and middle (200 u/l) regions of the basin, whereas the lower basin reported higher density during pre-monsoon (244 u/l) period.

Dash et al. (1993) conducted a detailed biological study on the Hirakud reservoir, which revealed good species diversity in the reservoir, reporting about 40 species and four families. Bacillariophyceae showed high density (35%), including *Frustulia* sp., *Nitzschia* sp., and *Amphora* sp. as major species, followed by Cyanophyceae (30%) and Chlorophyceae (28%),

which includes *Microcystis* sp., *Merismopedia* sp., *Anaebaena* sp., *Nostoc* sp. and *Oscillatoria* sp., and *Chlamydomonas* sp. and *Chlorella* sp. respectively.

Studies from the Cuttack region, such as by Sahu et al. (2019), conducted a two-year study and reported higher biomass in the year 2020 than in 2019. Chlorophyceae reported a higher composition (~50%), followed by Bacillariophyceae (~27%) and Cyanophyceae (~20%). Panigrahi and Patra's (2008-09) study showed seasonal variation reporting Chlorophyceae (45%) as the major family composition, highest during the pre-monsoon period, followed by Bacillariophyceae (30%) and Cyanophyceae (22%), highest during the post-monsoon period.

An ICAR report of 2017 revealed 147 species of phytoplankton with diverse families along the entire stretch of the river basin, where Bacillariophyceae dominated with 68 species, followed by Chlorophyceae (40 species) and Charophyceae (24 species). A thesis submitted to Sambalpur University by Satya Narayan Nanda in 2002 explored the biological aspects of the Hirakud reservoir, which showed phytoplankton species of abundance such as *Volvox Sp, Scenedesmus* Sp, and *Phacus* Sp.

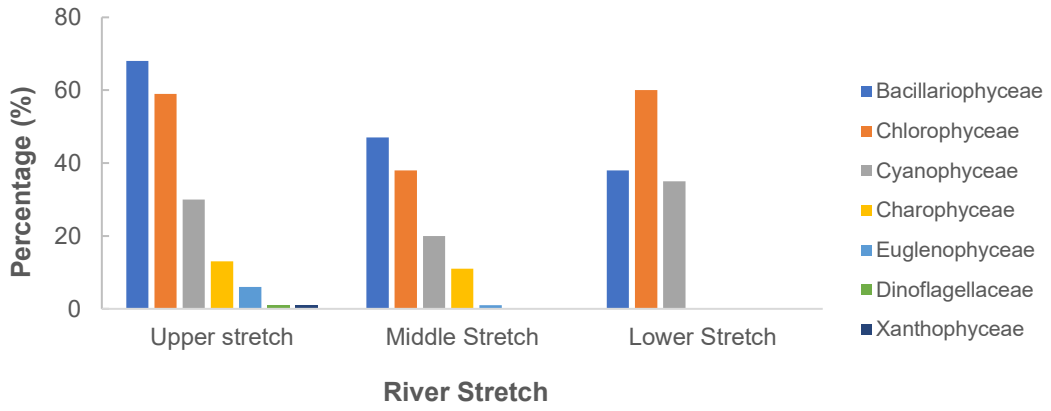


Figure 4 Spatial representation of phytoplankton families along the Mahanadi River.

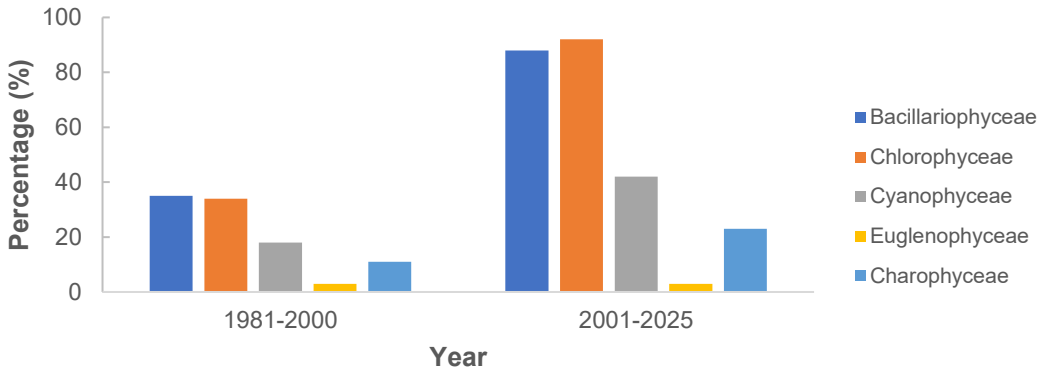


Figure 5 Temporal representation of phytoplankton families along the Mahanadi River.

A comprehensive analysis of phytoplankton data collected over the years from the Mahanadi River was conducted to determine phytoplankton density, identify key species across different regions of the entire river basin, and observe their changes over time. The analysis identified 428 species and three dominant families: Bacillariophyceae, Chlorophyceae, and Cyanophyceae. Chlorophyceae (36%) was the most prevalent across the entire basin, especially in the lower stretch. Meanwhile, Bacillariophyceae (35%) was dominant in the upper and middle stretches, contributing second to the overall composition, followed by Cyanophyceae (20%) (Fig.4).

Temporal analysis of all the data revealed 100 phytoplankton species with good diversity reported during 1980 and 2000. Whereas, studies reported during 2001 and 2025 showed nearly 250 species presenting a considerable increase in the richness (~60%) (Fig.5).

Genera of Bacillariophyta such as *Cymbella, Gomphonema, Amphora, Navicula, Nitzschia,* and *Synedra* dominated the entire stretch, with *Navicula* and *Nitzschia* prevalent in the upper and middle stretches, while Coscinodiscus was dominant in the lower stretch near the estuary. Similarly, Chlorophyta included dominant species like *Ankistrodesmus, Cladophora, Cosmarium, Scenedesmus*, and *Spirogyra*, while Cyanophyta contained common species such as *Anabaena, Chroococcus, Lyngbya, Nostoc*, and *Oscillatoria* throughout the basin. Other significant species, including *Cosmarium* and *Staurastrum* from *Charophyta, Phacus* and *Euglena* from Euglenophyta, and *Ceratium* species from the Dinoflagellate family, also contributed to the overall composition of the basin (Fig.6).

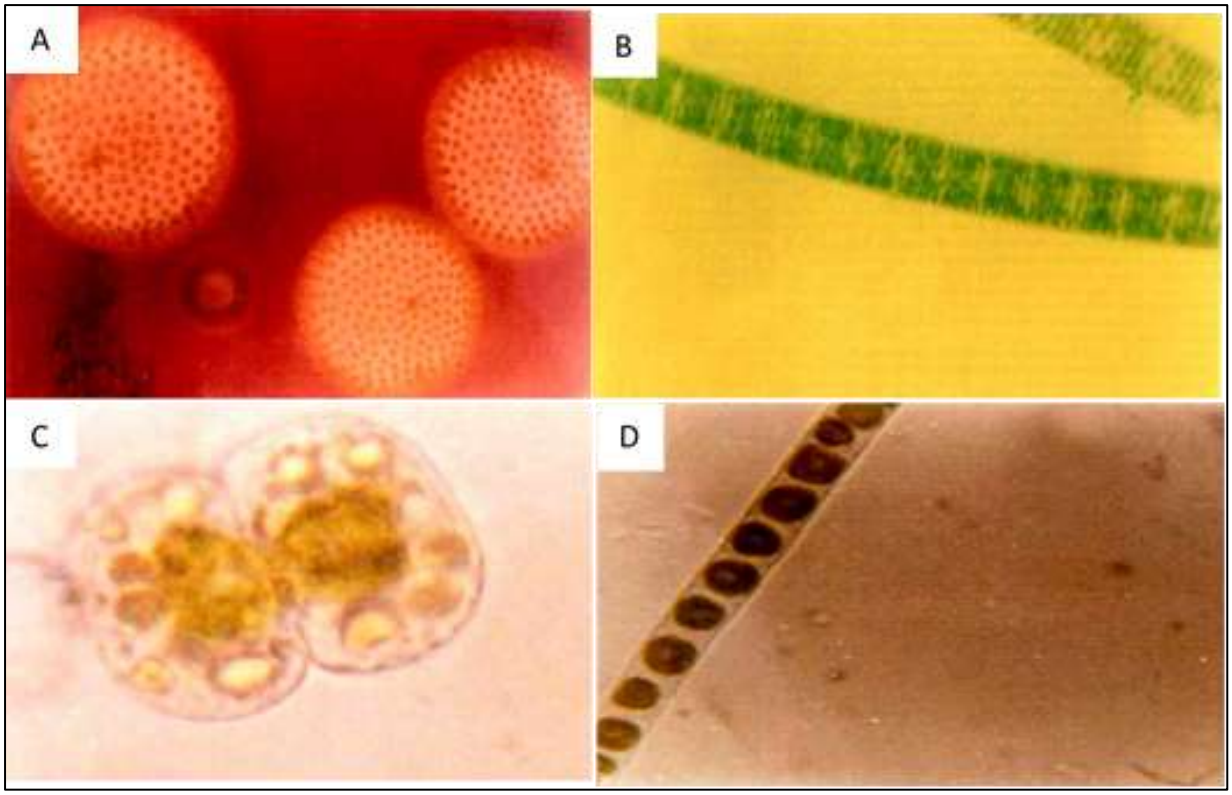


Figure 6 Phytoplankton of the Mahanadi River (Panigrahi S., 2008). A. Volvox colony (Volvox globator), B. Spirogyra sp., C. Cosmarium reniforme, D Zygnema peliosporum.

3.2.2. Periphyton

Periphyton refers to the complex community of microorganisms attached to submerged surfaces in a river ecosystem. These communities grow on rocks, sediments, aquatic plants, and other submerged substrates. Periphyton consists of green algae and diatoms, cyanobacteria, bacteria, fungi, and small protozoans embedded in a mucilaginous matrix. They play an important role in primary production, nutrient cycling, and energy transfer within aquatic food webs. Also serves as a food source for many grazing invertebrates and fish. Periphyton is considered an ideal indicator of the ecological health of river systems as they respond quickly to environmental changes such as water quality and nutrient levels.

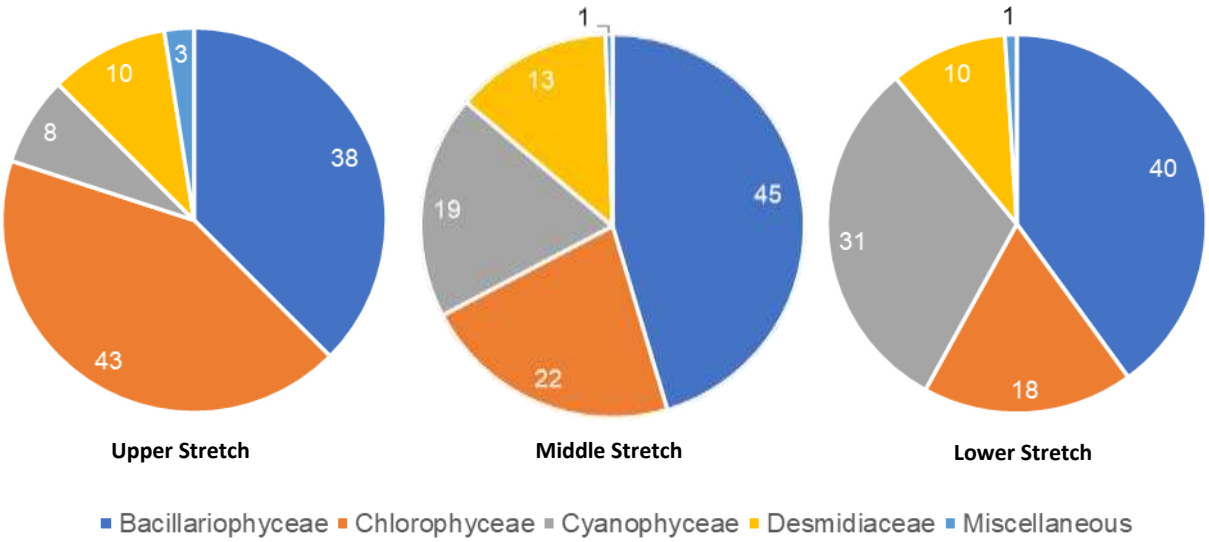


Figure 7 Percentage composition of periphyton population along various stretches of Mahanadi River.

Very few studies have been reported on periphyton from the Mahanadi River, with no independent detailed study reported. Only two studies reported between 1995 and 2007, which included periphyton. A study conducted during the 1995-96 period by CIFRI showed an overall periphyton of 542 u/cm² on average, with high richness at the upper stretch of the river basin due to dense presence of rocks and boulders, which favour substrate attachment. The lower stretch showed low richness due to less hard substrate and more soil presence.

Diatoms ranged from 40-60%, followed by green algae (5-40%) and Desmids (9-30%) along all the stretches. *Navicula, Synedra, Nitzschia* among diatoms, *Gonatozygon, Genicularia, Closterium* among desmids, *Spirogyra* (green algae) and *Spirulina* (blue-green algae) are the species that were available in the entire stretch. Another report by Pathak et al. 2007 explored the biological profile of the Mahanadi River at the Sambalpur region, which revealed 36 periphyton species. The region showed a high abundance of Bacillariophyta (46%), followed by Chlorophyta (37%) and other groups (17%). Important periphyton species that dominated the Sambalpur region were *Frustulia* sp., *Amphora* sp., *Cocconeis* sp., *Cymbella* sp. (Bacillariophyta), *Uronema* sp., *Draparnaldiopsis* sp., *Chaetophora* sp., *Protococcus* sp., *Cladophora* sp., *Microspora* sp., *Oedogonium* sp. (Chlorophyta), *Cosmarium* sp. (Desmids) and *Oscillatoria* sp. (Cyanophyta).

Combined data analysis from both studies revealed periphyton population in different stretches of the river, with Bacillariophyta dominating the middle (~45%) and lower (~40%) stretches. Second to Bacillariophyta, Chlorophyta (~20%) and Cyanophyta (18%) showed

richness in the middle stretch. The upper stretch was enriched with Chlorophyta (42%), followed by Bacillariophyta (37%) and Cyanophyta (~7%). The lower stretch was also largely contributed to by Cyanophyta (30%) and Chlorophyta (18%) (Fig. 7). Other groups (e.g. Desmids, Xanthophyceae, etc.) also contributed to the overall composition of the entire stretches. *Frustulia* sp., *Amphora* sp., *Cocconeis* sp., *Cymbella* sp. (Bacillariophyceae), *Microspora* sp., *Oedogonium* sp., *Desmidium* sp., *Cosmarium* sp. (Chlorophyceae) and other species such as *Anabaena* sp., *Zygnema* sp., *Oscillatoria* sp. were common among all the stretches. Due to no evidence, seasonal fluctuations of phytoplankton in the river basin were not obtained.

3.2.3. Riparian Vegetation

The riparian vegetation of the Mahanadi River plays a crucial role in maintaining riverbank stability, biodiversity, and ecological balance. Riparian zones along the river support a diverse assemblage of trees, shrubs, herbs, grasses, and climbers. These plant communities form a transitional ecosystem between the terrestrial landscape and the aquatic environment. This type of vegetation is typically dominated by species tolerant to seasonal flooding and sediment deposition. It acts as a natural buffer that reduces soil erosion, filters sediments and nutrients entering the river, and provides habitat and food resources for various aquatic and terrestrial organisms. Additionally, they support nesting sites for birds, shelter for small mammals and reptiles, and contribute organic matter to the aquatic ecosystem.

The riparian habitat of the Mahanadi River has been studied rarely over the years, limited to specific locations. A report issued by the Botanical Survey of India during 1960 explored the riverine flora of Bihar and Odisha. This report documented regional species of riparian trees of the Athagarh region, such as *Xylia xylocarpa* (Kangada), *Erioglossum edule* (Khandia), *Soymida febrifuga* (Rohini) and *Hugonia mystax* (Kanta Lata). S. Nanda (2002) had conducted a detailed study on the flora of the Hirakud region of Sambalpur district and submitted it as a thesis to Sambalpur University. The thesis documented all types of riparian plants along the Mahanadi River present in the entire region, which includes 15 species of trees (*Buchanania langan, Bombax ceiba, Terminalia arjuna, Shorea robusta, Diospyros malanoxylon, Bambusa* sp., *Madhuca indica,* etc.), 123 species of shrubs (*Annona squamosa, Polyalthia pendula, Polyalthia longifolia, Lannea coromandelica, Mitragyna parviflora, Citrus limon, Murraya koenigii* etc.),

44 species of herbs (*Achyranthus aspera, Amaranthus viridis, Acalypha indica, Euphorbia hirta, Euphorbia pulcherrima, Ageratum conyzoides, Eclipta alba* etc.), 13 climbers (*Argyreia speciosa,*

Capparis zeylanica, Entada scandens, Bougainvillea sp. etc.) and 27 types of grasses (*Arundinaria falcata, Cynodon dactylon, Saccharum munja, Axonopus affinis* etc.). After a gap of two decades, multiple studies were reported recently covering other regions of the river basin. Singh et al. 2024 identified rare medicinal plants of the Mahanadi River that belong to the history of the Odisha household by collecting documents from various sources. Riparian plants such as Suryavarti (*Chrozophora rottleri*), Velahathi (*Heliotropium ovalifolium*), Balibalua (*Portulaca pilosa*) and Pani jhau (*Tamarix ericoides*) were reported to be used for medicinal purposes. Specific parts of these plants, such as bark, root, or the whole plant, can be used to treat various diseases and wounds.

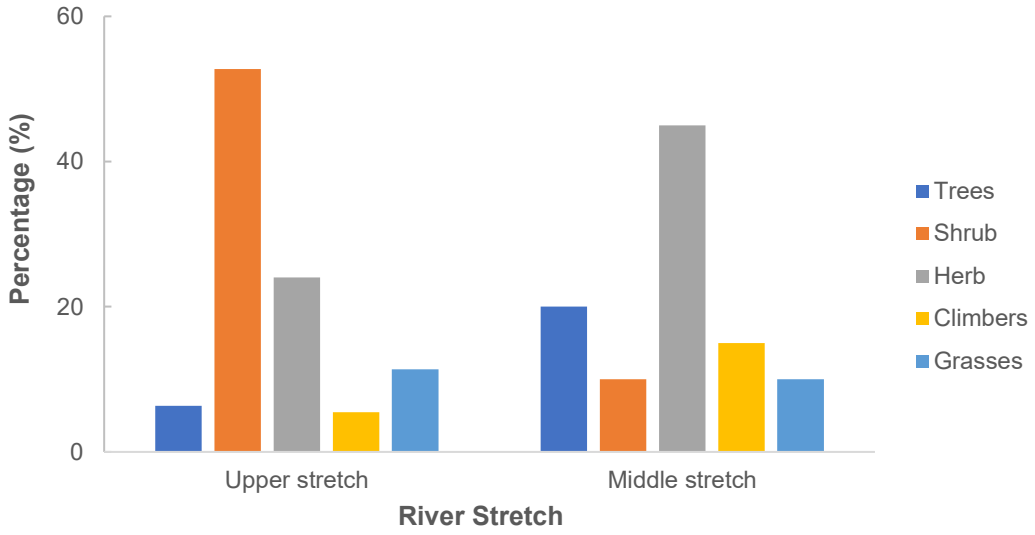


Figure 8 Percentage composition of riparian vegetation along various stretches of the Mahanadi River.

Another report was published by Ambika Prasad Research Foundation in 2024-25 in association with PCCF Odisha, which explored the middle stretch of the river basin (from Cuttack to Narasighpur forest division) and recorded 153 herbaceous species, 100 trees, 74 climbers, 50 species each of grass and shrubs and other small trees and ferns. *Acacia mangium, Achyranthes aspera, Aegle marmelos, Anacardium occidentale* and *Azadirachta indica* are some common species recorded along the study area.

An overall analysis of riparian vegetation revealed that herbs (~35%) dominated the total composition for the entire basin, whereas trees and shrubs showed a similar proportion (~20%) (Fig.10). Other groups, like climbers and grasses, contributed about 13-15% each. The analysis also determined compositional variations in the upper and middle stretches. While

trees and herbs dominated the middle stretch (~60%), the upper stretch was dominated by herbs and shrubs (~70%) (Fig. 8).

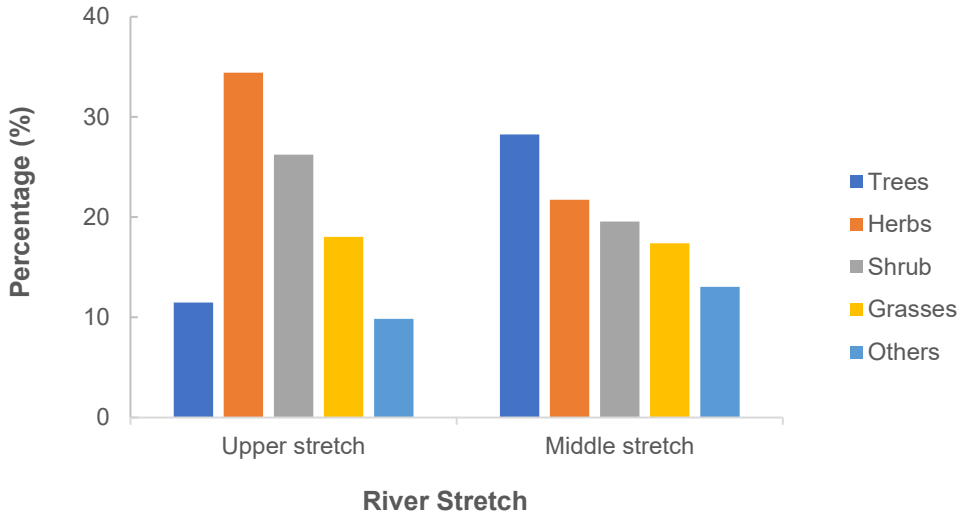


Figure 9 Percentage composition of floodplain vegetation along various stretches of the Mahanadi River.

3.2.4 Floodplain Vegetation

Floodplain vegetation forms a dynamic ecological community that develops along the low-lying areas adjacent to the river channel that are periodically inundated during seasonal floods. Due to this, the floodplain experiences regular deposition of nutrient-rich sediments, and these conditions create a mosaic of habitats that support diverse plant communities. Vegetation composition varies with flood frequency, soil moisture, and elevation from the river channel. These plants stabilise riverbanks, reduce soil erosion, and filter sediments and nutrients from surface runoff. These also provide habitat and food for many aquatic and terrestrial organisms.

Composite analysis revealed that the upper stretch was dominated by herbaceous species, followed by shrubs and grasses. Whereas the middle stretch showed a higher composition of trees with a similar proportion of herbs and shrubs, followed by grasses and others (Fig. 9).

Figure 10 Riparian and floodplain vegetation observed in the Mahanadi River. A. Hydrilla verticillata (Aquatic weed), B. Lindernia tamilnadensis (Herb) (Devi et al. 2025), C. Persicaria glabra (weed) (APRF, 2025). Medicinal plants, D. H. ovalifolium, E. T. ericoid

Details on this aspect are included in the same studies where riparian vegetation was reported. The thesis by S. Nanda (2002) is the earliest report found on this aspect. The thesis included 7 species of trees (*Terminalia arjuna, Bombax ceiba, Phoenix* sp., *Lagerstroemia parviflora, Bambusa sp* etc.), 21 herbs (*Achyranthes aspera, Euphorbia hirta, Eclipta alba, Blumea mollis, Heteropogon contortus* etc.), 16 shrubs (*Albizia lebbeck, Barringtonia acutangula, Lagerstroemia parviflora, Syzygium cumini* etc.), 11 grass species (*Saccharum spontaneum, Phalaris arundinacea, Panicum maximum* etc.) and other species like ferns and weeds (*Aeschynomenae aspera, Lindernia* sp., *Riccia* sp. etc.) comprises the floodplain vegetation of Hirakud reservoir.

Singh et al. (2024) identified nine species of herbs that grow on marsh habitats (e.g. *Alternanthera sessilis, Barringtonia acutangula, Marsilea minuta, Polygonum glabrum,* etc.) along entire river stretches. Ambika Prasad Research Foundation report in 2024-25 documented 13 trees, 10 herbs, 9 shrubs and 8 grasses along the middle stretch of the basin (Naraj-Narasinghpur). Species such as *Barringtonia acutangula, Ficus racemosa, Syzygium cumini, Pongamia pinnata* (trees), *Vitex negundo, Ricinus communis, Barleria prionitis, Pavetta indica (shrub), Acmella uliginosa, Bacopa monnieri, Acmella paniculata* (herbs), *Panicum repens, Urochloa mutica, Eragrostis tenella, Fimbristylis dichotoma* (grass) were found to be common along the stretch (Fig.10). Singh et al. (2024) reported 15 species of aquatic plants from the Mahanadi River.

3.3 Fauna

Mahanadi River support a rich and diverse fauna due to its wide network of rivers, wetlands, floodplains, and forests. The aquatic fauna comprises various fish species, such as carps and catfish, that support local fisheries, developing the livelihood of nearby residents. The basin also hosts freshwater prawns, crabs, molluscs, and diverse zooplankton communities, which contribute to the aquatic food web. Amphibians and reptiles such as frogs, turtles, and water snakes are common along riverbanks and wetlands. The riparian and floodplain habitats support birds, mammals, and insects that depend on the river ecosystem.

All these organisms contribute highly to the regional biodiversity and maintain the ecological balance of the river basin.

3.3.1 Zooplankton

Freshwater zooplankton is an important component of the riverine system, mainly composed of rotifers, cladocerans, copepods, and protozoans that drift in the water column. They have a key role in the aquatic food web by grazing on phytoplankton and bacteria and serving as a major food source for fish larvae and other aquatic organisms. Strong currents, seasonal changes and nutrient availability sometimes affect zooplankton population; however, stagnant zones such as backwaters and flood plains support diverse zooplankton species.

Several studies were conducted on the zooplankton population along the Mahanadi River over the years. A 1995 report by CIFRI, Kolkata, recorded various zooplankton species such as rotifers (50%), cladocerans (24%), protozoans (20%), copepods and ostracods from the middle stretch of the basin. The report highlighted lower density at the lower stretch and higher density at the middle stretch. A thesis by S. Nanda (2002) from Sambalpur University reported

Daphnia Sp. (Cladocera), *Cyclops* sp., and *Mesocyclops* (Copepod) species from Hirakud reservoir. Pathak et al. (2007) explored biological aspects of Hirakud reservoir, which recorded major species such as *Bosmina* sp., *Daphnia* sp., *Cyclops* sp., *Cypris* sp., *Trinema* sp., *Diplois* sp. and *Mytilina* sp. with rotifers (~50%) dominating the composition, followed by cladocerans (25%) and protozoans (20%). Another thesis from Utkal University, submitted by S. Panigrahi (2008), revealed the zooplankton population of the Cuttack region from upstream to downstream. She highlighted major species from the region, such as *Amoeba proteus, Arcella gibbosa, Centropyxis spinosa, Euglypha ciliata* (Protozoa), *Brachionus quadridentatus, Brachionus forficula, Filina longiseta* (Rotifers), *Diaphanosoma exisum, Ceriodaphnia rigaudi, Bosmina sp* (Cladocera), *Cypris sp, Centrocypris sp* (Ostracod) and *Mesocyclops leuckarti, Diaptomus wierzeskil* (Copepoda) from two years of study (Fig.13). Her analysis showed protozoan domination (50%) in the region, followed by rotifers (30%) and cladocerans (20%). Sahu and Rout (2021) conducted a seasonal zooplankton observation of the Mahanadi River at Cuttack during 2019 and 2020. They reported higher biomass during pre-monsoon, ranging from 600-700 u/l, and lower during monsoon, ranging from 150-300 u/l. They found species such as *Amoeba discoides, Amoeba radiosa, Euglypha ciliate* (Protozoa), *Keratella tropica, Rotaria vulgaris, Keratella tropica* (Rotifera), *Daphnia carinath, Diaphanosoma exisum, Moina micrura* (Cladocera), and *Mesocyclops leuckartii, Heliodiaptomus viduus* (Copepoda) were common among the study sites of the region. Srichandan et al. (2009) reported the seasonal distribution of zooplankton in the Mahanadi estuary region, which showed compositional transition from the freshwater region with high density of copepods (~80%), followed by cladocerans (3%) and the remaining others (Fig.13). This shift in composition is due to habitat preference, water current, salinity and other physical conditions.M. Das et al. (2014) reported common species from different study sites of the Cuttack region, such as *Diaptomus* sp., *Microcyclops sp,* Nauplius larvae and *Brachionus falcatus.*

The Mahanadi River in the Cuttack region has been studied frequently over the years, which presents a well-documented zooplankton population of the region. A total of 150 zooplankton species were identified to be present along the entire basin. *Alona* sp., *Alonella* sp., *Bosmina* sp., *Chydorus* sp., *Leydigia* sp., *Sida* sp. (Cladocera), *Cyclops* sp. (Copepoda), *Cypris sp* (Ostracod), *Ascomorpha* sp., *Colurella* sp., *Conochilus* sp., *Gastropus* sp., *Horaella* sp., *Keratella* sp., *Lecane* sp., *Mytilina* sp., *Pompholyx* sp., *Trichocerca* sp. (Rotifera) and *Blepharisma* sp., *Diplois* sp., *Oxytricha* sp., *Spirostomum* sp., *Trinema* sp. (Protozoa) species were found to be common among all the stretches of the basin. Rotifers (45-48%) dominated the upper and middle stretch, whereas the lower stretch was dominated by protozoans, followed by rotifers

(30%). Cladocerans (20-24%) maintained similar proportions along all the stretches, with copepods (12%) contributing highly to the lower stretch (Fig.11). Studies reported higher zooplankton population during the 2008-19 period than during the 1995-2000 period. It showed a decrease in rotifers and cladoceran population over the years, whereas others, such as protozoans and copepods, showed an increase in their density (Fig.12).

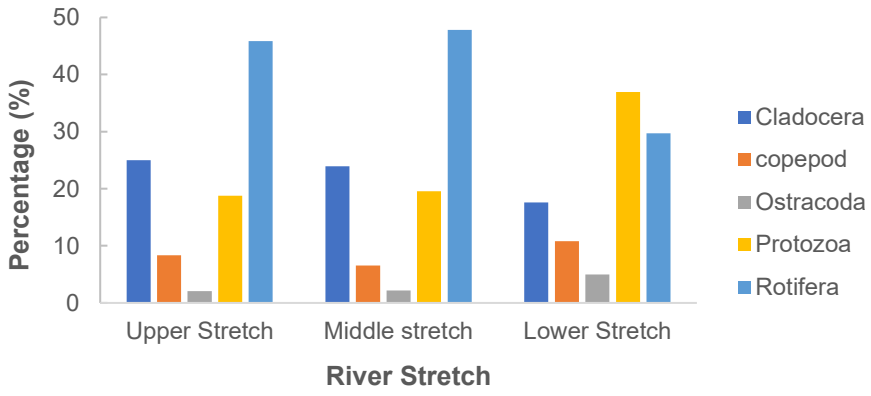


Figure 11 Percentage composition of zooplankton groups along the Mahanadi River stretches.

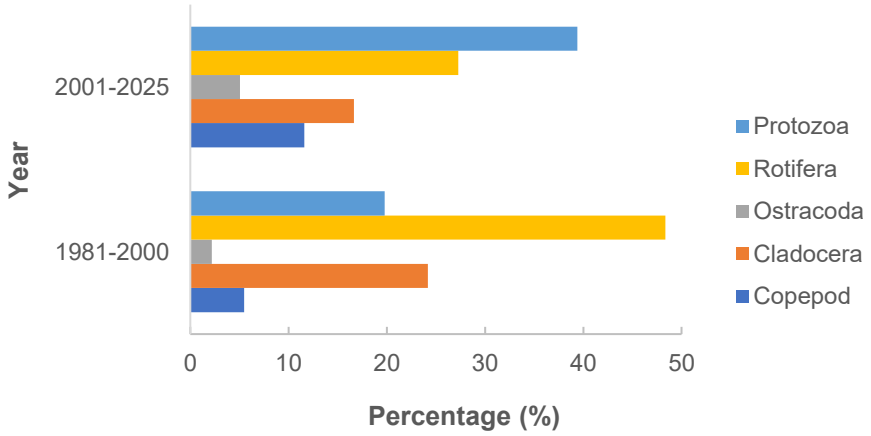


Figure 12 Temporal shifts in zooplankton groups along the Mahanadi River stretches.

3.3.2. Zoobenthos

Zoobenthos are bottom-dwelling organisms that live on or within the sediments. Mahanadi river supports wide range of benthic organisms such as insect larvae (chironomids and caddisflies), aquatic worms, mollusks, and small crustaceans. These organisms play a crucial role in river ecosystems by decomposing organic matter, recycling nutrients, and maintaining sediment quality. Zoobenthos serve as a major food source for fish and other aquatic animals thereby maintaining aquatic food chain. Due to their sensitivity to pollution and habitat

changes, zoobenthos are commonly used as indicators of aquatic ecosystem health and water quality.

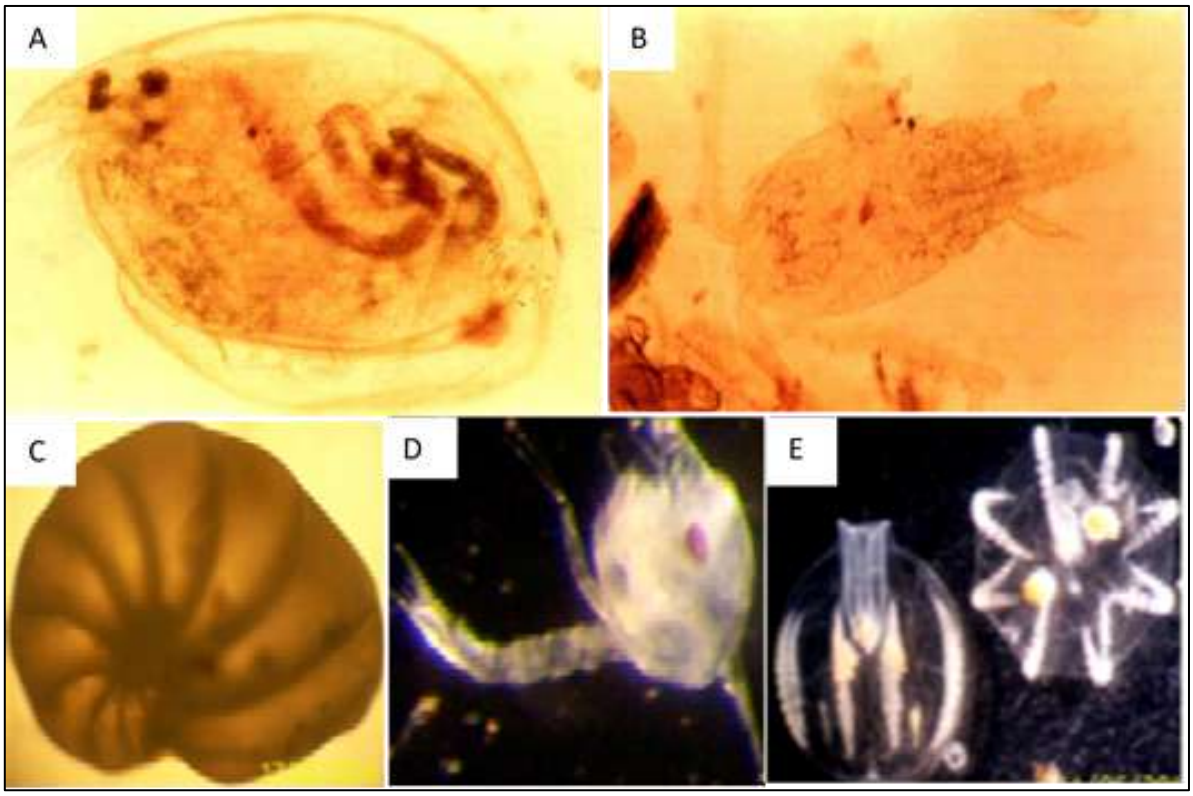


Figure 13 Zooplanktons of Mahanadi River. A. Daphnia carinata, B. Mesocyclops leuckartii (S. Panigrahi, 2008), C. Foraminifera, D. Zoea larva, E. Ctenophora (Srichandan et al., 2009).

Earlier studies on the Mahanadi River have examined zoobenthos composition and its temporal and seasonal changes over the years. One of the earlier studies by CIFRI, Kolkata (1995), revealed aquatic invertebrate composition throughout the Mahanadi River stretches. They reported a high density of zoobenthos from the middle stretch (1650 nos/m^2), followed by the upper (1600 nos/$m^{2)}$ and lower stretch (490 nos/m^2). Gastropods (50%) dominated the overall composition during this study, followed by nematodes (20%). *Amnicola, Campeloma, Cyprea, Pila* (Gastropod), *Cyclops, Harpacticus, Gammarus.* (Crustacea), *Leptocerus, Elophila, Caenis, Eretes* (Insecta), *Diopatra, Nereis, Tubifex* (Annelids) and *Chromodora* (Nematoda) species were common along all the stretches of the basin in this study. A 1999 study on the Hirakud region (S. Nanda, 2002) reported 4 species of annelids (*Hirudinaria viridis, Pheretima posthuma,* etc.), 2 species of molluscs (*Pila globosa, Lamellidens marginalis*) and 30 species of arthropods (*Palamnaeus* sp., *Scolopendra* sp., *Peripatus* sp., *Anopheles* sp., *Apis indica*, etc.) from the Hirakud reservoir. Pathak et al. (2007) also reported zoobenthos population from the Hirakud reservoir. The study documented gastropod and bivalve species from the Hirakud

reservoir, where Gastropods (70%) dominated with major species such as *Amnicola* sp., *Pila* sp., *Littorina* sp., *Nerita* sp., *Goniobasis* sp., and *Tarebia* sp. Other studies were confined to the estuary region of the river basin, where the zoobenthic population became highly diverse and abundant (Fig.15).

Overall analysis revealed 174 zoobenthos species along all the stretches of the Mahanadi river, dominated by molluscs (~50%), followed by annelids (20%) and arthropods (30%). Annelids were found less in the upper stretch (~7%) and increased gradually towards the lower stretch (40%). *Hirudinaria viridis, Pheretima posthuma, Lumbriculus, Tubifex,* and *Nereis* are the common species of polychaetes and oligochaetes found in all the stretches, contributing to the annelid composition. Mollusc showed high abundance in the middle stretch (~70%) and lower abundance at the lower stretch (18%). Arthropods comprised major species such as *Palamnaeus* sp., *Peripatus* sp., *Macrobrachium malcolmsonii, Mantis religiosa* and *Odontotermes* sp., with high density in the lower stretch (40%) followed by the upper stretch (30%), which had a similar diversity as the lower stretch (Fig.14).

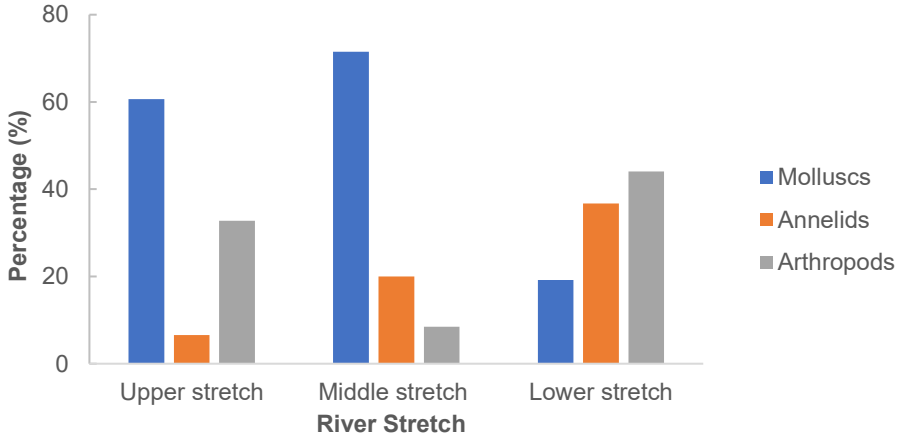
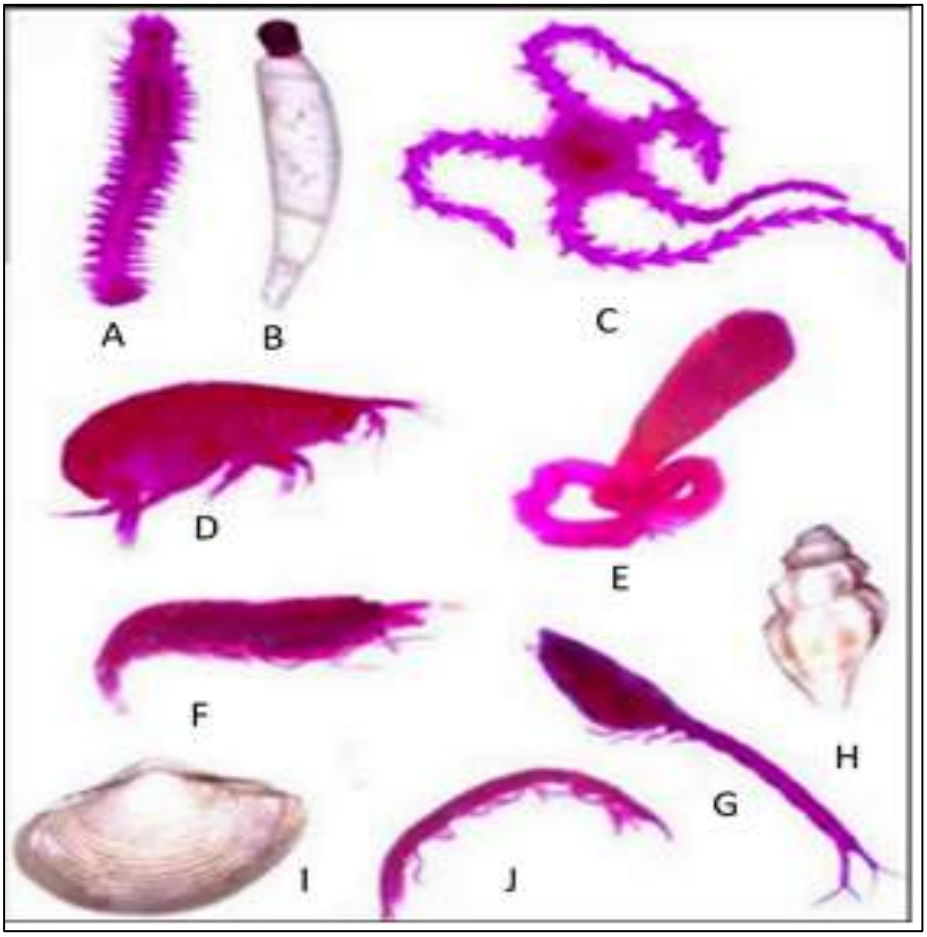


Figure 14 Percentage composition of zoobenthos from different stretches of the Mahanadi River.

3.3.3. Fishes

Fisheries play an important role in supporting aquatic biodiversity and local livelihoods. The continuous flow of water throughout the year provides suitable habitats for a variety of fish species, including major carps, minor carps, catfishes, and small indigenous fishes. Mahanadi River provides favourable conditions for breeding, feeding, and migration, particularly during seasonal floods that connect the main channel with floodplains and wetlands.

Figure 15



Zoobenthos of Paradeep estuary (Behera et al., 2019). A. Polychaete, B. Scaphopoda, C. Ophiuroidea, D. Amphipoda, E. Sipuncula, F. Decapoda, G. Cumacea. H. Gastropoda, I. Bivalvia, J. Isopoda

Z report in 2015 explored fish diversity from Hirakud to Jagatsingpur, which recorded 57 fish species with cyprinidae (21 species) dominating the composition, followed by bagiridae (4 species) and channidae (4 species). Another survey of Hirakud reservoir in 2016 recorded 16 species of the Cyprinidae family, followed by 4 species of the Bagridae family (Fig. 17).

Apart from Hirakud, other regions of the Mahanadi River have been studied. CIFRI report in 1995 documented 100 species of fish from all stretches of the river basin, highly dominated by

cyprinidae (50%) and other families such as bagridae (9%) and schilbeidae (6%). Another study in 2013 covered the entire river basin, recorded a total of 200 species with Cyprinidae (33%) domination, followed by Danionidae (11%) and Clupeidae (4%).

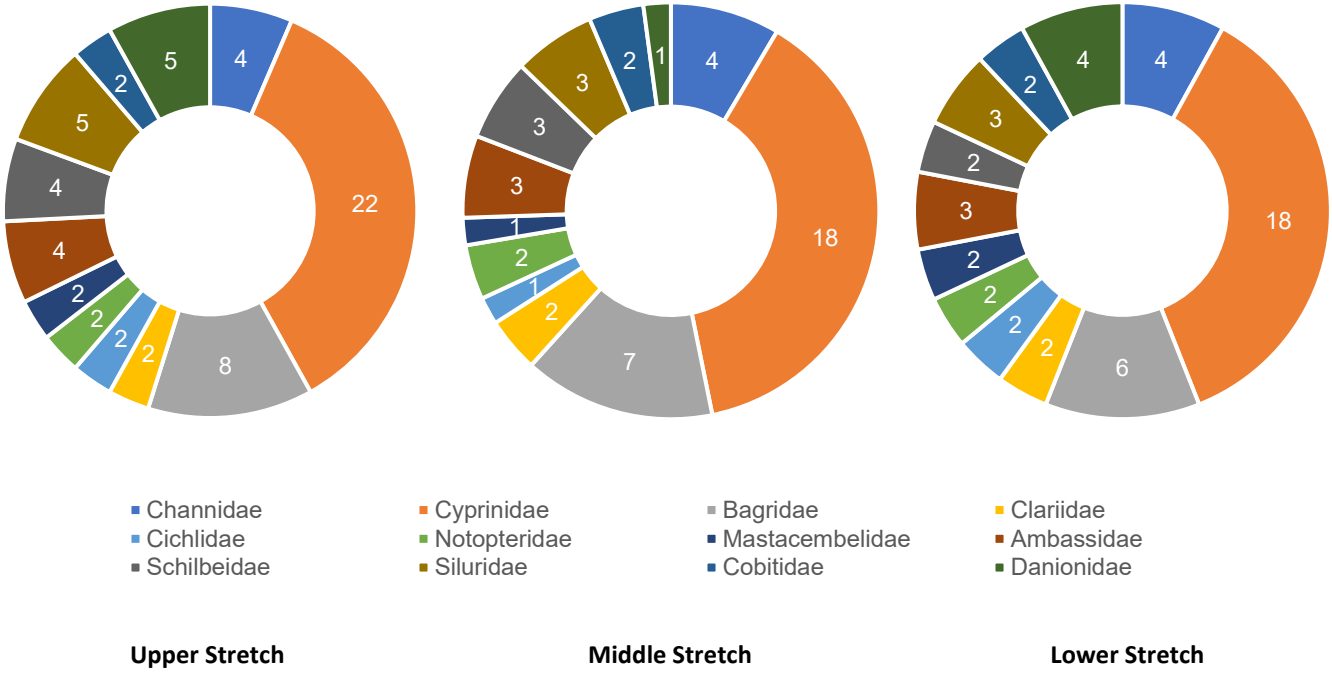


Figure 16 Percentage composition of various fish families along the different stretches of the Mahanadi River.

Sunder Lal Hora (1940) conducted a fish diversity study in the Mahanadi River at Raipur provinces and reported 43 species, among which most of the species belong to Cyprinidae and Bagridae families. Singh et al. (2013) identified 82 species from the Mahanadi River, where Cyprinidae contributed the most, followed by Siluridae, Bagridae and Schilbeidae families. A similar composition was reported by Tyagi et al. (2021), who recorded nearly 100 species from the entire river basin. Patel et al. (2024) recorded 50 species from the Mahanadi River at Cuttack.

Composite analysis from all studied regions of Mahanadi River basin showed the upper stretch with a higher fish population (62%) and middle stretch showed less abundance (46%) (Fig.16). A total of 34 families identified to be present along the entire stretch of the river basin with major families such as Channidae (9%), Cyprinidae (44%), Bagridae (16%), Ambassidae (8%), Schilbeidae (7%), Siluridae (8%) and Danionidae (8%). *Chanda nama, Mystus aor, Mystus seenghala, Mystus tengra, Gadusia chapra, Catla catla, Labeo bata, Labeo callbasu, Labeo rohita, Puntius ticto, Tor masal mahanadicus, Nandus nandus, Ailia coilia, Wallago attu* and *Bagarius bagarius* are the major species found across all the stretches. Temporal analysis

showed a decrease in species abundance belonging to families such as cyprinidae, bagridae, schilbeidae and sisoridae between 2000 and 2025 period but an increase in species density belonging to families such as Clupidae, Notopteridae and Danionidae (Fig.18).

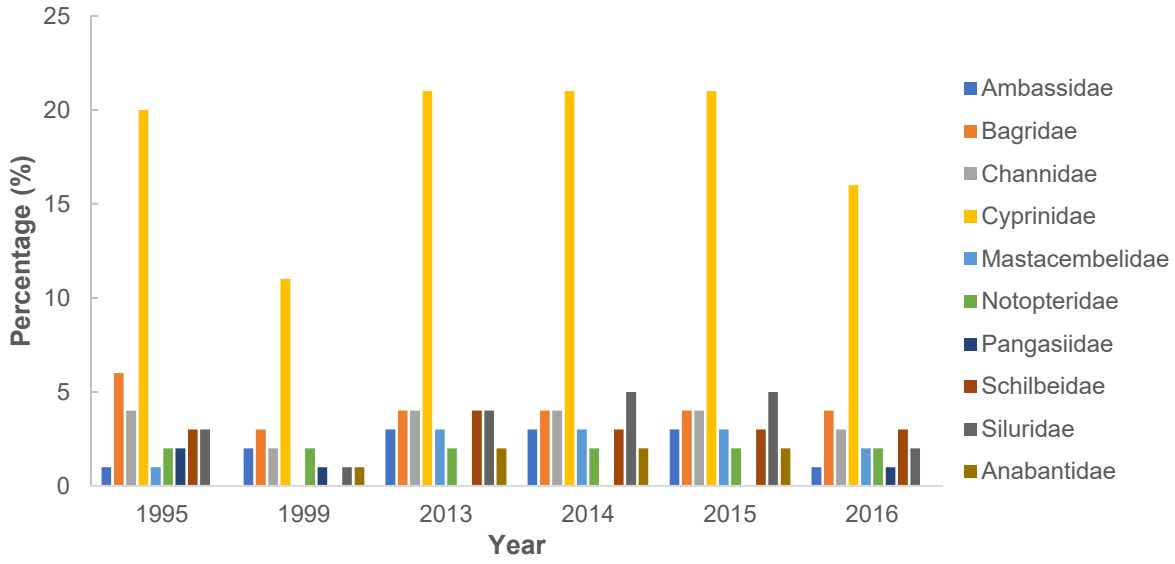


Figure 17 Temporal representation of various fish families recorded from Hirakud reservoir.

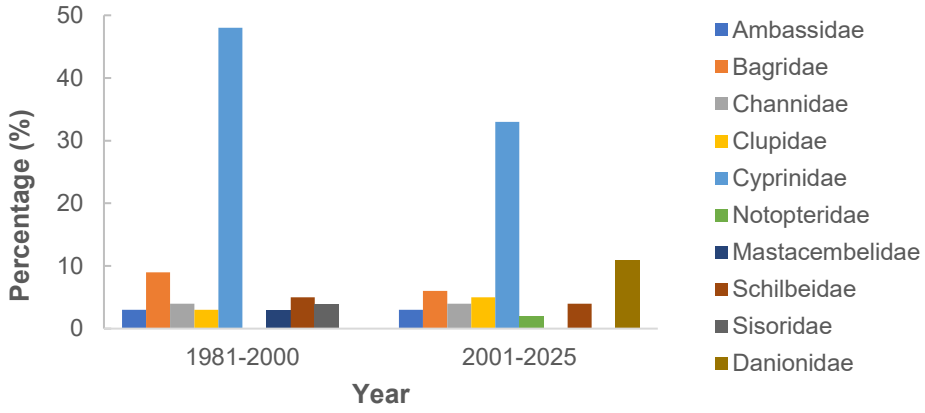


Figure 18 Temporal representation of various fish families recorded from entire river stretches.

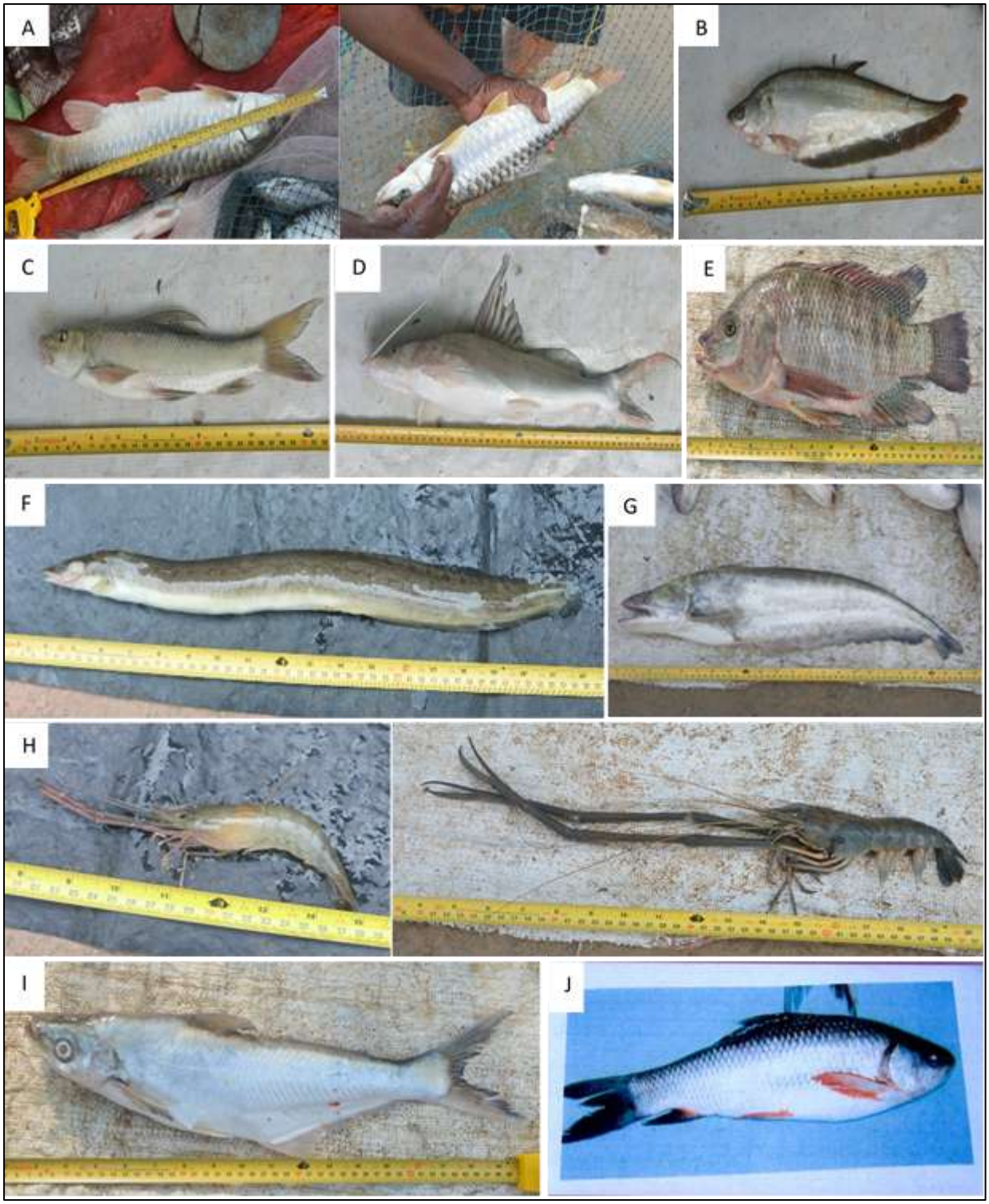


Figure 19 Fishes from the Mahanadi River. A. Tor masal mahanadicus (Mahanadi Mahseer), B. Notopterus notopterus, C. Cirrhinus cirrhosus (Mrigal Carp), D. Sperata aor, E. Oreochromis niloticus, F. Anguilla bengalensis, G. Wallago attu, H. Macrobrachium rosenbergii,

3.3.4. Higher Aquatic Vertebrates

The Mahanadi river system is home to various higher aquatic vertebrates, including reptiles, amphibians and mammals. The river basin provides adequate habitat, feeding and breeding grounds, easy migration, and a seasonal water system, which is why these organisms thrive here. These vertebrates occupy higher trophic levels and play important roles in maintaining ecological balance.

The Mahanadi River supports a moderate diversity of amphibians due to the presence of wetlands, floodplains, agricultural fields, and moist riparian habitats near it. Amphibians include mostly frogs and toads that depend on the river system for breeding and larval development, as reported by previous studies. A total of 40 species of amphibians were documented, belonging to 5 families from all stretches of the river, supported by previous studies. The middle stretch (40%) recorded more species among all the stretches, followed by the lower stretch (35%) (Fig. 20). A report by Dash and Mahanta (1993) recorded 10 amphibian species from the Mahanadi River at Sambalpur district, such as *Duttaphrynus melanostictus, Sphaerotheca breviceps, Hoplobatrachus tigerinus, Euphlyctis ehrenbergii, Microhyla ornata, Uperodon systoma,* etc. Amphibian study at the Satkosia region of the Mahanadi river by Bishnu Charan Pradhan in 2016 revealed 5 families and 16 species, including major ones such as *Duttaphrynus melanostictus, Euphlyctis cyanophlyctis, Fejervarya cancrivora, Hoplobatrachus tigerinus* and *Polypedates maculatus*. Deuti et al. (2016) reported 14 species of frog (12) and toads (2) from the lower stretch of the river basin.

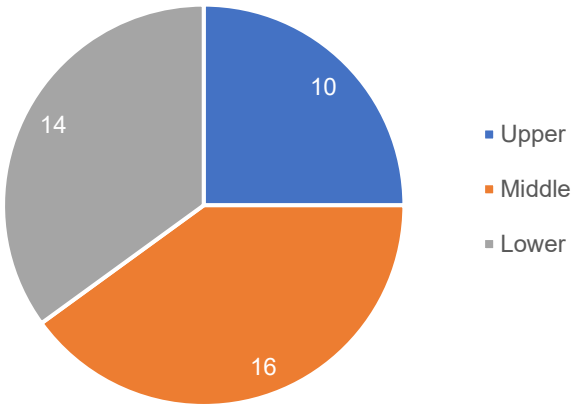


Figure 20 Amphibian population reported from various studies from different stretches of the Mahanadi River.

Odisha is the only state in India that supports all three native species of crocodiles: mugger (*Crocodylus palustris*), gharial (*Gavialis gangeticus*), and saltwater crocodile (*Crocodylus*

porosus). Overall analysis showed muggers are dominant in the Mahanadi river system, generally present throughout the river basin, and saltwater crocodiles are restricted to the estuarine region of the river. However, migration of the saltwater crocodile to freshwater regions of the river is sometimes reported. Gharials are the most important and endangered species of crocodiles in the Mahanadi river basin, restricted to only a few regions of the river (Satkosia and Tikerpada).

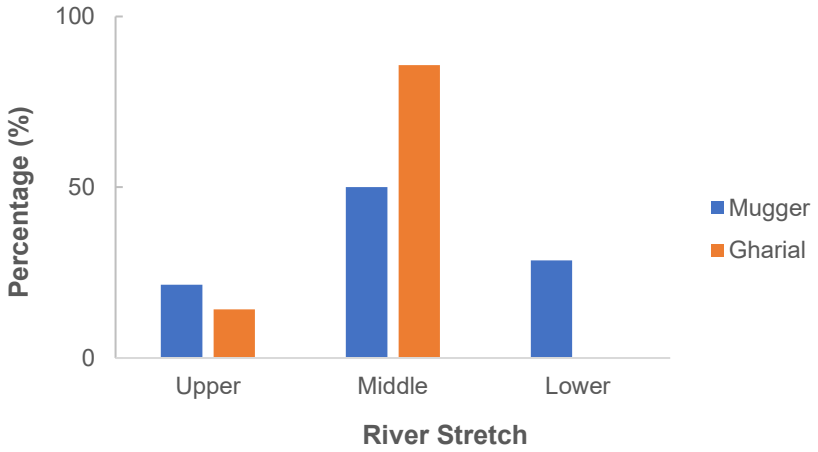


Figure 21 Percentage composition of crocodile species reported from various stretches of the Mahanadi river over the years.

The government has previously undertaken initiatives to revive the gharial population in the river. A study by Singh, L. A. K. (1999), recorded adult gharials in the Satkosia Gorge (a natural breeding and nesting centre) and a few juveniles near the Cuttack region. He also recorded muggers present throughout the river system. Senapati and Tripathy (1972) reported mugger from Cuttack and Hirakud reservoirs. A 2005 survey by Mohanty et al. revealed two pairs of gharial sightings in the Satkosia Gorge and 30-35 muggers (Fig.23). In 2006, a mugger survey recorded 40 muggers from the river stretches. A report by Nandankanan Zoological Park (2025) sighted some gharials at Satkosia Gorge and muggers in the entire middle stretch. Rufford Foundation for Nature Conservation, 2005, reported muggers and gharials from the Hirakud reservoir. Various articles on gharial and mugger sightings were reported specifically from the middle stretch of the river. The Wildlife Division of Odisha published a report in 2025 containing the wildlife census data from 2020 to 2025, which revealed the crocodile population in the Mahanadi river system (Fig. 21).

Freshwater turtles of the Mahanadi River inhabit river channels, reservoirs, sandbars, and associated wetlands. These turtles prefer slow-flowing stretches of the river, sandy banks, and floodplain wetlands where they can bask and nest. A total of 11 turtle species were recorded

from all stretches of the river basin, where species such as *Pangshura tentoria, Pangshura tecta, Batagur baska, Nilssonia gangetica* and *Chitra indica* were common along the entire stretch.

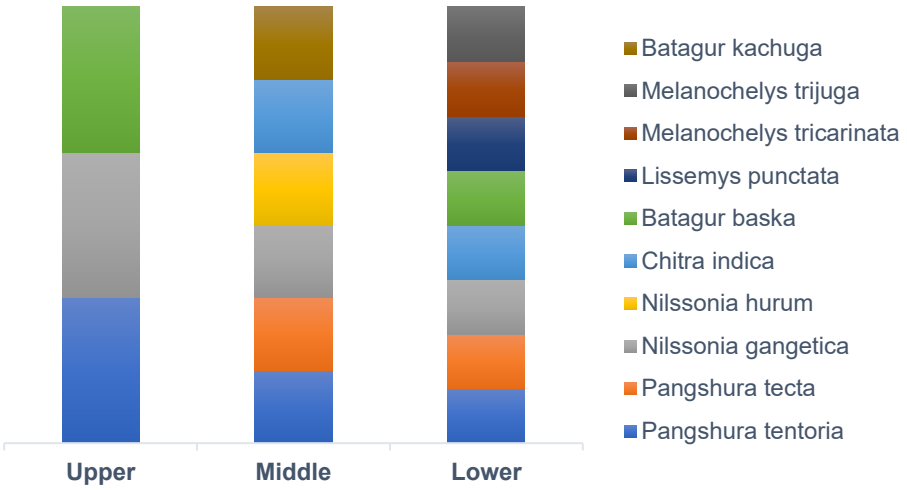


Figure 22 Types of turtle species found in different stretches of the Mahanadi river.

A turtle survey conducted in 2009 recorded 5 species of turtles from all stretches of the basin that are *Pangshura tentoria, Pangshura tecta, Nilssonia gangetica, Nilssonia hurum* and *Chitra indica*. Mahanadi in the Cuttack region reported 6 turtle species in 2015 (*Nilsonia gangeticus, Chitra indica, Pangshura tentoria, Melanochelys tricarinata*, etc.) (Fig.23). Rufford Foundation for Nature Conservation (2005) reported 3 species (*Nilssonia gangetica, Lissemys punctata*, and *Chitra indica*) from the lower stretch of the river. A documentation of reptiles of Odisha riverine systems revealed 4 species that are mostly present in the Mahanadi river. Mohanty et al. (2010) recorded *Kachuga* sp. (roofed turtle) from the middle stretch and *Chitra indica* from the Cuttack region. Composite analysis of data from all stretches revealed that the lower stretch comprises the most species (8), followed by the middle stretch (6) (Fig. 22). The upper stretch recorded only three species: *Pangshura tentoria*, Nilssonia gangetica, and *Batagur baska*.

Mahanadi River also hosts otters (Riparian) in some regions, mostly with abundant fish population, dense vegetation, large banks and low anthropogenic disturbances. Acharjyo, LN (1999) reported smooth-coated otter (*Lutrogale perspicillata*) from Barkul (*Chilika Lake*) and the Mahanadi River at the Cuttack region. In 2020, the Eurasian otter (*Lutra lutra*) was first recorded from Chilika Lake by Adhya and Dey (2020). Rath et al. (2022) reported *Lutrogale perspicillata* from the Mahanadi River at Boudh (Fig.23).

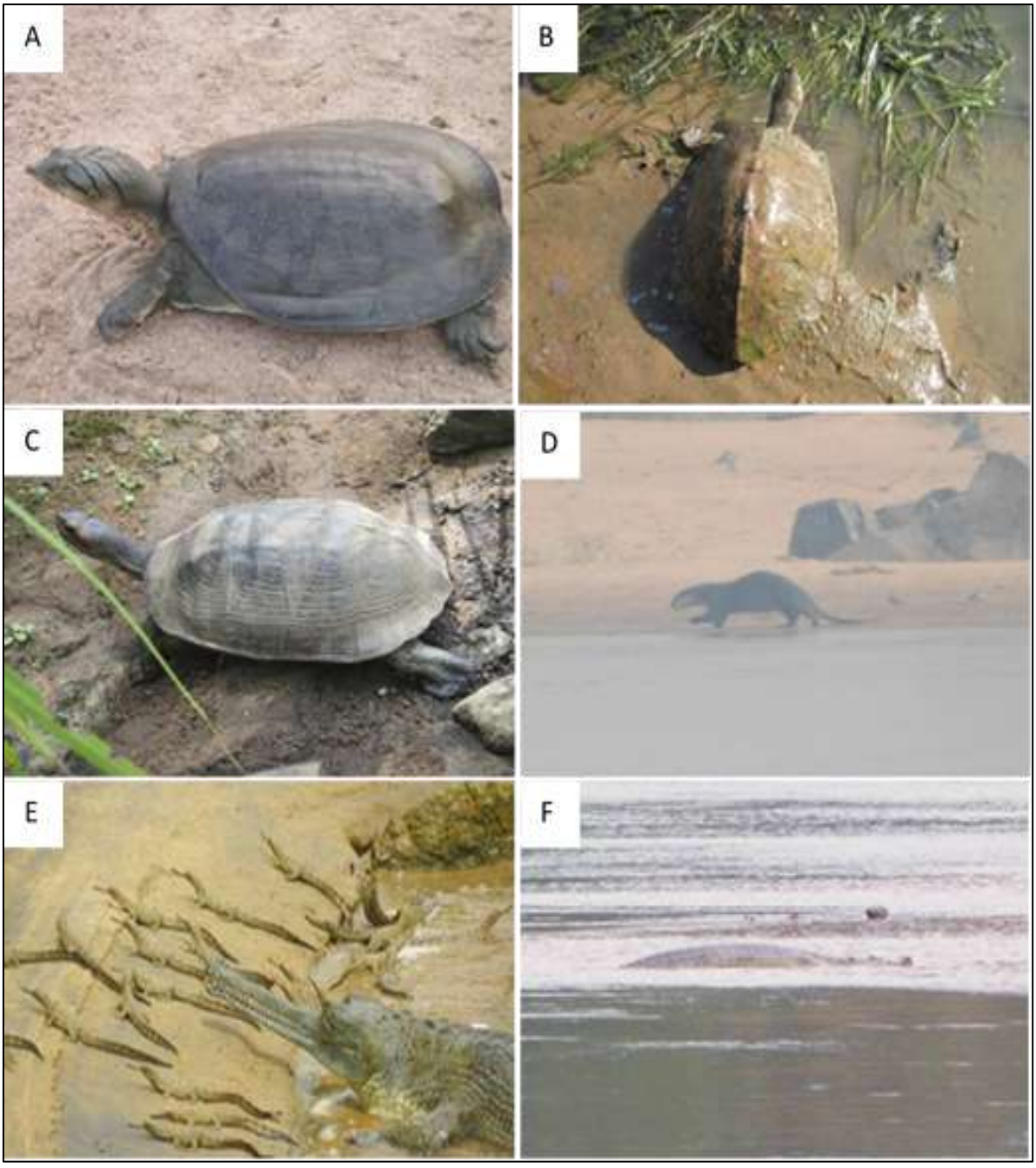


Figure 23 Megafauna of the Mahanadi River. A. Nilsonia gangeticus, B. Pangsura tentoria, C. Melanochelys trijuga (Sethy et al., 2015), D. smooth-coated otter (Lutrogale perspicillata) (Rath et al., 2022), E-F. Gharial (Gavialis gangeticus) (Mohanty et al., 2005).

3.3.5. Aquatic Aves

The Mahanadi River is a feeding, nesting, and resting ground for a rich diversity of resident and migratory birds. A total of 92 aquatic and water-associated birds were documented from all the sources, including 50 residents (e.g. A*cridotheres ginginianus, Acridotheres tristis, Alcedo atthis, Anas poecilorhyncha, Anhinga melanogaster, Apus affinis, Butorides striata, Ceryle rudis*, etc.) and 42 migratory birds (e.g. *Actitis hypoleucos, Anas acuta, Anas crecca,*

Anser anser, Aythya fuligula, Calidris minuta, Chlidonias hybrida, etc.) (Fig.25). S. Nanda (2002) reported 23 families of birds from the Hirakud region with Ardeidae (5 species), Cuculidae (5 species) and Sturnidae (4 species) of high species density, followed by other families with one or two species, such as Accipitridae, Alcedinidae, Columbidae, and Corvidae. Nair et al. (2014) reported 19 bird species from the Hirakud reservoir, with Anatidae (20%) family comprising the most species, followed by Laridae (12%) and Ardeidae (11%). A bird checklist released in 2025 by the eBird website recorded 68 species, dominated by the Anatidae (13 species) and Ardeidae (5 species) families. Jyethi et al. (2020) conducted a waterbird study in the Cuttack region and reported 42 species, mostly contributed by the Ardeidae family. Another waterbird study at Cuttack in 2016 revealed 50 species belonging to 13 families, largely contributed by Ardeidae, Charadriidae and Scolopacidae families. 81 aquatic birds from Satkosia, 10 from Paradeep, 98 from Jagatsinghpur, 25 from Tarapur, 16 from Banki, 8 from Boudh, 9 from Sonepur and 84 from Binka were observed and recorded on the eBird website.

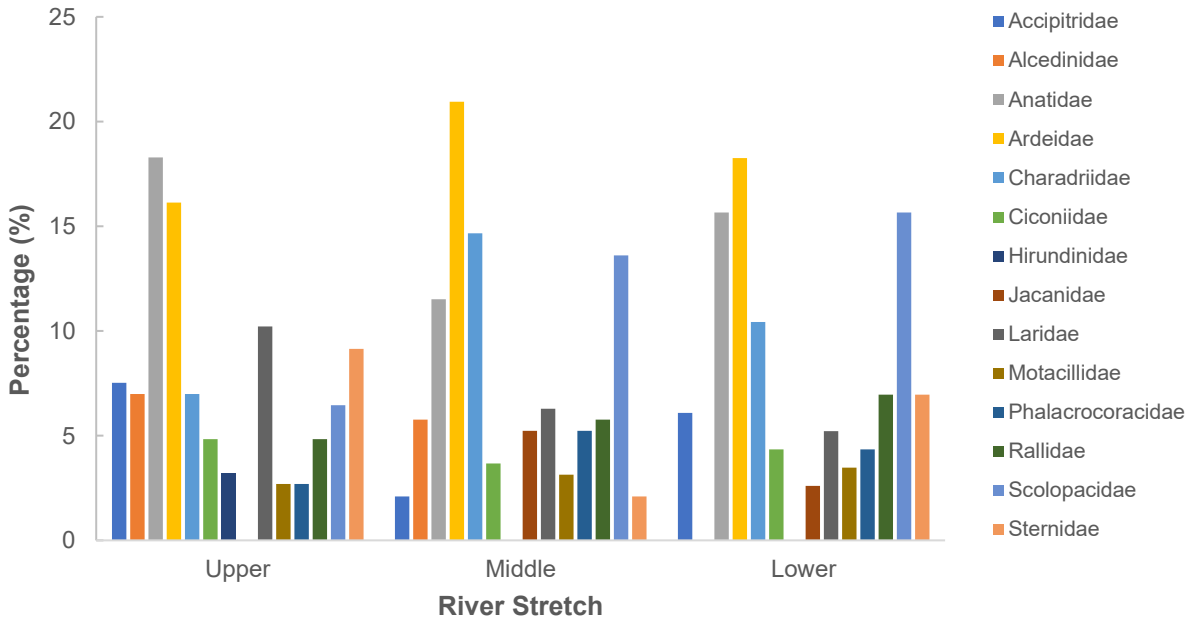


Figure 24 Percentage composition of major aquatic bird families recorded from all stretches of the Mahanadi River basin.

Composite analysis showed 22 major families of birds contributing to the overall composition of the river basin, where Anatidae (45%), Ardeidae (55%), Charadriidae (32%) and Scolopacidae (36%) contributed highly (Fig.24)

Figure 25 Aquatic aves from the Mahanadi River (Pradhan et al., 2021). A. River tern (Sterna aurantia), B. African Pied Wagtail (Motacilla aguimp), C. Rynchops albicollis (Indian Skimmer), D. Asian openbill (Anastomus oscitans), E. Black-bellied tern (Sterna acuti

3.4. Tributaries

Tributaries of the Mahanadi River form an interconnected network of rivers, wetlands, and forests that support diverse flora and fauna, making them ecologically vital components of the river basin. They host a wide variety of aquatic plants, plankton, fish, amphibians, reptiles, birds, and mammals by providing them with favourable habitats. These rivers support diverse fish communities that sustain local fisheries, Riparian vegetation and floodplain wetlands for breeding, feeding, and sheltering grounds for many resident and migratory birds and other wildlife.

However, the tributaries of the Mahanadi River have been studied very rarely, with some tributaries having no studies at all. Ong River, one of the major tributaries, reported no studies on any biological parameter.

3.4.1. Flora

Only a few studies have been conducted on floral diversity from the tributaries of the Mahanadi River.

3.4.1.1 Phytoplankton

Ghanendra Kumar Kar (1990) conducted a study on phytoplankton diversity of the Ib River, a doctoral thesis collected from Sambalpur University. He reported 38 species from 4 families, dominated by chlorophyceae (35%) and bacillariophyceae (32%), with major species such as *Ankistrodesmus* sp., *Clamydomonas globosa, Oedogonyum* sp. (Chlorophycae), *Cyclotolla* sp., *cymbella* sp., *Fragillaria* sp. (Bacilariophycae), *Anabena* sp., *Microcystis* sp., *Merismopedia glauca* (Cyanophycae). Chandran et al. (2021) reported 5 families and 48 species from the Ib river, where Chlorophyceae (20%) were more abundant, followed by Bacillariophyceae (10%) (Fig.26).

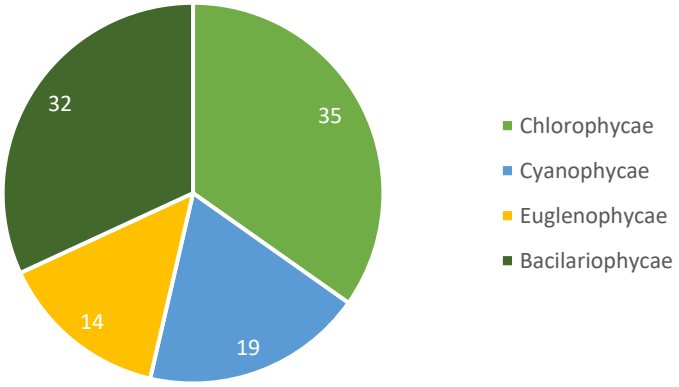


Figure 26 Percentage composition of major phytoplankton families recorded from the Ib River.

Overall analysis showed major species included Chlorella vulgaris, *Clamydomonas globosa, Closterium spp, Coelastrum reticulatum, Oedogonyum* sp., *Pediastrum simplex, Scendesmus* sp., *Spirogyra* sp. (Chlorophyceae), *Amphora* sp., *Achnanthes affinis, Cyclotolla* sp., *cymbella* sp., *Fragillaria* sp., *Frustulia* sp., *Navicula* sp. (Bacillariophyceae) and others such as *Euglena acus, Euglena viridis, Phacus caudatus* (Euglenophyceae), *Anabaena* sp., *Merismopedia glauca, Microcystis* sp., *Nostoc* sp. (Cyanophyceae). Temporal analysis from both studies showed an increase of Chlorophyceae and Euglenophyceae in recent studies (Fig.27).

Tandon et al. (2023) reported three genera of diatoms, *Melosira, Asterionella* and *Diatoma* from Shivnath River and 7 species, such as *Synedra, Cymbella, and Pinnularia* from the Hasdeo River.

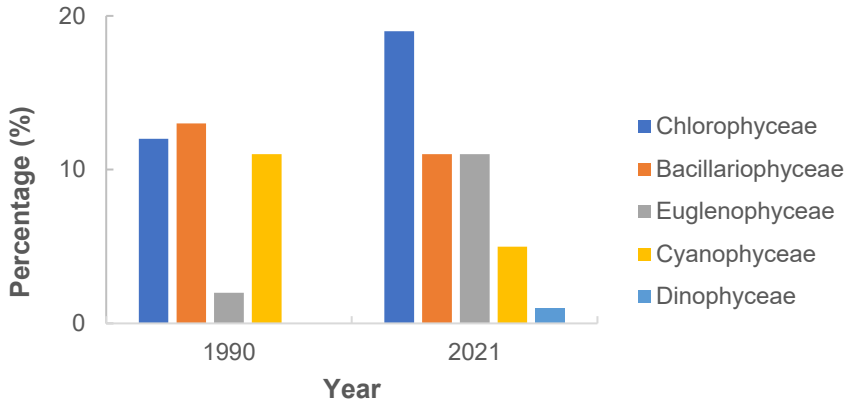


Figure 27 Temporal changes in phytoplankton families of the Ib River basin observed from the studies.

3.4.1.2 Periphyton

No study reported.

3.4.1.3 Riparian Vegetation

No study reported.

3.4.1.4 Floodplain Vegetation

Sohan Lal (2021) reported 16 species of floodplain weeds from the Shivnath River. Cyperaceae (19%) and Poaceae (25%) families contributed highly to the composition, with commonly found species such as *Cyperus polystachyos, Echinochloa colonum* and *Leptochloa chinensis* (Fig. 28).

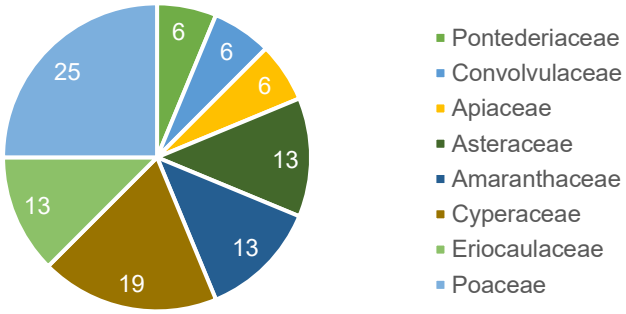


Figure 28 Family composition of semi-aquatic weeds recorded from Shivnath River

3.4.2. Fauna

Studies were very limited regarding the diversity of aquatic fauna in the tributaries.

3.4.2.1 Zooplankton

Studies conducted by Ghanendra Kumar Kar in 1990 and Chandran et al. (2021) recorded 10 and 14 zooplankton species, respectively, from the Ib River. In both studies, rotifers dominated the overall composition, followed by cladocerans and copepods. The recent study (i.e. 2021) included two extra groups in the composition, that are Ostracoda and Protozoa (Fig.29). Temporal analysis revealed an increase in species composition in most of the groups in the recent study (Fig.30).

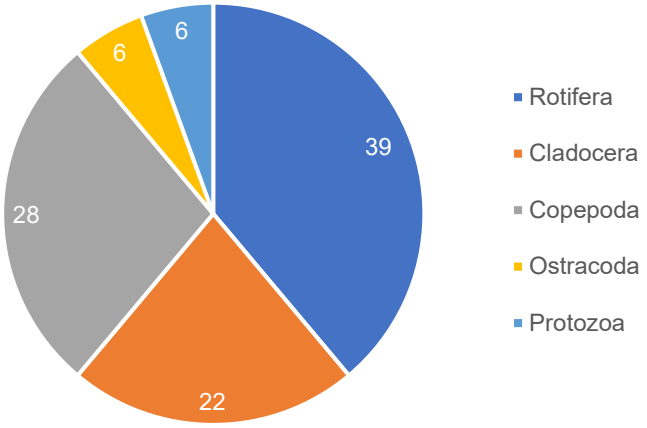


Figure 29 Percentage composition of zooplankton groups recorded from the Ib River.

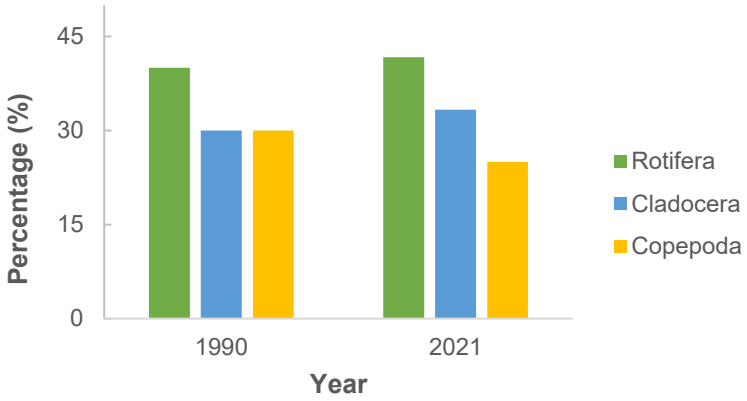


Figure 30 Temporal changes in zooplankton group composition reported from the Ib River.

3.4.2.2 Zoobenthos

No study reported.

3.4.2.3 Fishes

Two studies, Suryavanshi et al. (2024) and Chandran et al. (2019), reported a wide variety of fish from the Ib River. Chandran et al. (2019) recorded 55 species belonging to 18 families, with

species composition dominated by Cyprinidae (21%), and Suryavanshi et al. (2024) recorded 42 species from 21 families, with Anabantidae (43%) contributing the most, followed by Channidae (7%). Composite analysis from both studies revealed that Anabantidae (25%) and Cyprinidae (23%) dominated the overall composition, followed by other families, which contributed equally (Fig.31).

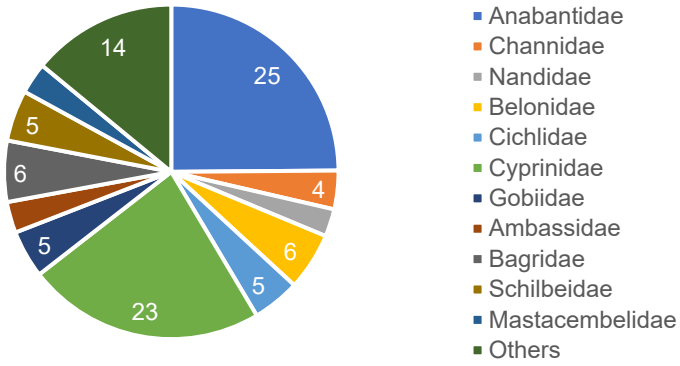


Figure 31 Percentage composition of fish families recorded from the Ib River

Khanani et al. (2018) reported 34 fish species, and Kumar et al. (2020) recorded 59 species from Shivnath River with dominance of *Cyprinidae, Bagridae and Channidae. Catla catla, Cirrhinus mrigala, Labeo rohita, Labeo calbasu, Puntius sarana, Mystus tengara* and *Channa punctata* were common among these. Pandey et al. (2024) reported 7 species, mostly from the Cyprinidae family. Guru and Pandey (2024) recorded 21 species from the Shivnath River, entirely belonging to the Cyprinidae family. Combinely, birds from Cyprinidae (40%) and Bagridae (11%) families dominate the Shivnath River region (Fig.32).

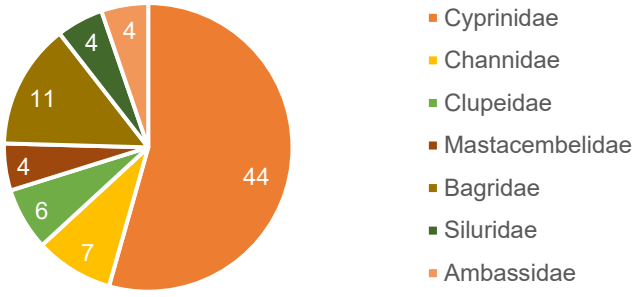


Figure 32 Percentage composition of fish families recorded from the Shivnath River.

Chandran et al. (2021) also reported an ichthyofaunal diversity study from the Tel River, another tributary of the Mahanadi River. 69 species and 22 families were recorded from this study, with Cyprinidae (50%) leading the composition, followed by Bagridae (6%). *Labeo catla, Labeo bata,*

Labeo boga, Labeo calbasu, Labeo rohita, Cirrhinus reba, Cirrhinus mrigala, Barilius barila, Osteobrama cotio, Ompok pabda, Wallago attu, Mystus cavasius, Bagarius bagarius, Channa punctata, Lates calcarifer, Notopterus notopterus and *Gudusia chapra* were commonly found during the study (Fig.33).

A study by Toppo et al. (2024) in the Hasdeo River recorded 25 fish species, with the Cyprinidae family comprising the most. Siddhiqui and Verma (2025) reported migratory fishes from the river, such as *Catla catla, Sirrhinus mrigal* and *Wallago attu*. Another study by Khanani et al. (2018) recorded Cyprinidae (50%) dominance followed by Channidae (15%) and Bagridae (15%) in the region (Fig.34). Overall analysis revealed Cyprinidae (50%) comprising the most in the Hasdeo River with *Rita* catfish and *Tor mahseer* like endangered species.

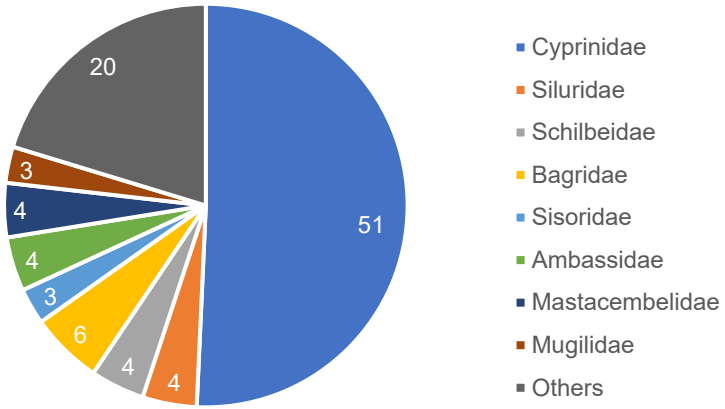


Figure 33 Percentage composition of fish families recorded from the Tel River.

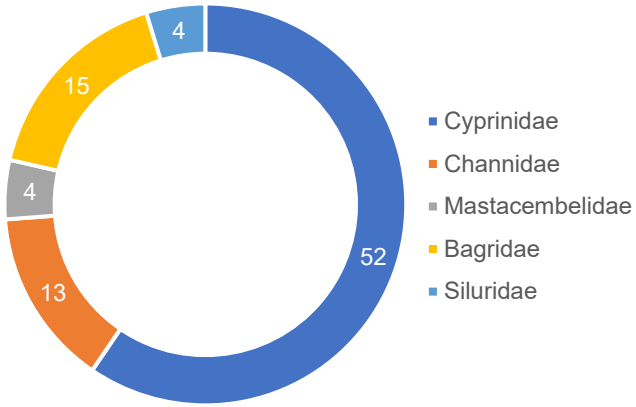


Figure 34 Percentage composition of major fish families recorded from the Hasdeo River.

3.4.2.4 Higher Aquatic Vertebrates

No study reported.

3.4.2.5 Aquatic Aves

No studies have been reported from the tributaries of the Mahanadi River in Odisha regarding aquatic bird diversity. Some bird species from the Ib River were collected from the eBird website, which records birds from any location at any time by anyone. The website recorded 71 aquatic bird species and 15 families, with families such as Anatidae (20%), Ardeidae (17%), Rallidae (10%), Charadriidae (10%), Scolopacidae (11%), and Laridae (10%) dominating the overall composition. *Nettapus coromandelianus, Anas poecilorhyncha, Anas acuta, Aythya fuligula, Aythya ferina, Tachybaptus ruficollis, Microcarbo niger, Phalacrocorax fuscicollis, Ardeola grayii, Ardea alba, Ardea cinerea, Butorides atricapilla, Threskiornis melanocephalus, Anastomus oscitans, Thinornis dubius, Sterna aurantia, Chlidonias hybrida* and *Rynchops albicollis* were the common species recorded from the Ib River basin (Fig.36).

Pandey et al. (2024) recorded 59 bird species and 14 families from the Shivnath River region. Major contributors were Anatidae (17%), Scolopacidae (17%), Charadriidae (9%), Rallidae (10%) and Ardeidae (19%). Bar-headed Goose, Common Teal, Common Snipe, Eurasian Coot, Common Moorhen, Little Egret and Grey Heron were the common birds observed during this study (Fig.35).

Several studies from the Hasdeo River revealed 63 species from 20 families, with Anatidae (20%) and Ardeidae (15%) families contributing the most. Bharos et al. (2023) and Anthony and Tiwari (2023) conducted these studies in different locations of the Hasdeo River. Common birds such as Bar-headed Goose, Purple Heron, Little Egret and Common Teal were recorded during these studies. Some species found are endangered, vulnerable and near threatened, such as *Heteroglaux blewitti, Neophron percnopterus* (Endangered), *Aythya ferina, Grus antigone* (Vulnerable) and *Threskiornis melanocephalus, Limosa limosa, Sterna aurantia* (Near Threatened) (Fig.37).

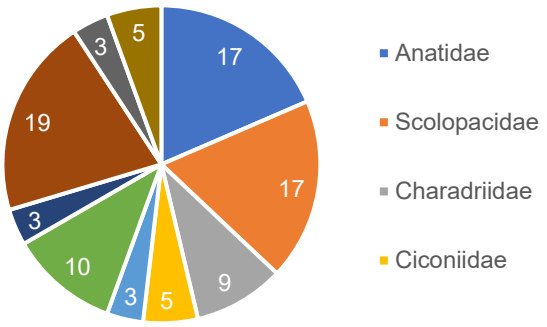


Figure 35 Percentage composition of aquatic bird families recorded from the Shivanath River.

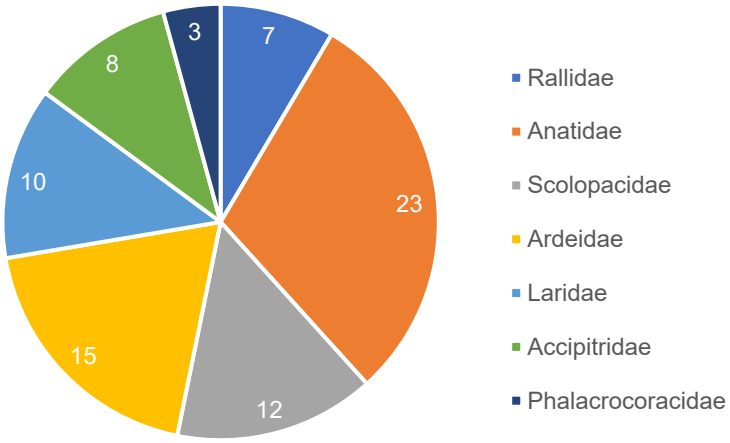


Figure 36 Percentage composition of aquatic bird families recorded from the Ib River.

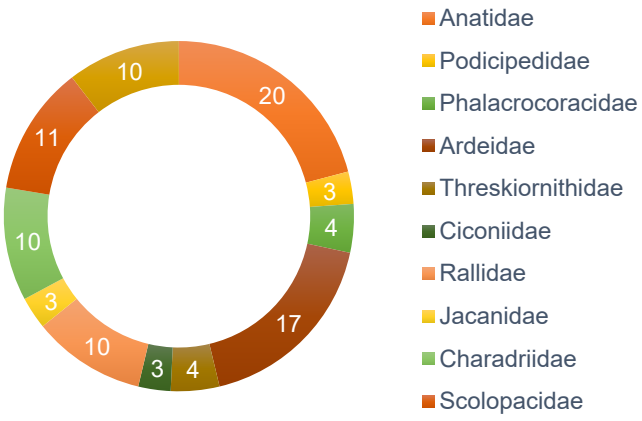


Figure 37 Percentage composition of aquatic bird families recorded from the Hasdeo River.

4. Status of major focal riverine species

All riverine systems have key species that contribute to the productivity, structure and stability of aquatic ecosystems. They play important environmental indicators providing status on river productivity, harsh environmental conditions and anthropogenic pressures. This allows them to be used as key components of biological factors to study the productivity status of the riverine system. These species include primary producers, consumers, and top predators that regulate ecological processes and energy flow. Phytoplankton and periphyton act as primary producers, forming the base of the food web and supporting higher trophic levels. Aquatic macrophytes provide habitat, breeding grounds, and shelter for fish, invertebrates, and amphibians. Zooplankton and benthic invertebrates serve as important links between primary producers and larger organisms by transferring energy through the food chain. Fish species function as predators, herbivores, and detritivores, helping to regulate population dynamics and nutrient cycling. Higher vertebrates such as turtles, crocodiles, otters, and aquatic birds contribute to maintaining ecological balance by controlling prey populations and facilitating nutrient redistribution.

The Mahanadi River system also hosts several key focal species across all of its stretches.

4.1. Identification of ecologically significant species for each stretch

Plankton and zooinvertebrates are major ecologically significant organisms and indicators that contribute to the overall health of the riverine ecosystem. Studies have shown that key families of phytoplankton, such as Bacillariophyceae, Chlorophyceae, and Cyanophyceae, are generally dominant across all stretches; however, Bacillariophyceae are more prominent in the upper stretch. Bacillariophyceae and Chlorophyceae significantly contribute to the phytoplankton biomass in the middle stretch of the basin. The lower stretch is mostly dominated by the Chlorophyceae family.

Zooplankton groups such as rotifers and cladocerans dominate the upper stretch according to the studies. Rotifers contributed majorly to the middle stretch zooplankton composition among all the stretches, followed by cladocerans. Protozoa contributed the most in the lower stretch for the zooplankton population, followed by rotifers.

Molluscs need hard substrates for attachment and are sensitive to environmental changes, making them important environmental indicators of aquatic systems. The studies showed molluscs (mostly gastropods) and arthropods are more abundant in the upper stretch than other zooinvertebrates. The middle stretch dominates the overall mollusc composition with 70% in the Mahanadi River, followed by annelids (mostly oligochaetes), which indicates good

habitat conditions for both. Arthropods (~50%) and annelids have shown high dominance in the lower stretch, but molluscs showed less abundance.

Carps (Cyprinidae) are highly distributed throughout the Mahanadi river basin, followed by catfishes (Bagridae). The upper stretch has the highest abundance. Snakeheads (Channidae) have managed to keep a similar composition at all stretches. *Tor mosal mahanadicus* (Cyprinidae) is the famous mahseer fish species endemic to the Mahanadi River in Odisha, mostly confined to the Hirakud region, which is included in the endangered species list. Lower and middle stretches represent a similar proportion of carp and catfish. The Mahanadi catfish *Rita chrysea* (Bagridae) are most commonly present in the river but are only reported in the upper stretch of the river, marking its lower abundance or absence in other stretches. *Ompok pabda* (Siluridae) and *Chitala chitala* (Notopteridae) are two endemic species found in all stretches that are now recognised as endangered.

Batagur baska (Northern River Terrapin) and *Nilssonia hurum* (Peacock Softshell Turtle) are recorded as critically endangered and vulnerable turtle species, respectively, in the Mahanadi River. *Batagur baska* has been reported only from the lower stretch near the Mahanadi delta, while *Nilssonia hurum* has been documented from multiple locations in the middle stretch. Among the commonly observed species categorised as least concern, *Lissemys punctata* (Indian Flapshell Turtle) has been recorded from Cuttack and the Mahanadi delta region; *Pangshura tecta* (Indian Roofed Turtle) from the middle and lower stretches (including Cuttack); *Pangshura tentoria* (Indian Tent Turtle) across all river stretches; and *Melanochelys trijuga* (Indian Black Turtle) only from the Cuttack region. *Nilssonia gangetica* (Indian Softshell Turtle) is the only listed vulnerable species reported across all river stretches.

The smooth-coated otter (*Lutrogale perspicillata*), the only semi-aquatic carnivorous mammal reported from the Mahanadi River basin, is generally observed in the middle (Satkosia) and lower (Cuttack) stretches. The species is considered vulnerable in the region and is rarely sighted. In addition, the Eurasian otter (*Lutra lutra*), a species long regarded as near threatened, has recently been reported from Chilika Lake within the Mahanadi River basin.

Crocodiles of the Mahanadi River were mostly reported from the middle stretch, as a reserve forest surrounds the river in this region. *Gavialis gangeticus* (Gharial), a critically endangered species, is mostly recorded from the middle stretch, specifically confined to Satkosia Gorge due to its strict habitat preference. *Crocodylus palustris* (Mugger) is generally observed throughout the river stretches listed as a vulnerable species. According to a recent wildlife

census, gharials have shown little increase in their abundance, and the mugger population has decreased in recent years (Fig.39).

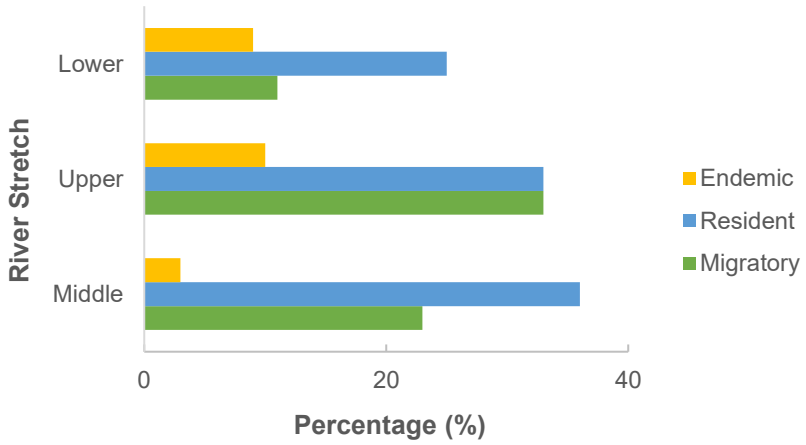


Figure 38 Percentage composition of different types of bird species in various stretches of the Mahanadi River.

Sterna aurantia (River Tern) and *Threskiornis melanocephalus* (Black-headed Ibis) are two endemic bird species of the lower stretch (Cuttack region) that are listed as near threatened in recent studies. A common resident, *Anhinga melanogaster* (Oriental Darter), is a near-threatened species in the region. Other residents and migratory birds such as *Anas acuta* (Northern Pintail), *Chroicocephalus brunnicephalus* (Brown-headed Gull), *Coracias benghalensis* (Indian Roller), *Corvus splendens* (House Crow), and *Acridotheres tristis* (Common Myna) are least concern species in the Cuttack region. Upper stretch hosts 10 endemic species, where *Sterna acuticauda* (Black-bellied Tern), *Rynchops albicollis* (Indian Skimmer) are registered as endangered, and *Sterna aurantia* (River tern), *Psittacula eupatria* (Alexandrine Parakeet) are considered near threatened. Studies reported only 3 bird species endemic to the middle stretch of the river, such as *Rynchops albicollis* (Indian Skimmer), *Sterna acuticauda* (Black-bellied Tern), and *Sterna aurantia* (River Tern) as endangered and *Sterna aurantia* (River Tern) as near threatened species (Fig.38).

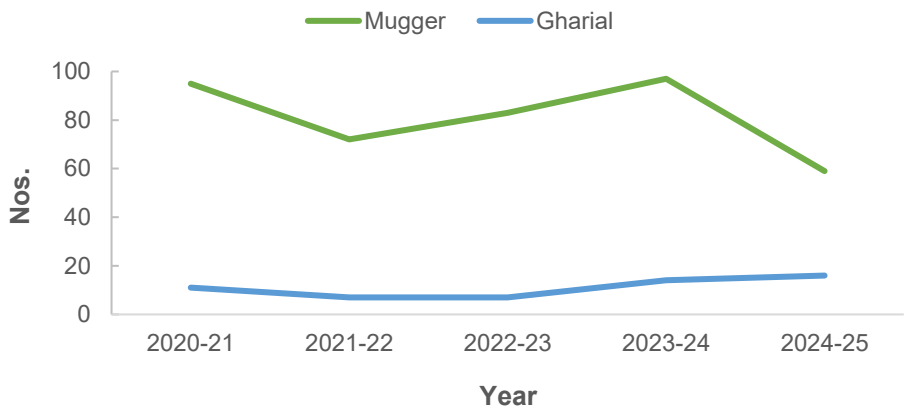


Figure 39 Temporal shifts in crocodile population in the Mahanadi river, census data from the year 2020 to 2025 published by Odisha Wildlife Division.

Temporal analysis indicates an increase in the diversity of all phytoplankton families in recent studies (2000–2025). However, this trend may be misleading, as the apparent increase could be attributed to a higher number of studies conducted in recent years, often covering multiple locations, compared to earlier periods. For zooplankton, the analysis reveals a decline in key groups such as rotifers and cladocerans over time. Similarly, carp and catfish have shown a decrease in abundance in recent years across all river stretches. Due to the lack of data on the abundance of Mahanadi mahseer, a temporal assessment for this species could not be performed.

4.2 Conservation and management needs

Plankton and zooinvertebrates form the foundation of riverine health. They are highly sensitive to sudden changes in water quality, making them reliable indicators of environmental and anthropogenic pressures. Therefore, periodic monitoring of these parameters is essential to assess river health and ensure suitable habitat conditions for higher-trophic-level organisms.

The gharial crocodile has been of significant conservation interest in Odisha for many decades. Several projects have been initiated to revive the gharial population in the Mahanadi River, most of which have been managed by Nandankanan Zoological Park in Bhubaneswar. The institute has been engaged in efforts to promote natural breeding in the Satkosia Gorge

stretch of the river for many years. Recently, successful breeding was reported in natural pools; however, the population continues to decline due to unsuitable habitat conditions. Focused attention is required to support these efforts through adequate funding, stricter regulations, and community engagement.

In addition to the gharial, the state also undertakes conservation measures for riverine turtles and other aquatic fauna. Awareness and participation among fishermen and local communities have improved conservation outcomes to some extent. However, riverine turtles require greater recognition in conservation programs, particularly for endemic species. Furthermore, otters are now rarely observed along river stretches, highlighting the urgent need for conservation measures to prevent them from becoming critically endangered within the state.

Odisha recently signed a Memorandum of Understanding (MoU) with ICAR-CIFA to conserve the iconic Mahanadi mahseer, the state fish. This marks a significant step toward biodiversity conservation and species restoration. Protecting endemic fish species requires special attention, as their revival in natural habitats is highly challenging and depends on the strict regulation of fishing practices, which support millions of livelihoods. Scientifically informed and economically viable management strategies can help achieve a balance between conservation and livelihood needs.

The Mahanadi River also supports both resident and migratory bird species, which depend on it for food, breeding, and nesting. Many resident and endemic bird species are now classified as near threatened or vulnerable due to rapid habitat alteration and human disturbances. Several studies have raised concerns regarding bird conservation and have recommended timely government intervention. Habitat restoration and maintaining overall river health will not only support endemic species but also attract a greater diversity of migratory birds.

Table 13 Conservation status of key species found in the Mahanadi River.

Group	Species	Stretch reported	IUCN status	Conservation status	Recommendation
Planktons		All	---	---	Need to be evaluated annually to maintain the productivity of the river.
Zoobenthos		All	---	---	

Fish (Endemic)					
Cyprinidae	*Tor mosal mahanadicus*	Upper	Endangered	Odisha govt. has signed MoU with ICAR-CIFA to conserve the Mahanadi Mahseer.	Specific attention towards endemic species conservation in the river.
Notopteridae	*Chitala chitala*	All	Endangered		
Siluridae	*Ompok pabda*	All	Endangered		
Reptiles					
Turtle	*Batagur baska*	Lower	Critically endangered	Awareness and local people engagement have shown some impact	Need similar attention to riverine turtles as marine ones near the coast.
	Nilssonia hurum	Middle	Vulnerable		
	Nilssonia gangetica	All	Vulnerable		
Crocodile	*Gavialis gangeticus* (Gharial)	Middle	Critically endangered	Multiple attempts by the govt. to revive the gharial population in the river. Recently, a breeding success at Satkosia Gorge has been reported.	Need habitat recreation and management in the river for their survival.
	Crocodylus palustris (Mugger)	All	Vulnerable		
Birds	*Sterna aurantia* (River Tern)	All	Near threatened		
	Threskiornis melanocephalus (Black-headed Ibis)	Lower	Near threatened		Real-time observation and habitat restoration may

	Sterna acuticauda (Black-bellied Tern)	Upper & Middle	Endangered		increase their population.
	Rynchops albicollis (Indian Skimmer)	Upper & Middle	Endangered		
	Psittacula eupatria (Alexandrine Parakeet)	Upper	Near threatened		
Mammal	Smooth-coated otter (*Lutrogale perspicillata*)	Middle	Vulnerable		A state-level priority project is needed to conserve them.
	Eurasian otter (*Lutra lutra*)	Middle & Lower	Near threatened		

5. Conclusion and recommendations

The Mahanadi River Basin exhibits considerable biological diversity supported by its varied geomorphology, hydrological conditions, and habitat types. The basin supports a wide range of aquatic and riparian communities, including phytoplankton, periphyton, macrophytes, zooplankton, benthic organisms, fishes, amphibians, reptiles, birds, and mammals. Biological composition varies across the Upper, Middle, and Lower Mahanadi and among the major tributary sub-basins, reflecting differences in climate, topography, river morphology, and land use.

The review also indicates that biological communities in several river stretches are influenced by flow regulation, habitat modification, pollution, urbanisation, mining, and floodplain alteration. While many ecologically important habitats continue to support rich biodiversity, systematic biological information remains fragmented and unevenly distributed across the basin.

Flagship species of the Mahanadi River basin, such as the gharial and Mahseer fish, require greater government support to strengthen conservation efforts. Separate initiatives should also be undertaken to conserve other key threatened freshwater species of the basin, including

otters, riverine turtles, endemic water birds, and fish, to improve the overall ecological health of the river. Periodic monitoring (annually or biannually) of plankton and zoobenthos should be conducted across different stretches of the river by a single organisational body. This would provide continuous updates on the river's health and support the planning and implementation of effective conservation strategies.

This report consolidates the available biological information into a single reference document and establishes a baseline for future biodiversity assessment, ecological monitoring, and river basin planning.

5.1 Recommendations

Based on the present assessment, the following actions are recommended:

1. Undertake systematic field surveys in poorly documented river stretches to validate and update species inventories.
2. Standardise biological monitoring protocols across the basin to enable comparison of biodiversity trends over time.
3. Periodically update the Biological Profile by incorporating new scientific studies, field observations, and monitoring data.
4. Identify priority river reaches requiring detailed ecological assessment based on species richness, habitat uniqueness, and existing anthropogenic pressures.
5. Integrate biological information with hydrological, geomorphological, and water quality datasets to support basin-level ecological assessment.
6. Develop a georeferenced biodiversity database for the Mahanadi River Basin to facilitate future monitoring and planning.
7. Encourage coordinated data sharing among research institutions, government agencies, and universities working within the basin.
8. Use this biological baseline while preparing river restoration, conservation, environmental assessment, and river management studies within the basin.

5.2 Intended Applications and Uses of this Report

This report is intended to serve as a technical reference for understanding the biological characteristics of the Mahanadi River Basin. It may be used for:

- preparation of river basin management and river rejuvenation plans;
- identification of ecologically important river reaches and biodiversity hotspots;
- providing baseline information for Environmental Impact Assessment (EIA) and environmental appraisal studies;
- planning biodiversity monitoring and ecological assessment programmes;
- supporting research on aquatic ecology, fisheries, wetlands, and river biodiversity;
- prioritising field investigations in data-deficient sub-basins;
- developing biodiversity databases and decision-support systems for the basin; and
- serving as a reference document for government departments, academic institutions, consultants, and conservation organisations working in the Mahanadi River Basin.

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Appendix-1: Distribution of all aquatic organisms at different stretches of the Mahanadi River.

1-a. Distribution of phytoplankton in the Mahanadi River.

Bacillariophyceae	**Stretches of the Mahanadi River**			**Chlorophyceae**	**Stretches of the Mahanadi River**		
	Upper	**Middle**	**Lower**		**Upper**	**Middle**	**Lower**
Amphora veneta	+	–	+	*Actinastrum* sp.	+	–	+
Amphora ulna	–	+	+	*Ankistrodesmus falcatus*	+	+	+
Aulacoseira granulata	+	+	–	*Ankistrodesmus* sp.	–	–	+
Bacillaria paradoxa	–	–	+	*Caloneis bacillum*	–	+	+
Caloneis silicula	+	+	–	*Chlamydomonas globosa*	+	–	–
Cocconeis sp.	–	+	–	*Chlorella vulgaris*	+	+	–
Coscinodiscus asteromphalus	–	–	+	*Chlorococcum humicola*	–	–	+
Coscinodiscus centralis	–	–	+	*Cladophora glomerata*	+	+	+
Coscinodiscus concinnus	–	–	+	*Cladophora laetevirens*	+	–	+
Coscinodiscus excentricus	–	–	+	*Closteriopsis* sp.	+	–	–
Coscinodiscus radiatus	–	–	+	*Closterium acerosum*	+	–	–
Coscinodiscus subtilis	–	–	+	*Coelastrum astroideum*	+	–	+
Cyclotella meneghiniana	+	–	–	*Coelastrum reticulatum*	+	+	–
Cyclotella comata	–	+	+	*Coelastrum microporum*	–	–	+
Cylindrotheca sp.	–	–	+	*Coelastrum stroidum*	+	+	–
Cymbella aspera	+	+	–	*Cosmarium boculetum*	–	+	+
Cymbella ehrenbergii	+	–	+	*Cosmarium botrytis*	–	+	+
Cymbella naviculiformis	–	+	+	*Cosmarium contractum*	+	–	+
Cymbella turgidula	–	+	–	*Cosmarium dentiferum*	+	+	+
Cymbella tumida	+	–	+	*Cosmarium eductum*	+	–	–
Diadesmis confervacea	+	–	+	*Cosmarium leave*	+	–	+
Diatoma elongata	+	–	–	*Cosmarium nitidulum*	+	+	+
Denticula sp.	–	+	–	*Cosmarium radiosum*	+	+	–
Diploneis elliptica	–	+	–	*Cosmarium reniforme*	–	+	+
Encyonema sp.	+	–	–	*Crucigenia* sp.	+	–	–
Epithemia turgida	+	+	–	*Dispora cuneiformis*	+	–	–
Epithemia turgidula	+	–	–	*Euastrum spinulosum*	+	–	+
Fragilaria intermedia	+	–	+	*Eudorina* sp.	+	–	–
Frustulia sp.	+	–	–	*Hydrodictyon reticulatum*	+	–	+
Gomphoneis herculeana	+	–	–	*Kirchneriella lunaria*	–	+	–

Gomphonema augur	+	–	–	*Kirchneriella lunaris*	–	+	–
Gomphonema clavatum	+	–	–	*Kirchneriella* sp.	+	–	–
Gomphonema constrictum	+	–	–	*Monoraphidium* sp.	–	–	+
Gomphonema lanceolatum	–	+	+	*Oedogonium chungkingense*	+	+	–
Gyrosigma sp.	+	–	–	*Oedogonium crispum*	+	–	–
Gyrosigma attenuatum	–	+	+	*Oocystis* sp.	–	+	–
Hantzschia amphioxys	–	+	–	*Pandorina* sp.	+	+	–
Mastogloia sp.	+	–	–	*Pediastrum duplex*	+	–	–
	Upper	**Middle**	**Lower**		**Upper**	**Middle**	**Lower**
Melosira ambiguna	+	–	–	*Pediastrum ovatum*	+	–	–
Melosira granulata	–	–	+	*Pediastrum simplex*	+	–	+
Navicula anglica	–	+	–	*Pediastrum tetras*	+	–	–
Navicula aponina	–	+	–	*Phacus pleronectes*	–	+	+
Navicula brebissonii	–	+	–	*Scenedesmus acuminatus*	–	+	+
Navicula cuspidata	–	+	+	*Scenedesmus acutiformis*	+	–	–
Navicula gonzalvensiana	+	–	–	*Scenedesmus armatus*	–	+	–
Navicula gregaria	+	–	–	*Scenedesmus bijugatus*	+	+	–
Navicula lanceolata	–	+	–	*Scenedesmus brasiliensis*	+	–	+
Navicula laterostrata	–	+	+	*Scenedesmus denticulatus*	–	–	+
Navicula microspora	+	–	–	*Scenedesmus dimorphus*	–	+	–
Navicula oblonga	+	–	–	*Scenedesmus ellipticus*	+	+	+
Navicula rostrella	–	+	–	*Scenedesmus longus*	+	–	–
Navicula spicula	+	+	–	*Scenedesmus perforatus*	–	+	–
Navicula truncata	–	+	–	*Scenedesmus quadricauda*	+	+	+
Navicula viridis	–	+	–	*Schroederia setigera*	–	+	–
Nitzschia acicularis	+	+	–	*Spirogyra longata*	–	+	+
Nitzschia closterium	–	+	+	*Spirogyra oblata*	+	–	+
Nitzschia frustulum	+	–	–	*Spirogyra varian*	–	+	+
Nitzschia incurva	+	–	+	*Spirogyra weberi*	–	+	+
Nitzschia lorenziana	–	+	–	*Staurastrum manfeldtii*	+	–	+
Nitzschia obtusa	+	–	+	*Surirella euglypta*	–	+	–
Nitzschia palea	+	–	–	*Surirella robusta*	–	–	+
Nitzschia sublinearis	–	+	–	*Synedra crystallina*	–	+	–
Pinnularia acrosphaeria	–	+	–	*Tetraedron caudatum*	–	–	+

Pinnularia gibba	−	+	+
Pinnularia viridis	−	+	+
Placoneis sp.	+	+	−
Plagiotropis lepidoptera	−	+	−
Planothidium sp.	−	+	−
Pleurosigma sp.	−	+	−
Rhopalodia gibba	+	+	+
Rhopalodia operculata	−	−	+
Sellaphora bacillum	+	−	−
Stauroneis africana	+	−	+
Surirella robusta	+	−	+
Surirella sp.	−	+	−
Synedra acus	+	−	+
Synedra ulna	+	−	+
Thalassiosira angulata	−	−	+
Tryblionella apiculata	−	+	−
Tryblionella sp.	−	+	−
	Upper	**Middle**	**Lower**
Homoeothrix janthiana	−	−	+
Homoeothrix varians	+	−	−
Leptolyngbya terebrans	+	+	−
Lyngbya latissima	−	−	+
Lyngbya majuscula	+	−	−
Lyngbya majuscuta	−	+	+
Lyngbya rubida	+	−	+
Merismopedia glauca	+	−	−
Merismopedia tenuissima	−	+	−
Microcystis aeruginosa	−	+	+
Microcystis sp.	+	−	−
Nostoc commune	−	+	+
Nostoc sp.	+	−	−
Oscillatoria amoena	+	−	−
Oscillatoria amphigranulata	−	+	+
Oscillatoria limosa	−	+	+
Oscillatoria nigro-viridis	+	−	+
Oscillatoria orientalis	+	−	−
Volvox sp.	+	−	+
Westella sp.	−	−	+
Cyanophyceae			
Anabaena blasoletana	−	+	+
Anabaena orientalis	+	−	−
Anabaena variabilis	+	+	+
Aphanocapsa conferta	−	+	−
Aphanocapsa grevillei	−	+	−
Aphanocapsa incerta	−	+	−
Aphanocapsa mucicola	−	−	+
Arthrospira sp.	+	−	−
Calothrix parietina	+	−	−
Chroococcus limneticus	−	+	+
Chroococcus minutus	−	−	+
Chroococcus turgidus	+	−	−
Gloeothece membranacea	−	+	−
Gloeocapsa granosa	+	−	−
Geitlerinema amphibium	+	−	−

Oscillatoria simplicissima	+	+	+
Phormidium autumnale	–	–	+
Phormidium favosum	–	+	+
Phormidium formosum	–	–	+
Phormidium retzii	+	–	–
Pseudanabaena catenata	+	+	+
Rivularia globiceps	–	–	+
Rivularia minulala	–	+	+
Schizothrix friesii	–	–	+
Spirulina sp.	+	–	–
Spirogyra sp.	+	–	–
Stigonema ocellatum	+	–	–
Woronichinia fremyi	+	–	–

1-b. Distribution of Zooplankton in the Mahanadi River.

Cladocera	**Stretches of the Mahanadi River**				**Stretches of the Mahanadi River**		
	Upper	**Lower**	**Middle**		**Upper**	**Lower**	**Middle**
Alona sp.	+	+	+	*Conochilus* sp.	+	+	+
Alonella sp.	+	+	+	*Filina longiseta*	-	+	+
Bosmina sp.	+	+	+	*Filinia* sp.	+	-	+
Ceriodaphnia reticulate	-	+	+	*Gastropus* sp.	+	+	+
Ceriodaphnia rigaudi	-	+	+	*Horaella* sp.	+	+	+
Ceriodaphnia sp.	+	-	+	*Keratella* sp.	+	+	+
Chydorus sp.	+	+	+	*Keratella tropica*	-	+	-
Daphnia Carinata	-	+	+	*Lecane* sp.	+	+	+
Daphnia sp.	+	-	+	*Lophocharis* sp.	+	-	+
Diaphanosoma exisum	-	+	+	*Monostyla bulla*	-	+	+
Diaphanosoma sp.	+	-	+	*Monostyla quadridentata*	-	+	+
Leydigia sp.	+	+	+	*Monostyla* sp.	+	-	+
Macrothrix sp	-	+	+	*Mytilina* sp.	+	+	+
Moina micrura	-	+	+	*Notholca accuminata*	-	+	+
Moina sp.	+	-	+	*Notholca* sp.	+	-	+
Sida sp.	+	+	+	*Platyias quadricornis*	-	+	+
Simocephalus vetulus	-	+	+	*Polyarthra* sp.	+	+	+
Copepoda				*Pompholyx* sp.	+	+	+
Copepod nauplii	-	+	+	*Rotaria* sp.	+	-	+

Cyclops sp.	+	+	+	*Rotaria vulgaris*	-	+	+
Diaptomus sp.	+	-	+	*Synchaeta* sp.	+	-	+
Diaptomus wierzeskil	-	+	+	*Testudinella* sp.	+	+	+
Heliodiaptomus viduus	-	+	+	*Trichocerca* sp.	+	+	+
Limnocalanus sp.	+	-	+	**Protozoa**			
Mesocyclops hyalinus	-	+	+	*Amoeba discoides*	-	+	+
Mesocyclops leuckarti	-	+	+	*Amoeba proteus*	-	+	+
Ostracoda				*Amoeba radiosa*	-	+	+
Centrocypris sp	-	+	+	*Arcella gibbosa*	-	+	+
Cypris sp	+	+	+	*Arecella discoides*	-	+	+
Stenocypris malcolmson	-	+	+	*Arecella vulgaris*	-	+	+
Rotifera				*Blepharisma* sp.	+	+	+
Ascomorpha sp.	+	+	+	*Bullinularia* sp.	+	-	+
Asplanchna priodonta	-	+	+	*Centropyxis acculeata*	-	+	+
Asplanchna sp.	+	-	+	*Centropyxis* sp.	+	-	+
Brachionus calcyflorus	-	+	+	*Centropyxis spinosa*	-	+	+
Brachionus forficula	-	+	+	*Chromogaster* sp.	-	+	+
Brachionus quadridentatus	-	+	+	*Colpoda aspera*	-	+	+
Brachionus rubens	-	+	-	*Colpoda* sp.	+	-	+
Brachionus sp.	+	-	+	*Difflugia accuminata*	-	+	+
Chromogaster sp.	+	-	-	*Difflugia corana*	-	+	+
Colurella sp.	+	+	+	*Difflugia oblonga*	-	+	+
	Upper	**Lower**	**Middle**				
Difflugia pyriformis	-	+	+				
Difflugia sp.	+	-	+				
Diplois sp.	+	+	+				
Euglypha acanthophora	-	+	+				
Euglypha ciliata	-	+	+				
Euglypha sp.	+	-	+				
Euglypha turerculata	-	+	-				
Oxytricha sp.	+	+	+				
Paramoecium caudatum	-	+	+				
Pelomyxa palustris	-	+	+				
Spirostomum sp.	+	+	+				
Trinema sp.	+	+	+				

Vorticella campanula	-	+	+				

1-c. Periphyton species found along the Mahanadi River.

Bacillariophyceae	**Desmidiaceae**	**Chlorophyceae**	**Cyanophyceae**
Amphora sp.	*Cosmarium* sp.	*Basicladia* sp.	*Anabaena* sp.
Anabaena sp.	*Desmidium* sp.	*Binuclearia* sp.	*Binuclearia* sp.
Asterionella sp.	*Spirotaenia* sp.	*Chaetophora* sp.	*Oscillatoria* sp.
Cocconeis sp.	*Staurastrum* sp.	*Cladophora* sp.	
Cymbella sp.	*Zygnema* sp.	*Draparnaldiopsis* sp.	
Diatoma sp.		*Hormidium* sp.	
Diploneis sp.		*Kirchneriella* sp.	
Frustulia sp.		*Microspora* sp.	
Mastogloia sp.		*Oedogonium* sp.	
Melosira sp.		*Protococcus* sp.	
Meridion sp.		*Treubaria* sp.	
Pinnularia sp.		*Tribonema* sp.	
Rhopalodia sp.		*Ulothrix* sp.	
Stauroneis sp.		*Uronema* sp.	
Surirella sp.			
Tabellaria sp.			

1-d. Distribution of zooinvertebrates in all the stretches of the Mahanadi River

Annelida	**Stretches of the Mahanadi River**				**Stretches of the Mahanadi River**		
	Upper	**Middle**	**Lower**		**Upper**	**Middle**	**Lower**
Hirudinaria viridis	+	–	–	*Littorina* sp.	+	+	–
Hirudinaria granulosa	+	–	–	*Lymnaea* sp.	+	+	–
Pheretima posthuma	+	–	–	*Melanoides* sp.	+	+	–
Pheretima sambalpuriensis	+	–	–	*Meretrix* sp.	+	+	+
Chaetogaster sp.	–	+	–	*Murex* sp.	+	+	–
Lumbriculus sp.	–	+	–	*Musculium* sp.	+	+	–
Nais sp.	–	+	–	*Nassarius* sp.	+	+	+
Stylaria sp.	–	+	–	*Nerita* sp.	+	+	–

Tubifex sp.	−	+	−	*Parreysia* sp.	+	+	−
Diopatra sp.	−	+	+	*Pila globosa*	+	−	−
Nereis sp.	−	+	−	*Pila* sp.	−	+	−
Prionospio sp.	−	−	+	*Pisidium* sp.	+	+	−
Polydora sp.	−	−	+	*Pleurocera* sp.	+	+	−
Capitella sp.	−	−	+	*Pugilina* sp.	+	+	−
Ancistrosyllis sp.	−	−	+	*Siliqua* sp.	+	+	−
Namalycastis sp.	−	−	+	*Sphaerium* sp.	+	+	−
Perinereis sp.	−	−	+	*Tarebia* sp.	+	+	−
Dendronereis arborifera	−	−	+	*Telescopium* sp.	+	+	+
Dendronereis aestuarina	−	−	+	*Thiara* sp.	+	+	−
Dendronereis heteropoda	−	−	+	*Tryonia* sp.	+	+	−
Glycera sp.	−	−	+	*Viviparus* sp.	+	+	−
Nephtys sp.	−	−	+	*Pirenella cingulata*	−	−	+
Eunice sp.	−	−	+	*Nassarius stolatus*	−	−	+
Sternaspis sp.	−	−	+	*Tellina* sp.	−	−	+
Cirratulidae sp.	−	−	+	*Solen* sp.	−	−	+
Sabella sp.	−	−	+	**Arthropod**			
Mollusca				*Cyclops* sp.	−	+	−
Amnicola sp.	+	−	−	*Harpacticus* sp.	−	+	−
Assiminea sp.	+	+	−	*Cypris* sp.	−	+	−
Bellamya sp.	+	+	−	*Ilyocypris* sp.	−	+	−
Campeloma sp.	+	+	−	*Gammarus* sp.	−	+	−
Cerithidea sp.	+	+	−	*Chydorus* sp.	−	+	−
Corbicula sp.	+	+	−	*Mysis* sp.	−	+	−
Donax sp.	+	+	−	*Cumaceans*	−	−	+
Goniobasis sp.	+	+	−	*Caprellid* sp.	−	−	+
Gyraulus sp.	+	+	−	*Eriopisa chilkensis*	−	−	+
Indoplanorbis sp.	+	+	−	*Sphaeroma* sp.	−	−	+
Lamellidens sp.	+	+	−	*Scylla serrata*	−	−	+
Ligumia sp.	+	+	−				

1-e. Ichthyofaunal (Fish) distribution in all the stretches of the Mahanadi River.

Channidae	**Stretches of the Mahanadi River**			**Clariidae**	**Stretches of the Mahanadi River**		
	Upper	**Middle**	**Lower**		**Upper**	**Middle**	**Lower**
Channa gachua	+	+	+	*Clarias batrachus*	+	+	+
Channa marulius	+	+	+	*Heteropneustes fossilis*	+	+	+
Channa punctata	+	+	+	**Cichlidae**			
Channa striata	+	+	+	*Oreochromis mossambicus*	+	+	+
Cyprinidae				*Oreochromis niloticus*	+	+	+
Catla catla	+	+	+	**Notopteridae**			
Chela chela	–	+	–	*Notopterus notopterus*	+	+	+
Chela bacaila	–	+	–	*Chitala chitala*	+	+	+
Cirrhinus mrigala	+	+	+	**Mastacembelidae**			
Cirrhinus reba	+	+	+	*Mastacembelus armatus*	+	+	+
Ctenopharyngodon idella	+	–	+	*Mastacembelus pancalus*	+	+	–
Cyprinus carpio	+	+	+	**Ambassidae**			
Eutropiichthys vacha	+	+	–	*Parambassis lala*	+	+	+
Labeo bata	+	+	–	*Parambassis ranga*	+	+	+
Labeo calbasu	+	+	–	*Chanda nama*	+	+	+
Labeo fimbriatus	+	+	–	**Gobiidae**			
Labeo gonius	+	+	–	*Glossogobius giuris*	+	+	+
Labeo rohita	+	+	–	**Schilbeidae**			
Osteobrama cotio	+	+	–	*Ompok bimaculatus*	+	+	+
Osteobrama vigorsii	+	+	–	*Ompok pabda*	+	+	+
Puntius chola	+	–	–	*Silonia silondia*	+	–	–
Puntius dorsalis	+	–	–	**Siluridae**			
Puntius sarana	+	+	–	*Wallago attu*	+	+	+
Puntius sophore	+	+	–	*Ailia coila*	+	+	–
Puntius ticto	+	+	–	*Clupisoma garua*	+	–	+
Tor tor	+	+	–	*Pangasius pangasius*	+	–	+
Tor putitora	–	+	–	*Pangasianodon hypophthalmus*	+	–	+
Tor khudree	–	+	–	*Rita rita*	–	+	–
Tor mosal mahanadicus	+	–	–	*Rita chrysea*	+	+	–

Trichogaster fasciatus	+	–	–	**Others**			
Bagridae				*Gudusia chapra*	+	+	+
Bagarius bagarius	–	+	+	*Setipinna phasa*	–	+	–
Mystus aor	+	+	+	*Anabas testudineus*	–	+	–
Mystus seenghala (Sperata seenghala)	+	+	+	*Monopterus cuchia*	+	+	+
Mystus cavasius	+	+	–	*Nandus nandus*	+	+	+
Mystus gulio	+	–	+	*Xenentodon cancila*	+	+	+
Mystus tengara	+	+	+	*Danio rerio*	+	+	–
Mystus vittatus	+	+	–	*Danio devario*	+	+	–
Sperata aor	+	+	–	*Rasbora daniconius*	+	+	–
				Esomus danricus	+	–	–

Appendix-2: Distribution of higher aquatic vertebrates at different stretches of the Mahanadi River.

2-a. Distribution of aquatic birds in all the stretches of the Mahanadi River.

Anatidae	**Stretches of the Mahanadi River**			**Rallidae**	**Stretches of the Mahanadi River**		
	Upper	**Middle**	**Lower**		**Upper**	**Middle**	**Lower**
Anas acuta	+	+	+	*Amaurornis phoenicurus*	–	+	–
Anas crecca	+	+	–	*Amaurornis akool*	–	+	–
Anas poecilorhyncha	–	+	–	*Fulica atra*	–	+	–
Spatula clypeata	+	+	–	*Gallinula chloropus*	–	+	–
Spatula querquedula	–	+	–	*Porphyrio poliocephalus*	–	+	–
Netta rufina	+	+	+	**Jacanidae**			
Aythya ferina	+	+	–	*Hydrophasianus chirurgus*	+	+	–
Aythya fuligula	+	+	+	*Metopidius indicus*	+	–	–
Aythya nyroca	–	+	–	**Scolopacidae**			
Tadorna ferruginea	+	+	+	*Tringa nebularia*	+	+	+
Dendrocygna javanica	+	+	–	*Tringa ochropus*	–	–	+
Nettapus coromandelianus	–	+	–	*Tringa glareola*	–	–	+
Anser indicus	+	+	–	*Actitis hypoleucos*	+	+	–

Anser anser	+	–	–	*Calidris minuta*	+	+	+
Mareca penelope	+	–	–	*Calidris ferruginea*	+	–	–
Ardeidae				*Calidris temminckii*	–	+	–
Ardea cinerea	+	+	+	*Gallinago gallinago*	+	+	–
Ardea alba	–	+	–	*Numenius arquata*	+	–	–
Ardea purpurea	+	+	+	*Limosa limosa*	+	–	–
Ardeola grayii	+	+	+	**Laridae & Sternidae**			
Bubulcus ibis	+	+	–	*Chroicocephalus ridibundus*	+	+	–
Egretta garzetta	+	+	+	*Chroicocephalus brunnicephalus*	–	–	+
Nycticorax nycticorax	+	+	–	*Larus brunnicephalus*	+	–	–
Butorides striata	–	+	–	*Larus fuscus*	+	–	–
Threskiornithidae				*Hydrocoloeus minutus*	+	–	–
Threskiornis melanocephalus	–	+	+	*Gelochelidon nilotica*	+	–	–
Anastomus oscitans	–	+	+	*Chlidonias hybrida*	+	+	–
Mycteria leucocephala	–	+	–	*Sterna aurantia*	+	+	–
Ciconia episcopus	–	+	–	*Sterna acuticauda*	+	+	–
Ciconia nigra	–	+	–	*Rynchops albicollis*	+	+	–
Pseudibis papillosa	–	+	–	**Alcedinidae**			
Phalacrocoracidae				*Alcedo atthis*	+	+	+
Phalacrocorax carbo	+	+	–	*Halcyon smyrnensis*	+	+	+
Microcarbo niger	+	+	–	*Ceryle rudis*	+	+	+
Anhinga melanogaster	+	+	+	*Pelargopsis capensis*	+	+	–
Podicipedidae							
Podiceps cristatus	–	+	–				
Tachybaptus ruficollis	–	+	–				

2-b. Distribution of amphibians in all the stretches of the Mahanadi River.

	Stretches of the Mahanadi River		
Bufonidae (Toads)	**Upper**	**Middle**	**Lower**
Duttaphrynus melanostictus	+	+	+
Duttaphrynus stomaticus	+	+	+
Dicroglossidae (True Frogs)			
Euphlyctis cyanophlyctis	–	+	+

Euphlyctis hexadactylus	–	+	+
Euphlyctis ehrenbergii	+	–	–
Hoplobatrachus tigerinus	+	+	+
Hoplobatrachus crassus	–	+	+
Fejervarya limnocharis	+	+	–
Fejervarya orissaensis	–	+	+
Fejervarya cancrivora	–	+	–
Fejervarya syhadrensis	–	–	+
Fejervarya moodiei	–	–	+
Microhylidae			
Microhyla ornata	+	+	+
Kaloula taprobanica	–	+	+
Ramanella variegata	+	+	–
Uperodon systoma	+	+	–
Ranidae			
Hylarana tytleri	–	+	+

2-c. Distribution of turtles in all the stretches of the Mahanadi River.

Species	**Upper**	**Middle**	**Lower**
Pangshura tentoria	+	+	+
Pangshura tecta	-	+	+
Nilssonia gangetica	+	+	+
Nilssonia hurum	-	+	-
Chitra indica	-	+	+
Batagur baska	+	-	+
Lissemys punctata	-	-	+
Melanochelys tricarinata	-	-	+
Melanochelys trijuga	-	-	+
Batagur kachuga	-	+	-

Appendix-3: Distribution of aquatic vegetation along the Mahanadi River.

Family	**Botanical Name**	**Common Name**
Hydrocharitaceae	*Hydrilla verticillata*	Hydrilla

	Vallisneria natans	Tape grass
Pontederiaceae	*Pontederia hastata*	Pickerel weed
Alismataceae	*Limnophyton obtusifolium*	Marsh herb
Menyanthaceae	*Nymphoides indica*	Water snowflake
	Nymphoides hydrophyllum	Floating heart
Ceratopteridaceae	*Ceratopteris thalictroides*	Water sprite
Salviniaceae	*Salvinia cucullata*	Water moss
Marsileaceae	*Marsilea minuta*	Water clover
Azollaceae	*Azolla pinnata*	Mosquito fern
Lentibulariaceae	*Utricularia aurea*	Bladderwort
Potamogetonaceae	*Potamogeton natans*	Pondweed
Plantaginaceae	*Lindernia procumbens*	False pimpernel
	Lindernia dubia	Yellowseed false pimpernel
Acanthaceae	*Hygrophila auriculata*	Marsh barbel
	Hygrophila difformis	Water wisteria
Amaranthaceae	*Alternanthera philoxeroides*	Alligator weed
	Alternanthera sessilis	Sessile joyweed
Plantaginaceae	*Bacopa monnieri*	Brahmi
Asteraceae	*Enhydra fluctuans*	Indian watercress
Onagraceae	*Ludwigia adscendens*	Water primrose
	Ludwigia perennis	Primrose willow
Cyperaceae	*Cyperus difformis*	Smallflower sedge
	Cyperus iria	Rice flat sedge
	Fimbristylis miliacea	Fimbry
	Schoenoplectiella articulata	Club rush
Poaceae	*Leersia hexandra*	Swamp rice grass

	Hymenachne amplexicaulis	Marsh grass
	Paspalum distichum	Water couch

Appendix- 4: Distribution of floodplain vegetation along the Mahanadi River.

Family	**Botanical Name**	**Common Name**
Fabaceae	*Acacia auriculiformis*	Earleaf acacia
	Acacia mangium	Mangium
	Albizia lebbeck	Siris tree
	Dalbergia sissoo	Indian rosewood
	Pongamia pinnata	Indian beech
	Cassia fistula	Golden shower tree
	Butea monosperma	Flame of the forest
Moraceae	*Ficus benghalensis*	Banyan
	Ficus religiosa	Peepal
	Ficus racemosa	Cluster fig
Myrtaceae	*Syzygium cumini*	Jamun
Combretaceae	*Terminalia bellirica*	Bahera
	Terminalia catappa	Indian almond
Phyllanthaceae	*Phyllanthus emblica*	Amla
Euphorbiaceae	*Ricinus communis*	Castor
	Mallotus nudiflorus	Mallotus
Apocynaceae	*Alstonia scholaris*	Devil tree
	Holarrhena pubescens	Kurchi
Arecaceae	*Cocos nucifera*	Coconut
	Borassus flabellifer	Palmyra palm

Malvaceae	*Hibiscus cannabinus*	Kenaf
	Sida cordifolia	Country mallow
Rutaceae	*Aegle marmelos*	Bael
	Bergera koenigii	Curry leaf
Lamiaceae	*Vitex negundo*	Chaste tree
Sapindaceae	*Allophylus serratus*	False currant
Rhamnaceae	*Ziziphus mauritiana*	Indian jujube
Poaceae	*Saccharum spontaneum*	Kans grass
	Imperata cylindrica	Cogon grass
	Cynodon dactylon	Bermuda grass
Asteraceae	*Parthenium hysterophorus*	Congress weed
	Tridax procumbens	Coat buttons
Convolvulaceae	*Ipomoea carnea*	Bush morning glory

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