नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

SOCIO-ECOLOGICAL *status of* CHAMBAL RIVER

FOR CONSERVATION PLANNING

REPORT 2026

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

SOCIO-ECOLOGICAL *status of* CHAMBAL RIVER

FOR CONSERVATION PLANNING

REPORT 2026

Director, WII
Gobind Sagar Bhardwaj

Dean, FWS, WII
Ruchi Badola

Principal Investigators
Ruchi Badola and Syed Ainul Hussain

Photo Credit
NMCG-WII team

Cover Photo
Ashish Panda, Surya Prasad Sharma

Design and layout
Maheshanand Pandey

Socio-Ecological Status of Chambal River For Conservation Planning
Report 2026

This document is an output of the project Biodiversity Conservation and Ganga Rejuvenation sponsored by the National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India, New Delhi.

Citation:
WII-GACMC (2026). Socio-Ecological Status of Chambal River For Conservation Planning. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Pp. iv, 323

ISBN : XXXXXX

National Mission for Clean Ganga (NMCG)
Wildlife Institute of India (WII)

ACKNOWLEDGEMENTS

Ministry of Jal Shakti (MoJS)
C. R. Patil, *Union Minister*
V. Somanna, *Minister of State*
Raj Bhushan Choudhary, *Minister of State*
V. L. Kantha Rao, *Secretary*

National Mission for Clean Ganga (NMCG)
Rajeev Kumar Mital, *Director General*
Nalin Kumar Srivastava, *Deputy Director General*
S. P. Vashishth, *Executive Director (Admin)*
Bhaskar Dasgupta, *Executive Director (Finance)*
Brijendra Swaroop, *Executive Director (Projects)*
Anup Kumar Srivastava, *Executive Director (Technical)*
Sandeep Behera, *Biodiversity Consultant*
Sunil Kumar, *Assistant Engineer*

Ministry of Environment, Forest and Climate Change
Bhupender Yadav, *Union Minister*
Kirti Vardhan Singh, *Minister of State*
Tanmay Kumar, *Secretary*
Naresh Pal Gangwar, *Additional Secretary*
Amandeep Garg, *Additional Secretary*
Sushil Kumar Awasthi, *Director General of Forest & Special Secretary*
Anjan Kumar Mohanty, *Additional Director General of Forest (Forest Conservation)*
Ramesh Pandey, *Additional Director General, Wildlife*
Vaibhav Chandra Mathur, *Inspector General, Wildlife*

Forest and Environment Department of Madhya Pradesh, Rajasthan and Uttar Pradesh

Special Gratitude
Gajendra Singh Shekhawat, *Former Union Minister of Jal Shakti*
Pankaj Kumar, *Former Secretary, Ministry of Jal Shakti*
Rajiv Ranjan Mishra, *Former Special Secretary and Director General, NMCG*
G. Asok Kumar, *Former Special Secretary and Director General, NMCG*

Other Organizations
State Project Management Groups of Madhya Pradesh, Rajasthan and Uttar Pradesh Districts Administration

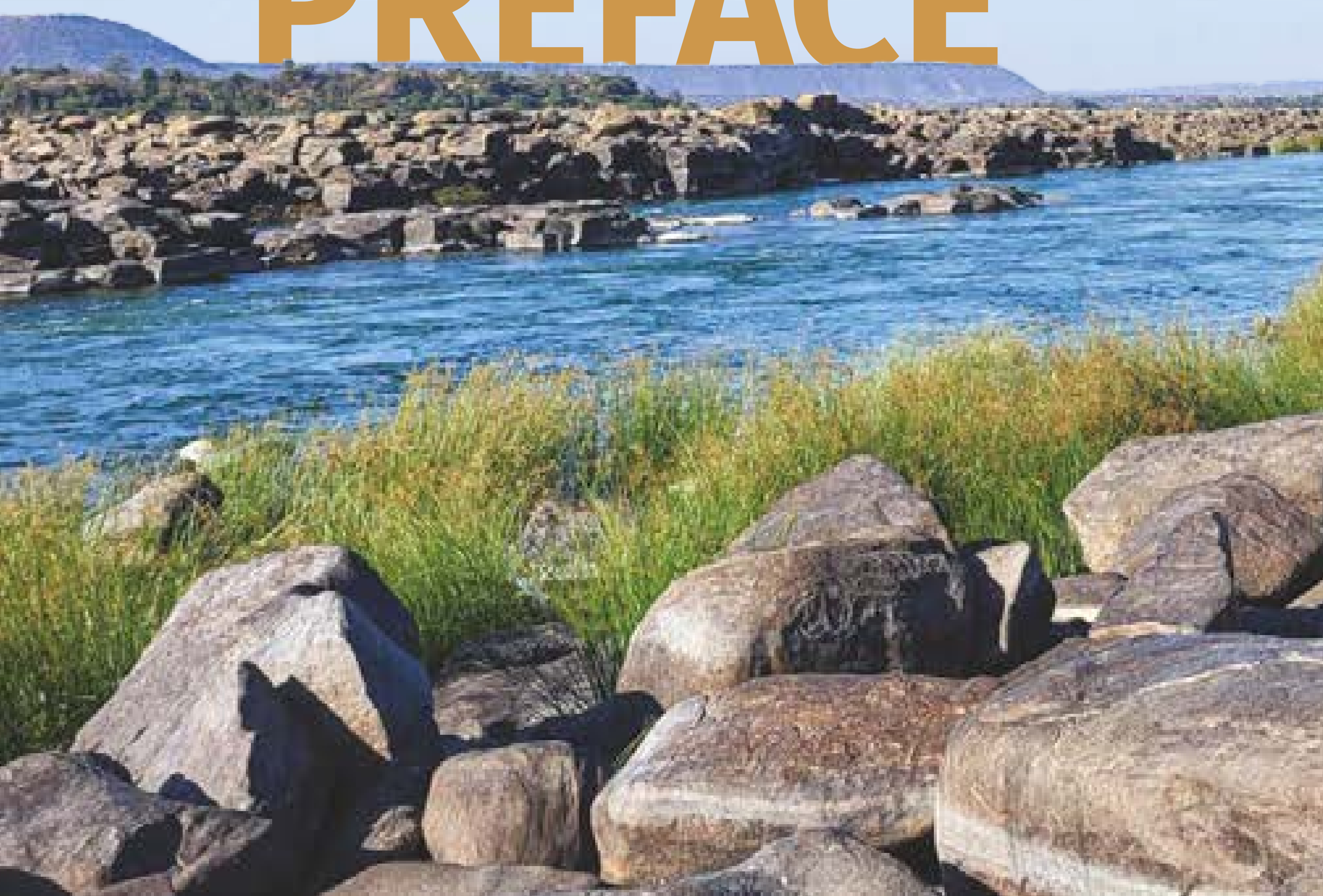
Support Staff
Ganga Praharis, Local community members, Frontline Forest staff

Wildlife Institute of India
Gobind Sagar Bhardwaj, *Director*
Ruchi Badola, *Dean*

PREFACE

Rivers constitute some of the most vital and dynamic ecosystems on Earth, yet they are frequently overlooked and subjected to extensive exploitation. Serving as lifelines of human civilization for millennia, rivers continue to perform essential ecological and societal functions. Acting as conduits between terrestrial and aquatic environments, they sustain a diverse range of aquatic and semi-aquatic life, including fishes, amphibians, reptiles, birds, mammals, and plants.

The Ganga River basin in India comprises a complex network of interconnected tributaries originating from the Himalayas and the Deccan Plateau. Among these, the Chambal River represents a major tributary of the Yamuna, traversing the states of Madhya Pradesh, Rajasthan, and Uttar Pradesh. Originating from the Janapav Hills in Madhya Pradesh, the river extends approximately 965 km before merging with the Yamuna near Bareh in Etawah district. Encompassing an area of approximately 141,600 km^2, the Chambal Basin spans semi-arid to sub-humid climatic zones and exhibits diverse geomorphological features. Its principal tributaries, Banas, Parbati, Kali Sindh, and Kuno, contribute significantly to maintaining the hydrological balance of the system. The basin is predominantly agricultural, interspersed with forested and wasteland areas, and experiences pronounced seasonal variations in temperature and monsoonal rainfall. Despite modifications arising from dam constructions, the Chambal River remains one of the least polluted rivers in northern India. The National Chambal Sanctuary (NCS), the longest riverine protected area in India, extends over 600 km along the Chambal River across Madhya Pradesh, Rajasthan, and Uttar Pradesh. It conserves freshwater biodiversity and provides critical breeding and nesting habitats for the Critically Endangered gharial (*Gavialis gangeticus*), Endangered Gangetic dolphin (*Platanista gangetica*), and several threatened turtles and waterbirds, including the Indian skimmer (*Rynchops albicollis*) and black-bellied tern (*Sterna acuticauda*). In addition to the NCS, the Chambal Basin includes other designated protected areas, including Gandhi Sagar Wildlife Sanctuary, Bhensrodgar Wildlife Sanctuary,



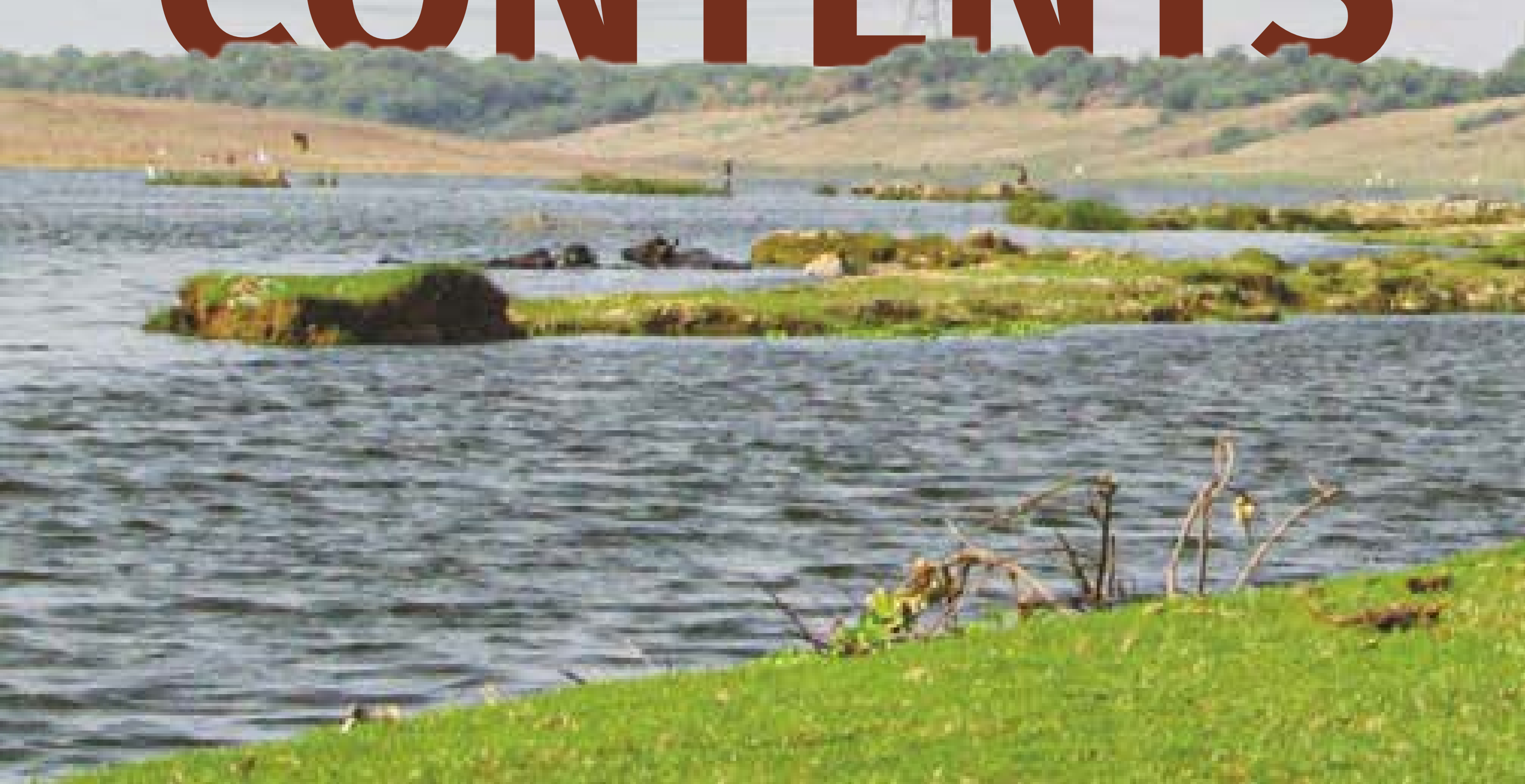
Darrah Wildlife Sanctuary, and Jawahar Sagar Wildlife Sanctuary, which collectively conserve the ecological integrity of terrestrial and aquatic habitats within the basin. Notwithstanding its protected status, the Chambal River faces substantial anthropogenic pressures. Upstream dams and barrages have altered natural flow regimes, generating disconnected pools and reducing sediment transport essential for maintaining riverine habitats. The proposed Parbati-Kali Sindh-Chambal interlink may further diminish tributary inflows. Activities such as sand mining, riparian agriculture, unregulated fishing, water extraction, urban expansion, industrial effluents, livestock grazing, and habitat encroachment exacerbate habitat degradation, soil erosion, and disruption of nesting areas, thereby impairing ecological connectivity and riverine function.

During Phase I of the project "*Biodiversity Conservation and Ganga Rejuvenation*", funded by the National Mission for Clean Ganga (NMCG), detailed biodiversity assessments of the Ganga River highlighted the critical role of tributaries in sustaining aquatic life. Building on this, Phase II focused on major tributaries, including the Chambal River. This report presents a comprehensive compilation of the socio-ecological characteristics of the Chambal River, based on literature review, field-based ecological assessment, and stakeholder engagement.

The report aims to build a comprehensive knowledge base for the Chambal River, guide ecological restoration, and support policymakers in sustainable river management. Given its ecological and hydrological importance and the presence of key protected areas, the river requires integrated management, strict conservation enforcement, sustainable resource use, and focused habitat restoration. Its long-term preservation depends on adaptive management, scientific monitoring, and community participation to maintain ecological integrity and resilience.

Ruchi Badola
Syed Ainul Hussain

CONTENTS



The Chambal River, a major tributary of the Yamuna River, originates near Janapav in Madhya Pradesh and extends for approximately 965 km across Madhya Pradesh, Rajasthan, and Uttar Pradesh before merging with the Yamuna. Flowing through the semi-arid biogeographic zone, the river directly traverses 18 districts, while its basin extends across 37 districts in total. It is sustained by four key tributaries—the Kali Sindh, Banas, Parbati, and Kuno rivers. Biogeographically, the basin spans the Punjab Plains (4A) and Gujarat–Rajputana (4B) provinces and supports dry deciduous and thorn forest ecosystems. The Chambal Basin exhibits pronounced ecological and environmental heterogeneity. Although hydrological interventions, including four major dams, have altered natural flow regimes, the river continues to be regarded as relatively unpolluted compared to other north Indian rivers.

Ecologically, the Chambal River serves as a critical refuge for freshwater biodiversity, most notably supporting the world's largest population of the Critically Endangered Gharial, alongside significant populations of the Endangered Gangetic Dolphin and the Vulnerable Smooth-coated Otter. Recognition of the river's ecological importance led to the creation of the National Chambal Sanctuary, a ~600 km-long protected riverine area that today represents India's longest continuous riverine sanctuary. The Chambal River is also hydrologically significant because its flow substantially revives the Yamuna River by diluting pollution loads and contributing to the downstream flow of the mainstem Ganga River. This interconnected river network provides critical habitat and dispersal corridors for freshwater species across the Ganga–Yamuna–Chambal system. Considering both its ecological and hydrological importance, the Chambal River was selected for a comprehensive socio-ecological assessment.

This study adopted a multidisciplinary approach combining literature review with field-based ecological surveys to assess biodiversity across the Chambal River system. For field-based assessments, the river was divided into 185 Biodiversity Evaluation Units (BEUs) and categorized into five zones: the Upper Vindhyan Zone (323 km), Lower Vindhyan Zone (48 km), Upper Middle Zone (173 km), Lower Middle Zone (142 km), and Lower Zone (233 km).

The assessment documented a total of 658 species across diverse taxonomic groups, including 520 angiosperm species, 34 fish species, 11 amphibian species, nine turtle species, two crocodilian species, 81 bird species, and one mammalian species.

Among vertebrates, 34 fish species were recorded, including one Vulnerable species. The herpetofaunal assemblage comprised 22 species, including two Critically Endangered and one Vulnerable species. Of the 81 avian species recorded—including waterbirds, water-associated birds, and terrestrial birds—two were classified as Endangered, one as Vulnerable, eight as Near Threatened, and 70 as Least Concern. The only mammalian species

EXECUTIVE

recorded was the Endangered Gangetic river dolphin. The findings indicate that although key aquatic fauna, including the Gangetic dolphin, Mugger Crocodile, and gharial continue to persist in the Chambal River, their distribution ranges have contracted significantly over recent decades.

A comprehensive floristic survey documented 520 angiosperm species belonging to 341 genera, 97 families, and 34 orders, highlighting the high riparian biodiversity of this semi-arid river system. The flora was dominated by the families Poaceae (66 species), Fabaceae (62 species), Asteraceae (44 species), Cyperaceae (23 species), Convolvulaceae (19 species), and Lamiaceae (16 species), reflecting the prevalence of grassland, scrub, and riparian vegetation. Herbaceous plants formed the largest life-form group (272 species), followed by graminoids (90 species), trees (68 species), shrubs (47 species), and climbers (41 species), indicating strong structural heterogeneity across riparian, ravine, wetland, and agricultural habitats.

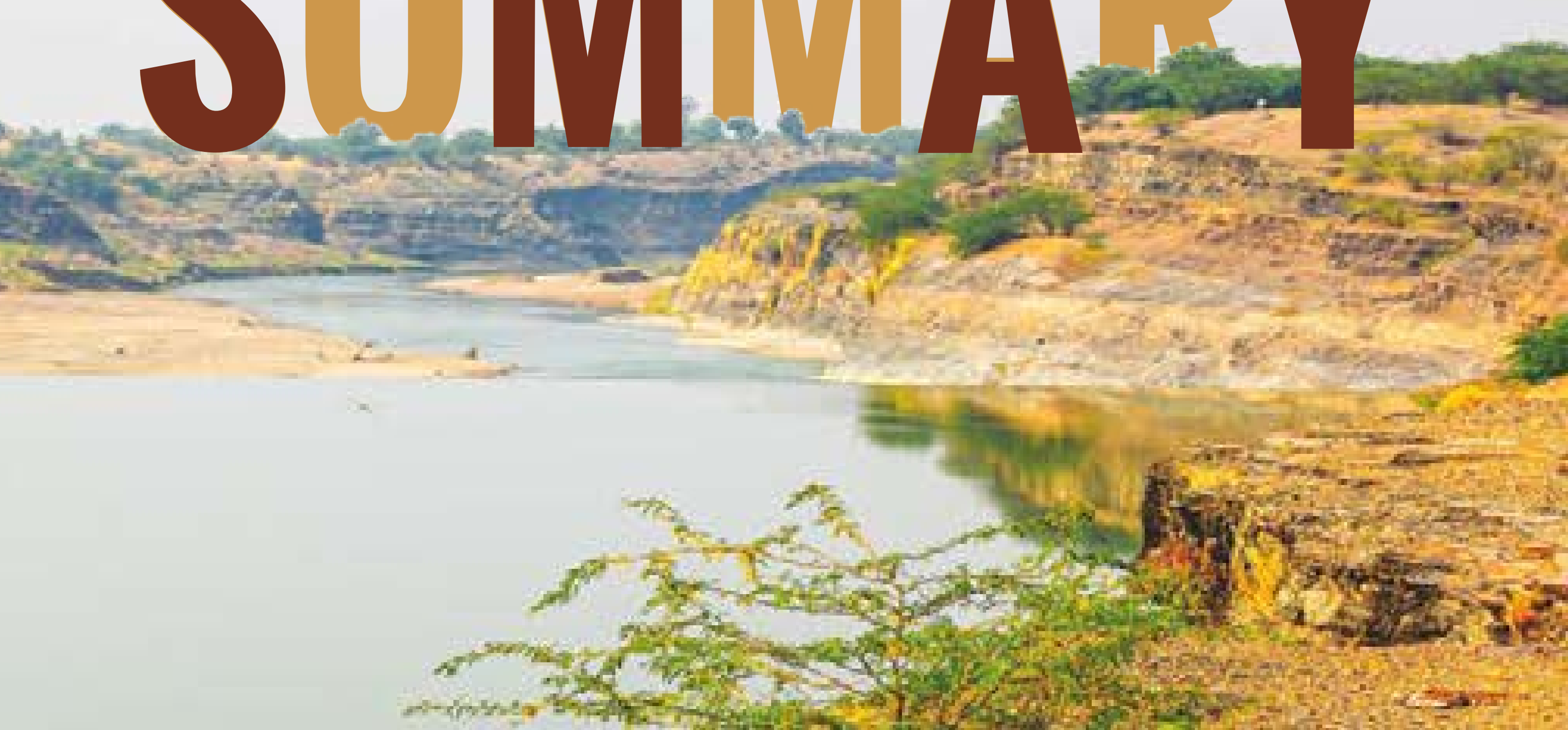
Habitat analysis showed a predominance of moisture-loving species (315 species), with substantial representation of semi-aquatic (99 species) and aquatic plants (34 species), underlining the ecological importance of wetlands, floodplains, and backwaters along the river corridor. Native flora strongly dominated the landscape, with 431 native species compared to 89 non-native taxa. However, invasive species such as Prosopis juliflora, Lantana camara, Ipomoea carnea, and Eichhornia crassipes were widespread in degraded ravines and disturbed floodplain habitats. Vegetation composition varied spatially, with species richness ranging from 72 species at Khirkhari to 128 species at Daulatganj, and diversity peaking in the midstream gorge sections where forest–scrub mosaics support higher regeneration and habitat complexity.

A post-monsoon ichthyofaunal survey across 13 stratified sites between Rawatbhata and Pachnada recorded 692 individuals representing 34 species, 26 genera, 14 families, and 8 orders. Cyprinidae (15 species) was the dominant family, while assemblages were largely composed of *Gonialosa manmina, Cabdio morar,* and *Gudusia chapra*. Catch-per-unit effort ranged from 49.25 individuals per panel hour at Pachnada to 2.5 at Gyanpura. Species richness was highest in the Middle Zone (25 species) and lowest in the Upper Zone (16 species), while Site-7 (Liloli; H = 2.09) exhibited the highest Shannon diversity. Regression analysis revealed no significant influence of physicochemical parameters on diversity, although positive correlations were observed with river width, depth, flow, and conductivity. Of the recorded fish species, 31 were classified as Least Concern and one (*Wallago attu*) as Vulnerable; two species (*Cyprinus carpio* and *Oreochromis niloticus*) were exotic. Ongoing pressures from sand mining, flow alteration, and destructive fishing practices continue to threaten native fish communities, although the river retains high ecological potential due to protection under the National Chambal Sanctuary and the Mukundara Hills Tiger Reserve.

A total of 11 amphibian species belonging to four families were recorded, dominated by Dicroglossidae (80.32%), with widespread species such as the Indian skipper frog and Indian bullfrog, while others exhibited restricted distributions. Species richness was highest in the upper zones, with peak diversity observed at Sarsaini and Rameshwar. Nine freshwater turtle species were documented, including the Critically Endangered Red-crowned Roofed Turtle and Three-striped Roofed Turtle, with richness highest in the lower zone (n = 8).

Between 2019 and 2023, gharial populations increased from 1,879 to 2,097 individuals, with over 80% concentrated in the lower zone. However, consistently low hatchling counts indicated poor recruitment. Mugger populations also increased from 617 to 860 individuals and were distributed more evenly across zones, with the highest encounter rates in the upper middle zone. Both species exhibited adult-dominated size-class structures with low

SUMMARY



representation of hatchlings and juveniles, although muggers showed initial evidence of recruitment in 2023. These findings highlight the Chambal River as a critical refuge for herpetofauna while underscoring concerns regarding low reproductive success and recruitment that warrant targeted conservation interventions.

A total of 81 bird species belonging to 15 orders and 28 families were recorded, including threatened species such as the Indian Skimmer, Black-bellied Tern, and River Tern. Species richness was highest in the lower zone, with waterbirds comprising more than 60% of the community and piscivores and carnivores dominating the feeding guilds. Intensive monitoring across eight sites and 28 transects revealed significant spatial variation in diversity, with agricultural plains and scrub habitats supporting particularly high richness, while sandbank habitats showed lower but more even distribution.

Monitoring of island-nesting birds documented 139 nesting events from eight species, with the Indian skimmer showing the highest fledgling success. However, nearly half of the nesting islands were threatened by sand mining, livestock grazing, and predation, indicating significant pressures even within protected areas. This study provides the first comprehensive baseline on bird diversity, habitat use, and associated threats in the Chambal River, offering critical insights for long-term monitoring and conservation planning.

Once widely distributed, the Gangetic dolphin is now largely restricted to the lower stretch of the Chambal River between Basai Dang and the Chambal–Yamuna confluence, with 75–96 individuals recorded between 2019 and 2022 at encounter rates of 0.30–0.32/km. Sightings were concentrated in deep pools (6–10 m), reflecting a preference for deeper waters. Smooth-coated otters, historically recorded in the upper and middle reaches, showed a sharp decline, with occupancy decreasing from 62 sites in 1988 to 41 in 1992, and no individuals detected during the present survey.

Increasing pressures from illegal fishing, sand mining, and flow regulation threaten aquatic mammal habitats by reducing prey availability, fragmenting river stretches, and increasing mortality risks. Conservation of deep-pool habitats, maintenance of ecological flows, strengthened enforcement, and community-led stewardship are urgently needed to safeguard the long-term survival of dolphins, otters, and associated freshwater biodiversity in the Chambal River.

Despite its protected status, the Chambal River faces mounting anthropogenic pressures. Upstream dams and the Kota Barrage have altered flow regimes, created disconnected pools, and reduced sediment inputs essential for sand-nesting species, while the proposed Parbati–Kali Sindh–Chambal link threatens further depletion of water and sediment from tributaries.

Sand mining destabilizes riverbanks, reduces nesting habitats for gharials, turtles, and ground-nesting birds, and increases turbidity. Riparian agriculture and agrochemical runoff further exacerbate habitat degradation and pollution, while unregulated gillnet fishing causes entanglement-related mortality of dolphins and gharials and reduces prey availability. Expanding agriculture, water extraction, urban growth, and industrialization across the basin alter base flows, increase pollution loads, and fragment habitats. Livestock grazing additionally degrades riparian vegetation and causes nest trampling, particularly in the lower zone.

A 2021–2025 assessment across nine monitoring stations identified heavy metals, phthalates, pesticides, and pharmaceuticals as dominant pollutants despite compliance with conventional indicators such as biochemical oxygen demand (BOD) and dissolved oxygen. Heavy metals—particularly chromium, zinc, nickel, and copper—constituted 83% of the contaminant burden, with clear evidence of bioaccumulation in fish and direct exposure risks to gharials, dolphins, otters, and turtles.

Major pollution hotspots included Nagda (industrial effluent), Kota (untreated sewage), the Parvati confluence (sediment contamination), and the upstream Yamuna confluence (basin export point). The highest ecological risk was observed within the National Chambal Sanctuary, particularly in the middle and lower zones. Seasonal patterns showed heavy metal concentrations peaking during the pre-monsoon period, while emerging contaminants increased post-monsoon. Pollution trends between 2021 and 2025 showed no sustained decline, and several emerging contaminants continue to rise unchecked. The study recommends urgent enforcement measures, expanded contaminant monitoring, stricter regulation of sand mining, and long-term tri-state basin governance integrating pollution control with wildlife conservation.

To evaluate freshwater biodiversity threats and delineate Conservation Priority Stretches (CPSs), the globally threatened Gangetic dolphin was selected as the indicator species for the Chambal River. Using MaxEnt modelling, 21 CPSs were identified across a 285 km stretch in the middle and lower zones spanning Madhya Pradesh, Rajasthan, and Uttar Pradesh. Of these, CPS 1 extended for 85 km, CPS 2 for 150 km, and CPS 3 for 50 km. The longest CPS 2 segment spanned 90 km between Lohasari and Tigri–Rithoura, while the largest CPS 1 covered 25 km between Pureni and Reha. These stretches underscore the ecological importance of the Chambal River in sustaining Gangetic dolphin populations and maintaining riverine connectivity. The CPS framework provides a science-based, state-level tool to guide targeted conservation planning, habitat restoration, and alignment with national and global biodiversity goals.

A comprehensive capacity-building programme was implemented across the Chambal River Basin to strengthen freshwater biodiversity conservation through a participatory, multi-stakeholder approach. The initiative targeted forest officials, veterinarians, researchers, and local communities, aiming to build expertise in biodiversity monitoring, rescue and rehabilitation, wetland management, participatory conservation, and conservation education.

Based on a Training Needs Assessment, five specialized training modules were developed and delivered between 2019 and 2025 across Rajasthan, Madhya Pradesh, and Uttar Pradesh. In total, 767 stakeholders were trained, including 154 participants through 11 spearhead training sessions and 548 participants through five rescue-focused and integrated training programmes. Despite logistical challenges and species-centric conservation perceptions, the programme successfully created a decentralized network of trained practitioners, highlighting the critical role of local capacity building in ensuring long-term ecological resilience and sustainable management of the Chambal River ecosystem.

The Chambal River Basin supports a socially and economically diverse riverine population whose livelihoods remain closely linked to the river's ecology, agriculture, fisheries, and wetlands. Despite improvements in governance and security, many communities—particularly those living in ecologically fragile ravine regions—continue to face socio-economic inequalities, water stress, limited livelihood opportunities, and low levels of ecological awareness. The basin spans three states and involves a complex stakeholder network of more than 90 institutions, including forest departments, pollution control boards, local administrations, research institutions, NGOs, and community groups.

To strengthen participatory conservation, awareness programmes, consultative meetings, participatory mapping exercises, and skill-building initiatives engaged more than 1,200 stakeholders across the basin. The Chambal supports agrarian livelihoods through irrigation systems, livestock rearing, fisheries, ravine reclamation, and emerging ecotourism activities within protected areas such as the National Chambal Sanctuary. Community participation was further enhanced through the registration of 122 Ganga Praharis, who were trained in ecological monitoring, rescue and rehabilitation, plantation activities, sustainable tourism, and microplanning. The establishment of the Jalaj Centre at Morena linked conservation efforts with livelihood generation, while gender-sensitive needs assessments highlighted the importance of tailored livelihood interventions.

The study identified several key challenges, including illegal sand mining, riverbed farming, inadequate sanitation, and weak institutional coordination. It emphasized inclusive stakeholder participation, habitat protection, livelihood diversification, and awareness-building as essential strategies for the sustainable conservation of the Chambal River.

A nature interpretation and conservation education initiative was also implemented across Uttar Pradesh, Madhya Pradesh, and Rajasthan to promote awareness and stewardship of Chambal River biodiversity among school students and teachers. Targeting students aged 13–17 years in government schools located near the river, the programme combined interactive workshops with permanent interpretation infrastructure. Eight awareness and sensitization workshops engaged 408 students through presentations, quizzes, games, and group discussions focused on river ecology, biodiversity, pollution, and conservation.

To ensure long-term learning, five low-cost "*Jalmala Samvaad*" interpretation corners were established in schools across the basin, collectively reaching 3,530 students and 104 teachers. These spaces served as localized knowledge hubs featuring educational panels and conservation-themed artwork, thereby reinforcing classroom learning and fostering continued dialogue on river conservation. The initiative successfully institutionalized environmental education and strengthened community-based conservation awareness throughout the Chambal Basin.

The Chambal River, a major tributary of the Yamuna River within the Ganga Basin, supports exceptional aquatic biodiversity and serves as a critical refuge for endangered species, including more than 80% of the global gharial population, the Gangetic dolphin, the Critically Endangered red-crowned roofed turtle, and the Indian skimmer. Nearly 600 km of the river has been protected under the National Chambal Sanctuary since 1978, significantly contributing to the conservation of its aquatic fauna.

However, increasing anthropogenic pressures, pollution, habitat degradation, illegal sand mining, and unregulated development continue to threaten the river's ecological integrity. Existing policies and programmes such as the *Namami Gange* Programme provide an important legal and institutional framework for river management and biodiversity conservation, yet major gaps persist in basin-level coordination, ecological flow management, enforcement, monitoring, and community participation.

The study proposes an integrated conservation framework combining ecological restoration, environmental flow regulation, species-specific management, and community-based stewardship. Recommended actions include habitat restoration, continuous water-quality and flow monitoring, strengthened legal protection, nest protection, telemetry-based species monitoring, and participatory conservation planning involving local communities. The assessment emphasizes that safeguarding the Chambal River is essential not only for conserving its globally significant biodiversity, but also for advancing India's national and international commitments to biodiversity conservation and sustainable river management.

SECTION I

CHAPTER 1

RIVER PROFILE

Coordinating Lead Authors
Syed Ainul Hussain,
Ruchi Badola,
Shivani Barthwal

Lead Authors
Surya Prasad Sharma,
S.K. Zeeshan Ali

Contributing Authors
Khadija,
Ashish Mani,
Shatakshi Sharma

SUMMARY

The Chambal River, a major tributary of the Yamuna, originates in the Janapav Hills of Madhya Pradesh and flows 965 km through Madhya Pradesh, Rajasthan and Uttar Pradesh before its confluence with the Yamuna River at Bareh, near Etawah in Uttar Pradesh. Renowned for its rich biodiversity and historical significance, the River harbours the endangered Gangetic Dolphin, the largest breeding population of gharials, and several species of freshwater turtles and birds, including the endangered Indian skimmer and black-bellied tern.

The ~141,600 km² Chambal Basin lies within the Ganga River Basin, spanning semi-arid to sub-humid zones with distinctive geomorphology. The course of the River is divided into five zones based on geomorphological features and confluence of tributaries. Major tributaries include Banas, Parbati, Kali Sindh, and Kuno, contributing to its hydrological balance. Land use in the basin is dominated by agriculture (70%), followed by forest (14%) and wasteland (9%). Soils range from black and red soils in the upper basin to alluvium in the lower reaches. The climate is characterised by temperature extremes (5°C to 45°C) and monsoonal rainfall (797 mm annually). Hydrological modifications, including four major dams, have significantly altered flow regimes, though the river remains relatively unpolluted.

Ecologically, the basin spans the Gujarat-Rajputana and Punjab Plains biogeographic provinces. The forest comprises dry deciduous and thorn forests. Faunal diversity includes 173 fish, 56 reptiles, 307 birds, and 60 mammal species, with several threatened taxa. The Chambal hosts India's longest riverine protected area, the National Chambal Sanctuary, covering ~600 km.

Despite its ecological significance, only 3.64% of the basin falls under protected areas. Human population (~71 million) is unevenly distributed, with low average density (333/km²) and stark disparities in literacy and Human Development Index, highlighting the need for inclusive conservation and development strategies.

1 INTRODUCTION

The Chambal River is one of the major rivers in Central India, flowing through the states of Rajasthan, Madhya Pradesh, and Uttar Pradesh. It is the largest tributary of the Yamuna River, and the Chambal River Basin occupies about 39% of the Yamuna River Basin. The Chambal River basin, spread over an area of 1,41,600 km^2, in the three states - Rajasthan, Madhya Pradesh and Uttar Pradesh, is renowned for its historical heritage, cultural contributions, and the diverse array of plant and animal species. The Chambal River basin is mentioned in ancient texts such as the Mahabharata, where the River is referred to as Charmanyawati, and it is one of the last remnant rivers in the Ganges River basin, which has retained significant conservation values. It harbours the largest gharial (*Gavialis gangeticus*) population in the world (Hussain, 1999), population of the Gangetic dolphin (*Platanista gangetica*), and is a staging ground for migratory waterfowl. It also serves as a nesting ground for many threatened birds. Apart from the gharial and dolphin, the major fauna of the river includes the smooth-coated otter (*Lutrogale perspicillata*) (Hussain & Choudhury, 1997), mugger (*Crocodylus palustris*), nine species of freshwater turtles, and over 300 species of birds, including Indian skimmer (*Rynchops albicollis*), black-bellied tern (*Sterna acuticauda*) and small Indian pratincole (*Glareola lacta*) (Hussain, 1993; Nair & Krishna, 2013). The major characteristics of the Chambal River Basin are given in Table 1.1.

Table 1.1: Characteristics of the Chambal River basin

Type	Rainfed perennial
Origin	Janapav kuti, Vindhyan hills
Length	965 km
Discharge (m^3/s)	465
Basin area (km^2)	1,41,600
Altitude of the basin	63 m to 1318 m (asl)
States along the river	Madhya Pradesh, Rajasthan and Uttar Pradesh
States in the Basin	Madhya Pradesh, Rajasthan and Uttar Pradesh
No. of districts in the basin	37
No. of districts along the River	18
Major sub-basin	Banas, Kali Sindh, Parbati,
Major tributaries	Mej, Kali Sindh, Parbati, Banas and Kuno
Number of barrages on the River	One (Kota)
Dams in the basin	Gandhi Sagar, Jawahar Sagar and Rana Pratap Sagar
Human population	7,11,51,277
Population density (persons/km^2)	
Biogeographic zones	Semi-Arid (4) - Punjab Plains (4A) and Gujarat Rajputana (4B)
Forest cover in the basin (km^2)	12883.84 km^2
Total irrigated area	2,734 km^2
Fish (no. of species) **	173
Reptile species (Crocodiles and turtles)***	56
Freshwater Mammals	2
Protected Area in the basin	28
Protected Area on the mainstem Chambal River	Five (Gandhi Sagar WLS, Bhensrodgarh WLS, Darrah WLS, Jawahar Sagar WLS, National Chambal Sanctuary)
Percentage coverage of Chambal basin by Protected Areas	3.64%

*** Annexure II ; *** Annexure IV*

1.1 Course of the Chambal River

The Chambal River flows for 965 km through the three largest states of India, namely Madhya Pradesh, Rajasthan and Uttar Pradesh. The Chambal River is considered to originate from the Janapav valley (Janapav Shiv Temple) at Malwa ridge, surrounded by Manpur Reserve Forest, Madhya Pradesh, India. The source of Chambal water is considered to be from seepage of groundwater from the Basaltic columnar joint rock (Malwa Ridge), where the water flows from the weak columnar joints of Basalts and follows a gradient slope facing in a Northward direction (Kaushik & Ghosh, 2015). After originating in the Vindhyas of Madhya Pradesh, the river flows in a northerly course for about 257 km, where the Shipra and Choti Kali Sindh rivers join the Chambal River. The River then enters Rajasthan through a gorge near the historic fort of Chaurasi Garh. Subsequently, the River turns northeast, flows past the town of Kota, where it is joined by one of its major tributaries, the Kali Sindh near Norera village (Laban). Another major tributary, the Parbati, joins about 48 km downstream. Banas River, the largest tributary of the Chambal River, joins near the village Rameshwar in Khandar Block at Sawai Madhopur district. Further downstream, it flows in a straight course for 212 km, turning southeast at Panihat and continues to join the Yamuna near Bareh, after a total run of 965 km. The first 274 km of the Chambal lies entirely in Madhya Pradesh, the next 153 km entirely in Rajasthan. During its passage from Pali to Panihat, for 241 km of the River forms the border between Rajasthan and Madhya Pradesh. In its last lap of 105 km, a little before it merges with the Yamuna, it forms the border between Madhya Pradesh and Uttar Pradesh. The last 40 km of the River is entirely in Uttar Pradesh. The Chambal River thus has a complex administrative regime (Figure 1.1).

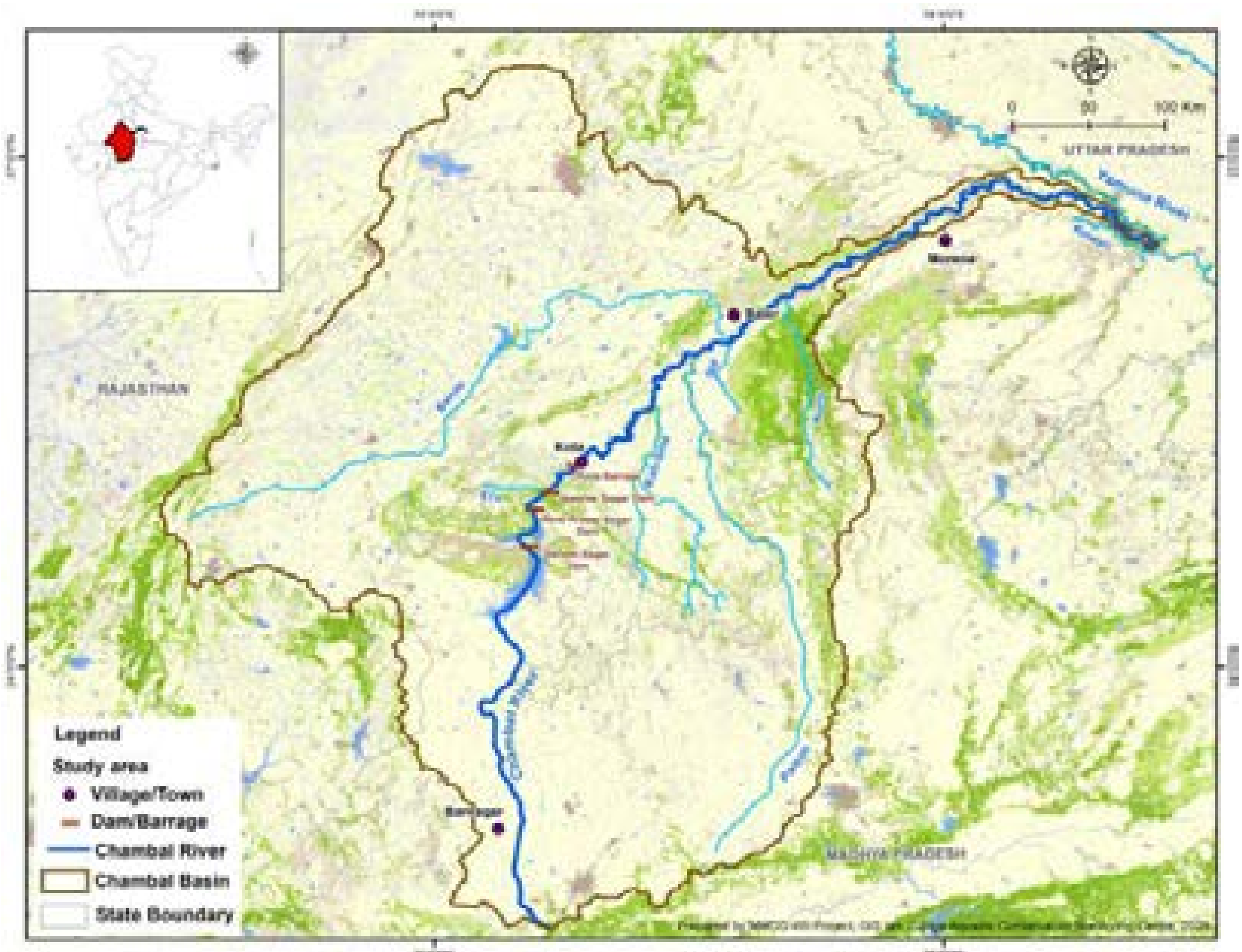


Figure 1.1: Origin and Course of the Chambal River

1.1.1 Description of the Chambal Basin

The Chambal River Basin lies in the southeastern part of Rajasthan and extends into Madhya Pradesh and Uttar Pradesh (Jain et al., 2007). The Chambal River Basin, a sub-basin of the Yamuna and ultimately the Ganga River Basin, is a rain-fed system covering approximately 141,600 km², with the largest portion in Rajasthan (84,025.96 km², 59.34%), followed by Madhya Pradesh (56,893.36 km², 40.18%) and a small part in Uttar Pradesh (680.68 km², 0.48%). The Aravalli hills bound the basin in the west and the Vindhya plateau in the south. The Mukundra Hills influence the drainage of the basin in the southern region. The basin resembles a fig leaf, with tributaries branching out like the veins of a leaf. The key tributaries of the Chambal River are the Banas, Kali Sindh, Parbati and Kuno rivers. The basin falls within Semi-arid to Sub-humid climatic regions. The basin is characterized by an undulating floodplain, gullies, forests, ravines, and a mosaic of land-use types (Hussain & Badola, 2001; Gopal & Srivastava, 2008). The basin supports several towns and villages that depend on the river for agriculture, water supply, and fisheries. The Gandhi Sagar dam divides the basin into upper and lower parts. A large part of the basin falls under the Gujarat-Rajputana (4B) biogeographic province, and a smaller part of the basin falls under the Punjab Plains (4A) biogeographic province.

The Chambal River basin is characterised by its distinctive badlands formation, also known as 'ravines'. These geomorphic formations have evolved under humid to sub-humid climatic conditions due to intense fluvial erosion, resulting in deeply incised ravines reaching depths of up to 80 meters, steep slopes, and a dense drainage network. Ecologically, the basin supports a mosaic of riparian vegetation including grasses, shrubs, and trees, as well as aquatic flora and dry deciduous forests. This unique habitat supports a rich array of wildlife, including several species of conservation concern like the Gharial, Gangetic Dolphin, Mugger, and Indian Skimmer and several freshwater turtles (Hussain & Badola, 2011; Nair & Krishna, 2013).

1.1.2 Zones of the Chambal River

The Chambal River is classified into three zones: Vindhyan, Middle, and Lower, based on its geomorphological characteristics. These zones are further subdivided into five sub-zones, demarcated by key river confluences and water control structures (Table 1.2 and Figure 1.2).

Upper Vindhyan Zone

The uppermost zone of the Chambal River originates in the Vindhyan highlands near Janapav Hills in Madhya Pradesh and extends up to Rana Pratap Sagar Dam. In this segment, the river traverses rugged terrain dominated by hard sandstone and slate formations of Precambrian age. The zone is characterised by narrow valleys, steep gradients, and deeply incised gorges, with the river flowing through a relatively confined channel that forms gorge landscapes. Two major hydrological structures, viz. the Gandhi Sagar and Rana Pratap Sagar dams, are located within this zone.

Lower Vindhyan Zone

In the Lower Vindhyan Zone, the Chambal River continues its journey downstream from the Rana Pratap Sagar Dam to the Kota Barrage. This zone includes the Jawahar Sagar Dam. The narrow gorges and steep escarpments characterise this zone. The terrain transitions from rugged highlands to more dissected plateaus. The River remains confined within a gorge until it approaches Kota, where it flows through a narrow valley with steep banks, making this stretch critical for hydroelectric infrastructure and flow regulation. The Kota Barrage marks the transition from the lower Vindhyan to the middle reach.

Upper Middle Zone

The Upper Middle Zone of the Chambal River extends from the Kota Barrage to its confluence with the Banas River. At Kota, the River emerges from the Vindhyan gorge system onto the plateau. The gradient decreases, and the River begins to meander across a relatively open floodplain, interspersed with rocky patches. This section also receives inflow from major tributaries, including the Kali Sindh, Parbati, and Banas rivers. However, a significant volume of water is diverted through dams and barrages in the upstream, resulting in negligible flow immediately downstream of the Kota Barrage. The Parbati River, a key tributary, joins the Chambal River in this stretch, contributing to its overall discharge and helping reinstate the Chambal's water flow thereafter.

Lower Middle Zone

The lower middle zone extends from the Banas-Chambal confluence to Basai Dang. This stretch represents the beginning of the Chambal badlands, a geomorphologically unique region characterized by ravines, gullies, and highly dissected terrain caused by intense water erosion and the presence of unconsolidated sediments. Though less suitable for cultivation, these areas harbor significant ecological value and support diverse flora and fauna.

Lower Zone

This stretch extends from Basai Dang to the Chambal-Yamuna confluence near Etawah in Uttar Pradesh. This zone is characterised by a wide floodplain with large sand banks and extensive ravines. This zone supports a mosaic of habitats that are critical for aquatic and terrestrial biodiversity.

Table 1.2: Zonation of the Chambal River basin

Zone	**Vindhyan**		**Middle**		**Lower**
Sub-zone	**Upper Vindhyan**	**Lower Vindhyan**	**Upper Middle**	**Lower Middle**	**Lower**
Length (km)	335	48	173	142	233
Stretch	Janapav Kuti - Rana Pratap Sagar Dam	Rana Pratap Sagar- Kota	Kota-Barrage- Banas Confluence	Banas Confluence- Basai Dang	Basai Dang - Yamuna Confluence
Geological characteristics	Rugged terrain composed of hard sandstone and slate formations of Precambrian age	Terrain transitions from rugged highlands to more dissected plateaus. The river remains confined within a gorge until it approaches Kota	River begins to meander across a relatively open river stretches interspersed with rocky patches	Characterized by ravines, gullies, and highly dissected terrain caused by intense water erosion and the presence of unconsolidated sediments	Characterized by ravines, and wide floodplain caused by lower elevations till confluence with the Yamuna River
Dam	Gandhi Sagar and Rana Pratap Sagar	Jawahar Sagar	–	–	–
Barrages	--	Kota	–	–	–
Protected area	Gandhi Sagar WLS, Bhensrodgar WLS	Jawahar Sagar WLS, Darrah WLS, Bhensrodgar WLS, National Chambal Sanctuary	National Chambal Sanctuary	National Chambal Sanctuary	National Chambal Sanctuary

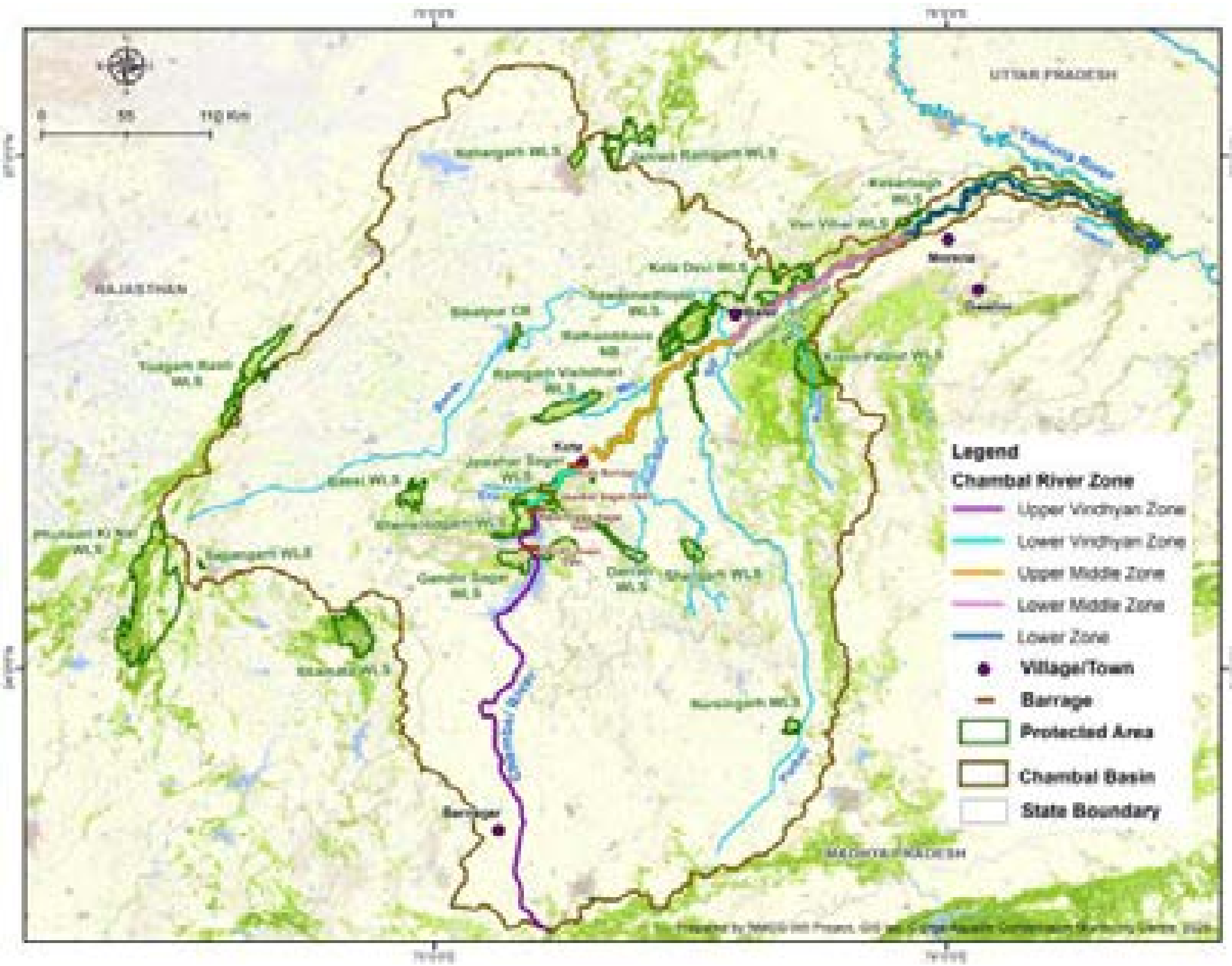


Figure 1.2: Map showing the zones along the Chambal River

1.2 Geology and Geomorphology

The Chambal River, a major tributary of the Yamuna River, forms an integral part of the Ganga River Basin. The basin is characterized by an undulating floodplain, gullies, forests, ravines, and a mosaic of land-use types (Hussain et al., 2013; Gopal & Srivastava, 2008). The geomorphology of the region is shaped by a combination of aeolian, fluvial, denudational, and structural processes, giving rise to diverse landforms. Aeolian features such as eolian and sandy plains are formed by wind activity, characterized by sand dunes and gently undulating surfaces composed of fine to coarse sand and silt. Denudational landforms include buried pediments, intermontane valleys, and dissected plateaus, typically formed by erosion and weathering, often exhibiting varied lithology and deep valleys created by fractures and faults. Fluvial processes dominate the landscape, having formed extensive alluvial features such as alluvial fans, mixed and sandy alluvial plains, paleochannels, and valley fills, largely through sediment deposition by rivers and streams. Other prominent features, including ravines and wetlands, are shaped by intense water erosion and seasonal submergence. Collectively, these landforms reflect a complex geological history and dynamic environmental processes influencing the basin (Kumar et al., 2024).

The Chambal River valley consists of massive sandstone, slate and limestone deposits, of perhaps pre-Cambrian age, resting on the surface of older rocks. It is a part of the Vindhyan system, composed of large sandstone, slate and limestone. According to Heron (1953), the eastern peneplain, occurring between the Vindhyan plateau and the Aravalli hill range, contains a thin veneer of quaternary sediments, reworked soil and river channel fills. At least two erosional surfaces can be recognised within the Pedeplain, which are of the Tertiary age. The Vindhyan upland, the adjoining Chambal valley and the Indo-Gangetic alluvial tract (older alluvium) are of Pleistocene to sub-recent age. The ravines or badlands topography is a characteristic feature of the Chambal valley, where Kankar has extensively developed in the older alluvium.

1.3 Land Use and Land Cover (LULC)

In the Chambal River Basin, agriculture is the predominant land use type, covering 70.47% of the total area, followed by forest (14.40%), wastelands (8.79%), waterbodies (3.57%), built-up areas (2.10%), and grasslands, which represent the least extent at 0.67% (Table 1.3 and Figure 1.3). Notably, unlike other sub-basins within the Ganga River Basin, the Chambal Sub-basin exhibits a relatively low proportion of built-up areas, indicating limited urban development (Table 1.3). However, change analysis reveals a gradual increase in built-up area from 2,754.11 sq. km in 2008-09 to 2,965.75 sq. km in 2018-19, reflecting a 0.16% rise. Likewise, agricultural land expanded by 3.07%, while wastelands, the third-largest LULC category, declined by 3.69% during the same period (Figure 1.4).

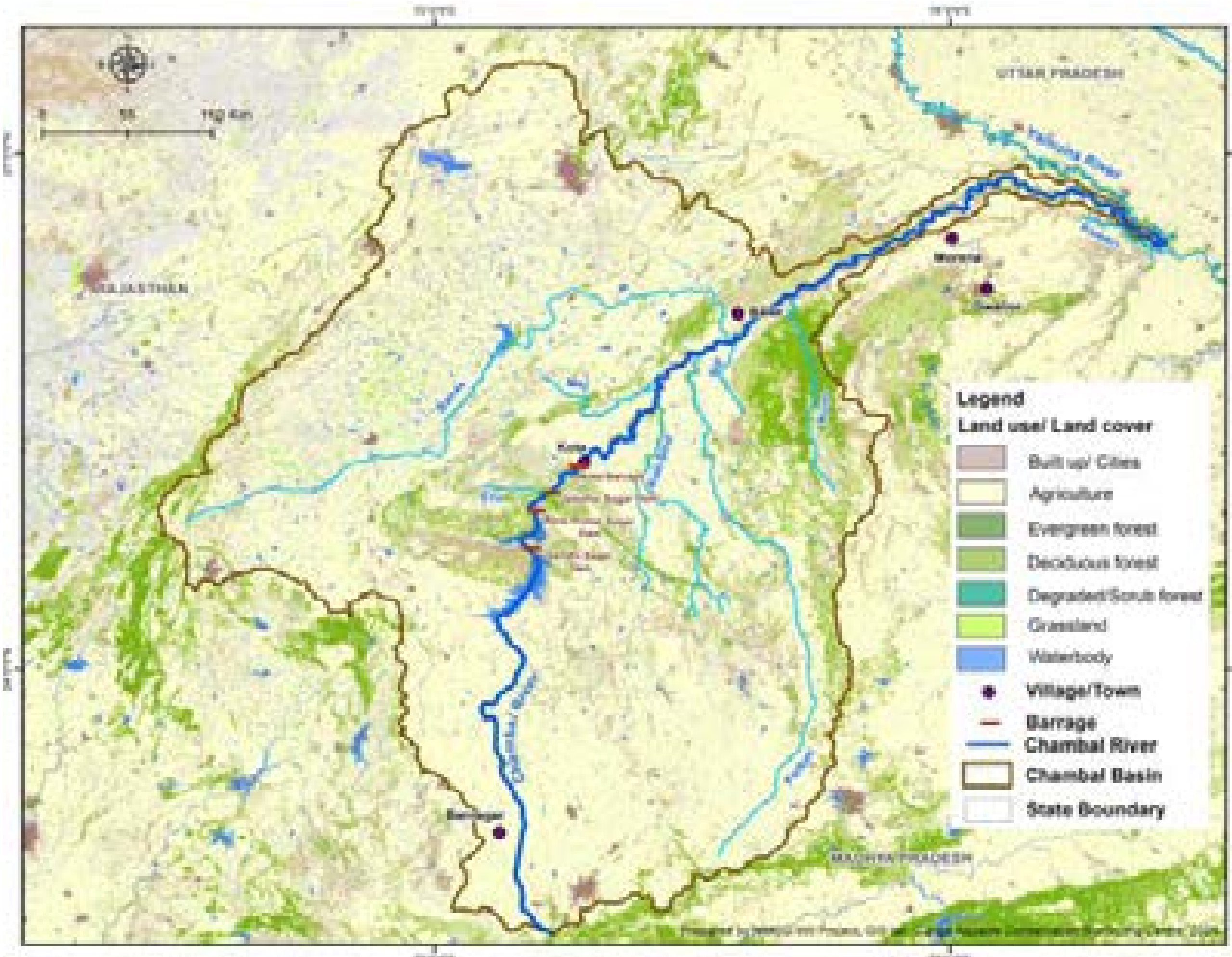


Figure 1.3: Land use land cover of the Chambal River Basin

Table 1.3: Land use and land cover changes in the Chambal River Basin, India (Source NRSC)

Classes	2008-09		2018-19		Change	
	Sq. km	%	Sq. km	%	Sq. km	%
Built up	2754.11	1.94	2965.75	2.1	211.64	0.16
Agriculture	95439.55	67.4	99773.99	70.47	4334.44	3.07
Forest	20401.26	14.41	20394.87	14.4	-6.39	-0.01
Grassland	979.01	0.69	955.44	0.67	-23.57	-0.02
Wasteland	17663.62	12.48	12450.15	8.79	-5213.47	-3.69
Waterbodies	4362.45	3.08	5059.8	3.57	697.35	0.49
Total Area	**141600**	**100**	**141600**	**100**		

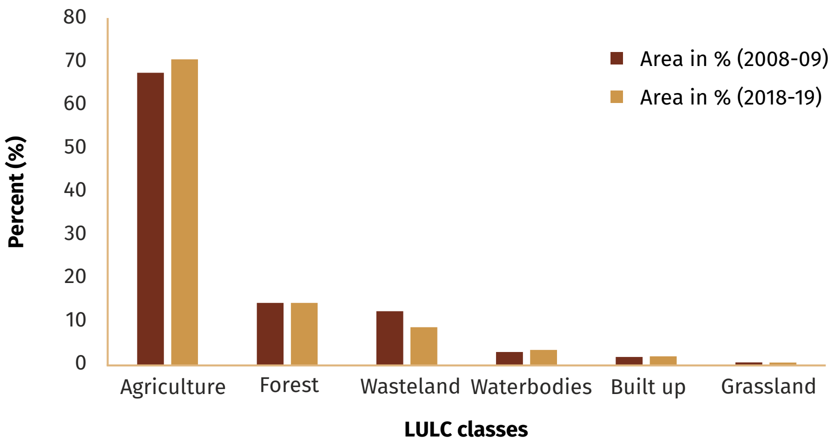


Figure 1.4. Change in LULC for the Chambal River Basin, India

1.4 Soil Types

The predominant soil type in the Chambal River Basin is black soil, which is extensively distributed across the upper reaches of Madhya Pradesh. A mixture of red and black soils is found in the Mandsaur and Chittaurgarh districts of the upper basin, while lateritic soils occur in isolated pockets, particularly in the Romper Plateau. In contrast, alluvial soils dominate the lower basin, where deposits can reach up to 60 meters in thickness (Sharma, 1980; Hussain & Badola, 2001). In the basin, clayey soils constitute the largest proportion (43.14%) of soil texture, followed by loamy (37.45%), loamy skeletal (7.72%), and areas with rock outcrops (5.21%) (Table 1.4 and Figure 1.5).

Table 1.4: Soil texture of the Chambal River Basin, India (Source: NRSC, ISRO).

Soil class	Area	
	Sq. km	%
Sandy	4436.30	3.13
Loamy	53020.6	37.45
Clayey	61087.04	43.14
Clay skeletal	2579.70	1.82
Loamy skeletal	10934.41	7.72
Rock outcrops	7372.66	5.21
Water bodies	2169.29	1.53
Total area	141600*	100

*based on GIS layer assessment

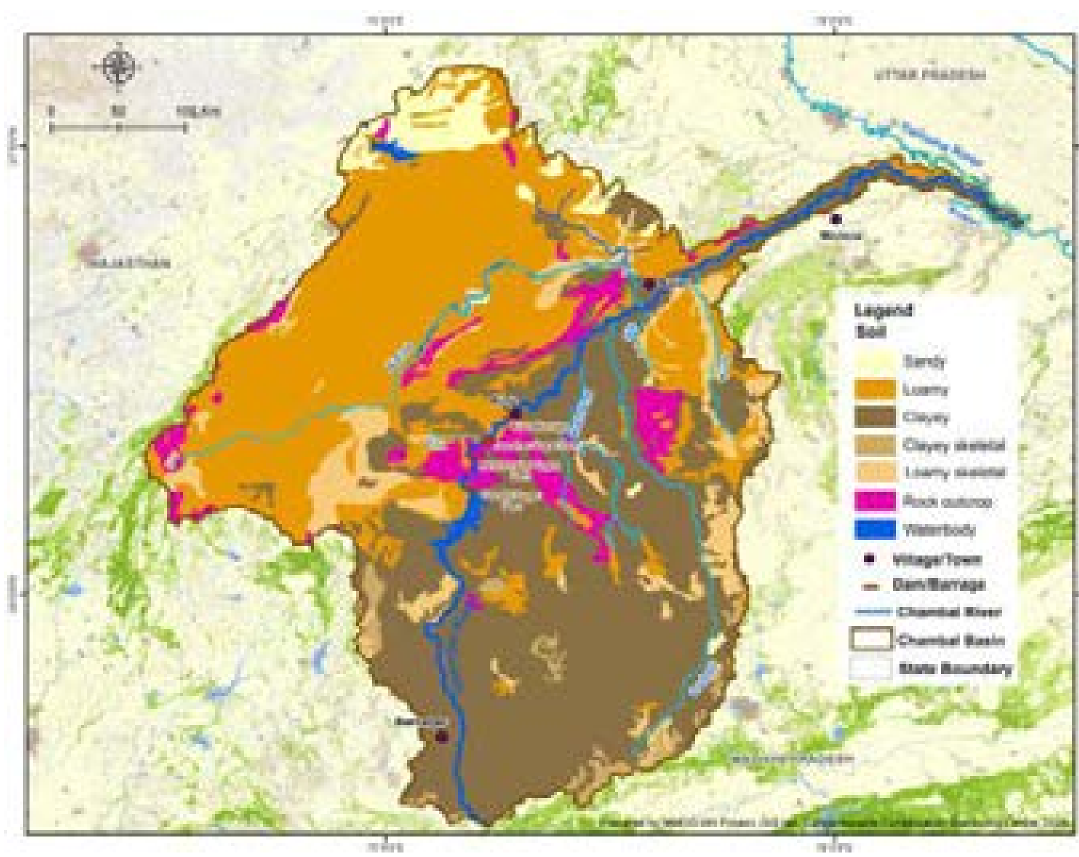


Figure 1.5: Soil texture in the Chambal River Basin, India

1.5 Climate

The climate of the Basin is a vital physical factor, which decides the nature and the extent of the weathering and erosion processes and has a profound influence on the biodiversity assemblages and agricultural conditions. In general, the Chambal River Basin is part of the sub-humid regions of India with extremes of temperature and rainfall. The mean annual rainfall over the Chambal River Basin is reported to be 797 mm, of which about 93% falls during the three monsoon months (July-September). Only 5% of the rainfall occurs during the cold season in the basin. Although the annual rainfall is not heavy, it can fall in intensive bouts.

One of the characteristics of the climate of the Chambal River Basin, as in other Semi-arid climatic regions, is the extremes of temperature. The temperature during the winter dips below 5°C at many places, while during summer the temperature reaches up to 45°C. The period from October to February constitutes the winter season, with January being the coldest month. At Kota, the daily mean maximum and minimum temperatures are 25.02°C and 10.61°C, respectively, the mean being 17.81°C. From February to April, the daily mean maximum and minimum temperatures rise at a rate of about 2.5°C to 3.0°C during the successive months. The highest temperature is recorded in May when the summer season is at its peak, with daily mean maximum and minimum temperatures at 41.5°C and 29.08°C, respectively, the mean being 35.29°C (as recorded at Kota). The weather cools down with the onset of the monsoon and brings relief after the prolonged heat of the summer season. July-August is the most humid period, averaging 70% to 80% humidity. Relative humidity drops to about 20% during March, April and May.

1.6 Drainage and Hydrology

The Chambal River Basin has primary characteristics of dendritic drainage, with some elements of a parallel drainage pattern in the sub-basins. The Basin resembles a fig leaf, with tributaries arranged in a dendritic pattern, resembling the veins of a leaf. The River has a large number of small and large tributaries that contribute to its hydrology and ecological stability.

1.6.1 Major tributaries of the Chambal River

The tributaries of the Chambal River are broadly classified into right-bank and left-bank tributaries based on their direction of confluence (Central Water Commission, 2017). The major left bank tributaries are Mej, Eru, and Banas, and right bank tributaries are Kali-Sindh, Parbati, Sip and

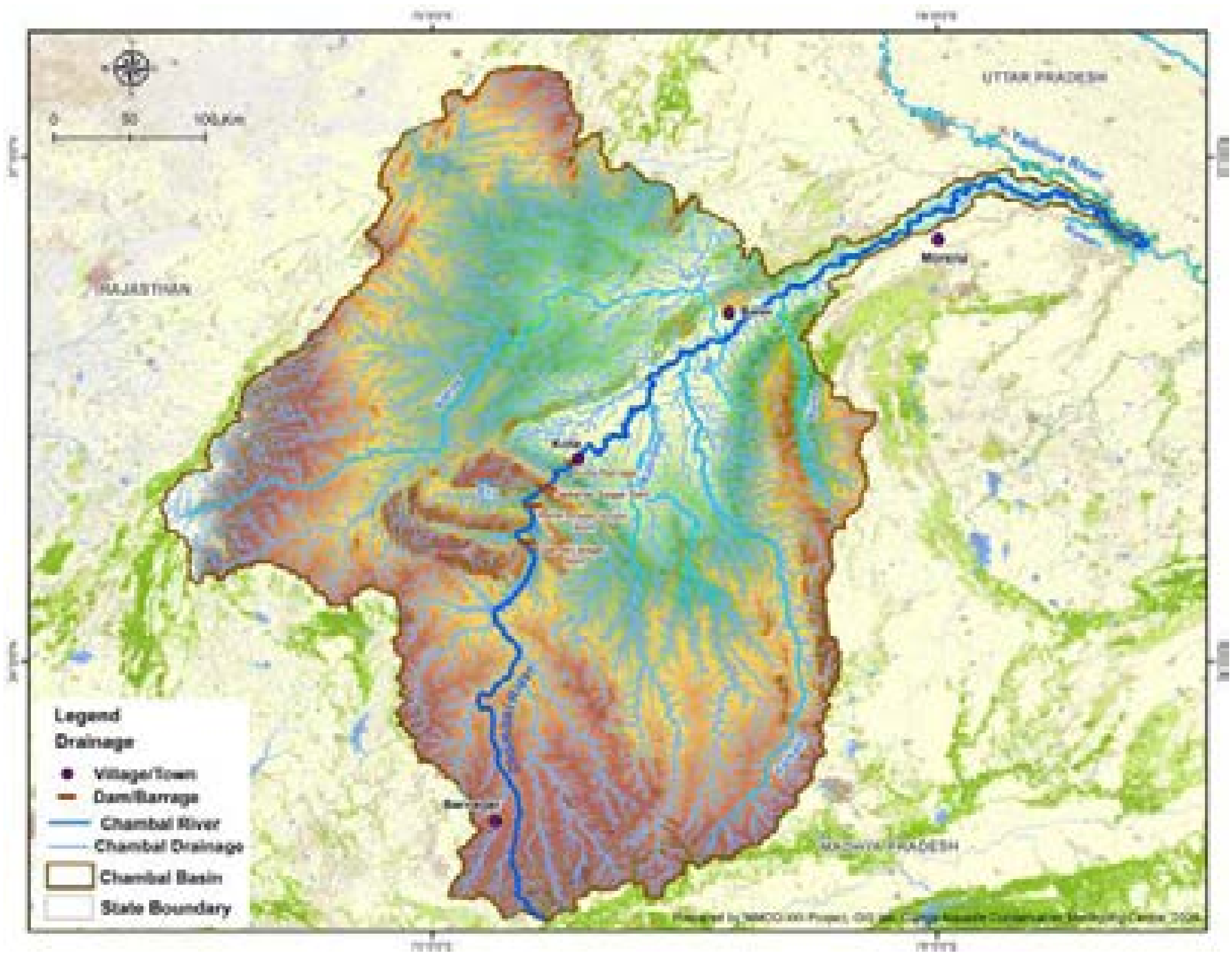
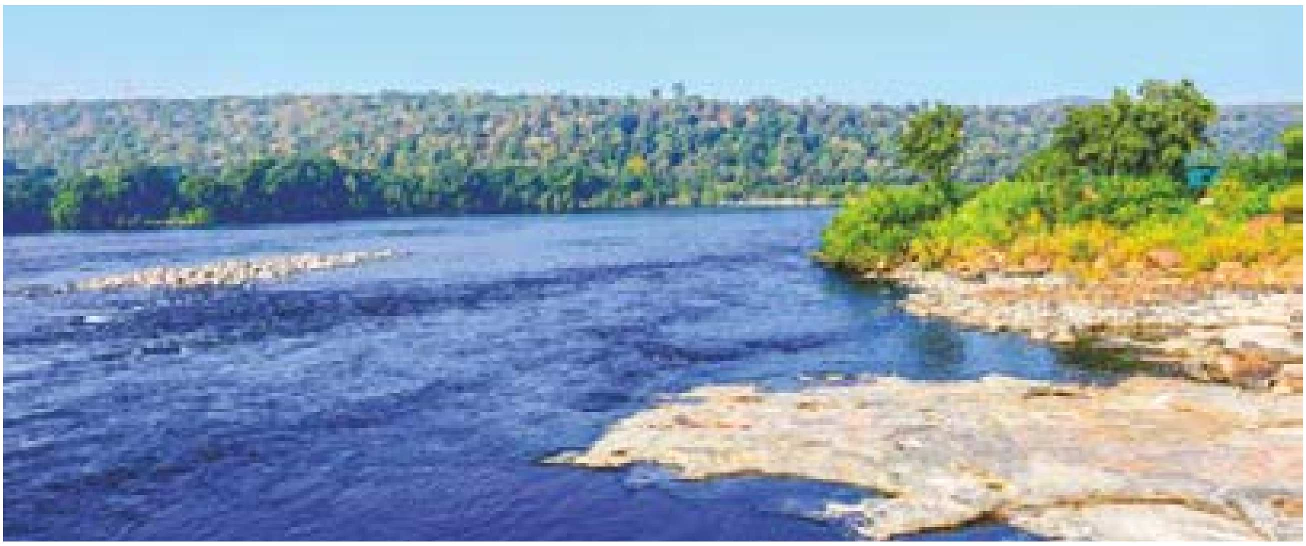


Figure 1.6: Major tributary of the Chambal River Basin, India

Kuno (Figure 1.6). The Mej River originates near Mandalgarh in Bhilwara, Rajasthan, and flows for 58 km before joining the Chambal River at Lakheri in Kota district. The Mej River supports agriculture and local communities' water needs (Central Water Commission, 2017). The Eru River, another left bank tributary, originates from Astoli on the Uparmal Plateau in Bhilwara district, Rajasthan. It traverses the districts of Bhilwara, Chittaurgarh, and Bundi before merging with the Chambal River upstream of the Jawahar Sagar Dam. The Banas River, a major left bank tributary, originates in the Khamnor hills of the Aravali range near Kumbhalgarh and flows along its entire length through Rajasthan. Banas confluences with the Chambal River at Rameshwar in Khandar Block in Sawai Madhopur district. Among the major right bank tributaries, the Kali Sindh River, originating from Bagli in the Dewas district of Madhya Pradesh, flows for approximately 285 km and joins the Chambal River at Nonera village in Baran district, Rajasthan (Saksena, 2008). The Parbati River, which originates from the northern slopes of the Vindhyan Range in Sehore district, Madhya Pradesh, merges with the Chambal at Pali village along the Sawai Madhopur-Kota border (Parveen & Sharma, 2015).

The Kuno River originates north of Guna town in Madhya Pradesh and joins the Chambal River near Gordhanpura village in Kota district, playing a critical role in the conservation of species such as Asiatic lions and leopards near the Kuno National Park (Singh et al., 2021). Additionally, several smaller tributaries such as Shipra, Choti Kalisindh, Sivanna, Retam, Ansar, Seep, Kuwari, Chamla, Gambhir, Lakhunder, Khan, Bangeri, Kedel, and Teelar also contribute to the flow of the Chambal River, enhancing its ecological and hydrological balance (Jain et al., 2007; Gopal & Srivastava, 2008). These tributaries, both major and minor, play an essential role in maintaining the River's biodiversity, ensuring sustained water flow, and supporting local livelihoods (Figure 1.6).



1.6.2 Hydrology of the Chambal River

The Chambal River averages 400 m in width, while depth ranges from 1 to 26 m (Hussain et al., 2013). During the monsoon, the water level rises 10 to 15 m and often spreads to more than 500 m from either bank. The mean maximum discharge of the River recorded was 2074.28 m3/s and the minimum 58.53 m^3/s during 1996-2004. Between 1960 and 1972, four multipurpose dams, namely Gandhi Sagar, Jawahar Sagar, Rana Pratap Sagar and Kota Barrage, were built on the Chambal River, which has affected its flow considerably (Hussain et al., 2011). In the Vindhyan zone, the Chambal River flows through a deep gorge. Owing to its favourable geomorphology for retaining large volumes of water, three major dams are located in this zone. The presence of steep gorges immediately upstream of these dams enables the formation of reservoirs with substantial storage capacity, even though the dam structures themselves are relatively low in height.

1.6.3 Channel characteristics, water flow and water quality

During 1996-2004, the mean monthly flow of the Chambal River varied between 58.53 m3 /sec in the month of April to 2074.28 m^3 /sec in August. As little as 16.38 ±1.99 m^3 /sec flow was recorded during the months of June-July 2009 (WII, 2010). The study showed that discharge has decreased by 3.4% of the monthly flow of the Chambal River for the period 1996-2004 (Hussain et al., 2011). Unlike other rivers of the Ganga River basin, the Chambal River is relatively unpolluted (Hussain, 1999). The water quality exhibits very low suspended solids and low Biological Oxygen Demand (BOD), and high Dissolved Oxygen (DO). There is no indication of organic matter discharge or eutrophication in the River as the values of Chemical Oxygen Demand (COD), ammonia (NH4), and phosphate (PO4) were below the threshold limits. The essential cations (Ca, Mg, Na and K) were also within the range to support the aquatic organism. Based on standards set by the Central Pollution Control Board (CPCB), Government of

India, the Chambal River water can be considered as `A' category. Also, by comparing the water quality parameter with the ranges given by Allen (1989), the Chambal River can be considered as clean.

However, the increasing human population, expanding agricultural activities, reduced river flow, and growing industrialisation are emerging as major concerns contributing to rising pollution levels in the Chambal River. The major urban settlement along the River, such as Kota discharges untreated domestic and industrial sewage into the River. In recent years, the rapid expansion of agriculture along the riverbanks has emerged as a key concern, particularly due to non-point source pollution (Hussain et al., 2013).

1.7 Biogeography, Flora and Fauna

1.7.1 Biogeography of the Chambal River

The Chambal River Basin lies within the Semi-Arid biogeographic zone and spans two biogeographic provinces: Punjab Plains (4A) and Gujarat-Rajputana (4B). Over 95% of the basin falls within the Gujarat-Rajputana province, while a smaller portion situated between the north bank of the Chambal River and the south bank of the Yamuna River lies within the Punjab Plains province (Rodgers et al., 2000; Figure 1.7).

1.7.2 Flora of Chambal Basin

The Chambal region lies within the semi-arid zone of north-western India at the border of Madhya Pradesh, Rajasthan and Uttar Pradesh states. The vegetation consists of ravine thorn forest, a sub-type of the Northern Tropical Forests (Champion & Seth, 1968). This sub-type typically occurs in areas receiving rainfall between 600-700 mm. Alkaline Babul savannah (5E/8b), a type of Northern Tropical Dry Deciduous Forest, also occurs in this region. Evergreen riparian vegetation is completely absent, with only sparse ground cover along the severely eroded river banks and adjacent ravine lands. The forests of the basin are a combination of semiarid tract, thorny bushes or small trees, miscellaneous forest, mixed forest and grasslands (Pathak, 2013) (Figure 1.8). In addition to these, almost pure plantations of Acacia nilotica, Prosopis juliflora may be seen. Over 1000 flowering plants have been reported from the area (Verma, 1993). The forest cover of the basin is mainly moderate to open (Figure 1.8).

1.7.3 Fauna of Chambal Basin

The gharial (*Gavialis gangeticus*), red-crowned roofed turtle (*Batagur kachuga*) and the Gangetic dolphin (*Platanista gangetica*) are the flagship aquatic species of

Figure 1.7: Biogeographic zones of the Chambal River Basin, India.

the Chambal River Basin. The River harbours the largest breeding population of gharial, one of the highest densities of Gangetic dolphin, and provides nesting ground to the Indian skimmer, black bellied tern, river tern and small Indian pratincole. Smooth-coated otter and eight species of turtles are also reported from the Chambal River Basin. The River supports a large breeding population of the Indian vulture (*Gyps indicus*), White-rumped vulture (*Gyps bengalensis*) and Egyptian vulture (*Neophron percnopterus*).

A comprehensive review of literature assessing the biodiversity of the Chambal River Basin, conducted in 2012 (Nair & Krishna, 2013), documented a total of 146 fish species belonging to 32 families, 56 reptile species across 19 families, 308 bird species from 64 families, and 60 mammal species representing 27 families. This rich faunal diversity includes several threatened taxa, comprising six Critically Endangered, 12 Endangered, and 18 Vulnerable species as per the IUCN Red List of Threatened Species (IUCN, 2011). The Basin also supports a range of terrestrial fauna, including large carnivores such as the common leopard (*Panthera pardus*), grey wolf (*Canis lupus*), caracal (*Caracal caracal*), jungle cat (*Felis chaus*), and sloth bear (*Melursus ursinus*), alongside ungulates like the chinkara (*Gazella bennettii*) and nillgai (*Boselaphus tragocamelus*).

1.8 Forest type and cover

Based on The Forest Types of India, first classified by Champion (1936) and later revised by Champion and Seth (1968), the Chambal River Basin is dominated by Tropical Dry Deciduous Forests (Group 5), including Dry Teak, Dry Shisham, and Northern Dry Mixed Deciduous types (Table 1.5). The Chambal River Basin also has elements of the Tropical Thorn Forests (Group 6) (Table 1.5). The forest cover in the Chambal River Basin is categorized into five forest cover classes. While the majority of the basin (88.64%) is classified as non-forest, open forest accounts for 6.63%, followed by moderately dense forest (2.46%) and scrub (2.26%). Very dense forest covers a minimal portion of the basin (0.01%) (Table 1.5 and Figure 1.8).

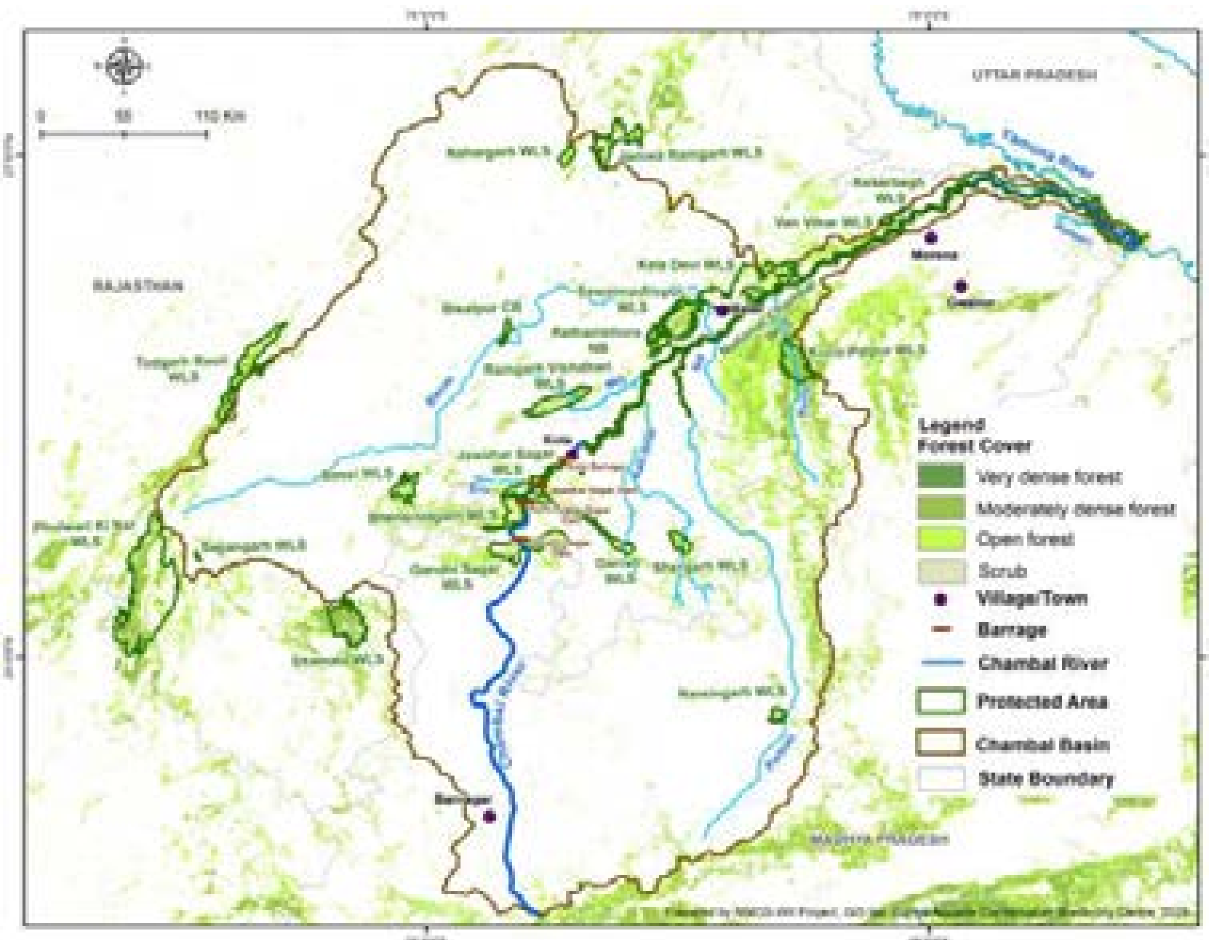


Figure 1.8: Map showing Forest Cover of Chambal River Basin (Source: NRSC).

Table 1.5: Forest types in the Chambal River Basin

Forest Type (Champion & Seth 1968)	Dominant Species
5A/C1 - Dry Teak Forest	*Tectona grandis, Anogeissus latifolia, Boswellia serrata, Terminalia tomentosa, Lagerstroemia parviflora*
5A/C3 - Southern Dry Mixed Deciduous Forest	*Anogeissus latifolia, Butea monosperma, Acacia catechu, Terminalia alata, Boswellia serrata*
5B/C1 - Dry Shisham Forest (patchy/localized)	*Dalbergia sissoo, Acacia catechu, Terminalia arjuna*
5B/C2 - Northern Dry Mixed Deciduous Forest	*Terminalia tomentosa, Acacia catechu, Lannea coromandelica, Diospyros melanoxylon*
6A/C1 - Desert Thorn Forest	*Prosopis cineraria, Capparis decidua, Ziziphus nummularia, Balanites aegyptiaca*
6A/C2 - Ravine Thorn Forest (typical of Chambal ravines)	*Acacia nilotica, Capparis sepiaria, Carissa spinarum, grasses and thorny shrubs.*
	Invasive exotic (widespread across ravines and riparian tracts)- Prosopis juliflora
6B - Southern Tropical Thorn Forests	*Acacia leucophloea, Maytenus emarginata, Capparis decidua, Ziziphus mauritiana*
Riparian vegetation associated with dry deciduous and thorn forest zones (within 5B & 6A zones)	*Dalbergia sissoo, Acacia nilotica, Tamarix dioica, Ficus religiosa, Terminalia arjuna*

Table 1.6: Forest cover in the Chambal River Basin

Forest Cover Classes	Area in Sq. km	Area in %
Very Dense Forest	12.56	0.01
Moderately Dense Forest	3479.51	2.46
Open Forest	9391.77	6.63
Scrub	3199.65	2.26
Non-Forest	125516.51	88.64
Total Area	**141600**	**100**

1.9 Conservation Status of the Chambal River Basin

About 3.64% of the Chambal River basin is under the Protected Area (PA) network, with twenty-eight PAs notified under the Wildlife (Protection) Act, 1972 (Figure 1.8), as Wildlife sanctuaries and National parks, including India's longest riverine protected area, the National Chambal Sanctuary (NCS). The NCS extends across three states, Rajasthan, Madhya Pradesh, and Uttar Pradesh, forms the ecological backbone of the basin and plays a critical role in conserving the unique biodiversity (Hussain et al., 2011). The NCS consists of a ~600 km long stretch of the Chambal River, from Jawahar Sagar Dam to the Chambal-Yamuna confluence in Uttar Pradesh. The Sanctuary was established in 1978 and is the longest riverine protected area of the country. It contains the most important breeding populations of the gharial and red-crowned roofed turtle. Since 1978, a ~600 km stretch of the Chambal River between Jawahar Sagar and Chambal - Yamuna confluence in Uttar Pradesh and a ~60 km stretches of Parbati River in Madhya Pradesh (south bank) between Badodiya Bindi and Pali (Chambal-Parbati confluence) has been protected as National Chambal Sanctuary for the conservation and management of aquatic fauna such as gharial, mugger, dolphin, and freshwater turtles. The administrative limits of the Sanctuary fall under the jurisdiction of the north Indian states of Rajasthan, Madhya Pradesh, and Uttar Pradesh, which are managed by the concerned State Forest Departments (Hussain, 1993).

In addition to the mainstem, several adjoining terrestrial PAs also provide incidental protection through their connectivity to adjoining protected areas, thereby enhancing the basin's ecological resilience and conservation potential. Apart from the NCS, the major protected areas in the basin are Kuno National Park and Gandhi Sagar Wildlife Sanctuary in Madhya Pradesh, Ranthambore National Park, Jawahar Sagar Wildlife Sanctuary, and Sawai Madhopur Wildlife Sanctuary in Rajasthan.

1.10 Demography and Human Development Index (HDI)

The Chambal River Basin, spanning across the Indian states of Madhya Pradesh, Rajasthan, and Uttar Pradesh, encompasses 37 districts (Jain et al., 2007). Of these, the Chambal River directly flows through 17 districts in Madhya Pradesh, 18 in Rajasthan, and two in Uttar Pradesh (Table 1.7; Figure 1.9). Of 37 districts, 24 are fully within the Basin, while 13 districts lie partially within the Chambal River Basin.

The Chambal Basin supports a population of approximately 71.15 million, with an average population density of 333 persons/km² (Table 1.6). Agra district (1093 persons/km²), which partly falls in the basin, is the most densely populated district and Sheopur district holds the lowest population density (104 persons/km²). Population distribution within the basin is spatially uneven, with Northern and eastern districts such as Agra, Etawah, and Kota exhibiting high population density, whereas southern and central districts such as Guna, Neemuch, Bundi, Nagaur, Baran, Shivpuri, and Sheopur remain sparsely populated, with densities below 200 persons/km². This region is inhabited by diverse communities that are primarily rural and rely heavily on agriculture, livestock rearing, inland fishing, and small-scale industries for their livelihoods (Taigor & Rao, 2010; Kumar et al., 2017). Mean human density of the basin rose from 256 persons/km² in 2000 to 333 persons/km² in 2011. The human density is lower than the national average of 382 persons/km² (Census of India, 2011).

Rapid population growth was observed across districts along the Chambal River during the 2001-2011 decade, indicating demographic pressure on the riverine ecosystem and associated resources. Kota, a major urban centre in Rajasthan located on the Chambal River, has a population of 1.95 million as per the 2011 census (Census of India, 2011).

The Human Development Index (HDI) across the Chambal River Basin exhibits substantial spatial variation, reflecting socio-economic gradient within the region. HDI values range from 0.31 among marginalised fishing communities near the Rana Pratap Sagar Reservoir in Rajasthan (Bunkar et al., 2022) to higher values in urban districts such as Agra and Kota. While a basin-wide average HDI has not been formally calculated, district-level assessments suggest that urbanised districts in Uttar Pradesh and Rajasthan tend to have higher HDI values compared to the rural interiors of Madhya Pradesh.

Table 1.7: Population and population density in the districts of the Chambal River basin

State	District	Area (km²)	Population	Density (Ind./km)
Rajasthan	Sikar*	7,732	2677333	346
	Nagaur*	17,718	3307743	187
	Pratapgarh*	3, 717	867848	195
	Rajsamand	4, 522.26	1156597	248
	Ajmer	8,481	2583052	305
	Chittaurgarh	7,822	1544338	197
	Udaipur*	11,724	3068420	262
	Dausa*	3,432	1634409	476
	Bhilwara	10,455	2408523	230
	Tonk	7,194	1421326	198
	Bundi	5,776	1110906	192
	Jaipur	11,143	6626178	595
	Kota	5,217	1951014	374
	Jhalawar	6,219	1411129	227
	Baran	638.8	1222755	175
	Karauli*	5,524	1458248	264
	Dholpur*	3,033	1206516	398
	Sawai Madhopur	4,498	1335551	297
Madhya Pradesh	Bhind*	4,459	1703005	382
	Dhar*	8,153	2185793	268
	Bhopal	2,772	2371061	855
	Rajgarh	6,154	1545814	251
	Shajapur	6,195	1512681	244
	Shivpuri*	10, 278	1726050	171
	Vidisha*	7,371	1458875	198
	Sehore*	6,578	1311332	199
	Ujjain	6,091	1986864	326
	Indore	915.52	3276697	841
	Ratlam	4,861	1455069	299
	Neemuch	4000.44	826067	194
	Guna	6,484.63	1241519	194
	Dewas	7020.84	1563715	223
	Mandsaur	5,535	1340411	242
	Sheopur	6,606	687861	104
	Morena	4998.78	1965970	394
Uttar Pradesh	Etawah	2311	1581810	684
	Agra*	4027	4418797	1093

Districts marked with asterisk are partially within the Chambal River basin

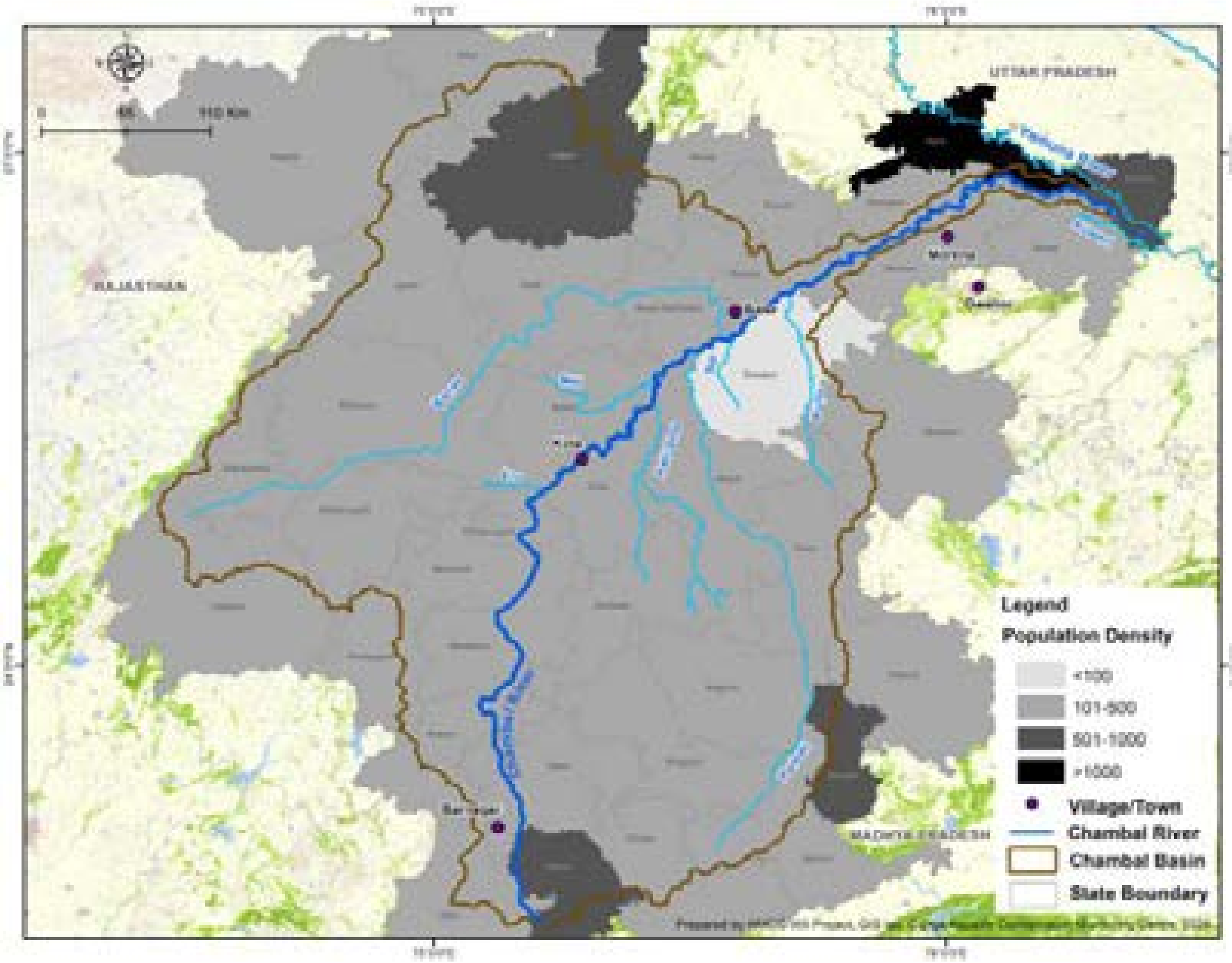


Figure 1.9: Population density of the Chambal River basin, India

REFERENCES

Allen, R. G., & Gichuki, F. N. (1989). Effects of projected CO2-induced climate changes on irrigation water requirements in the Great Plains states (Texas, Oklahoma, Kansas and Nebraska). In *The Potential Effects of Global Climate Change on the United States: Appendix C-Agriculture* (EPA-230-05-89-053). U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, Washington, D.C.

Bunkar, K., Ananthan, P.S., Qureshi, N.W., Sharma, L.L. & Sundaramoorthy, C. (2022). Human development of small scale fishers: Evidence from Rana Pratap Sagar reservoir region, India. *Journal of Indian Fisheries Association, 49*(1).

Central Water Commission. (2017). *Report on river basin classification: Chambal basin*. Ministry of Water Resources, Government of India.

Champion, H. G. (1936). *A preliminary survey of the forest types of India and Burma. Indian Forest Records, 1*.

Champion, H. G., & Seth, S. K. (1968). *A revised survey of forest types of India*. Controller of Publication, New Delhi.

Gopal, L., & Srivastava, V. C. (2008). History of Agriculture in India (up to c. 1200 A.D.). History of Science, Philosophy and Culture in Indian Civilization. Centre for Studies in Civilizations, New Delhi.

Heron, A. M. (1953). *The geology of Central Rajaputana* (Memoir of Geological Survey of India, Vol. 79, pp. 1-389). Geological Survey of India.

Hussain, S. A. (1993). *Aspects of the ecology of smooth coated Indian otter Lutra perspicillata, in National Chambal Sanctuary*. Doctoral dissertation, Aligarh Muslim University.

Hussain, S. A. (1999). Reproductive success, hatchling survival and rate of increase of Gharial *Gavialis gangeticus* in National Chambal Sanctuary, India. *Biological Conservation, 87*(2), 261-268.

Hussain, S. A., & Badola, R. (2001). Integrated conservation planning for Chambal River basin. In *National Workshop on Regional Planning for Wildlife Protected Areas* (pp. 1-20). Wildlife Institute of India, Dehradun.

Hussain, S. A., Badola, R., Sharma, R., & Rao, R. J. (2013). Planning conservation for Chambal River basin taking gharial *Gavialis gangeticus* and Ganges River dolphin *Platanista gangetica* as umbrella species. In *Faunal Heritage of Rajasthan, India: Conservation and Management of Vertebrates* (pp. 135-156). Cham: Springer International Publishing.

Hussain, S. A., & Choudhury, B. C. (1997). Distribution and status of the smooth-coated otter *Lutra perspicillata* in National Chambal Sanctuary, India. *Biological Conservation, 80*(2), 199-206.

Hussain, S., Sharma, R. K., Dasgupta, N., & Raha, A. (2011). Assessment of minimum water flow requirements of Chambal River in the context of Gharial (*Gavialis gangeticus*) and Gangetic Dolphin (*Platanista gangetica*) conservation. *Study Report*. Wildlife Institute of India, Dehradun, 40.

IUCN. (2011). Guidelines for application of IUCN Red List Criteria. Version 9. IUCN Species Survival Commission. IUCN, Gland & Cambridge.

Jain, S. K., Agarwal, P. K., & Singh, V. P. (2007). Ganga basin. In S. K. Jain, P. K. Agarwal, & V. P. Singh (Eds.), *Hydrology and water resources of India* (pp. 333-418). Springer.

Kaushik, P., & Ghosh, P. (2015). Geomorphic evolution of Chambal River origin in Madhya Pradesh using remote sensing and GIS. *International Journal of Advanced Remote Sensing and GIS,* 4(1), 1130-1141.

Kumar, A., Sharma, M. P., & Rai, S. P. (2017). A novel approach for river health assessment of Chambal using fuzzy modeling, India. *Desalination and Water Treatment, 58,* 72-79.

Kumar, R., Kasana, P., Devrani, R., & Devrani, S. P. (2024). The Chambal badlands of Ganga River Basin, India: a fading geoheritage odyssey. *Geoheritage, 16*(4), 93.

Nair, T., & Krishna, Y. C. (2013). Vertebrate fauna of the Chambal River basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa, 5*(2), 3620-3641.

Office of the Registrar General & Census Commissioner, India. (2011). *Census of India 2011: Provisional Population Totals - India - Series 1.* Ministry of Home Affairs, Government of India, New Delhi.

Parveen, W., & Sharma, A. (2015). Wildlife tourism: Prominent panorama at Hadoti region of Rajasthan. *International Journal of Science and Research (IJSR), 3*(9), 1135-1149.

Pathak, H. (2013). Nitrogen and climate change: Interactions, impacts, mitigation and adaptation. *Journal of the Indian Society of Soil Science, 60* (Supplement), 109-119.

Rodgers, W. A., Panwar, H. S., & Mathur, V. B. (2000). *Wildlife protected area network in India: A review (executive summary).* Wildlife Institute of India, Dehradun.

Saksena, D. N., Garg, R. K., & Rao, R. J. (2008). Water quality and pollution status of Chambal river in National Chambal sanctuary, Madhya Pradesh. *Journal of Environmental Biology, 29*(5), 701-710.

Sharma, H. S. (1980). *Ravine erosion in India*. Concept Publishing Company, New Delhi.

Singh, U. S. (2022). Kuno National Park is not yet ready for Cheetahs. *The Applied Biology & Chemistry Journal, 3*(3), 56-61.

Taigor, S. R., & Rao, R. J. (2010). Habitat features of aquatic animals in the National Chambal Sanctuary, Madhya Pradesh, India. *Asian Journal of Experimental Biological Sciences, 1*(2), 409-414.

Verma, D. M., Balakrishnan, N. P., & Dixit, R. D. (1993). Flora of Madhya Pradesh Vol. I. *Botanical Survey of India*, Calcutta, 280.

Wildlife Institute of India. (2010). Assessment of minimum water flow requirements of Chambal River and associated biota (Final technical report). Ministry of Environment and Forests, Government of India.

CHAPTER 2

METHODOLOGICAL FRAMEWORK

Coordinating Lead Authors
Syed Ainul Hussain,
Ruchi Badola,
Shivani Barthwal

Lead Authors
Surya Prasad Sharma,
S.K. Zeeshan Ali

Contributing Authors
Khadija,
Ashish Mani,
Shatakshi Sharma

SUMMARY

The objective of the study was to assess the current status of the Chambal River and its aquatic biodiversity. To achieve the objective, a combination of review of literature and field surveys (ecological assessment) was employed to assess the current as well as past ecological conditions of the Chambal River. Rivers are characterised by a dendritic and linear drainage pattern that intricately guides the ecological and hydrological dynamics of the basin. Given the strong interlinkages between ecological and socio-economic systems, the study also incorporated an analysis of the socio-economic and policy dimensions, along with the identification of key stakeholders.

2.1 Review of literature

A comprehensive review of literature was undertaken to establish baseline information on the biodiversity of the Chambal River and its basin. Information was sourced from peer-reviewed publications, technical reports, and grey literature, as well as field observations available through databases such as Google Scholar, ResearchGate, Web of Science, and JSTOR. The review compiled data on the historical and current distribution, population trends, and conservation status of key indicator species. This consolidated knowledge base was used to support ecological monitoring and to inform long-term conservation strategies for the Chambal River Basin.

2.2 Field Survey

To assess the present ecological status of the Chambal River, field-based biodiversity surveys were conducted, covering major taxa including fish, amphibians, reptiles, aquatic mammals, and birds. A combination of rapid assessments, intensive site-based surveys, and continuous boat-based surveys was employed depending on the ecology and detectability of each taxon (Table 2.1).

The River was divided into three ecological zones: Upper Middle, Lower Middle, and Lower Zone-based on hydrological features and accessibility. Standardised protocols were followed across taxa, with survey timing adjusted seasonally to match species activity.

Table 2.1: Summary of taxa wise information on survey type, year, season, and survey period

Taxa	Survey type	Year	Season	Start date	End date
Flora	Boat and Intensive survey	2025	Post monsoon	18.09.2025	28.09.2025
Fish	Intensive sites	2024	Post monsoon	13.11.2024	24.11.2024
Amphibians	Intensive sites	2024	Monsoon	20.09.2024	29.09.2024
Crocodiles, turtles and mammals	Continuous boat survey	2019	Post monsoon	15.02.2020 13.03.2020	20.02.2020 18.03.2020
		2021	Post monsoon	08.02.2022	21.02.2022
		2022	Post monsoon	09.02.2023	22.02.2022
Birds		2021	Post monsoon	08.02.2022	21.02.2022

Considering the variety of taxa and length of the River, a methodological framework was conceived to monitor different elements of biodiversity in the Chambal River (Figure 2.1). Each taxon had its own protocol for monitoring and assessment, which also varied in time and space. A combination of boat-based continuous survey and intensive monitoring sites was used. The River was divided into 5 km segments known as Basic/Biodiversity Evaluation Unit (BEU), which was retained throughout the survey and report writing. Due to time constraints in different methods, an alternative approach was opted for sampling of the physiochemical parameters, flora, and the fish as they require time intensive long hour efforts, specific sites were selected based on the biogeography and logistic feasibility. The intensive sampling sites spanned across the different river zones, for vegetation plots of shrubs and trees, fixed transects were laid in riparian zones, and deployment of suitable nets for fish sampling required at least 2-4 hours at each site. For physiochemical analysis, sample collections also took a considerable amount of time, and handheld devices provided real time measurements. In contrast, taxa that required time constrained observation-based monitoring, like amphibians, reptiles, birds and mammals, point counts and continuous boat transects were adopted to avoid any possible biases like double counts or missing observations. Among these taxa, amphibians were sampled during dusk and night hours of post-winter season since they hibernate during winter, while other taxa were found active during daylight hours of all seasons. Whereas winter migratory bird species needed to be monitored during the winter season, and island nesting birds during the summer. Taxa-wise detailed methods have been provided in the individual chapters. In addition, the hydrological profile of the Chambal River required a zone-specific sampling approach; two different types of approaches were adopted in terms of monitoring of aquatic reptiles, birds, and mammals. River depth remained an issue at most of the stretches owing to various reasons in the upper and middle River zones; thus, a vehicle survey was adopted, focusing on the BEUs, and point data were collected on the different vertebrate taxa. While the lower zone of the River remained comparatively deeper and feasible for continuous boat surveys, the inflatable boat was used for continuous monitoring of the lower stretch, where data were collected on different taxa, related anthropogenic threats, and river profile. The data were collated, and using MaxEnt, Conservation Priority Stretches were identified (Chapter 13).

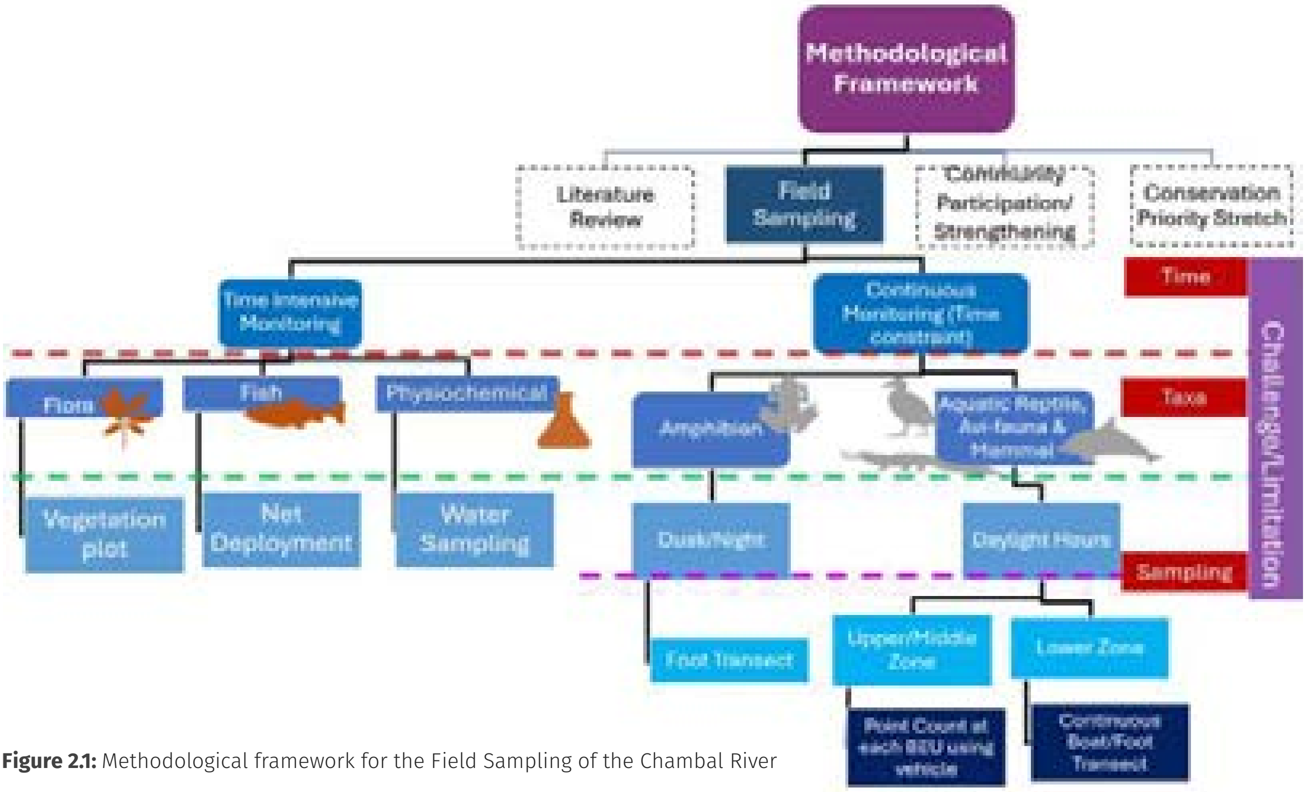


Figure 2.1: Methodological framework for the Field Sampling of the Chambal River

2.3 Spatial Analysis

Geospatial tools (ArcGIS 10.2) were employed to map species occurrence, habitat parameters, and anthropogenic pressures along the Chambal River. Species distribution models were developed in MaxEnt using presence-only records and environmental predictors. For the Gangetic Dolphin, 758 occurrence points across 22 rivers of the Ganga Basin and 28 environmental variables (climatic, hydrological, and geomorphological) were used, with highly correlated variables (r > 0.70) excluded prior to modeling. Conservation Priority Stretches (CPS) were identified using MaxEnt model outputs, which classified habitat suitability into three categories: CPS 1 (high suitability, 0.7-1.0), CPS 2 (moderate suitability, 0.61-0.70), and CPS 3 (low suitability, 0.51-0.60). Spatial analysis tools were additionally used to delineate and visualize the Chambal River basin, including its mainstem and tributaries, land use changes, species distribution, habitat parameters, threats, and socioeconomic structure.

REFERENCES

Guide, G. R. B. D. (2003). ArcGIS® 9. Redlands, CA: ESRI.

Google Scholar. https://scholar.google.com/

JSTOR. https://www.jstor.org/

Priem, J., Piwowar, H., & Orr, R. (2022). OpenAlex: A fully-open index of scholarly works, authors, venues, institutions, and concepts. ArXiv. https://arxiv.org/abs/2205.01833

CHAPTER 3

FLORAL ASSEMBLAGE OF CHAMBAL RIVER

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain,
Shivani Barthwal

Lead Authors
Umama Khan,
Revan Chaudhari

Contributing Authors
Monal Jadhav,
Satyam Saumya,
Khadija

SUMMARY

The floristic survey along the Chambal River documented 520 angiosperm taxa belonging to 341 genera and 97 families, highlighting the considerable botanical diversity sustained within this semi-arid river system. Vegetation was dominated by herbaceous flora (272 species) and graminoids (90 species), followed by trees (68 species), shrubs (47 species), and climbers (41 species), reflecting the structural complexity of plant communities associated with riparian, ravine, agricultural, and scrub ecosystems along the river corridor. Habitat preference analysis revealed the predominance of moist-loving species (315 spp.), followed by semi-aquatic (99 spp.) and aquatic plants (34 spp.), underscoring the ecological importance of riparian wetlands and seasonal floodplain habitats in sustaining plant diversity within the otherwise dry Chambal landscape.

The study employed a standardized sampling framework across 19 Biodiversity Evaluation Units (BEUs) distributed across Madhya Pradesh, Rajasthan, and Uttar Pradesh. Vegetation was analysed along perpendicular transects at 1 m, 500 m, and 1000 m from the riverbank, allowing assessment of changes in plant composition and diversity across varying geomorphological conditions. Species richness varied considerably across the river stretch, ranging from 72 species at Khirkhari to 128 species at Daulatganj, with native taxa consistently dominating the flora, while non-native species were more common in areas influenced by agriculture, settlements, and degraded ravine landscapes. The analysis revealed a clear ecological gradient, where the immediate riverbank zone remains highly dynamic and flood-disturbed, intermediate zones (at 500 m) support diverse shrub-grass

mosaics, and outer zones (1km from the river) reflect broader landscape influences including agriculture and dry deciduous forests.

A total of 68 tree species were recorded along the river, with dominant taxa including *Prosopis juliflora*, *Acacia nilotica*, *Butea monosperma*, *Bombax ceiba*, *Phoenix sylvestris*, and *Ziziphus* spp. Tree diversity was highest in the midstream gorge sections such as Rawatbhata (H'= 2.67) where rocky cliffs and forest-scrub mosaics support regeneration, and lowest in erosion-prone ravine zones such as Barhi (H' = 0.62) where unstable sandy substrates restrict establishment. Shrub vegetation comprised 47 species, dominated by taxa such as *Ziziphus nummularia*, *Calotropis procera*, *Grewia flavescens*, and *Capparis* spp., while graminoids (90 species) were largely native and dominated by *Saccharum spontaneum*, *Phragmites karka*, *Cynodon dactylon*, and *Desmostachya bipinnata*. Shrub and grass diversity peaked in the 500-1000 m zones, where ravine-scrub mosaics create structurally heterogeneous habitats.

Herbs represented the most species-rich life form (272 species; 218 native and 54 exotic), while climbers (41 species) and aquatic plants (34 species) contributed to the overall riparian diversity. Dominant aquatic species included *Hydrilla verticillata*, *Vallisneria natans*, *Pistia stratiotes*, and *Nymphaea* spp., whereas semi-aquatic plants occupied marshy backwaters and sandbars. Quantitative ecological metrics such as the Importance Value Index (IVI) and Shannon Diversity Index (H') revealed strong dominance of the invasive *Prosopis juliflora*, particularly in degraded ravine systems where it suppresses native regeneration. Other invasive species including *Ipomoea carnea*, *Lantana camara*, *Eichhornia crassipes*, and *Alternanthera philoxeroides* were also widely distributed. Overall, vegetation patterns along the Chambal River reflect strong influences of geomorphology, seasonal flooding, erosion, and anthropogenic pressures, and the study provides an important baseline dataset for long-term ecological monitoring, conservation planning, and restoration of riparian ecosystems in the Chambal basin.

3.1 Introduction

The Chambal River flows through one of the most distinctive fluvial landscapes of semi-arid India. The River traverses a unique ravine-dominated terrain characterized by extensive sandbanks, pebble beds, rocky outcrops, and boulder-strewn margins shaped by intense fluvial incision and long-term erosion. These deeply dissected ravines form the ecological backbone of the Chambal River basin and support a diverse continuum of forest and vegetation types reflecting semi-arid climatic conditions, rugged geomorphology, and altitudinal transitions from the Vindhyan plateau to the river corridor. The upper basin of the River around Gandhi Sagar, Shivpuri, and the Kuno region is dominated by Tropical Dry Deciduous Forests (5A/C1a, 5A/C3, 5B/C3, 5B/C1, 5B/C2) composed of *Anogeissus pendula*, *Boswellia serrata*, *Acacia catechu*, and *Diospyros melanoxylon*, which remains leafless from March to June (Champion and Seth, 1968). Towards Mukundra Hills, Jawahar Sagar, and the Ranthambhore landscape, the forests grade into tropical thorn scrub, while closer to the active channel, within the National Chambal Sanctuary, tropical thorn forest which can be further classified into Southern subtropical (6A/C1, 6A/C2), and Northern subtropical (6B), comprising Prosopis-Acacia shrublands, along with *Zizyphus*, *Adhatoda vasica* and narrow but ecologically vital riparian belts of *Tamarix dioica*, *Dalbergia sissoo*, *Ficus* spp., and *Saccharum* grass complexes prevail (Table 1.5).

Ecological studies consistently highlight the high heterogeneity and conservation value of Chambal's vegetation (Chorghe et al., 2012, Pathak, 2013, Kala et al., 2017, Uthappa et al., 2018 and Sikarwar, 2023). Floristic surveys by Pathak (2013) documented diverse semi-arid flora dominated by dry-deciduous and thorn forest elements, while Sikarwar (2023) recorded 203 species from rocky ravines, with Poaceae, Fabaceae, and Acanthaceae as dominant families. Investigations within the National Chambal Sanctuary (Chorghe et al., 2012; Thomas et al., 2011; Uthappa et al., 2018; Kala et al., 2017) further emphasized the richness of riparian, ravine, medicinal, and fuelwood species across sandbanks, marshy beds, and flowing channels.

Pathak (2013) conducted a comprehensive floristic survey of the Chambal region of Madhya Pradesh, documenting a diverse semi-arid flora. Dominant tree species included *Anogeissus latifolia*, *A. pendula*, *Tectona grandis*, *Lannea coromandelica*, *Diospyros melanoxylon*, *Sterculia urens*, *Mitragyna parviflora*, *Butea monosperma*, *Emblica officinalis*, *Boswellia serrata*, *Bridelia squamosa*, and *Hardwickia binata*. Shrub and ground-layer vegetation resembled that of the semi-arid tracts of Gujarat.

Common climbers recorded were species of *Rhynchosia, Atylosia, Cocculus*, Cissampelos, *Ipomoea*, *Pergularia daemia*, *Pueraria tuberosa* and *Tinospora cordifolia*. Thorny bushes and small trees frequently encountered included *Capparis decidua, C. sepiaria, Balanites aegyptiaca, Acacia senegal, A. nilotica, A. leucophloea, Prosopis juliflora, Maytenus emarginata, Tamarix* sp., *Salvadora persica, S. oleoides, Crotalaria burhia, Clerodendrum phlomidis, Calotropis procera, Zizyphus xylopyra, Holoptelea integrifolia* and others accompanied by climbers like *Maerua oblongifolia* and *Ceropegia bulbosa* and herbs including *Argemone mexicana, Tephrosia purpurea, Tribulus terrestris, Glinus lotoides* and *Boerhavia diffusa*.

In mixed and miscellaneous forests, dominant trees consisted of *Buchnania lanzan, Cassia fistula, Hardwickia binata, Terminalia arjuna, Mangifera indica, Tamarindus indica, Anogeissus pendula, Albizia lebbeck, Mimusops hexandra, Wrightia tinctoria, Dalbergia sissoo, Azadirachta indica, Ficus religiosa*, and others. Undershrubs frequently recorded included *Adhatoda vasica, Achyranthes aspera, Capparis horrida, Opuntia dillenii, Zizyphus rotundifolia, Vitex negundo, Nyctanthes arbor-tristis*, and *Balanites roxburghii*. Common climbers and stragglers included *Mucuna pruriens, Abrus precatorius*, and *Asparagus racemosus*. Grass flora featured *Saccharum spontaneum, Desmostachya bipinnata, Vetiveria zizanioides, Dendrocalamus strictus, Dichanthium annulatum*, and *Fimbristylis* spp. Parasitic and epiphytic species such as *Cuscuta reflexa, Dendrophthoe falcata*, and *Vanda tessellata* were also documented. Hydrophytes typical of the Chambal basin included *Nelumbo nucifera, Trapa natans, Ceratophyllum demersum, Hydrilla verticillata, Potamogeton pectinatus* and *Eichhornia crassipes*. Pathak noted the proliferation of *Acacia nilotica*, leading to the expansion of thorn forest conditions.

Chorghe et al. (2012) surveyed a 110-km stretch of the sanctuary and recognized five main habitat types: ravines, flowing river channels, marshy riverbeds, sandbanks, and cultivated fields. They reported 61 angiosperm species across 31 families, with Poaceae being the most common. Flowing-river habitats supported the highest richness (20 species), highlighting the ecological significance of riparian zones for biodiversity and gharial conservation. Kala et al. (2017) assessed medicinal plant richness in rehabilitated ravine landscapes and recorded 106 species from 54 families. Herbs (42.5%) formed the largest life-form group, followed by trees (23.6%), shrubs (21.6%), climbers (10.4%), and grasses (2%). The native flora documented was predominantly drought-tolerant and adapted to harsh ravine conditions, demonstrating the high ecological value of restored ravines.

The focus of these studies varied from documenting the floral composition to non-timber forest produce and habitat types across the Chambal landscape, but comprehensive information on floristic composition along the Chambal River was lacking, and hence this study was undertaken to understand the dynamics of floral composition across the River's journey, and the associated landscape.

Methodology

The study was conducted between September 2025 and October 2025 to sample vegetation along the Chambal River. The entire river was divided into 5 km river segments called Biodiversity Evaluation Unit (BEU). The surveyed river stretch was stratified into five longitudinal zones to ensure systematic representation of the upstream-downstream gradient. A minimum of 10% of the total surveyed river length was covered to obtain a representative population. Within each zone, at least three sampling sites were selected to ensure adequate replication. Sites were chosen randomly while considering geomorphic variability and field feasibility. Final site selection was confirmed based on accessibility and the feasibility of laying standardized transects across both riverbanks to ensure uniform and comparable vegetation sampling.

A total of 19 BEUs, spanning across different river zones along Uttar Pradesh, Madhya Pradesh and Rajasthan were surveyed to assess riparian vegetation (Table 3.1). In each Basic Evaluation Unit (BEU), line/belt transects were laid on both banks of the river. A 3 km long line/belt transects were placed at the centre of the BEU. At the beginning and end of the two line/belt transects, perpendicular transects were laid. Thus, in total, six line transects were laid. The four perpendicular transects extended 1 km from the river (Figure 3.1). In each perpendicular transects, three circular plots were established at distances of 1 m, 500 m, and 1000 m from the riverbank to document and collect plant species. Within the circular plots, nested plots of varying radius, 20 m for trees, 5 m for shrubs and 4 quadrats of 1x1m for herbs, were laid. The two line/belt transects of 3 km were walked and the species were noted down.

Table 3.1: BEU number and corresponding geographical location of the sampling points

BEU	Location
2	Ghatabillod, Madhya Pradesh
10	Karki, Madhya Pradesh
18	Dharankhedi, Madhya Pradesh
27	Nagda, Madhya Pradesh
36	Barkheda khurd, Madhya Pradesh
46	Aawra, Madhya Pradesh
56	Gandhi Sagar, Madhya Pradesh
66	Rawatbhata, Rajasthan
72	Daulatganj, Madhya Pradesh
75	Kota, Rajasthan
103	Khirkhari, Rajasthan
113	Rodawad, Rajasthan
125	Mandrayal, Rajasthan
135	Sewarpali, Rajasthan
144	Sagarpada, Rajasthan
156	Ludhawali, Madhya Pradesh
167	Hatkani, Uttar Pradesh
173	Barhi, Madhya Pradesh
183	Katrauli, Uttar Pradesh

Important Value Index (IVI)

The Importance Value Index (IVI) is a metric used in ecology to assess the relative importance of plant species in a given area (Curtis & McIntosh, 1950). It combines three key components: relative frequency, relative density, and relative dominance, offering a comprehensive measure of species ecological roles. Dominant tree species were identified as those exhibiting equal Importance Value Index (IVI) scores at a given sampling point, indicating their comparable contribution to the composition of the dominant plant community in that area

Formulas Used in Vegetation Analysis

Shannon Index (H') – Biodiversity Index

H' = – Σ (pi × ln pi)

Where:

H' = Shannon diversity index

pi = Proportion of individuals of species i = ni / N

ni = Number of individuals of species i

N = Total number of individuals of all species

S = Total number of species

a) Frequency (%)

Frequency (%) = (Number of quadrats in which the species occurs / Total number of quadrats) × 100

b) Abundance

Abundance = Total number of individuals of a species / Number of quadrats in which the species occurs

c) Density

Density = Total number of individuals of a species / Total number of quadrats studied

d) Relative Frequency (RF)

RF (%) = (Frequency of a species / Sum of frequencies of all species) × 100

e) Relative Abundance

Relative Abundance = Number of individuals of a species / Total number of individuals of all species

f) Relative Density (RD)

RD (%) = (Density of a species / Sum of densities of all species) × 100

g) Importance Value Index (IVI)

IVI = Relative Frequency + Relative Density + Relative Dominance

Abundance for trees

In each 20 m radius circular plot, the number of individuals for each tree species was recorded (Figure 3.1). The formula for abundance was applied (Box 1). The value provides a measure of how frequently a species occurs within the sampled area.

Species Richness and Diversity

For species richness and diversity, Shannon Diversity Index (H'), was calculated (using percentage cover of shrubs and grasses) to indicate species diversity in a community (Box 1). This method accounts for both species' richness and evenness, and is widely applied in vegetation studies where individual counts are impractical (Kent, 2012; Magurran, 2004).

Parallel transects were walked on foot to record the plant species encountered along the route. During the present work, the collected plants, their photographs and field notes were critically studied for their identification, keys and descriptions from local flora and available literature (Uttar Pradesh, Madhya Pradesh and Rajasthan). Nomenclature, author citations and first place of publication of the plant species are followed using International Plant Name Index (https://www.ipni.org/) and Plants of the World Online (https://powo.science.kew.org/). Family-level classification follows the Angiosperm Phylogeny Group IV (APG IV; 2016).

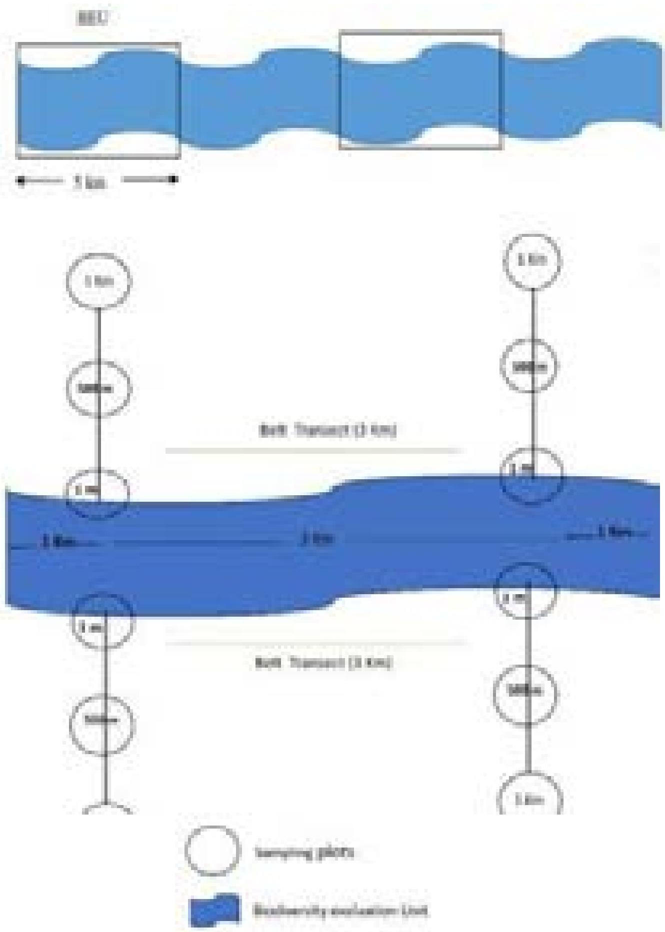


Figure 3.1. Methodology adopted to sample plant species along the river Chambal

3.3. Results

Based on field surveys conducted, previous studies and forest types recorded in and along the Chambal River, the dominant families representing riparian flora were Poaceae, Fabaceae, Asteraceae, Cyperaceae, Convolvulaceae, and Lamiaceae.

A total of 520 angiospermic species belonging to 341 genera, 97 families, and 34 orders were recorded during the survey (Figure 3.2). Poaceae emerged as the most dominant family with 66 species, followed by Fabaceae (62 spp.), Asteraceae (44 spp.), Cyperaceae (23 spp.), Convolvulaceae (19 spp.), and Lamiaceae (16 spp.) (Figure 3.3). Life-form (habit) dominance in the river based on the number of species was dominated by herbaceous flora (272 spp.), followed by graminoids (90 spp.), trees (68 spp.), shrubs (47 spp.), climbers (41 spp.), and climbing shrubs (2 spp.) (Figure 3.4). Habitat preference of the recorded species indicated predominance of moist-loving taxa (315 spp.), followed by semi-aquatic (99 spp.), terrestrial (68 spp.), aquatic (34 spp.), and epiphytic parasitic species (3 spp.) (Figure 3.5). Among the species documented, 431 were native, while 89 species were classified as non-native (Figure 3.7).

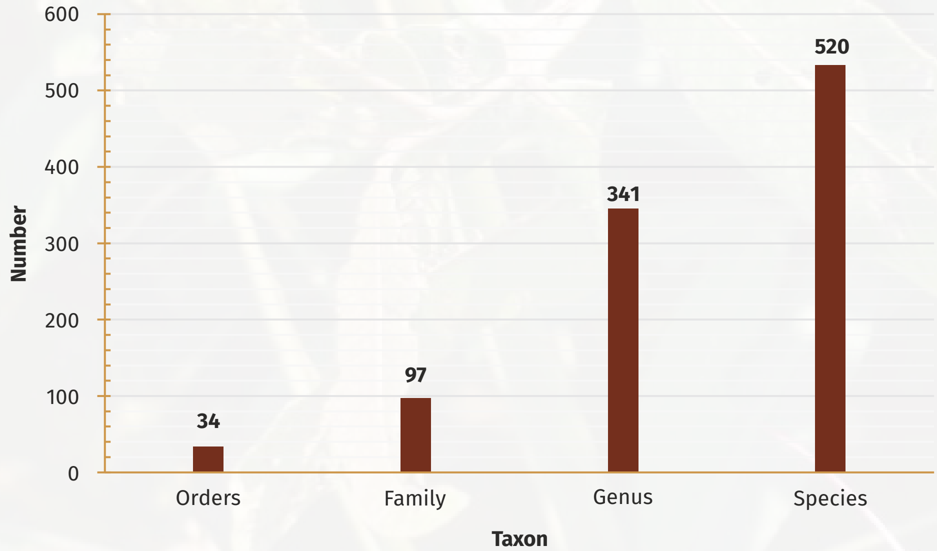


Figure. 3.2: Taxonomic classification of plants recorded during the survey

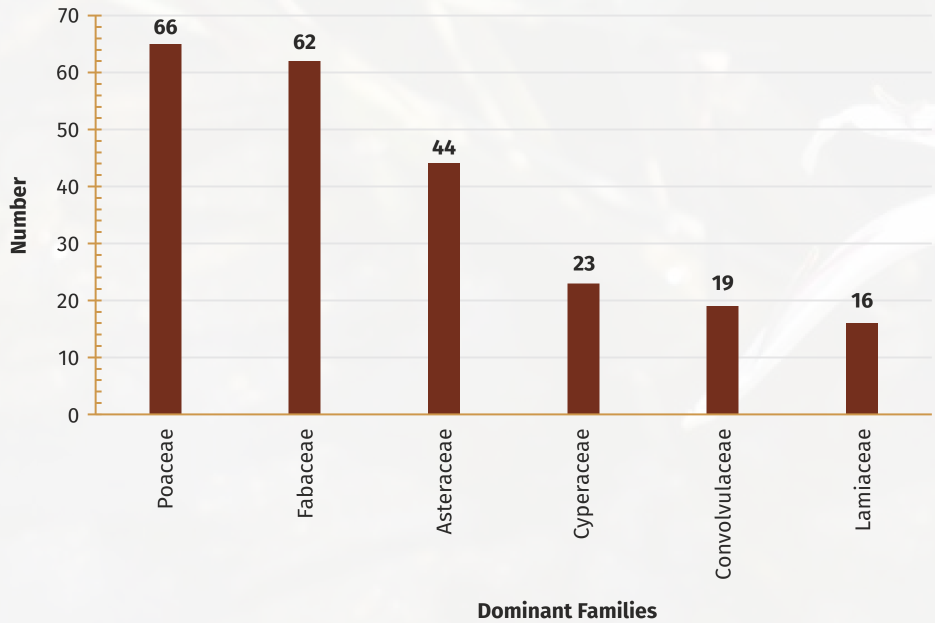


Figure. 3.3: Dominant plant families recorded during the survey

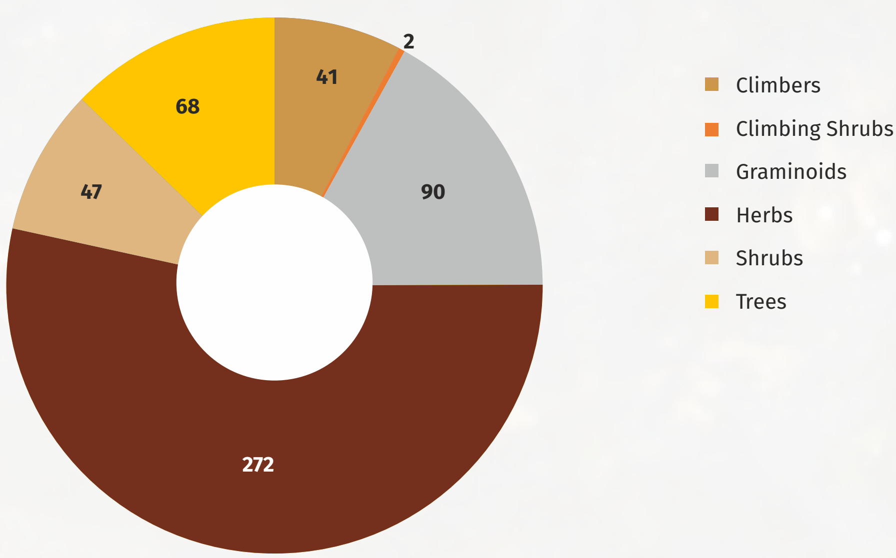


Figure.3.4: Habit-wise classification of species

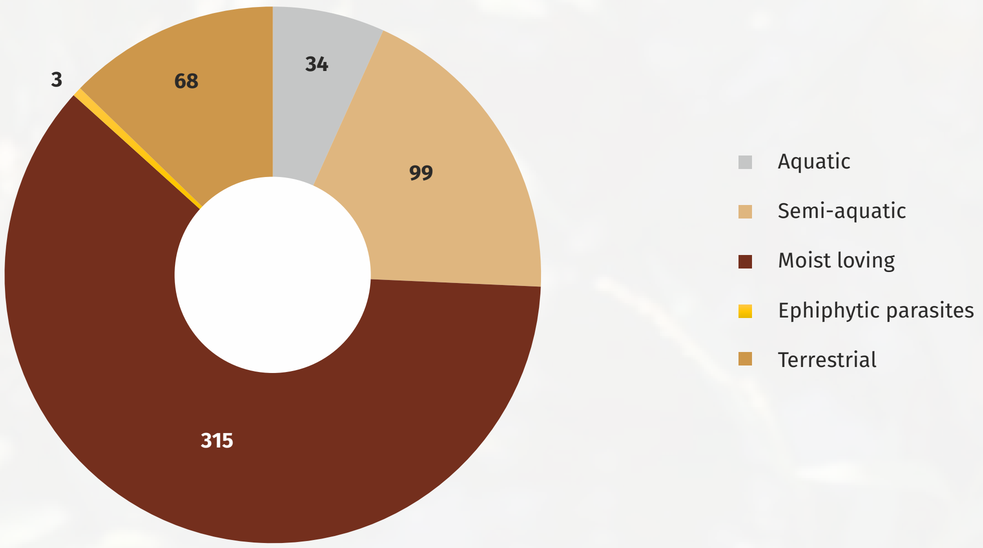


Figure 3.5: Habitat-wise classification of species

Table 3.2: Plant species classification based on habit.

Plant Group	Trees	Shrubs	Herbs	Graminoids	Climbers	Climbing Shrubs
Order	14	15	26	1	9	2
Family	32	22	66	3	9	2
Genus	52	36	184	50	32	2
Species	68	47	272	90	41	2
Native	57	34	218	86	34	2
Exotic	11	13	54	4	7	0

3.3.1 Richness and Diversity

In the upper reaches of the Chambal River (BEUs 2-36), the river is narrow, flowing through agricultural lands and human settlements. Species richness in this stretch ranges from 81 to 102, with native species varying from 62 to 77 and non-native species varying between 19 and 25 (Figure 3.6). The landscape is dominated by human-planted and settlement-associated trees and shrubs, with seasonal agriculture influencing vegetation composition. Natural scrub remnants survive in patches; however, frequent human activity, narrow floodplains, and exposed sandy banks limit overall diversity. Recent flood scouring further restricts vegetation establishment in the immediate 1 m riparian zone.

As the river enters the middle course (BEUs 46-75) near Gandhi Sagar, Rawatbhata, and the Mukundra Tiger Hills, richness increases substantially, which ranges from 72 to 128 species (Figure 3.6). Native species dominate this stretch, contributing 47 to 100 species, while non-native species remain moderate, from 23 to 29, higher than

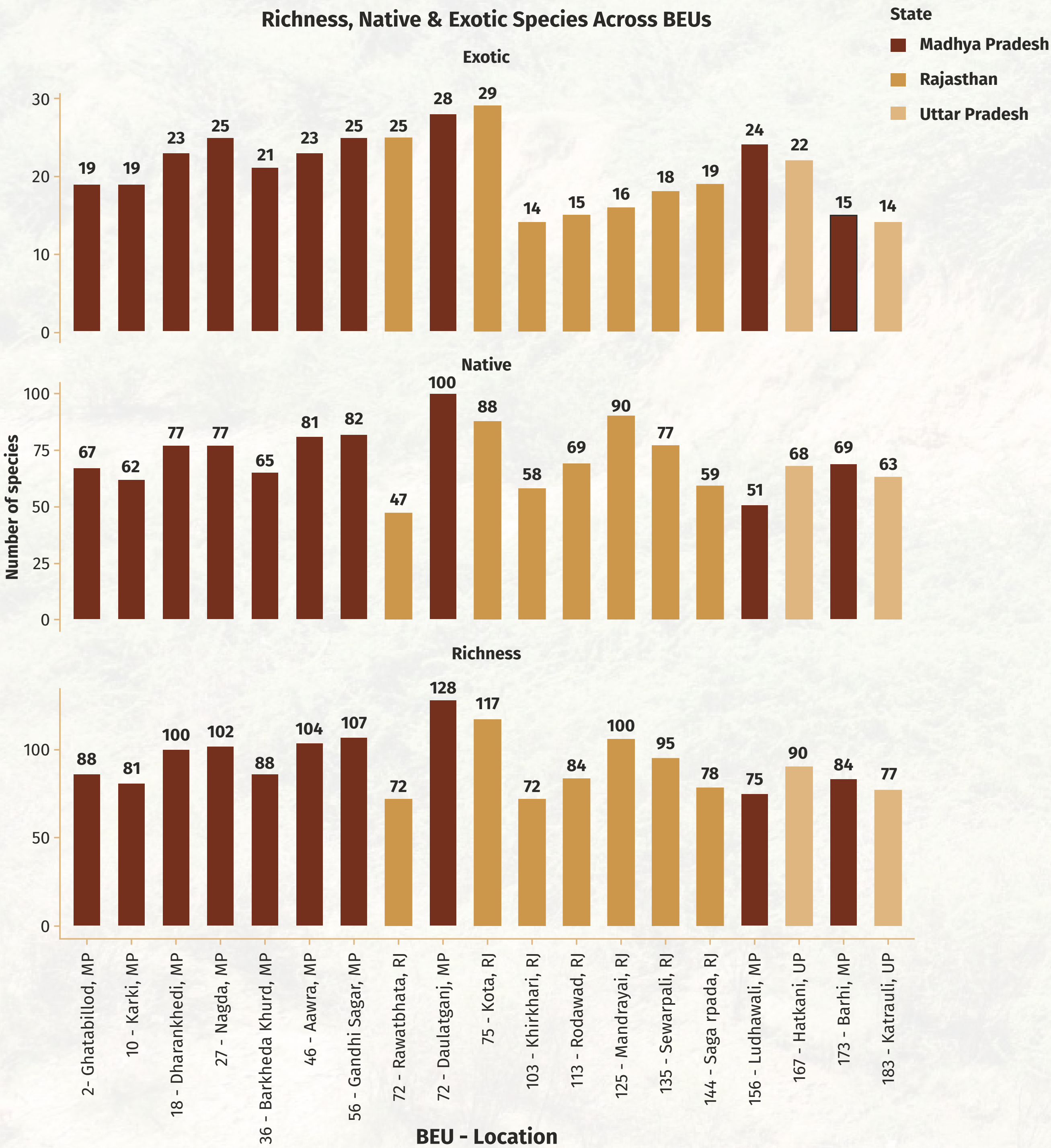


Figure 3.6: BEU wise Species Richness and Nativity (all points 1m, 500m and 1000m combined)

found in the human dominated landscape of the Chambal River. Protected forest patches, rocky escarpments, and stable riparian zones create refugia for native flora, including scrub and dry deciduous communities. Human interference is relatively limited here, and the combination of bedrock channels, gorges, and seasonal wetlands supports higher species richness and more continuous native cover compared to upstream and downstream stretches.

In the lower reaches of the Chambal (BEUs 103-183), the river flows through highly undulating, erosion-prone ravine landscapes, with large sandy beds and unstable banks. Overall richness, in this stretch, ranges from 72 to 106 species, with native species contributing 58 to 90 and non-native from 14 to 24 (Figure 3.6). The invasive Prosopis juliflora dominates the degraded ravines and abandoned agricultural terraces, while native shrubs and trees survive mostly on steeper slopes and less accessible ravine sections. Flood disturbance, substrate instability, and human-modified terraces create patchy vegetation, resulting in variable richness across BEUs. In some areas (e.g., BEU 167), richness remains relatively high despite presence of non-native species due to a mosaic of native scrub, riparian grasses, and scattered trees, whereas other BEUs (e.g., 183 and 156) show reduced richness due to recent flood scouring and sandy exposures.

Across the entire river, the immediate riverbank is characterized by frequent flooding, exposed sandy beds, and sparse vegetation, limiting species establishment. Overall, the Chambal exhibits a clear gradient of biodiversity: moderately rich, human-influenced agricultural and settlement zones upstream; highly diverse, native-dominated forested and rocky middle reaches; and downstream ravines dominated by non-native and subject to erosion and flood disturbances. These patterns reflect the combined effects of natural river geomorphology, seasonal flooding, and varying degrees of human influence along the river corridor.

3.3.2 Trees

Trees reported from the Chambal River are represented by 14 orders, 32 Families, 52 genera and 68 species, of which 57 species are native and 11 species are non-native (Table 3.2). Dominant tree species recorded along the river are; *Prosopis juliflora*, *Acacia nilotica*, *Beutea monosperma*, *Anogeissus pendula*, *Balanites aegyptiaca*, *Phoenix sylvestris*, *Ziziphus* spp., *Mangifera indica*, *Moringa oleifera*, *Acacia leucophloea*, *Azadirachta indica*, *Leucaena leucocephala*, *Grewia flavescens*.

3.3.2.a Richness and Diversity - Trees

Field observations along the Chambal River reveal a clear ecological gradient in species richness, nativity patterns, and shrub-grass diversity, strongly shaped by geomorphology, ravine systems, human activity, and hydrological regulation.

Upstream BEUs near the River's origin (BEUs 2 to 36) show moderate richness (11-37 species) with high native representation (Figure 3.7). These BEUs occur in relatively narrow valleys and semi-arid scrub-agricultural mosaics, where vegetation structure is shaped by ravine terraces, seasonal moisture, and human settlements. Shannon diversity values for shrubs (0-0.04) and grasses (0.014-0.049) were low, reflecting simplified vegetation layers dominated by hardy xerophytic species, characteristic of dry, erosion-prone terrains.

Mid-reach BEUs influenced by protected forests, rocky escarpments, and dam-modified hydrology, from BEUs 46 to 113 higher richness (35-48 species) and a more structured vegetation profile (Figure 3.7). The River here flows through gorges, bedrock-controlled channels, and semi-deciduous forest patches. Notably, BEUs 56 and 66 have some of the highest richness values (35-48), supported by strong native species pools and mixed woodland scrub habitats. Shrub diversity rises significantly in some locations (e.g., H' = 0.291 at BEU 56), indicating more developed understory layers. Grass diversity also increases (0.032-0.069), reflecting stable riparian zones and enhanced moisture availability.

Downstream and confluence-adjacent BEUs (125 to 183) exhibit increased dominance of Prosopis juliflora, with overall richness declining sharply (Figure 3.7). Some BEUs retain moderate richness (15-29 species), while others show severe decline. These patterns correspond with deeply dissected ravine landscapes where erosion, sand deposition, and disturbance suppress native vegetation. The lowest richness scores occur in heavy ravine zones and areas recently impacted by flooding or sand deposition. Shrub diversity remains near zero across most sites, except the unusually high value at BEU 173 (H' = 0.76), possibly driven by patchy shrub proliferation in erosion-prone ravines. Grass diversity is consistently low but present (0.022-0.045), reflecting scattered Cynodon patches and disturbance-tolerant species.

Overall, the highest richness and more complex vegetation structure occur within mid-reach forested and gorge-bound sections influenced by Gandhi Sagar, Rawatbhata, Mukundra hills, and semi-deciduous woodlands, while the lowest richness and diversity characterize ravine-dominated, highly eroded downstream sections dominated by Prosopis invasion and recent flood scouring.

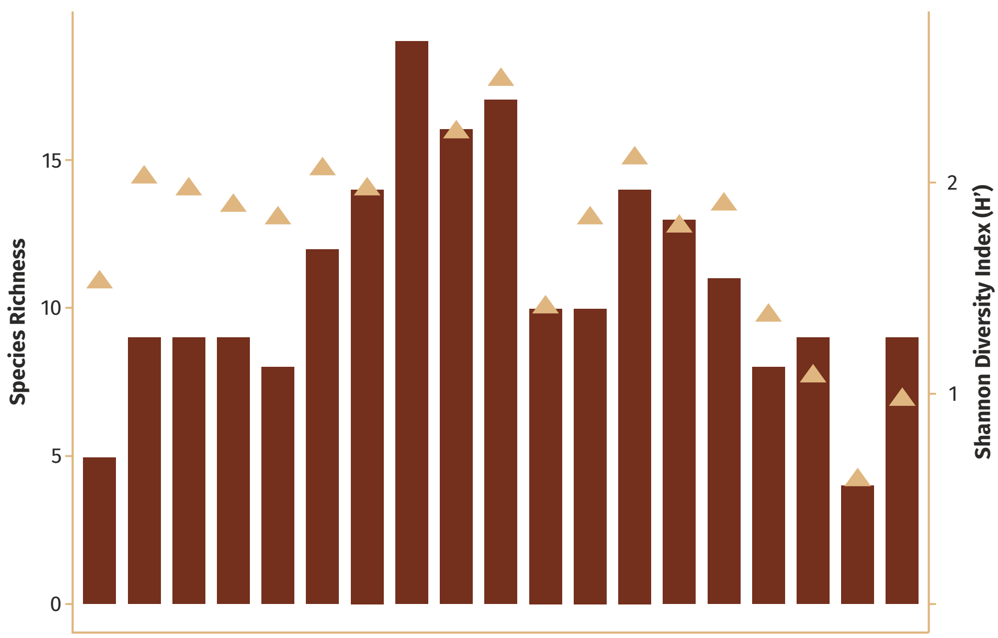


Figure 3.7: Shannon Diversity Index (H') and Richness of trees species across all 19 BEU

3.3.2.b Abundance - Trees

Based on abundance values across different BEUs, the following species were observed to be more prevalent along the river:

- At 1 m: *Prosopis juliflora*, *Phoenix sylvestris* were the most abundant species.
- At 500 m: In addition to the species recorded above *Acacia nilotica*, *Acacia leucophloea*, *Leucaena leucocephala* were also found to be abundant.
- At 1000 m: The abundance of species observed at 500 m persisted, along with *Mangifera indica*, *Moringa oleifera*, *Eucalyptus* spp.
- Additionally, species like Morus alba and Tectona grandis were observed in patches, primarily as plantation stands. These species play a significant role in the landscape, serving as shelterbelts to reduce wind erosion, and stabilizers for riverbanks.

3.3.2.c Dominant Tree Communities

Species with the highest IVI values represent the dominant tree communities within each BEU, contributing significantly to the structural makeup and ecological functioning of those zones (Table 3.3).

At 01 m IVI from the river

The IVI patterns observed along the 1 m riparian margin of the Chambal River reflect a vegetation structure shaped overwhelmingly by the semi-arid ravine landscape and chronic disturbance pressures typical of this basin. Across most BEUs, *Prosopis juliflora* emerges as the defining structural species, often achieving exceptionally high IVI values approaching 300. Its dominance is especially pronounced in deeply dissected ravine stretches such as BEUs 173, 167, 156, 135, 113, and 103, where unstable slopes, erosion-prone substrates, and persistent grazing pressure limit the establishment of native riparian trees. In these sections, *P. juliflora* forms dense monospecific stands or near-monocultures at the water's edge, suppressing native regeneration through its drought tolerance, aggressive dispersal, and competitive advantage in degraded soils.

The influence of the ravine geomorphology is particularly evident at BEUs with little to no tree presence such as 173 and 144 (Table 3.3) where steep, rugged terrain and xeric conditions create discontinuous riparian fringes with minimal canopy development. Where tree cover does occur in these erosion-prone zones, it is typically restricted to hardy species such as *Acacia nilotica*, *Prosopis cineraria*, or occasional clumps of *Phoenix sylvestris* that can tolerate shallow soils and limited moisture. This aligns closely with the general vegetation character of the Chambal ravines, where thorny xerophytic scrub dominates and riverbank trees are unable to form continuous galleries.

A few BEUs provided notable exceptions where native species retain a measurable foothold despite the broader dominance of *P. juliflora*. BEU 75 near Kota, Rajasthan stands out with *Holoptelea integrifolia* attaining the highest native IVI values in the dataset, supported by the presence of *Phoenix sylvestris* and mixed scrub elements. Similarly, BEU 72 near Daulatganj, Madhya Pradesh reflects a more balanced riparian assemblage, where *Butea monosperma* and *Pongamia pinnata* contribute meaningfully to overall structure, indicating microhabitats with slightly higher moisture availability and reduced disturbance compared to the surrounding ravine belt. In other BEUs such as 125, 56, and 46 species like *Acacia nilotica*, *Bombax ceiba*, and *Phoenix sylvestris* appear as co-dominants or secondary contributors, representing small pockets where native woodland characteristics persist along the immediate river margin.

In sections where terraces broaden or substrate moisture is marginally higher, *Phoenix sylvestris* becomes locally dominant, such as in BEUs 18 and 2, where its exceptionally high IVI values suggest the presence of seasonal moist edges or older palm groves closely tied to the floodplain microtopography. These patches reflect the naturally patchy riparian structure of the Chambal, where palm-dominated fringes alternate with scrub-dominated, eroded banks.

Overall, IVI dataset for vegetation at 1 m from the River illustrates a riparian corridor undergoing substantial structural homogenization, driven largely by the expansion of *Prosopis juliflora*. Native riparian trees persist only in fragmented, site-specific niches where terrain, moisture, or disturbance conditions momentarily allow their establishment. The dominance of hardy, drought-adapted species and the scarcity of typical riverine taxa underscore a system where anthropogenic pressure and ravine dynamics override natural riparian processes. While small native pockets remain ecologically valuable, the broader pattern indicates an ongoing shift toward exotic-led vegetation structure with implications for long-term riparian resilience along the Chambal River.

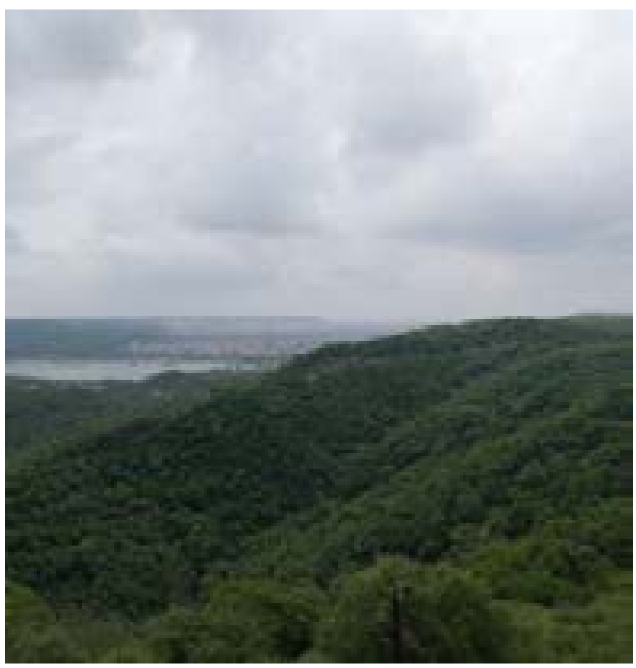


Table 3.3: IVI of Trees at 01m from the river

BEU	Dominant Trees	IVI	Other contributing species
183	*Prosopis juliflora*	225	*Azadirachta indica, Acacia nilotica*
173	-	0	-
167	*Prosopis juliflora, Acacia nilotica*	150	-
156	*Prosopis juliflora*	183.33	*Moringa oleifera*
144	-	0	-
135	*Prosopis juliflora*	300	-
125	*Acacia nilotica, Bombax ceiba*	150	-
113	*Prosopis juliflora*	300	-
103	*Prosopis juliflora*	300	-
75	*Holoptelea integrifolia*	92.04	*Prosopis juliflora, Phoenix sylvestris*
72	*Butea monosperma, Pongamia pinnata*	48.18	*Leucaena leucocephala, Prosopis cineraria, Acacia leucophloea*
66	*Prosopis juliflora*	200	*Acacia nilotica*
56	*Prosopis juliflora, Acacia nilotica*	77.14	*Ficus religiosa, Butea monosperma, Ailanthus excelsa*
46	*Balanites aegyptiaca, Phoenix sylvestris,* Ziziphus sp.	100	-
36	*Pongamia pinnata, Prosopis juliflora*	70.05	*Azadirachta indica, Phoenix sylvestris*
27	*Prosopis juliflora*	213.33	*Acacia nilotica*
18	*Phoenix sylvestris*	300	-
10	*Prosopis juliflora*	300	-
2	*Phoenix sylvestris*	153.33	*Acacia nilotica, Prosopis juliflora*

At 500 m IVI from the river

The tree composition recorded at 500 m from the Chambal River reflects a semi-arid riparian-ravine system, where vegetation is shaped primarily by ravine geomorphology, soil erosion, agriculture, and human disturbance. Across most sites, *Prosopis juliflora* emerges as the dominant species, reflecting its strong invasive behaviour and ecological advantage in degraded slopes, abandoned fields, erosion-prone ravines and disturbed scrublands. Dry-deciduous species like *Acacia leucophloea*, *Prosopis cineraria*, *Capparis sepiaria*, *Anogeissus pendula*, and *Boswellia serrata* occur mainly as co-dominant (Table 3.4).

The agriculture-dominated BEUs 2, 10, 18, 27, and 36 support sparse natural vegetation, species such as *Acacia nilotica*, *Azadirachta indica*, and *Moringa oleifera* occur mainly as scattered individuals on broader flat land. It is interesting to note that the BEUs 18 and 27 fall within core agricultural land, and trees are absent in these BEUs because repeated ploughing, crop rotation, and soil disturbance prevent natural regeneration of woody species. In addition, the semi-arid conditions, shallow soils, and erosion-prone terrain further limit seedling establishment, resulting in no tree cover. As the landscape transitions into ravine-scrub and reservoir-influenced BEUs 46, 56, 66, and 72, near the Gandhi Sagar reservoir and semi-natural ravine systems the vegetation shifts to semi-natural dry deciduous communities dominated by *Acacia leucophloea*, *A. nilotica*, and *Prosopis juliflora*, shaped by rocky plateaus, seasonal moisture pockets, and dam-regulated hydrology.

Beyond this, the confluence-zone and protected-area-influenced BEUs (75-183) lie within the larger Ranthambore National Park-Kailadevi wildlife sanctuary landscape and extend into the National Chambal Wildlife Sanctuary. This segment exhibits increasingly rugged ravine systems, undulating hilly terrain, and dense xeric thorn scrub, sparse tree cover, and limited agricultural activity, resulting in very high IVI values of P. juliflora (notably at BEU 103, 135, 144, 156, 167, and 173) (Table 3.4). Here, co-dominant species such as *Butea monosperma*, *Holoptelea integrifolia*, *Boswellia serrata*, and *Acacia leucophloea* appear only in scattered pockets where soil depth and moisture permit limited regeneration.

The BEU near the Yamuna-Chambal confluence lies completely within the National Chambal Wildlife

Sanctuary, supporting semi-natural thorn scrub of *A. nilotica*, *A. leucophloea*, and *Capparis decidua*, yet *P. juliflora* continues to dominate even under reduced human pressure (Table 3.4). Overall, the 500-m corridor along the Chambal River reflects a clear ecological gradient from agriculture-dominated floodplain margins to ravine-scrub complexes to semi-protected confluence habitats, yet across all geomorphological settings, *Prosopis juliflora* persists as the structurally and ecologically dominant species.

Table 3.4: IVI of Trees at 500m from the river

BEU	Dominant Trees	IVI	Other contributing species
2	*Prosopis juliflora, Acacia nilotica*	85	*Azadirachta indica*
10	*Azadirachta indica*	133.33	*Leucaena leucocephala*
18	-	0	0
27	-	0	0
36	*Azadirachta indica*	93.57	*Acacia nilotica, Moringa oleifera*
46	*Acacia leuchophloa*	110.71	*Morus alba, Acacia nilotica*
56	*Acacia leuchophloa*	86.66	*Acacia nilotica, Prosopis juliflora, Anogeissus pendula*
66	*Acacia leuchophloa*	60.95	*Anogeissus pendula, Holoptelea integrifolia, Prosopis juliflora*
72	*Acacia nilotica*	87.22	*Prosopis juliflora, Azadirachta indica*
75	*Azadirachta indica*	55.29	*Acacia nilotica, Butea monosperma*
103	*Prosopis juliflora*	116.65	*Acacia leucophloea, Acacia nilotica, Azadirachta indica*
113	*Prosopis juliflora, Acacia nilotica*	74.11	*Azadirachta indica, Melia azedarach, Moringa oleifera*
125	*Prosopis cineraria*	92.33	*Acacia nilotica, Prosopis juliflora, Anogeissus pendula*
135	*Prosopis juliflora*	86.1	*Acacia leucophloea, Prosopis cineria*
144	*Acacia nilotica*	116.92	*Prosopis cineraria, Salvadora oleoides*
156	*Prosopis juliflora*	88.27	*Butea monosperma, Azadirachta indica, Acacia nilotica*
167	*Prosopis juliflora*	127.27	*Holoptelea integrifolia, Boswellia serrata*
173	*Prosopis juliflora*	165.17	*Capparis sepiaria, Grewia flavescens*
183	*Prosopis juliflora*	95.1	*Acacia nilotica, Acacia leucophloea, Capparis decidua*

At 1000 m from the river

The tree IVI values along the 1000 m Chambal transect revealed a strong ecological gradient driven by shifting land use, underlying geology, and the progressive development of Chambal's characteristic ravine landscapes. In the upper reaches near the river's origin (BEUs 2-46), the geomorphology consisted of a narrow alluvial valley gradually modified into agricultural fields and settlements, resulting in repeated soil disturbance, clearing of native scrub, and planting of homestead species. Consequently, IVI values reflected the dominance of *Azadirachta indica*, *Mangifera indica*, *Moringa oleifera*, and *Acacia nilotica*, with contributions from planted or disturbance-tolerant trees such as *Leucaena leucocephala* and *Prosopis juliflora* (Table 3.5). This zone represents a converted scrub forest mosaic, where human activities shape both the composition and structure of the tree layer.

Downstream, through BEUs 56-113, the river enters the granite hill terrain and bedrock channels of Gandhi Sagar Wildlife Sanctuary and the Mukundra Tiger Hills. Here, the river cuts through older geological formations, creating steeper banks, narrow gorges, perennial pools, and forested hill slopes. These geomorphic controls supported stronger habitat integrity, reflected in IVI values dominated by *Butea monosperma*, *Acacia nilotica*, and occasionally *Prosopis juliflora*, with important native associates such as *Boswellia serrata*, *Sterculia urens*, *Phoenix sylvestris* and *Acacia leucophloea*. The combination of protected forest areas, intact rocky substrates, and limited agricultural pressure maintains relatively diverse and structurally stable dry-tropical forest communities, although plantation species like Eucalyptus appeared near settlements and tourist sites.

As the river approached the lower segment (BEUs 125-183), the geomorphology shifts dramatically. The Chambal enters its iconic ravine belt, a landform created by centuries of gully erosion, mass wasting, and the river's lateral undercutting of easily erodible alluvium and old

Table 3.5: IVI of Trees at 1000m from the river

S. no	BEU	Dominant trees	IVI	Other contributing species
1	2	-	0	0
2	10	*Azadirachta indica*	71.94	*Acacia nilotica, Moringa oleifera*
3	18	*Mangifera indica*	63.93	*Azadirachta indica, leucaena leucocephala*
4	27	*Moringa oleifera*	63.67	*Prosopis juliflora*
5	36	-	0	0
6	46	*Azadirachta indica*	59.97	*Acacia nilotica, Morus alba, Butea monosperma*
7	56	*Butea monosperma*	78.42	*Acacia nilotica, Prosopis juliflora, Phoenix sylvestris*
8	66	*Butea monosperma*	55.11	*Acacia nilotica, Prosopis juliflora, Sterculia urens*
9	72	*Acacia nilotica*	61.22	*Prosopis juliflora, Acacia leucophloea*
10	75	*Prosopis juliflora*	50.17	*Butea monosperma, Boswellia serrata*
11	103	*Prosopis juliflora*	126.32	*Acacia nilotica, Leucaena leucocephala*
12	113	*Acacia nilotica*	104.60	*Eucalyptus sp., Prosopis juliflora*
13	125	*Acacia nilotica*	78.16	*Holoptelea integrifolia, Balanites aegyptiaca, Salvadora sp., Prosopis cineraria, Ailanthus excelsa*
14	135	*Prosopis juliflora*	146.64	*Acacia nilotica*
15	143	*Prosopis juliflora*	109.69	*Eucalyptus sp.*
16	156	*Prosopis juliflora*	178.97	*Pithecellobium dulce, Morus alba, Azadirachta indica*
17	167	*Prosopis juliflora*	235.01	*Capparis sepiaria, Pithecellobium dulce*
18	173	*Prosopis juliflora*	233.24	*Capparis sepiaria, Grewia flavescens*
19	183	*Prosopis juliflora*	300	0

floodplain deposits. This produces an intensely dissected, highly undulating terrain with sharp gullies, narrow ridges, and continuous soil loss. Such geomorphic instability reduced canopy continuity, increased exposure, and created harsh microhabitats ideal for drought-tolerant invaders. Accordingly, the IVI pattern becomes sharply skewed: *Prosopis juliflora* reached extremely high importance values (often >100-300), outcompeting native species and replacing Acacia-dominated scrub. The remaining contributors *Capparis sepiaria*, *Pithecellobium dulce*, *Grewia flavescens*, *Salvadora* sp., *Balanites aegyptiaca*, *Ailanthus excelsa*, and *Prosopis cineraria* represented fragments of the original thorn scrub vegetation adapted to dry ravine slopes but now overshadowed by the aggressive spread of *P. juliflora*. Thus, the lower reach reflects an ecologically simplified but structurally dominant Prosopis-driven landscape, directly linked to the geomorphic evolution of the Chambal ravines.

3.3.3 Shrubs and grasses

Shrubs reported from the Chambal River are represented by 15 orders, 22 families, 36 genera, and 47 species, of which 34 are native while 13 are non-native (Table 3.2). Dominant shrubs species recorded were *Ziziphus nummularia*, *Calotropis procera*, *Capparis sepiaria*, *Capparis decidua*, *Grewia flavescens*, *Grewia hirsuta* (Annexure Table 1).

Graminoids reported from the Chambal River are represented by 1 order, 3 families, 50 genera, and 90 species, of which 86 were native and 4 were exotic (Table 3.2). The term Graminoids is used for grass and grasslike plants including Grasses (66 spp.), Sedges (23 spp.) and Cattails (01 spp.) (Figure 3.8). Dominant graminoid species recorded were *Saccharum bengalense*, *S. spontaneum*, *Phragmites karka*, *Cynodon dactylon*, *Cyperus rotundus*, *Fimbristylis* spp., *Desmostachya bipinnata*, *Eragrostis tenella*, *Echinochloa colona*, *Cenchrus ciliaris* (Annexure Table 1).

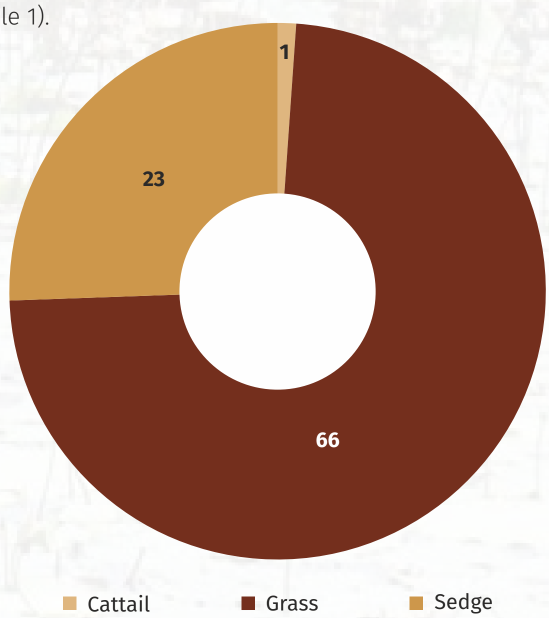


Figure 3.8: Classification of Graminoids at family level.

3.3.3.a Shrubs and grasses diversity

The Shannon Diversity Index (H') patterns at 1 m, 500 m, and 1000 m along the Chambal River reflect a clear ecological gradient driven by flood disturbance, ravine geomorphology, and land-use intensity. At 1 m, frequent scouring and unstable sandy banks produce very low richness and minimal shrub establishment, with only a few stable pockets such as Gandhi Sagar and Aawra supporting higher diversity. Pioneer grasses dominate recently exposed sediments, particularly in Barhi, where rapid colonizers thrive. At 500 m, shrub diversity remains low to moderate in erosion-prone ravine stretches like Karki and Ludhawali, while grasses maintain consistently higher diversity due to their adaptability to open, moisture-variable habitats. Mixed shrub-grass mosaics emerge in agricultural-ravine interfaces such as Nagda and Barkheda Khurd, and sites like Gandhi Sagar, Kota, and Mandrayal sustain some of the highest grass diversity values linked to flatter terrain and seasonal moisture. By 1000 m, broader landscape attributes drive the patterns. Upper agricultural belts show high richness but reduced nativity due to exotic introductions, while the mid-reach granite hill and sanctuary zone supports elevated native richness and peak grass diversity under protected forest-grassland conditions. In the lower ravine zone, gully erosion, soil instability, and Prosopis invasion suppress shrub layers but allow diverse grasses to persist, with Barhi again showing the highest H?. Overall, the Chambal's vegetation structure reflects strong interactions among hydrology, geomorphology, and land use, with grasses proving more resilient than shrubs across spatial scales.

Table 3.6. BEU-wise species richness, nativity, and Shannon index values (H') for shrubs and grasses (at 1m)

BEU	Location	Richness	Nativity		H' (Shrubs)	H' (Grasses)
			Native	Non-native		
2	Ghatabillod, Madhya Pradesh	19	15	04	00	0.045
10	Karki, Madhya Pradesh	21	18	03	00	0.049
18	Dharankhedi, Madhya Pradesh	34	30	04	00	0.043
27	Nagda, Madhya Pradesh	37	31	06	00	0.029
36	Barkheda khurd, Madhya Pradesh	11	07	04	00	0.014
46	Aawra, Madhya Pradesh	44	38	06	0.005	0.049
56	Gandhi Sagar, Madhya Pradesh	35	27	08	0.291	0.0417
66	Rawatbhata, Rajasthan	48	43	05	0.016	0.069
72	Daulatganj, Madhya Pradesh	45	31	14	0.011	0.032
75	Kota, Rajasthan	44	33	11	0.032	0.048
103	Khirkhari, Rajasthan	08	06	02	0.00092	0.011
113	Rodawad, Rajasthan	07	06	01	00	0.022
125	Mandrayal, Rajasthan	29	21	08	00	0.026
135	Sewarpali, Rajasthan	06	03	03	00	0.022
144	Sagarpada, Rajasthan	00	00	00	00	00
156	Ludhawali, Madhya Pradesh	15	09	06	00	0.02
167	Hatkani, Uttar Pradesh	17	11	06	00	0.023
173	Barhi, Madhya Pradesh	05	05	00	00	0.76
183	Katrauli, Uttar Pradesh	15	11	04	0.00623	0.045

At the 1 m from the River, vegetation patterns reflect extremely strong influence from recent flood scouring, sandy exposed beds, and unstable riverbanks, resulting in low richness and very limited shrub and grass diversity across much of the river corridor (Table 3.6). Several sites including BEU 144 (Sagarpada; richness = 0), BEU 135 (Sewarpali; richness = 6), and BEU 113 (Rodawad; richness = 7) exhibit minimal vegetative development, matching field observations of bare sandy substrates and fresh flood deposits. In these reaches, native species dominate simply because overall richness is low; for example, BEU 135 contains only 3 native species, and BEU 113 contains 6 natives, indicating extremely simplified riparian communities. A few segments serve as localized biodiversity nodes, where partial stability allows riparian vegetation to persist. BEU 56 (Gandhi Sagar) stands out with relatively high richness (35 species, 27 native and 8 exotic) and the highest shrub diversity (H' = 0.29), reflecting mixed vegetation in backwater conditions where repeated scouring is reduced. BEU 46 (Aawra) also shows elevated richness (44 species, 38 native and 6 exotic) with low but measurable shrub diversity (H' = 0.005), suggesting a more resilient riparian fringe compared to highly dynamic sandy stretches. Grass diversity reaches its highest value at BEU 173 (Barhi) (H' = 0.76), despite having only 5 total species (all 5 native). This reflects a community dominated by pioneer taxa particularly *Cynodon* that rapidly colonize recently exposed sediment. Other sites such as BEU 66 (Rawatbhata; richness = 48, with 43 native species) and BEU 75 (Kota; richness = 44, with 33 natives and 11 exotics) show moderate grass diversity (0.048-0.069), supported by bedrock exposures and semi-stable banks in Rawatbhata, and urban riparian conditions in Kota that maintain vegetation between disturbance episodes. Upstream segments such as BEU 2 (Ghatabillod) and BEU 10 (Karki), despite exhibiting moderate richness (19-21 species), show very low shrub diversity (H' = 0.00) and minimal grass diversity (H' ≈ 0.045-0.049). These patterns align with field notes describing strong meandering and extensive flood-related vegetation loss, resulting in patchy native-dominated grass cover with almost no shrub establishment.

Overall, richness and nativity patterns reveal that native species overwhelmingly dominate the 1 m layer. The highest richness values (e.g., BEU 66, BEU 46, BEU 72) occur in locations with either structural bank stability or reduced scouring, while the most disturbed sandy reaches exhibit sharp declines in both richness and diversity. These results underscore that episodic monsoonal floods, unstable sandy banks, and localized stable pockets collectively determine the structure of 1m vegetation along the Chambal, producing a system where pioneer grasses recover rapidly but mature shrub communities remain highly restricted.

Table 3.7. BEU-wise species richness, nativity, and Shannon index values (H') for shrubs and grasses (500 m)

BEU	Location	Richness	Nativity		H' (Shrubs)	H' (Grasses)
			Native	Non-native		
2	Ghatabillod, Madhya Pradesh	46	32	14	1.17	1.82
10	Karki, Madhya Pradesh	30	24	6	0.48	1.98
18	Dharankhedi, Madhya Pradesh	45	33	12	0.78	1.6
27	Nagda, Madhya Pradesh	50	31	19	1.21	1.81
36	Barkheda khurd, Madhya Pradesh	50	34	16	1.01	1.4
46	Aawra, Madhya Pradesh	53	39	14	0.9	1.95
56	Gandhi Sagar, Madhya Pradesh	46	33	13	1.02	2.02
66	Rawatbhata, Rajasthan	40	25	15	1.44	1.21
72	Daulatganj, Madhya Pradesh	49	36	13	1.04	1.45
75	Kota, Rajasthan	52	39	13	1.16	2.03
103	Khirkhari, Rajasthan	48	37	11	1	1.68
113	Rodawad, Rajasthan	56	47	9	1.64	1.56
125	Mandrayal, Rajasthan	46	37	9	0.92	2
135	Sewarpali, Rajasthan	66	55	11	1.88	1.76
144	Sagarpada, Rajasthan	55	44	11	1.11	1.49
156	Ludhawali, Madhya Pradesh	48	33	15	0.88	1.53
167	Hatkani, Uttar Pradesh	56	42	14	1.36	1.45
173	Barhi, Madhya Pradesh	49	37	12	1.09	1.49
183	Katrauli, Uttar Pradesh	56	45	11	1.39	1.52

Shrub and grass diversity along the Chambal River at 500 m continues to show a clear ecological gradient shaped by ravine depth, moisture variation, land-use pressure, and proximity to protected areas (Table 3.7). Overall, grass communities maintain higher diversity (H' = 1.21-2.03) than shrub communities (H' = 0.48-1.88), reflecting the dominance of semi-arid scrub systems and the stronger sensitivity of grasses to microhabitat and seasonal moisture. Low shrub diversity (H' < 1.0) at BEU 10 Karki (0.48), BEU 18 Dharankhedi (0.78), BEU 125 Mandrayal (0.92), BEU 156 Ludhawali (0.88), and BEU 46 Aawra (0.90) indicates harsh ravine terrain, erosion-prone slopes, and xeric soils where only hardy shrubs such as *Capparis decidua*, *Ziziphus nummularia*, and *Calotropis procera* can persist. These same BEUs show comparatively higher grass diversity (H' 1.53-2.00), suggesting that grasses exploit open ground, seasonal moisture, and disturbance more effectively than shrubs.

Moderate shrub diversity (H' ≈ 1.0-1.3) at BEU 2 Ghatabillod, BEU 27 Nagda, BEU 36 Barkheda Khurd, BEU 56 Gandhi Sagar, BEU 72 Daulatganj, BEU 75 Kota, BEU 103 Khirkhari, BEU 144 Sagarpada, and BEU 173 Barhi corresponds to ravine agriculture interfaces where thorn scrub is interspersed with cultivated margins, grazing corridors, and scattered tree cover. In these sites, grass diversity ranges between 1.40 and 1.82, reflecting moisture pockets within ravines and moderate disturbance. High shrub diversity (H' > 1.3) at BEU 66 Rawatbhata (1.44), BEU 113 Rodawad (1.64), BEU 167 Hatkani (1.36), BEU 183 Katrauli (1.39), and particularly BEU 135 Sewarpali (1.88) indicates stable substrates, reduced agricultural pressure, and well-developed scrub-grass mosaics. Sewarpali supports the highest shrub diversity (1.88), consistent with its broad ravine landscape and semi-arid scrub. Grass diversity peaks at BEU 56 Gandhi Sagar (2.02), BEU 75 Kota (2.03), BEU 125 Mandrayal (2.00), and BEU 46 Aawra (1.95), which represent flatter land, seasonal moisture zones, and well-developed riparian grass communities. Lower grass diversity at Rawatbhata (1.21) reflects rocky terrain and dam-regulated hydrology, where shallow soils and fluctuating water levels restrict grass establishment.

Table 3.8. BEU-wise species richness, nativity, and Shannon index values (H') for shrubs and grasses (1000 m)

BEU	Location	Richness	Nativity		H' (shrubs)	H' (grasses)
			Native	Non-native		
2	Ghatabillod, Madhya Pradesh	57	45	12	0.54	0.75
10	Karki, Madhya Pradesh	54	38	16	0.90	0.83
18	Dharankhedi, Madhya Pradesh	51	33	18	0.49	1.02
27	Nagda, Madhya Pradesh	57	40	17	0.44	0.91
36	Barkheda khurd, Madhya Pradesh	62	51	11	0.60	0.97
46	Aawra, Madhya Pradesh	48	34	14	0.67	0.85
56	Gandhi Sagar, Madhya Pradesh	65	49	16	0.52	2.08
66	Rawatbhata, Rajasthan	50	33	17	0.43	1.20
72	Daulatganj, Madhya Pradesh	74	58	16	0.67	1.98
75	Kota, Rajasthan	65	46	19	0.51	1.48
103	Khirkhari, Rajasthan	39	32	7	0.18	1.55
113	Rodawad, Rajasthan	52	40	12	0.32	1.45
125	Mandrayal, Rajasthan	57	50	7	0.34	1.82
135	Sewarpali, Rajasthan	51	39	12	0.28	1.68
144	Sagarpada, Rajasthan	49	34	15	0.39	1.51
156	Ludhawali, Madhya Pradesh	40	25	15	0.28	1.25
167	Hatkani, Uttar Pradesh	50	38	12	0.40	1.83
173	Barhi, Madhya Pradesh	68	52	8	0.82	2.26
183	Katrauli, Uttar Pradesh	35	26	9	0.47	1.48

In the upper agricultural settlement zone (BEUs 2-46), richness remained moderately high (48-62 species), but the native/non-native ratio was diluted, with many sites showing 10-18 exotic species due to cropland conversion and plantation trees introduced around villages. Shrub diversity (H' ≈ 0.44-0.90) remained moderate because boundary hedges, field margins, and homestead vegetation provide microhabitats, while grass diversity (H' ≈ 0.75-1.02) reflected mixed agricultural fallows and semi-natural grass patches. This aligns with the geomorphic context of a modified alluvial belt where disturbance and human management increased exotics without severely reducing total richness. In the mid-reach forested granite hill zone (BEUs 56-113) associated with Gandhi Sagar Wildlife Sanctuary, richness increased (50-74 species) with a strong rise in native species (up to 58) due to intact dry-tropical forest patches. Shrub diversity remains low to moderate (H' ≈ 0.18-0.67), reflecting steep rocky slopes where shrub layers were discontinuous, but grass diversity peaked (H' up to 2.08), due to grassy openings, riverine meadows, and protected habitats with minimal grazing. This pattern was consistent with bedrock channels, gorges, and forested slopes, where reduced anthropogenic pressure favoured natives and enhanced overall habitat heterogeneity. In the lower ravine and confluence zone (BEUs 125-183), species richness becomes more variable, ranging from 35 to 68, but the decline in native species at several sites (e.g., only 25-39 natives in BEUs 135-156) reflected the combined effects of severe gully erosion, soil instability, and Prosopis invasion. Shrub diversity remains low to moderate (H' ≈ 0.28-0.82) because ravines created fragmented, exposure-intensive environments where only hardy shrub species persist. In contrast, grass diversity remained relatively high (H' ≈ 1.25-2.26) due to open ravine slopes that favoured hardy, colonizing grasses adapted to erosion-prone soils. The very high grass H' at BEU 173 (2.26) corresponds to highly dissected ravine terrain where grasses dominate due to repeated soil disturbance. This vegetation structure mirrors the geomorphic evolution of the Chambal ravines, where erosion, undulating terrain, and invasive dominance simplify the shrub and tree layers but allow diverse grasses and hardy native scrub species to persist in patches.

3.3.3.b Dominant shrubs and grasses (based on percentage cover)

Based on raw field data collected from quadrats laid along perpendicular transects across the riverbanks, the following species exhibited the highest percentage cover and were identified as dominant within the sampled sites.

Shrub: *Calotropis procera*, *Capparis sepiaria*, *Capparis decidua*, *Grewia flavescens*, *Grewia hirsuta* etc.

Shrubby weeds: *Ricinus communis*, *Lantana camara*, etc.

Grasses: *Saccharum bengalense*, *S. spontaneum*, *Phragmites karka*, *Cynodon dactylon*, *Cyperus rotundus*, *Fimbristylis* spp., *Desmostachya bipinnata*, etc.

3.3.4 Herbs, Aquatic and Non-native species

Herbs reported from the Chambal River are represented by 26 orders, 66 families, 184 genera and 272 species among which 218 species are native and 54 species are non-native (Table 3.2 and Figure 3.9). Dominant herb species are *Alternanthera philoxeroides*, *Alternanthera sessilis*, *A. ficoidea*, *Parthenium hysterophorus*, *Cannabis sativa*, *Tridax procumbens*, *Ammannia baccifera*, *Croton boplandianus*, *Sida acuta*, *Ageratum conyzoides*, *Solanum* spp., *Xanthium strumarium*, *Phyla nodiflora*, *Grangea maderaspatana*, *Glinus oppositifolius*, *Glinus lotoides*, *Torenia crustacea*, *Mazus pumilus*, *Aerva lanata*. Along the Chambal River, herb richness and nativity show clear longitudinal variation shaped by ravine terrain, riparian stability, and land-use pressures. In the upper agricultural settlement reaches (BEUs 2-36), richness remains moderate to high (36-53 species), with natives forming the bulk of the flora. Exotic herbs occur in small but consistent numbers (10-15 species), linked to cropland margins and village disturbance. Local dips, such as at BEU 10, correspond to sandy, erosion-prone stretches offering limited habitat diversity.

In the mid-reach granite hill and semi-protected forest zone (BEUs 46-113) and presence of a reservoir, herb richness increases, peaking at BEUs 56, 72, and 75 (55-65 species). These segments support high native representation due to rocky slopes, riparian forest fragments, and reduced human pressure. Exotic herbs also increase slightly (15-19 species) but remain secondary to strong native dominance. Lower richness at sites like BEUs 66 and 103 reflects narrow riparian corridors and unstable slopes.

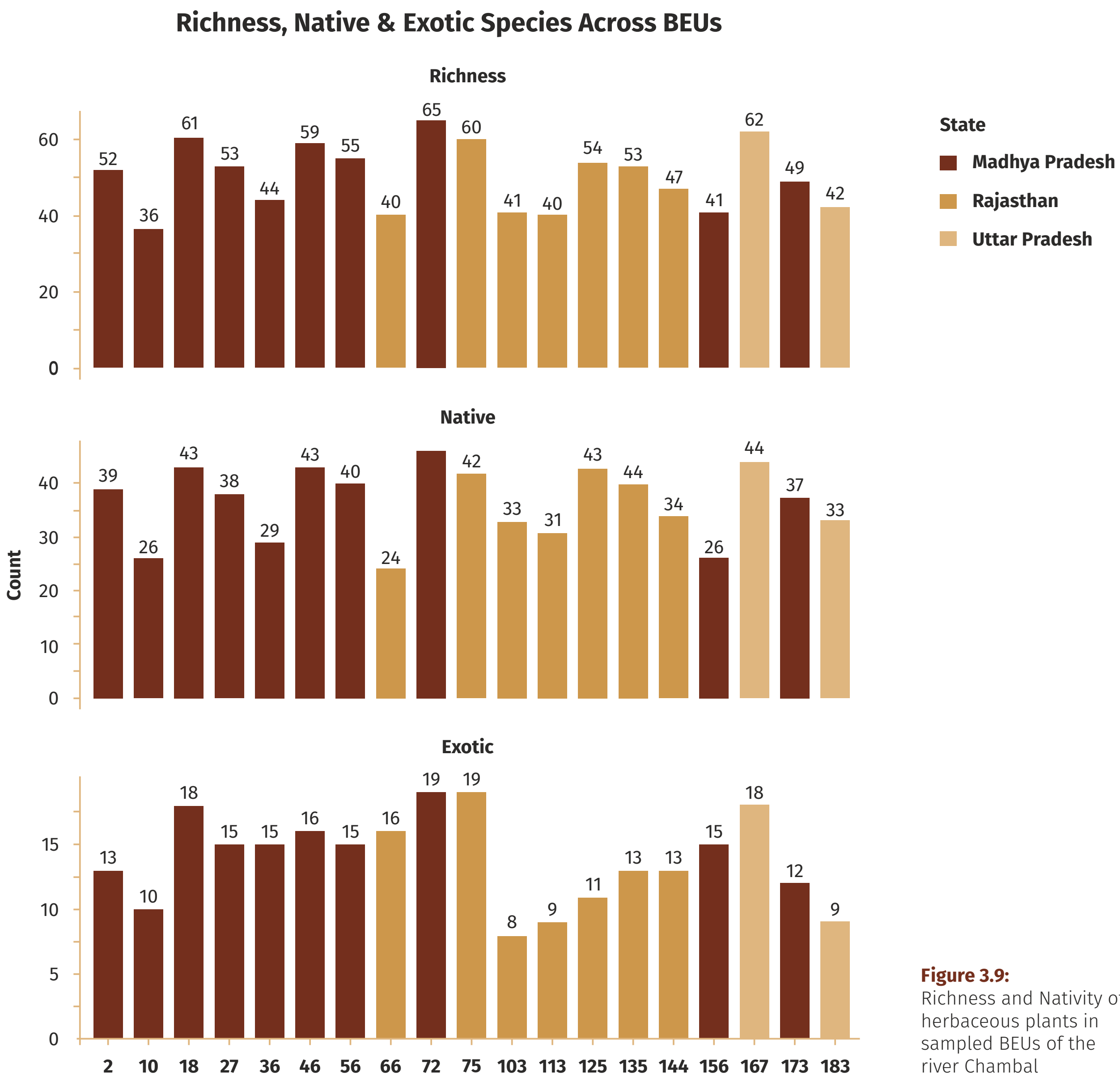


Figure 3.9: Richness and Nativity of herbaceous plants in sampled BEUs of the river Chambal

Aquatic species recorded in the Chambal River were represented by 12 orders and 19 families, among these dominant families were Hydrocharitaceae (5 spp.), Araceae, Lythraceae, (4 spp. Each) and Pontederiaceae, Potamogetonaceae (3 spp. each) (Figure 3.10). Dominant Aquatic and semi-aquatic plants frequently encountered were *Pontederia crassipes*, *Pistia stratoites*, *Lemna perpusilla*, *Spirodela polyrhiza*, *Najas minor*, *Hydrilla verticillata*, *Vallisneria natans*, *Ludwigia adscendens*, *Nymphaea nouchali*, *Nymphaea pubescens*, *Stuckenia pectinata*, *Trapa natans*, *Ceratophyllum demersum*, *Ammannia baccifera*, *Bolboschoenus maritimus*, *Carex fedia*, *Chrysopogon zizanioides*, Hygrophila polysperma, *Ipomoea aquatica*, *Nasturtium officinale*, *Nymphaea pubescens*, *Sagittaria trifolia*.

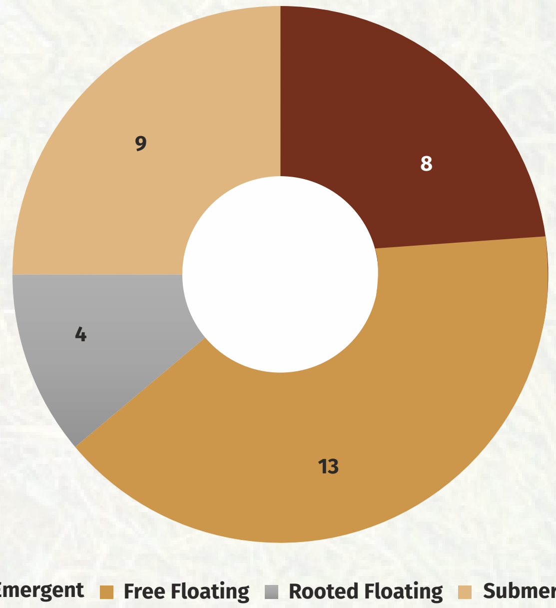


Figure 3.10: Sub-categories of Aquatic plants

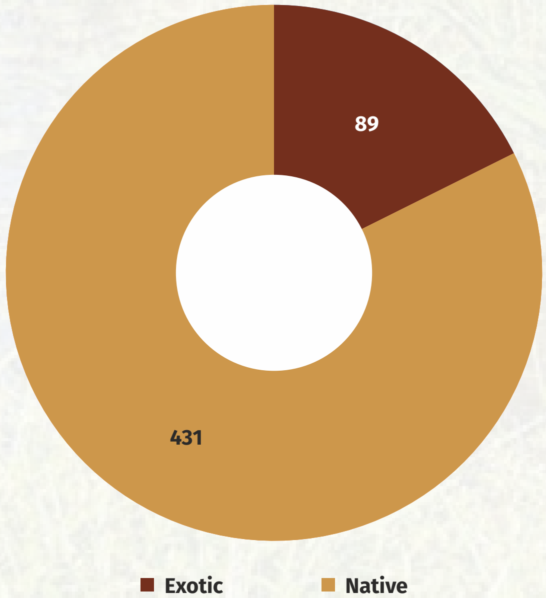


Figure 3.11: Nativity of plant species recorded along Chambal River

Aquatic plants (n=36) were sub divided into emergent (8 spp.), free floating (13 sp.), rooted but floating (4 spp.) and submerged (9 spp.) (Figure 3.10). Semi-aquatic plants (n=101) included riparian (11 spp.) and marshy (89 spp.) plants.

3.3.5. Invasive and Non-native species

About 82% (n = 431) of the recorded plant species were native to India, while the rest were non-native (89 spp., 17%) (Figure 3.11). Dominant families with highest number of introduced plants were Asteraceae (18 spp.), Fabaceae (16 spp.), Euphorbiaceae (9 spp.), Convolvulaceae (7 spp.) and Solanaceae (6 spp.). Dominant non-native tree species in the basin were *Prosopis juliflora*, *Pithecellobium dulce*, *Solanum erianthum*, *Broussonetia papyrifera*, *Leucaena leucocephala*. Dominant exotic shrub species were *Jatropha gossypifolia*, *Ricinus communis* and *Senna occidentalis*, *Lantana camara*, *Lippia alba*, *Solanum chrysotrichum*, *Ipomoea carnea*. Dominant exotic herbs noted were *Euphorbia hirta*, *Senna tora*, *Alternanthera ficoidea*, *Hyptis suaveolens*, *Ageratum conyzoides*, *Alternanthera paronychioides*, *Alternanthera philoxeroides*, *Amaranthus spinosus*, *Argemone mexicana*, *Calyptocarpus vialis*, *Croton boplandianus*, *Erigeron bonariensis*, *Portulaca pilosa*. Dominant introduced grasses were *Paspalum dilatatum*, *P. distichum*, and *Urochloa mutica*, Axonopus compressus. These species were most frequently encountered and were widespread across the river basin due to their highly adaptive nature, allelopathic effects, and reproductive strategies.

3.4 DISCUSSION

The Chambal River flows through the semi-arid landscapes of central India, traversing portions of the Vindhyan and Gangetic regions and supporting a mosaic of riverine, ravine, and dry deciduous forest habitats. As one of India's least polluted major rivers, the Chambal holds exceptional ecological significance and supports several threatened and endemic faunal species, including the gharial (*Gavialis gangeticus*), Gangetic dolphin (*Platanista gangetica*), mugger crocodile (*Crocodylus palustris*), and numerous freshwater turtles. Despite its relatively intact hydrological condition, large portions of the river basin have experienced ecological degradation due to accelerated soil erosion, fragmentation of ravine habitats, and increasing anthropogenic pressures such as agriculture, grazing, and settlement expansion. These geomorphological and land-use factors strongly influence vegetation structure and composition across the basin.

The floristic patterns observed in the present study largely align with previous studies conducted in the Chambal basin. Similar to our results, Sikarwar (2023) reported Poaceae as the most dominant plant family, followed by Fabaceae and Acanthaceae, reflecting the strong ecological adaptation of these taxa to arid and erosion-prone ravine landscapes. In the present study as well, graminoid species belonging to Poaceae constituted a major component of the flora, dominating sandy riverbanks, ravine slopes, and disturbed floodplain habitats. The dominance of Poaceae in such environments can be attributed to their extensive fibrous root systems, high regenerative capacity, and tolerance to shallow, unstable substrates, which allow rapid colonization of disturbed soils and contribute significantly to slope stabilization (Misra, 1968; Kent, 2012). Similarly, members of Fabaceae possess deep root systems and symbiotic nitrogen-fixing ability, enabling them to establish in nutrient-poor soils typical of ravine landscapes (Grime, 1977; Singh et al., 2006). Species belonging to Acanthaceae also display xerophytic adaptations such as reduced leaf area, thick cuticles, and efficient water-use strategies, which allow them to survive under moisture-limited conditions and high thermal stress characteristic of exposed ravine habitats (Whittaker, 1975; Odum & Barrett, 2005).

Our findings also corroborate observations made by Chorghe et al. (2012) and Uthappa et al. (2018), who reported that semi-natural and protected stretches of the river, particularly within the National Chambal Sanctuary, support relatively higher native species richness due to reduced anthropogenic disturbance. Similarly, in the present study, the middle reaches of the Chambal River-especially around the Gandhi Sagar-Rawatbhata region-exhibited higher species richness and diversity compared to heavily eroded downstream ravine systems and agriculturally modified upstream segments. Lower levels of lopping, grazing, and land-use conversion in protected areas facilitate the persistence and regeneration of native dry-deciduous and thorn forest species adapted to ravine environments. Many of these species possess ecological traits such as drought tolerance, deep or extensive root systems, and the ability to establish in shallow, erosion-prone substrates, enabling them to maintain structural stability in semi-arid landscapes with minimal human disturbance (Misra, 1968; Singh et al., 2006).

Several studies have contributed to the understanding of vegetation diversity and ecological characteristics of the Chambal River basin. Chorghe et al. (2012), Pathak (2013), Kala et al. (2017), Uthappa et al. (2018), and Sikarwar (2023) documented the floral diversity, habitat types, and vegetation characteristics of the Chambal landscape. While these studies primarily focused on floristic inventories, medicinal plant diversity, or habitat classification, the present study provides a more comprehensive assessment of vegetation structure along the river corridor by integrating floristic documentation with spatial analysis across multiple riparian distances and geomorphological settings. The patterns observed in our study therefore reinforce earlier findings while providing additional insights into the distribution of plant communities across agricultural landscapes, rocky gorge systems, and ravine-dominated terrains of the Chambal basin.

CONCLUSION

The Chambal River basin supports a diverse but highly heterogeneous vegetation structure, reflected in species richness, Shannon Index (SI), Importance Value Index (IVI), and abundance patterns across trees, shrubs, grasses, and herbs. The basin's semi-arid climate, rugged ravine geomorphology, and varying land-use intensity create a mosaic of habitats ranging from agricultural margins and rocky gorges to highly dissected ravines. Herbaceous flora and graminoids dominate in species numbers, while dry-deciduous trees such as *Acacia nilotica*, *Prosopis juliflora*, *Anogeissus pendula* and *Ziziphus* species are widespread. Semi-aquatic herbs and riparian grasses including *Saccharum spontaneum*, *Desmostachya bipinnata*, *Phragmites karka*, *Cynodon dactylon*, and *Cyperus rotundus* thrive along moist pockets, especially in stable mid-reach zones.

The river banks (1 m from the river) have extremely low vegetation richness due to frequent flooding, unstable sandy substrates, and steep ravine edges. IVI patterns show overwhelming dominance of *Prosopis juliflora*, often forming near-monocultures that suppress native riparian species. *Phoenix sylvestris*, *Acacia nilotica*, and *Butea monosperma* occur only in localized pockets where moisture retention and substrate stability allow partial establishment. Shrub and grass diversity remain minimal, reflecting strong disturbance pressure and the inability of most species to tolerate repeated erosion. Despite the presence of pioneer grasses on freshly deposited sediments, this zone remains structurally simplified and vulnerable to geomorphic instability, leading to fragmented habitats and reduced ecological resilience.

Vegetation at 500 m from the river represents a transitional mosaic between riparian and upland dry-deciduous habitats. Richness and diversity increase across all life forms, with tree IVI values indicating a mixture of disturbance-tolerant species (*Prosopis juliflora*, *Acacia nilotica*, *Acacia leucophloea*) and native dry deciduous elements in semi-protected stretches (e.g., *Anogeissus pendula*, Boswellia serrata). Agricultural landscapes upstream feature planted species such as *Azadirachta indica* and *Moringa oleifera*, while mid-reach gorges and rocky terrain near Gandhi Sagar and Rawatbhata support more natural assemblages with higher native representation. Shrubs and grasses show moderate to high SI values in ravine agriculture interfaces and semi-stable slopes, benefitting from the "edge effect," where overlapping landforms enhance microsite diversity. This intermediate zone thus reflects the strongest balance between natural dry-deciduous scrub and human-modified vegetation.

Beyond a distance of 1000 meters from the river bank, vegetation shifts toward broader landscape controls, influenced by agricultural expansion, settlement pressure, and the gradual intensification of ravine networks. Tree IVI patterns reflect the dominance of planted or disturbance-adapted species in the upper reaches (*Azadirachta indica*, *Mangifera indica*, *Moringa oleifera*, *Leucaena leucocephala*), whereas mid-reach granite hill and sanctuary zones exhibit stronger native dry-deciduous signatures (*Butea monosperma*, *Phoenix sylvestris*, *Boswellia serrata*, *Sterculia urens*). In the lower ravine belt, severe gully erosion and substrate instability drive sharp declines in native tree and shrub richness, with *Prosopis juliflora* emerging as the overwhelmingly dominant species. Shrub diversity declines due to harsh xeric conditions, but grasses maintain relatively high SI, evidencing their resilience in disturbed, erosion-prone terrains. Herbaceous flora shifts toward ruderal and exotic weeds, reflecting increasing fragmentation and habitat simplification with distance from the river.

REFERENCES

Angiosperm Phylogeny Group. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society, 181*(1), 1-20.

Chorghe, A., Rasal, V., & Khandal, D. (2012). Riparian flora along the ravines of the National Chambal Sanctuary. *Indian Journal of Ecology, 39*(2), 289-296.

Curtis, J. T., & McIntosh, R. P. (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology, 31*(3), 438-455. https://doi.org/10.2307/1931497

Grime, J. P. (1977). Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. *The American Naturalist, 111*(982), 1169-1194. https://doi.org/10.1086/283244

Kala, S., Meena, H. R., Rashmi, I., Prabavathi, M., Singh, A. K., & Singh, R. K. (2017). Status of medicinal plant diversity and distribution at rehabilitated Yamuna and Chambal ravine land ecosystems in India. *International Journal of Current Microbiology and Applied Sciences, 6*(3), 618-630.

Kent, M. (2012). Vegetation description and data analysis: *A practical approach* (2nd ed.). Wiley-Blackwell.

Magurran, A. E. (2004). *Measuring biological diversity*. Blackwell Publishing.

Misra, R. (1968). *Ecology work book*. Oxford & IBH Publishing.

Odum, E. P., & Barrett, G. W. (2005). *Fundamentals of ecology* (5th ed.). Thomson Brooks/Cole.

Pathak, S. K. (2013). Study of vegetation and flora of Chambal region (Madhya Pradesh). *International Journal of Scientific Research, 2*, 38-39.

Sharma, K. D., & Upadhyaya, S. K. (2002). Role of grasses in soil conservation and restoration of degraded lands. *Journal of Soil and Water Conservation, 57*(2), 86-90.

Sikarwar, R. L. (2023). Floristic diversity of Chambal ravines, Madhya Pradesh. *International Journal of Scientific Research, 26*, 55-65.

Singh, J. S., Singh, S. P., & Gupta, S. R. (2006). *Ecology, environment and resource conservation*. Anamaya Publishers.

Thomas, S., Deka, D. C., & Maiti, S. K. (2011). Fuelwood and medicinal plant diversity of ravine ecosystems in Morena district, Madhya Pradesh, India. *Indian Journal of Traditional Knowledge, 10*(3), 426-437.

Uthappa, A. R., Chavan, S. B., Ramesha, M. N., Kala, S., Kumar, V., Handa, A. K., & Chaturvedi, O. P. (2018). Plant biodiversity of ravine ecosystem: Opening new vistas for enhancing productivity. *In Ravine lands: Greening for livelihood and environmental security* (pp. 119-141). Springer.

Whittaker, R. H. (1975). *Communities and ecosystems* (2nd ed.). Macmillan Publishing Co.

SECTION II

CHAPTER 4

ICHTHYOFAUNA OF CHAMBAL RIVER

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Kante Krishna Prasad,
Rahul Rana

Contributing Authors
Shivani Farswan,
Khadija,
Surya Prasad Sharma,
Shivani Barthwal

SUMMARY

The Chambal River, a biodiversity hotspot in the semi-arid region of the Ganga River Basin, sustains a rich assemblage of native fishes and provides critical habitat for numerous threatened aquatic species. A post-monsoon survey was conducted between Rawatbhata and Pachnada, spanning 13 stratified sampling sites, employing monofilament gill nets and cast nets to assess ichthyofaunal diversity. A total of 692 individuals belonging to 34 fish species across 8 orders, 14 families and 26 genera were recorded in our present study. The family Cyprinidae (15 species) was the most abundant, followed by Bagridae (3 species). Assemblage structure was dominated by *Gonialosa manmina, Cabdio morar*, and *Gudusia chapra*, while large-bodied and migratory taxa occurred infrequently. Catch-per-unit-effort (CPUE) ranged from 49.25 Individuals per panel hour at Pachnada (Site 13) to 2.5 Individuals per panel hour at Gyanpura (Site 12). Site-wise highest species richness (13) was recorded in the middle and lower zones, Site-7 (Liloli, Madhya Pradesh) and Site-13 (Pachnada, Madhya Pradesh), and the lowest species richness (4 species) was recorded at Site-1 (Rawatbhata, Rajasthan). Zone-wise highest species richness was recorded in the Middle Zone (Site 5 to Site 8) with 25 species, followed by the Lower Zone (Site 9 to Site 13) with 20 species and the Upper Zone (Site 1 to Site 4) with 16 species. In terms of species diversity, Site-7 (Liloli, Madhya Pradesh) had the highest Shannon diversity index (H = 2.09), followed by

Site-9 (Near Rajghat, Rajasthan, H = 1.89), emphasising the importance of the middle zone in conservation.

The regression analysis showed no significant influence of physicochemical parameters or habitat factors on the species diversity index (H), although there were some low-level correlations. The highest positive correlation was with river width, depth and water flow, conductivity, indicating that broader and deeper river sections are likely to have a more diverse fish population. Negative trends were observed in parameters such as ORP, pH, TDS, and salinity; however, none were statistically significant due to the small sample size.

Of the 34 species documented in the present study, 31 species are listed in the Least Concern category of the IUCN redlist, and one species, *Wallago attu*, is in the Vulnerable category. This large carnivorous catfish species is facing population declines due to habitat degradation and overfishing. Two species, *Cyprinus carpio* and *Oreochromis niloticus*, are exotic. The presence of exotic fish in the Chambal River ecosystem raises concerns for conservation and management. Human-induced pressures such as sand mining, altered flow regimes, and harmful fishing practices remain key threats to native fish communities. Despite numerous challenges, the Chambal River still shows high ecological potential because of its protected status, especially in areas such as the National Chambal Sanctuary and Mukundara Hills Tiger Reserve. These protected areas have helped preserve aquatic biodiversity by reducing human disturbances and providing ecological processes to flourish.

4.1 Introduction

The fish community forms a critical component of the aquatic food web that directly influences the survival, distribution of apex predators such as Gangetic dolphin, otters, gharial, freshwater turtles and ecological health of the river ecosystem (Katdare et al., 2011; Singh & Rao, 2017). The ichthyofaunal diversity of the Chambal River comprises both native and invasive species, representing a wide range of taxonomic families and ecological guilds. The community exhibits notable seasonal fluctuations, with significant variation in species richness and abundance between the dry and wet seasons (Bose et al., 2019). The presence of a wide variety of fish species, both in terms of size and abundance, is crucial for sustaining a healthy food chain.

Fish diversity in the Chambal River basin has been studied over the years to understand its ichthyofaunal composition across different stretches and associated reservoirs (Table 4.1). The earliest significant contributions to the fish fauna of the Chambal River basin were made by Dubey & Mehra (1959); Sale (1982); Molur & Walker (1998); Sivakumar (2002); Vyas & Singh (2004); Saksena (2007); Sharma & Choudhury (2007); Srivastava (2007); Sivakumar & Choudhury (2008), and Meshram (2010). Gaur et al. (2012) further contributed by consolidating the fish diversity of the region. Vyas & Singh (2004) documented 21 species from the Gandhi Sagar Reservoir in Madhya Pradesh, while Sharma (2007) reported a comprehensive list of 172 fish species belonging to 68 genera, 27 families, and 10 orders from various aquatic systems across Madhya Pradesh. Studies limited to the small stretches of the river have continued to add to the inventory of ichthyofaunal diversity. Jaiswal et al. (2010) recorded 16 fish species from Ranthambhore National Park, Rajasthan. Ridhi et al. (2012) identified 22 species from the Chambal River stretch in Madhya Pradesh, and in the same year, Uchchariya et al. (2012) documented 40 species from the Tighra Reservoir, Gwalior, in the Chambal River basin. Nair & Krishna (2013), based on a comprehensive literature review and primary survey, reported 146 species, comprising 32 families from the Chambal River at National Chambal Sanctuary. Sarkar et al. (2015) documented 43 species belonging to 32 genera and 14 families from the Chambal stretch in Uttar Pradesh. Further assessments by Rathore et al. (2017) from Udai Sagar Reservoir in the Chambal River basin of Rajasthan yielded 31 species, while Sharma & Uchchariya (2017) identified 20 species in the Morena district of Madhya Pradesh. Bhat & Rao (2018) recorded 40 species from the Tighra Reservoir. Bose et al. (2019) conducted a broader assessment across the Chambal basin in Madhya Pradesh, identifying 56 species across 9 orders, 18 families, and 39 genera. Banyal & Kumar (2019) reported 26 species from the Kali Sindh River near Jetpura village, Rajasthan. Gautam & Sharma (2019) contributed by documenting 21 species from the Parvati River in Baran district, while Bairwa et al. (2020) recorded 32 species representing 9 families from

Goverdhan Sagar Lake, Udaipur. In the same year, Narway et al. (2019) recorded 29 species from the Kotwal Reservoir, spanning 21 genera, 11 families, and 7 orders.

Recent studies have continued to document local ichthyofaunal richness in tributaries and associated systems. Banyal & Kumar (2020) identified 11 species from the Mej River, part of the Chambal Riverine system in Rajasthan. Gautam & Sharma (2021) reported 34 species across 12 families and 7 orders from the Parvati River. Johnson et al. (2021) conducted a seasonal comparison between the Kota Barrage and Jawahar Sagar Dam, identifying 46 species in total-34 during the pre-monsoon and 29 post-monsoon. Most recently, Summarwar et al. (2021) conducted a focused study on *Tor tor* (mahseer) populations from the Chambal River and adjoining areas, emphasizing its ecological and conservation importance.

The Chambal River hosts remarkably rich ichthyofaunal diversity, with ichthyological studies reporting the presence of 172 valid fish species belonging to 14 orders, 36 families and 93 genera across various stretches of the Chambal River (Annexure-II).

The ichthyofauna inventory of the Chambal River reflects the taxonomic richness and ecological heterogeneity and underscores the importance of continuous monitoring, given the dynamic nature of freshwater fish communities and the increasing anthropogenic pressures in the region. Monitoring fish populations and assessing their health can provide valuable insights into the overall condition of the Chambal River ecosystem and inform conservation efforts aimed at protecting its unique biodiversity. Hence, an assessment of the ichthyofaunal diversity was undertaken in the Chambal River.

Table 4.1: Fish species documented by earlier studies in the Chambal River basin, India.

Location/River	Fish species Recorded	Source
Chambal River	71	Dubey & Mehra (1959)
National Chambal Sanctuary	37	Sale (1982)
Chambal River at Gandhi Sagar Reservoir	41	Rao et al. (1998)
Chambal River	13	Molur & Walker (1998)
Gandhisagar reservoir, Madhya Pradesh	41	Vyas & Singh (2004)
Chambal River, Rajasthan	73	Sharma & Choudhury (2007)
Chambal River, Madhya Pradesh	69	Sharma (2007)
Chambal River, Rajasthan	112	Srivastava (2007)
Ranthambore National Park, Rajasthan	16	Jaiswal et al. (2010)
Chambal Madhya Pradesh	21	Ridhi et al. (2012)
Tighra reservoir, Gwalior, Madhya Pradesh	40	Uchchariya et al. (2012)
National Chambal Sanctuary	146*	Nair & Krishna (2013)
Chambal Uttar-Pradesh	43	Sarkar et al. (2015)
Chambal Rajasthan	54	Banyal & Kumar (2015)
Udaisagar reservoir, Rajasthan	31	Rathore et al. (2017)
Morena district, Madhya Pradesh	20	Sharma & Uchchariya (2017)
Tighra reservoir Gwalior, Madhya Pradesh	40	Bhat & Rao (2018)
Chambal River basin of Madhya Pradesh.	56	Bose et al. (2018)
KaliSindh, Jhalawar, Rajasthan	26	Banyal & Kumar (2019)
Parvati River, Baran district, Rajasthan	21	Gautam & Sharma (2019)
Goverdhan Sagar Lake, Udaipur, Rajasthan	32	Bairwa et al. (2019)
Kotwal reservoir.	29	Narway et al. (2019)
Mej River, Rajasthan	11	Banyal & Kumar (2020)
Parvati River, Baran district, Rajasthan.	34	Gautam & Sharma (2021)
Kota barrage and Jawahar Sagar Dam	46	Johnson et al. (2021)
Chambal River and nearby areas.	1 (*Tor tor*)	Summarwar et al. (2021)

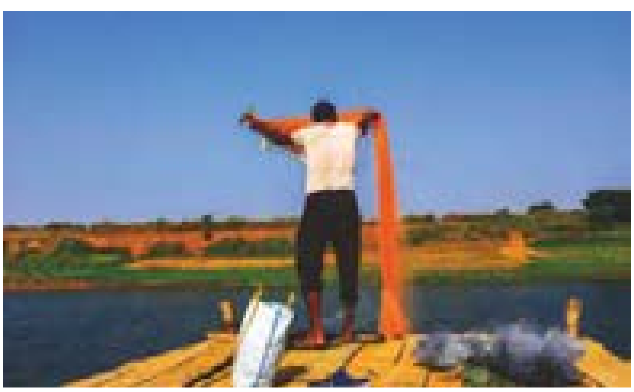
*One species *Trichogaster lalius* (Hamilton, 1822), recorded by Nair & Krishna (2013), was synonymised to *Trichogaster fasciata* (Bloch & Schneider 1801) as per the latest taxonomical revision by Knight et al. (2022). For this reason, the valid fish species reported by Nair & Krishna (2013) is 146 and not 147.

4.2 Methods

The study was conducted from Rawatbhata, Rajasthan, to Pachnada, Madhya Pradesh (Yamuna confluence) along the entire course of the Chambal River during the post-monsoon season from 13th to 24th November 2024. A stratified sampling method was conducted in the main course of the Chambal River. A total of 13 intensive sampling points were identified and sampled using the monofilament gill nets of varying mesh sizes from 0.5 inches to 6 inches (Table 4.2). Cast nets were also used based on feasibility (Figure.4.2). An average of 2 hours of net effort was given at each sampling site location. Fish samples were collected during morning (06:00-08:00) and evening (16:00-18:00) sessions. The other habitat parameters, like river width, were measured using a Range finder, depth was recorded using a Hondex Depth sounder Model-PS-7, and flow was recorded using the Geopack Advanced River Pack digital flow meter, and the physicochemical parameter was recorded using a YSI Ecosense digital handheld multiparameter. Species richness and diversity indices such as the Shannon Diversity Index (H') were calculated to indicate species diversity in a community. Fish abundance was estimated using the standard CPUE (Catch Per Unit Effort) method, expressed as individuals per panel hour (Musick & Bonfil, 2005). Collected fish were photographed and preserved in 7-10% formalin, properly tagged with labels for further laboratory study. Morphometric and meristic studies were conducted in the laboratory to identify species and resolve ambiguities. Fish identification followed standard literature by Jayaram (1999, 2010); Talwar & Jhingran (1991), and the electronic version of FishBase (Froese & Pauly, 2025).

Table 4.2: Fish sampling sites along the Chambal River, India.

Site ID	Site Name	BEU No.	Latitude	Longitude
S-1	Rawatbhata, Rajasthan	66	24 55 51.46	75 33 28.37
S-2	Gandhisagar Downstream	59	24 42 4.19	75 32 55.18
S-3	Badana, Kota, Rajasthan	77	25 14 45.94	75 53 55.49
S-4	Mandawara, Rajasthan	87	25 22 48.58	76 08 41.38
S-5	Shahanpur, Rajasthan	97	25 41 33	76 71 24.00
S-6	Pali, Rajasthan	105	25 50 58.71	76 33 47.5
S-7	Liloli, Madhya Pradesh	119	26 10 27.51	77 02 46.81
S-8	Bateshavpa-Dhavapura, Madhya Pradesh	128	26 21 45.6	77 25 27
S-9	Rajghat, Rajasthan	142	26 39 26.53	77 54 16.36
S-10	Barsala, Madhya Pradesh	151	26 47 10.5	78 08 55.59
S-11	Kenjra Ghat, Madhya Pradesh	162	26 46 33.95	78 31 37.73
S-12	Gyanpura, Madhya Pradesh	175	26 40 22.45	78 59 57.37
S-13	Pachnada, Madhya Pradesh	184	26 26 11.18	79 12 43.75



4.3 Results

The review of previous studies revealed the presence of about 173 fish species in the Chambal River Basin. Nair & Krishna (2013) recorded 146 species from the National Chambal Sanctuary. Their study was the comprehensive documentation of the past studies as well as the primary data for the stretch of the Chambal River, which is part of the NCS. The details of the present study are provided in the following sections.

4.3.1 Richness and diversity

A total of 692 individuals of 34 species belonging to 8 orders, 14 families and 26 genera were recorded in the Chambal River during the post-monsoon survey in November 2024. Valid scientific names, species name, IUCN status, historical and present survey records are presented in Annexure-II. Cypriniformes was the most dominant order with 17 species, followed by Siluriformes contributed 7 species. The order with the lowest abundance was Osteoglossiformes, Cichliformes, Beloniformes, and Acanthuriformes, with only one species present (Figure 4.2). Family Cyprinidae has the highest number of species (15 species), followed by Bagridae (3 species). The least abundant families are Notopteridae, Engraulidae, Ritidae, Siluridae, Cichlidae, Belonidae, Mugilidae and Sciaenidae, each accounting for only one species (Figure 4.3). Of the 34 species recorded, 31 are listed as Least Concern in the IUCN redlist, one species, *Wallago attu*, is Vulnerable, and two species were exotic, viz., *Cyprinus carpio* (Linnaeus, 1758) and *Oreochromis niloticus* (Linnaeus, 1758). Species such as the *Johnius coitor* (Hamilton, 1822) and *Setipinna phasa* (Hamilton, 1822) were recorded for the first time from the Chambal River.

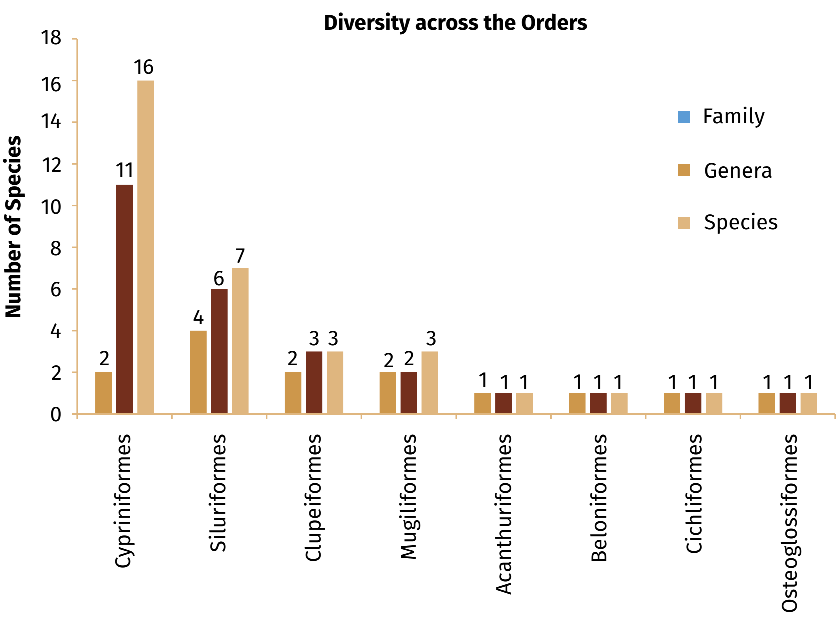


Figure. 4.2: Number of fish species, families, and genera recorded among the orders during the survey of the Chambal River

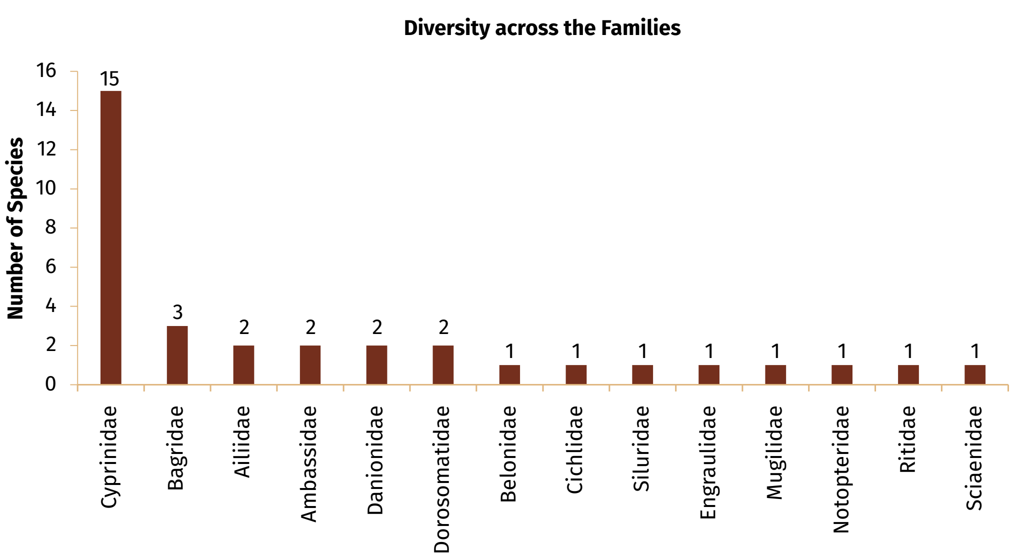


Figure 4.3: Species richness recorded among the families during the survey of the Chambal River

Site-wise species richness

The Site-7 (Liloli, Madhya Pradesh; H = 2.09) had the greatest diversity of fish species (Table 4.3; Figure 4.4), followed by Site-9 (Near Rajghat, Rajasthan; H = 1.89), Site-6 (Pali, Rajasthan; H = 1.70), Site-3 (Kota, Rajasthan; H = 1.71), Site-13 (Panchnada, Madhya Pradesh; H = 1.72), Site-2 (Gandhisagar Downstream, Rajasthan; H = 1.59), Site-4 (Mandawara, Rajasthan, H = 1.59), Site-10 (Barsala, Madhya Pradesh; H = 1.46), Site-12 (Gyanpura, Madhya Pradesh; H = 1.36), Site-11 (Kenjra Ghat, Madhya Pradesh; H = 1.15), Site-5 (Shahanpur, Rajasthan; H = 1.06), Site-1 (Ranapratap Sagar, Rawatbhata, Rajasthan; H = 1.06), and Site-8 (Bateshavpa-Dhavapura, Madhya Pradesh; H = 0.85).

The Site-7 and Site-13 (Liloli & Pachnada, each with 13 species) had the greatest richness among all the sites (Table 4.3; Figure 4.4), followed by Site-3 (Kota; 10 species), then Site-5, Site-9, and Site-10 (Shahanpur, Rajghat, & Barsala; each with 9 species), Site-6 (Pali; 8 species), Site-2 (Gandhisagar; 7 species), and Site-8 and Site-4 (Mandawara and Bateshavpa; each with 6 species), Site-11 and Site-12 (Kenjra Ghat and Gyanpura; each with 5 species), with the lowest species richness recorded at Site-1 (Ranapratap Sagar; 4 species) among all the survey locations along the Chambal River.

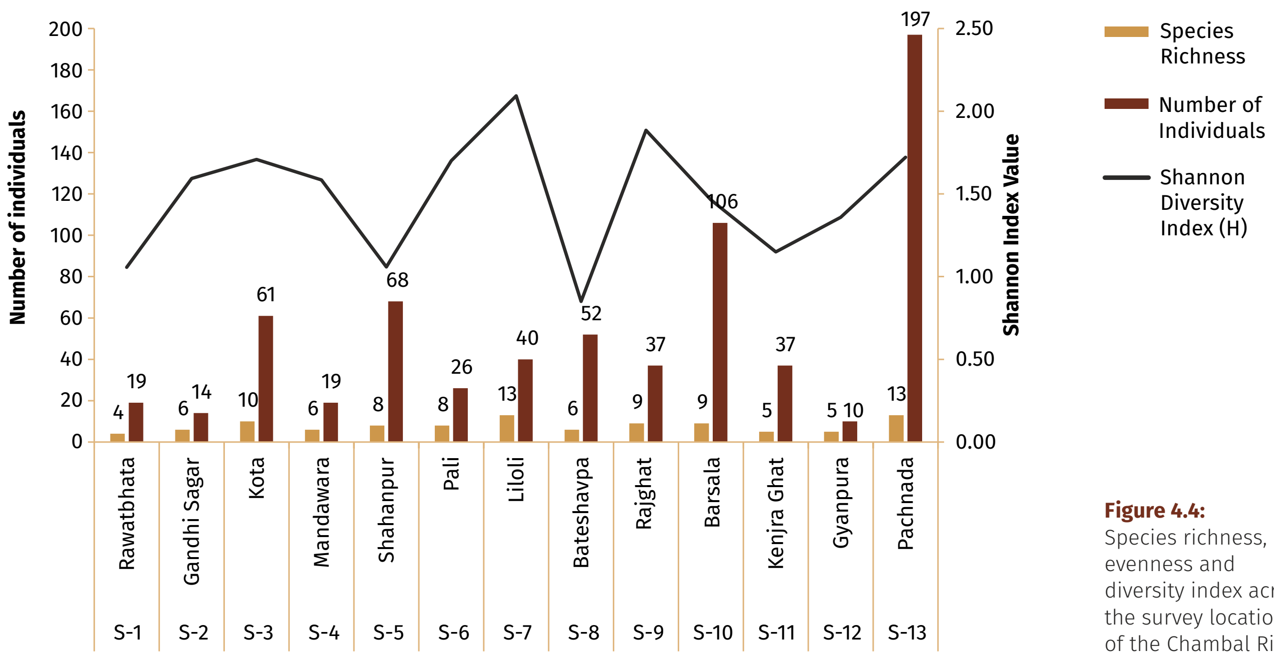


Figure 4.4: Species richness, evenness and diversity index across the survey locations of the Chambal River.

Zone-wise richness

If we observed zone-specific species richness, the highest species richness was observed in the Middle Zone which comprised sites 5 to 8 (Site 5, Shahanpur, Rajasthan, to Site 8, Bateshavpa-Dhavapura, Madhya Pradesh) with 25 species, followed by the Lower Zone (Site 9, Rajghat, Rajasthan, to Site 13, Pachnada, Madhya Pradesh) with 20 species and Upper Zone (Site 1, Rawatbhata, Rajasthan, to Site 4, Mandawara, Rajasthan) with 16 species (Figure 4.5). Two exotic species, *Cyprinus carpio* and *Oreochromis niloticus*, were observed in the Zone-1 and Zone-3.

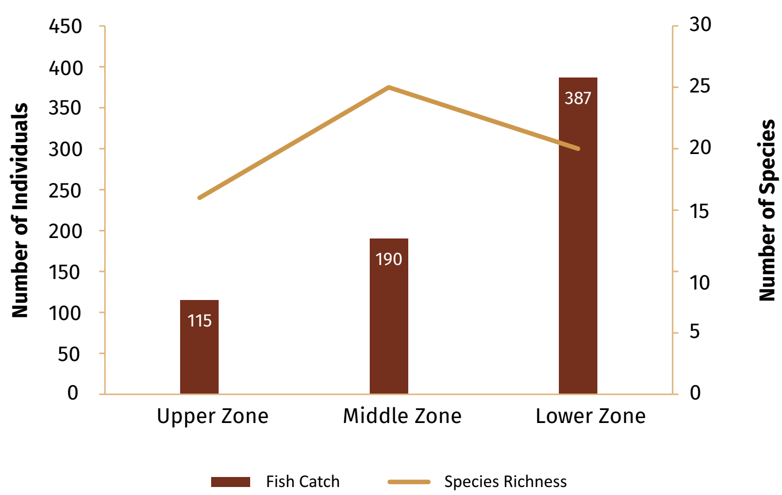


Figure 4.5: Zone-wise species richness and fish catch in the Chambal River

Table 4.3: Species Diversity Indices among all the survey locations in the Chambal River

Diversity Parameters	Species Richness	Number of Individuals	Dominance (D)	Simpson (1-D)	Shannon (H)	Evenness (e^H/S)
Site 1	4	19	0.446	0.554	1.056	0.7184
Site 2	6	14	0.2347	0.7653	1.593	0.8201
Site 3	10	61	0.2502	0.7498	1.708	0.5519
Site 4	6	19	0.241	0.759	1.585	0.8133
Site 5	8	68	0.5242	0.4758	1.059	0.3604
Site 6	8	26	0.2456	0.7544	1.701	0.6847
Site 7	13	40	0.1675	0.8325	2.093	0.6238
Site 8	6	52	0.5725	0.4275	0.8502	0.39
Site 9	9	37	0.1833	0.8167	1.885	0.7321
Site 10	9	106	0.3143	0.6857	1.464	0.4802
Site 11	5	37	0.4112	0.5888	1.15	0.6316
Site 12	5	10	0.32	0.68	1.359	0.7786
Site 13	13	197	0.2607	0.7393	1.722	0.4303

4.3.2 Relative Abundance

Of the total 34 species, *Gonialosa manmina* (27.60%) had the highest relative abundance (Figure 4.6) followed by *Cabdio morar* (16.18%), *Gudusia chapra* (7.08%), *Xenentodon cancila* (4.05%), *Salmostoma bacaila* (3.32%), *Sperata lamarrii* (3.18%), *Cirrhinus mrigala* (3.03%), *Chagunius chagunio* (2.75%), *Cirrhinus reba* (2.75%), *Labeo bata* (2.75%), *Osteobrama cotio* (2.75%), *Puntius* spp. (2.46%), *Chanda nama* (2.31%), *Pethia conchonius* (1.58%), *Barilius vagra* (1.58%), *Mystus vittatus* (1.58%), *Pethia ticto* (1.31%), *Labeo gonius* (2.17%), *Oreochromis niloticus* (1.88%), *Systomus sarana* (1.88%), *Clupisoma garua* (1.59%), *Johnius coitor* (1.45%), *Rhinomugil corsula* (1.16%) and *Sperata aor* (1.16%). In contrast, the lowest relative abundance (0.14%) was recorded for *Mystus* spp. *Setipinna phasa* and *Wallago attu*. These findings indicate that medium and large-sized indigenous fish species, e.g., *Gonialosa manmina, Gudusia chapra, Salmostoma bacaila, Sperata lamarrii, Chagunius chagunio* in the Chambal River have greater adaptations.

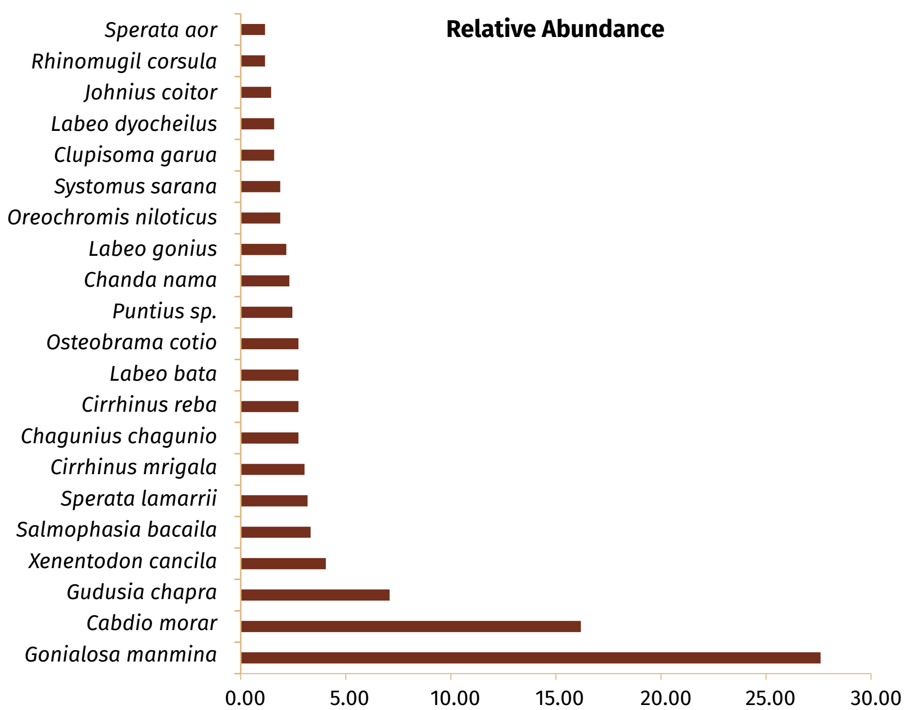


Figure 4.6: Relative Abundance of the fish species recorded during the survey in the Chambal River

4.3.3 Catch Per Unit Effort (CPUE)

The fish abundance of the Chambal River was measured using the Catch Per Unit Effort (CPUE) method, and the findings were reported as individuals per panel hour (Figures 4.7, 4.8 & 4.9). The highest Catch Per Unit Effort per panel hour (Fish abundance in individuals per panel hour) was recorded at the Site 13 - Pachnada (49.25 Individuals per panel hour), followed by Site 1 - Ranapratap Sagar (38 individuals per panel hour), Site 4 - Mandawara (38 individuals per panel hour), Gandhi Sagar (28 individuals per panel hour), Barsala (26 individuals per panel hour), Shahanpur (17 individuals per panel hour), Kota (15 individuals per panel hour) and the lowest was recorded at the sites Liloli (9.5 individuals per panel hour), Kenjra Ghat (9.25 individuals per panel hour), Rajghat (7 individuals per panel hour), Pali (6.5 individuals per panel hour), and Gyanpura (2.5 individuals per panel hour) (Figures 4.7 & 4.8).

Figure 4.7: Map representing Catch Per Unit Effort (CPUE) values from all the Intensive Sampling Locations

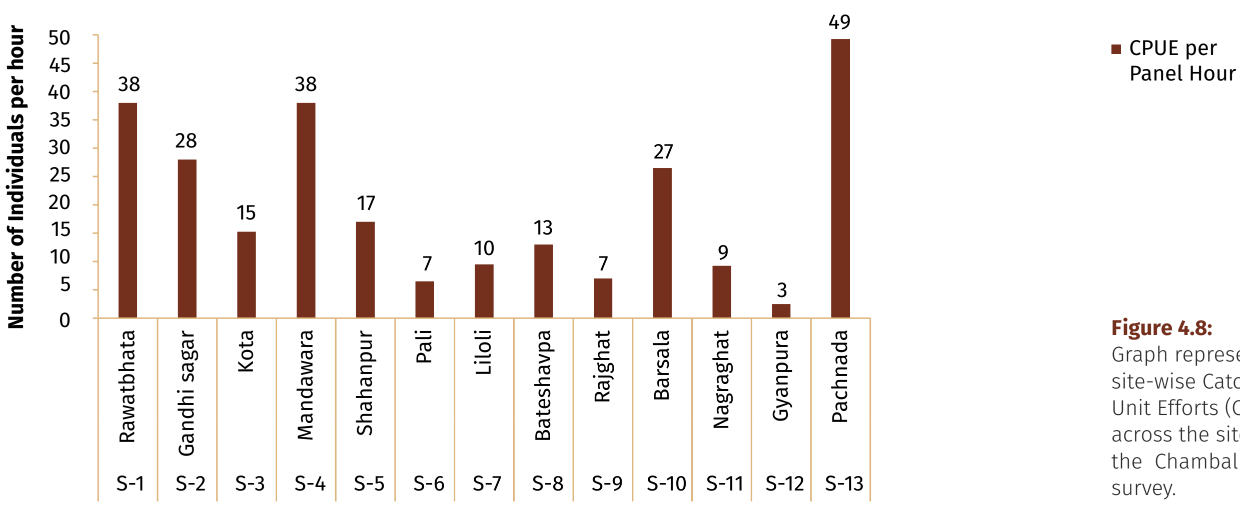


Figure 4.8: Graph representing site-wise Catch per Unit Efforts (CPUE) across the sites in the Chambal River survey.

Figure 4.9: A) Fish caught in the gill net, and B) taking the length and weight measurements of the fish at the sampling site in the Chambal River.

4.3.4 Environmental variables influencing fish abundance

The correlation analysis shows that the Species Diversity index (H) has a positive correlation with average width (R^2 = 0.2819), depth (R^2 = 0.0124), and average flow (R^2 = 0.0681), suggesting that wider, deeper river sections and faster flow may support higher fish diversity (Table 4.4). Average width has a moderate explanatory power compared to average depth and flow, but the effect is not statistically significant. Specific Gravity shows a positive correlation with species diversity, with R^2 = 0.0948; the effect is not statistically significant, though it has moderate explanatory power. Conductivity (R^2 = 0.0393) shows a weak positive correlation with species diversity, and if conductivity increases, species diversity may also increase, but it has a minimal and non-significant effect. Salinity shows a strong negative correlation, suggesting that higher salinity will decrease species diversity, with a large effect size, and salinity's effect is not statistically significant (R^2 = 0.0557). Conversely, the Species Diversity index (H) is negatively correlated with ORP (R^2 = 0.1110) and TDS (R^2 = 0.0430), implying that higher oxidation-reduction potential and TDS might slightly reduce diversity. Elevation (R^2= 0.094) and Water Temperature (R^2= 0.022) show a negative correlation with diversity and exhibit minimal impact.

Environmental variables such as elevation, Depth, Flow, temperature, Conductivity, and TDS, showed no significant impact on the Species Diversity index (H). The elevation showed a slight negative impact, and that means higher elevation slightly decreases the species Diversity index (H), but the effect is not significant. Average width shows a slight positive impact on the species Diversity index (H). A wider river may slightly increase diversity, but the effect is weak. Average Flow also shows no significant impact on the species Diversity index (H), but suggests higher flow may increase diversity. Suggests that faster water flow might increase diversity, but not statistically significant. Water temperature shows a slight negative relationship with species Diversity index (H), and it shows that higher temperatures may reduce diversity. Salinity also shows a large but insignificant negative effect.

Table 4.4: Relationship between Species Diversity (H') and Environmental Variables

Environmental Variables	Coefficients	Standard Error	t Stat	P-value	R^2
Elevation (m)	-0.0086	0.0101	-0.8527	0.5505	0.0094
Average Width (m)	0.0055	0.0033	1.6758	0.3425	0.2819
Average Depth (m)	0.0227	0.1148	0.1977	0.8757	0.0124
Average Flow (m/s)	1.2361	0.7867	1.5714	0.3608	0.0681
Water Temperature (°C)	-0.2755	0.1710	-1.6109	0.3537	0.0022
Conductivity (µs/cm)	0.0978	0.1626	0.6015	0.6553	0.0393
TDS (ppm)	-0.1926	0.3327	-0.5790	0.6659	0.0430
Salinity (% ppt)	-86.1616	56.6079	-1.5221	0.3701	0.0557
pH	-0.3964	1.8508	-0.2142	0.8657	0.0235
S.G.	1902.3088	1263.9916	1.5050	0.3734	0.0948
ORP (mv)	-0.0027	0.0052	-0.5186	0.6954	0.1110

PLATE 1.

Fish species recorded during the post-monsoon survey of the Chambal River

Botia dario

Sicamugil cascasia

Gogangra viridescens

Gudusia chapra

Wallago attu

Setipinna phasa

Rita rita

Osteobrama cotio

Notopterus synurus

Gonialosa manmina

Sperata lamarrii

Clupisoma garua

Chagunius chagunio

Labeo calbasu

Chanda baculis

Salmostoma bacaila

Labeo bata

Clupisoma garua

4.3.5 Status of species conservation significance

Several species in the Chambal River exhibit varying degrees of conservation concern, necessitating a nuanced approach to their management (Sarkar et al., 2012). Of the total 34 species recorded in the survey, 31 species (91.18%) are listed in the Least Concern (LC), one species (2.94 %), *Wallago attu*, is Vulnerable, and two species are exotic. *Wallago attu*, a large carnivorous catfish species, is facing population decline due to habitat degradation and overfishing. Most of the fish species are in the Least Concern category according to IUCN status, indicating they currently face no major threats of extinction. Overall, the Chambal River is home to 173 species, of which 137 species are placed under the Least Concern, 8 species in Near Threatened, 6 species in Vulnerable, 4 species in Endangered categories of the IUCN Redlist, the 3 species are not evaluated, 6 are data deficient, and the remaining 9 species are exotic (IUCN 2025; Annexure II). Species like *Wallago attu* and *Bagarius bagarius* are classified as Vulnerable, indicating a high risk of endangerment in the near future, while *Chitala chitala* is considered Near Threatened, suggesting that it may qualify for a threatened category soon (Das et al., 2023). Conversely, several species, including *Labeo bata, Chagunius chagunio, Cirrhinus mrigala, Labeo rohita,* and *Raiamas bola*, are categorised as Least Concern, suggesting relatively stable populations (Sarkar et al., 2012). However, this does not diminish the importance of monitoring these species, as environmental changes and habitat degradation can rapidly alter their status (Sarkar et al., 2012). Among the Tor species, *Tor khudree* is listed as Least Concern, *Tor putitora* is Endangered, and *Tor tor* is Data Deficient, highlighting the need for more research to assess the latter's population status and threats (Nair & Krishna 2013; Srivastava, 2007). Even common species such as *Channa punctata*, which are under the least concern category, need constant monitoring and conservation efforts (Banyal & Kumar, 2014).

The economic significance of these fish species is multifaceted, encompassing commercial fisheries, recreational angling, and local livelihoods. Many of these species are important components of local diets and economies, providing income and sustenance for riparian communities. Large catfishes like *Bagarius bagarius*, known locally as Goonch, are economically important (Das et al., 2023). The conservation of these economically valuable species is crucial for ensuring food security and supporting sustainable livelihoods. Ecological roles, encompassing their positions in the food web, habitat preferences, and sensitivity to environmental changes, are also critical. The ecological roles of these fish species are diverse and crucial for maintaining the health and stability of the Chambal River ecosystem (Sarkar et al., 2015).

4.3.6 Invasive Fish Species

During the post-monsoon survey of the Chambal River, two invasive/exotic fish species, *Oreochromis niloticus* and *Cyprinus carpio*, were recorded throughout its course from Rawatbhata to Pachnada. The relative abundance of *Cyprinus carpio* was 0.87% and *Oreochromis niloticus* was 1.88 %, of the total capture. Their presence in the Chambal ecosystem is of concern from a conservation and management perspective.

Figure 4.10: *Oreochromis niloticus*

Figure 4.11: *Cyprinus carpio*

4.4 Discussion

The Chambal River, a tributary of the Yamuna River, is known for its rich fish diversity (Singh & Sharma, 1998). However, recent studies have highlighted the need for a more comprehensive understanding of the factors influencing the fish assemblage structure in this region (Sarkar et al., 2012). The observed variations in fish diversity among current and previous studies suggest that factors such as habitat characteristics, water quality, and anthropogenic pressures, such as sand mining, may be significant contributors to these changes (Sarkar et. al., 2012). The Chambal River supports a diverse fish community, with the most abundant families being Cyprinidae, Bagridae, and Danionidae. These families are often considered indicators of ecological imbalance, as their dominance may be a result of prevailing environmental stressors (Jusmaldi et al., 2019). These families can flourish where more sensitive species decline because they are more resilient to adverse environmental conditions like low water quality, decreased water volume, and habitat alteration (Ahmad & Venkateshwarlu, 2012). The Chambal River's fish fauna is experiencing environmental stressors, as demonstrated by decades of data, where in 2007 Cyprinidae, Danionidae, and Bagridae made up 25.6%, 16.8%, and 5.3%, respectively, of the fish diversity (Srivastava, 2007), another study found these families contributing 35.6%, 12.3%, and 8.2% (Sharma & Choudhury, 2007), respectively to the diversity, which changed to 24% of Cyprinidae, followed by Danionidae (17%) and Sisoridae (7.5%) by 2012-13 (Nair & Krishna, 2013); and most recently Cyprinidae was observed at 47% and Bagridae at 10.8% of the total fish diversity (Johnson et al., 2021). The current survey indicates that the most diverse families in the river are Cyprinidae (44%), Bagridae (8.8%), and Danionidae (5.8%), highlighting the continued rising environmental stress in the Chambal, evident from the changes in assemblage and dominant families.

The major portion of the Chambal River is protected, which contributes to the diversity of fish species and their abundance. The insights gained from these studies highlight the stretches with high fish diversity, as well as the regions with lower diversity, which can inform the development of effective management strategies and regulations for the Chambal River, ensuring the long-term sustainability of its aquatic resources and the communities that depend on them. The regression model explains 95.1% ($R^2 = 0.951$) of the variance in the fish species diversity index [Shannon Diversity index (H)], but the adjusted R^2 (0.416) suggests overfitting due to the small sample size ($n = 13$). None of the variables are statistically significant ($p > 0.05$), their effects on the Species Diversity index (H') are uncertain in the Chambal River.

The fish diversity of the Chambal River has been impacted by several anthropogenic factors, similar to the threats faced by the Ganges River. These factors include habitat destruction, pollution from agricultural runoff and industrial discharge, and unsustainable fishing practices and rapid colonization by invasive fish (Sarkar et al., 2012). Apart from Cyprinus carpio and *Oreochromis niloticus*, exotic species, seven other invasive species, including *Carassius carassius, Gambusia affinis, Ctenopharyngodon idella, Hypophthalmichthys molitrix, H. nobilis, Oreochromis mossambicus* and *Pangasianodon hypophthalmus* have been recorded in the Chambal River (Bose et al., 2018; Nair & Krishna, 2013; Sharma & Choudhury, 2007; Srivastava 2007). The introduction and proliferation of invasive fish species, such as tilapia, have potentially altered the food web dynamics in the majority of the rivers in India (Joshi et al., 2016; Trivedi et al., 2021). The long-term consequences of a change in fish composition can have cascading effects on the entire river ecosystem. The exotic fish species are now established and common in the Yamuna-Chambal system (Alam et al., 2015). Invasive fish species in the Chambal riverine environment pose challenges for both the conservation and management of native fish species. The long-term shift in fish community composition caused by such invasions may result in cascading effects throughout the aquatic ecosystem, primarily by invasive fishes, which are now well documented in the Chambal River system, posing significant challenges to native biodiversity. This issue must be addressed and prioritised as soon as possible to conserve native species. Conservation strategies must consider the intricate relationships between fish diversity, habitat quality, and the needs of the indicator species.

Furthermore, alterations to the river flow regime can disrupt fish migration patterns and spawning habitats, ultimately affecting fish populations. Management strategies must address these threats by implementing measures to improve water quality, regulate fishing activities, and restore degraded habitats. Additionally, understanding the impacts of invasive species like tilapia on native fish populations and the overall ecosystem health is crucial for developing targeted control measures.

To maintain the long-term sustainability of fish diversity in the Chambal River, a multifaceted approach is required. The identification and conservation of high-priority zones, including hotspots of fish diversity and fish breeding and nursery grounds, can be crucial steps. Regulatory measures can also contribute to the survival of fish broods and fingerlings (Singh & Sharma, 1998; Paul et al., 2021). Since fish are not only a source of food for humans but also crucial for the long-term survival of other aquatic animals, such as otters, gharials, and aquatic birds, the conservation of fish diversity in the Chambal River is of paramount importance. Additionally, state administrative departments, in collaboration with NGOs and community organisations, can implement alternative livelihood methods for people dependent on the river's resources.

The findings from the present and previous studies, such as the assessment of fish diversity and physicochemical aspects of the river, offer valuable insights into the current status of the fish in the river and their conservation management strategies (Paul et al., 2021). These studies highlight the need for a holistic approach to river basin management, incorporating the ecological and economic aspects of the Chambal River ecosystem.

Conclusion

The post-monsoon fish diversity assessment in the Chambal River provides baseline information about the current status of fish diversity. The findings of this study indicate that the habitat conditions in the Chambal are highly diverse, providing suitable habitat for the thriving fish diversity since the river traverses from the regions of major Protected Areas, Mukundara Hills Tiger Reserve and National Chambal Sanctuary. These Protected Areas play a pivotal role in maintaining an undisturbed aquatic ecosystem. Among the major fish identified in the study, some of the major ecologically and economically important species include *Sperata lamarrii, Wallago attu, Chagunius chagunio, Labeo rohita*, and *Cirrhinus mrigala*. The species are essential components of the river's aquatic biodiversity, contributing to both ecological balance and fish of economic importance.

Additionally, the presence of several other native fish species underscores the River's ability to sustain a rich ichthyofaunal diversity. The findings of this post-monsoon study contain immense significance in aiding conservation plans for the native fish species of the Chambal River. The study also aids in understanding species distribution, population dynamics, and habitat preference. This information is crucial for formulating effective conservation strategies aimed at sustaining the existing fish populations while mitigating potential threats such as habitat degradation, pollution, and climate change. Furthermore, identifying the areas of high biodiversity within the river ecosystem is crucial for future management and conservation plans. These high-priority zones can be designated as conservation hotspots, ensuring that necessary measures are implemented to conserve and enhance fish populations in their natural habitats. The study not only enriches our understanding of the current fish diversity but also provides groundwork for future biodiversity management and conservation plans. By safeguarding the ecological integrity of the Chambal River, we can ensure the continued survival of its rich and diverse aquatic life for the future. The information obtained from the current findings can help in sustaining and conserving the native fish diversity in the present habitat and will also help in identifying the areas of high biodiversity zones and future management and action plans.

REFERENCES

Ahmad S & M. Venkateshwarlu (2012). Habitat Ecology of Cyprinid Fish Community in Relation to Environmental Factors of Tunga and Bhadra Rivers, Western Ghats, Karnataka (India). *Journal of Research & Development,* 12: 65-91.

Alam, A., Chadha, N. K., Joshi, K. D., Chakraborty, S. K., Sawant, P. B., Kumar, T., Srivastava, K., Das, S. C. S., & Sharma, A. P. (2015). Food and feeding ecology of the non-native Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1758) in the River Yamuna, India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 85*(1), 167-174.

Bairwa, V. P., Sharma, B. K., Sharma, S. K., Keer, N. R., & Vijay Kumar, V. K. (2020). Icthyofaunal diversity of Goverdhan Sagar Lake, Udaipur, Rajasthan. *Journal of Experimental Zoology India, 23*(1), 631-633.

Banyal, H. S., & Kumar, S. (2014). Fish diversity of Chambal River, Rajasthan State. In *Aquatic Ecosystem: Biodiversity, Ecology and Conservation* (pp. 271-281). New Delhi: Springer India.

Banyal, H. S. & Kumar, S. (2019). Studies on ichthyofaunal diversity of Kali Sindh River near Jetpura village, Jhalawar, Rajasthan, India. *Journal of Environment & Bio-sciences, 33*(2), 227-230.

Banyal, H. S., & Kumar, S. (2020). A preliminary study on the ichthyofaunal diversity of the Mej river in Bundi district, Rajasthan. *Records of Zoological Survey of India, 120*(4), 401-407. doi: 10.26515/rzsi/v120/i4/2020/150628.

Bhat, H., & Rao, R. J. (2018). Studies on fish diversity of Tighra reservoir Gwalior, Madhya Pradesh, India. *International Journal of Zoology Studies, 3*(2), 68-73. www.zoologyjournals.com.

Bose, R., Bose, A. K., Das, A. K., Parashar, A., & Roy, K. (2019). Fish diversity and limnological parameters influencing fish assemblage pattern in Chambal River Basin of Madhya Pradesh, India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 89*, 461-473. https://doi.org/10.1007/s40011-017-0958-5.

Das, B. K., Ray, A., Johnson, C., Verma, S. K., Alam, A., Baitha, R., Manna, R. K., Roy, S., & Sarkar, U. K. (2023). The present status of ichthyofaunal diversity of river Ganga India: Synthesis of present v/s past. *Acta Ecologica Sinica, 43*(2), 307-332. https://doi.org/10.1016/j.chnaes.2021.10.008

Dubey, G. P. & Mehra, R. K. (1959). Fish and fisheries of Chambal River. Proceedings of the All-India Congress of Zoology, 1, 647-665.

Froese, R. and D. Pauly. (Eds.) (2025). FishBase. World Wide Web electronic publication. www.fishbase.org, version (04/2025)

Gaur, K. S., Sharma, V., Verma, B. K. & Sharma, M. S. (2012). Ethnozoological study of hill stream fish inhabiting the streams and the tributaries of the Chambal River in South-Eastern Rajasthan (India). *Research & Reviews: Journal of Ecology, 2*(3), 4-10.

Gautam, H., & Sharma, M. (2019). Study of fish diversity in relation to seasonal changes of Parvati River, Baran district, Rajasthan. *Journal of Emerging Technologies and Innovative Research, 6*(2), 335-338.

Gautam, H., & Sharma, M. (2021). Biodiversity of fishes of Parvati River, Baran district, Rajasthan. *International Journal of Advanced Research in Science, Engineering and Technology, 8*(1), 16374-16385.

IUCN. (2025). The IUCN Red List of Threatened Species. Version 2024-1. https://www.iucnredlist.org. Accessed on [23/08/2024].

Jaiswal, D., Rao, C. A. N., Kumar, S., & Mond., H. (2010). Ichthyofauna. Zoological Survey of India, Fauna of Ranthambhore National Park. *Conservation Area Series, 40*, 145-158.

Jayaram, K. C. (1999). *The freshwater fishes of the Indian region*. Narendra Publishing House, 551.

Jayaram, K. C. (2010). *The freshwater fishes of the Indian region*. 2nd Eds. Narendra Publishing House, Delhi, pp.625.

Johnson, J. A., George, A., Sharma, M., Kavin, D., Sreelekha Suresh, P. C., Gopi, G. V., & Hussain, S. A. (2021). Status of wildlife between Kota Barrage and Jawahar Sagar Dam, Rajasthan, Wildlife Institute of India, Dehradun 59p. *RAPID ASSESSMENT REPORT*, 4.

Joshi, K. D., Alam, A., Jha, D. N., Srivastava, S. K., & Kumar, V. (2016). Fish diversity, composition and invasion of exotic fishes in river Yamuna under altered water quality conditions. *Indian Journal of Animal Sciences, 86*(8), 957-963. https://doi.org/10.56093/ijans.v86i8.60837.

Jusmaldi, J., Hariani, N., & Doq, N. (2019). Diversity, potentiality, and conservation status of fish fauna in the upper Mahakam's tributaries, East Kalimantan. *Jurnal Iktiologi Indonesia, 19*(3),391-410. https://doi.org/10.32491/jii.v19i3.471.

Katdare, S., Srivathsa, A., Joshi, A., Panke, P., Pande, R., Khandal, D., & Everard, M. (2011). Gharial (Gavialis gangeticus) populations and human influences on habitat on the River Chambal, India. *Aquatic Conservation: Marine and Freshwater Ecosystems, 21*(4), 364-371. DOI: 10.1002/aqc.1195.

Knight, J. D. M., M. Nallathambi, B. Vijayakrishnan and P. Jayasimhan (2022). On the identity of the banded gourami Trichogaster fasciata with notes on the taxonomic status of Trichopodus bejeus (Teleostei: Perciformes: Osphronemidae). *Journal of Fish Biology v.* 101 (no. 5): 1343-1347

Meshram, P. K. (2010). Diversity of some fauna in National Chambal Sanctuary in Madhya Pradesh, India. *Biodiversitas, 11*(4), 211-215. DOI: 10.13057/biodiv/d110408.

Molur, S. & Walker, S. (1998). Report of the Workshop" Conservation Assessment and Management Plan for Freshwater Fishes of India". Zoo Outreach Organisation & CBSG South Asia, Coimbatore, India, 156pp.

Musick, J. A., & Bonfil, R. (eds) (2005). Management techniques for elasmobranch fisheries. FAO Fisheries Technical Paper. No. 474. Rome, FAO. 2005. 251p.

Nair, T. & Krishna, Y. C. (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa, 5*(2), 3620-3641; doi:10.11609/JoTT.o3238.3620-41.

Narway, K., Chakravarty, S., Jain, A., Pailan, G. H. & Dasgupta, S. (2019). Fish diversity and fisheries of Kotwal reservoir, Morena, Madhya Pradesh. *Journal of Entomology and Zoology Studies, 7*(6), 316-323. http://www.entomoljournal.com.

Paul, T. T., Manoharan, S., Salim, S. S., Sreenath, K. R., Sarkar, U. K., Landge, A. T., & Das, B. K. (2021). Understanding the trade-offs in tropical reservoir fishery in a socio-ecological perspective. *Indian Journal of Fisheries, 68*(4), 118-127.Indian Council of Agricultural Research. https://doi.org/10.21077/ijf.2021.68.4.107880-13.

Rao, K. S., Kartha, K. N., Shrivastava, S., Pandya, S. S. & Choubey, U. (1988). Studies of the Commercial Fisheries and its fluctuations in Gandhi Sagar Reservoir. Proceedings of the National Symposium Past, Present and Future of Bhopal Lakes: 55-65 (unpublished).

Rathore, L. K., Sharma, B. K., & Dangi, P. L. (2017). Fish biodiversity and fisheries potential of reservoir Udaisagar (Udaipur, Rajasthan). *International Journal of Fisheries and Aquatic Studies, 5*(3), 587-592.

Ridhi, Jha, B. C., Parashar, A., Das, A. K. & Bose, A. K. (2012). Ichthyofaunal diversity of river Chambal in Madhya Pradesh. (In: Pandey, B. N., Sharma, A. P., Pandey, P. N., Katiha, P. K., & Jaiswal, K. (eds), *Biodiversity: Issues, Threats and Conservation*, 47-53. Narendra Publishing House.

Saksena, D. N. (2007). Fish diversity of Northern Madhya Pradesh (Gwalior and Chambal Divisions), pp. 50-57. In: Lakra, W. S. & Sarkar, U. K. (eds.). Fresh Water Fish Diversity of Central India. National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research, xiv+183pp.

Sale, J. B. (1982). 2nd Draft. Management Plan for the National Chambal Sanctuary. First Five Year Period 1982/83 - 1986/87. Central Crocodile Breeding and Management Institute, Hyderabad, iii+82pp.

Sarkar U. K., Pathak, A. K., Pal, A., Khan, G. E., Rebello, S., & Agnihotri, P. (2015). Pattern of distribution, abundance, diversity and threats to fish biodiversity of the Chambal River (Uttar Pradesh). *Indian Journal of Tropical Biodiversity, 23*(1), 11-20.

Sarkar, U. K., Pathak, A. K., Sinha, R. K., Sivakumar, K., Pandian, A. K., Pandey, A., ... & Lakra, W. S. (2012). Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives. *Reviews in Fish Biology and Fisheries, 22*(1), 251-272.

Sharma, D. K., & Uchchariya, R. (2017). A study of ichthyofauna of Pagara dam of Morena District, Madhya Pradesh. *Indian Journal of Scientific Research, 7*(2), 51-57. http://www.indianjournals.com.

Sharma, H. S. (2007). Freshwater fishes. Zoological Survey of India. *Fauna of Madhya Pradesh (including Chhattisgarh), State Fauna Series, 15*(Part-1), 147-244.

Sharma, L. L. & Choudhary, C. S. (2007). Conservation and management of fish diversity in Rajasthan, pp. 110-117. In: Lakra, W.S. & Sarkar, U. K. (eds.). Fresh Water Fish Diversity of Central India. National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research, xiv+183pp.

Singh, D., & Sharma, R. C. (1998). Biodiversity, ecological status and conservation priority of the fish of the River Alaknanda, a parent stream of the River Ganges (India). *Aquatic Conservation: Marine and Freshwater Ecosystems, 8*(6), 761-772. https://doi.org/10.1002/(SICI)1099-0755(1998110)8:6<761::AID AQC311>3.0.CO;2-3.

Singh, H., & Rao, R. J. (2017). Status, threats and conservation challenges to key aquatic fauna (crocodile and dolphin) in National Chambal Sanctuary, India. *Aquatic Ecosystem Health & Management, 20*(1-2), 59-70. https://doi.org/10.1080/14634988.2017.1298964.

Sivakumar, K. (2002). The rare freshwater giant stingray in the National Chambal Sanctuary: Needs more attention for conservation. *WII Newsletter, 8*(4) & 9(1), 5.

Sivakumar, K. & B. C. Choudhury (2008). Chambal River, Rajasthan: Importance of water flow and minimum water level in conservation of all tropic levels in different habitats and biodiversity. *Journal of Landscape Architecture, 19*, 52-57.

Srivastava, N. (2007). Freshwater fish diversity in Rajasthan, pp 142-155. In: Lakra, W.S. & Sarkar, U. K. (eds.). Fresh Water Fish Diversity of Central India. National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research, xiv+183pp.

Summarwar, S., Yadav, K. P., & Tailor, S. P. (2021). Genetic differentiation among Himalayan and local Mahseer populations. *International Journal of Fauna and Biological Studies, 8*(1), 08-10. doi: https://doi.org/10.22271/23940522.2021.v8.i1a.784.

Talwar, P. K., & Jhingran, A. G. (1991). *Inland Fishes of India and Adjacent Countries*, Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi-Calcutta, pp. 346-347.

Trivedi, A., Pathak, R., & Agniwanshi, S. (2021). Status of Exotic fishes from the Yamuna River (Ganga Basin), *Uttar Pradesh, India: A Review. Uttar Pradesh Journal of Zoology, 42*(24), 1123-1126.

Uchchariya, D. K., Saxena, M., & Saksena, D. N. (2012). Fish biodiversity of Tighra reservoir of Gwalior, Madhya Pradesh, India. *Journal of Fisheries & Aquaculture, 3*(1), 37-43. http://www.bioinfo.in/contents.php?id=68.

Vyas, R. & Singh, H. (2004). Biodiversity survey of Gandhi Sagar Reservoir, Madhya Pradesh. *Zoos' Print Journal, 19*(7), 1525-1529.

CHAPTER 5

HERPETOFAUNA OF CHAMBAL RIVER

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Surya Prasad Sharma,
Syed Abdullah Hussain

Contributing Authors
Shantanu,
Asif Mohammad,
Khadija,
Shivani Barthwal

SUMMARY

The Chambal River, a biodiversity hotspot in the Semi-arid region, serves as a critical refuge for several threatened aquatic and semi-aquatic vertebrates. The present study assesses the status of herpetofauna, amphibians and reptiles (crocodile and turtles) along the river. The study recorded 11 amphibian species from four families. Dominated by Dicroglossidae (80.32%), species like the Indian skipper frog and Indian bullfrog were widespread, while others, such as Pierre's wart frog and Indian tree frog, showed highly restricted distributions. Species richness was highest in the upper zones, and diversity peaked at Sarsaini and Rameshwar.

We recorded nine freshwater turtle species, including the Critically Endangered red-crowned roofed turtle (*Batagur kachuga*) and three-striped roofed turtle (*Batagur dhongoka*). The lower zone recorded the highest turtle richness (n=8), followed by the lower middle (n=6) and upper middle (n=4) zones. Elusive species like *Chitra indica* and *Hardella thurjii* were also observed during the survey.

Three post-monsoon surveys between 2019 and 2023 showed increasing gharial populations, rising from 1879 to 2097 individuals, with over 80% sightings in the lower zone. Adult gharials were the dominant class, although hatchlings were consistently low, indicating low recruitment. The mugger population also increased from 617 to 860 individuals, with more even distribution across zones and the highest encounter rates in the upper middle zone.

5.1 Introduction

5.1.1 Amphibians

Amphibians, due to their sensitivity to environmental perturbations, are widely recognized as reliable bioindicators of ecosystem health and environmental degradation. Globally, they contribute to essential ecosystem services by regulating insect populations and serving as prey for higher trophic levels, while also participating in nutrient cycling and energy transfer (Wyman, 1998; Hopkins, 2007; Böhm et al., 2013; Kraus, 2015; Kanaujia & Kumar, 2017). Amphibians, with their dual life modes in aquatic and terrestrial environments (Pankaj, 2020), are essential for maintaining ecological balance. Despite their ecological significance, amphibians remain one of the most threatened vertebrates, with declines linked to habitat fragmentation, climate change, chemical pollution, and disease (Stuart et al., 2004; Bovo et al., 2018). Amphibians face numerous challenges in coexisting with urbanisation and habitat loss (Rubbo & Kiesecker, 2005).

Although the Chambal River has received considerable attention for its Critically Endangered gharial and other large macrofauna such as freshwater turtles and waterbirds, amphibians remain one of the least studied faunal groups in the region. Only a handful of studies have attempted to document amphibian diversity along the river. A study conducted by the Madhya Pradesh Forest Department in 2013 reported the presence of ten amphibian species along the River. A study conducted in the basin by Ishaque & Sarsavan (2014) reported the presence of nine amphibian species in the Gandhi Sagar Wildlife Sanctuary, a forested area through which the Chambal River flows. Sharma & Dube (2020) reported five amphibian species from the Kota region of Rajasthan.

Apart from a few localized efforts, no comprehensive assessment exists for amphibians in the Chambal River. The current state of knowledge is fragmented and inadequate, underscoring a critical gap in biodiversity documentation and conservation planning, the present study was undertaken to document the presence of amphibians along the Chambal River systematically.

5.1.2 Turtles

The Chambal River is as a crucial stronghold for freshwater turtle in India, providing habitat for nine species, several of which are listed as endangered or vulnerable on the IUCN Red List. The freshwater turtles recorded from the NCS are: red crowned roofed turtle (*Batagur kachuga*), three-striped roofed turtle (*Batagur dhongoka*), Indian tent turtle (*Pangshura tentoria*), Indian roof turtle (*Pangshura tecta*), brahminy river turtle (*Hardella thurjii*), Indian narrow-headed softshell turtle (*Chitra indica*), Indian softshell turtle (*Nilssonia gangetica*), peacock softshell turtle (*Nilssonia hurum*) and Indian flapshell turtle (*Lissemys punctata*). The Indian tent turtle is one of the most frequently sighted turtles in the NCS. Most notably, it is regarded as the last known natural breeding ground for the critically endangered red-crowned roofed turtle (*Batagur kachuga*) (Nair & Krishna, 2013). This assemblage reflects the ecological richness of the Chambal River and highlights its role as a vital refuge for India's imperilled freshwater turtle fauna.

The red crowned roofed turtle (*Batagur kachuga*), one of India's most threatened freshwater turtles, now survives almost exclusively in the Chambal River, where it nests along sandbanks within the NCS (Narain et al., 2006; Nair & Krishna, 2013). Pareek et al. (2024) recorded 640 nests between 2017-2019 along a 35 km stretch in NCS, indicating key reproductive habitats. Its nesting ecology has been further described by Singh et al. (2024). While recently rediscovered in the Ganga River (Singh et al., 2025), the Chambal River remains its last stronghold, though threatened by growing anthropogenic stressors (Bhardwaj et al., 2024; Taigor & Rao, 2010). Similarly, the Critically Endangered *Batagur dhongoka* also nests in the Chambal River (Pareek et al., 2024; Nair & Krishna, 2013). Reproductive patterns and range contractions of this species have been detailed by Sale (1982), Sirsi et al. (2017), and Rao (1998). The Endangered *Chitra indica*, a softshell species requiring sandy, deep riverbeds, is also known to occur in the Chambal River (Hanfee, 1999; Das & Singh, 2009), though its population is declining due to illegal trade and fishing gear entanglement (Paul, & Rhodin, 2000; Vyas, 2004; Taigor & Rao, 2010). *Hardella thurjii*, another large riverine turtle, prefers deep pools and is documented by Rao (1998), Nair & Krishna (2013), and Narain et al. (2006). Among the most commonly sighted species are the Vulnerable *Pangshura tecta* (Nair & Krishna, 2013; Narain et al., 2006). *Pangshura tentoria*, although Least Concern, is a dominant species recorded throughout the Chambal River (Bhupathy & Mathur, 2013). The Endangered *Nilssonia gangetica* and *Nilssonia hurum* are both softshell turtles frequently observed in the Chambal (Nair & Krishna, 2013; Narain et al., 2006), with the former studied for reproductive traits (Vasudevan, 1998) and the latter for its omnivorous diet and behavior (Das et al., 2010). Both species face intense pressure from the meat trade and habitat loss (Sale, 1982; Vyas, 2004). The Vulnerable *Lissemys punctata*, a generalist flapshell turtle, is prevalent in the Chambal backwaters (Rao, 1998) and is heavily exploited. Among the testudines, a terrestrial turtle the Indian Star Tortoise (*Geochelone elegans*), has been reported from the sanctuary (Nair & Krishna, 2013), making it the only tortoise species native to Rajasthan (Bhupathy & Mathur, 2013). This species is poached for the pet trade, which is a persistent threat to the species (Choudhury & Bhupathy, 1993).

5.1.3 Crocodiles

Once abundant throughout the major river systems in India, the freshwater crocodile population underwent a drastic decline in the last century. By the early 1970s, the population became restricted to a few isolated locations in the Ganga, Mahanadi, and Brahmaputra river systems (Singh, 1978). The decline in the crocodile populations throughout their range prompted the Government of India to list all three crocodile species occurring in India in

Schedule I of the Indian Wildlife (Protection) Act, 1972, with the aim to provide enhanced protection. Subsequently, reintroduction and restocking under the grow and release program were initiated in the mid-1970s to restore its population in the wild (Bustard, 1978). The Chambal River within the National Chambal Sanctuary has been a stronghold of the gharial population even before the inception of the translocation program (Singh, 1978; Singh, 1985). In the first systematic survey conducted in 1979, about 107 gharial individuals and 19 mugger individuals across all size classes were recorded from the Chambal River (Hussain, 1999; Singh, 1978; Singh, 1985; Hussain, 1999). Conservation efforts, including grow and release, protection of suitable habitat as protected areas, aided in reversing the decline in the gharial and mugger population in the Chambal River. Since then, the River has remained a critical stronghold for the gharial in its entire range.

5.1.3.1 Gharial (*Gavialis gangeticus*)

The gharial (*Gavialis gangeticus* Gmelin, 1789) is a Critically Endangered freshwater crocodilian species endemic to the northern part of the Indian subcontinent (Hussain, 1999; Lang et al., 2019). The gharial has the narrowest distribution range and is the most threatened species among all other crocodilians occurring in the Indian subcontinent. Until the early 20th century, the gharial was widely distributed in the Indus, Ganges, Mahanadi, Brahmaputra, Kaladan and Irrawaddy River systems spanning across Pakistan, India, Nepal, Bangladesh, Bhutan, and Myanmar (Singh 1978; Hussain 1999). Over the years, the gharial has suffered a population decline of over 80% and substantial range contraction due to habitat loss, poaching, and mortalities in passive fishing (Bustard 1975, Hussain, 1999; 2009). A survey conducted in 2019 documented an increase in gharial population, with 1879 individuals of all size classes recorded in the Chambal River (WII-GACMC, 2022).

The Chambal River holds the largest breeding gharial population, accounting for over 80% of individuals. The first census, conducted in 1979, reported 107 gharials of all size classes and sexes in the Chambal River (Hussain, 1999; Singh, 1985). Subsequent conservation interventions, including habitat protection and restocking efforts, led to a rapid recovery of the population. By the 2019 survey, a total of 1857 gharials across all size classes and sexes were recorded in the Chambal River within the National Chambal Sanctuary (WII, 2021) (Table 5.8).

5.1.3.2 Mugger (*Crocodylus palustris*)

The mugger (*Crocodylus palustris* Lesson, 1831) is a medium-sized freshwater crocodile, a member of the family Crocodylidae. It is principally restricted to the Indian subcontinent, extending up to eastern Iran. The mugger occurs in inland freshwater habitat types, including lakes, marshes and rivers, or any other slow moving and shallow rivers (Jacobson, 1999). The muggers are adapted well to natural as well as man-made habitats. The species occurs in sympatric relation with gharial in the north Indian rivers such as the Chambal, Girwa and Ramganga, and the Mahanadi in eastern India (Choudhary et al., 2017).

5.2 Methods

5.2.1 Amphibians

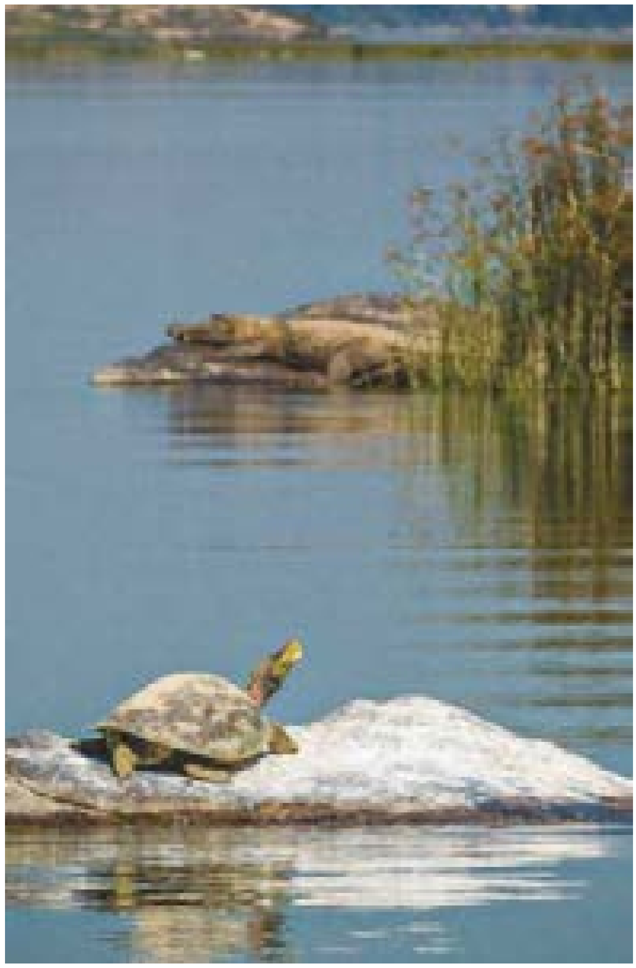
The study was conducted at 10 sites along the Chambal River during the monsoon season (September) (Table 5.1). Observers walked 1-2 km along a 5 m wide bank transect and applied time-constrained visual encounter surveys (VES) following Crump (1994), conducted at dusk between 1900h and 2100h. Sampling effort was standardized by maintaining a constant number of observers across sites. Surveys covered all potential habitats within 2 km of the River, including River mouths, wetlands, pools, crop fields, and temporary water bodies.

Surveys were conducted using powerful flashlights and headlamps, and weather data was recorded using a Kestrel 5200 Professional Environmental Meter. Recorded data included the number of individuals, species encountered, and microhabitat parameters such as ambient temperature, humidity, substrate type (muddy, rocky, dry leaves), and ground cover, which was determined using the point intercept method. Representative photographs of each species were taken in their natural habitat. Collected specimens were fixed in formalin and preserved in 70% ethanol, while tissue samples from unidentified individuals were preserved in molecular-grade ethanol.

Species identification was based on field guides by Smith (1935, 1943), Das (1996), Dutta (1997), Chanda (2002), Schleich and Kästle (2002), and Das & Das (2017). Nomenclature and taxonomic arrangement followed Frost (2018) and Dinesh et al. (2023), and the IUCN Red List was used to determine the threat status of recorded species. Species richness and diversity were estimated for each survey site.

Table 5.1: List of sites surveyed for assessment of amphibian diversity along the Chambal River

Zone	Site name	GPS coordinates
Upper middle	Pali	25.8741N 76.54693E
	Rameshwar	25.88194N 76.72447E
Lower middle	Rijhenta	26.09235N 76.92408E
	Ater	26.7644N 78.64666E
	Batesura	26.35553N 77.42408E
	Sarsaini	26.49541N 77.72470E
Lower	Rajghat	26.6483N 77.90842E
	Pinahat	26.86245N 78.36547E
	Barhi	26.70153N 78.94045E
	Pachnada	26.48263N 79.25852E



5.2.2 Crocodiles and Turtles

Boat-based visual encounter surveys were conducted to document the occurrence and number of gharials along the river banks. The survey was conducted during daylight between 1000 and 1600 h. A motorboat fitted with a 25HP outboard engine was used to survey the river, and the speed of the boat was maintained between 8 and 10 km/hr. Two observers equipped with 8 × 40 mm binoculars were positioned to spot the basking gharial. The gharial was identified based on their morphology using established description keys following the identification guide. When spotted, the number of gharial individuals, visually estimated size and associated habitat variables were recorded for each sighting. The observed individuals were categorized into the following size classes: Hatchlings (< 0.6 m), Yearlings (0.6-0.9 cm), Juveniles (0.9-1.8 cm), Sub-adults (1.8-3.0 m), and Adults (> 3.0 cm) (Hussain, 1999).

The total number of gharials observed during the surveys was referred to as Minimum Population Size (MPS). MPS is the minimum number of individuals to be present within the surveyed area. The MPS provides a conservative baseline estimate of population size (Barao-Nobrega et al., 2022). We used the MPS to estimate of gharial encounter rate, i.e., individuals sighted per km of the river stretch. For each river surveyed, we also calculated the encounter rate, referred to as the relative density index, which is defined as the number of gharials observed per kilometre of river surveyed (Bayliss, 1987). This index serves as a useful comparative metric for evaluating population density across spatial units and temporal periods and helps inform conservation prioritization and management interventions. Additionally, presence-absence data of freshwater species were recorded during the ecological assessment.

5.3 Results

5.3.1 Amphibians

5.3.1.1 Richness and diversity

A total of 11 species from four families - Bufonidae, Dicroglossidae, Microhylidae, and Rhacophoridae- were documented from the Chambal River (Table 5.2). The Indian skipper frog (*Euphlyctis cyanophlyctis*), the Indian bullfrog (*Hoplobatrachus tigerinus*), the Indian cricket frog (*Fejervarya limnocharis*), and the Nilphamarai narrow-mouthed frog (*Microhyla nilphamariensis*) were the most commonly observed species across all 10 survey sites within the Chambal River. Four species had restricted distributions, viz., Pierre's wart frog (*Minervarya pierrei*) was recorded only at Ater, while the Terai wart frog (*Minervarya teraiensis*), the common cricket frog (*Minervarya agricola*), and the Indian tree frog (*Polypedates maculatus*) were documented at only Rameshwar (Table 5.2).

Highest richness was recorded in the upper zone (n=10), followed by lower middle (n=8) and lower zone (n=6).

Among the sampling sites, the highest richness was recorded in Rameshwar (n=10), while Pali exhibited the lowest species richness (n=4) and diversity (H'=0.84), indicating a smaller demography of amphibian species in the area (Figure 5.1). In contrast, Sarsaini had the highest species diversity (H'=1.84), followed by Rameshwar (H'=1.80), which also demonstrated significant diversity (Figure 5.1).

Table 5.2: Amphibian species encountered during the survey.

Common Name	Scientific Name	Upper Middle		Lower Middle				Lower			
		Rameshwar	Pali	Rijetha	Ater	Batesura	Sarsaini	Rajghat	Pinnahat	Barhi	Pachnada
Asian Common Toad	*Duttaphrynus melanostictus*	+	-	+	+	+	+	+	+	-	-
Marbled Toad	*Duttaphrynus stomaticus*	+	-	+	-	+	-	-	-	-	-
Indian Skipper Frog	*Euphlyctis cyanophlyctis*	+	+	+	+	+	+	+	+	+	+
Indian Cricket Frog	*Fejervarya limnocharis*	+	+	+	+	+	+	+	-	+	+
Indian Bullfrog	*Hoplobatrachus tigerinus*	+	+	+	+	+	+	+	+	+	+
Common Cricket Frog	*Minervarya agricola*	+	-	+	+	+	+	+	+	+	-
Pierre's wart Frog	*Minervarya pierrei*	-	-	-	+	-	-	-	-	-	-
Terai Wart Frog	*Minervarya teraiensis*	+	-	-	-	-	-	-	-	-	-
Indian Burrowing Frog	*Sphaerotheca breviceps*	+	-	-	-	-	-	-	-	-	+
Nilphamarai Narrow-Mouthed Frog	*Microhyla nilphmariensis*			+	+	+	+	+	+	+	+
Indian Tree Frog	*Polypedates maculatus*			-	-	-	-	-	-	-	-

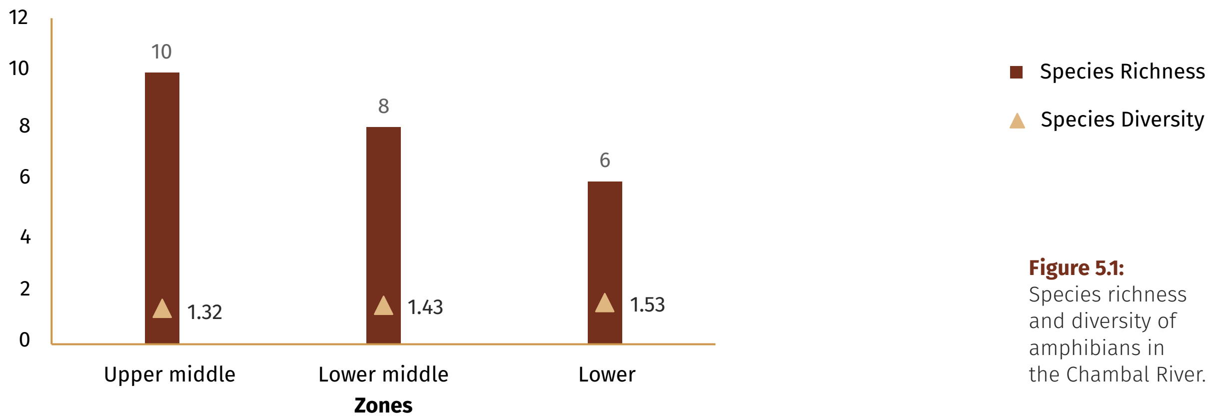


Figure 5.1: Species richness and diversity of amphibians in the Chambal River.

5.3.1.2 Relative abundance

We recorded a dominance of the Dicroglossidae family, which accounted for 80.32% of the total amphibian species, followed by Rhacophoridae with 13.76% and Bufonidae with 5.92% of the total recorded species. *Euphlyctis cyanophlyctis* from the Dicroglossidae family was the most abundant species (49.5%). While *Minervarya pierrei, Minervarya agricola,* and *Minervarya teraiensis* from Dicroglossidae and *Polypedates maculatus* from Rhacophoridae were the least abundant, with just 0.051% of the total species encountered throughout the Chambal River system (Figure 5.2).

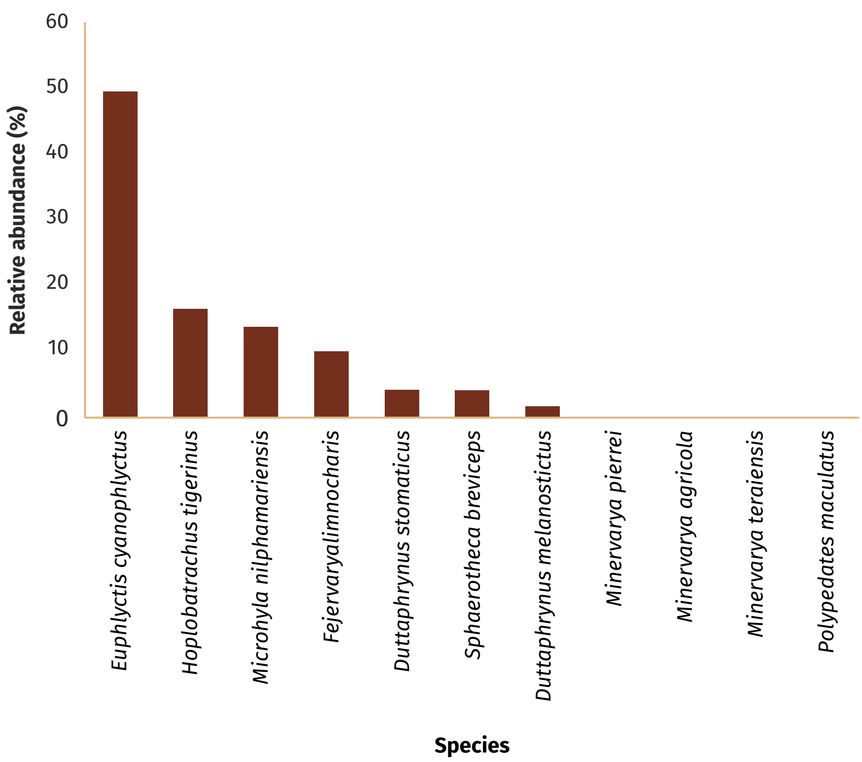


Figure 5.2: Relative abundance of amphibian species in the Chambal River.

5.3.2 Reptiles

Turtles

Richness

During the survey, a total of nine turtle species were recorded from the Chambal River (Table 5.3). Highest richness was observed in the lower zone (n=8) of the River, followed by the lower middle zone (n=6), and the lowest richness was recorded in the upper middle zone (n=4). In the Upper Middle Zone of the Chambal River, only four species, viz. *Pangshura tecta, Pangshura tentoria, Lissemys punctata*, and *Nilssonia gangetica* were recorded. In the Lower Middle Zone, in addition to the four species recorded in the Upper Middle Zone, two key Batagur species, *Batagur dhongoka* and *Batagur kachuga*, were also recorded. The Lower Zone emerged as the most species-rich segment of the River. All recorded species except *Nilssonia hurum* were found in this zone, including rare and conservation-priority species such as *Hardella thurjii* and *Chitra indica* (Table 5.3 & Figure 5.3).

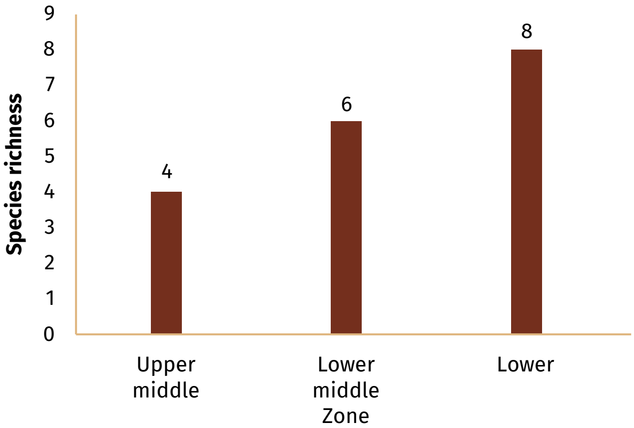


Figure 5.3: Zone-wise species richness of turtles in the Chambal River

Table 5.3: Turtle species encountered during the survey in the Chambal River

Species	Upper middle	Lower middle	Lower
Batagur dhongoka	-	+	+
Batagur kachuga	-	+	+
Hardella thurjii	-	-	+
Pangshura tecta	+	+	+
Pangshura tentoria	+	+	+
Lissemys punctata	+	+	+
Chitra indica	-	-	+
Nilssonia gangetica	+	+	+
Nilssonia hurum	-	-	-

Gharial

Distribution, population count and encounter rate

In the present study, three post-monsoon surveys were conducted in PoM 2019 (2020), PoM 2021 (2022), and PoM 2022 (2023) to assess the population status of gharials in the Chambal River. During the first post-monsoon survey in 2019, a total of 1879 individuals of all size classes were recorded, with an overall encounter rate of 4.62 (±0.50 SE) individuals/km. In subsequent surveys, 2014 individuals were recorded in PoM 2021 with an encounter rate of 4.96 (±0.51), and 2097 individuals were recorded in PoM 2022 with an encounter rate of 5.18 (±0.51) (Table 5.4).

Gharials were distributed throughout the surveyed stretch of the Chambal River, with the highest counts consistently recorded in the Lower Zone across all survey years. In PoM 2019, 1568 individuals, comprising 83.45% of the total gharial sighted were recorded in the lower zone, with an encounter rate of 6.49 (±0.66) individuals/km. Similarly, 1651 individuals (81.98%) in PoM 2021 and 1744 individuals (83.17%) in PoM 2022 were documented from the lower zone. In contrast, the Upper Middle Zone contributed the least with no more than 4% of the total sightings across the survey years (PoM 2019: 3.3%; PoM 2021: 2.23%; PoM 2022: 2.62%), while the lower middle zone, spanning between the Banas Confluence and Basaidang, accounted for 249 (13.25%), 318 (15.79%), and 298 (14.21%) individuals in PoM 2019, PoM 2021, and PoM 2022, respectively.

The size class composition remained relatively consistent across the three years. Adults represented the highest proportion in each survey (PoM 2019: 54.71%; PoM 2021: 41.96%; PoM 2022: 49.02%), followed by sub-adults (PoM 2019: 24.22%; PoM 2021: 22.89%; PoM 2022: 21.7%) and juveniles. Hatchlings constituted the lowest proportion in all three surveys (Table 5.4 & Figure 5.4).

Table 5.4: Population count and encounter rate of gharial in three zones of the Chambal River during post-monsoon surveys in 2020, 2022, and 2023.

Zones	PoM 2019 (2020)		PoM 2021 (2022)		PoM 2022 (2023)	
	Count	ER (±SEM)	Count	ER (±SEM)	Count	ER (±SEM)
Upper Middle zone	62	2.48 (±1.38)	45	1.80 (±1.37)	55	2.20 (±1.23)
Lower Middle zone	249	1.72 (±0.47)	318	2.19 (± 0.71)	298	2.06 (±0.68)
Lower zone	1568	6.67 (±0.65)	1651	7.03 (±0.61)	1744	7.42 (± 0.57)
Total	1879	4.64 (±0.50)	2014	4.97 (±0.51)	2097	5.18 (±0.51)

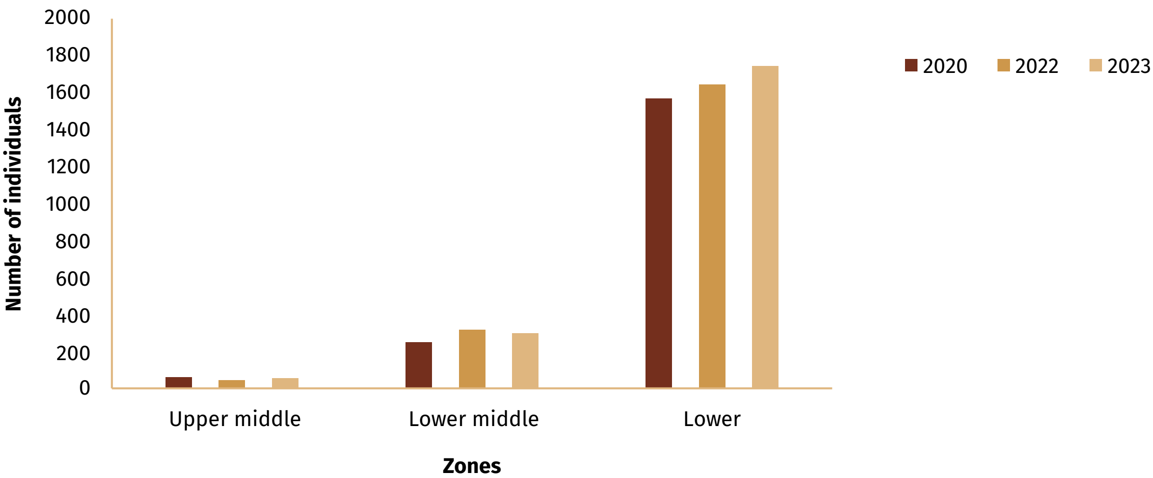


Figure 5.4: Plot showing gharial count in the three zones of the Chambal River.

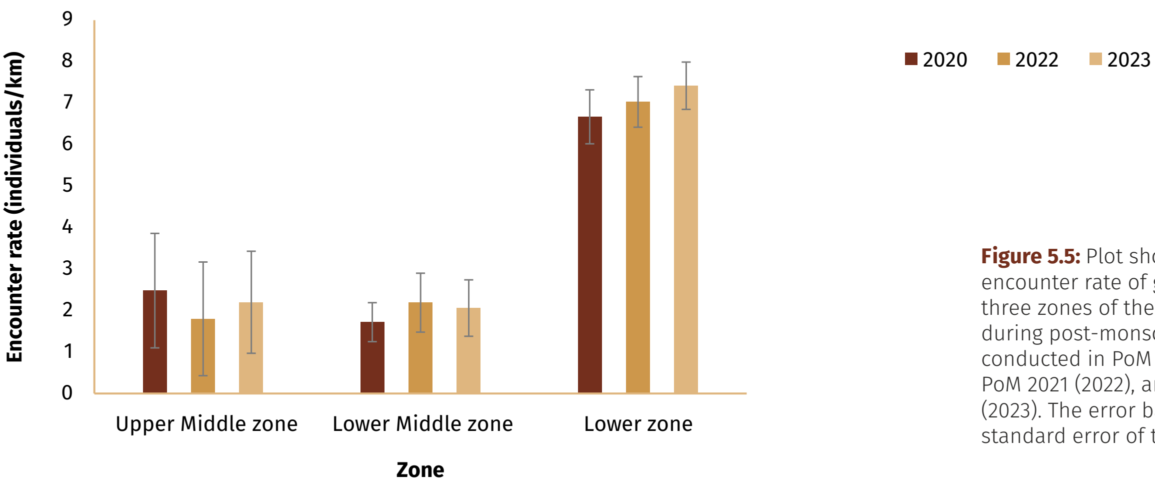


Figure 5.5: Plot showing encounter rate of gharial across three zones of the Chambal River during post-monsoon surveys conducted in PoM 2019 (2020), PoM 2021 (2022), and PoM 2022 (2023). The error bar indicates standard error of the mean.

Figure 5.6: Locations of Gharial occurrence along the Chambal River.

Table 5.5: Size class composition of gharial in the Chambal River.

Size Class	Number of Individuals		
	PoM 2019 (2020)	PoM 2021 (2022)	PoM 2022 (2023)
Hatchling	6	25	26
Yearling	74	247	102
Juvenile	240	324	328
Sub-adult	415	461	268
Adult	1144	957	1373
Total	1879	2014	2097

Most sightings were in the stretches of the River less than 5 m depth, followed by 6 to 10 m, during three survey periods (Table 5.6). Sightings further declined with increasing depth, with depth class between 6-10 m accounting for 21-30% of all sightings across the years. Surprisingly, only a few individuals were recorded beyond 15 m depth class. The consistent trend across years indicates that gharial preferentially utilize river stretches with 5 m depth, likely due to greater availability of basking sites, ease of prey capture, and suitability for thermoregulation. Deeper stretches (> 20 m) were rarely used, suggesting limited importance of these habitats for the species.

Table 5.6: Gharial sightings across different depth class during the survey in the Chambal River

Depth (m)	PoM 2019 (2020)		PoM 2021 (2022)		PoM 2022 (2023)	
	Sightings	%	Sightings	%	Sightings	%
<5	230	64.79	208	69.33	222	73.75
6-10	106	29.86	75	25.00	63	20.93
11-15	12	3.38	9	3.00	11	3.65
16-20	3	0.85	3	1.00	3	1.00
21-25	1	0.28	3	1.00	2	0.66
26-30	1	0.28	2	0.67	0	0.00
>30	2	0.56	0	0.00	0	0.00
	355	100.0	300	100.0	301	100.0

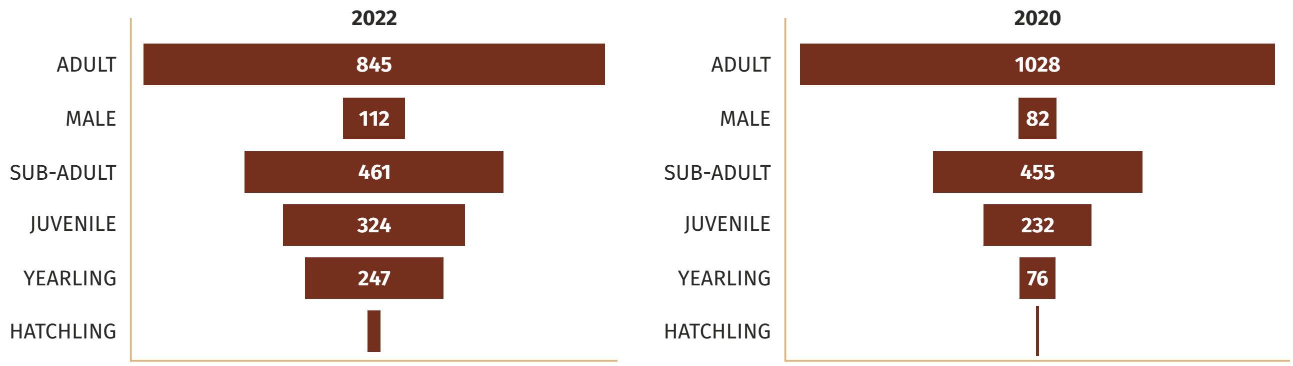


Figure 5.7: Size class composition of gharial in the Chambal River.

Mugger

Mugger though present in lower numbers compared to gharials, also showed a gradual increase in population over the years, from 617 individuals in 2020 to 860 in 2023. The overall encounter rate also showed an increasing trend from 1.52 to 2.12 individuals/km during the survey period. During the first post-monsoon survey in 2019, a total of 617 individuals of all size classes were recorded, with an overall encounter rate of 1.52 (±0.16 SE) individuals/km. In subsequent surveys, individuals were recorded in PoM 2021 with an encounter rate of 2.08 (±0.17), and 860 individuals were recorded in PoM 2022 with an encounter rate of 2.12 (±0.18) (Table 5.7). Unlike gharials, muggers were more evenly distributed across all zones, with the highest overall encounter rate in the Upper middle zone, followed by the Lower Zone and Lower Middle Zones. The size-class distribution of muggers was heavily skewed toward adults (89% in all years), with a smaller proportion of sub-adults and juveniles (Table 5.8). Notably, hatchlings and yearlings were either absent or present in very low numbers during the surveys, indicating limited detectability (Figure 5.9). Across all survey years, the majority of mugger sightings in the Chambal River were recorded in depth class lower than 5 m, accounting for over 55% of total observations (Table 5.9). Sightings further declined with increasing

depth, with depth class between 5-10 m accounting for 20-31% of all sightings across the years. Surprisingly, only a few individuals were recorded beyond 15 m depth class. The consistent trend across years indicates that muggers preferentially utilize shallow river stretches, likely due to greater availability of basking sites, ease of prey capture, and suitability for thermoregulation. Deeper stretches (20 m) were rarely used, suggesting limited importance of these habitats for the species.

Table 5.7: Year-wise Population & Encounter Rates of Mugger in the Chambal River (2019–2023)

Zones	PoM 2019 (2020)		PoM 2021 (2022)		PoM 2022 (2023)	
	Count	ER (±SE)	Count	ER (±SE)	Count	ER (±SE)
Upper Middle zone	50	2.00 (±0.71)	83	3.32 (±0.93)	89	3.56 (±1.79)
Lower Middle zone	173	1.19 (±0.31)	195	1.34 (±0.22)	240	1.66 (±0.24)
Lower zone	394	1.68 (±0.18)	564	2.40 (±0.61)	531	2.26 (±0.20)
Total	617	1.52 (±0.16)	842	2.08 (±0.17)	860	2.12 (±0.18)

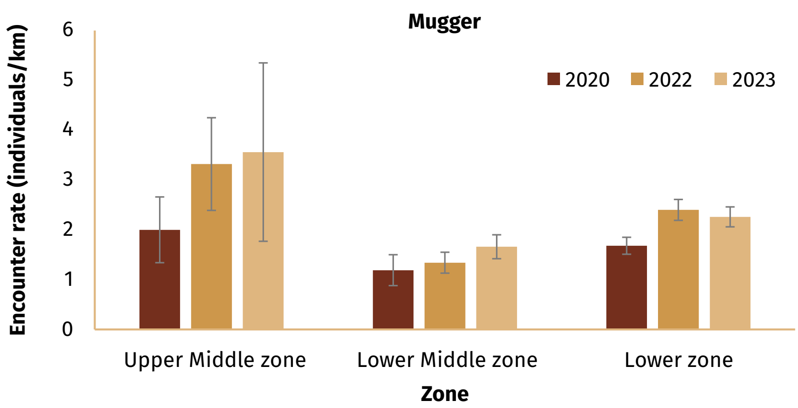


Figure 5.8: Plot showing encounter rate of gharial across three zones of the Chambal River during post-monsoon surveys conducted in 2020, 2022, and 2023. The error bar indicates standard error of the mean.

Table 5.8: Size class composition of Mugger in the Chambal River

Size Class	Number of Individuals		
	PoM 2019 (2020)	PoM 2021 (2022)	PoM 2022 (2023)
Hatchling	0	0	2
Yearling	0	2	4
Juvenile	6	34	30
Sub-adult	52	39	58
Adult	559	767	766
Total	617	842	860

Table 5.9: Mugger sightings across different depth class during the survey in the Chambal River

Depth (m)	PoM 2019 (2020)		PoM 2021 (2022)		PoM 2022 (2023)	
	Sightings	%	Sightings	%	Sightings	%
<5	152	60.56	230	64.97	206	58.19
6-10	79	31.47	103	29.1	79	22.32
11-15	15	5.98	14	3.95	19	5.37
16-20	3	1.2	3	0.85	3	0.85
21-25	0	0	3	0.85	1	0.28
26-30	0	0	1	0.28	0	0
>30	2	0.8	0	0	0	0
	251	100.0	354	100.0	308	100.0

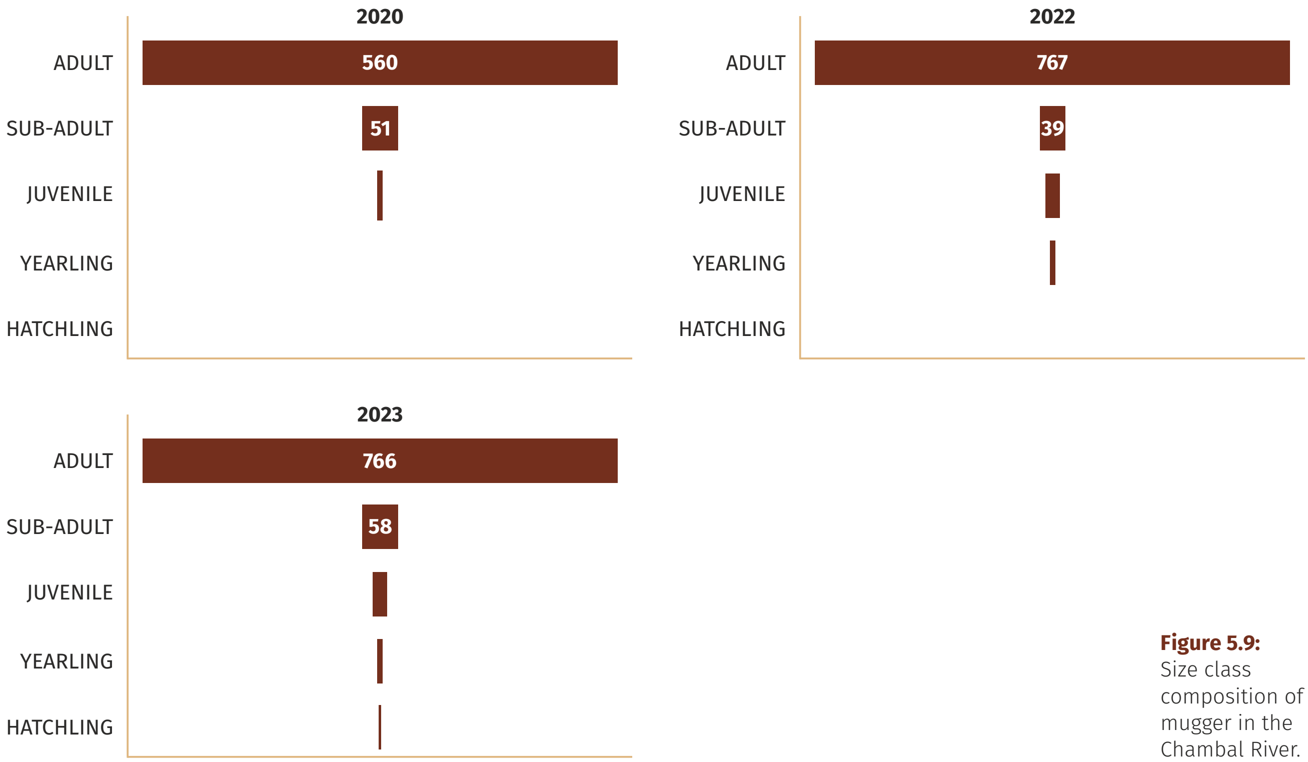
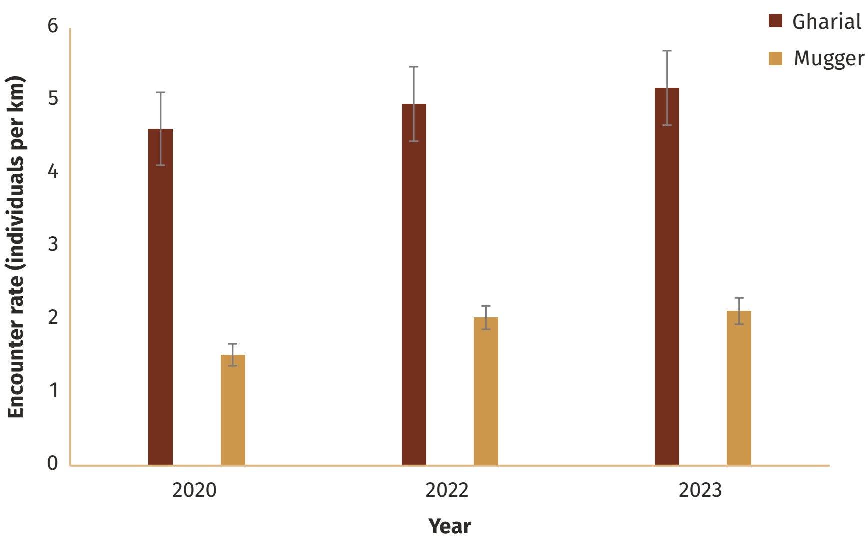


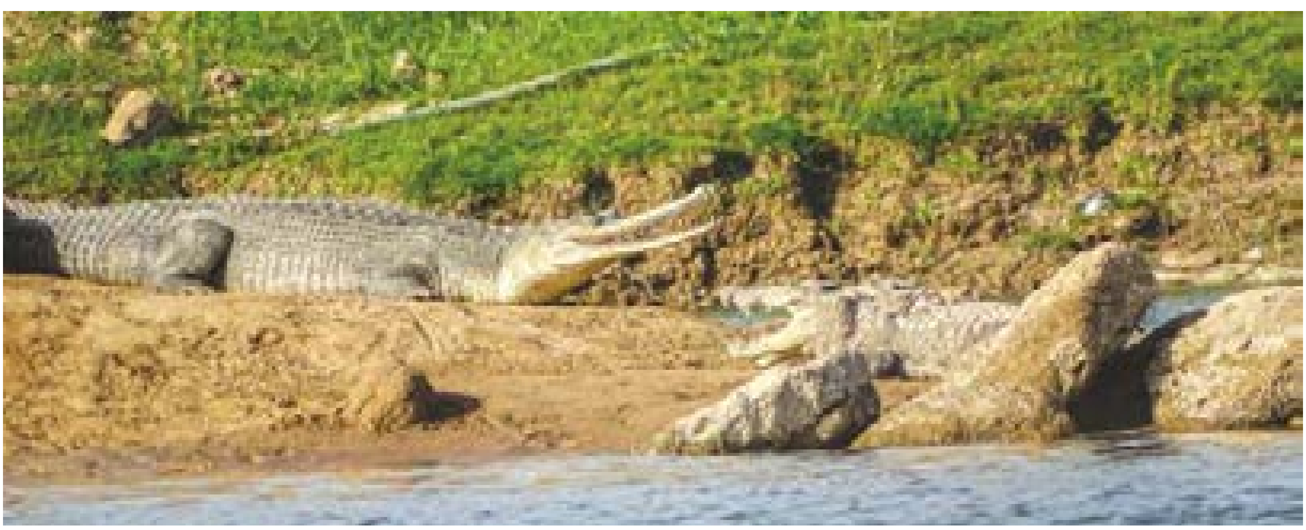
Figure 5.9: Size class composition of mugger in the Chambal River.



Encounter rate

During the survey period we observed a steady increase in the gharial and mugger encounter rate in the Chambal River (Figure 5.10).

Figure 5.10: Plot showing gharial and mugger encounter rate between PoM 2019 (2020), PoM 2021 (2022) and PoM 2022 (2023) in the Chambal River.



5.4 Discussion

This study provides the baseline of the amphibian richness and diversity along the different zones of the Chambal River. We recorded 11 amphibian species across four families: Bufonidae, Dicroglossidae, Microhylidae, and Rhacophoridae during the survey. Among the recorded species, the Indian skipper frog, Indian bullfrog, the Indian cricket frog, and Nilphamarai narrow-mouthed frog were recorded from all sampling sites. The widespread distribution of these species indicates their adaptability to diverse habitats. In contrast, species such as Pierre's wart frog, Terai wart frog, common cricket frog, and Indian tree frog were found at only a single location each, highlighting their restricted distributions and possible habitat specializations.

Dicroglossidae showed the widest distribution among all the families, indicating their localized adaptation and strong adaptability to the local environment, including habitats influenced by human disturbance and urbanization. Within this family, the Indian skipper frog (*Euphlyctis cyanophlyctis*) was the most abundant species, accounting for 49.5% of all individuals observed. This dominance likely reflects its generalist behavior and capacity to thrive under a range of environmental conditions. On the other hand, species such as Pierre's wart frog (*Minervarya pierrei*), common cricket frog (*Minervarya agricola*), Terai wart frog (*Minervarya teraiensis*), and the Indian tree frog (*Polypedates maculatus*) were among the least frequently recorded, comprising only 0.036% of the total observations. Their rarity may be attributed to specific habitat requirements, lower detectability, or pressures from anthropogenic activities. The spatial patterns of species richness and diversity revealed notable differences between sites and river systems.

Sites along the Chambal River, such as Pinahat and Pali, showed the lowest richness, possibly due to environmental or anthropogenic pressures. Similarly, species diversity varied significantly across sites, with Sarsaini and Ramshewar sites on the Chambal River having the highest diversity as well as the highest species richness, indicating a well-balanced and diverse amphibian population. However, the Rijentha and Pali displayed the lowest diversity, suggesting limited species distribution and potentially degraded habitat conditions. Protecting amphibians in their natural habitats is vital not only for conserving individual species but also for maintaining the health and resilience of the ecosystem (Saber et al., 2017). Amphibians act as bioindicators, reflecting changes in environmental conditions, and their presence or absence can signal shifts in ecosystem stability (Calderon et al., 2019). Conservation efforts to safeguard critical amphibian habitats, mitigate anthropogenic threats, and promote habitat restoration are necessary for the long-term stability of amphibian populations and their habitats.

The Chambal River also supports one of the richest assemblages of freshwater turtles with nine species recorded during the survey, the Critically Endangered red-crowned roofed turtle (*Batagur kachuga*) and three-striped roofed turtle (*Batagur dhongoka*). Species richness was highest in the lower zone, highlighting its ecological importance as a biodiversity hotspot. Notably, the river serves as the last known natural stronghold for the red-crowned roofed turtle, with key nesting sites

documented within the National Chambal Sanctuary (Narain et al., 2006; Nair & Krishna, 2013). Other threatened species such as *Batagur dhongoka, Chitra indica*, and *Hardella thurjii* also utilize the Chambal for nesting and foraging, underscoring the river's role as a vital refuge. However, this fragile turtle assemblage faces mounting threats from anthropogenic pressures such as habitat alteration, illegal poaching for trade, entanglement in fishing gear, and the degradation of key microhabitats including sandbanks and mid-river inlands. Ensuring the continued survival of freshwater turtle populations in the Chambal River is not only vital for species-specific conservation but also for maintaining the broader ecological functioning and biodiversity of this unique riverine ecosystem. Considering the global conservation significance of the freshwater turtle species inhabiting the Chambal River, integrated management approaches like community engagement and strict enforcement of wildlife protection laws are critical for the sustained survival of these taxa.

In contrast, the Upper Middle Zone exhibited less than 4% of total sightings, reflecting either suboptimal habitat conditions or increased anthropogenic pressures. The size-class structure of the gharial population showed a healthy representation of adults (2020: 54.71%; 2022: 41.96%; 2023: 49.02%), with stable proportions of sub-adults and juveniles. However, the consistently low proportion of hatchlings may be a concern, potentially indicating issues with nest survival or hatchling recruitment. This trend calls for further investigation into reproductive success and juvenile survival in the wild.

Mugger, though present in lower numbers compared to gharials, also showed a gradual increase in population over the years, from 617 individuals in 2020 to 860 in 2023. The overall encounter rate also showed an increasing trend from 1.52 to 2.12 individuals/km during the survey period. Unlike gharials, muggers were more evenly distributed across all zones, with the Lower Zone consistently supporting the highest number of individuals, followed by the Lower Middle and Upper Middle Zones. Unlike the population count encounter rate for mugger was highest in the Upper middle zone.

The size-class distribution of muggers was heavily skewed toward adults (>89% in all years), with a smaller proportion of sub-adults and juveniles. Notably, hatchlings and yearlings were either absent or present in very low numbers during the surveys, indicating limited detectability or low recruitment success. The first appearance of hatchlings and yearlings in 2023 is encouraging, suggesting recent breeding activity and potential improvement in nesting success.

Overall, the Chambal River remains a critical refuge for both species. However, targeted interventions are required to enhance recruitment success, particularly in nesting areas. These include habitat protection, community-based nest monitoring, regulation of disruptive activities, and maintenance of adequate ecological flow regimes. Continued long-term monitoring, integrating demographic and reproductive assessments, will be essential to evaluate conservation outcomes and develop adaptive strategies for long-term conservation of these reptiles.

REFERENCES

Barão-Nóbrega, J. A. L., González-Jaurégui, M., & Jehle, R. (2022). N-mixture models provide informative crocodile (*Crocodylus moreletii*) abundance estimates in dynamic environments. *PeerJ, 10*, e12906.

Bayliss, P. (1987). Survey methods and monitoring within crocodile management programmes. *Wildlife management: crocodiles and alligators*, 157-175.

Bhardwaj, Y., Hamid, A., & Irshad, Q. (2024). Integration of urban water management in the town proposed under industrial corridor development, India. In *Water resource management in climate change scenario: Innovations in geospatial techniques and models* (pp. 185-196). Cham: Springer Nature Switzerland.

Bhupathy, S., & Mathur, R. (2013). Chelonian status and conservation in Rajasthan. In *Faunal heritage of Rajasthan, India: General background and ecology of vertebrates* (pp. 277-286). Springer, New York, NY.

Böhm, M., Collen, B., Baillie, J. E., Bowles, P., Chanson, J., Cox, N., Hammerson, G., Hoffmann, M., Livingstone, S. R., Ram, M., & Rhodin, A. G. (2013). The conservation status of the world's reptiles. *Biological Conservation, 157*, 372-385.

Bovo, A. A., Ferraz, K. M., Magioli, M., Alexandrino, E. R., Hasui, É., Ribeiro, M. C., & Tobias, J. A. (2018). Habitat fragmentation narrows the distribution of avian functional traits associated with seed dispersal in tropical forest. *Perspectives in Ecology and Conservation, 16*(2), 90-96.

Bustard, H.R. (1975). A future for the gharial. *Cheetal, 17* (2), 3-8.

Bustard, H. R., & Singh, L. A. K. (1978). Studies on the Indian gharial *Gavialis gangeticus* (Gmelin) (Reptilia, Crocodilia): Change in terrestrial locomotory pattern with age. *Journal of the Bombay Natural History Society, 74*, 534-536.

Calderon, M. R., Almeida, C. A., González, P., & Jofré, M. B. (2019). Influence of water quality and habitat conditions on amphibian community metrics in rivers affected by urban activity. *Urban Ecosystems, 22*(4), 743-755.

Chanda, S. K. (2002). *Handbook: Indian amphibians* (p. 335). Zoological Survey of India, Kolkata.

Choudhury, B. C., & Bhupathy, S. (1993). Turtle trade in India: A study of tortoises and freshwater turtles.

Choudhary, S., Choudhury, B. C., & Gopi, G. V. (2017). Differential response to disturbance factors for the population of sympatric crocodilians (*Gavialis gangeticus* and *Crocodylus palustris*) in Katarniaghat Wildlife Sanctuary, India. *Aquatic Conservation: Marine and Freshwater Ecosystems, 27*, 946-952.

Crump, M. L. (1994). Visual encounter surveys. In W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, & M. S. Foster (Eds.), *Measuring and monitoring biological diversity: Standard methods for amphibians* (pp. 84-92). Smithsonian Institution Press.

Das, I. (1996). Resource use and foraging tactics in a south Indian amphibian community. *Journal of South Asian Natural History, 2*(1), 1-30.

Das, I., Basu, D., & Singh, S. (2010). *Nilssonia hurum* (Gray 1830) - Indian peacock softshell turtle. In A. G. J. Rhodin, P. C. H. Pritchard, P. P. van Dijk, R. A. Saumure, K. A. Buhlmann, J. B. Iverson, & R. A. Mittermeier (Eds.), *Conservation biology of freshwater turtles and tortoises: A compilation project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group* (Chelonian Research Monographs No. 5, 6 pp.).

Das, I., & Das, A. (2017). *A naturalist's guide to the reptiles of India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka*. John Beaufoy Publishing, England.

Das, I., & Singh, S. (2009). *Chitra indica* (Gray 1830)-narrow-headed softshell turtle. Conservation biology of freshwater turtles and tortoises: a compilation project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs, 5, 027-1.

Dinesh, K. P., Radhakrishnan, C., Deepak, P., & Kulkarni, N. U. (2023). *A checklist of Indian amphibians with common names for the country and their IUCN conservation status* (Version 5.0, updated till January 2023, pp. 1-19). Zoological Survey of India. Retrieved from http://zsi.gov.in

Dutta, S. K. (1997). *Amphibians of India and Sri Lanka: Checklist and bibliography*. Odyssey Publishing House, Bhubaneswar.

Frost, D. R. (2018). *Amphibian species of the world: An online reference* (Version 6, July 11, 2018). American Museum of Natural History.

Hanfee, F. (1999). *A WWF-India field guide to freshwater turtles and tortoises of India*. TRAFFIC-India/WWF-India.

Hopkins, W. A. (2007). Amphibians as models for studying environmental change. *ILAR Journal, 48*(3), 270-277.

Hussain, S. A. (1999). Reproductive success, hatchling survival and rate of increase of gharial *Gavialis gangeticus* in National Chambal Sanctuary, India. *Biological Conservation, 87*(2), 261-268.

Hussain, S. A. (2009). Basking site and water depth selection by gharial *Gavialis gangeticus* Gmelin, 1789 (Crocodylia, Reptilia) in National Chambal Sanctuary, India and its implication for river conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems, 19*(2), 127-133.

Hussain, S. A., & Singh, R. K. (1999). *Report of ecological survey of the National Chambal Sanctuary to assess the need for desiltation*. Wildlife Institute of India, Dehradun, India.

Ishaque, S., & Sarsavan, A. (2014). Herpetofaunal Diversity of Gandhisagar Wildlife Sanctuary, Madhya Pradesh. *International Journal of Scientific Research in Biological Sciences*.

Jacobson, C. (1999). Reintroduction of the Mugger Crocodile, *Crocodylus palustris*, in India.

Kanaujia, A., Kumar, A., & Kumar, A. (2017). Herpetofauna of Uttar Pradesh, India. In *Biological Forum-An International Journal* (Vol. 9, No. 1, pp. 118-130).

Kraus, F. (2015). Impacts from invasive reptiles and amphibians. *Annual Review of Ecology, Evolution, and Systematics, 46*(1), 75-97.

Lang, J. W., Chowfin, S., & Ross, J. P. (2019). *Gavialis gangeticus*. In The IUCN Red List of Threatened Species 2019 (errata version published in 2019).

Nair, T., & Krishna, Y. C. (2013). Vertebrate fauna of the Chambal River basin, with emphasis on the National Chambal Sanctuary, India. Journal of Threatened Taxa, 5(2), 3620-3641.

Narain, S., Tripathi, A., & Mishra, S. B. (2006). Population ecology of a freshwater turtle *Kachuga tentoria* near Panchnada (Etawah: U.P.) and its role as water purifier. *Journal of Environmental Biology, 27*(3), 589-596.

Pankaj, N. (2020). An assessment about habitat preference and diversity of amphibian fauna (Anurans) in Aurangabad, Bihar, India. *Electronic Journal of Biology, 16*(S1).

Pareek, P. S., Singh, S., & Dutta, S. (2024). Nesting crawls and associated behaviors of turtles in the genus *Batagur* along the Chambal River, India. *Reptiles & Amphibians, 31*(1), e21297.

Paul, P., Stuart, L., & Rhodin, G. (2000). Asian turtle trade.

Rao, R. J. (1998). Status of crocodiles and freshwater turtles in the Chambal river and Ganga river: a comparative analysis. Cobra 33, 31-34.

Rubbo, M. J., & Kiesecker, J. M. (2005). Amphibian breeding distribution in an urbanized landscape. *Conservation Biology, 19*(2), 504-511.

Saber, S., Tito, W., Said, R., Mengistou, S., & Alqahtani, A. (2017). Amphibians as bioindicators of the health of some wetlands in Ethiopia. *The Egyptian Journal of Hospital Medicine, 66*(1), 66-73.

Sale, J.B. (1982). 2nd Draft. Management Plan ForThe National Chambal Sanctuary. First Five Year Period 1982/83 - 1986/87. Central Crocodile Breeding and Management Institute, Hyderabad, iii+82pp

Schleich, H. H., & Kästle, W. (2002). *Amphibians and reptiles of Nepal: Biology, systematics, field guide*. Koenigstein: Koeltz Scientific Books.

Sharma, J., & Dube, P. (2020). Diversity of aquatic herpetofauna of River Chandloi, Kota, Rajasthan.

Singh, A., Yadav, S., Pareek, P. S., & Singh, S. (2025). Occurrence of red-crowned roofed turtle (*Batagur kachuga*) from the Upper Ganga, Uttar Pradesh, India, after 30 years. *Reptiles & Amphibians, 32*(1), e21859.

Singh, L. A. K. (1978). Ecological studies on the Indian gharial (*Gavialis gangeticus* Gmelin) (Reptilia, Crocodilia) (Ph.D. thesis). Utkal University, Bhubaneswar, India.

Singh, L. A. K. (1985). Gharial population trend in National Chambal Sanctuary with notes on radio-tracking. *Crocodile Research Centre, Wildlife Institute of India*, Hyderabad, Government of India.

SINGH, S., TRIPATHI, A., HORNE, B. D., & SHANTIPRAKASH, P. (2024). Conservation recovery of *Batagur kachuga* and *Batagur dhongoka* turtles in India: Development and operation of a head-starting facility. *The Herpetological Bulletin*, (167).

Sirsi, S., Singh, S., Tripathi, A., McCracken, S. F., Forstner, M. R., & Horne, B. D. (2017). Variation in reproductive output of the red-crowned roofed turtle (*Batagur kachuga*) and the three-striped roofed turtle (*Batagur dhongoka*) in the Chambal River of North India. *Chelonian Conservation and Biology, 16*(2), 203-214.

Smith, M. A. (1935). T*he fauna of British India, including Ceylon and Burma: Reptilia and Amphibia. Vol. 2: Sauria*. London: Taylor & Francis Ltd.

Smith, M. A. (1943). *The Fauna of British India, Ceylon, and Burma, Including the Whole of the Indo-chinese Sub-region: Reptilia and Amphibia. Serpentes*. Today & Tomorrow's Printers & Publishers.

Stuart, S. N., Chanson, J. S., Cox, N. A., Young, B. E., Rodrigues, A. S. L., Fischman, D. L., & Waller, R. W. (2004). Status and trends of amphibian declines and extinctions worldwide. *Science, 306*(5702), 1783-1786.

Taigor, S. R., & Rao, R. J. (2010). Anthropogenic threats in the National Chambal Sanctuary, Madhya Pradesh, India. *Tigerpaper, 37*(1), 23-27.

Vasudevan, K. (1998). Reproductive ecology of the Indian softshell turtle, Aspideretes gangeticus, in northern India. *Chelonian Conservation and Biology, 3*, 96-98.

Vyas, R. (2004). Fauna of Protected Areas-9: Herpetofauna of Vansda National Park, Gujarat. *Zoos' Print Journal, 19*(6), 1512-1514.

Wildlife Institute of India, (2021). Ecological monitoring of Chambal River basin with special reference to water requirement of key aquatic species.

WII-GACMC (2022). Chambal River: Ecological status and trends. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Pp. 41

Wyman, R. L. (1998). Experimental assessment of salamanders as predators of detrital food webs: Effects on invertebrates, decomposition and the carbon cycle. *Biodiversity and Conservation, 7*(5), 641-650.

CHAPTER 6

AVIFAUNA OF CHAMBAL RIVER

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Surya Prasad Sharma,
Khadija

Contributing Authors
Vikas,
Neeraj Mahar,
Ajay Prakash Rawat,
Shivani Barthwal

SUMMARY

The Chambal River, supports rich avian biodiversity, particularly within the ~600 km stretch protected under the National Chambal Sanctuary (NCS). A continuous boat survey was undertaken during daylight hours (0700-1700 hrs) to enumerate birds in BEU following standardized methods. Results show that the region hosts 81 bird species across 15 orders and 28 families, including globally threatened species like the Indian skimmer (*Rynchops albicollis*), black-bellied tern (*Sterna acuticauda*), and river tern (*Sterna aurantia*). These species, along with storks, pelicans, and raptors, reflect the ecological significance of the River. Species richness was highest in the lower zone (n=74), followed by the lower middle (n=34) and upper middle (n=19), with Shannon diversity indices shows relative uniformity across the zones. Waterbirds accounted for 61.72% of the total, while terrestrial and WD/A birds represented 22.22% and 16.04%, respectively. Feeding guild analysis revealed a dominance of piscivores and carnivores (~70%), indicating a high reliance on aquatic prey and reflecting productive riverine conditions.

Additionally, eight intensive monitoring sites with 28 transects were identified along the Chambal River to evaluate bird diversity using the point count method at different distances from the shore. Analysis with Shannon-Weiner, Simpson's, and evenness indices showed clear variation across transects. Species richness was highest in CHM78 (65 species) and lowest in Transect 143 (6 species). Simpson's index was highest in CHM105 (0.95) and lowest in Transect 184 (0.43), while Shannon's index was highest in CHM78 (3.15). Evenness was highest in 143(2) (0.85) and lowest in CHM78 (0.36). Transects such as CHM78 (Agricultural Plains) and CHM105

(Agricultural Plains with Dense Scrub) supported particularly high numbers of bird species, whereas CHM184 (Sand Banks) showed more evenly distributed but overall lower diversity across faunal groups.

Island-nesting bird monitoring identified 139 nesting events of eight species, including Indian skimmer, little tern, river tern, and small pratincole. Indian skimmer showed the highest fledgling success, while little tern had the most unhatched eggs. Mean clutch sizes ranged from 1.8 to 2.82, with sand serving as the uniform nesting substrate. However, threats like sand mining, livestock grazing, and predation were observed on 45% of nesting islands, highlighting significant pressures even within protected areas.

This study provides the first comprehensive assessment of avian diversity, habitat use, and threats in the Chambal River. It establishes a baseline for future monitoring and conservation planning of threatened waterbird species in the Chambal River.

6.1 Introduction

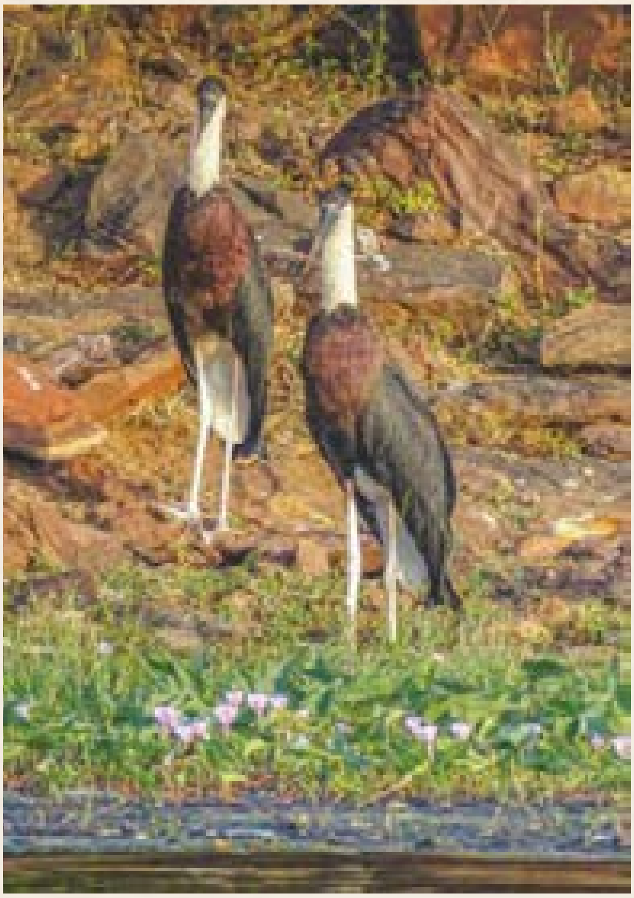
The Chambal River, flowing through the semi-arid regions of Central India, serves as a vital freshwater ecosystem supporting rich avian biodiversity. The NCS is particularly renowned for sustaining the largest known population of the globally threatened Indian skimmer (*Rynchops albicollis*), a species that serves as an indicator of riverine habitats (Singh & Sharma, 2018).

In addition to skimmers, the region supports a diverse array of birds of prey. Thirty raptor species have been recorded here, of which several are listed as conservation concern species under IUCN criteria. Notably, populations of the white-rumped vulture have declined, reflecting broader ecological degradation in the region (Singh et al., 2022). As apex predators, raptors provide critical insights into ecosystem health (Naoroji, 2011). The River also sustains significant populations of large wading birds such as storks and pelicans. Noteworthy species include the black-necked stork (*Ephippiorhynchus asiaticus*), painted stork (*Mycteria leucocephala*), black stork (*Ciconia nigra*), Asian openbill (*Anastomus oscitans*), and Asian woolly-necked stork (*Ciconia episcopus*) (Sharma & Singh, 2018; Sharma, 2024). Among pelicans, the dalmatian pelican (*Pelecanus crispus*), great white pelican (*Pelecanus onocrotalus*), and spot-billed pelican (*Pelecanus philippensis*) have also been recorded from the Chambal River basin (Singh & Sharma, 2023).

According to Nair & Krishnan (2013), the Chambal River basin sustains 307 avian species, from 64 families. Notable among them is the bar-headed goose, brahminy duck, various cormorants, herons, egrets, ibises, painted storks, brown-headed gulls, common and sarus cranes, spoonbills, and pelicans. The River also provides ideal nesting habitats for island-nesting waterbirds such as Indian skimmer, terns, lapwings, plovers and pratincoles. Among these, the Chambal River is the stronghold for the Indian skimmer and black-bellied tern, supporting the largest known breeding population of skimmers in India (Sundar, 2004; Pramanick 2016).

Although the River retains substantial conservation value within the broader Ganga River Basin (Hussain & Badola, 2001), it faces mounting threats from extractive activities and other anthropogenic pressures (Nair & Krishnan, 2013). Despite its ecological richness, avian studies in the region have been limited, often species-specific, and lacking standardized data collection methods and were mainly based on intermittent field studies and literature surveys. This presents a critical gap in our understanding of avian community, its habitat associations, and conservation priorities.

To address this, study was conducted using systematic methods to assess the diversity, abundance, distribution and ecological status of the entire avian community along the Chambal River.



6.2 Methods

6.2.1 Waterbirds, water- associated bird species

To assess the diversity and abundance of birds along the Chambal River, the total count method was employed. A continuous boat survey was conducted during daylight hours (0700-1700 hrs) to enumerate birds in each BEU following standardized methods (Bibby et al., 2000; WII-NMCG, 2019). Each BEU was sampled during the post-monsoon season by multiple observers (2-3). The bird identifications were done using 50×10 binocular followed by identification with the help of the field guide by Grimmett et al. (2012). A detailed guild-wise (Kumar et al., 2005) and IUCN Red List status-based checklist of recorded bird species was prepared (BirdLife International, 2025; Praveen & Jaypal, 2025). The bird species recorded were categorized into three groups: Water Birds (WB), Terrestrial Birds (T), and Water-Dependent/Associated Birds (WD/A). The results are presented in four sections i) avifaunal distribution across various river zones ii) species richness and diversity, (iii) relative abundance of species within each habitat, and (iv) feeding guilds.

6.2.2 Island Nesting Birds

The continuous monitoring of the river islands was carried out during the pre-monsoon season (May-June, 2024). The survey was conducted using an inflatable boat from 0700 to 1800 hrs in the lower zone of the river following standard protocol (WII-NMCG 2019; WII-GACMC 2024). On locating a river island, the observer dismounted the boat and visually examined the presence of nests, clutch size, hatchlings, or fledglings. Their numbers were counted carefully along with other habitat parameters like distance to nearest nest, distance to river current, and distance to river bank. Substantial distance was maintained from nests/hatchlings, ensuring minimum disturbance to them. In addition, anthropogenic parameters like the presence of humans, livestock, potential predators, and other site variables were also recorded at each nesting island.

6.2.3 Intensive Sites Monitoring of Bird Species

Additionally, eight intensive sites along the river were identified to establish a baseline and monitor long-term changes in the avian community in the Chambal River. In each selected site (BEUs), two to four 1-km transects were laid perpendicular to the riverbank at two locations on each bank, extending from the shoreline to the high flood level. Bird data were collected using the point count method at three fixed distances (1 m, 500 m, and 1000 m from shore) along each transect (Figure 6.1). A total of 28 transects were surveyed across the upper, middle, and lower zones of the Chambal River. The Shannon-Weiner diversity index (H') was used to calculate species diversity. Calculations were conducted in R using the 'vegan' package (Oksanen et al., 2020; R Core Team, 2025).

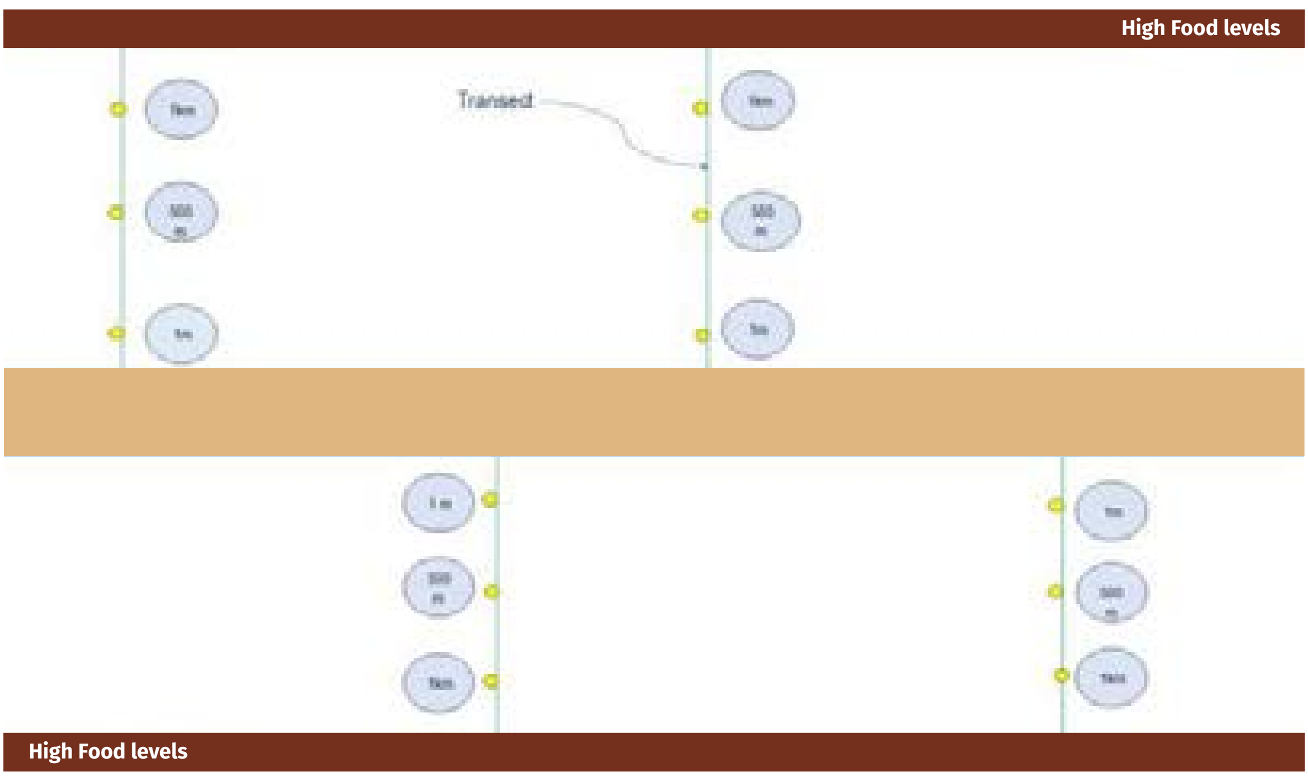


Figure 6.1: Methodology adopted to monitor Intensive sites

6.3 Results

6.3.1 Waterbirds and Water dependent/ associated Birds

Richness and diversity

During the survey, a total of 8,024 individuals representing 81 species of waterbirds were recorded along the Chambal River. These belonged to 15 orders and 28 families, with the family Anatidae (ducks, geese, and swans) being the most dominant, accounting for 17% of all individuals, followed by Scolopacidae (sandpipers and allies) at 16%.

Of the 81 species, about 61.72% (n=50) were waterbirds (WB), 22.22 % (n=18) were terrestrial birds (T) and 16.04 % (n= 13) were water dependent/ associated birds (WD/A) (Figure 6.3). Among the recorded bird species, three species viz., black-bellied tern (*Sterna acuticauda*) and Indian skimmer (*Rynchops albicollis*) are listed as Endangered, river tern (*Sterna aurantia*) is listed as Vulnerable (VU), and black-necked stork (*Ephippiorhynchus asiaticus*), dalmatian pelican (*Pelecanus crispus*), great thick-knee (*Esacus recurvirostris*), oriental darter (*Anhinga melanogaster*), painted stork (*Mycteria leucocephala*), river lapwing (*Vanellus duvaucelii*), spot-billed pelican (*Pelecanus philippensis*) and woolly necked-stork (*Ciconia episcopus*) are listed as Near Threatened (NT) in the IUCN RedList (Table 6.1; Figure 6.2).

Table 6.1: Globally Threatened Species recorded across the Chambal River during the surveys

Family	Bird species	Common name	IUCN Status
Anhingidae	*Anhinga melanogaster* (Pennant, 1769)	Oriental Darter	NT
Burhinidae	*Esacus recurvirostris* (Cuvier, 1829)	Great thick-knee	NT
Charadriidae	*Vanellus duvaucelii* (Lesson, 1826)	River lapwing	NT
Ciconiidae	*Mycteria leucocephala* (Pennant, 1769)	Painted Stork	NT
Ciconiidae	*Ephippiorhynchus asiaticus* (Latham, 1790)	Black-necked Stork	NT
Ciconiidae	*Ciconia episcopus* (Boddaert, 1783)	Woolly necked-stork	NT
Laridae	*Sterna acuticauda* (Gray, 1832)	Black-bellied Tern	EN
Laridae	*Rynchops albicolli* (Swainson, 1838)	Indian Skimmer	EN
Laridae	*Sterna aurantia* (J.E. Gray, 1831)	River tern	VU
Pelecanidae	*Pelecanus crispus* (Bruch, 1832)	Dalmatian Pelican	NT
Pelecanidae	*Pelecanus philippensis* (Gmelin, 1789)	Spot-billed Pelican	NT

Figure 6.2: Distribution of globally threatened waterbirds in the Chambal River

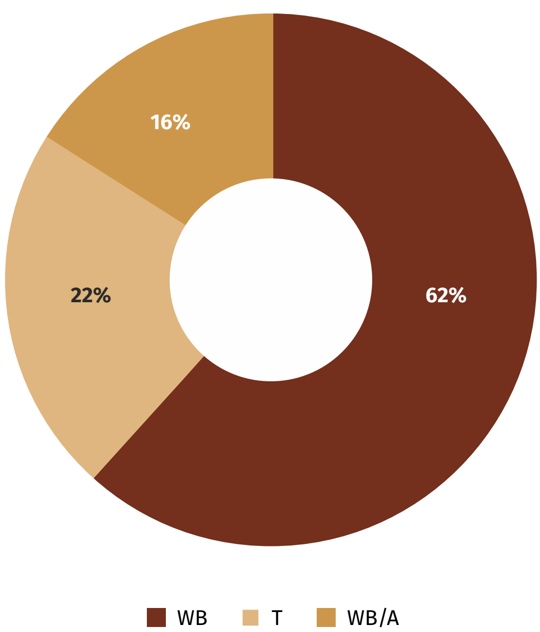


Figure 6.3: Graph showing percentage composition of Water Birds (WB), Terrestrial Birds(T), and Water-Dependent/Associated Birds (WD/A) across the Chambal River

The Upper middle zone of the Chambal River supports a total of 19 species belonging to nine families. Of the recorded species in the upper zone, 26.31% were WD/A and 73.68% were WB (Figure 6.5). The diversity of the overall birds, viz., T, WB, WD/A Birds in the Upper zone was 2.3 and 1.5, respectively (Figure 6.4). Species like the Indian skimmer, black-bellied tern, and Egyptian vulture were also observed in this zone.

In the Lower middle zone, a total of 34 species belonging to 15 families were recorded. Among the recorded species in the middle zone, 17.64% were water-dependent/associated birds, 73.52% were waterbirds, and the remaining 8.82% were terrestrial birds. The diversity of the terrestrial, waterbirds, and water-dependent/associated birds in the middle zone was 2.3, 1.5, and 0.86, respectively. The lower zone of the Chambal supported 74 species belonging to 28 families. Of the total birds, 64,86% were waterbirds, 20.27% were terrestrial, and 48% were water-dependent/associated birds. The diversity of terrestrial, waterbirds, and water-dependent/associated birds in the lower zone was 1.5, 1.83, and 1.16, respectively (Table 6.2). During the survey, the highest overall Shannon-Weiner diversity index (H'=2.62) was recorded in the Lower Zone, followed by the Upper Zone (H'=2.58) and the Middle Zone (H'=2.54) (Figure 6.4).

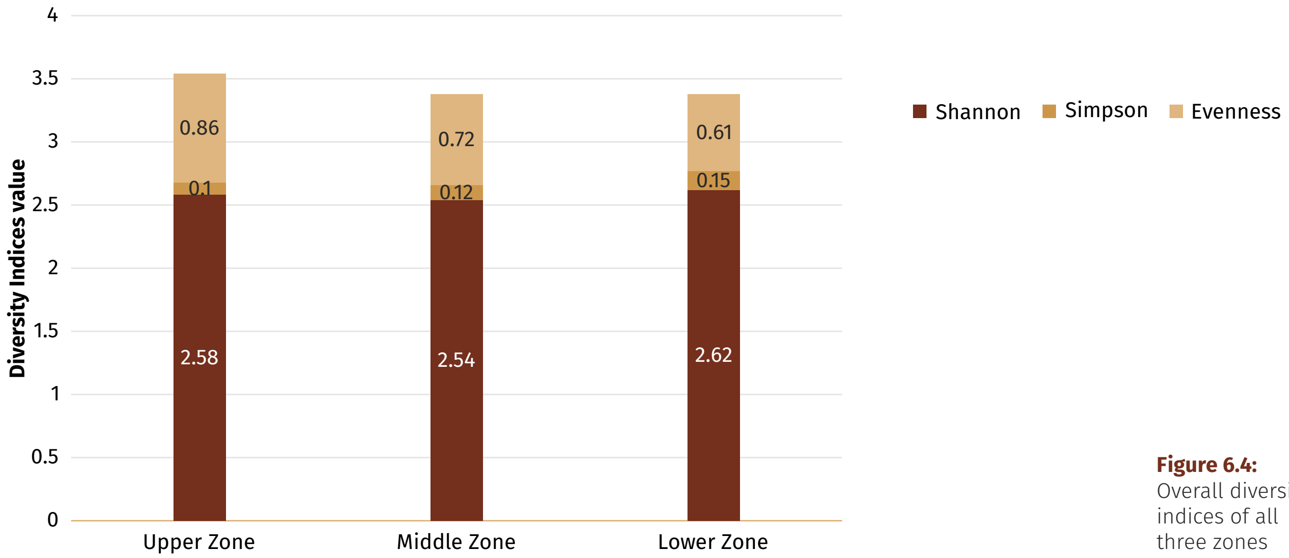


Figure 6.4: Overall diversity indices of all three zones

Table 6.2: Diversity Indices (Shannon, Simpson, and Evenness) of Water Birds, Water-Dependent Birds, and Terrestrial Birds across Different Zones of the Chambal River

Zones		Upper zone	Middle zone	Lower zone
Water Birds	Shannon	2.3	2.37	1.57
	Simpson	0.13	0.14	0.004
	Evenness	0.87	0.73	0.09
Water-Dependent/ Associated Birds	Shannon	1.5	1.54	1.83
	Simpson	0.24	0.24	0.2
	Evenness	0.93	0.86	0.77
Terrestrial Birds	Shannon	-	0.87	1.16
	Simpson	-	0.5	0.46
	Evenness	-	0.79	0.43

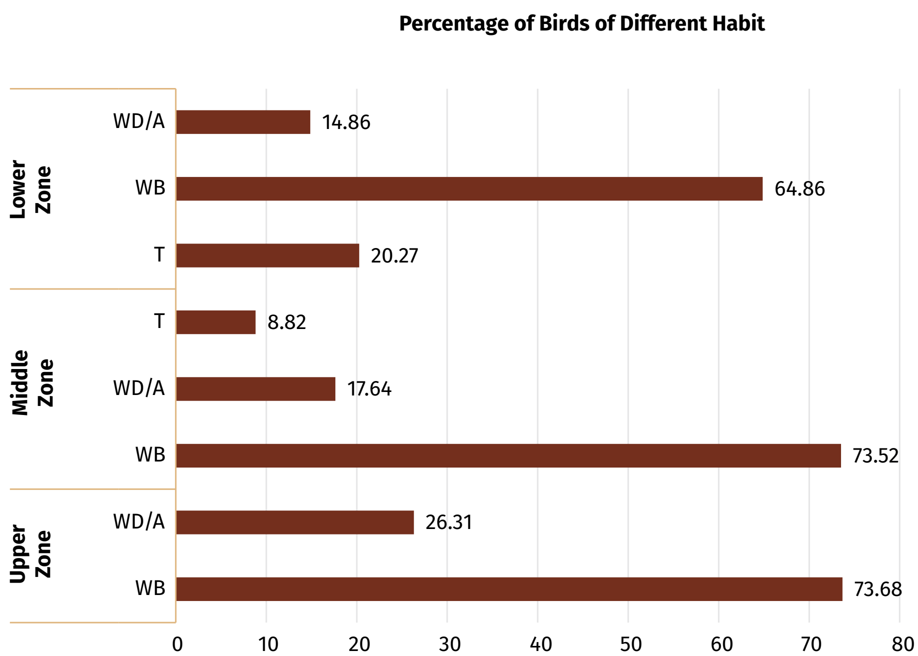


Figure 6.5: Comparing the percentage of WB, T, and WD/A birds in all three zones of the Chambal River, India.

Overall species richness was 81, with a Shannon Index of H'=2.69 and a Simpson Index of 0.85, while the evenness index was 0.61. The waterbird exhibited the highest species richness with a total of 50 species, and a Shannon Index (H') of 2.37, indicating relatively high species diversity, and with a moderate degree of evenness (E = 0.607). The Simpson Index for this group was 0.82. The terrestrial birds showed the lowest species richness (S = 18), the lowest Shannon Index (H' = 1.5), and an evenness index of 0.53, implying lower species diversity compared to the waterbirds. The Simpson Index was 0.705. A total of 13 species of water-dependent/associated birds were recorded. The Shannon and Simpson's Indices for this group of birds were 1.88, and 0.809, respectively. This group of birds had the highest evenness value at 0.73.

Table 6.3: Diversity Indices for birds

Bird category	Shannon Index (H')	Simpson Index (1-D)	Species Richness (S)	Evenness (E)
Water Birds (WB)	2.37	0.82	50	0.61
Terrestrial (T)	1.55	0.71	18	0.53
Water-Dependent/ Associated (WD/A)	1.88	0.81	13	0.73
Overall	**2.69**	**0.85**	**81**	**0.61**

6.3.2 Relative Abundance

6.3.2.1 Waterbirds (WB)

The little pratincole (*Glareola lactea*) was the dominant species, with 2,589 individuals, accounting for 35.5% of relative abundance (RA), followed by the great cormorant (*Phalacrocorax carbo*) (1,410 individuals; RA: 19.37%) and the Indian skimmer (*Rynchops albicollis*) (419 individuals; RA: 5.75%). Species such as the ruddy shelduck (*Tadorna ferruginea*), bar-headed goose (*Anser indicus*), and northern pintail (*Anas acuta*) also showed significant presence.

6.3.2.2 Water-Dependent/Associated Birds (WD/A)

Within this category, the red-naped Ibis (*Pseudibis papillosa*) was the most frequently observed species, with 116 individuals and a relative abundance of 29.21%. It was followed by the grey-throated martin (*Riparia chinensis*) (RA: 25.18%) and the great white pelican (*Pelecanus onocrotalus*) (RA: 15.11%). Although fewer in number compared to waterbirds, this group of birds contributed substantially to the habitat-specific avian community.

6.3.2.3 Terrestrial Birds (T)

This group had the lowest diversity and richness among the three habitats. However, notable species such as the Egyptian vulture (Neophron percnopterus) (72 individuals; RA: 20.63%) and the red-collared dove (*Streptopelia tranquebarica*) (155 individuals; RA: 44.41%) were recorded in considerable numbers.

6.3.3 Feeding Guilds and Residential Status

The avian community along the Chambal River is primarily composed of five feeding guilds, viz., carnivorous, herbivorous, insectivorous, omnivorous, and piscivorous, respectively. Our analysis reveals that piscivorous and carnivorous (32.09%) species dominate the bird assemblage, collectively comprising over 64% of the recorded species (Figure 6.6). This assemblage indicates a strong dependence on aquatic prey resources such as fish, amphibians, and smaller vertebrates, which are abundant in riverine and associated wetland habitats. Species like the great cormorant (*Phalacrocorax carbo*) and Indian skimmer (*Rynchops albicollis*) are examples of this pattern, as they live and feed mainly in open water areas where there are plenty of fish available.

In contrast, herbivorous (16.04%) and omnivorous (9.87%) species constitute lesser proportions of the community. Herbivores such as the bar-headed goose (*Anser indicus*) and ruddy shelduck (*Tadorna ferruginea*) mainly feed on aquatic vegetation and agriculture, while omnivores such as the African comb duck, whose feeding behaviour suits varied habitats. Insectivorous birds (9.87%), though less represented in our result, however, play an important role in controlling invertebrate populations of a food chain.

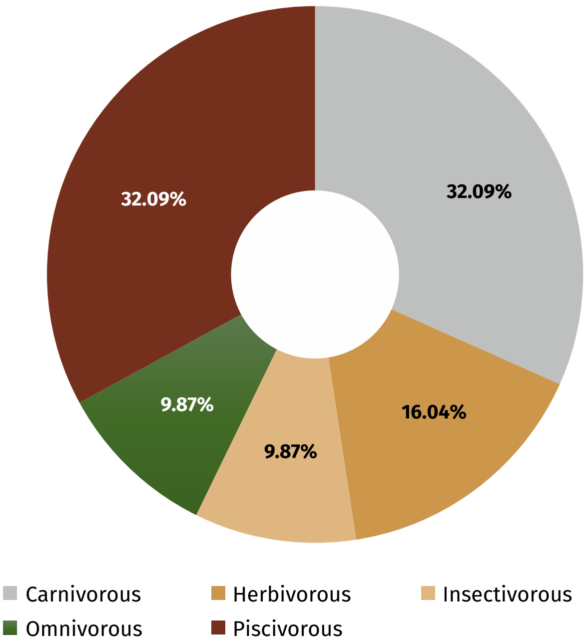


Figure 6.6: Overall proportion of feeding guilds of avifauna in the Chambal River

6.3.3.1 Waterbirds

A total of 50 waterbird species were categorized, with the majority belonging to the piscivorous guild (44%), reflecting their reliance on aquatic prey. Carnivorous species made up 30%, while herbivores accounted for 18%. Insectivorous and omnivorous birds each represented 4%, indicating a more specialized diet composition in waterbird communities compared to terrestrial ones (Figure 6.7).

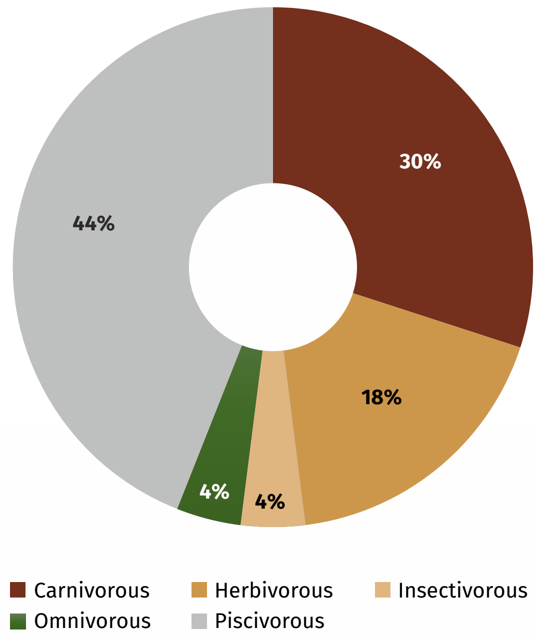


Figure 6.7: Feeding guilds of waterbirds in the Chambal River

6.3.3.2 Water-Dependent/Associated Birds

Among the 14 water-dependent or associated bird species, piscivorous birds constituted a significant portion (35.71%), followed by carnivorous species (28.57%). Insectivores made up 21.43%, while both herbivores and omnivores were the least represented, each contributing 7.14% (Figure 6.8). This pattern suggests a higher trophic specialization in wetland ecosystems, particularly toward aquatic prey.

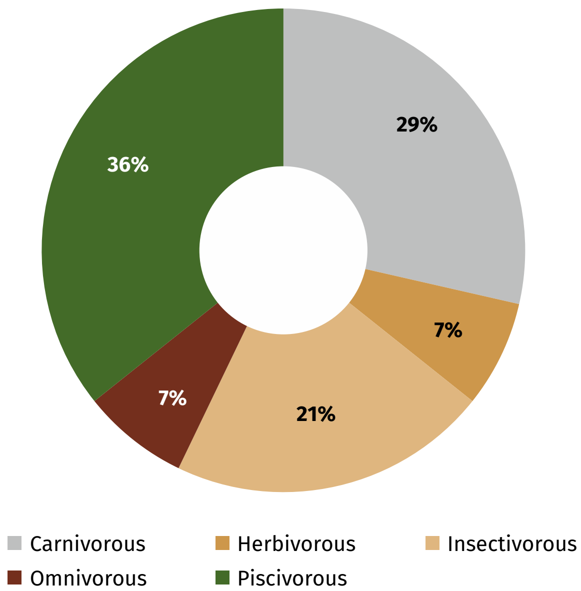


Figure 6.8: Feeding guilds of water-dependent/associated birds in the Chambal River

6.3.3.3 Terrestrial Birds

Among terrestrial birds (n = 18), the dominant feeding guild was carnivorous, accounting for 38.89% of the total species. Omnivores followed with 27.78%, while herbivorous and insectivorous species constituted 16% and 17%, respectively (Figure 6.9).

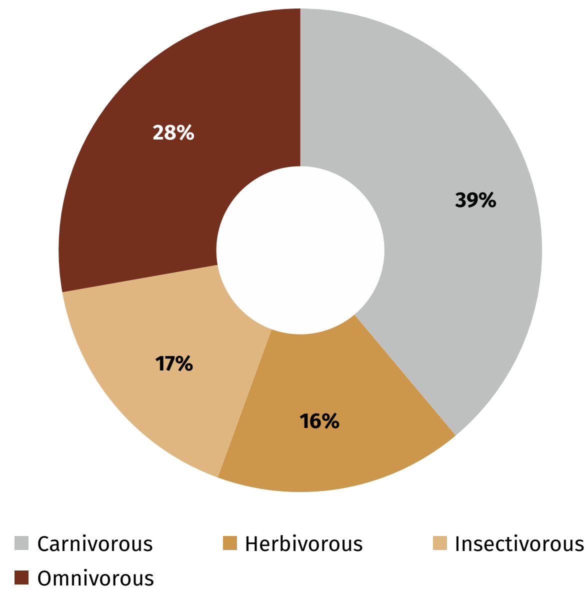


Figure 6.9: Feeding guilds of terrestrial birds in the Chambal River

This distribution reflects a habitat that is largely aquatic and wetland-dominated, supporting species adapted to such environments. The dominance of predatory feeding types (piscivores and carnivores) suggests high prey availability and ecological productivity, especially within waterbird and water-associated habitats. Meanwhile, the lower representation of herbivores and insectivores could reflect lower primary productivity in terrestrial zones.

Concluding the results, the feeding guild analysis emphasizes the ecological richness and functional diversity of the Chambal River region, which highlights the importance of aquatic ecosystems in sustaining a broad assemblage of avifaunal trophic interactions.

Table 6.4: Summary of feeding guild percentage in different habitats

Feeding Guild	Terrestrial (%)	Waterbirds (%)	WD/A Birds (%)
Carnivorous	39	31	29
Herbivorous	16	18	7
Insectivorous	17	4	21
Omnivorous	28	4	7
Piscivorous	00	43	36

Residential status

Across the three zones of the Chambal River, a total of 81 bird species were recorded during the survey. In the Upper Zone, 19 species were observed, of which 17 (89.5%) were resident, including those with Indian skimmer and black-bellied tern (resident and local migrant) and River tern (resident and winter migrant). Only two species (10.5%), like Pallas's gull and ruddy shelduck, were strictly migratory. In the Middle Zone, 34 species were recorded, with 26 (76.5%) identified as residents and 8 (23.5%) as migratory, including species such as bar-headed goose and Eurasian wigeon. The Lower Zone had the highest diversity, with 74 species, of which 54 (73%) were resident and 20 (27%) migratory, including dalmatian pelican and northern pintail. The high presence of resident species across all zones highlights the river's role as a stable breeding and foraging habitat, while the presence of migratory species underscores its importance as a seasonal stopover for long-distance migrants (Table 6.5).

Table 6.5: Residential status of birds in the Chambal River

Zone	Residential Status	Number of Species	Percentage (%)
Upper Zone	Resident	11	57.89%
	Resident & Local Migrant	4	21.05%
	Resident & Winter Migrant	2	10.53%
	Migratory	2	10.53%
	Total	19	
Middle Zone	Resident	20	58.82%
	Resident & Local Migrant	4	11.76%
	Resident & Winter Migrant	2	5.88%
	Migratory	8	23.52%
	Total	34	
Lower Zone	Resident	42	56.75%
	Resident & Local Migrant	4	5.40%
	Resident & Winter Migrant	9	12.16%
	Migratory	19	25.67%
	Total	74	

6.4 Status of Island Nesting Birds

Island Nesting Birds of the Chambal River during 2024

A total of 25 potential nesting islands were monitored on the Chambal River, covering ~405 km of the River. A total of 139 nesting events of eight island nesting species, viz. black-bellied tern, black-winged stilt, great thick-knee, Indian skimmer, little tern, river lapwing, river tern, and small pratincole were recorded from nine river islands of the Chambal River between Pali and Bareh (Chambal-Yamuna confluence) (Figure 6.10). For species like great thick-knee and river lapwing, only hatchlings were recorded, whereas for the rest of the species, unhatched eggs, hatchlings, and fledglings were recorded (Table 6.6).

Out of 139 nesting events, 51 were recorded for little tern, followed by 40 events for river tern, 31 for Indian skimmer, and nine for small pratincole. Little tern had the highest number of unhatched eggs (n=50), followed by river tern (n=38) and Indian skimmer (n=31). While, highest fledgling numbers belonged to the Indian skimmer (n=75), followed by the river tern and pratincole with five each. The highest number of hatchlings belonged to the little tern and the river tern (Table 6.6). The average clutch size of Indian skimmer was found to be 2.82±0.26 (Range 1-4), which was 2.50±0.22 (1-4) for river tern, followed by 2.32±0.17 (1-4) for little tern, and 1.80±0.37 (1-3) for small pratincole (Figure 6.11).

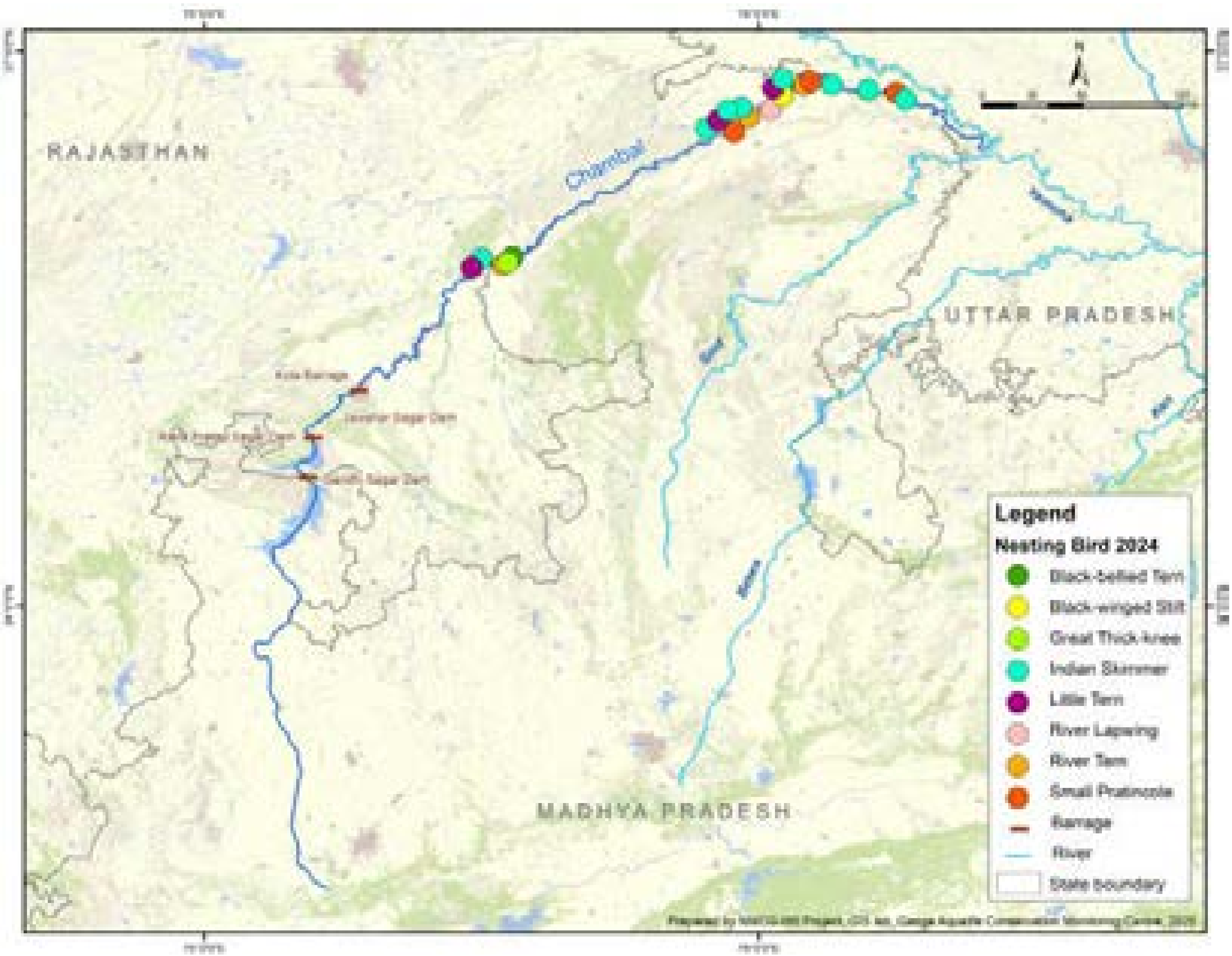


Figure 6.10: Nesting sites of different island nesting birds in the Chambal River during Second Pre-Monsoon Survey (2024)

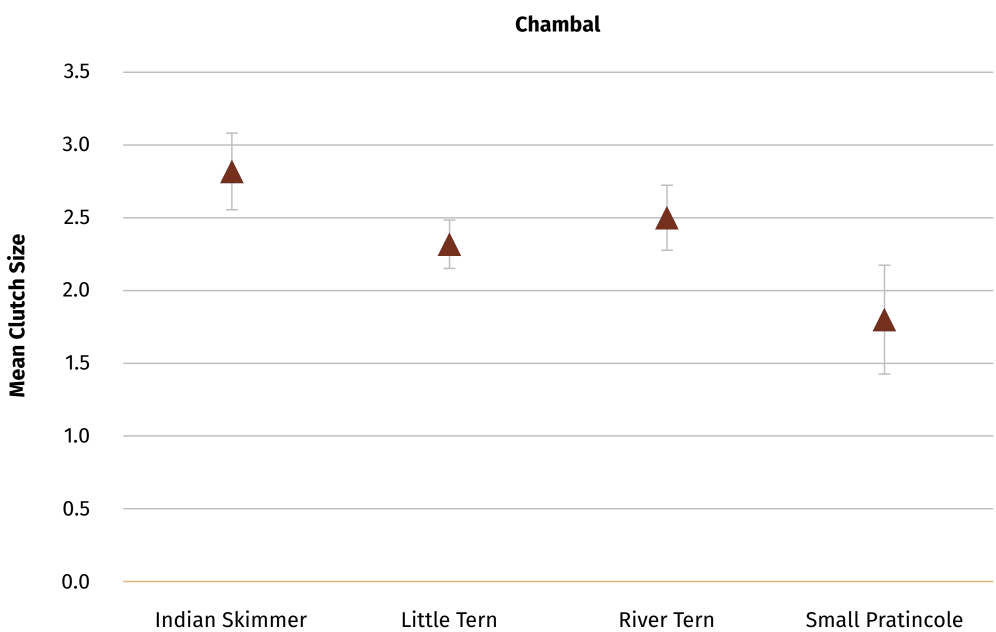


Figure 6.11: Mean clutch size of key nesting island birds from the Chambal River

Table 6.6: Summary of island nesting bird species and nests observed in the Chambal River

Species	Nesting Events	Total Unhatched eggs	Total Hatchlings	Total Fledglings
Black-bellied tern	5	2	3	-
Black-winged stilt	3	3	-	-
Great thick-knee	-	-	1	-
Indian skimmer	31	31	2	75
Little tern	51	50	6	2
River lapwing	-	-	3	-
River tern	40	38	6	5
Small pratincole	9	9	2	5
Grand Total	139	133	23	87

Sand was the uniformly used nest substrate by all nesting waterbird species between the Pali and Dholpur stretch of the Chambal River, except on a rare occasion where the Indian skimmer used sand with pebbles to construct a nest cavity. The average distance of nests from the river shoreline was 153.89 m ±3.22. Despite the Chambal River being a Protected Area, several threats to the species were visible. Among anthropogenic pressures, out of nine nesting islands, five had active sand mining during the breeding season of waterbirds, while 27% of nesting islands were facing the problem of livestock grazing that often leads to trampling of eggs and chicks. The presence of natural predators like jackals was confirmed on one of the nesting islands.

Diversity Indices across the Intensive Sites

Bird species richness varied significantly across eight intensive sites, with the highest recorded in BEU78 (65 species) and the lowest at BEU 143 (6 species). Simpson's index (1-D) was highest in BEU 105 (0.95) and lowest in BEU 184 (0.43). Shannon's diversity index (H) was highest in BEU 78 (3.15), suggesting a well-distributed bird community. BEU 143 had the highest evenness (0.85), while BEU 78 had the lowest (0.36), indicating species in BEU 78 are more unevenly distributed.

6.5 Discussion

Riverine habitats are important for biodiversity globally (Sinha et al., 2019). Our present study reveals that the riverine habitats of the Chambal River support a rich avian community, with a representation of 81 species belonging to 28 families and 15 orders. Among these, 50 are waterbirds (WB), 18 are terrestrial birds (T), and 13 are water-dependent/associated birds (WD/A). This comparatively lower representation of terrestrial birds is likely a reflection of the study's focus on river-specific habitats.

About two-thirds of these species belonged to carnivorous and piscivorous feeding guilds, while the rest were herbivorous, insectivorous, or omnivorous. This assemblage indicates that the Chambal River provides a range of habitats suitable for species with different ecological requirements. Endangered species such as the Indian skimmer (*Rynchops albicollis*) and black-bellied tern (*Sterna acuticauda*) were found to be more abundant in the lower zone compared to other zones, indicating that this area provides ideal habitat conditions for their breeding and conservation within the National Chambal Sanctuary. However, it is also important to understand how anthropogenic pressures in the NCS are affecting these species. Our study also confirmed the presence of five stork species, as previously reported by Sharma & Singh (2018): black-necked stork (*Ephippiorhynchus asiaticus*), painted stork (*Mycteria leucocephala*), black stork (*Ciconia nigra*), Asian openbill (*Anastomus oscitans*), and Asian woolly-necked stork (*Ciconia episcopus*). Interestingly, all these stork species were recorded from the lower zone. Bar-headed goose (*Anser indicus*), Pelicans (Pelecanus spp.), and greater flamingos (*Phoenicopterus roseus*) were also reported from the lower zone, indicating that this part of the river provides favorable habitat conditions for such migratory species.

Species richness showed a clear gradient, with the lower zone hosting the highest number of species (74), followed by the middle zone (34), and the upper zone (19). Although the Lower Zone had the highest species richness, the Shannon diversity index was similar across all three zones. This distribution suggests that species in the Upper and Middle Zones were more evenly distributed, while the Lower Zone had a more uneven distribution. The balance between richness and evenness explains the comparable diversity values, highlighting the ecological value of each zone despite differences in species count.

Our survey recorded 25 potential nesting islands along the Pali to Bareh stretch of the Chambal River, primarily within the National Chambal Sanctuary. Nesting events were documented for eight island-nesting bird species: Indian skimmer (*Rynchops albicollis*), little tern (*Sternula albifrons*), river tern (*Sterna aurantia*), small pratincole

(*Glareola lactea*), black-bellied tern (*Sterna acuticauda*), black-winged stilt (*Himantopus himantopus*), great thick-knee (*Esacus recurvirostris*), and river lapwing (*Vanellus duvaucelii*). The nesting of the Indian skimmer and the black-bellied tern, both listed as Endangered, highlights the conservation importance of this riverine landscape. The mean clutch size of Indian skimmer in our study (2.82 ± 0.26; n=31) was slightly lower than reported from the Mahanadi River (3.12 ± 0.41; n=64) (Rajguru, 2017) but intermediate than the values reported from the Ganga River (2.54 ± 1.11) in 2017 and (3.05 ± 1.27) in 2018 (Ankit et al., 2024). These variations may be attributed to site-specific ecological conditions and levels of disturbance. Species like the little tern and river tern had high numbers of unhatched eggs (n=50 and n=38, respectively), relatively few fledglings. This skew may suggest elevated nest failure rates, possibly linked to predation, trampling, or suboptimal incubation conditions.

Among the island nesting waterbirds, we observed the presence of hatchlings only for the great thick-knee and river lapwing, which indicates either low detectability of earlier nesting stages or higher mortality rates post-hatching. The average nest distance from the shoreline likely reflects adaptive strategies to minimize disturbance and predation risk. Despite the area's protected status, threats such as cattle grazing, sand mining, and predation continue to pose significant risks to nesting success, as reported in other studies as well (Arjun et al., 2023; Freidrick et al., 1989; Das, 2015). These findings suggest the urgent need for targeted management interventions to safeguard critical nesting habitats during the breeding season.

Our study lays a foundation by documenting the avian diversity of one of the most important rivers of the Ganga River Basin. A key advancement over previous studies (Nair, 2013; Sharma & Singh, 2018; Singh et al., 2022; Singh & Sharma, 2023) lies in the comprehensive and systematic documentation of the avifaunal diversity along the Chambal River, achieved through the standardized survey methods. Several anthropogenic stressors were recorded during the study, including sand mining, fishing, and riparian agriculture, all of which are known to affect waterbird diversity in a riverine system. The practice of seasonal crop farming on riverine sandbars, earlier observed by Hussain (2009) and Katdare et al. (2011), was recorded during the present survey as well. The study reaffirms that the Chambal River supports high avian diversity, including several threatened and migratory species. In summary, the findings from this study provide a valuable baseline for understanding the distribution, threats, and habitat needs of waterbirds in the Chambal River, and call for integrated conservation planning and management of aquatic and island-nesting habitats.

REFERENCES

Ankit, K., Ahmad, M., Ranjan, V., Kumar, S., Hussain, S. A., & Gopi, G. V. (2024). Observations on Indian Skimmer (*Rynchops albicollis* Swainson, 1838) (Aves: Charadriiformes: Laridae) breeding colonies in Middle Ganges stretch, India. *Journal of Threatened Taxa, 16*(2), 24737-24745.

Arjun, M. S., Panda, B. P., & Arun, P. R. (2023). Sand mining as a contemporary threat to sandbar nesting birds: A review. *Contemporary Problems of Ecology, 16*(2), 189-204.

Bibby, C. J. (2000). *Bird census techniques* (2nd ed.). Elsevier.

BirdLife International. (2025). Birds. In *The IUCN Red List of Threatened Species*. Retrieved from https://www.iucnredlist.org

Das, D. K. (2015). Breeding status of Indian Skimmer (*Rynchops albicollis*) in the National Chambal Sanctuary, India. *Indian Birds, 10*(2), 53-54.

Frederick, P. C., & Collopy, M. W. (1989). The role of predation in determining reproductive success of colonially nesting wading birds in the Florida Everglades. *The Condor, 91*(4), 860-867.

Grimmett, R., Inskipp, C., & Inskipp, T. (2012). *Birds of the Indian Subcontinent* (2nd ed.). Princeton University Press.

Kumar, A., Sati, J. P., Tak, P. C., & Alfred, J. R. B. (2005). *Handbook on Indian wetland birds and their conservation*. Zoological Survey of India, Kolkata.

Hussain, S. A., & Badola, R. (2001, August 6-8). Integrated conservation planning for Chambal River Basin. Paper presented at the National Workshop on Regional Planning for Wildlife Protected Areas, India Habitat Centre, New Delhi. Dehradun: Wildlife Institute of India.

Hussain, S. A. (2009). Basking site and water depth selection by gharial (*Gavialis gangeticus* Gmelin, 1789) (Crocodylia, Reptilia) in National Chambal Sanctuary,

India and its implication for river conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems, 19*(2), 127-133.

Katdare, S., Srivathsa, A., Joshi, A., Panke, P., Pande, R., Khandal, D., & Everard, M. (2011). Gharial (*Gavialis gangeticus*) populations and human influences on habitat on the River Chambal, India. *Aquatic Conservation: Marine and Freshwater Ecosystems, 21*(4), 364-371.

Naoroji, R. (2011). *Birds of prey of the Indian subcontinent.* Noida: Om Books International.

Nair, T., & Krishna, Y. C. (2013). Vertebrate fauna of the Chambal River basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa, 5*(2), 3620-3641.

Oksanen, J., Simpson, G. L., Blanchet, F. G., et al. (2024). Vegan: Community ecology package. Retrieved from https://CRAN.R-project.org/package=vegan

Pramanick, S. (2016). Black-bellied tern (*Sterna acuticauda*) - adult in breeding plumage. Retrieved March 15, 2019, from http://orientalbirdimages.org/birdimages.php?p=2&action=birdspecies&Bird_ID=968&Bird_Family_ID=&pagesize=1

Praveen, J., & Jayapal, R. (2025). *Checklist of the birds of India* (v9.0). Retrieved January 1, 2025, from http://www.indianbirds.in/india/

Rajguru, S. K. (2017). Breeding biology of Indian Skimmer (*Rynchops albicollis*) at Mahanadi River, Odisha, India. *Indian Birds, 13*(1), 1-7.

R Core Team. (2024). R: *A language and environment for statistical computing.* R Foundation for Statistical Computing.

Sharma, H. (2024). Occurrence and documentation of stork species in selected water bodies of Kota region, Rajasthan, India. Delhi: Akinik Publications

Sharma, R. K., & Singh, L. A. K. (2018). Spatial and temporal patterns of stork sightings (Aves: Ciconiidae) in National Chambal Sanctuary of Gangetic River system. *Journal of Threatened Taxa, 10*(3), 11410-11415.

Singh, L. A., & Sharma, R. K. (2023). Long-term monitoring of pelicans in National Chambal Sanctuary, India. *Journal of Threatened Taxa, 15*(1), 22419-22429.

Singh, L. A. K., & Sharma, R. K. (2018). Sighting trend of the Indian Skimmer (Charadriiformes: Laridae: *Rynchops albicollis* Swainson, 1838) in National Chambal Gharial Sanctuary (1984-2016) reflecting on the feasibility of long-term ecological monitoring. *Journal of Threatened Taxa, 10*(5), 11574-11582.

Singh, L. A. K., Sharma, R. K., & Pawar, U. R. (2022). Raptors observed (1983-2016) in National Chambal Gharial Sanctuary: Semi-arid biogeographic region suggestions for parametric studies on ecological continuity in Khathiar-Gir Ecoregion, India. *Journal of Threatened Taxa, 14*(1), 20444-20460.

Sinha, A., Hariharan, H., Adhikari, B. S., & Krishnamurthy, R. (2019). Bird diversity along riverine areas in the Bhagirathi Valley, Uttarakhand, India. *Biodiversity Data Journal, 7*, e31588.

Sundar, K. G. (2004). Observations on breeding Indian Skimmers Rynchops albicollis in the National Chambal Sanctuary, Uttar Pradesh, India. Forktail, 20, 89-90.

WII-NMCG. (2019). *Biodiversity profile of the Ganga River.* Dehradun, Uttarakhand, India: Wildlife Institute of India. 223 pp. ISBN 81-85496-41-2.

WII-GACMC. (2024). *Socio-ecological status of Chambal River for conservation planning.* Dehradun, India: Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India. 296 pp.

CHAPTER 7

AQUATIC MAMMALS OF CHAMBAL RIVER

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Surya Prasad Sharma

Contributing Authors
Goura Chandra Das,
Khadija,
Shivani Barthwal

SUMMARY

The Chambal River is a crucial stronghold for the endangered Gangetic Dolphin (*Platanista gangetica*) and smooth-coated otter (*Lutrogale perspicillata*). The Gangetic Dolphin was historically distributed across a broader stretch of the river; recent surveys show its presence has become restricted to the lower reaches between Basai Dang and the Chambal-Yamuna confluence. Surveys from 2019 to 2022 recorded 75-96 individuals, with encounter rates ranging from 0.30 to 0.32/km. Most sightings occurred in deep pools with water depth ranging from 6 to 10 m, indicating species preference for deep-water habitats. Smooth-coated otters persist in fragmented populations, especially in the upper and middle reaches of the river. Past surveys reported declining trends, with occupancy reducing from 62 sites in 1988 to 41 in 1992. No sightings of otters were recorded during the survey.

The presence of dolphins despite the rapid increase in anthropogenic stressors such as illegal fishing, sand mining, and flow alteration from dams poses serious risks to the long-term conservation of the species. These activities degrade aquatic habitats, reduce prey abundance, and increase mortality from entanglement or habitat fragmentation. Hence, protection of deep-pool habitats, ecological flow regulation, community-based stewardship, and strict enforcement laws are essential. This study reinforces the importance of Chambal as a conservation hotspot and underscores the need for integrated management to ensure the long-term survival of aquatic mammals and other freshwater fauna in the Ganga River Basin.

7.1 Introduction

The Chambal River has long been recognized as a stronghold for several endangered aquatic species. Among these, aquatic mammals the Gangetic dolphin (*Platanista gangetica*), and the smooth-coated otter (*Lutrogale perspicillata*) are key aquatic mammals found in the Chambal River Basin. Although the river is known for the presence of the critically endangered gharial, and studies have focused on the gharial, most of the studies pertaining to the otters and the earliest scientific studies on the Gangetic dolphin are from the Chambal River.

The Chambal River has long served as an important refuge for several endangered aquatic species, notably the Gangetic dolphin (*Platanista gangetica*) and a small, fragmented population of the smooth-coated otter (*Lutrogale perspicillata*) (Hussain et al., 2013). These species play critical ecological roles as apex predators and bioindicators of riverine health, regulating fish populations and reflecting the overall ecological integrity of freshwater systems (Paudel et al., 2020). Regular monitoring of these species is essential, as it provides valuable insights into habitat quality, pollution levels, and the broader impacts of anthropogenic activities such as habitat fragmentation, reduced prey availability, and hydrological alterations (Braulik et al., 2021; Paudel et al., 2021).

Despite their ecological importance, both species are increasingly threatened. Population trends suggest fragmentation and possible decline, driven largely by infrastructure development-particularly dams and barrages, which alter flow regimes and disrupt aquatic connectivity (Braulik et al., 2014; 2021). Additionally, declining fish availability due to overfishing, pollution, and habitat degradation further impacts the abundance and distribution of these species (Das et al., 2025). Notably, the Chambal remains one of the least polluted rivers in India (Yadav et al., 2014). This relatively pristine condition offers a unique opportunity for long-term ecological studies and conservation initiatives targeting endangered aquatic fauna. Scientific research using standardized survey methodologies is needed to guide evidence-based conservation planning and maintain the ecological integrity of this freshwater ecosystem.

Gangetic Dolphin

The Gangetic dolphin, the national aquatic animal, is one of the two aquatic mammal species found in the Chambal River. It is present in the lower stretch of the River, between Basai dang and the Chambal-Yamuna confluence. In studies conducted between 1983-85, a total of 45 dolphins were counted over a stretch of approximately 320 km in Chambal between Batesura and Chambal-Yamuna confluence (Nair, 2009; Singh & Sharma 1985).

Over the years, the sighting of the Gangetic dolphin has decreased upstream of Dangbasai. In the years 2013 and 2014, a total of 59 and 66 adults were counted, respectively, all restricted to the lower zone, particularly between Basaidang and Chakarnagar (Sharma & Singh, 2014)

The population status of dolphins of the Chambal River was determined by surveys conducted every year between 2007 and 2010. The survey reported 82.75 ±09.1 individuals per year, with an encounter rate of 0.19 per km (Singh & Rao, 2017). Annual census surveys conducted in 2016 recorded 78 dolphins, 75 dolphins were sighted in 2017 and in 2018, 74 individuals were recorded.

Smooth-coated otter

The smooth-coated otter is the second mammalian species known to be found in the Chambal River. The first study of otters in the Chambal River within NCS was initiated in 1988, during which otter presence was found in 62 sites between Pali and Panchhnada. Whilst the survey conducted later in 1992, otter presence was recorded in only 41 sites (Hussain, 1993). The study concluded that the smooth-coated otters occupy the NCS in low densities, and there has been a decline in population based on the annual surveys between 1988 and 1992 (Hussain & Choudhury, 1997).

7.2 Methods

The information on the otters and Gangetic dolphin was collected from each BEU using boat-based visual encounter method (Smith & Reeves, 2000; Das et al., 2022; 2024), in the post-monsoon 2019, 2021, and 2022. Using an inflatable rubber (25 hp)/country boat, the surveys were carried out in daylight between 0800 and 1200 hrs, and 1500 and 1700 hrs during the three post-monsoon (November to March) seasons. The boat's speed was maintained at 6 to 10 km/h to prevent missing any surfacing person sightings. In accordance with Smith et al. (2006), a group of four skilled observers, outfitted with binoculars, a GPS unit, and a rangefinder, was positioned at the bow of the vessel to collect simultaneous least counts of dolphin sightings and related habitat variables. Three observers on each team were tasked with searching for surfacing dolphins, while the fourth observer was in charge of documenting related habitat factors at every encounter.

7.3 Results

7.3.1 Gangetic dolphin - distribution and encounter rate

In the PoM 2019 survey, 75 dolphin sightings were reported along a 235 km stretch of the lower zone, with an encounter rate of 0.32 ±0.07 SE. The mean group size was 2 ±1.13 SD, and the largest group of five individuals was recorded downstream of the Barhi Bridge (Table 7.1; Figures 7.1 and 7.2). Sightings were most frequent in <5 m depth (44.4%), followed by 30.6% in 6-10 m, and 11% in 11-15 m (Table 7.2 and Figure 7.3).

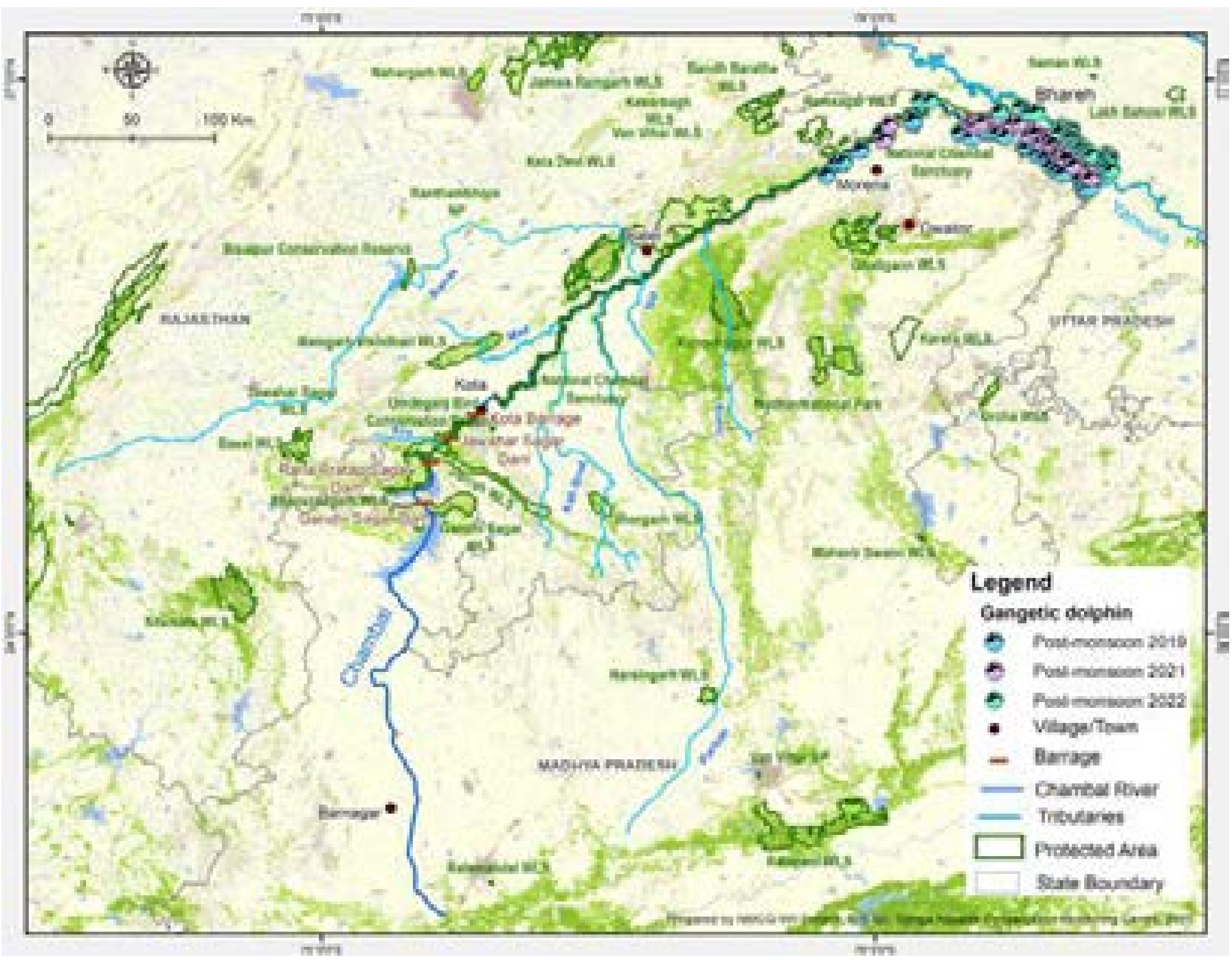


Figure 7.1: Distribution of Gangetic Dolphin in the Chambal River

During the second survey (PoM 2021), 72 sightings were recorded in the lower zone, yielding an encounter rate of 0.30 ±0.07 SE. The mean group size was 2 ±0.72 SD, with the largest group of four individuals, sighted approximately 15 km upstream of the Chambal-Yamuna confluence (Table 7.1; Figures 7.1 and 7.2). Depth-wise, 35.9% of sightings were in the 6-10 m class, 33.3% in <5 m, and 28.2% in 11-15 m (Table 7.2 and Figure 7.3).

During the PoM 2022 survey, a total of 96 Gangetic dolphin sightings were recorded in the lower zone of the Chambal River, with a mean group size of 3 ±2.65 SD. The largest group observed comprised 13 individuals, sighted approximately 5 km upstream of the Sahson Bridge (Table 7.1; Figures 7.1 and 7.2). In terms of depth preference, the majority of sightings (50.0%) occurred in the 6-10 m depth class, followed by 21.9% in depths <5 m and 15.6% in 11-15 m (Table 7.2 and Figure 7.3).

Table 7.1: Gangetic Dolphin sightings, encounter rate and group size in the Chambal River.

Zones	2020	2022	2023
Upper Middle zone	--	--	–
Lower Middle zone	--	--	–
Lower zone	75	72	96
Total	**75**	**72**	**96**
Encounter rate (sightings/km)	0.32 ±0.07 SE	0.30 ±0.07 SE	0.41 ±14 SE
Group size (number of individuals)	2 ±1.13 SD	2 ±0.72 SD	3 ±2.65 SD

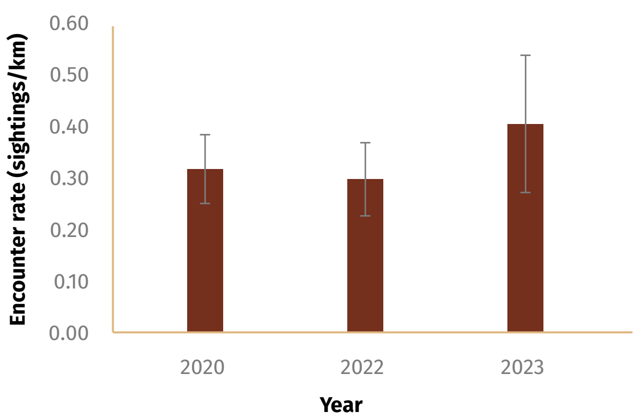


Figure 7.2: Gangetic Dolphin encounter rate

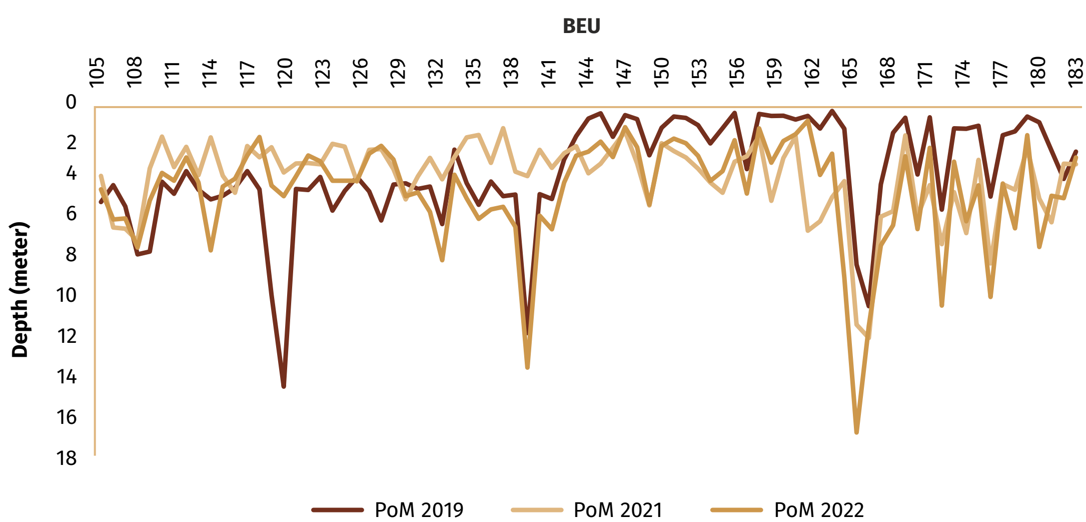


Figure 7.3: Depth profile (in meters) of the Chambal River and average water depth during the surveys

Table 7.2: Gangetic Dolphin sightings at various depth classes.

Depth class (m)	2020		2022		2023	
	Sightings	%	Sightings	%	Sightings	%
<5	16	44.4	13	33.3	7	21.9
6-10	11	30.6	14	35.9	16	50
11-15	4	11.0	11	28.2	5	15.6
16-20	2	5.6	0	0	2	6.3
21-25	0	0	0	0	1	3.1
26-30	2	5.6	0	0	1	3.1
>30	1	2.8	1	2.6	0	0
Total	36	100.0	39	100.0	32	100.0

7.3.2 Smooth-coated otter - distribution and encounter rate

During the current survey, otter presence was not recorded either through direct sightings or indirect evidence.

7.4 Discussion

The Chambal River remains a vital refuge for the Gangetic dolphin. While historical records suggest that the species once inhabited upstream stretches of the Chambal River, recent systematic surveys indicate a spatial contraction in its distribution. Sightings were predominantly restricted to the lower zone, particularly between Rajghat in Morena district and the Chambal-Yamuna confluence. This stretch comprises deep river pools, meandering channels that are known to support dolphins due to increased prey availability and hydrological stability (Sinha, 1997; Kelkar et al., 2010; Das et al., 2025). A majority of sightings during the surveys were recorded at depths exceeding 10 meters, indicating the species' preference for deeper water pools (Hussain et al., 2011).

The presence of Gangetic dolphins and other species of conservation significance, such as gharials, and freshwater turtles, including the red-crowned roofed turtle, and the three-striped roofed turtle, underscores the importance of the Chambal River as a critical conservation hotspot. The conservation of the Gangetic dolphin as a flagship species offers strategic leverage to safeguard broader aquatic biodiversity. Effective protection of this species inherently contributes to maintaining ecological connectivity, habitat quality, and the resilience of other co-occurring aquatic fauna. Therefore, conservation prioritisation in the Chambal basin must adopt a multi-pronged approach, integrating regular ecological monitoring, local community stewardship, habitat restoration, and strict regulation of resource-extractive pressures.

While no direct sightings of otters were made during the present survey within the sampled lower reaches, indirect evidence and community reports suggest their occasional presence, particularly after monsoon floods. Historical records and prior assessments have confirmed the occurrence of smooth-coated otters (*Lutrogale perspicillata*) and Eurasian otters (*Lutra lutra*) in the upper Vindhyan and middle zones of the Chambal, particularly in less-disturbed tributaries and riparian forest stretches (Hussain & Choudhury, 1990; Nawab, 2013). Their elusive nature and sensitivity to disturbance may explain the lack of contemporary sightings in high-disturbance zones.

Anthropogenic threats remain a significant concern across the basin. Illegal fishing practices, including the use of gill nets, pose direct threats to dolphins and otters, often resulting in accidental entanglements and mortality. Sand mining disrupts benthic habitats and increases turbidity, thereby affecting prey availability and altering channel morphology. Furthermore, flow regulation through upstream dams and barrages interferes with the natural hydrological regime, fragmenting habitat, altering sediment deposition patterns, and degrading critical breeding and feeding zones (Choudhury et al., 2012; Badola et al., 2025). These pressures cumulatively threaten the long-term viability of aquatic fauna and demand urgent, well-informed river basin management interventions.

REFERENCES

Badola, R., Das, G. C., Sharma, S. P., Usmani, A. A., Barthwal, S., Badola, S., & Hussain, S. A. (2025). Mapping hotspots and unveiling drivers of mortality in the endangered Gangetic dolphin (*Platanista gangetica*) to mitigate human-mediated conservation conflicts in the Ganga River Basin, India. *Ecological Informatics,* Article 103239.

Braulik, G. T., Arshad, M., Noureen, U., & Northridge, S. P. (2014). Habitat fragmentation and species extirpation in freshwater ecosystems: Causes of range decline of the Indus River dolphin (*Platanista gangetica* minor). *PLOS ONE, 9*(7), e101657.

Braulik, G., Atkore, V., Khan, M. S., & Malla, S. (2021). *Review of scientific knowledge of the Ganges river dolphin*. WWF report commissioned by the World Bank.

Choudhary, S., Dey, S., Dey, S., Sagar, V., Naird, T., & Kelkar, N. (2012). River dolphin distribution in regulated river systems: Implications for dry-season flow regimes in the Gangetic Basin. *Aquatic Conservation: Marine and Freshwater Ecosystems, 22*(1), 11-25.

Das, G. C., Sharma, S. P., Ali, S. Z., Gawan, S., Usmani, A. A., Sarkar, A., Katdare, S., Rawat, A., Gangaimaran, P., Panda, A. K., & Agnihotri, U. (2022). Prioritising river stretches using multi-modelling habitat suitability of Gangetic dolphin (*Platanista gangetica*) as a flagship species for aquatic biodiversity conservation in the Ganga River Basin, India. *Ecological Indicators,* 145, 109680.

Das, B. K., Bhakta, D., Johnson, C., Chanu, T. N., Ramteke, M., Chauhan, S. K., Ray, A., Nandy, S., Kunui, A., Roy, S., & Mohanty, T. R. (2025). Status of Ganges River dolphin (*Platanista gangetica* Lebeck, 1801) in the lower stretch of the Ganga River, India, with emphasis on threats, conservation, and recommendations. *Frontiers in Ecology and Evolution,* 13, 1523537.

Hussain, S. A. (1993). *Aspects of the ecology of smooth coated otter (Lutra perspicillata) in National Chambal Sanctuary* (Unpublished doctoral dissertation). Centre for Wildlife and Ornithology, Aligarh Muslim University, Aligarh, India.

Hussain, S. A., & Choudhury, B. C. (1997). Distribution and status of the smooth coated otter (*Lutra perspicillata*) in National Chambal Sanctuary, India. *Biological Conservation, 80*(2), 199-206.

Hussain, S. A., & Choudhury, B. C. (in press). A preliminary survey of the status and distribution of smooth coated otter (*Lutra perspicillata*) in the National Chambal Sanctuary. In Proceedings of the 1st International Seminar on Asian Otters, Bangalore, India.

Hussain, S. A., Badola, R., Sharma, R., & Rao, R. J. (2013). Planning conservation for Chambal River basin taking gharial (*Gavialis gangeticus*) and Ganges River dolphin (*Platanista gangetica*) as umbrella species. In *Faunal Heritage of Rajasthan, India: Conservation and Management of Vertebrates* (pp. 135-156). Cham: Springer International Publishing.

Kelkar, N., Krishnaswamy, J., Choudhary, S., & Sutaria, D. (2010). Coexistence of fisheries with river dolphin (*Platanista gangetica*) conservation. *Conservation Biology, 24*(4), 1130-1140.

Nair, A. K. (2009). The status and distribution of major aquatic fauna in the National Chambal Gharial Sanctuary in Rajasthan with special reference to the Gangetic Dolphin *Platanista gangetica gangetica* (Cetartiodactyla: Platanistidae). *Journal of Threatened Taxa*, 141-146.

Nawab, A. (2013). Conservation prospects of smooth coated otter (*Lutrogale perspicillata* Geoffroy Saint-Hilaire, 1826) in Rajasthan. In *Faunal Heritage of Rajasthan, India: Conservation and Management of Vertebrates* (pp. 273-283). Cham: Springer International Publishing.

Paudel, S., Koprowski, J. L., & Cove, M. V. (2020). Seasonal flow dynamics exacerbate overlap between artisanal fisheries and imperiled Ganges River dolphins (*Platanista gangetica*). *Scientific Reports, 10*(1), 18798.

Paudel, S., Koprowski, J. L., Thakuri, U., & Karki, A. (2021). In-stream habitat availability for river dolphins (*Platanista gangetica*) in response to flow: Use of ecological integrity to manage river flows. *PLoS ONE, 16*(7), e0241099.

Sharma, R. K., & Singh, L. A. K. (2014). Status of Gangetic Dolphin (*Platanista gangetica*) in National Chambal Sanctuary after thirty years. *Zoos' Print Magazine, 29*(7), 22-27.

Singh, L. A. K., & Sharma, R. K. (1985). Gangetic dolphin (*Platanista gangetica*): Observations on habits and distribution pattern in National Chambal Sanctuary. *Journal of the Bombay Natural History Society, 82*(3), 648-653.

Singh, H., & Rao, R. J. (2017). Status, threats and conservation challenges to key aquatic fauna (crocodile and dolphin) in National Chambal Sanctuary, India. *Aquatic Ecosystem Health & Management, 20*(1-2), 59-70.

Sinha, R. K. (1997). Status and conservation of Ganges River dolphin (*Platanista gangetica*) in Bhagirathi-Hooghly River systems in India. *International Journal of Ecology and Environmental Sciences, 23*(4), 343-355.

Smith, B. D., & Reeves, R. R. (2000). Survey methods for population assessment of Asian river dolphins. *Environmental Conservation*, 3, 341-350.

Yadav, N. S., Sharma, M. P., Kumar, A., & Pani, S. (2014). Water quality assessment of Chambal River in National Chambal Sanctuary of Madhya Pradesh. In *Ecological sustainability: Concept, principle, evidences and innovations* (pp. 44-52).

CHAPTER 8

WATER QUALITY OF CHAMBAL RIVER: POLLUTION THREATS AND HOTSPOT ASSESSMENT

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Ruchika Sah

Contributing Authors
Pooja Chaudhary, Samridhi Gururani, Soham Dutta, Anjali Bhandari, Swati Negi

SUMMARY

The Chambal is hydrologically intact, statutorily protected, and chemically compromised on parameters its regulatory framework does not monitor. This is the central finding of the 2021 to 2025 contamination assessment across nine stations from Nagda to the upstream Yamuna confluence. The river that feeds the only protected gharial habitat in India, the National Chambal Gharial Sanctuary, is presently managed through monitoring instruments that capture biochemical oxygen demand, dissolved oxygen and faecal coliforms, while the contaminant flux to which the gharial (*Gavialis gangeticus*), a confirmed sub-population of the endangered Gangetic dolphin (*Platanista gangetica*), the mugger crocodile (*Crocodylus palustris*), the smooth-coated otter, and several freshwater turtle species are actually exposed is dominated by heavy metals, plasticisers, persistent organic pollutants and emerging contaminants. The two signals are independent. Sustaining conventional compliance will not address the unmonitored flux; addressing the unmonitored flux will not displace the conventional programme.

This chapter presents an integrated, evidence-based assessment of the Chambal across nine sampling stations from Nagda to the upstream Yamuna confluence, three contamination matrices (surface water, sediment, fish biota), two seasons (pre-monsoon and post-monsoon), and four monitoring years (2021, 2023, 2024, 2025). Results are reported at three nested spatial scales: river-wide, zone-wide (Vindhyan, Middle, Lower) and state-wide, with the 2025 annual mean defining current status and 2021-2025 trends distinguishing parameter responding to mitigation from those of continuing concern.

Surface water quality exceeds established thresholds at the majority of stations: 89 % exceed the conductivity criterion, 67 % exceed total dissolved solids, and 33 % exceed salinity. Heavy metals are the dominant contaminant class by mass across all three matrices with chromium, zinc, nickel and copper jointly contributing 83 % of the load. Fish-tissue ΣHMs (22,295 µg/kg river-wide mean) exceed total endocrine-disrupting chemicals in the same biota by approximately 100-fold, establishing heavy metals as the principal contaminant mass in the sanctuary food web. The pattern reflects the combined influence of upstream industrial effluent, urban-industrial discharge at Kota, tributary loading from the Parvati and Banas sub-catchments, and sand-mining-mediated sediment remobilisation. Emerging endocrine-disrupting chemicals are present river-wide and fall outside the regulatory framework. Phthalate esters dominate across water (ΣPAEs 2,878 ng/L), sediment (486 µg/kg) and fish biota (194 µg/kg), reflecting plastic waste leachate, untreated municipal sewage, agricultural plastic residues and fishing gear inputs. Bisphenol A is detectable at all stations and reaches its sediment peak at the basin export point. Pharmaceutical residues reach a river-wide maximum of 105 ng/L at the upstream Yamuna confluence, confirming cumulative domestic-effluent loading at the export point. India presently prescribes no ambient, discharge or monitoring standards for any of these compound classes.

The contamination signal is spatially concentrated at four monitoring stations that carry the operational priority. Nagda (Vindhyan Zone) shows a chlor-alkali industrial signature on a historically polluted upstream stretch. Kota (sanctuary boundary) discharges 155.33 MLD of untreated municipal sewage daily, against 236.17 MLD generated, 158 MLD installed and 80.84 MLD actually treated. Parvati Confluence (Middle Zone) carries the river-wide sediment phthalate hotspot (1,160 µg/kg, more than double any other station) and a chromium-copper signature that propagates into the river-wide fish bioaccumulation peak. Upstream Yamuna Confluence is the basin export point, carrying the fish bioaccumulation peak for heavy metals and organophosphate pesticides delivered into the Ganga.

Sand mining is also identified as the plausible non-biological driver of the river-wide ionic exceedance signal, because TDS, conductivity and salinity peak together at the Middle Zone confluences while nitrate stays low, a signature consistent with carbonate and pore-water salt remobilisation from disturbed bed material rather than sewage or fertiliser runoff. Regulating sand mining is therefore a pollution abatement instrument, not solely a wildlife protection one.

Ecological risk follows a non-monotonic but spatially diagnostic distribution. Across the assessed corridor of Chambal River, 22 % is high risk and 5 % very high risk. The Middle Zone (Kota to Sabalgarh, 320 km) is the most stressed segment (53 % high, 47 % moderate). The Lower Zone (Dholpur to upstream Yamuna confluence, 237 km) is 21 % high and 79 % moderate. The combined High-risk burden of both zones falls entirely within the National Chambal Gharial Sanctuary, which spans 485 km and constitutes 57 % of the assessed corridor.

Bioaccumulation is confirmed across the contaminant spectrum. Benthic species (*Labeo bata, Labeo gonius, Rhinomugil corsula, Gonialosa manmina*) exceed pelagic species in tissue heavy metal burden by 5 to 10-fold, identifying sediment ingestion as the dominant uptake pathway. Documented gharial prey species at Dholpur carry the river-wide phthalate and organophosphate pesticide peaks, confirming direct exposure of the apex predator through the prey base.

Contamination patterns invert by season: emerging contaminants peak post-monsoon under sewage overflow and plastic leachate mobilisation, while heavy metals and legacy contaminants peak pre-monsoon under reduced dilution. The single most consequential observation in the dataset is a pre-monsoon hypoxic event at D/S Kota Barrage, with dissolved oxygen at 2.80 mg/L, below the 4 mg/L aquatic life floor, located precisely at the sanctuary boundary. Post-monsoon nitrate exceeds 10 mg/L at Banas Confluence and approaches it at Parvati Confluence; the annual mean masks both excursions. No single sampling window captures the full burden, and no single source-control instrument is sufficient on its own.

The 2021 to 2025 trend record shows the current regulatory framework is not delivering sustained decline in any contaminant class. Heavy metals and organochlorine pesticides spiked in 2023 and remain several-fold above 2021 baselines despite existing instruments. Three of five unregulated emerging classes are escalating unchecked: pharmaceuticals, personal care products, and steroids. Bisphenol A and phthalates are declining, but for reasons unrelated to formal regulation (no contaminant-specific standard exists for either), most plausibly the indirect effect of plastic waste interception under Namami Gange and the single-use plastic ban.

Closing the documented gaps requires four sequenced priority tiers, building on the National Mission for Clean Ganga's existing geographic focus and extending it to the contaminant classes and pathways currently outside its instrument set. The priority tiers below address enforcement, performance, coverage and structural reform in sequence.

Priority 1- Immediate (0 to 6 months): Enforcement and capacity action at critical stations.

Issue Environment (Protection) Act compliance orders for the underperforming Kota STPs, with 90-day remediation and financial penalty. Commission the three Kota STPs under installation within the NGT-mandated March 2026 deadline. Initiate independent receiving-water characterisation downstream of the Nagda industrial cluster and re-open the 2020 decision to substitute in-situ bioremediation for hard treatment capacity at Nagda. Operationalise the Supreme Court direction on sanctuary protection: seal illegal mining sites, geo-fence boundaries, establish anti-mining check posts. Finalise drain-wise plans for the remaining untapped Kota drains. Initiate pre-monsoon floodplain plastic cleanup at Nagda, Kota, Dholpur and the Etawah confluence. Establish dedicated tributary monitoring nodes at the Parvati and Banas confluences, the two largest non-Kota contributors to the sanctuary inflow, as permanent stations under the National Water Monitoring Programme.

Priority 2- Near-term (6 to 24 months): Close performance and monitoring gaps.

Convert all sanctuary-corridor STP contracts at Kota and Dholpur to performance-based agreements with effluent-linked payment and CPCB-SPCB dashboard integration. Extend the NWMP suite at all nine stations beyond BOD-DO-coliforms to a chlor-alkali diagnostic panel (chloride, sulphate, sodium, mercury, lead, aluminium) and emerging contaminants (phthalates, BPA, pharmaceuticals, personal care products). Complete independent quarterly receiving-water characterisation downstream of the Nagda industrial cluster. Re-evaluate the in-situ bioremediation pilot at Nagda against the originally committed 16 MLD STP. Complete cooling tower retrofit and ETP commissioning at the Kota thermal complex within the NGT timeline. Deploy DEWATS along sanctuary-adjacent settlements in Madhya Pradesh and Uttar Pradesh to close the rural treatment gap.

Priority 3-Medium-term (2 to 4 years): New instruments for coverage gaps.

Notify ambient water quality criteria for priority emerging contaminants under the Water (Prevention and Control of Pollution) Act. Adopt a unified, contaminant-aware basin classification that replaces the present inconsistent CPCB Priority I (Madhya Pradesh) and Priority V (Rajasthan) designations. Operationalise the Ganga Ecological Risk Index framework, with Critical Conservation Corridor and Dolphin Conservation Tier multipliers, at all nine Chambal stations on an annual basis. Establish source-apportionment surveillance of the Banas sub-catchment lead-zinc mining belt and the Parvati sub-catchment metal-finishing cluster, with the Cr-Cu-Zn signature and the Pb-Zn signature as analytical priorities. Operationalise the Sustainable Sand Mining Management Guidelines basin-wide, with district mining plans excluding sanctuary and 1 km buffer areas from any auction or lease. Scale up manufactured sand and recycled construction aggregate alternatives to reduce river sand demand in the basin construction market. Extend Plastic Waste Management Rules Extended Producer Responsibility enforcement to the riparian urban catchments to reduce the phthalate and Bisphenol A loading that dominates the sanctuary EDC profile.

Priority 4-Long-term (4 to 10 years): Structural and institutional reform.

Establish a Tri-State Chambal Coordination Committee chaired by DG, NMCG, with a dedicated National Chambal Gharial Sanctuary Sub-Committee under the three state Chief Wildlife Wardens. Embed contaminant-aware species management plans for the gharial, dolphin and mugger under Project Dolphin and the National Wildlife Action Plan. Operationalise environmental flows in the Gandhi Sagar to Kota Barrage impoundment chain through dam operating rules calibrated to gharial nesting and dolphin habitat. Develop a Chambal sediment management plan for the four impoundments. Institutionalise the contamination monitoring network at the Ganga Aqua Labs, WII, as a permanent NMCG programme with a public dashboard.

8.1 Introduction

The Chambal River is the largest right-bank tributary of the Yamuna and one of the most ecologically significant rivers of the Ganga basin. Its lower 425 km stretch constitutes the National Chambal Gharial Sanctuary, a tri-state protected area that supports the largest surviving wild population of the critically endangered gharial (*Gavialis gangeticus*), a viable sub-population of the Gangetic dolphin (*Platanista gangetica*), the mugger crocodile, smooth-coated otter, several species of freshwater turtles and a rich assemblage of resident and migratory waterbirds (WII-GACMC, 2022).

Despite its protected status and its long-held reputation as one of the relatively cleaner rivers of the Ganga basin, the Chambal corridor is increasingly exposed to chemical pressures arising from upstream industrial discharge, urban expansion at Kota and surrounding towns, agricultural intensification in the Malwa and Chambal ravines region, sediment trapping at the Gandhi Sagar, Rana Pratap Sagar, Jawahar Sagar and Kota Barrage hydraulic structures, and tributary loading from the Parvati, Banas and other sub-catchments. Because the Chambal ultimately discharges into the Yamuna, which in turn joins the Ganga at Prayagraj, the contamination signature of the Chambal directly influences the chemical quality of the Ganga main stem and is therefore of direct relevance to the National Mission for Clean Ganga and the Ministry of Jal Shakti. This chapter responds to that policy mandate by providing an integrated, evidence-based assessment of the Chambal River that covers three contamination matrices, two seasons and four monitoring years. The assessment is built around following objectives:

i. Investigate the contamination status and spatiotemporal distribution of legacy and emerging contaminants, particularly endocrine-disrupting compounds (EDCs), in biotic and abiotic matrices across the Chambal River.

ii. Assess the ecotoxicological risks posed by priority emerging contaminants to aquatic organisms and their food webs in the Chambal River.

iii. Integrate contaminant exposure profiles to inform spatial prioritization of pollution abatement interventions for aquatic species conservation in the Chambal River.

This evidence-based analysis is intended to inform policy, restoration strategies, and conservation efforts for improving the health and sustainability of the Chambal River ecosystem.

Results are presented at three nested spatial scales, river-wide, zone-wide and state-wide, to support both basin-scale policy and site-specific operational decisions.

8.2 Methodology

Study area and zonation

For the purposes of this assessment the Chambal River has been divided into three contiguous zones reflecting catchment character, hydraulic regulation and dominant pressure types:

1. Vindhyan Zone (380km), extending from origin to downstream of the Rana Pratap Sagar Dam, representing the upper Chambal under the combined influence of industrial inputs around Nagda and impoundment-induced flow regulation. This zone lies upstream of the National Chambal Gharial Sanctuary.
2. Middle Zone (320km), extending from downstream of the Kota Barrage to Sabalgarh, characterised by urban discharge at Kota, tributary loading from the Parvati and Banas, and the trans-boundary Rajasthan-Madhya Pradesh ravine landscape. This zone lies almost entirely within the National Chambal Gharial Sanctuary, with the upstream site (C3, D/S Kota Barrage) located at the sanctuary boundary.
3. Lower Zone (237km), extending from Dholpur to the upstream of the Yamuna confluence near Etawah, lying entirely within the National Chambal Gharial Sanctuary and ending at the principal export point of the Chambal into the Yamuna and the Ganga basin.

This report presents water quality conditions and chemical contamination levels based on recent sampling data collected in 2025 to provide the current status.

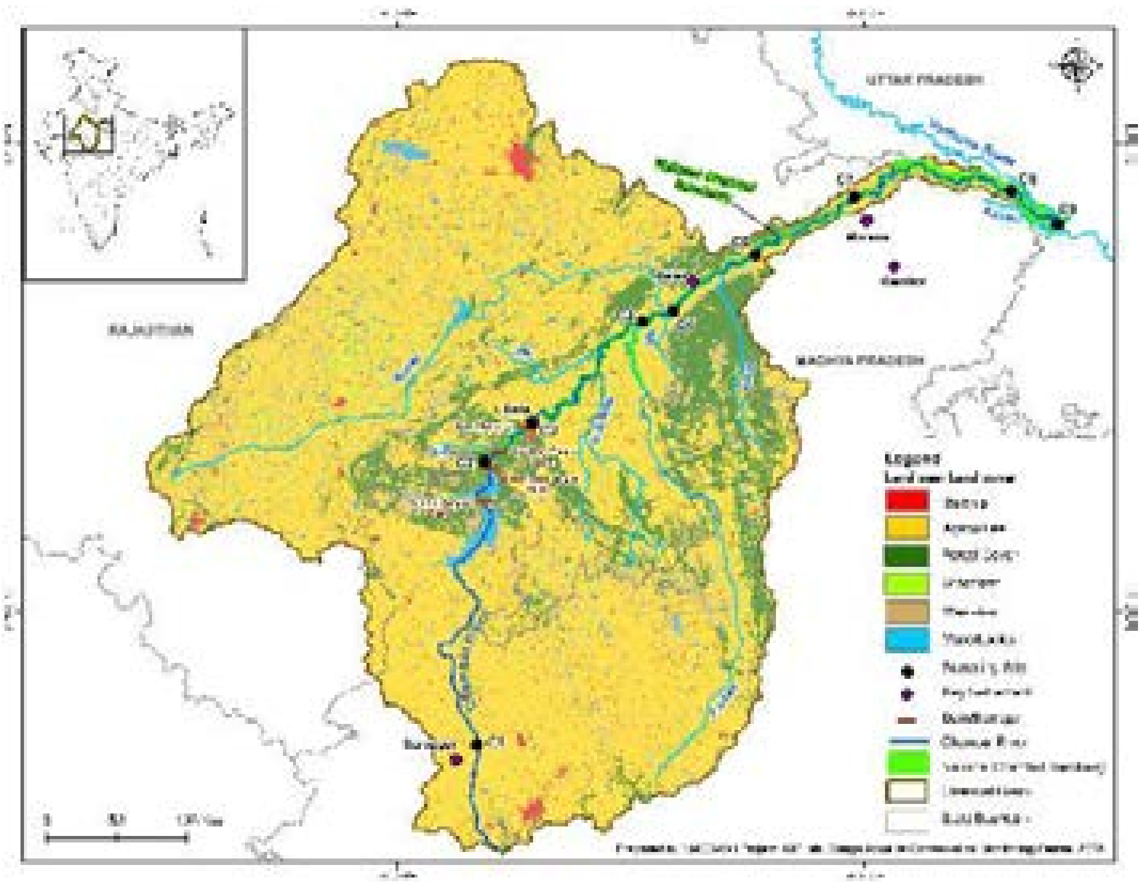


Figure 8.1: Spatial distribution of Sampling Sites along the Chambal River

Sampling Strategy

Surface water, sediment and fish samples were collected from nine designated sampling sites along the Chambal River (Figure 8.1; Table 8.1) in accordance with standard sampling protocols and established guidelines. Sampling campaigns were conducted during the pre-monsoon (April to June) and post-monsoon (October to December) periods in 2021, 2023, 2024 and 2025.

Physical and chemical properties of surface water were measured in situ using a ProDSS Multiparameter Digital Water Quality Meter (YSI, USA). At each site, four to five grab samples were collected at an average depth of 0 to 15 cm below the water surface and bulked into a single composite sample. At confluence sites, water and sediment were sampled within the zone of mixing of tributary and main-stem water. Samples were collected in pre-cleaned amber glass bottles (water) and aluminium-foil-lined zip-lock pouches (sediment), labelled, preserved at 4°C during transport and processed within 48 to 72 hours of collection. A total of 17 fish species were sampled from routine catches of local fishermen at sites where fish were available. Total length and body weight were recorded in the field, specimens were identified on site, sealed in labelled bags, transported in ice-boxes to the laboratory and stored at minus 20 °C until processing.

Table 8.1: Details of Sampling locations in Chambal River

Code	Site	Zone	State	District	Latitude	Longitude
C1	Nagda	Vindhyan Zone	Madhya Pradesh	Ujjain	23.1455	75.5091
C2	D/S Ranapratap Sagar		Rajasthan	Chittorgarh	24.9631	75.5585
C3	Kota	Middle Zone	Rajasthan	Kota	25.2172	75.8587
C4	Parvati Confluence		Madhya Pradesh	Sheopur	25.8586	76.5726
C5	Banas Confluence		Rajasthan	Morena	25.9306	76.7735
C6	Sabalgarh		Rajasthan	Morena	26.2902	77.2963
C7	Dholpur	Lower Zone	Madhya Pradesh	Bhind	26.6590	77.9334
C8	Bhind		Uttar Pradesh	Etawah	26.6980	78.9344
C9	U/S Yamuna Confluence		Uttar Pradesh	Etawah	26.4856	79.2397

Sample treatment and instrument analysis

Sample preparation and analysis followed established and validated in-house methods for the relevant contaminant classes across the different matrices (Sah et al., 2024a; Sah et al., 2024b). Target analytes were identified and quantified using Ultra-High Performance Liquid Chromatography Tandem Mass Spectrometry (UHPLC-MS/MS), Gas Chromatography Tandem Mass Spectrometry (GC-MS/MS) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) at the Ganga Aqua Labs, Wildlife Institute of India. Data quality was ensured through in-house standard operating procedures, multipoint calibration against certified reference standards, reagent blanks, recovery checks against Standard Reference Materials and replicate analyses. The full list of target chemicals is provided in Table 8.2.

Table 8.2: Target chemicals monitored

Category	Number of analytes (Total No: 61)
Plastics Additives	7 Phthalates (PAEs) and BPA
Polychlorinated Biphenyls (PCBs)	7 (Priority Congeners)
Pesticides	26 : Organochlorine Pesticides (OCP): 20 compounds
	Organophosphate Pesticides (OPP): 6 compounds
Hormones	Natural (3) and Synthetic (2: Pharmaceutics)
Personal care products (PCPs)	Anti-microbial (2)
Pharmaceuticals (Pharma)	5 (Analgesic / Antipyretic, Central Nervous System Stimulant, Non-Steroidal Anti-Inflammatory Drug (NSAID), Anti-inflammatory and pain relief, Antibiotic)
Heavy Metals (HMs)	9 (Mercury, Cadmium, Lead, Arsenic, Chromium, Cobalt, Zinc, Nickel, Copper)

8.3 Results and Discussion

8.3.1. Annual and Seasonal Water Quality Assessment of the Chambal River (2025)

Six principal pollution indicators were assessed across the nine monitoring sites: dissolved oxygen (DO), pH, total dissolved solids (TDS), conductivity, nitrate and salinity. For each parameter, results are summarised at three spatial scales: river-wide, zone-wide and state-wide. The 2025 annual mean classifies 67% of the Chambal stretch as meeting good water quality criteria and 33% as poor (Table 8.3). Conductivity is the dominant driver of non-compliance, followed by TDS and salinity, while DO and nitrate achieved full river-wide compliance, although DO compliance is seasonally conditional.

Two principal driver complexes underlie the observed water quality pattern. The first is diffuse anthropogenic loading from municipal activity, agricultural runoff, religious tourism and recreational use, concentrated in the Middle Zone. The second is a set of hydrological and sediment-associated processes in the Lower Zone, particularly near the Yamuna-Chambal confluence, that enhance the retention and redistribution of contaminants exported downstream.

Table 8.3: Current River-wide Water Quality Status of the Chambal River Based on 2025 Annual Mean

Parameter	Threshold	River-wide Mean±SEM	Good (%)	Poor (%) (%)	Priority Pollution Zones
DO (mg/L)	≥5	7.89 ± 0.47	100	-	-
pH	6.5-8.5	8.27± 0.06	89	11	LZ (33%)
TDS (mg/L)	£500	548± 59.42	33	67	VZ (50%), MZ (75%), LZ (67%)
Conductivity (µS/cm)	£500	831± 94.49	11	89	VZ (50%), MZ (100%), LZ (100%)
Nitrate	<10	2.85 ± 0.51	100	-	-
Salinity (ppt)	<0.5	0.41 ± 0.05	67	33	VZ (50%), MZ (25%), LZ (33%)

Vindhyan Zone: VZ; Middle Zone: MZ; Lower Zone: LZ

Table 8.4: Zone-wide assessment of physical-chemical parameters based on 2025 Annual Mean

	Zone-wide			
Category	Vindhyan Zone	Middle Zone	Lower Zone	River Wide (Annual Mean±SEM)
DO (mg/L)	6.47 - 6.80	5.31-9.69	8.09-8.81	7.89±0.47
pH	8.06-8.29	7.95-8.41	8.33-8.52	8.27± 0.06
TDS (mg/L)	267 - 837	342 - 715	465 - 664	548 ± 59.42
Cond (µS/cm)	423 - 1339	541 - 1126	721 - 981	831 ± 94.49
Nitrate (mg/L	1.51 - 2.87	0.97 - 6.15	2.13 - 3.74	2.85 ± 0.51
Salinity (ppt)	0.19 - 0.85	0.25 - 0.54	0.34 - 0.50	0.41 ± 0.05

Dissolved Oxygen (threshold ≥5 mg/L)

River-wide. DO, the primary indicator of aquatic habitat viability, recorded an annual river-wide mean of 7.89 ± 0.47 mg/L, with all monitored sites meeting the threshold of 5 mg/L (Table 8.3). The river-wide oxygen regime is therefore well within the range required to sustain aquatic life. The single most consequential observation is the pre-monsoon DO at D/S Kota Barrage (2.80 mg/L), falling below the 4mg/L absolute floor and identifying a severe hypoxic event at the sanctuary boundary (Table 8.5). Post-monsoon DO is uniformly elevated (7.70 to 11.10 mg/L) across the river, confirming recovery after monsoon flushing (Table 8.5).

Zone-wide. The Vindhyan Zone shows compliant but sub-optimal DO (6.47 to 6.80 mg/L), with the lower bound at D/S Rana Pratap Sagar pre-monsoon reflecting limited reaeration through the impoundment chain. The Middle Zone displays the widest range on the river (2.80 to 11.10 mg/L), with the Kota hypoxic event at the lower extreme and the Parvati Confluence post-monsoon supersaturation at the upper. Continuous DO and BOD profiling at D/S Kota Barrage during the pre-monsoon low-flow window is recommended, with regulatory follow-up on Kota urban discharge through RSPCB and the NMCG sewage abatement programme (Table 8.4; Figure 8.2a).

pH (threshold 6.5-8.5)

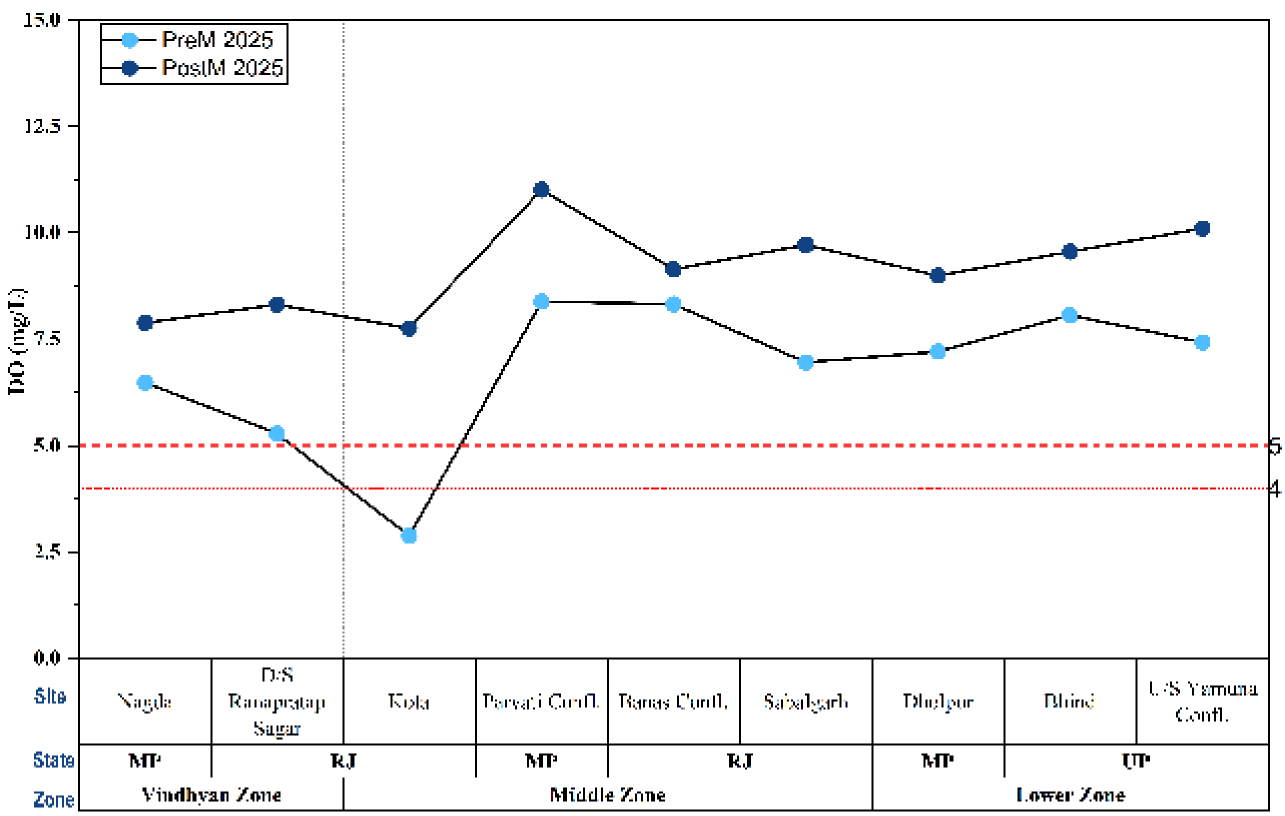
River-wide:

The annual mean pH was 8.19 ± 0.13, with 89% good and 11% poor observations, primarily associated with upper-threshold exceedances (>8.5), indicating localized alkalinity stress within the river system (Table 8.3). Overall, the river remained slightly alkaline, reflecting moderate anthropogenic influence and carbonate buffering across the study stretch.

Zone-wide:

The Vindhyan Zone (8.06-8.29) remained largely compliant, showing comparatively stable pH conditions with no major exceedance concern. The Middle Zone (7.95 - 8.41) displayed the widest pH fluctuation and recorded the highest pH values across the river stretch, indicating elevated alkalinity likely associated with municipal discharge, agricultural runoff, and localized anthropogenic inputs. This zone contributed the majority of poor observations and reflected persistent alkaline conditions at impacted locations. The Lower Zone recorded consistently alkaline conditions (8.33-8.52), suggesting downstream accumulation of dissolved ions and relatively stable carbonate-rich water chemistry. The occurrence of values exceeding the upper permissible threshold within the Middle Zone indicates localized chronic alkalinity stress that may persist independent of seasonal flow variations (Table 8.4; Figure 8.2b).

Targeted regulation and monitoring of municipal and domestic discharge sources contributing to alkalinity are recommended, particularly within the Middle Zone. Long-term seasonal monitoring of pH and associated nutrient dynamics should be prioritized to minimize ecological stress and maintain riverine water quality stability.



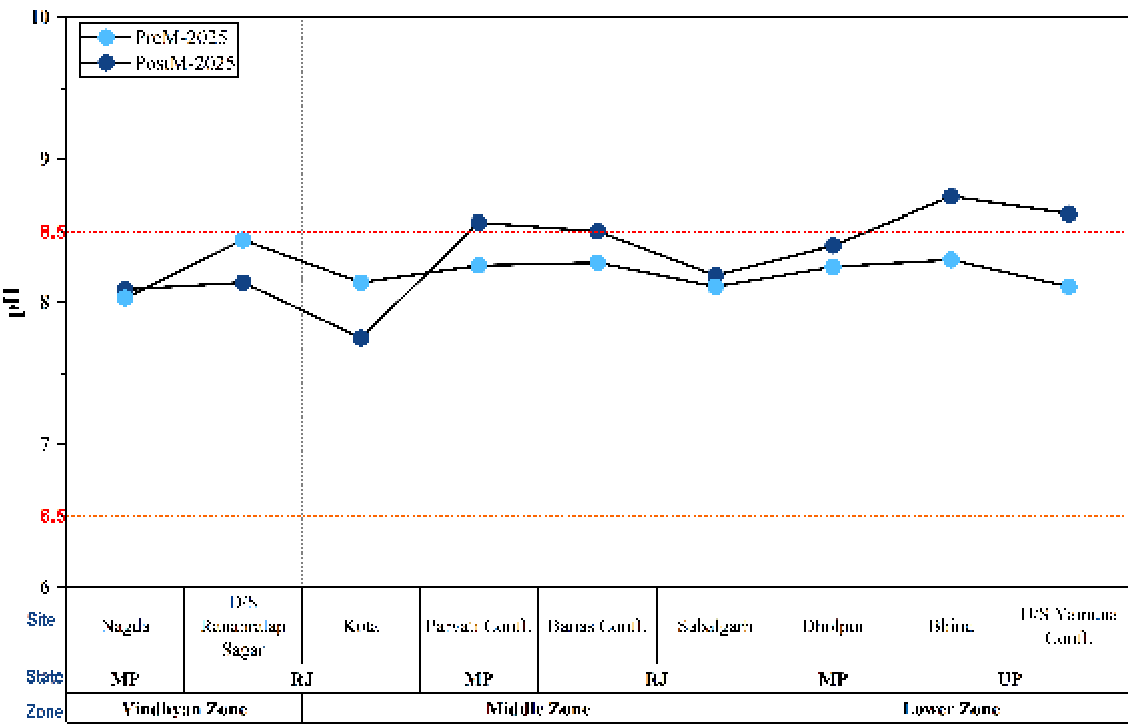


Figure 8.2: Spatiotemporal variation in (a) Dissolved Oxygen (DO, mg/L) (b) pH along the Chambal River 2025. Dashed line denotes the regulatory threshold

Note: MP: Madhya Pradesh; RJ: Rajasthan; UP: Uttar Pradesh.

Table 8.5: Seasonal Fluctuations in Water Quality Condition across Chambal River

		Water Quality Condition (%)				
Season (2025)	**Category**	**DO (mg/L)**	**pH**	**TDS (mg/L)**	**Cond (uS/m)**	**Salinity (mg/L)**
Pre-Monsoon	Good	89%	56%	44%	-	78%
	Poor	11%	44%	56%	100%	22%
Post-Monsoon	Good	100%	100%	56%	22%	89%
	Poor	-	-	44%	78%	11%
Priority Pollution Sites		D/S Kota barrage	Parvati Confl., Banas Confl., Bhind, U/S Yamuna Confl.	Nagda, Parvati Confl., Banas Confl., Dholpur, U/S Yamuna Confl.	Nagda, D/S Ranapratap Sagar, D/S Kota Barrage, Parvati Confl., Banas Confl., Sabalgarh, Dholpur, Bhind, U/S Yamuna Confl..	Nagda, Parvati Confl., U/S Yamuna Confl.

Note: Priority pollution sites are color-coded based on seasonal exceedance patterns: sites marked in green indicate exceedance during the pre-monsoon season, blue indicate exceedance during the post-monsoon season, and orange represent sites showing exceedance in both seasons.

TDS (threshold ≤500 mg/L)

River-wide:

The annual mean TDS was 548 ±59.42 mg/L, with 33% good and 67% poor observations, indicating substantial dissolved solid enrichment across the study stretch (Table 8.3). The river-wide peak is at Nagda pre-monsoon (2.30 times the threshold), declining to half post-monsoon after monsoon dilution. Sustained exceedances are recorded across the Middle Zone, and an anomalous accumulation peak is recorded at the export point (U/S Yamuna Confluence, 790 mg/L post-monsoon) (Table 8.5).

Zone-wide:

The Vindhyan Zone (267 to 1154 mg/L) displayed a strong Nagda-driven TDS fluctuation and recorded the highest concentrations across the river stretch, indicating localized dissolved ion enrichment likely associated with sewage discharge, runoff, and mineral weathering processes. The Middle Zone (342-715 mg/L) shows persistent exceedance at Parvati Confluence, Banas Confluence, and Sabalgarh. The Lower Zone (465-664 mg/L) exhibited consistently elevated TDS levels, reflecting downstream accumulation of dissolved constituents and cumulative anthropogenic influence. Catchment-level audit of industrial discharge at Nagda through MPSPCB and designation of U/S Yamuna Confluence as a priority monitoring node for continuous TDS surveillance is recommended (Table 8.4; Figure 8.3a).

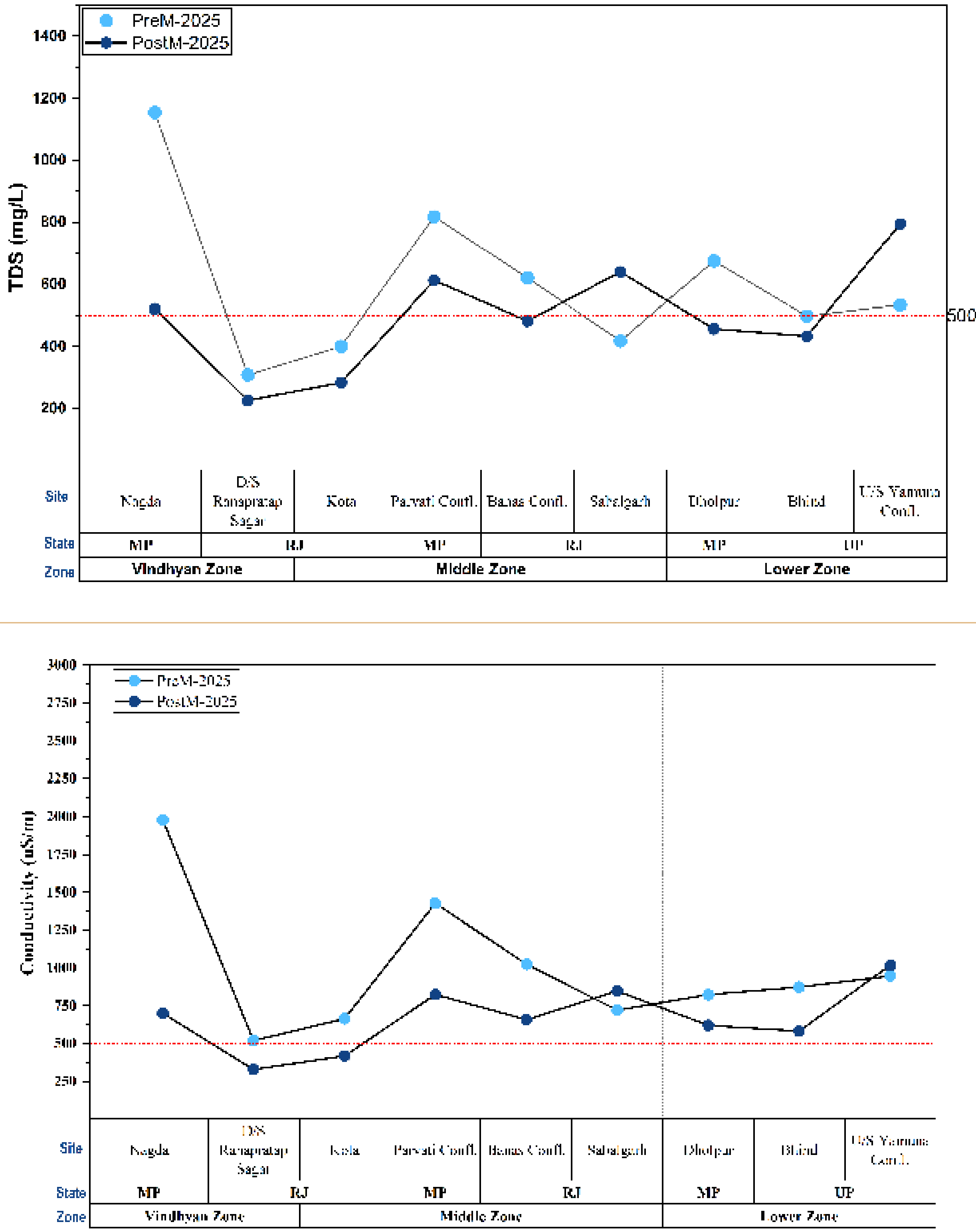


Figure 8.3: Spatiotemporal variation in (a) Total Dissolved Solids (TDS, mg/L) (b) Conductivity (µS/cm) along the Chambal River 2025. Dashed line denotes the regulatory threshold.

Conductivity (threshold ≤500 µS/cm)

River-wide:

Conductivity, reflecting the overall ionic concentration and dissolved pollutant load within the river system, showed substantial compliance stress across the study stretch, with 11% good and 89% poor observations. The annual mean conductivity was 881.31 ± 94.49µS/cm, indicating elevated ionic enrichment and persistent anthropogenic influence throughout the river corridor (Table 8.3). The two largest peaks occur at Nagda pre-monsoon and Parvati Confluence pre-monsoon. Only D/S Rana Pratap Sagar post-monsoon and Kota post-monsoon fall within the compliant range (Table 8.5).

Zone-wide:

The Vindhyan Zone (423 to 1339 µS/cm) remained comparatively stable and largely within permissible limits, although localized exceedances at Nagda above the threshold were observed. The Middle Zone (541-1126 µS/cm) recorded consistently elevated conductivity and contributed a major share of poor observations, indicating substantial ionic loading likely associated with municipal discharge, agricultural runoff, sand-mining and industrial influence particularly at confluence points. The Lower Zone shows uniformly elevated values (721 to 981 µS/cm), with U/S Yamuna Confluence (1020 µS/cm) the highest in the zone. Conductivity is the single most informative low-cost early-warning indicator for the Chambal and should be the primary parameter for sustained NMCG monitoring of the corridor at all nine stations (Table 8.4; Figure 8.3b).

Nitrate (threshold <10 mg/L)

River-wide:

Nitrate, an important indicator of nutrient enrichment and agricultural runoff, recorded a river-wide annual mean concentration of 2.85 ± 0.51 mg/L, which remained well below the prescribed threshold limit of 10 mg/L (Table 8.3). All nine stations were compliant on the annual mean basis. However, seasonal disaggregation reveals a post-monsoon spike at the Banas Confluence that is masked by the annual mean. Post-monsoon nitrate at the Banas Confluence reaches 12.50 mg/L, exceeding the limit, and at Parvati Confluence reaches 8.50 mg/L, approaching it. The annual mean alone therefore understates the ecological-health relevance of this parameter, and seasonal monitoring is essential for accurate compliance assessment (Table 8.5).

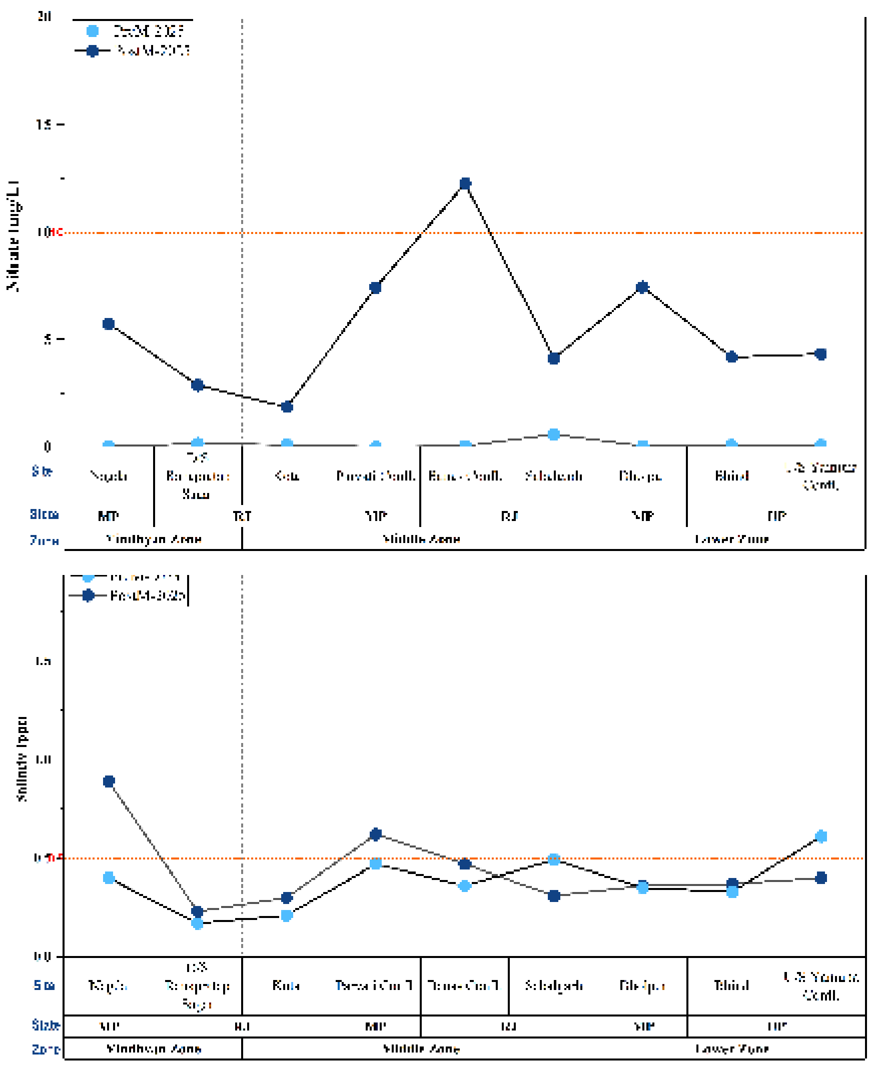


Figure 8.4: Spatiotemporal variation in (a) Nitrate (mg/L) (b) Salinity (ppt) along the Chambal River 2025. Dashed line denotes the regulatory threshold

Zone-wide:

The Vindhyan Zone (1.51 to 2.87 mg/L) shows the most pronounced seasonal variation, with Nagda spiking to 5.73 mg/L post-monsoon. The source is upstream agricultural fertiliser runoff from the Malwa Plateau catchment, mobilised during the late-monsoon recession and concentrated under post-monsoon low-flow conditions, with additional reservoir-mediated nitrogen cycling at the Rana Pratap Sagar Dam. The Middle Zone (0.97 to 6.15 mg/L) shows the widest spatial variability with localised peaks at the Parvati and Banas confluences from tributary loading. The Lower Zone (2.13 to 3.74 mg/L) is uniformly moderate, with no seasonal spike, indicating downstream dilution and in-stream denitrification along the sanctuary stretch. Post-monsoon surveillance is recommended in the Nagda-Ratlam stretch, where the seasonal spike directly exceeds the threshold limit. Catchment-level fertiliser management in the Malwa Plateau through MPSPCB and the State Agriculture Department. Continued seasonal (not annual mean) monitoring at all Vindhyan Zone stations to capture the post-monsoon signal (Table 8.4; Figure 8.4a).

Salinity (<0.5 ppt)

River-wide:

Salinity, reflecting dissolved salt concentration and associated osmotic stress on freshwater biota, recorded an annual mean of 0.41 ± 0.05 ppt, with 67% good and 33% poor observations across the study stretch (Table 8.3). Pre-monsoon showed 78% good and post-monsoon 89% good (Table 8.5). The largest excursion is at Nagda post-monsoon (0.90 ppt), followed by Parvati Confluence post-monsoon (0.62 ppt), U/S Yamuna Confluence pre-monsoon (0.60 ppt) and Sabalgarh pre-monsoon (0.50 ppt)

Zone-wide:

The Vindhyan Zone (0.19 to 0.85 ppt) showed moderate salinity variation, with several observations exceeding the freshwater threshold, indicating localized dissolved salt enrichment likely associated with runoff and evaporative concentration. The Middle Zone (0.25-0.54 ppt) recorded the highest salinity variation and contributed the largest share of poor observations, reflecting substantial ionic loading and localized salt accumulation within impacted stretches. The Lower Zone (0.35 to 0.50 ppt) remained comparatively stable and largely within the freshwater threshold, although values approached the upper permissible limit at several sites. Elevated salinity within the Middle Zone suggests persistent anthropogenic influence and seasonal concentration effects, particularly during reduced flow conditions (Table 8.4; Figure 8.4b).

TDS, conductivity and salinity peak together at the Middle Zone confluences and at U/S Yamuna Confluence, but nitrate stays low. Sewage and fertiliser runoff would raise nitrate in parallel; its absence indicates a non-biological source. Sand mining in the Middle Chambal and the Parvati sub-catchment is the likely driver, dissolving carbonate and sulphate from the disturbed bed and releasing pore-water salts without adding nitrogen. Regulation of sand mining within the sanctuary stretches is therefore a direct NMCG priority for both gharial-dolphin conservation and control of ionic export to the Ganga basin

Current status of Endocrine Disrupting Chemicals (EDCs) and Heavy Metals (HMs) in Chambal River

Endocrine-disrupting chemicals (EDCs) and heavy metals (HMs) are among the most ecologically consequential pollutants due to their persistence, bioaccumulation, mobility, and toxicity. These contaminants adversely affect a wide range of taxa, from primary producers to aquatic mammals, and are continuously released into freshwater systems through agriculture, healthcare, industry, and domestic activities via pathways such as runoff, sewage discharge, landfill leachate, and wastewater effluents. Stormwater events and aging sewer infrastructure further intensify their diffuse loading in urban river reaches.

A detailed analyte-wise assessment is presented below at river-wide and zone-wide scales covering the Vindhyan Zone (Nagda-Ranapratap-Sagar Dam), Middle zone (Kota Barrage-Sabalgarh), and Lower Zone (Dholpur to U/S Yamuna confluence).

8.3.2 Endocrine Disrupting Chemicals (EDCs) and Heavy Metals (HMs) in Surface Water of Chambal River

Endocrine Disrupting Chemicals

River-wide:

The surface water EDC profile is phthalate-dominated across the entire river. The river-wide order is ΣPAEs (2878 ± 305 ng/L) > ΣPharma (28.25 ± 11.28 ng/L) > BPA (23.70 ± 1.94 ng/L) > ΣPCPs (9.37 ± 1.50 ng/L) > ΣOCPs (6.58 ± 1.16 ng/L) > ΣSteroids (3.25 ± 0.66 ng/L) > ΣOPPs (1.94 ± 1.17 ng/L). Phthalate esters (PAEs) dominated the emerging EDC profile, reflecting ubiquitous municipal sewage (domestic PVC, medical waste, cosmetics), solid waste/landfill leachate, and plastic waste contamination. Pharmaceutical residues reach their river-wide maximum at U/S Yamuna Confluence (105 ng/L), confirming cumulative urban-effluent loading at the export point (Table 8.6; Figures 8.5a, 8.6a).

Zone-wide:

The Vindhyan Zone (Nagda- D/S Ranapratap Sagar) exhibited a moderate contaminant burden, with ΣEDCs averaging 2676.63 ± 86.12 ng/L, predominantly driven by ΣPAEs (2633 ± 89.24 ng/L) with maximum values in D/S Rana Pratap Sagar. Elevated phthalates are likely influenced by agricultural runoff carrying plastic residues and agrochemical contaminants, fishing activities involving plastic nets and gear, and improper solid waste disposal along the reservoir margins. BPA (17.67 ± 5.89 ng/L), ΣPharma (12.61 ± 3.81 ng/L), ΣPCPs (9.72 ± 0.75 ng/L), and ΣSteroids (3.54 ± 0.28 ng/L) were comparatively low. Legacy pesticides were minimal, with ΣOCPs (7.61 ± 1.96 ng/L) and absence of ΣOPPs (Table 8.6).

The Middle Zone (D/S Kota Barrage to Sabalgarh) recorded the highest overall contaminant load, with ΣEDCs reaching 3415 ± 414 ng/L, largely due to elevated ΣPAEs (3349 ± 407 ng/L) followed by pharmaceutical (ΣPharma) residues (28.61 ± 11.85 ng/L), and BPA (24.85 ± 2.03 ng/L). This pattern likely reflects intensified urban discharge, plastic waste inputs, wastewater effluents, and reduced flow conditions around the barrage that favor contaminant accumulation.

Table 8.6: Zone-wide Contamination Status of surface water (ng/L) of the Chambal River (2025 Annual Mean)

Analyte	Zone-wide			River-wide
	Vindhyan Zone	Middle Zone	Lower Zone	Mean±SEM
ΣHMs	7400 - 15310 (11350 ± 3960)	8680 - 34410 (21550 ± 12860)	4850 - 18690 (12420 ± 4050)	12860 ± 3120
ΣPAEs	2543 - 2722 (2633 ± 89.24)	2338 - 4164 (3348 ± 407)	1003 - 3286 (2414± 711)	2878± 305
BPA	11.77 - 23.56 (17.67 ± 5.89)	21.30 - 30.6 (24.85 ± 2.03)	22.5 - 32.16 (26.2 ± 3.01)	23.7 ± 1.94
ΣPharma	8.81 - 16.42 (12.61 ± 3.81)	9.54 - 63.25 (28.61 ± 11.85)	1.6 - 104.74 (38.19 ± 33.33)	28.25 ± 11.28
ΣSteroids	3.26 - 3.82 (3.54 ± 0.28)	<DL - 5.35 (3.39 ± 1.18)	<DL - 5.18 (2.87 ± 1.52)	3.25 ± 0.66
ΣPCPs	8.97 - 10.47 (9.72 ± 0.75)	5.09 - 13.26 (10.07 ± 1.96)	0.49 - 15.24 (8.21 ± 4.27)	9.37 ± 1.5
ΣOCPs	5.65 - 9.56 (7.61 ± 1.96)	7.84 - 10.61 (9.13 ± 0.61)	0.57 - 3.83 (2.49 ± 0.99)	6.58 ± 1.16
ΣOPPs	<DL	<DL - 5.16 (1.29 ± 1.29)	<DL- 9.99 (4.08 ± 3.02)	1.94 ± 1.17

<DL: Below (instrument) detection limit;

The D/S Kota Barrage stretch carries elevated phthalates and pharmaceuticals attributable to Kota urban discharge and the sediment-retention effect of the barrage. Legacy pesticides are comparatively elevated here as well (9.13 ± 0.61 ng/L); ΣOPPs detectable at 1.30 ng/L).

The Lower zone (Dholpur to U/S Yamuna Confluence) showed variable contaminant levels, with ΣEDCs averaging 2489 ± 736ng/L. Although ΣPAEs (2414 ± 711 ng/L) remained dominant, pharmaceutical residues were highest in this stretch (38.19 ± 33.33 ng/L). BPA (26.2 ± 3.01 ng/L) and ΣOPPs (4.08 ± 3.02 ng/L) were comparatively elevated, while ΣOCPs declined (2.49 ± 0.99 ng/L). The pharmaceutical peak at the U/S Yamuna Confluence point is the principal Lower Zone finding.

Heavy Metals

River-wide:

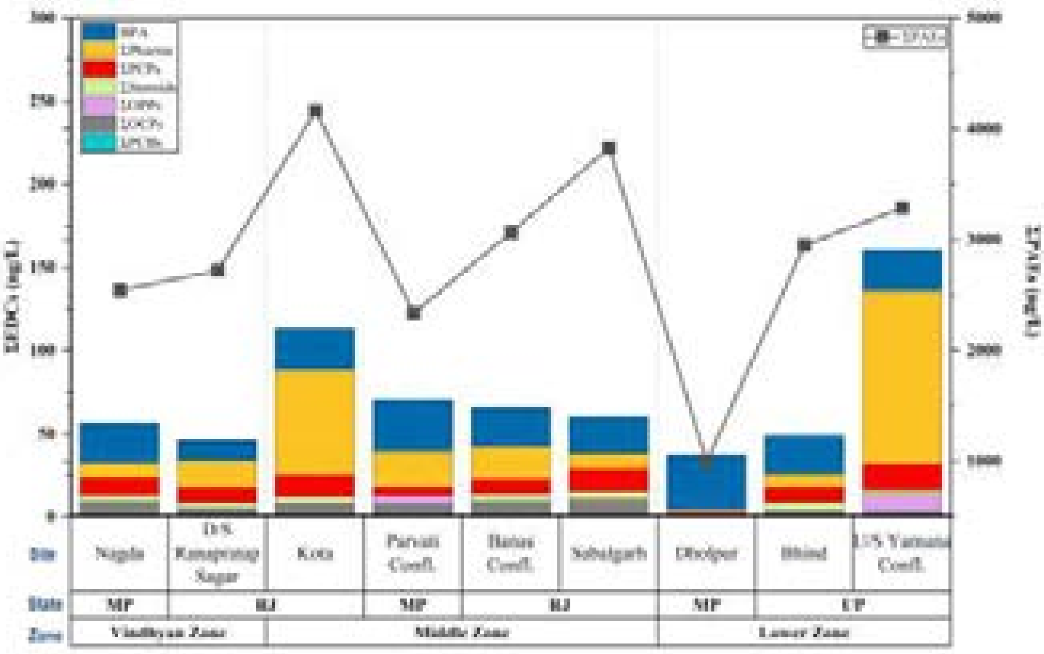
Heavy metals represent a significant contamination, with zonal mean concentrations ranging from 11350 ± 3960 to 21550 ± 12860 ng/L (Table 8.6). Concentrations spanned from 4850 to 34410 ng/L across the river continuum, indicating substantial spatial heterogeneity in metal distribution.

Zone-wide:

The Vindhyan Zone recorded a mean concentration of 11350 ± 3960 ng/L, with values ranging from 7400 to 15310 ng/L. Zinc dominates with secondary cobalt and arsenic contributions attributable to inputs at Nagda. Concentrations are spatially stable across the zone.

The Middle Zone exhibited the highest zonal mean (21550 ± 12860 ng/L), nearly double that of the Vindhyan zone. Concentrations ranged from 8,680 to 34410 ng/L, reflecting marked spatial variability and peak enrichment within this stretch. Chromium dominates near the Kota Barrage, accompanied by zinc and copper. The source mix combines urban-industrial effluent at Kota with the barrage-mediated sediment trapping that promotes localised metal accumulation.

The Lower Zone recorded an intermediate mean concentration (12420 ± 4050 ng/L), with values ranging from 4850 to 18690 ng/L. Arsenic dominates the metal profile upstream of the Yamuna confluence, attributable to geogenic inputs from arsenic-rich alluvial sediments, with secondary contributions from zinc, copper and chromium. Concentrations decline from the Middle Zone peak but remain spatially variable (Table 8.6; Figure 8.5b, 8.6b)



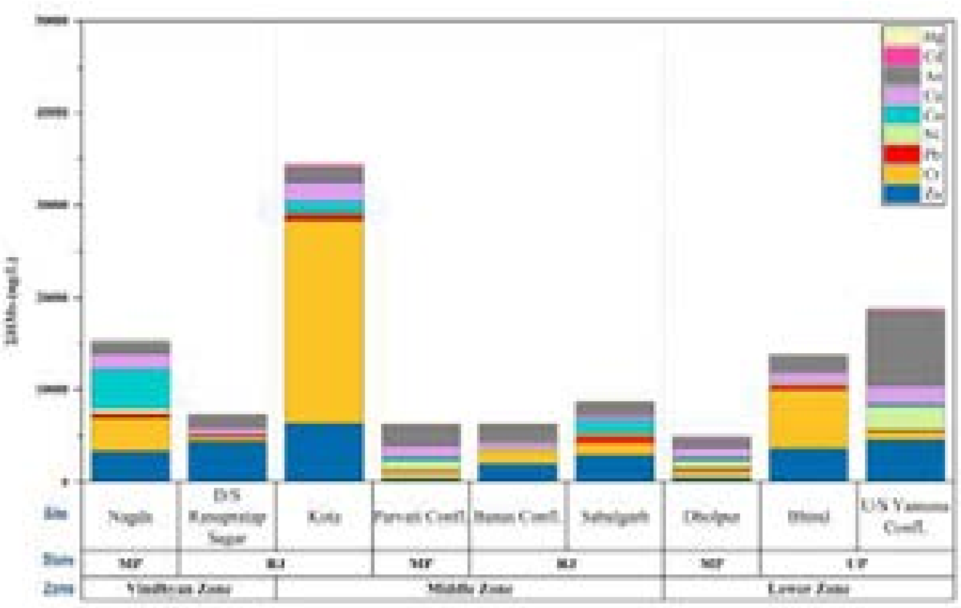


Figure 8.5: Site-wide, zone-wide, and state-wide spatial distribution of (a) legacy and emerging endocrine-disrupting chemicals (EDCs) and (b) heavy metals (HMs) in the surface water of the Chambal River.

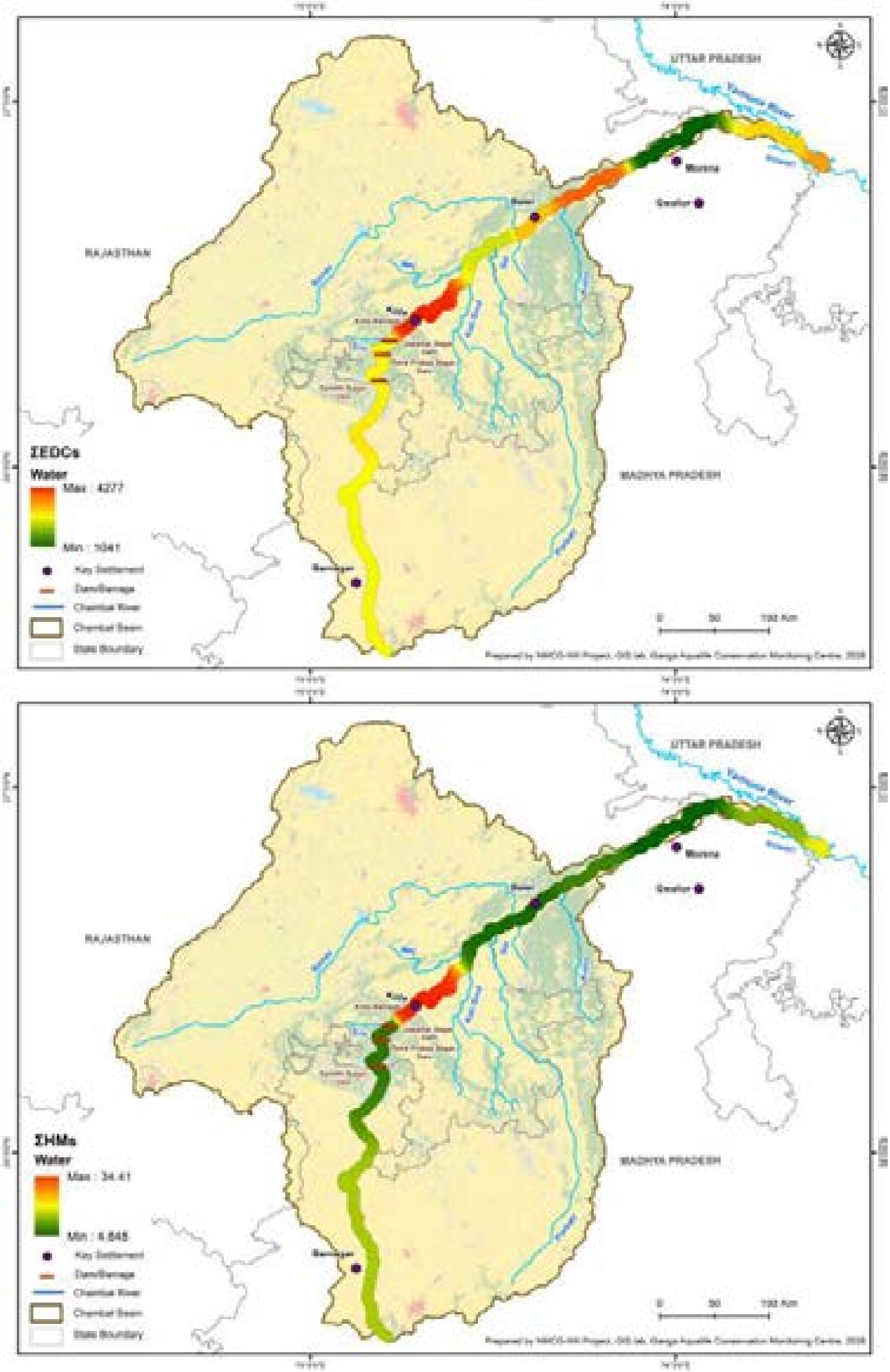


Figure 8.6: Spatial distribution of (a) legacy and emerging endocrine-disrupting chemicals (ΣEDCs; ng/L) and (b) heavy metals (ΣHMs; ng/L) in the surface water of the Chambal River 2025.

Seasonal Dynamics of Legacy and Emerging EDCs in Surface Water of Chambal River

Emerging contaminants (ΣPAEs > BPA > ΣPharma > ΣPCPs > ΣSteroids) peaked post-monsoon, driven by sewage overflow from Kota, urban stormwater first-flush, and plastic leachate mobilisation from riparian solid waste (ΣPharma 41.96 ng/L, BPA 32.36 ng/L). Legacy contaminants (ΣOPPs > ΣOCPs > ΣPCBs) and heavy metals peaked pre-monsoon under lean-flow conditions, with re-suspension of historical residues from disturbed bed sediment (ΣOCPs 9.91 ng/L, ΣHMs 14190 ng/L, declining 27 % post-monsoon). The pre-monsoon co-peak of heavy metals and legacy contaminants identifies the lean-flow phase as the dominant exposure window for the sanctuary food web.

This seasonal inversion confirms that no single monitoring window captures the full contamination burden. NMCG action requires year-round surveillance with season-specific interventions: STP capacity and solid waste management before monsoon onset to reduce the post-monsoon emerging-contaminant spike; industrial discharge regulation in the Parvati and Banas sub-catchments and flow augmentation during lean flows to reduce the pre-monsoon heavy metal and legacy-contaminant peak; and sustained continuous monitoring at all nine stations rather than periodic campaigns (Figure 8.7).

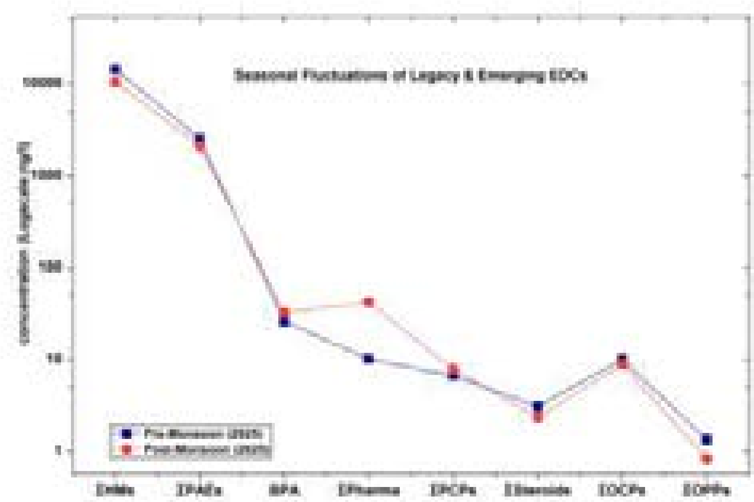


Figure 8.7: Seasonal fluctuations of legacy and emerging Endocrine-disrupting chemicals (EDCs)

8.3.3 EDCs and HMs in surface sediment of Chambal River

Endocrine Disrupting Chemicals

River-wide

Surface sediment is BPA-elevated and phthalate-rich at every station. The contamination profile along the Chambal River follows the order of ΣPAEs (486 ± 96.23 µg/kg) > BPA (18.35 ± 5.68 µg/kg) > ΣPharma (1.99 ± 0.58 µg/kg) > ΣPCPs (1.38 ± 0.33 µg/kg) > ΣOPPs (1.05 ± 0.4 µg/kg) > ΣOCPs (0.17 ± 0.1 µg/kg) > ΣSteroids (<DL). Two spatially distinct hotspots dominate the sediment EDC profile: the U/S Yamuna Confluence carries the highest BPA load on the river (60 µg/kg, more than twice any other station), and the Parvati Confluence carries the highest ΣPAEs load (1160 µg/kg, at least double any other station). Pharmaceutical residues concentrate at D/S Kota Barrage (approximately 7.00 µg/kg), reflecting hospital and pharmaceutical retail effluent in the Kota urban catchment (Table 8.7).

Zone-wide:

In the Vindhayan Zone, total sediment EDCs 528 ± 52.00 µg/kg, dominated by ΣPAEs (509 ± 56.00 µg/kg) and BPA (15.60 ± 5.20 µg/kg). Other classes were present at trace levels (ΣPharma 0.77 ± 0.12 µg/kg; ΣPCPs 0.68 ± 0.25 µg/kg; ΣOCPs 0.02 ± 0.01 µg/kg; ΣSteroids below detection). Nagda shows higher BPA (approximately 20.81 µg/kg) than D/S Rana Pratap Sagar, indicating sustained plastic-additive loading at the industrial reach.

Distribution of EDCs was dominant in the Middle Zone (D/S Kota Barrage-Sabalgarh), with overall EDCs load (594 ± 212 µg/kg), mostly contributed by ΣPAEs (577 ± 208 µg/kg) and then by BPA (11.34 ± 4.61 µg/kg) with the Parvati Confluence carrying highest load. ΣPharma (2.96 ± 1.15 µg/kg), showed the river-wide peak at D/S Kota Barrage whereas ΣPCPs (1.98 ± 0.65 µg/kg), also peaking in this zone. The dual signature (PAEs at Parvati, Pharma and PCPs at Kota) integrates two distinct source types in this single zone.

The Lower Zone showed a lower contaminant burden in surface sediment with total EDCs amounting to (383 ± 108 µg/kg), contributed mostly by ΣPAEs (349 ± 93.07 µg/kg), followed by BPA (29.52 ± 15.43 µg/kg), the rest of them being - ΣPharma (1.52 ± 0.44 µg/kg), ΣPCPs (1.06 ± 0.1 µg/kg), ΣOCPs (0.47 ± 0.24 µg/kg) & ΣOPPs (0.94 ± 0.57 µg/kg) and ΣSteroids (<DL). The BPA peak at U/S Yamuna Confluence (approximately 65.00 µg/kg) is the policy-critical observation in this zone: it identifies sediment accumulation of plastic-derived contaminants immediately before the export point into the Yamuna main stem (Table 8.7; Figure 8.8a, 8.9a).

Table 8.7: Zone-wide Contamination Status of surface sediment (µg/kg) of the Chambal River (2025 Annual Mean)

Analyte	Zone Demarcation			River-wide Mean±SEM
	Vindhyan Zone	Middle Zone	Lower Zone	
ΣHMs	125723-52260 (88992 ± 36731)	28380-199654 (93753 ± 37191)	56533-127951 (95973 ± 20951)	93435 ± 17476
ΣPAEs	453-564 (509.1 ± 55.56)	213-1159 (577.2 ± 207.9)	225-532 (349.89 ± 93.07)	486 ± 96.23
BPA	20.81-10.37 (15.59 ± 5.22)	3.77-24.75 (11.34 ± 4.61)	12.4-60.33 (29.52 ± 15.43)	18.35 ± 5.68
ΣPharma	0.9-0.65 (0.77 ± 0.12)	0.1-5.62 (2.96 ± 1.15)	0.9-2.36 (1.52 ± 0.44)	1.99 ± 0.58
ΣSteroids	<DL	<DL-0.03 (0.01 ± 0.01)	<DL	<DL
ΣPCPs	0.93-0.43 (0.68 ± 0.25)	1.24-3.91 (1.98 ± 0.65)	0.92-1.27 (1.06 ± 0.1)	1.38 ± 0.33
ΣOCPs	0.03-0.01 (0.02 ± 0.01)	0.01-0.03 (0.82 ± 0.51)	<DL-0.76 (0.47 ± 0.24)	0.17 ± 0.1
ΣOPPs	<DL-3.37 (1.68 ± 1.68)	<DL-2.3 (0.82 ± 0.51)	<DL-1.96 (0.94 ± 0.57)	1.05 ± 0.4

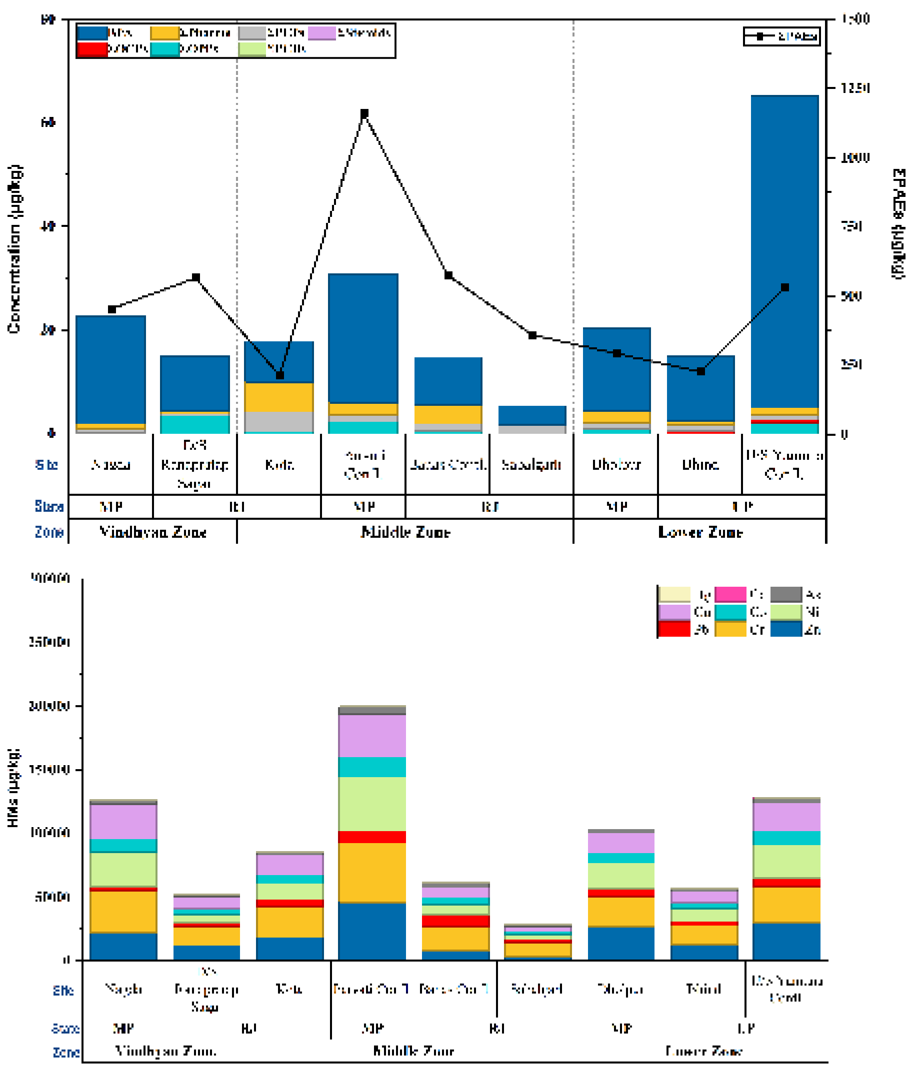
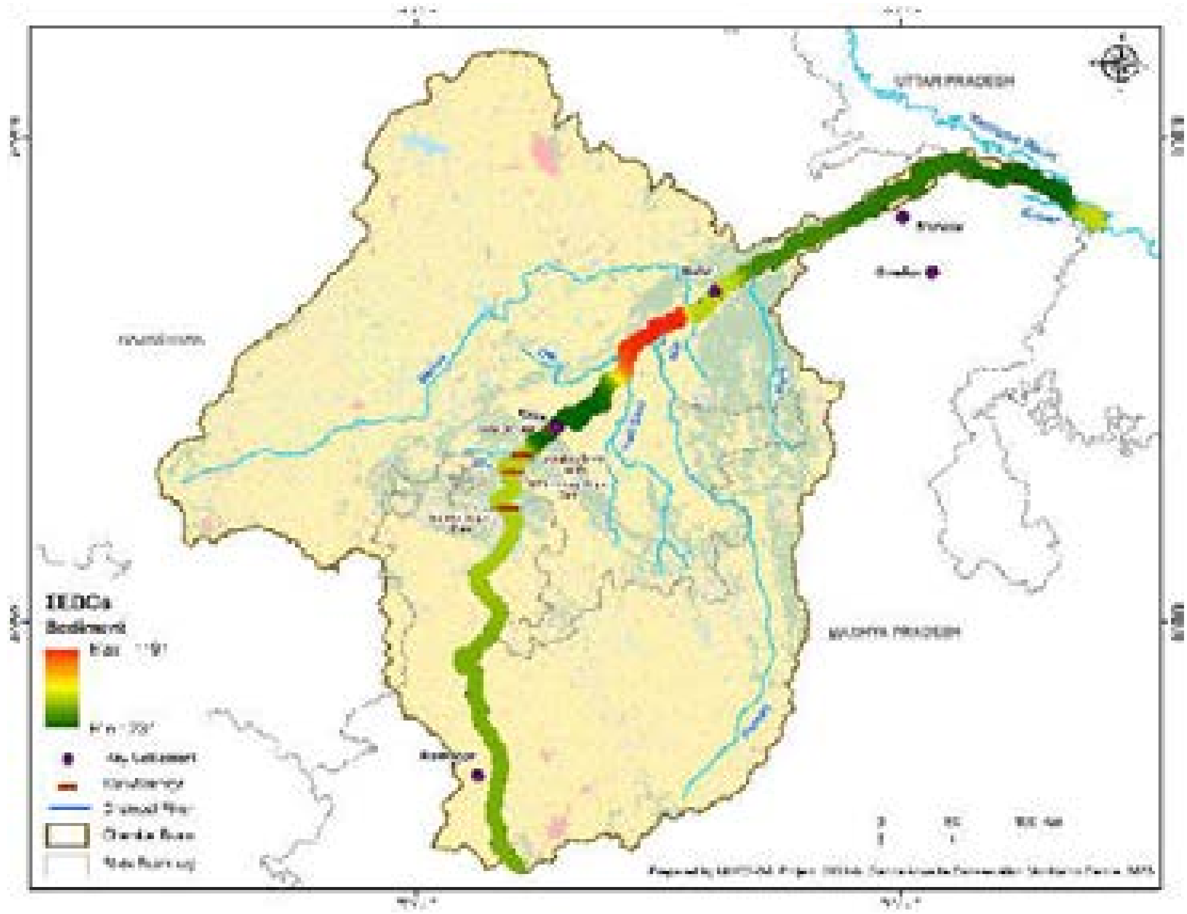


Figure 8.8: Site-wide, zone-wide, and state-wide spatial distribution of (a) legacy and emerging endocrine-disrupting chemicals (EDCs) and (b) heavy metals (HMs) in the surface sediment of the Chambal River.



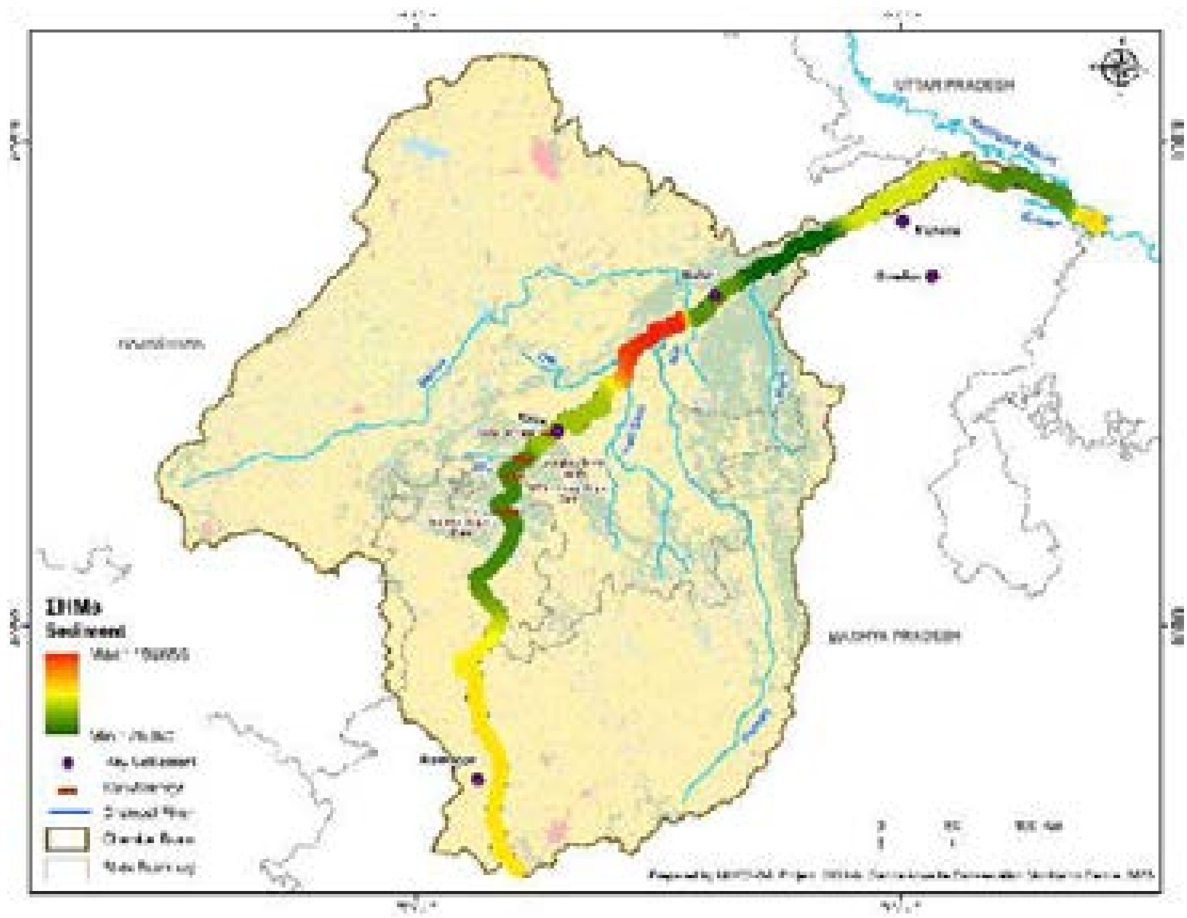


Figure 8.9: Spatial distribution of (a) legacy and emerging endocrine-disrupting chemicals (ΣEDCs; µg/Kg) and (b) heavy metals (ΣHMs; µg/Kg) in the surface sediment of the Chambal River 2025.

Heavy Metals in Surface Sediment of the Chambal River

River-wide:

A significant amount of pollution is caused by the presence of Heavy Metals in surface sediment of the Chambal River. ΣHMs was found to be (93435 ± 17476 µg/kg), ranging (28380-199654 µg/kg), indicating a substantial load of HMs. The contaminant trend in Heavy Metal was Cr (23978 ± 3654µg/kg) > Zn (20031± 4356 µg/kg) > Ni (17498 ± 4219 µg/kg) > Cu (16017 ± 3323µg/kg) > Co (7533 ± 1412µg/kg) > Pb (5172 ± 903 µg/kg) > As (3111 ± 416 µg/kg) > Cd (87.38 ± 16.56 µg/kg) > Hg (4.51 ± 1.74 µg/kg), clearly indicating half of the load from Cr, Zn & Ni & Cu (83%) and pointing to industrial discharge, sand-mining municipal wastewater, and runoff from surrounding land, with metals also moving in from sediments during flow changes (Table 8.7). The Parvati Confluence is the single dominant hotspot, with three further enriched stations at U/S Yamuna Confluence, Nagda, and Dholpur. Dedicated source-apportionment audit of the Parvati sub-catchment by MPSPCB with CPCB technical input. The Cr-Ni-Cu-Zn signature points to metal-finishing, tannery and small-industry effluent, with the audit required to identify discharging units for regulatory action.

Zone-wide:

Heavy Metal contamination in the Vindhyan Zone was (88992 ± 36731µg/kg), primarily contributed by Cr (23835 ± 9121 µg/kg), Cu (18503 ± 8958 µg/kg), Zn (17201 ± 4912 µg/kg), Ni (16741 ± 10348 µg/kg). Nagda carries the zone-wide peak (approximately 125000 µg/kg), with copper unusually elevated relative to other stations. The zone-wide signature is industrial point-source loading at Nagda combined with reservoir-mediated sediment trapping at D/S Rana Pratap Sagar. In the Middle Zone, the ΣHMs concentration (93753 ± 37191 µg/kg), dominated by Cr (25159 ± 7563 µg/kg), Zn (19008 ± 9555), Ni (16996 ± 8838 µg/kg), Cu (15146 ± 6665 µg/kg). The Banas Confluence shows a distinct signature with elevated lead, suggesting a separate source mix from the Parvati sub-catchment. The Middle Zone is the operational priority for source apportionment.

In the Lower Zone, a higher value of ΣHMs is found (95973 ± 20951 µg/kg), and contributed by Zn (23281 ± 5331 µg/kg), Cr (22499 ± 4008 µg/kg), Ni (18673 ± 4548 µg/kg), Cu (15524 ± 3783 µg/kg) (Table 8.7; Figure 8.8b, 8.9b).

The Banas Confluence sediment carries elevated lead, distinct from the Parvati signature. The Banas drains the Rampura-Agucha, Rajpura-Dariba and Sindesar Khurd lead-zinc mining belt (Bhilwara and Rajsamand) and receives Chanderiya smelter (Chittorgarh) discharge via the Berach, together with textile effluent from the Bhilwara cluster via the Kothari, identifying the Banas sub-catchment as a second industrial corridor distinct from the Parvati and requiring separate regulatory action through Rajasthan and Madhya Pradesh State Pollution Control Boards.

Bioaccumulation Profiles of EDCs And Heavy Metals in Fish Biota from Chambal River

Endocrine Disrupting Chemicals (EDCs) in Fish Biota

Fish from 17 species were sampled across four stations inside the sanctuary (Kota, Parvati Confluence, Sabalgarh, Dholpur). All bioaccumulation values reported below therefore represent biota exposed within the National Chambal Gharial Sanctuary, with direct food-chain relevance for the resident gharial and Gangetic dolphin populations.

River Wide

Total ΣEDCs in fish ranged from 72.64 to 593.84 µg/kg (mean 208 ± 37.08 µg/kg). Phthalates dominated the EDC profile (ΣPAEs 66.43 to 586 µg/kg, mean 194 ± 36.06 µg/kg), followed by total pesticides (ΣOCPs and ΣOPPs combined 1.21 to 46.50 µg/kg, mean 11.08 ± 2.70 µg/kg). BPA, pharmaceuticals, personal care products, steroids and PCBs were detectable across most species at low concentrations (mean values 0.22 to 1.07 µg/kg) (Table 8.8). The persistence of legacy organochlorine pesticides in fish tissue, against the low water-column and sediment OCP concentrations reported in Sections 8.3.2 and 8.3.3, confirms active biomagnification of historical inputs through the river food web.

Five species-site combinations carry the river-wide bioaccumulation extremes. *Rita corsula* at Dholpur (ΣPAEs ~580 µg/kg) holds the river-wide phthalate peak; as a bottom-feeding cyprinid and documented gharial prey, it represents direct trophic transfer to the apex predator. *Sperata sarana* at Dholpur (ΣOPPs ~45 µg/kg) is an order of magnitude above any other site-species pair, pointing to active OPP use in the Dholpur catchment. *Eutropiichthys vacha* at Dholpur (ΣOCPs ~19 µg/kg) holds the legacy pesticide peak, confirming biomagnification within the sanctuary. Rita rita at the Parvati Confluence (BPA ~6.16 µg/kg) holds the BPA peak, mirroring the sediment hotspot. *Osteobrama cotio* at Kota (ΣPharma ~2.85 µg/kg) holds the pharmaceutical peak, reflecting chronic exposure to Kota urban effluent.

Zone Wide

The Lower Zone shows substantially higher bioaccumulation than the Middle Zone across every EDC class. ΣEDCs in the Lower Zone (mean 373 ± 120 µg/kg) are 2.40 times the Middle Zone (mean 157 ± 19.20 µg/kg). ΣPAEs in the Lower Zone (352 ± 116 µg/kg) are 2.40 times the Middle Zone (145 ± 19.54 µg/kg). Total pesticides in the Lower Zone (19.40 ± 10.19 µg/kg) are 2.30 times the Middle Zone (8.52 ± 1.54 µg/kg). The Lower Zone therefore acts as the principal bioaccumulation sink on the Chambal, despite having fewer apparent point sources than the Middle Zone. This decoupling between point-source location (Middle Zone) and bioaccumulation peak (Lower Zone) reflects sediment transport, depositional dynamics and species ecology, and identifies the Dholpur reach as a priority for sanctuary-specific food-chain monitoring (Table 8.8; Figure 8.10a).

Heavy Metals (HM) in Fish Biota

River-wide

ΣHMs in fish tissue ranged from 12251 to 49039 µg/kg (mean 22295 ± 2048 µg/kg), exceeding total EDCs by approximately 100-fold and establishing heavy metals as the dominant contaminant mass in the sanctuary food web (Table 8.8). Zn dominates across all 17 species sampled, with Pb, Cu, Cr and Ni as the principal non-Zn contributors at impacted sites.

Zone-wide

The Lower Zone (mean 22703 ± 3280 µg/kg) and Middle Zone (mean 22169 ± 2545 µg/kg) carry comparable mean burdens, but with distinct signatures. The Middle Zone shows wider variability (12251 to 49039 µg/kg) driven by a single extreme accumulation event at the Parvati Confluence. The Lower Zone shows uniform high-level loading (16723 to 31401 µg/kg) at every station, with the river-wide highest mean recorded at Dholpur (~22704 µg/kg across four species) (Table 8.8; Figure 8.10b).

Table 8.8: River and Zone-wide contamination status (µg/kg) in fishes of Chambal River

Analyte	Zone-wide		River-wide
	Middle Zone	Lower Zone	Mean±SEM
ΣHMs	12251- 49039 (22169± 2545)	16771- 31400 (22703± 3280)	12251-49039 (22295± 2048)
ΣPAEs	92.68 - 353 (145± 19.54)	66.43 - 586 (352± 116)	66.43 - 586 (194± 36.06)
BPA	<DL - 6.16 (1.24 ± 0.42)	<DL - 0.63 (0.26 ± 0.16)	<DL- 6.16 (1.01± 0.36)
ΣPharma	0.06 - 2.85 (0.59 ± 0.20)	0.12 - 0.18 (0.14 ± 0.01)	0.06 - 2.85 (0.49± 0.16)
ΣSteroids	<DL - 0.45 (0.15 ± 0.04)	<DL - 0.26 (0.13± 0.06)	<DL - 0.45 (0.15± 0.03)
ΣPCPs	<DL - 5.04 (1.06 ± 0.46)	<DL - 4.23 (1.07 ± 1.05)	<DL - 5.04 (1.07± 0.41)
ΣOCPs	1.11 - 13.55 (6.93 ± 1.28)	0.93 - 18.53 (7.19 ± 3.94)	0.93 - 18.53 (6.99 ± 1.27)
ΣOPPs	0.10 - 4.56 (1.6 ± 0.37)	0.19 - 43.56 (12.21 ± 10.5)	0.1 - 43.56 (4.09± 2.49)

Species-resolved hotspots. Labeo bata at the Parvati Confluence carries the river-wide ΣHMs extreme (49039 µg/kg), driven by Cr (4263 µg/kg), Cu (13262 µg/kg), Zn (28806 µg/kg) and elevated Ni (240 µg/kg) and Co (1810 µg/kg). This biota peak mirrors the sediment Cr-Cu signature at the same station and confirms active sediment-to-biota transfer from Parvati sub-catchment industrial discharge. *Rhinomugil corsula* at Dholpur carries the river-wide second-highest ΣHMs (31401 µg/kg), with the highest Cr (2864 µg/kg), Pb (629 µg/kg) and As (469 µg/kg) recorded in any species on the river, identifying it as the principal multi-metal accumulator at the export-end reach and a critical bioindicator for trans-basin contamination monitoring. *Osteobrama cotio* at Kota holds the river-wide Zn peak (29398 µg/kg), reflecting urban-industrial loading at the sanctuary boundary. *Labeo gonius* at the Parvati Confluence carries the second-highest non-Zn HMs (~10056 µg/kg), with Cu reaching 8134 µg/kg, confirming the Parvati Cu signature across multiple benthic species. *Gudusia chapra* and *Gonialosa manmina* at Dholpur show elevated As (227 and 365 µg/kg) and Cr (443 and 1181 µg/kg) respectively, extending the Lower Zone metal exposure footprint to small-bodied prey species. Across both zones, benthic and detrital-feeding species (*L. bata, L. gonius, R. corsula, G. manmina*) consistently exceed pelagic species in tissue HM burden by 5- to 10-fold, confirming sediment ingestion as the dominant uptake pathway.

Sanctuary-specific monitoring of indicator species (*R. corsula, L. bata, L. gonius, S. sarana, O. cotio*) under the NMCG Aquatic Species Programme, with annual tissue burden tracking at all four sampled stations. Integration with the gharial and Gangetic dolphin conservation programmes of the Rajasthan, Madhya Pradesh and Uttar Pradesh Forest Departments, with operational priority on the Parvati Confluence and Dholpur reaches as the river-wide bioaccumulation hotspots.

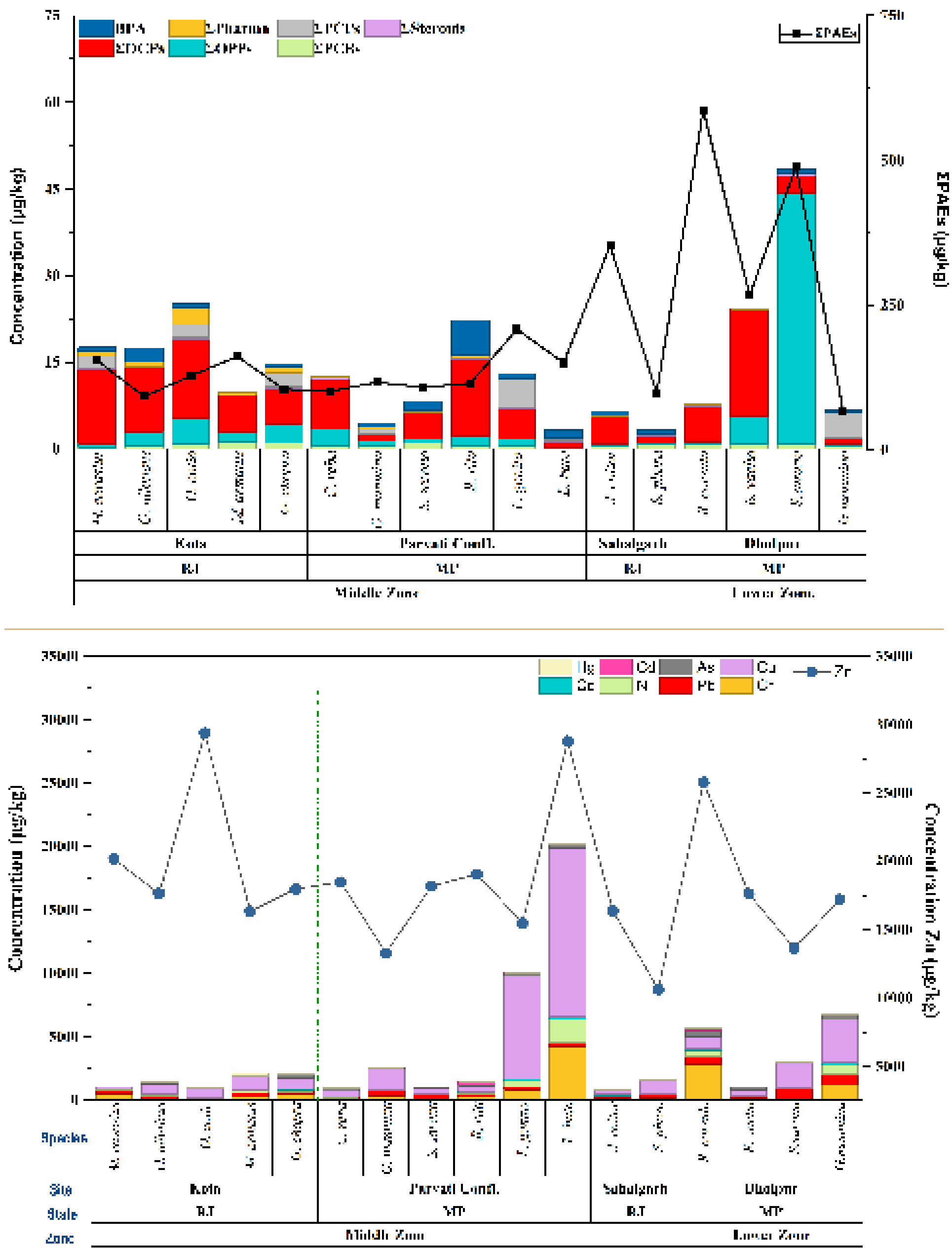


Figure 8.10: Species-specific bioaccumulation profile (µg/kg, wet weight) of (a) Endocrine-disrupting chemicals (EDCs) and (b) Heavy Metals in fish biota across Chambal River

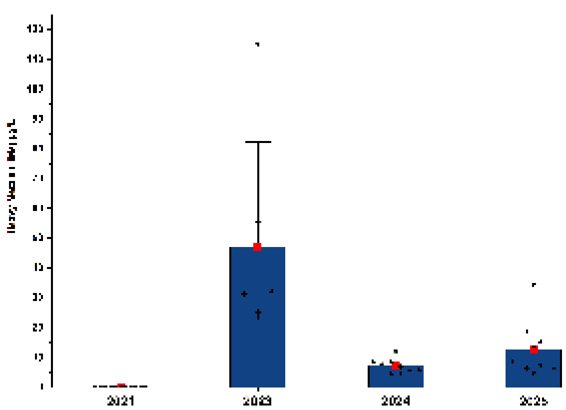
Temporal Patterns of the Chambal River (2021-2025)

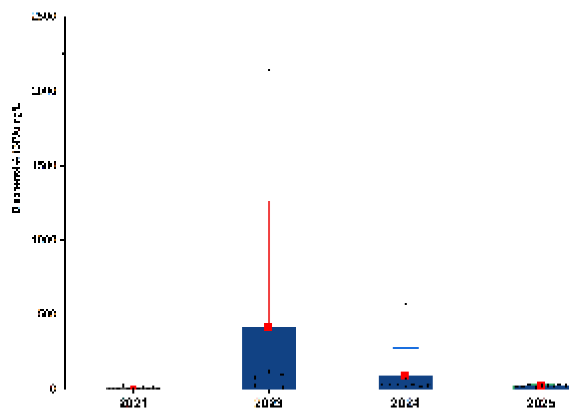
The 2021 to 2025 monitoring record reveals a bifurcated trajectory across the Chambal contaminant profile, structurally identical to the trajectory documented on the Ganga main stem over 2018 to 2025 (Figure 8.11). The legacy contaminants that India regulates are responding to the existing instrument set: phthalates show a sustained decline from the 2021 peak, while heavy metals and organochlorine pesticides, despite discrete 2023 anomalies, are trending toward partial recovery. The emerging contaminants for which India has no regulatory framework are escalating in parallel: BPA, pharmaceuticals and personal care products record their highest concentrations in the dataset in 2025. Kruskal-Wallis testing confirms statistically significant year-to-year differences for every contaminant class. The river's regulatory monitoring is succeeding where it is applied and failing where it is absent.

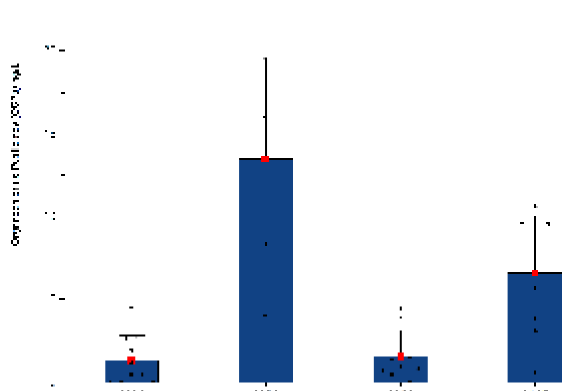
Both regulated contaminant classes spiked in 2023 and remain elevated above the 2021 baseline. Heavy metals ($p < 0.001$) rose from a near-zero 2021 baseline of 0.01 µg/L to 47.06 µg/L in 2023, moderating to 12.86 µg/L in 2025. Organochlorine pesticides ($p < 0.001$) followed the same pattern, rising from 1.32 ng/L in 2021 to a peak of 13.47 ng/L in 2023, with 2025 levels at 6.58 ng/L, approximately five times the 2021 baseline. The Stockholm Convention, the Insecticides Act ban on Target OCPs, and existing industrial discharge standards have not delivered sustained decline on the Chambal.

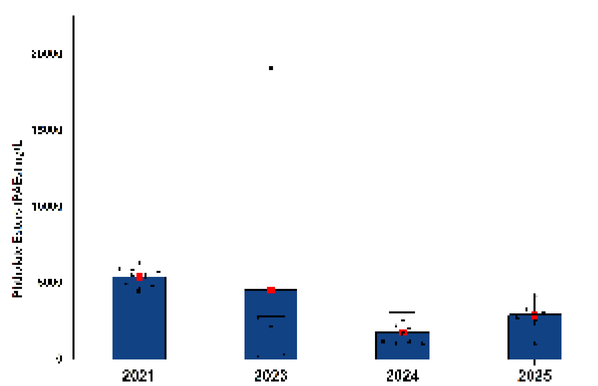
Among the five emerging contaminant classes, three are escalating monotonically and two have peaked and are declining. Steroids/Hormones ($p < 0.001$) show the strongest signal: from a 2021 mean below the detection limit to 3.25 ng/L in 2025, escalating in every successive year. Personal care products ($p < 0.001$) follow a similar trajectory, from 0.48 ng/L in 2021 to 9.37 ng/L in 2025, a nineteen-fold rise. Steroids ($p = 0.017$) record their highest concentration of the assessment period in 2025 (3.25 ng/L). Bisphenol A ($p < 0.001$) peaked at 412.08 ng/L in 2023 and has since declined to 23.70 ng/L in 2025, though still nearly five times the 2021 baseline. Phthalates ($p < 0.001$) have declined from 5,367 ng/L in 2021 to 2,878 ng/L in 2025, a reduction of nearly half. None of these five classes is covered by an Indian ambient, discharge or monitoring standard; the declines in BPA and phthalates are therefore not attributable to formal contaminant-specific regulation.

The findings highlights the regulatory framework currently applied to the Chambal is not delivering sustained decline in any contaminant class. The two regulated classes (heavy metals, OCPs) are several-fold above baseline despite existing instruments. Three of the five unregulated emerging classes (pharmaceuticals, personal care products, steroids) are escalating without any regulatory check. Where declines are visible (BPA, phthalates), they are not attributable to contaminant-specific regulation but most plausibly to indirect plastic waste interception under Namami Gange and the single-use plastic ban.









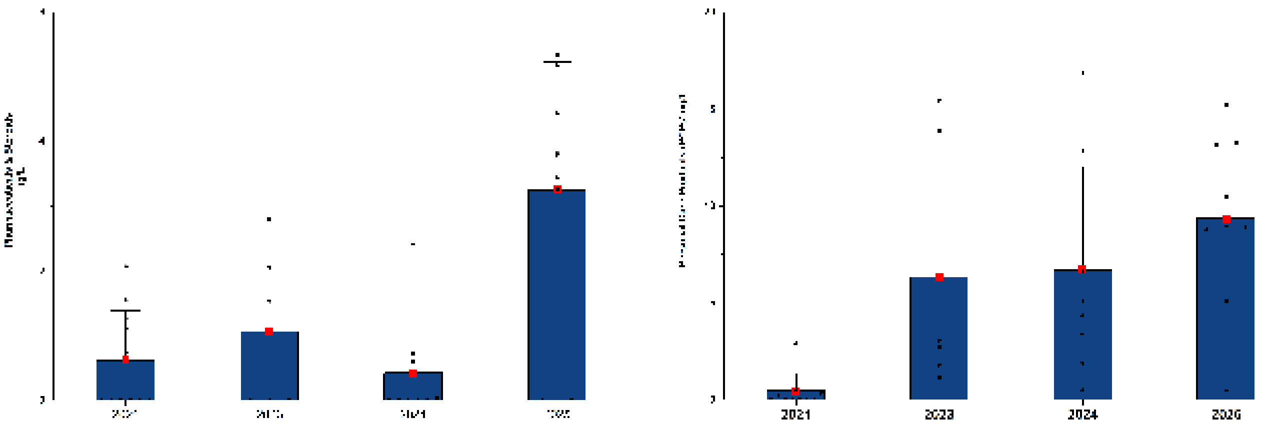


Figure 8.11: Temporal patterns of Legacy and Emerging Endocrine-Disrupting Chemicals (EDCs) & Heavy Metals (HMs) in Chambal River

Identification of Threats and Pollution Hotspot Assessment:

Conventional river monitoring in India relies on single-parameter compliance assessment (BOD, DO, faecal coliform), which fails to capture the cumulative ecological burden at sites exposed to multiple contaminant classes simultaneously. The Ecological Risk Assessment (ERA) addresses this limitation by integrating multi-contaminant ecological risk into a single, site-specific, conservation-weighted priority score. Each monitoring station is evaluated across four dimensions: Pollution Severity (ERA score), quantifying the breadth of multi-contaminant ecological risk through weighted ecological Risk Quotient (RQ) > 1 exceedances across eight contaminant groups; Ecological Severity, which amplifies pollution severity by dolphin conservation tier to prioritise locations where contamination intersects with the highest conservation value; Pollutant Signature, identifying the dominant contaminant classes driving risk at each site based on persistence, bioaccumulation, and estrogenic potential; and Toxicity Threshold Diagnostics, which specify the individual analytes responsible, their RQ magnitudes, and their mechanisms of toxicological action (neurotoxicity, estrogenic disruption, chronic organ toxicity), translating each site's ERA score into targeted, actionable intervention prescriptions. Integrating these dimensions, each monitoring site is stratified into four threshold-defined priority categories:

1. **CRITICAL:** Multiple high-weight contaminant groups at ecological risk within conservation-sensitive habitat. Immediate intervention required.
2. **HIGH:** Two or more contaminant groups at ecological risk, or single high-weight exceedances amplified by conservation tier. Targeted remediation priority required.
3. **MODERATE:** Typically, single-compound exceedance. Enhanced monitoring and source control required.
4. **LOW:** Routine baseline surveillance required.

Using this classification framework, pollution hotspots are delineated across Chambal River (Figure 8.12, 8.13).

As the Chambal flows from the Vindhyan headwaters to its confluence with the Yamuna, ecological risk follows a non-monotonic but spatially diagnostic gradient. Specific stretches of the Chambal River (notably around Nagda in Madhya Pradesh and Kota in Rajasthan) have been officially categorized as "polluted river stretches" by the CPCB due to Biochemical Oxygen Demand (BOD) levels exceeding the acceptable threshold for bathing standards. Similarly, Nagda to Rampura was identified under Priority Stretch-I in the CPCB 2018 report, and even in CPCB PRS 2022 the water quality remained in Priority Stretch-I, with

maximum BOD reported as 72 mg/L.

Across the 965 km assessed corridor, 22% of the river sits in High and 5% in Very High risk, with the river-wide maximum recorded at the U/S Yamuna Confluence, the export point into the Ganga basin. Zone-wide, the pattern is sharply differentiated.

The Vindhyan Zone (Origin to Rana Pratap Sagar; 380 km) is the least stressed segment of the river, with 73% Moderate, 23% Low and only 4% High risk, reflecting limited anthropogenic loading upstream of Kota. The Middle Zone (Kota to Sabalgarh; 320 km) is the most stressed segment, with 53% High and 47% Moderate risk, driven by urban discharge from Kota and industrial loading from the Parvati sub-catchment. The Lower Zone (Dholpur to U/S Yamuna Confluence; 237 km) records 79% Moderate and 21% High risk, with the High-risk fraction concentrated at the terminal Yamuna confluence reach where cumulative basin contamination is exported into the Ganga system. The 220 km central reach from Sabalgarh to Bhind shows the lowest sustained risk on the river, confirming effective in-sanctuary protection through the middle stretch.

The National Chambal Gharial Sanctuary begins at D/S Kota Barrage and extends to the Yamuna confluence, covering 485 km, or 57% of the assessed corridor. It hosts the largest surviving wild population of the gharial (Gavialis gangeticus), a viable sub-population of the Gangetic dolphin (*Platanista gangetica*), the mugger crocodile and seven freshwater turtle species. The 53% High-risk burden of the Middle Zone and the 21% High-risk burden of the Lower Zone fall entirely within the sanctuary.

Two hotspots account for all critical-risk stretches on the river. The first is at the sanctuary entry, between D/S Kota Barrage and the Parvati Confluence, where untreated urban sewage and solid waste from Kota city converge with industrial effluent from metal-finishing, tannery and small-industry units discharging through the Parvati sub-catchment. This reach carries the highest sediment heavy metal burden recorded on the river, with active accumulation of chromium and copper in fish tissue, entering the gharial and dolphin food chain directly. The second is at the sanctuary exit, between Dholpur and the U/S Yamuna Confluence, where contamination accumulated across the entire upstream basin is delivered to the Yamuna and onward to the Ganga main stem. Fish tissue at this reach carries the highest plastic-additive and organophosphate pesticide burdens recorded on the river, indicating sustained bioaccumulation at the export point. Both hotspots require coordinated source control: enforced sewage treatment and solid waste management at Kota, regulated industrial discharge in the Parvati sub-catchment, and basin-level abatement of the cumulative load reaching the Yamuna confluence (Table 8.9).

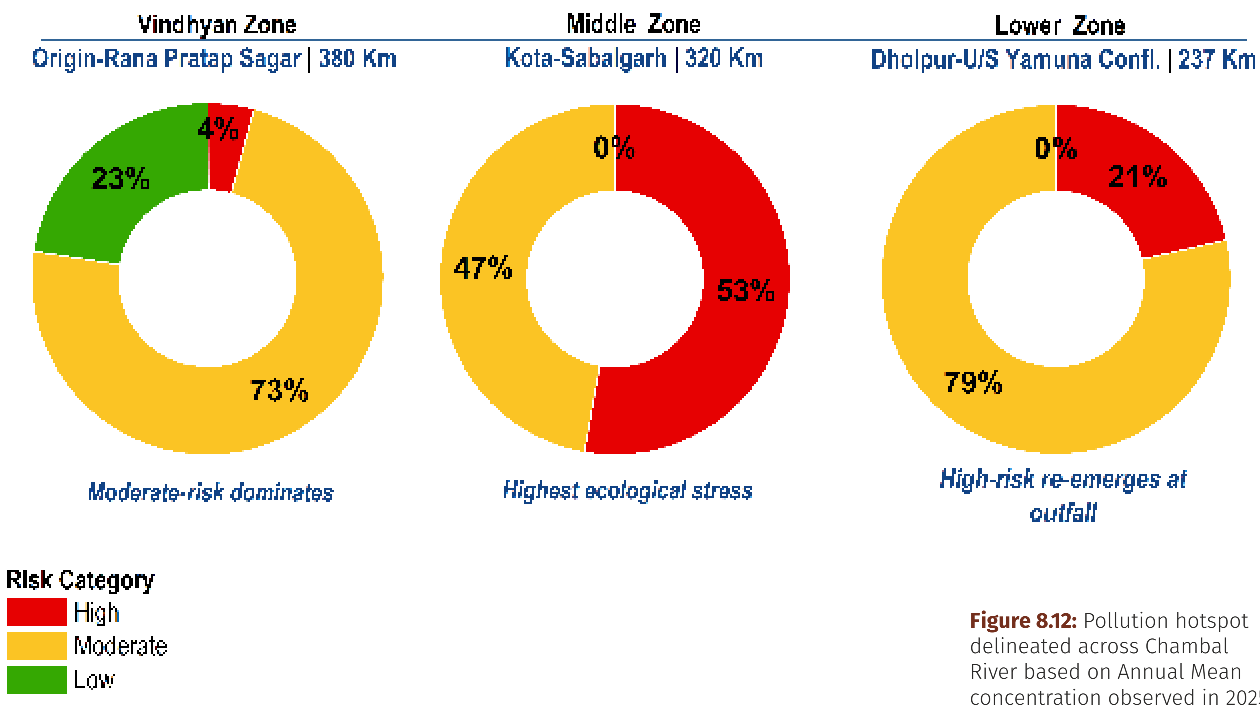


Figure 8.12: Pollution hotspot delineated across Chambal River based on Annual Mean concentration observed in 2025

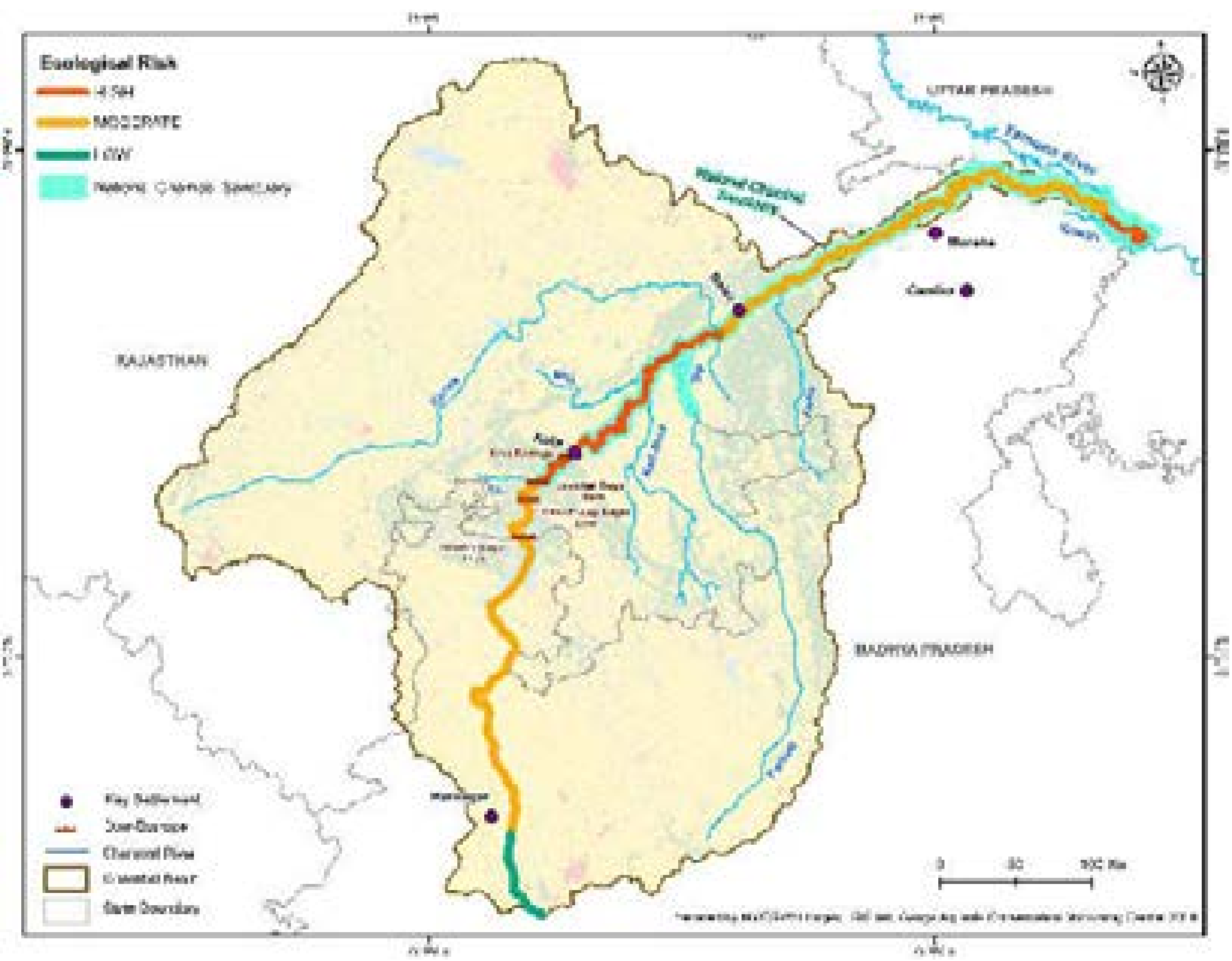


Figure 8.13: Ecological risk distribution across Vindhyan, Middle and Lower zone of Chambal River

Table 8.9: Pollution hotspot and threats across zones along the Chambal River.

	Vindhyan Zone	**Middle Zone**	**Lower Zone**
Priority Sites	Nagda, D/S Ranapratap Sagar	Kota, Parvati Confluence	U/S Yamuna Confluence
District	Ujjain, Chittorgarh	Kota, Sheopur	Etawah
State	RJ, MP	RJ, MP	UP
Threats	Industrial inputs around Nagda and impoundment-induced flow regulation Ranapratap Sagar Dam	Urban-industrial effluent at Kota and barrage-mediated sediment trapping, municipal sewage (domestic PVC, medical waste, cosmetics) + solid waste/landfill leachate + plastic waste + unregulated emerging contaminants in pharmaceuticals and personal care products; Copper-based agrochemicals; Tributary-delivered legacy pesticidel runoff,	Pesticides run-offs; Copper-based agrochemicals, Livestock and dairy waste, domestic sewage (domestic PVC, medical waste, cosmetics) + solid waste/landfill leachate + plastic waste
Action Required	Enhanced monitoring and source control required.	Immediate intervention and remediation required.	Immediate intervention and remediation required.

The Chambal River requires a management framework distinct from generic urban-river abatement models because it functions simultaneously as a regulated river, a tri-state protected sanctuary, a tributary-export pathway to the Yamuna-Ganga system, and a food-web exposure corridor for gharial, dolphin, turtles and fish. The framework should therefore move beyond BOD-only compliance and adopt an integrated ecological-risk approach using water, sediment and fish matrices across the Vindhyan, Middle and Lower Zones. Priority interventions should focus on Nagda for upstream sewage-industrial control, Kota for sewer connectivity, drain interception, STP utilisation and low-flow hypoxia management, Parvati and Banas confluences for tributary-specific source apportionment of metals and pesticides, and the U/S Yamuna confluence for cumulative export-load monitoring. The framework should combine STP/ETP compliance, tertiary treatment for emerging contaminants, plastic and solid-waste control, agricultural pesticide reduction, sand-mining regulation, environmental-flow management, sanctuary biodiversity protection and a real-time monitoring dashboard for key stations.

The management framework, is provided in Table 8.10 to achieve a good ecological status of Chambal River in the state of Uttar Pradesh, Rajasthan, and Madhya Pradesh through integrated and sustainable approaches. This framework formulates objectives for pollution management and abatement in Chambal River, with specific measures identified to ensure a comprehensive and effective strategy for river health improvement.

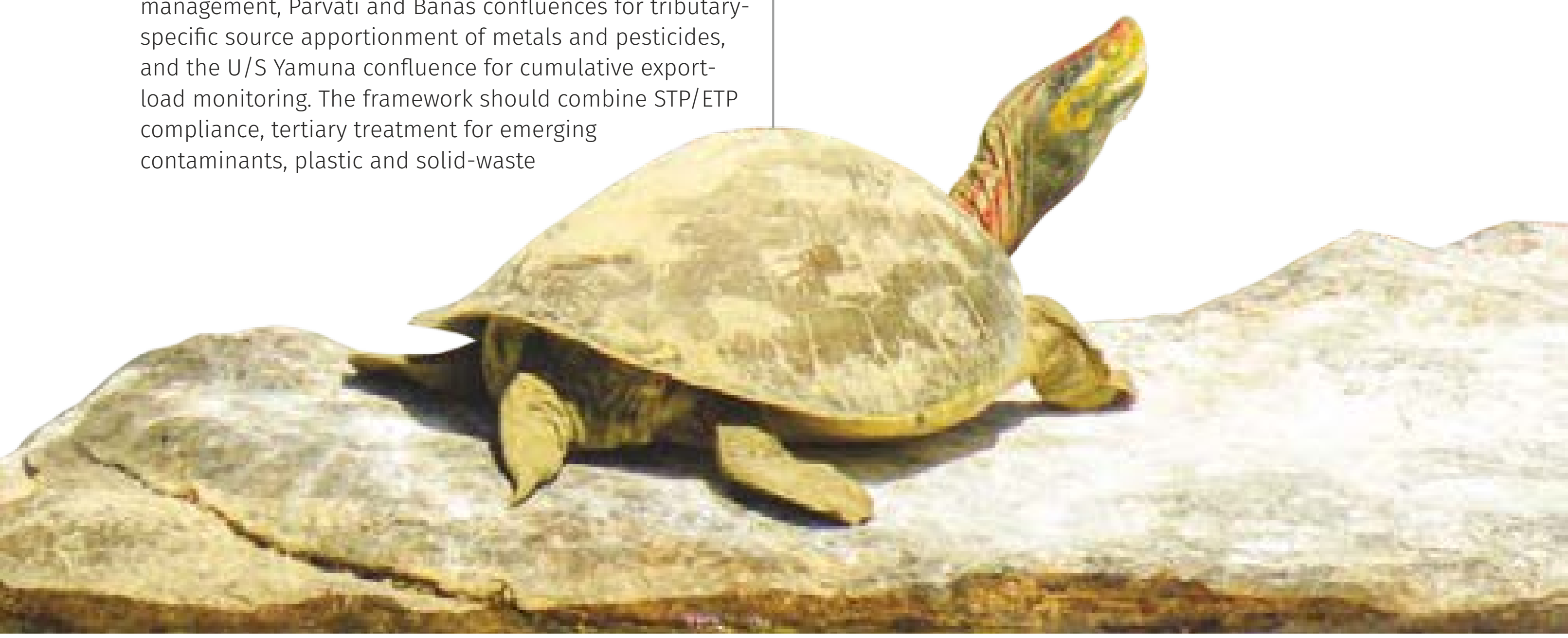


Table 11: Framework for Sustainable Pollution Abatement of the Chambal River

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
Objective 1: Reduce point-source and diffuse pollution loading into the Chambal River across the Vindhyan, Middle and Lower Zones			
1.1	**Bridge the Kota municipal sewage treatment deficit and decommission discharge to the National Chambal Gharial Sanctuary corridor** • Close the 155.33 MLD untreated sewage gap at Kota (236.17 MLD generated against 158 MLD installed and only 80.84 MLD actually treated, as recorded by Nagar Nigam Kota in February 2024 and reaffirmed in NGT OA 189/2023, order dated 16 October 2025). • Commission the three Kota STPs already under installation (2 MLD Oxyzone, 15 MLD Balita, 40 MLD Dhakadkhedi) with phased loading and third-party performance verification. • Bring the 30 MLD Balita STP into compliance with phosphate norms and the 30 MLD Sajidehra STP into compliance with TSS and total nitrogen, as per RSPCB sampling of February 2024. • Extend the Kota sewer network from the current 750 km of 1053 km laid, and house-to-sewer connections from 49,890 of 141,568, complete by the March 2026 NGT deadline. • Develop matching STP capacity for Dholpur (current 13 MLD across two RUIDP Phase II plants) ahead of further peri-urban expansion.	• MLD of untreated sewage discharged to Chambal from Kota (target zero by 2027). • % of generated sewage actually treated (currently 34.2 % at Kota; target 95 %). • Number of drains tapped STP-wise compliance with CPCB discharge standards across BOD, COD, TSS, total N, phosphate, residual chlorine.	• Monthly RSPCB consent register and STP performance reports. • NMCG quarterly progress reports for Kota under Namami Gange (Rs 258.48 crore sanctioned package, 36 MLD additional STP, 146 km sewer, six lifting stations). • NGT compliance affidavits filed under OA 189/2023. • Independent third-party audit by NEERI or designated IIT, with GPS-tagged drain inspections.
1.2	**Independently characterise and regulate the chlor-alkali industrial discharge signature at Nagda (Vindhyan Zone) and re-evaluate the in-situ bioremediation pilot** • Conduct quarterly independent monitoring of receiving water at reference, Juna Nagda (point source) and downstream, with chlor-alkali diagnostic suite (chloride, sulphate, sodium, mercury, lead, aluminium, residual chlorine), in addition to the conventional BOD/DO/coliform monitoring. • Independently verify the Zero Liquid Discharge (ZLD) claim of Industries, with parallel surveillance of the installed ETP. • Re-evaluate the decision to substitute in-situ bioremediation for the originally proposed 16 MLD Nagda STP, and reinstate hard treatment infrastructure given the documented high BOD load.	• Quarterly independent receiving-water chloride, sulphate, sodium, mercury, lead, aluminium and pH at the three Nagda stations. • Number of industrial units monitored against consent conditions • BOD at Chambal d/s Nagda below 3 mg/L (current value 10 mg/L, more than three times the bathing criterion).	• MPPCB ambient water monitoring reports under NWMP. • Industry-wise Form V environmental statements and consent compliance audits. • Independent peer-reviewed assessments

Critical Assumptions	Responsible Agencies	Supporting Organisations
• Sustained financial sanction under Namami Gange, AMRUT 2.0, RSTDSP and ADB-funded RUIDP Phase IV. • Strict enforcement of the NGT environmental compensation regime (Rs 7.20 crore against Nagar Nigam Kota and KSTPS, with Rs 5 lakh per drain per month continuing damages until full compliance). • Sewer-house connection compliance by households. • Conformity with the Water (Prevention and Control of Pollution) Act 1974 and the Environment (Protection) Rules 1986.	• Nagar Nigam Kota (North & South). • Rajasthan State Pollution Control Board (RSPCB), Kota Regional Office. • Public Health Engineering Department, Government of Rajasthan. • Ministry of Jal Shakti and NMCG. • Urban Development & Housing Department, Government of Rajasthan.	• RUIDP / ADB. • Central Pollution Control Board. • NEERI, Nagpur. • MNIT Jaipur (action plan author, RRC/673/2018). • Wildlife Institute of India for sanctuary-stretch downstream verification.
• MPPCB willingness to extend the routine monitoring suite beyond BOD/DO/coliforms to chlor-alkali diagnostics. • Compliance with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016 for the secured landfill. • NMCG and MoEFCC alignment with the NGT OA 2/2023 findings. • Public disclosure of consent conditions and environmental statements.	• Madhya Pradesh Pollution Control Board (MPPCB), Ujjain Regional Office. • Ministry of Environment, Forest and Climate Change. • Central Pollution Control Board. • NMCG and Ministry of Jal Shakti.	• NEERI, Nagpur. • Wildlife Institute of India. • IIT Bombay and IIT Kanpur for source-apportionment. • National Green Tribunal Central Zonal Bench, Bhopal (judicial oversight).

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
1.3	**Phase out Once-Through Cooling at Kota Super Thermal Power Station and intercept thermal-power-plant effluent before it reaches the sanctuary**	• Cooling-tower retrofit completion at all four OTC units (Units 1 to 4). • Functional 7.2 MGD ETP at KSTPS. • Compliance with the thermal power plant effluent norms.	• Continuous Effluent Monitoring System (CEMS) data uploaded to the CPCB CARE-Air / CARE-Water portal. • RSPCB quarterly compliance reports. • NGT compliance affidavits in OA 189/2023. • Independent third-party verification.
1.4	**Identify, intercept and divert the high-priority drains discharging into the Chambal in the Middle and Lower Zones** • Complete interception and diversion of all remaining untrapped drains in Kota to functional STPs within the NGT-mandated compliance timeline. The number, identity and prioritisation of drains should be drawn from the most recent RSPCB drain monitoring report and the drain registers maintained by Nagar Nigam Kota under Namami Gange. • Prioritise drains with documented BOD exceedance above the 3 mg/L bathing criterion as recorded in the most recent RSPCB sampling cycle. The current list of priority drains, with site-specific BOD loads, is available in the RSPCB Kota Regional Office records. • Conduct a complete GPS-tagged inspection of all Kota nalas discharging to the Chambal, building on the inspection record annexed to NGT OA 189/2023, and place all such drains on a defined-period tapping schedule. • Tributary loading from the Parvati and Banas confluences in the Middle Zone should be addressed through interception at Sabalgarh and Morena upstream of the sanctuary core.	• Number of drains tapped and diverted. • Drain-wise BOD, COD, TSS, total coliform load reduction. • Compliance with the bathing criterion of BOD less than 3 mg/L.	• Municipal Corporation drain registers. • RSPCB drain-monitoring reports. • NGT compliance affidavits. • Independent GPS-tagged drain inspection reports.
1.5	**Reduce agrochemical runoff from the Malwa Plateau catchment and the Chambal ravines, with priority abatement at the Parvati and Banas confluences** • Promote organic and integrated farming across the Malwa Plateau (Nagda-Ratlam-Mandsaur belt) and the Chambal ravines (Morena-Bhind-Etawah belt). • Phase down copper-based agrochemicals.	• Hectares under organic / NPOP-certified production in the Chambal catchment. • Reduction in post-monsoon nitrate at Parvati and Banas confluences (target less than 5 mg/L).	• Agriculture department records (district-wise). • Krishi Vigyan Kendra extension records. • Annual Chambal monitoring data on agrochemical residues from NMCG-WII surveillance.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• KSTPS adheres to the NGT Rs 5 lakh per drain per month continuing damages regime till compliance. • Availability of capital for retrofit (KSTPS capital plan). • Compliance with Central Electricity Authority guidelines and CPCB SOPs.	• Rajasthan Rajya Vidyut Utpadan Nigam Limited (RVUNL). • Rajasthan State Pollution Control Board. • Central Electricity Authority. • Ministry of Power.	• Central Pollution Control Board. • NGT Central Zonal Bench, Bhopal. • IIT Roorkee / IIT Delhi (thermal pollution modelling).
• Central and state government commitment to divert priority drains as ordered by the NGT. • Operationalisation of the CPCB Guidelines on Water Quality Monitoring (2017). • Sustained financing under Namami Gange and AMRUT 2.0.	• Nagar Nigam Kota. • Urban Local Bodies (Keshoraipatan, Dholpur, Bhind, Etawah). • RSPCB and MPPCB. • NMCG.	• RSPCB Regional Offices. • NEERI. • IIT Delhi and IIT BHU (advanced remediation). • Public and private remediation technology providers.
• Subsidy support for organic and integrated farming. • Effective enforcement of the Insecticides Act 1968 on banned and restricted pesticides. • Willingness of farmers to adopt sustainable practices. • Continued procurement support and minimum support price for organic produce.	• Ministry of Agriculture & Farmers Welfare (Central and State). • State Agriculture Departments of Madhya Pradesh, Rajasthan, Uttar Pradesh. • Directorate of Plant Protection, Quarantine & Storage. • MoEFCC (Stockholm Convention focal point).	• Krishi Vigyan Kendras. • ICAR-Indian Institute of Soil Science, Bhopal. • Rajasthan Agricultural Research Institute, Durgapura. • JNKVV Jabalpur; MPUAT Udaipur.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
	• Strengthen organochlorine pesticide (OCP) phase-out • Enforce the Stockholm Convention obligations on persistent organic pollutants, in coordination with the National Implementation Plan	• Number of farmers transitioned, by district • Reduction in OCP and OPP residues in surface water, sediment and indicator fish tissue.	• Stockholm Convention national reporting.
Objective 2: Restore the Chambal corridor through nature-based solutions adapted to the ravine landscape and the impoundment chain			
2.1	**Establish constructed wetlands and bioremediation infrastructure at priority drain outfalls in Kota and at the Parvati-Banas confluences**	• Area (ha) under functional constructed wetland and bioremediation units. • Reduction in N, P, BOD, total coliform, ΣPAEs and ΣHMs at outlet points (pre- and post-treatment). • Increase in benthic macroinvertebrate diversity and native macrophyte cover (Ipomoea aquatica, Hydrilla, Vallisneria, Trapa).	• GIS maps and status reports of nature-based solution installations. • Pre- and post-treatment water quality assessments. • Ecological health monitoring datasets (annual baseline plus quarterly verification). • Independent third-party performance audits.
2.2	**Stabilise and restore the Chambal ravine landscape and floodplain ecological corridor** • Bio-stabilise the gully and ravine network across Morena, Bhind, Sheopur and Etawah districts using indigenous deep-rooted species to reduce sediment yield and the associated ionic load that drives the river-wide conductivity exceedance. • Restore degraded floodplain stretches in the National Chambal Gharial Sanctuary, with priority to gharial basking, nesting and dolphin pool habitats. • Reintroduce indigenous riparian vegetation along the Critical Conservation Corridor and re-establish ecological flow connectivity between the Chambal main stem and oxbow lakes in the Lower Zone. • Demarcate and protect the floodplain and enforce zoning against encroachment.	• Kilometres of ravine-floodplain area bio-stabilised and restored. • Number of native species reintroduced. • Reduction in suspended sediment yield at downstream gauging stations. • Annual carbon sequestration estimated. • Floodplain demarcation completed in all three states.	• Satellite imagery analysis (Sentinel-2, LISS-IV). • Forest cover assessment reports (FSI biennial cycle). • Species diversity surveys. • Flood management studies. • Carbon stock measurements.
2.3	**Promote Decentralised Wastewater Treatment Systems (DEWATS) at sanctuary-adjacent settlements where conventional STP coverage is absent**	• Number of DEWATS units installed and functional. • % population covered by decentralised treatment.	• Municipal records and project reports. • Community monitoring dashboards. • Sanitation and drain mapping reports.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• Land availability along the floodplain and at drain outfalls. • Maintenance protocols developed and implemented. • Long-term integration with state river management plans and the NCS management plan.	• Municipal Corporations (Kota, Dholpur, Bhind, Etawah). • Rajasthan and Madhya Pradesh State Irrigation Departments. • RSPCB and MPPCB. • Forest Departments of Rajasthan, Madhya Pradesh, Uttar Pradesh (for NCS-overlap interventions).	• TERI, NEERI, IITs. • WWF-India and INTACH. • CSE. • Wildlife Institute of India.
• Effective floodplain zoning enforcement under the NGT orders. • Removal of encroachments, particularly mining-related. • Inter-state government coordination across Rajasthan, Madhya Pradesh, Uttar Pradesh. • Sustainable financing through CAMPA, Namami Gange and Green India Mission.	• Ministry of Environment, Forest and Climate Change. • State Forest Departments (Rajasthan, Madhya Pradesh, Uttar Pradesh). • DCF, National Chambal Gharial Sanctuary (all three states). • Soil Conservation Departments.	• WWF-India. • Forest Survey of India. • ICFRE. • Bombay Natural History Society. • Wildlife Institute of India.
• Inclusion of DEWATS in district master plans. • Behavioural change and ownership by local communities. • Sustainable O&M arrangements.	• Urban Local Bodies of Rajasthan, Madhya Pradesh, Uttar Pradesh. • Rajasthan Jal Nigam. • Madhya Pradesh Jal Nigam. • Uttar Pradesh Jal Nigam.	• CSR wings of industries operating in the basin. • UN-Habitat, GIZ, World Bank. • ADB (RUIDP).

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
		• Sanctuary-adjacent settlements achieving zero direct discharge into Chambal.	
2.4	**Manage sediment-bound contaminant load retained in the Gandhi Sagar to Kota Barrage impoundment chain** • Conduct sediment contamination characterisation in the four impoundments (Gandhi Sagar, Rana Pratap Sagar, Jawahar Sagar, Kota Barrage) and develop a sediment management plan, given that reservoirs do not effectively process conservative metals and may concentrate them in bioavailable fractions. • Maintain controlled releases and the established environmental flow, with re-evaluation against gharial nesting flow requirements. • Re-suspend and remove contaminated sediment hotspots where appropriate, with proper disposal in lined and monitored disposal facilities.	• Sediment characterisation completed for the four impoundments. • Sediment heavy metal and EDC inventory. • E-flow compliance records. • Volume of contaminated sediment removed and properly disposed.	• Hydrology and sediment monitoring reports from Central Water Commission. • Reservoir operation logs. • NMCG sediment audit reports.
Objective 3: Regulate sand mining within and adjacent to the National Chambal Gharial Sanctuary as a primary driver of habitat degradation and ionic loading			
3.1	**Enforce the Supreme Court interim direction (March 2026) staying the de-notification of 732 hectares of the National Chambal Gharial Sanctuary** • Implement the Supreme Court interim order (March 2026, in the Wildlife Trust of India and related petitions) staying Rajasthan's December 2025 notification de-notifying 732 hectares of NCS land for mining. • Address the documented illegal sand mining caseload in the Kota-Sawai Madhopur Chambal stretch, as recorded in Forest Department offence registers and Supreme Court submissions, with priority to the sanctuary corridor previously used for gharial release. • Geo-fence all sanctuary boundaries with permanent marking and establish dedicated anti-mining check posts at known offload points along National Highway 27 and connecting state highways.	• Number of illegal mining sites detected and closed. • Value of penalties imposed and recovered. • Number of prosecutions filed under the Wild Life (Protection) Act 1972 and the Mines and Minerals (Development and Regulation) Act 1957. • Confirmed gharial nesting and basking sites in previously mined areas (annual census).	• Forest Department offence records. • Supreme Court compliance affidavits. • State forest departments quarterly reports. • Satellite-based change detection (Sentinel-2 monthly mosaics).

Critical Assumptions	Responsible Agencies	Supporting Organisations
	• NGOs facilitating community sanitation.	
• Reservoir authorities cooperate on multi-sector water release schedules. • Disposal facilities meet hazardous waste norms. • Hydropower generation schedules accommodate ecological flow requirements.	• Central Water Commission. • Madhya Pradesh Power Generating Company (MPPGCL). • Rajasthan Water Resources Department. • Water Resources Department, Kota.	• Central Soil and Materials Research Station. • IIT Roorkee. • NEERI.
• Continued political support and judicial oversight from the Supreme Court. • Inter-state coordination among Rajasthan, Madhya Pradesh, Uttar Pradesh Forest Departments. • Compliance with the Wild Life (Protection) Act 1972 and the National Wildlife Action Plan. • Conformity with the Sariska and Sustainable Sand Mining Management Guidelines (CPCB-MoEFCC 2016, revised 2020).	• DCF, National Chambal Gharial Sanctuary (Rajasthan, Madhya Pradesh, Uttar Pradesh). • DCF, Ramgarh Vishdhari Tiger Reserve. • Department of Mines and Geology (states). • State Forest Departments. • District Magistrates of Kota, Sawai Madhopur, Dholpur, Morena, Bhind, Etawah.	• Wildlife Institute of India. • Wildlife Trust of India. • Bombay Natural History Society. • National Tiger Conservation Authority. • Indian Space Research Organisation (ISRO) for satellite surveillance.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
3.2	**Diagnose and abate the sand mining-driven geochemical signature in the Middle and Lower Zones** • Investigate and document the sand mining geochemical fingerprint identified in 2025 monitoring of this report. • Audit and regulate the Banas sub-catchment lead-zinc mining belt (Rampura-Agucha, Rajpura-Dariba, Sindesar Khurd in Bhilwara and Rajsamand districts) and the associated Chanderiya smelter (Chittorgarh), discharge to which is consistent with elevated sediment lead at the Banas Confluence (distinct from the Parvati Cr-Cu signature).	• Conductivity, TDS and salinity reduction at the Parvati and Banas confluences. • Source-apportionment study completed for sediment heavy metals at the Banas Confluence (Pb-Zn signature). • Number of unauthorised mining operations closed in the Parvati sub-catchment. • Compliance with the Sustainable Sand Mining Management Guidelines (MoEFCC 2016, revised 2020).	• RSPCB and MPPCB consent and compliance records. • District Mining Officer registers. • Source-apportionment study reports. • Independent peer-reviewed assessments.
3.3	**Develop sustainable sand mining alternatives and rehabilitation pathways for mining-dependent communities** • Identify and promote alternative livelihood options for communities currently dependent on sand mining in the ravine districts. • Promote use of manufactured sand (M-sand) from quarry overburden, recycled construction and demolition waste, and fly ash from KSTPS and other thermal power plants in the basin as substitutes for river sand. • Enforce district mining plans that exclude sanctuary and 1 km buffer areas from any auction or lease.	• Number of mining-dependent households transitioned to alternative livelihoods. • Proportion of construction sand demand in Kota, Bhopal, Jaipur and Lucknow met from M-sand and recycled aggregate. • Number of district mining plans excluding sanctuary and buffer.	• District mining plan compliance records. • M-sand production data from Bureau of Indian Standards-certified plants. • Livelihood transition tracking by State Rural Livelihood Missions.
Objective 4: Address knowledge gaps in legacy and emerging contaminants through systematic research and monitoring			
4.1	**Establish a Chambal Basin research and monitoring network spanning ecotoxicology, hydrology, fisheries and conservation biology** • Constitute a Chambal Basin Research Consortium with at least one nodal institution from each riparian state, anchored by the Wildlife Institute of India as technical lead and Ganga Aqua Labs as the analytical hub for GC-MS/MS, LC-MS/MS and ICP-MS analyses. • Develop river-specific aquatic life standards for the Chambal that account for the gharial, Gangetic dolphin and	• Number of institutions in the network. • Aquatic life standards developed for the Chambal for priority contaminants. • Ecosystem health indices developed. • Number of joint research publications.	• Records of network of institutions. • Annual Chambal State of Contamination Report. • Peer-reviewed publications. • WII institutional repository.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• MoEFCC and CPCB joint inspection of the Banas mining-smelting corridor. • Hindustan Zinc Limited and other mining lessees comply with environmental clearance conditions. • Adequate Environmental Impact Assessment review for any sand mining lease renewal.	• Ministry of Mines. • MoEFCC. • Department of Mines and Geology (Rajasthan, Madhya Pradesh). • RSPCB and MPPCB. • Geological Survey of India.	• Hindustan Zinc Limited (HZL). • National Mineral Development Corporation (NMDC). • Rajasthan State Mines and Minerals Limited. • IIT Roorkee and IIT Mumbai (mining engineering).
• Continued political and judicial commitment to sanctuary protection. • Demand-side acceptance of M-sand by builders and PWDs. • Adequate skill-development and credit support for transitioning households.	• Ministry of Mines. • Ministry of Rural Development. • State Mining Departments. • State Rural Livelihood Missions. • PWDs of Rajasthan, Madhya Pradesh, Uttar Pradesh.	• Bureau of Indian Standards. • CSIR-Central Building Research Institute. • National Skill Development Corporation. • ICAR-Indian Institute of Soil and Water Conservation.
• Institutes are willing and incentivised to collaborate. • Funds are mobilised by NMCG, MoEFCC and DST. • Expansion of the National Water Monitoring Programme (NWMP) to include EDCs and HMs at all nine Chambal stations.	• Ministry of Jal Shakti and NMCG. • MoEFCC. • State Forest Departments. • Department of Science and Technology.	• Wildlife Institute of India. • Indian Institute of Toxicological Research. • IIT Delhi, IIT Kanpur, IIT BHU. • Central Inland Fisheries Research Institute. • ICAR-IISWC. • WWF-India and Wildlife Trust of India.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
	mugger crocodile as apex aquatic predators, since the National Water Quality Criteria do not currently include species-specific or sanctuary-specific endpoints. • Develop and apply the Ganga Ecological Risk Index (GERI) framework, with Critical Conservation Corridor and Dolphin Conservation Tier multipliers, to all nine Chambal monitoring stations on an annual basis.		
4.2	**Sustain systematic monitoring of legacy and emerging contaminants in water, sediment and indicator fish biota across all three Chambal zones, with sanctuary-prioritised food-chain surveillance**	• Number of stations under continuous monitoring. • Number of analytes routinely tracked. • Annual GERI score per station, with hotspot delineation. • Indicator-species tissue burden tracking. • Number of master's and doctoral theses and peer-reviewed publications.	• Scientific and technical reports. • Peer-reviewed publications in journals such as Journal of Hazardous Materials, Science of the Total Environment, Environmental Pollution. • WII annual reports. • NMCG monitoring portal.
4.3	**Develop an open-access Chambal Basin contamination data repository** • Establish a single Chambal Basin contamination data repository linked to the NMCG Ganga River Basin Management Plan portal, integrating MPPCB, RSPCB, UPPCB, CPCB, WII, and academic monitoring data. • Publish all monitoring data with appropriate metadata (sampling protocol, instrument, QA/QC, detection limit), in line with the Open Government Data Platform standards. • Synthesise the data through periodic review papers and meta-analyses, with priority synthesis on the Chambal contamination pathway from Nagda through Kota to the Yamuna confluence.	• Repository established and accessible. • Periodic data updates. • Number of reviews and meta-analyses published.	• Repository portal. • Open Government Data Platform listings. • Citations of repository data in peer-reviewed literature.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• Adequately trained personnel available. • Government mandate to include ECs in the NWMP. • Government commitment to establish, upgrade and support such studies and facilities. • Incentives to early-career researchers and university students.	• Ministry of Jal Shakti and NMCG. • MoEFCC. • State Forest Departments.	• Wildlife Institute of India (Ganga Aqua Labs). • Indian Institute of Toxicological Research. • IIT Delhi, IIT Kanpur, IIT BHU. • ICAR-NBFGR. • Salim Ali Centre for Ornithology and Natural History.
• Coordination across multiple monitoring agencies. • Dedicated and trained personnel for repository management. • Compliance with data protection and biosecurity protocols where relevant.	• Ministry of Jal Shakti. • MoEFCC. • State Forest Departments. • National Informatics Centre.	• Wildlife Institute of India. • Central and State Pollution Control Boards. • ICAR institutions. • Academic and research institutions.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
Objective 5: Develop sustainable pollution abatement with priority focus on plastic and phthalate management, given their dominance of the Chambal EDC profile			
5.1	**Reduce microplastics, phthalate and BPA loading to the Chambal corridor through targeted plastic waste interception** • Implement systematic plastic waste collection at riparian solid waste hotspots and floodplain encroachments • Decommission riparian dumpsites within 1 km of the river bank in Nagda, Kota, Keshoraipatan, Sawai Madhopur, Dholpur, Morena, Bhind and Etawah. • Eliminate plastic fishing gear and PVC residues from the Rana Pratap Sagar and Gandhi Sagar fishing zones, given the documented contribution to ΣPAEs in the Vindhyan Zone.	• Reduction in plastic waste at sampled floodplain transects. • Reduction in ΣPAEs and BPA in surface water and sediment at the three priority hotspots. • Number of riparian dumpsites decommissioned.	• Regular monitoring reports and visual inspections. • Quarterly sediment and water EDC monitoring. • Municipal solid waste management records.
5.2	**Strengthen plastic recycling, sustainable alternatives, and Extended Producer Responsibility (EPR) enforcement in the Chambal Basin** • Establish formal plastic recycling units in Kota, Bhopal and Jaipur to handle the basin's plastic waste stream. • Promote sustainable alternatives to single-use plastics in tourism circuits (Chambal Safari at Dholpur, Kota Garadia Mahadev, Sawai Madhopur). • Enforce EPR registration and the Polluter Pays Principle on producers, importers and brand owners (PIBOs) under the Plastic Waste Management Rules 2021 amendment. • Conduct sustained public awareness campaigns on plastic reduction and the human and wildlife consequences of phthalate and BPA contamination, with emphasis on the documented bioaccumulation in fish consumed by riparian communities and by the Gangetic dolphin and gharial.	• Volume of plastic waste recycled (tonnes per year). • Decrease in single-use plastic at riparian markets. • Number of PIBOs registered and compliant under EPR. • Number of awareness events conducted and stakeholders sensitised.	• Recycling facility records and reports. • Sales data of sustainable products. • EPR portal compliance records. • Surveys and feedback from community members.
Objective 6: Develop supportive institutional mechanisms, including tri-state coordination, for the Chambal Basin			
6.1	**Establish a multi-tier institutional mechanism for Chambal Basin pollution abatement, with a dedicated Tri-State Chambal Coordination Committee** • Constitute a Tri-State Chambal Coordination Committee chaired by the Director General, NMCG, with Secretary-level representation from the Environment, Forest, Mining, Urban	• Tri-State Coordination Committee functional and meeting quarterly. • NCS Sub-Committee functional and meeting half-yearly. • District-level implementation cells established.	• Government notifications and orders. • Committee minutes. • Implementation reports.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• Adequate funding and resources. • Compliance with the Plastic Waste Management Rules 2016 (and 2021/2022 amendments) and Extended Producer Responsibility framework.	• Central and State Governments. • Ministry of Jal Shakti and NMCG. • MoEFCC. • CPCB, MPPCB, RSPCB, UPPCB. • Urban Local Bodies of riparian towns.	• Local Municipal Corporations. • NGOs and Community Groups. • Self-Help Group Federations.
• Public participation in recycling. • Availability and affordability of sustainable alternatives. • Strong regulatory framework and enforcement. • Effective communication strategies and public engagement.	• Central and State Governments. • MoEFCC and CPCB. • State Pollution Control Boards. • State Urban Development Departments.	• Private Recycling Companies. • Manufacturers, Retailers. • District Administrations, Village Panchayats. • Educational Institutions, Media Outlets, NGOs.
• Continuation of policy support at Centre and state level. • Continued political will and funding for river management. • Adequate human and financial resources. • Inter-state cooperation despite competing water-resource interests.	• MoEFCC. • Ministry of Jal Shakti and NMCG. • State Forest Departments (RJ, MP, UP). • State Pollution Control Boards. • State PHEDs and Water Resources Departments. • Local Municipal Corporations.	• Wildlife Institute of India. • Central Pollution Control Board. • National Tiger Conservation Authority. • WWF-India. • NGOs and community organisations.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
	Development, Public Health Engineering and Water Resources Departments of Rajasthan, Madhya Pradesh and Uttar Pradesh. • Embed a dedicated National Chambal Gharial Sanctuary Sub-Committee chaired jointly by the three Chief Wildlife Wardens, with mandate over all sanctuary-overlapping interventions described in Objectives 1 to 5. • Operationalise the Ganga River Basin Management Plan (Chambal Sub-Basin Chapter) with district-level implementation cells in Ujjain, Mandsaur, Chittorgarh, Kota, Sawai Madhopur, Sheopur, Morena, Bhind, Dholpur and Etawah. • Reconcile the inconsistent regulatory designations of the Chambal stretches (CPCB Priority I in MP for BOD greater than 30 mg/L on the basis of 2023 monitoring, Priority V in Rajasthan in the 2018 RPCB plan) into a single basin-wide, contaminant-class-aware classification.	• Unified Chambal Basin classification published.	• Compliance with the National Mission for Clean Ganga Authority Order 2016 and the River Basin Management Plan framework.
Objective 7: Engage and empower local communities and stakeholders for sustainable resource use in the Chambal corridor			
7.1	**Promote sustainable, chemical-free agriculture and aquaculture among Chambal Basin farmers and fishers** • Roll out National Programme for Organic Production (NPOP) certification and Aquaculture Stewardship Council (ASC) certification across the catchment, with priority to the post-monsoon nitrate-hotspot Banas and Parvati confluences. • Phase in pesticide and fertiliser subsidies aligned to integrated nutrient management. • Pilot integrated multi-trophic aquaculture (IMTA) at Rana Pratap Sagar and Jawahar Sagar reservoirs to reduce nutrient and plastic loading from open-cage fishing operations.	• Number of NPOP and ASC certificates issued in the Chambal districts. • Hectares under integrated farming. • Number of fishers and farmers transitioned.	• Agriculture department records. • Fisheries department records. • NPOP and ASC certification registers.
7.2	**Conduct sustained awareness, sensitisation and capacity building of riparian communities, with focus on the conservation value of the National Chambal Gharial Sanctuary** • Annual sensitisation programmes for riparian Panchayats across Kota, Sawai Madhopur, Karauli, Dholpur, Sheopur, Morena, Bhind, Etawah and Auraiya districts.	• Number of programmes conducted. • Number of stakeholders sensitised. • Number of community-reported violations leading to action.	• Official records. • Community surveys. • Forest Department offence registers.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• Streamlined extension activities. • Subsidies and procurement support for sustainable practices. • Adequate skill development.	• Ministry of Agriculture & Farmers Welfare. • Ministry of Fisheries, Animal Husbandry and Dairying. • Directorate of Plant Protection. • State Agriculture and Fisheries Departments.	• ICAR-CIFRI, ICAR-NBFGR. • Krishi Vigyan Kendras. • State Agricultural Universities (RAU, JNKVV, MPUAT). • FPO networks.
• Willingness of local communities to participate. • Continued institutional support. • Sustainable livelihood incentives for sanctuary protection.	• MoEFCC. • Ministry of Jal Shakti. • State Forest Departments. • State Biodiversity Boards. • Panchayati Raj Institutions.	• Wildlife Institute of India. • Village panchayats. • Local fisher and farmer collectives. • Sanctuary-edge schools.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
	• Community-based monitoring of sanctuary boundaries and reporting of illegal mining, fishing, hunting and habitat encroachment, building on the existing Gharial Conservation Project structure. • Specialised training of local guides at Chambal eco-tourism circuits (Pali, Pinahat, Nadigaon, Dholpur) to combine sustainable livelihood with sanctuary protection.	• Reduction in sanctuary-boundary violations year on year.	
Objective 8: Deploy technology integration for real-time monitoring, source detection and decision support across the Chambal corridor			
8.1	**Deploy a real-time water quality monitoring network (WQMS) at all nine Chambal stations with sentinel emphasis on the sanctuary boundary**	• Number of functional WQMS units installed and operational. • Frequency and accuracy of real-time data transmission. • Number of parameters monitored. • Hypoxia event detection at D/S Kota Barrage.	• IoT dashboard reports. • Central monitoring system logs (CPCB CARE-Water). • Third-party calibration and maintenance reports.
8.2	**Integrate SCADA and AI-based analytics into Kota STPs and the Nagda CETP infrastructure** • Mandate SCADA integration at all eight Kota STPs (Balita, Dhakadkheri, Sajidehra, Oxyzone, Kala Talab, plus the three under installation) and at the Nagda industrial CETP (currently the only CETP node in the Vindhyan Zone, with the 2020 commitment for an 11.5 MLD CETP not yet reflected in the operational list). • Deploy AI-based fault prediction and load optimisation, with priority to the chronic underperformance documented at Balita (phosphate 1.48 mg/L) and Sajidehra (TSS 39 mg/L, total N 12.72 mg/L) in February 2024. • Develop a public-facing STP performance dashboard mandated under NGT OA 189/2023 compliance.	• Number of STPs and CETPs with SCADA and AI integration. • Reduction in downtime and operational failures. • Compliance rate with discharge standards (currently 6 of 8 Kota STPs compliant).	• Performance audit reports. • Daily SCADA logs and alerts. • AI system reports on fault predictions and load optimisation. • Public dashboard.
8.3	**Use satellite-based remote sensing, drones and AI surveillance for pollution hotspot detection, illegal mining detection and sediment mapping in the National Chambal Gharial Sanctuary** • Monthly satellite analysis of the entire Chambal corridor for surface water discoloration, drain discharge plumes and floodplain encroachment.	• Number of satellite and drone surveys conducted per year. • Identification and mapping of polluted and mining-impacted stretches.	• Remote sensing analysis reports. • Drone survey reports. • GIS pollution and mining maps. • AI accuracy validation studies.

Critical Assumptions	Responsible Agencies	Supporting Organisations
		• Local NGOs (Madhya Pradesh Gharial Conservation Society etc.).
• Availability of telecom and data network coverage. • Timely sensor calibration and maintenance. • Conformity with the CPCB Guidelines for Real-Time Continuous Effluent Monitoring Systems.	• CPCB, MPPCB, RSPCB, UPPCB. • Ministry of Jal Shakti. • Urban Local Bodies.	• Tech vendors (Envirotech, Forbes Marshall, ABB, Bosch). • IITs and CSIR labs. • ISRO.
• Skilled manpower available. • SCADA-AI systems interoperable with legacy infrastructure. • Sustained capital and O&M financing.	• Rajasthan Jal Nigam. • Madhya Pradesh Jal Nigam. • Municipal Corporations. • Private STP and CETP operators.	• Industry automation partners (Tata Elxsi, IBM India, L&T Smart World). • Digital solution providers. • IIT Delhi and IIT Roorkee.
• Access to high-resolution satellite data. • Skilled GIS and AI analysts available. • Legal framework for AI-based evidence in environmental and wildlife prosecutions. • Public awareness and cooperation.	• ISRO. • Forest Departments (RJ, MP, UP). • Police and Border Security Force (where applicable). • District Magistrates.	• NRSC, IIT Roorkee, NIC, NMCG. • Computer vision AI startups. • Mobile app development companies. • Wildlife Conservation Trust.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
	• Drone-based surveys of the sanctuary stretch for illegal sand mining detection. • AI-powered computer vision surveillance at high-risk offload nodes along the sanctuary corridor, with automated alerts to Forest Department control rooms. • Citizen-science mobile application with AI verification for crowd-sourced reporting of pollution and mining incidents.	• Accuracy of AI-based illegal dumping and mining detection. • Reduction in mining-related incidents in the sanctuary.	• Citizen reporting app usage statistics.
8.4	**Develop an integrated Chambal Ecosystem Health Dashboard linking contamination, hydrology, biodiversity and sanctuary management data** • Integrate water quality, sediment, fish bioaccumulation and biodiversity datasets into a single AI-driven dashboard with a Chambal Ecosystem Health Index. • Include species-specific modules for the gharial (Gavialis gangeticus), Gangetic dolphin (Platanista gangetica), mugger crocodile (Crocodylus palustris), smooth-coated otter (Lutrogale perspicillata) etc. • Incorporate the latest biodiversity census data and update annually. • Link to the Ganga Aqua Labs analytical pipeline at WII for contaminant uptake.	• Real-time ecosystem health index per station. • Biodiversity monitoring with AI-assisted species recognition. • Habitat quality assessment using satellite and drone data. • Fish population dynamics modelling. • Dashboard usage by policy-makers.	• Ecosystem health index reports. • Species identification and counting logs. • Habitat quality studies. • Population trend analysis. • Dashboard usage and decision impact metrics.
Objective 9: Conserve apex aquatic species in the National Chambal Gharial Sanctuary through contamination-aware species management plans			
9.1	**Operationalise contaminant-aware species management plans for the gharial, Gangetic dolphin, mugger, smooth-coated otter and freshwater turtle assemblage**	• Species management plans updated and approved. • Annual contamination-aware census of gharial, dolphin, mugger. • Gharial and dolphin tissue contamination surveillance through non-invasive matrices. • Number of contamination-induced mortality events investigated.	• DCF Ramgarh Vishdhari Tiger Reserve and DCF NCS quarterly reports. • Annual sanctuary management reports. • Wildlife Institute of India species monitoring reports. • Project Dolphin annual reports.
9.2	**Investigate and document contamination-linked aquatic species mortality events in the sanctuary** • Establish a sanctuary-wide rapid response protocol for unusual mortality events (gharial, mugger, dolphin, turtle), including standardised post-mortem and tissue	• Rapid response protocol operational. • Number of unusual mortality events investigated.	• Registry records. • Post-mortem reports. • Annual review reports to the Standing Committee of the National Board for Wildlife.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• Baseline ecological data establishment. • Expert validation of AI-generated insights. • Regular field surveys for ground-truthing. • Inter-disciplinary collaboration. • Long-term data consistency.	• Wildlife Institute of India. • Zoological Survey of India. • Botanical Survey of India. • National Biodiversity Authority. • ICAR-CIFRI.	• WWF-India and Wildlife Trust of India. • Conservation International. • International biodiversity monitoring networks. • Academic ecology research institutions.
• Continued integration of contamination data into species management. • Adequate funding under Project Dolphin and the Gharial Conservation Action Plan. • Conformity with the Wild Life (Protection) Act 1972 (Schedule I species listings) and the IUCN Red List assessments (gharial CR, Gangetic dolphin EN). • Compliance with the National Wildlife Action Plan.	• State Forest Departments (RJ, MP, UP). • DCF, National Chambal Gharial Sanctuary. • DCF, Ramgarh Vishdhari Tiger Reserve. • Ministry of Environment, Forest and Climate Change (Project Dolphin and Crocodile Programme). • National Mission for Clean Ganga (Aquatic Species sub-programme).	• Wildlife Institute of India. • Zoological Survey of India. • WWF-India and Wildlife Trust of India. • Bombay Natural History Society. • International gharial and dolphin conservation networks (Gharial Conservation Alliance).
• Coordination between Forest Departments and analytical institutions. • Adequate cold-chain and sample transport infrastructure. • Compliance with biomedical waste and biosafety norms.	• State Forest Departments. • DCF, National Chambal Gharial Sanctuary. • MoEFCC. • Wildlife Crime Control Bureau.	• Wildlife Institute of India. • ICAR-Indian Veterinary Research Institute. • National Centre for Disease Control.

#	Strategy / Action	Objectively Verifiable Indicators (OVI)	Means of Verification (MoV)
	contamination analysis at the Ganga Aqua Labs.	• Registry maintained and publicly accessible (with sensitive data appropriately protected).	
Objective 10: Manage tributary loading from the Parvati and Banas sub-catchments, the two largest non-Kota contributors to Chambal contamination, with state-specific source-apportionment and regulatory action.			
10.1	**Conduct source-apportionment surveillance and abatement of the Parvati sub-catchment.**	• Source-apportionment study completed and published. • Industrial sources contributing to the documented signatures identified and brought under consent compliance. • Continuous monitoring node operational at the Parvati-Chambal confluence. • Reduction in sediment ΣPAEs and ΣHMs at the Parvati confluence against the 2025 baseline.	• Source-apportionment study reports. • MPPCB consent and compliance registers • Annual monitoring data integrated into the NMCG dashboard.
10.2	**Conduct source-apportionment surveillance and abatement of the Banas sub-catchment.**	• Source-apportionment study completed and published. • Mining and industrial sources brought under environmental clearance compliance. • Continuous monitoring node operational at the Banas-Chambal confluence. • Reduction in post-monsoon nitrate and sediment lead at the Banas confluence against the 2025 baseline.	• Source-apportionment study reports. • RSPCB consent and compliance registers. • Environmental clearance compliance records under MoEFCC. • Annual monitoring data integrated into the NMCG dashboard.

REFERENCES

Central Monitoring Committee. (2020, June 23). Minutes of the 3rd meeting of the Central Monitoring Committee held on 23.06.2020 through video conferencing regarding 351 polluted river stretches based on the directions of Hon'ble NGT in the matter OA No. 673 of 2018. Ministry of Jal Shakti, Government of India.

Central Pollution Control Board. (2021). Water quality data of rivers monitored under National Water Quality Monitoring Programme (NWMP), 2021.

Central Pollution Control Board. (2024, August 9). Status report in the matter of Original Application No. 491/2024 in ref: News item published in Hindustan Times dated 26.02.2024 titled "Ganga water unsafe even for bathing says Bihar Govt. report on river pollution". National Green Tribunal, Principal Bench, New Delhi.

Central Pollution Control Board. (2025, October). Polluted river stretches for restoration of water quality (Updated version). Ministry of Environment, Forest and Climate Change, Government of India.

Goyal, R., Gupta, A. B., Shrivastava, S., Dadhich, A. P., & Rajput, H. (2018). Prevention and control of pollution in River Chambal and Banas: An action plan for river rejuvenation (Rajasthan State). Department of Civil Engineering, Malaviya National Institute of Technology Jaipur.

Ministry of Environment, Forest and Climate Change. (2015, August 4). Dumping of pollutants in Chambal River: Lok Sabha unstarred question no. 2399. Government of India.

Critical Assumptions	Responsible Agencies	Supporting Organisations
• MPPCB capacity and willingness to extend monitoring beyond the conventional BOD-DO-coliform suite. • Inter-state coordination between Madhya Pradesh and Rajasthan, given that the loading is generated in MP and arrives in the sanctuary stretch in Rajasthan.	• Madhya Pradesh Pollution Control Board. Madhya Pradesh • Department of Environment. NMCG and Ministry of Jal Shakti.	• Wildlife Institute of India. • Regional academic/research institutes • CPCB/SPCBs
• Coordination between RSPCB, the Rajasthan Department of Mines and MoEFCC. • Mining and industrial operators comply with environmental clearance conditions. • Adequate review under EIA Notification for any new or expanded operations in the sub-catchment.	• Rajasthan State Pollution Control Board. • Rajasthan Department of Mines and Geology. • Ministry of Environment, Forest and Climate Change. NMCG and Ministry of Jal Shakti.	• Geological Survey of India. • NEERI. • Wildlife Institute of India. • Regional academic/research institutes • CPCB/SPCBs.

National Mission for Clean Ganga. (2024, February 26). Minutes of the 54th meeting of the Executive Committee (EC) of National Mission for Clean Ganga held on 13th February 2024 through hybrid mode. Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti, Government of India.

Sah, R., Khanduri, M., Chaudhary, P., Paul, K. T., Gururani, S., Banwala, K., Paul, C., Jose, M. A., Bora, S., Ramachandran, A., Badola, R., & Hussain, S. A. (2024). Dietary exposure of potentially toxic elements to freshwater mammals in the Ganga River basin, India. Environmental Pollution, 351, 123928. https://doi.org/10.1016/j.envpol.2024.123928

Sah, R., Talukdar, G., Khanduri, M., Chaudhary, P., Badola, R., & Hussain, S. A. (2024). Do dietary exposures to multi-class endocrine disrupting chemicals translate into health risks for Gangetic dolphins? https://doi.org/10.1016/j.heliyon.2024.e35130

WII-GACMC (2022). Chambal River: Ecological status and trends. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Pp. 41

CHAPTER 9

ANTHROPOGENIC THREATS

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Surya Prasad Sharma,
SK Zeeshan Ali

Contributing Authors
Srijani Guha,
Ashish Mani,
Khadija,
Asif Mohammad
Shivani Barthwal

SUMMARY

The longest riverine Protected Area in India, the National Chambal Sanctuary (NCS), stretches over 600 km along the Chambal River, encompassing parts of Madhya Pradesh, Rajasthan, and Uttar Pradesh. Established to safeguard the unique assemblage of freshwater biodiversity, the NCS harbors the largest breeding population of the Critically Endangered gharial (*Gavialis gangeticus*), along with key species such as the Gangetic dolphin (*Platanista gangetica*), Indian skimmer (*Rynchops albicollis*), and several threatened freshwater turtles. Despite its protected status, the sanctuary faces mounting pressures from upstream dams, illegal and unscientific sand mining, riparian agriculture, unregulated fishing, and habitat degradation. These threats compromise ecological connectivity, alter hydrological regimes, and jeopardize critical nesting and basking habitats.

Construction of dams and barrages, especially the Kota Barrage, has drastically reduced downstream flow, creating disconnected pools vulnerable to human disturbance. The proposed Parbati-Kali Sindh-Chambal link threatens to curtail tributary inputs further, exacerbating sediment loss critical for sand nesting vertebrates. Sand mining destabilizes riverbanks and reduces sandbar habitats essential for gharials and turtles, while increasing turbidity affects visual foraging efficiency. Riparian agriculture contributes to sedimentation, habitat destruction, and agrochemical runoff, particularly during the monsoon. Human and livestock presence increases erosion and nest trampling, especially impacting sand-nesting species like the Indian skimmer. Fishing with gillnets causes entanglement-related mortality in gharials and dolphins

and reduces prey availability for piscivorous fauna. Water extraction for agriculture and urban expansion, particularly in the lower middle zone, lowers base flows, impacting aquatic species during dry periods.

As the ecological backbone of the Ganga River Basin, the Chambal River and its protected stretch require urgent integrated management, strict enforcement of protective laws, regulated resource use, community involvement, and final sanctuary notification are urgently needed to restore habitat connectivity and protect this critical biodiversity hotspot.

9.1 Introduction

Flowing through the Semi-arid landscapes of Madhya Pradesh, Rajasthan, and Uttar Pradesh, the Chambal River is a critical ecological as well as livelihood resource (Hussain & Badola, 2001). The river harbours the largest population of gharial and Indian skimmer, along with several species of freshwater turtles. To safeguard these freshwater faunal communities, a 600 km stretch of the river has been designated as the National Chambal Sanctuary (NCS). Despite this protected status, the river continues to face multiple anthropogenic stressors, including habitat loss, degradation, fragmentation, overexploitation, and the introduction of invasive species (Katdare et al., 2011; WII, 2020). In past few decades, however, the river has come under increasing pressure due to the growing reliance on river resources, rapid infrastructure development-such as dams, barrages, irrigation canals, and artificial embankments along with sand mining, riparian agriculture, pollution, and fishing-related mortality, have intensified pressures on riverine biodiversity (Katdare et al., 2011; Hussain et al., 2011). These stressors often act synergistically, compounding their adverse effects on riverine biodiversity and ecological integrity.

The construction of dams and barrages in the upstream of the Chambal River has already reduced the flow of the river almost to zero, below the Kota barrage in Rajasthan. Dams and barrages obstruct the dispersal and migration, and these and other effects have been directly linked to loss of population connectivity, often leading to local extirpation of riverine species (Nilsson et al., 2005). Impoundments further reduce water flow in the downstream, decrease available habitat, and create isolated pools that are highly vulnerable to anthropogenic activities (Dubey & Mehra, 1959; Katdare, 2011). Reduced water flow has often resulted in increased access to people for river crossing by foot and tractor, sand mining, and cultivation (Nair, 2010).

Riparian agriculture in riverine systems across India poses a significant ecological threat to both aquatic and semi-aquatic species. Agricultural activities, such as continuous ploughing and cultivation along floodplains, contribute to soil erosion, sedimentation, and alterations in natural river hydrology, leading to the degradation of critical aquatic habitats (Issaka & Ashraf, 2017). Extensive riparian agriculture often extends to the river's edge, destroying sandbanks and sandbars essential for nesting and basking for species like the gharial and freshwater turtles (Hussain, 2009; Taigor & Rao, 2010). In addition to habitat loss, riparian agriculture introduces agrochemical runoff, especially during the monsoon when the runoff carries pollutants into the river systems.

Sandy substrate plays an essential role in the ecology of riverine species, as they retains more moisture than rocky or dry substrates. This moisture provides a warmer and more humid microenvironment, which is particularly important for basking species such as reptiles, by reducing the risk of desiccation during prolonged exposure to the sun (Hussain, 2009). Despite the ecological importance of the sand, its extraction from islands and riverbanks is on the rise due to growing demand for construction material. Unregulated extraction of sand alters river morphology, leading to the erosion of sandy banks that are crucial for gharials, muggers, and turtles. Remote sensing and GIS-based assessments have documented severe shoreline erosion at illegal sand mining sites, with rates reaching up to 1.26 meters per year in some regions of the Chambal River (Singh et al., 2023). Continuous sand removal destabilizes riverbanks and increases turbidity, impairing visibility for visual predators like the gharial and thereby reducing their foraging efficiency (Lunt & Smee, 2015). Despite the legally protected status of the Chambal River as a Wildlife Sanctuary, enforcement against illegal sand mining remains inconsistent and often inadequate.

Fishing is widely practiced across the Chambal River. The use of gill nets and other indiscriminate fishing gear has been the primary threat to obligate piscivores, such as the gharial and the Gangetic dolphin (He, 2006; Kumar et al.,2022; Kelkar & Dey, 2021). The presence of active fishing within gharial habitats not only increases the risk of entanglement and mortality, especially of juveniles, but also reduces prey availability, as fish constitute a significant component of the gharial's diet. Fish are also targeted by other piscivorous wildlife such as otters, Gangetic dolphins, storks, pelicans, and cormorants. Consequently, unsustainable fishing pressure can have cascading ecological effects, disrupting the entire aquatic food web. Fishing in the region is primarily carried out by individual fishermen who operate from inflated inner tubes or small rafts, using nets such as gill nets and cast nets. Nets are often deployed overnight or for extended hours, increasing the risk of bycatch, including gharials.

A systematic study was undertaken to quantify the anthropogenic threats prevalent in the Chambal River and spatially map them.

9.2 Methods

The Chambal River was divided into 5 km segments, referred to as BEU, using ArcGIS 10.2 (ESRI, Redlands, USA). At each BEU, data on a range of anthropogenic variables were systematically collected. Parameters recorded within each BEU included the presence and intensity of fishing activity, number of fishing boats and nets, extent of bank and island agriculture, and sand mining operations, including mode of transportation and extraction (e.g., trucks, boats, earth movers). Additional variables captured were the number of ferries, industrial or domestic drains, and sewage outlets, and the presence of dams or barrages. In addition, to identify the hotspots of Gangetic dolphin mortality, multi-criteria evaluation (MCE)-based Weighted Overlay Analysis (WOA) was undertaken (Badola et al., 2025).

9.3 Results

The occurrence of anthropogenic threats varied considerably across the different zones of the Chambal River. Human presence was recorded in all surveyed BEUs, yielding 100% occurrence across all zones. Cattle presence was also recorded in all BEUs in the lower zone, yielding 100% occurrence, followed by the Lower Middle (80%) and Upper Middle (60%) zones (Figure 9.1). Fishing intensity was most pronounced in the Upper Middle zone (40%), slightly lower in the Lower Middle (30%), and lowest in the Lower zone (10%), indicating that upstream stretches experience higher fishing pressure. Similarly, ferry boat activity was more common in the Upper and Lower Middle zones, but minimal in the Lower zone (10%). Water extraction was highest in the Lower Middle zone (70%), followed by the Upper Middle (55%) and Lower zone (45%). The presence of ghats was primarily observed in the Upper Middle zone (40%), and was negligible in the downstream stretches. Mining activity was recorded in the Lower middle and lower zones only.

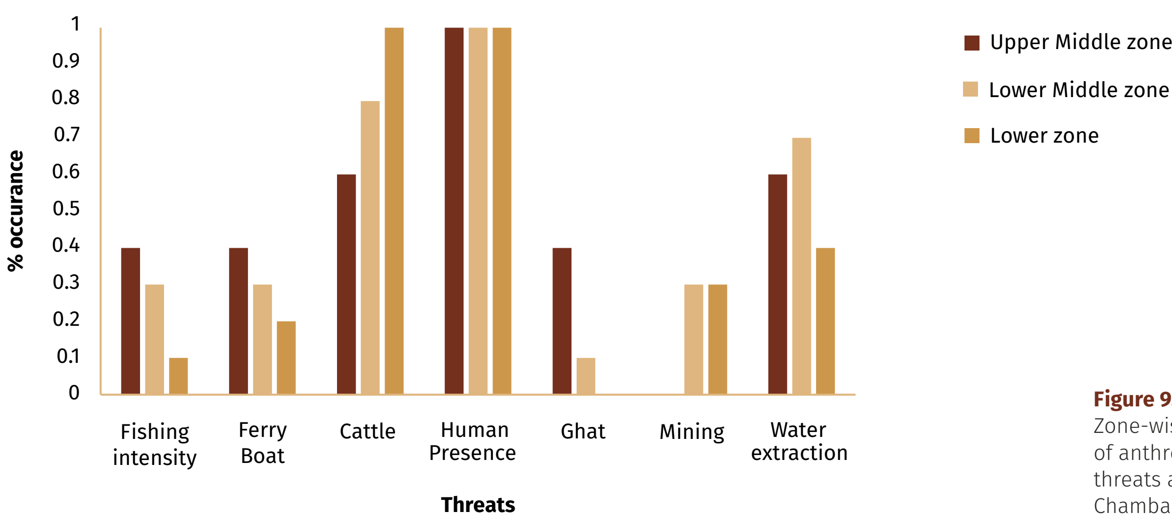


Figure 9.1: Zone-wise occurrence of anthropogenic threats along the Chambal River

One incidence of Gangetic dolphin mortality was reported from the Chambal River in Etawah, near the confluence of the River with the Yamuna River, which constitutes 1.3% of the mortaility records from the entire Ganga River Basin (Badola et al., 2025). Of the 240 km length of the Chambal River occupied by the Gangetic dolphin, about 10% of the River stretch is under high risk while the remaining 90% of the dolphin occupied length is moderate risk.

9.4 Discussion

The Chambal River is increasingly experiencing pressures from unsustainable development, intensive resource extraction, and anthropogenic disturbances (Katdare et al., 2011). These stressors alter the hydrology, sediment dynamics, and aquatic biodiversity, posing a growing threat to the ecological integrity of the basin. Over the last few decades, the expansion of sand mining along the Chambal River has led to morphological and hydrological changes, particularly in its middle and lower stretches. Excessive sand removal destabilizes riverbanks, reduces the availability of nesting habitats for species like the gharial and Indian skimmer, and affects spawning sites for native fish species (Hussain, 2009; Asim & Rao, 2024). Despite legal protection under the National Chambal Sanctuary (NCS), enforcement remains weak, and illegal mining continues in several zones, often carried out using heavy machinery that destroys riparian vegetation and disrupts aquatic microhabitats. The hydrology of the Chambal River has been affected by three large upstream storage dams, viz., Gandhi Sagar, Rana Pratap Sagar and Jawahar Sagar, and the Kota Barrage, which were built between 1960 and 1972. These impoundments have altered the natural flow of the Chambal River to the extent that the River ceases to flow below the Kota barrage during the lean season (Hussain et al., 2011). The river revives after the Kali Sindh, and the Parvati rivers join further downstream. However, the new Parbati-Kali Sindh-Chambal Link proposes to divert the 'surplus' waters of the Parbati, Newaj, and Kalisindh rivers to the Gandhi Sagar/Rana Pratap Sagar Dam on the Chambal. This proposed river linking will deny the Chambal whatever water, sand, and silt it receives from these tributaries. Sand banks, bars, and spits are essential resting and breeding sites in the National Chambal Sanctuary for crocodilians, freshwater turtles, and island nesting birds, and the loss of these sites is a significant cause for their population declines. Dams also exacerbate the problem by preventing the replacement of sand downstream, while increasing erosion by periodic and unseasonal elevation of water levels (Moll, 1997). Upstream and downstream effects of dams are well-known, stemming from inundation, flow manipulation, and fragmentation. Inundation destroys terrestrial ecosystems and eliminates turbulent reaches, disfavoring lotic biota. It can cause anoxia, greenhouse gas emissions, sedimentation, and an upsurge of nutrient release in new reservoirs. The combination of two factors, sand mining and a decline in the river's sand deposition potential, results not only in loss of habitat for aquatic species but also changes the River's course, which poses a significant risk to the people living downstream.

The Chambal River is also impacted by unregulated fishing practices, including the use of gill nets and small-mesh nets that result in the accidental capture and drowning of gharial juveniles. Fishing intensity has increased, particularly in upstream areas where dependence on riverine resources is high. Such activities not only deplete fish stocks but also disturb basking and breeding behaviors of sensitive aquatic fauna.

Additionally, urban expansion and agricultural intensification within the basin have contributed to increased water extraction, particularly in the lower middle stretches. Such practices have led to altered base flows, especially during the dry season, affecting habitat availability for aquatic species. In areas like Kota and Etawah, growing urban populations and industrial activities have increased pollution load and infrastructure development, including roads and bridges, fragmenting habitats and modifying natural flow regimes.

Riparian agriculture and associated activities like water abstraction via water pumps, persistent human presence as a result of pump operation and crop protection, risks of water pollution from agrochemical use, and oil leaks contribute substantially to habitat loss, degradation, and pollution. Increased use of submersible pumps leads to further risk of electrocution through live wires and hazardous installations. The settlement of the rights of villages falling within the sanctuary boundary and the final notification of the sanctuary have not been carried out yet, which is a major hurdle in preventing the spread of agriculture along the banks of the Chambal River.

Conservation challenges are compounded by livestock grazing, which is widespread along the banks and on the river islands. Grazing not only results in vegetation loss but also leads to nest trampling, particularly affecting species like river terns and the Indian skimmer. Surveys also indicate that cattle presence is highest in the lower zone, further stressing the already vulnerable nesting habitats.

The cumulative impacts of these threats demand an integrated river basin management approach, emphasizing stronger enforcement, community-based conservation, and habitat restoration. Given the ecological importance of the Chambal River for species such as the Critically Endangered gharial and multiple threatened freshwater turtles, urgent action is required to ensure the long-term health of this unique riverine ecosystem.

The Chambal River, probably due to its protected status and lower anthropogenic pressures has currently been classified primarily as moderate-risk rather than high-risk for dolphin mortality. This categorization should be approached with caution, and it warrants stricter conservation actions, considering the inevitable increase in resource demand, particularly water, sand, fish and other consumable riverine resources.

REFERENCES

Asim, M., & Rao, K. N. (2024). Flow dynamics and channel changes at Yamuna River in Delhi-National Capital Region, India. *International Journal of River Basin Management*, 1-17.

Dubey, G. P., & Mehra, R. K. (1959). Fish and fisheries of Chambal River. In *Proceedings of the All India Congress of Zoology* (Vol. 1, No. 2, pp. 647-665).

He, P. (2006). Gillnets: Gear design, fishing performance and conservation challenges. *Marine Technology Society Journal, 40*(3), 12-19.

Hussain, S. A. (2009). Basking site and water depth selection by Gharial (*Gavialis gangeticus* Gmelin, 1789) (Crocodylia, Reptilia) in National Chambal Sanctuary, India and its implication for river conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems, 19*(2), 127-133.

Hussain, S. A., Sharma, R. K., Dasgupta, N., & Raha, A. (2011). Assessment of minimum water flow requirements of Chambal River in the context of Gharial (*Gavialis gangeticus*) and Gangetic Dolphin (*Platanista gangetica*) conservation. Study report, Wildlife Institute of India, Dehradun, India, 40 pp.

Hussain, S. A., & Badola, R. (2001). Integrated conservation planning for Chambal River Basin. Paper presented at the National Workshop on Regional Planning for Wildlife Protected Areas, August 6-8, 2001, India Habitat Centre, New Delhi. Wildlife Institute of India, Dehradun, 20 pp.

Issaka, S., & Ashraf, M. A. (2017). Impact of soil erosion and degradation on water quality: A review. *Geology, Ecology, and Landscapes, 1*(1), 1-11.

Katdare, S., Srivathsa, A., Joshi, A., Panke, P., Pande, R., Khandal, D., & Everard, M. (2011). Gharial (*Gavialis gangeticus*) populations and human influences on habitat on the River Chambal, India. *Aquatic Conservation: Marine and Freshwater Ecosystems, 21*(4), 364-371.

Kelkar, N., & Dey, S. (2021). Ganges river dolphins and other biodiversity in the Mahananda River in Bihar and West Bengal: A report on the first complete survey, November 2021. Department of Environment, Forests, and Climate Change, Government of Bihar; Wildlife Conservation Trust, Mumbai, India.

Kumar, A., Ram, R. K., Kumar, S., & Srivastava, P. P. (2022). Sustainability challenges for traditional fisheries: bycatch impact of gillnets in river Burhi Gandak.

Lunt, J., & Smee, D. L. (2015). Turbidity interferes with foraging success of visual but not chemosensory predators. *PeerJ,* 3, e1212.

Moll, E. O. (1997). Effects of habitat alteration on river turtles of tropical Asia with emphasis on sand mining and dams (pp. 37-41). In J. V. Abbema (Ed.), *Proceedings: Conservation, restoration, and management of tortoises and turtles - An international conference, New York.* New York Turtle and Tortoise Society.

Nair, T. (2010). *Ecological and anthropogenic covariates influencing Gharial (Gavialis gangeticus) distribution and habitat use in Chambal River, India* (Unpublished Master's thesis).

Nilsson, C., Reidy, C. A., Dynesius, M., & Revenga, C. (2005). Fragmentation and flow regulation of the world's large river systems. *Science, 308*(5720), 405-408.

Singh, S., Meraj, G., Kumar, P., Singh, S. K., Kanga, S., Johnson, B. A., Prajapat, D. K., Debnath, J., & Sahariah, D. (2023). Decoding Chambal river shoreline transformations: A comprehensive analysis using remote sensing, GIS, and DSAS. *Water, 15*(9), 1793.

Taigor, S. R., & Rao, R. J. (2010). Anthropogenic threats in the National Chambal Sanctuary, Madhya Pradesh, India. *Tigerpaper, 37*(1), 23-27.

Wildlife Institute of India (WII) & National Mission for Clean Ganga (NMCG). (2020). *Biodiversity profile of the Ganga River.* Wildlife Institute of India. ISBN 81-85496-41-2.

SECTION III

CHAPTER 10

CONSERVATION PRIORITY STRETCHES

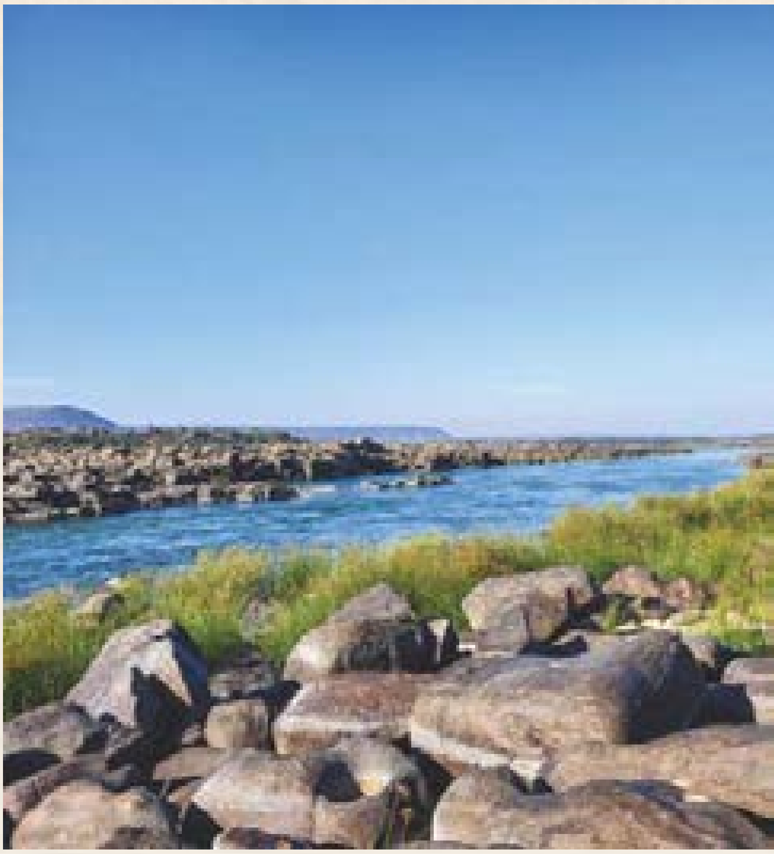
Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Surya Prasad Sharma,
SK Zeeshan Ali,
Goura Chandra Das

Contributing Authors
Srijani Guha,
Satakshi Sharma,
Ashish Mani,
Khadija,
Shivani Barthwal

SUMMARY

This chapter evaluates freshwater biodiversity threats and delineates Conservation Priority Stretches (CPSs) for the endangered Gangetic Dolphin (*Platanista gangetica*) in the Chambal River, a major tributary of the Ganga Basin. Using MaxEnt species distribution modeling and spatial environmental data, 21 CPSs spanning 285 km were identified and classified into high (CPS1, 85 km), moderate (CPS2, 150 km), and low (CPS3, 50 km) priority categories. These CPSs occur primarily in the middle and lower zones of Chambal across Madhya Pradesh, Rajasthan, and Uttar Pradesh. The study highlights the ecological significance of the river segments in supporting Gangetic Dolphin populations and maintaining riverine connectivity. It emphasizes the utility of CPS-based frameworks for site-specific conservation planning, habitat restoration, and alignment with national and global biodiversity targets.



10.1 Introduction

Freshwater ecosystems are among the most threatened globally due to habitat loss, fragmentation, pollution, overexploitation, and climate change (Linke et al., 2011; Reid et al., 2019). Despite providing critical ecosystem services, rivers and wetlands are rapidly degrading due to unsustainable urbanization, industrialization, and land-use change (Carpenter et al., 2011; Bai et al., 2017; Liu et al., 2023). These stressors result in biodiversity loss and ecological disruption, especially for aquatic macrofauna (Fierro et al., 2017). Infrastructure development, such as dams, barrages, agricultural runoff, and pollution, severely alters hydrology, degrades habitats, and affects species viability (Dudgeon, 2006; Echols et al., 2009). Additionally, agricultural runoff, industrial discharge, and domestic sewage degrade water quality by reducing dissolved oxygen levels and triggering algal blooms (Dudgeon, 2006; Echols et al., 2009; Grimm et al., 2008). Climate change further intensifies these impacts by altering flow regimes, water temperature, and precipitation patterns, thus affecting species distribution and ecosystem stability.

The escalating threats to freshwater biodiversity demand a science-based conservation strategy. Identifying Conservation Priority Areas is critical, especially given increasing habitat fragmentation and declining species populations (Howard et al., 2018; Reid et al., 2019). Effective conservation planning involves habitat assessment, prioritization, and management, incorporating spatial modeling, connectivity analyses, and multi-criteria decision-making tools (USGS, 2017). Key indicator species like the Gangetic dolphin (*Platanista gangetica*), gharial (*Gavialis gangeticus*), smooth-coated otter (*Lutrogale perspicillata*), and riparian birds such as the black-bellied tern (*Sterna acuticauda*) and Indian skimmer (*Rynchops albicollis*) are particularly affected. Their decline signals a broader ecological crisis, threatening the integrity of freshwater ecosystems (Strayer & Dudgeon, 2010; IUCN, 2023).

In response to these challenges, conservationists and policymakers have emphasized the urgency of identifying and safeguarding Conservation Priority Stretches (CPS) - ecologically valuable river segments requiring immediate action (Bonn & Gaston, 2005; Margules et al., 2002). CPS serve as focal points for habitat restoration, species conservation, and sustainable management, enabling long-term ecosystem resilience (Karam et al., 2021).

Establishing CPS enhances gene flow, supports seasonal migrations, and stabilizes populations of threatened species in river systems like the Ganga River Basin (Kumar, 2021). Using species distribution models (SDMs), spatial prioritization, and connectivity assessments, critical river stretches can be identified for immediate protection. Integrating these results into conservation, habitat restoration, and management frameworks offers a cohesive and sustainable approach to freshwater biodiversity conservation (Jain & Singh, 2018, 2024; Dudgeon et al., 2006).

A systematic approach to CPS identification involves spatial modeling tools such as MaxEnt (Maximum Entropy Modeling), AHP (Analytical Hierarchy Process), and WOA (Weighted Overlay Analysis) (Moilanen et al., 2007; Nel et al., 2008). These tools integrate species occurrence data and ecological connectivity parameters to highlight high-priority zones (Albuquerque & Beier, 2015; Howard et al., 2018). SDMs, particularly MaxEnt, are widely used in freshwater conservation due to their ability to work effectively with presence-only data and limited sampling records (Elith et al., 2006; Ma & Sun, 2018).

By combining spatial modeling with ecological and anthropogenic data, CPS identification supports effective river basin management, aligning with global and national biodiversity targets (Strassburg et al., 2020).

10.1.1 Indicator species

The Gangetic dolphin is an evolutionarily distinct, endemic river dolphin of the Indian subcontinent, inhabiting the Ganga, Brahmaputra, and Meghna River systems (Sinha et al., 2000). Functionally blind, it relies on echolocation to navigate, feed, and communicate. As a top predator, it plays a crucial ecological role in regulating aquatic food webs (Gomez-Salazar et al., 2012). The species is threatened by habitat fragmentation from dams and barrages, flow alterations, pollution, and incidental mortality (Behera et al., 2013; Braulik et al., 2012). It is listed as Endangered on the IUCN Red List and is protected under Schedule I of the Indian Wildlife (Protection) Act, 1972. It is also included in Appendix I of CITES and both Appendix I & II of CMS. In the Ganga River Basin, the species is distributed in the mainstem river and tributaries such as the Yamuna, Chambal, Son, Ghagra, Gandak, and Kosi rivers (Choudhary et al., 2012).

Given its ecological importance and declining status, the Gangetic dolphin serves as a flagship and umbrella species for freshwater conservation in South Asia. Protecting its habitats through CPS-based strategies will benefit overall river ecosystem integrity and biodiversity.

10.2 Methods

The information on the occurrence of key indicator species and environmental variables (hydro-morphological and anthropogenic) was collected at each BEU of the Chambal River. The collected variables were converted to raster using ArcGIS, and the Maximum entropy (MaxEnt) methods were used to predict the potential distribution and identify priority stretches for conservation of indicator species. MaxEnt models are based on the principle of maximum entropy that accounts for presence-only data of rare or threatened species with environmental variables (Phillips et al., 2006; Clements et al., 2012; Kramer-Schadt et al., 2013) to project future distributions under global climate change impacts (Hu & Jiang, 2011) and are considered as one of the efficient methods for predicting species distribution models (Elith et al., 2006). Species distribution modeling was conducted for the Gangetic Dolphin in 22 rivers within the Ganga River Basin, including the Chambal River. A total of 758 occurrence records were used to predict suitable habitats. Altogether, 28 variables were included based on published literature for species distribution modelling using MaxEnt (Kelkar et al., 2010; Paudel et al., 2015; Choudhary et al., 2022). The climatic variables were downloaded from WorldClim version 2 at a spatial resolution of 2.5 arc minutes (~4.5 km^2) (Fick & Hijmans, 2017). Each of the variables was checked for multicollinearity, and highly correlated (Pearson correlation $r>0.70$) variables with low ecological influence were removed from the final modeling (Zurell et al., 2009). Potential distribution stretches (probability distribution score >0.50) were categorized into three CPSs: high (0.7-1.0) as CPS 1, moderate (0.61-0.70) as CPS 2, and low (0.51-0.60) as CPS 3.

10.3 Results

In the Chambal River, 21 Conservation Priority Stretches (CPSs) were identified based on habitat suitability for the Gangetic dolphin across a 285 km segment spanning the lower middle and lower zones (Table 10.1). Among these, 150 km were classified as CPS2, 85 km as CPS1, and the remaining 50 km as CPS3. The longest of all, a 90 km segment, extends from Lohasari to Tigri-Rithoura and was identified as CPS2. Among the CPS1, a 25 km segment between Pureni and Reha was the longest continuous segment. The remaining CPSs are below 20 km in length (Table 10.2).

Table 10.1: Conservation Priority Stretches along the Chambal River, India

CPS category	CPS 1	CPS 2	CPS 3
Length (km)	**85**	**150**	**50**
States	Madhya Pradesh and Rajasthan (30 km)	Madhya Pradesh and Uttar Pradesh (40)	Madhya Pradesh and Rajasthan (100 km)
	Madhya Pradesh and Uttar Pradesh (40)	Madhya Pradesh and Uttar Pradesh (40)	Madhya Pradesh and Uttar Pradesh (45)
	Uttar Pradesh (15)	Uttar Pradesh (10)	

Table 10.2: Detailed information of identified Conservation Priority Stretches (CPS) in the Chambal River.

State	Town	Start Town	Start Coordinates	End Town	End Coordinates	Length (km)	CPS type
Madhya Pradesh and Rajasthan	Morena and Dhaulpur	Loha Sarai	26.363784N 77.366058E	Tigri-Rithoura	26.692562N 78.011909E	90	CPS-2
	Morena and Dhaulpur	Tigri-Rithoura	26.692562N 78.011909E	Shankarpura	26.682463N 78.060639E	5	CPS-3
	Morena and Dhaulpur	Shankarpura	26.682463N 78.060639E	Kuthiyana	26.686698N 78.095883E	5	CPS-1
	Morena and Dhaulpur	Kuthiyana	26.686698N 78.095883E	Pureni	26.757175N 78.115217E	10	CPS-2
	Morena and Dhaulpur	Pureni	26.757175N 78.115217E	Reha	26.824867N 78.242278E	25	CPS-1
Madhya Pradesh and Uttar Pradesh	Morena and Agra	Reha	26.824867N 78.242278E	Malhan ka pura	26.829199N 78.274226E	5	CPS-2
	Morena and Agra	Malhan ka pura	26.829199N 78.274226E	Himmat pura	26.861393N 78.301066E	5	CPS-1
	Morena and Agra	Himmat pura	26.861393N 78.301066E	Pinnahat	26.867865N 78.351058E	5	CPS-2
	Morena and Agra	Pinnahat	26.867865N 78.351058E	Khilli	26.799094N 78.452118E	15	CPS-1
	Morena and Agra	Khilli	26.799094N 78.452118E	Ater	26.768264N 78.62095E	20	CPS-3
	Bhind and Agra	Ater	26.768264N 78.62095E	Din-ka pura	26.793204N 78.702268E	10	CPS-2
	Bhind and Agra	Mau	26.774916N 78.729548E	Nakhloli	26.773907N 78.763935E	5	CPS-3

State	Town	Start Town	Start Coordinates	End Town	End Coordinates	Length (km)	CPS type
	Bhind, Agra and Etawa	Nakhloli	26.773907N 78.763935E	Bijora	26.762344N 78.80364E	5	CPS-2
	Bhind and Etawah	Bijora	26.762344N 78.80364E	Chilonga	26.734418N 78.836442E	5	CPS-2
	Bhind and Etawah	Chilonga	26.734418N 78.836442E	Sidh Baba Mandir, Barhi	26.699814N 78.869878E	5	CPS-1
	Bhind and Etawah	Sidh Baba Mandir, Barhi	26.699814N 78.869878E	Barhi Road Bridge	26.705827N 78.916924E	5	CPS-3
	Bhind and Etawah	Barhi Road Bridge	26.705827N 78.916924E	Khera	26.657269N 78.956835E	10	CPS-2
	Bhind and Etawah	Khera	26.657269N 78.956835E	Barecha	26.597795N 79.017165E	15	CPS-3
	Bhind and Etawah	Barecha	26.597795N 79.017165E	Kuwarpura	26.527253N 79.136675E	15	CPS-1
Uttar Pradesh	Etawah	Kuwarpura	26.527253N 79.136675E	Patharra	26.502479N 79.20807E	10	CPS-2
	Etawah	Patharra	26.502479N 79.20807E	Chambal-Yamuna Confluence	26.492366N 79.248875E	15	CPS-1

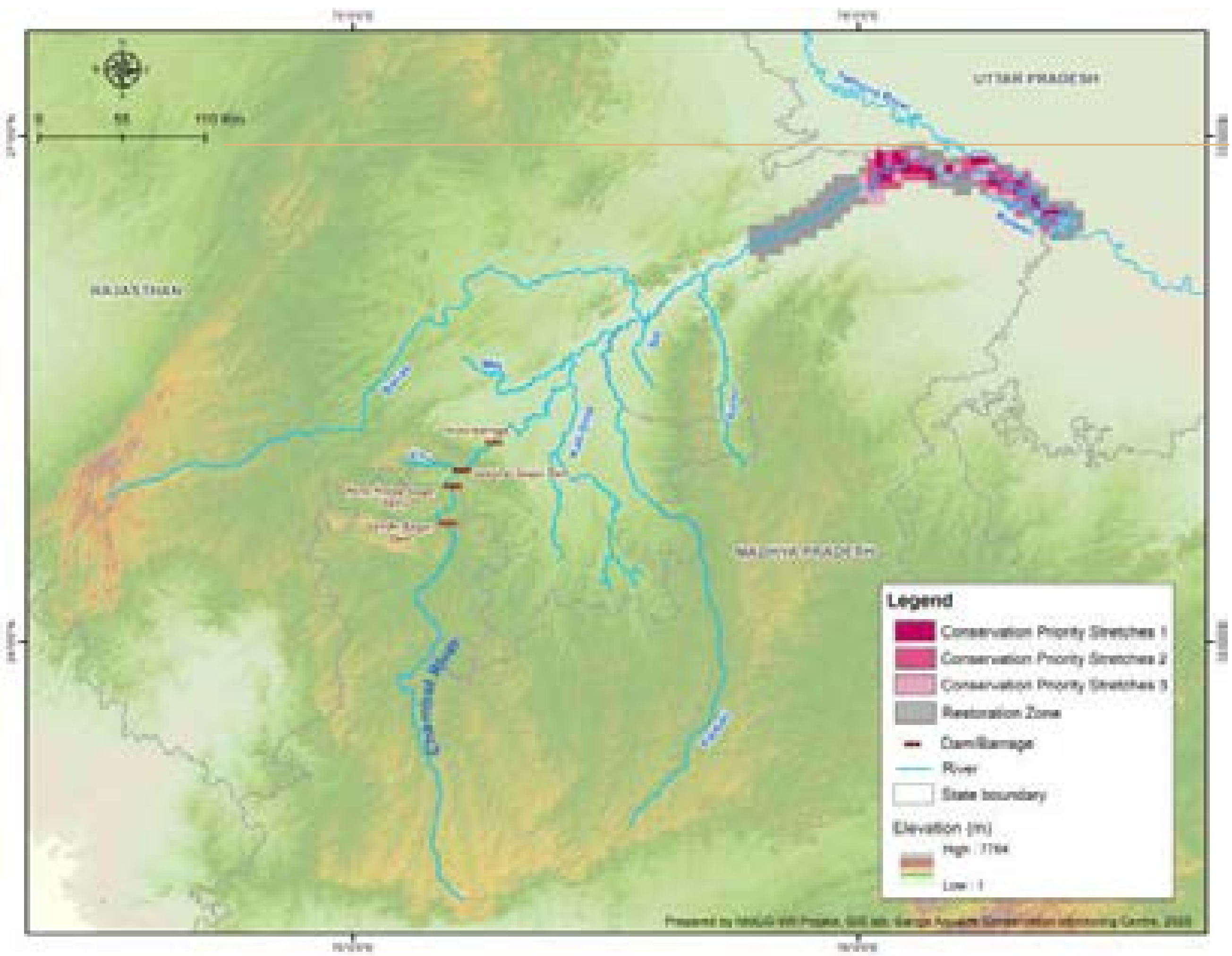


Figure 10.1: Conservation priority stretches the Chambal River

REFERENCES

Albuquerque, F., & Beier, P. (2015). Rarity-weighted richness: A simple and reliable alternative to integer programming and heuristic algorithms for minimum set and maximum coverage problems in conservation planning. PLOS ONE, 10(3), e0119905.

Bai, Y., Wu, J., Clark, C. M., Pan, Q., Zhang, Y., Chen, X., & Han, X. (2017). Grazing alters ecosystem functioning and C:N:P stoichiometry of grasslands along a regional precipitation gradient. *Journal of Ecology, 105*(1), 138-150.

Behera, S. K., Singh, H., & Sagar, V. (2013). Status of Ganges River dolphin (*Platanista gangetica gangetica*) in the Ganga River basin, India: A review. *Aquatic ecosystem health & management, 16*(4), 425-432.

Bonn, A., & Gaston, K. J. (2005). Capturing biodiversity: Selecting priority areas for conservation using different criteria. *Biodiversity and Conservation, 14*, 1083-1100.

Braulik, G. T., Reichert, A. P., Ehsan, T., Khan, S., Northridge, S. P., Alexander, J. S., & Garstang, R. (2012). Habitat use by a freshwater dolphin in the low-water season. *Aquatic Conservation: Marine and Freshwater Ecosystems, 22*(4), 533-546.

Carpenter, S. R., Stanley, E. H., & Vander Zanden, M. J. (2011). State of the world's freshwater ecosystems: Physical, chemical and biological changes. *Annual Review of Environment and Resources, 36*, 75-99.

Choudhary, S. K., Smith, B. D., Dey, S., Dey, S., & Prakash, S. (2012). Conservation and biomonitoring in the Vikramshila Gangetic Dolphin Sanctuary, Bihar, India, using a community-based approach. Oryx, 46(1), 65-73.

Clements, G. R., Rayan, D. M., Zafir, A. W. A., Venter, M., Laurence, W. F., & Aziz, S. A. (2012). Predicting the distribution of the Sunda clouded leopard (*Neofelis diardi*) in Peninsular Malaysia using maximum entropy modeling. In D. W. Macdonald & K. J. Willis (Eds.), *Key topics in conservation biology 2* (pp. 182-192). Wiley-Blackwell.

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Lévêque, C., ... & Sullivan, C. A. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews, 81*(2), 163-182.

Echols, K. R., Peterman, P. H., Hinck, J. E., Orazio, C. E., McKee, M. J., & Gale, R. W. (2009). Environmental contaminants in fish and their associated risk to piscivorous wildlife in the United States, 1999-2001. *Environmental Monitoring and Assessment, 157*, 41-48.

Elith, J., Graham, C. H., Anderson, R. P., Dudík, M., Ferrier, S., Guisan, A., Hijmans, R. J., Huettmann, F., Leathwick, J. R., Lehmann, A., Li, J., Lohmann, L. G., Loiselle, B. A., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., Overton, J. M. C., Peterson, A. T., ... Zimmermann, N. E. (2006). Novel methods improve prediction of species distributions from occurrence data. *Ecography, 29*(2), 129-151.

Fick, S. E., & Hijmans, R. J. (2017). WorldClim 2: New 1?km spatial resolution climate surfaces for global land areas. *International Journal of Climatology, 37*(12), 4302-4315.

Fierro, P., Valdovinos, C., Arismendi, I., Díaz, M. E., & Vargas?Chacoff, L. (2017). Macroinvertebrate responses to human pressures in central Chilean rivers. *Ecological Indicators, 72*, 254-265.

Gomez-Salazar, C., Coll, M., & Hevia, M. (2012). River dolphins as indicators of ecosystem degradation in large tropical rivers. *Ecological Indicators, 143*, 109-126.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *Science, 319*(5864), 756-760.

Howard, C., Stephens, P. A., Tobias, J. A., Sheard, C., Butchart, S. H., & Willis, S. G. (2018). Flight range, fuel load and the impact of climate change on the journeys of migrant birds. *Proceedings of the Royal Society B: Biological Sciences, 285*(1885), 20172329.

Hu, J., & Jiang, Z. (2011). Predicting the potential distribution of the endangered Przewalski's gazelle. *Journal of Zoology, 280*(2), 134-140.

IUCN. (2023). The *IUCN Red List of Threatened Species* (Version 2023-1). https://www.iucnredlist.org

Jain, A., & Singh, S. K. (2018). Riverine ecosystem challenges and management strategies. *Environmental Conservation Journal, 19*(1-2), 57-64.

Jain, P., & Singh, S. K. (2024). Integrating biodiversity conservation with ecosystem service management in river basins: A framework for freshwater prioritization. *Journal of Environmental Management, 335*, 117570.

Karam, J. N., Dudgeon, D., & Monaghan, M. T. (2021). Conservation priorities for freshwater biodiversity in Asia: A systematic review of the literature. *Science of the Total Environment, 754*, 142242.

Kelkar, N., Krishnaswamy, J., Choudhary, S. K., & Sutaria, D. (2010). Coexistence of fisheries with river dolphin conservation. *Conservation Biology, 24*(4), 1130-1140.

Kramer-Schadt, S., Niedballa, J., Pilgrim, J. D., Scharf, A. K., Schröder, B., Lindenborn, J., Reinfelder, V., Stillfried, M., Heckmann, I., Scharf, A. K., Augeri, D. M., Cheyne, S. M., Hearn, A. J., Ross, J., Macdonald, D. W., & Wilting, A. (2013). The importance of correcting for sampling bias in MaxEnt species distribution models. *Diversity and Distributions, 19*(11), 1366-1379.

Kumar, S. (2021). Conservation prioritization of aquatic megafauna in the Ganga River Basin using spatial tools. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(6), 1325-1339.

Linke, S., Turak, E., & Nel, J. (2011). Freshwater conservation planning: The case for systematic approaches. *Freshwater Biology, 64*(4), 651-666.

Liu, M., Chen, W., Ma, H., Liu, X., Wang, S., & Wang, Y. (2023). Land use change and ecosystem service dynamics in China's major river basins. *Sustainability, 15*(2), 987.

Ma, H., & Sun, Y. (2018). MaxEnt modeling for predicting the potential distribution of endangered medicinal plant *Ferula sinkiangensis* in China. *Ecological Informatics, 47*, 68-74.

Margules, C. R., Pressey, R. L., & Williams, P. H. (2002). Representing biodiversity: Data and procedures for identifying priority areas for conservation. *Journal of Biosciences, 27*(2), 309-326.

Moilanen, A., Wilson, K. A., & Possingham, H. P. (2007). *Spatial conservation prioritization: Quantitative methods and computational tools*. Oxford University Press.

Nel, J. L., Reyers, B., Roux, D. J., Impson, N. D., & Cowling, R. M. (2008). Incorporating multiple scales and productivities into conservation planning for freshwater ecosystems. *Freshwater Biology, 53*(3), 576-592.

Paudel, B., Acharya, K. P., & McCann, N. P. (2015). A review of human-wildlife conflicts and wildlife conservation in Nepal. *International Journal of Environmental Protection and Policy, 3*(4), 97-105.

Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological Modelling, 190*(3-4), 231-259.

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J., & Cooke, S. J. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews, 94*(3), 849-873.

Sinha, R. K., Smith, B. D., Sharma, G., Prasad, G., Choudhury, B. C., Sapkota, K., ... & Behera, S. K. (2000). Status and distribution of the Ganges susu (*Platanista gangetica*) in the Ganges River system of India and Nepal. *Occas. Pap. IUCN Species Survival Comm., 23*, 54-61.

Strassburg, B. B. N., Iribarrem, A., Beyer, H. L., Cordeiro, C. L., Crouzeilles, R., Jakovac, C. C., ... Balmford, A. (2020). Global priority areas for ecosystem restoration. *Nature, 586*(7831), 724-729.

Strayer, D. L., & Dudgeon, D. (2010). Freshwater biodiversity conservation: Recent progress and future challenges. *Journal of the North American Benthological Society, 29*(1), 344-358.

USGS Publications Archive. (2017). *National Fish Habitat Action Plan: Through partnerships, sustaining fish habitats*. U.S. Geological Survey.

Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., & Smith, G. M. (2009). *Mixed effects models and extensions in ecology with R* (Vol. 574). Springer, New York.

SECTION IV

CHAPTER 11

CAPACITY BUILDING OF STAKEHOLDERS OF CHAMBAL RIVER BASIN

Coordinating Lead Authors

Ruchi Badola,
Syed Ainul Hussain,
Sangeeta Angom

Lead Authors

Simran Aggarwal,
Soufil SM Malek,
Rohit Kumar,
Danish Kaleem,
Anshul Bhawsar

Contributing Authors

Aarti Chauhan,
Ashmika Aggarwal,
Alankrita Sharma,
SK Pal,
Rahul Gupta

SUMMARY

A comprehensive capacity-building framework implemented across the Chambal River Basin to enhance institutional and individual competencies for freshwater biodiversity conservation. Adopting a multi-stakeholder and participatory model, the initiative aimed to empower a diverse cadre including forest officials, veterinarians, researchers, and local communities to act as proactive contributors in biodiversity monitoring and restoration. The methodology utilized an iterative, need-based approach, beginning with a Training Needs Assessment followed by the development of five specialized training modules: biodiversity monitoring, wetland management, rescue and rehabilitation, participatory management, and conservation education. Between 2019 and 2025, 767 stakeholders were trained across the states of Rajasthan, Madhya Pradesh, and Uttar Pradesh. 11 spearhead training sessions were successfully conducted, engaging a total of 154 participants across the three Chambal basin states. Furthermore, a total of 548 participants were trained through 5 dedicated rescue-specific sessions and integrated modules. Despite challenges such as gharial-centric conservation perceptions and logistical hurdles in remote areas, the initiative successfully established a decentralized network of skilled practitioners. These findings underscore the importance of building local capacity to ensure the long-term ecological resilience and sustainable management of the Chambal River ecosystem.

11.1 Capacity Building Approaches

Capacity building refers to a systematic approach to develop the skills, competencies, and institutional capabilities of stakeholders, to enhance their contribution to river conservation and restoration. The NMCG project adopts a multi-stakeholder and participatory model (Carr, 2015), aimed at empowering forest officials, field veterinarians, researchers, Civil Society Organizations, entrepreneurs, school teachers, college professors, university students, and volunteers to act as proactive contributors in biodiversity monitoring and species conservation across the Ganga basin. The approach emphasizes that sustainable river conservation can only be achieved when local capacities are built, nurtured, and retained (O'Keeffe, 2018). This model aligns with the broader goals of adaptive ecosystem management by equipping individuals and institutions with tools and knowledge to respond to emerging conservation challenges (OECD, 2006; Bloomfield et al., 2018). Freshwater biodiversity conservation approach requires mobilization of stakeholders for sustainable conservation of biodiversity of the Chambal River and its tributaries. The effort aims to provide different capacity building programmes which would aid in creating a cadre of trained stakeholders in various aspects of conservation of macro aquatic fauna and its habitat who would be the future trainers for successful biodiversity monitoring and restoration of the Chambal River Basin and carry forward the activities individually or at institutional level. The overall approach would assist in developing and strengthening the participant's skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt, and thrive in conserving the ecosystem of the river. Through workshops, trainings, and stakeholder engagement meetings, participants gain exposure to field-based methods, rescue and rehabilitation techniques, community mobilization, and ecological monitoring.

11.1.1 Key elements of capacity building

The foundational principle of this programme is that the long-term engagement leads to sustainable outcomes. As outlined by Leidel et al. (2012), effective capacity development should be iterative and need-based. The process begins with the identification and engagement of relevant stakeholder groups, achieved through preliminary meetings, outreach, and consultation workshops. This is followed by an assessment of their development needs, conducted through participatory exercises and feedback tools to understand knowledge gaps, technical challenges, and local priorities. Based on the identified requirements, training modules are designed with contextual relevance, incorporating technical and soft skills necessary for biodiversity conservation. Once the programmes are formulated, they are implemented through a mix of classroom and field based sessions, carefully aligned with the stakeholders existing roles and potential contributions. Finally, regular evaluation mechanisms are embedded into the programme to assess its effectiveness, record lessons learned, and refine future capacity building strategies. These interlinked stages are visually represented in Figure 11.1, which illustrates the core elements of capacity building adopted under the NMCG initiative capacity building initiatives contain elements of (i) Identification of target groups and engagement of stakeholders through meetings, correspondence, workshops etc. (ii) Identification of needs (iii) Formulation of capacity development programmes (iv) Implementation (v) Evaluation. These are the essential management skills of any capacity building programmes that allow for planning, implementation, monitoring and evaluating initiatives for conservation of freshwater biodiversity of Ganga River Basin.

Figure 11.1: Core Elements of Capacity Building for River Conservation

11.1.2 Building the base- Implementations and Logistics

As highlighted by Alaerts (2008), organizing successful training programmes requires continuous coordination, beginning at the design phase and continuing through post-training follow-up process. The process involves logistical planning, communication with participants, stakeholder mapping, and onboarding resource persons. The training execution begins with identifying the role of each stakeholder group through consultative meetings and dialogue. Based on this input, training content is tailored to meet contextual needs and skill levels.

A structured checklist for training logistics and feedback is used to track progress and effectiveness. Participants are trained on diverse modules such as aquatic species documentation, monitoring, habitat restoration, community conservation strategies, and species rescue protocols. These modules help to develop a cadre of informed, skilled individuals who can act as multipliers and mentors in their respective institutions and communities. The sequential flow of training stages is shown in Figure 11.2, which maps the Stages of capacity building initiatives from planning to delivery.

11.1.2.1 Constraints and Challenges

Despite being one of the last remnant rivers in the greater Gangetic Drainage Basin to have retained significant conservation values (Hussain & Badola, 2001), the Chambal River faces severe extractive and intrusive pressures for resources. The major constraint is in terms of engaging multiple stakeholders and mobilizing them for effective implementation of sustainable efforts in maintaining the ecological integrity of the river, considering the wide spectrum of stakeholder categories also poses a limitation at times, since each stakeholder groups have specific requirements in terms of training needs and methodologies to be utilised.

Figure 11.2: Stages of Capacity Building Initiative

One of the major challenges in conserving the Chambal River is the gharial-centric perception among local communities. While the gharial has become the symbol of conservation, other equally significant species, such as the Gangetic dolphin, otters, and mugger crocodiles, often receive little attention. This limited awareness poses difficulties in promoting holistic conservation, making it necessary to strengthen outreach efforts that highlight the importance of the entire spectrum of aquatic biodiversity in the river.

Through continuous input and engagement of stakeholders expanded its scope significantly, reaching a wider array of stakeholders across the Chambal River Basin. Stakeholders such as forest officials, professors, line agencies, community leaders, researchers, volunteers and NGOs have varying learning needs and engagement capacities, requiring the development of customised training modules. While participation has improved compared to engagement of target groups since 2017, sustaining involvement and translating knowledge into action continues to require targeted follow-ups, refresher sessions, and local support systems. Additionally, logistical hurdles such as the availability of expert trainers and consistent coordination mechanisms occasionally affect the scale and continuity of training activities.

Despite these challenges, continuous capacity building programmes present opportunities for innovation and deeper impact. Strategic partnerships with academic institutions, local organisations, and subject experts have helped broaden the knowledge base and delivery mechanisms. Efforts are underway to strengthen inter-departmental coordination, incorporate community knowledge, and consolidate existing biodiversity data for more informed decision-making. Rather than setbacks, these challenges are viewed as areas for continual learning and system improvement, supporting the overarching goal of building a resilient, inclusive, and adaptive framework for riverine biodiversity conservation along the Chambal River Basin.

11.1.3 Capacity Building Framework

The capacity building framework adopted here is a structured, multi-tiered approach aimed at strengthening institutional and individual competencies for Freshwater biodiversity conservation across the Chambal basin states. This framework is designed to build technical, operational, and community-level capacities essential for effective implementation of conservation strategies, especially in ecologically sensitive and socially complex landscapes such as the Chambal River basin (Figure 11.3).

For developing the contents of the training curriculum, a comprehensive process of literature review, consultations and communication was done with the forest department and other stakeholders of Chambal Basin states. Training and capacity building workshops were designed and delivered according to the constitution of target groups divided at three levels viz. Policy, implementation and execution levels.

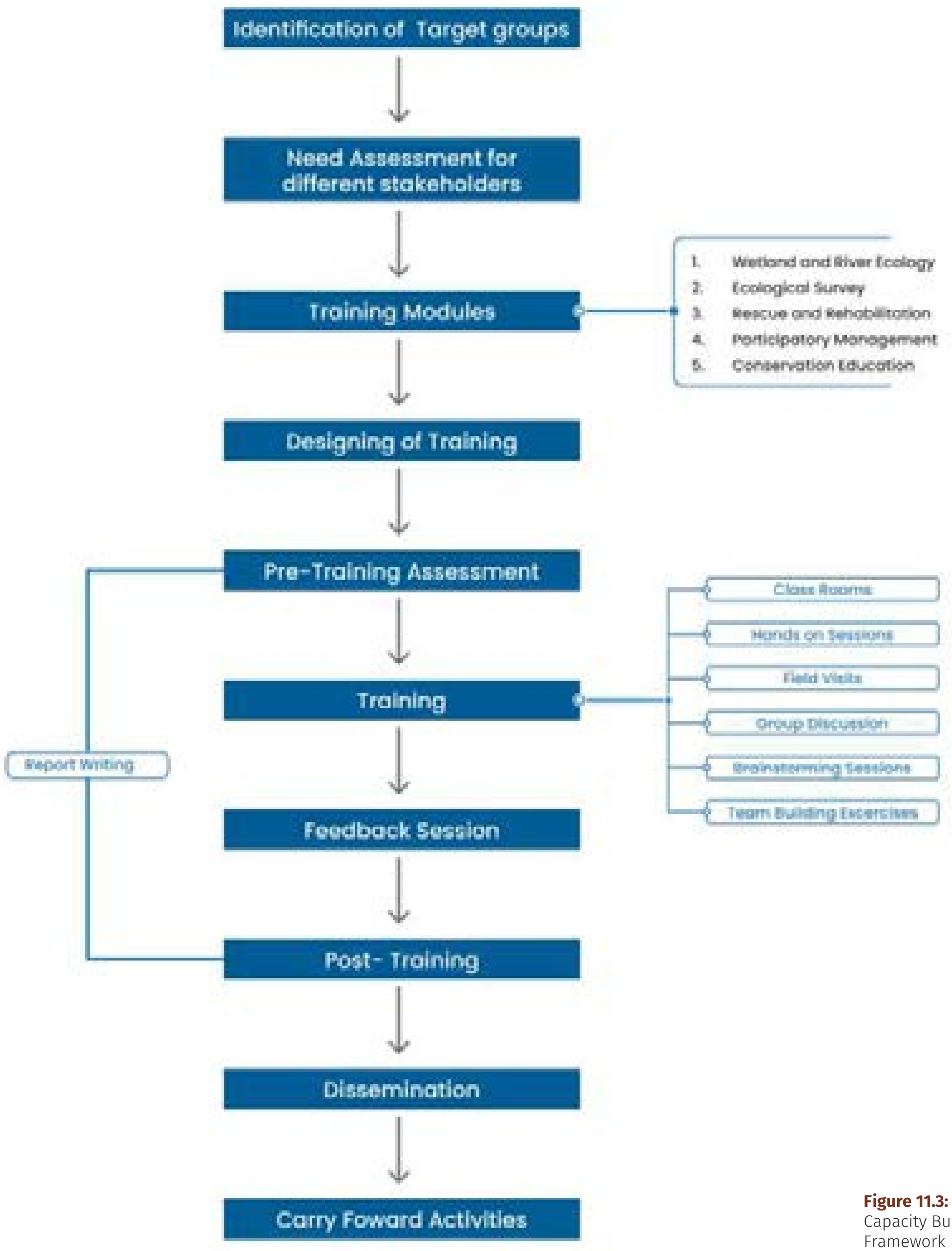


Figure 11.3: Capacity Building Framework

The capacity building process begins with the identification of target groups. These include a diverse range of engagement of stakeholders such as forest and fisheries department personnel, academic professionals and students, frontline staff, veterinarians, and community volunteers, line agencies etc. Selection is based on their geographic relevance, institutional responsibilities, and potential role in aquatic species conservation and habitat management. Initial engagement is carried out through field visits, correspondence, and stakeholder meetings to understand their current involvement and assess readiness for capacity enhancement (Hamza, 2012; UNDP, 2009). Following identification, a systematic assessment of capacity development needs is undertaken. This diagnostic phase considers factors such as participants' existing knowledge and skill levels, their operational context (e.g., field postings or academic institutions), level of access to technical resources, and their motivation and willingness to contribute to conservation outcomes. The findings inform the development of structured training objectives aligned with both institutional mandates and site-specific ecological challenges (OECD, 2006).

The design of training modules is guided by the identified needs and tailored for each stakeholder group. These modules cover key topics such as biodiversity monitoring techniques, rescue and rehabilitation protocols for aquatic fauna, ecological survey methods, wetland and riverine habitat management, community engagement strategies, and conservation-linked livelihoods. The instructional approach integrates classroom-based theoretical sessions with field-based demonstrations, case studies, simulation exercises, and participatory group discussions to ensure practical comprehension and applicability. Implementation of the training programmes requires detailed logistical planning, especially since many training sites are located in areas with limited infrastructure. Resource persons are carefully selected for their subject expertise and field experience, and training materials are developed in multiple languages to ensure accessibility across states. Sessions are scheduled in alignment with ecological and administrative calendars, allowing field staff and community members to participate meaningfully.

A key feature of the capacity building process is the emphasis on evaluation of learning outcomes through pre- and post-training assessments. At the beginning of each programme, participants complete a pre-training questionnaire designed to gauge their baseline understanding of the subject matter, prior experience, and expectations. At the end of the training, a corresponding post-training questionnaire is administered to measure knowledge gain, shifts in attitudes, and perceived improvements in technical confidence. These assessments help determine the effectiveness of the training intervention and identify areas for future refinement. In addition to assessing individual learning outcomes, the evaluation process includes feedback forms capturing participants' views on the content relevance, delivery methods, field components, and overall quality of the programme.

11.1.4 Training Needs

Following the identification of diverse stakeholder groups engaged in the Chambal River Basin, ranging from government officials and academic institutions to community-based volunteers and line agencies, it becomes critical to systematically assess their existing capabilities and the competencies they require to carry out their roles effectively. This process, known as a training needs assessment, is the cornerstone of a well-structured capacity-building initiative.

In the context of Chambal biodiversity conservation, training needs vary significantly across target groups based on their institutional mandates, levels of engagement, and technical exposure. Forest department personnel require training in ecological monitoring, species-specific rescue protocols, and integrated river basin management. Fisheries and irrigation officials need to understand the ecological implications of their operational activities and how these can be aligned with conservation goals. Veterinarians require exposure to wildlife health protocols for aquatic species, while academic stakeholders benefit from technical modules on field-based data collection, research methods, and biodiversity informatics. Similarly, for community groups and volunteers, the emphasis lies in building awareness, species identification, first-response reporting mechanisms, and linking conservation with sustainable livelihoods.

The training needs assessment (TNA) process was conducted through a combination of qualitative and quantitative methods, including stakeholder consultations, structured and semi-structured interviews, group discussions, feedback from past trainings, and expert inputs. This mixed-methods approach ensured the collection of actionable insights while remaining responsive to local socio-institutional dynamics (Czabanowska et al., 2024). Prioritization of training needs was carried out through consultative processes involving relevant departments and institutional stakeholders. This participatory prioritization ensured alignment with both field realities and policy objectives. Furthermore, the TNA served as a platform to initiate dialogue, build ownership, and refine the curriculum based on direct feedback from end users. By investing in a robust needs assessment process, the programme ensured that capacity-building interventions are not generic but tailored to the real-world functions, constraints, and expectations of each stakeholder group. The outputs of this assessment have informed the design of multi-tiered training programmes, ranging from foundational modules for volunteers to advanced thematic workshops for decision-makers and technical experts.

11.1.5 Training Modules

Effective conservation of aquatic biodiversity in the Chambal River Basin requires the involvement of multiple stakeholders with enhanced knowledge and skills. To address the existing gaps in technical expertise and institutional capacity, five comprehensive training modules (Figure 11.4) were developed: (1) Biodiversity monitoring of macro aquatic species of Chambal River Basin (2) Conservation and management of Wetland and its associated habitat (3) Rescue and Rehabilitation of macro aquatic animal in distress (4) Participatory Management and (5) Conservation Education.

Figure 11.4. Capacity Building Modules

Together, these modules are essential for strengthening institutional roles and ensuring coordinated, informed action for long-term biodiversity conservation and ecosystem health in the Chambal River Basin. Based on these training modules, the capacity building programmes was designed and implemented for multiple stakeholders in Chambal Basin states.

11.2 Objectives

The aim of the study was to enhance the institutional and individual capacities of stakeholders involved in freshwater biodiversity conservation across the Chambal River Basin. It focuses on equipping them with the knowledge, skills, and tools necessary for the effective implementation of conservation strategies and long-term ecological management. Following were the objectives of the study

1. Development of training materials targeting different stakeholder groups.
2. Expand the spearhead teams to the Chambal basin states and train them in monitoring macro aquatic species of conservation significance, management planning of wetland, rescue and
3. Develop capacity of University Professors and Students, Forest officials, local communities and other stakeholders for monitoring of aquatic species of conservation concern, management planning of rivers and wetlands, community-based conservation.
4. Enhance capacity of the personnel of the forest departments, animal husbandry departments, field veterinarians, and volunteers in rescue and rehabilitation of aquatic fauna in distress.
5. Capacity building of local communities, including the Ganga Praharis for reporting and managing emergent situations.

11.3 Methods

11.3.1 Training techniques

In continuation of the training needs assessment, the design and delivery of the capacity building interventions were structured using a targeted methodology that ensured both relevance and practical utility for diverse stakeholder groups involved in freshwater biodiversity conservation of Chambal River Basin. Given their varying roles, exposure levels, and technical backgrounds, a flexible training strategy and methods of andragogy was adopted, rooted in adult learning principles and designed to meet identified knowledge and skill gaps.

To enhance participant engagement and effectiveness, the trainings were conducted using a blend of structured and interactive learning formats. These included expert lectures, group exercises, case-based discussions, participatory planning activities, field demonstrations, hands-on sessions, and exposure visits. This mix of methods catered to different learning preferences and facilitated better comprehension and retention of complex ecological and technical information. Training was delivered in a competency-based format, with a focus on developing practical skills that could be directly applied in the participants' respective professional or community roles. Each module was designed with a specific set of learning outcomes, and content was contextualised to the local biodiversity conditions and institutional frameworks. Trainers with field expertise ensured that theoretical concepts were linked with real-world applications, making the learning process more meaningful and actionable.

To ensure inclusivity and accessibility, sessions were conducted in both Hindi and English depending on the composition of the group, and examples were drawn from site-specific case studies across the Ganga River states. Special attention was paid to simplifying technical jargon, using visuals and locally relevant analogies, especially for field-level personnel and community participants.

11.3.2 Training Model

The effectiveness of the training initiatives was evaluated using the Kirkpatrick Four-Level Training Evaluation Model (Figure 11.5), which provided a structured approach to monitor and analyse the impact of training across various dimensions. The four levels-Reaction, Learning, Behaviour, and Results were adapted to suit the context of riverine biodiversity conservation and stakeholder engagement along the Chambal River basin. The Kirkpatrick Model served as a structured framework to ensure that the training programmes were not only informative but also impactful across multiple levels of stakeholder engagement from individual learning to institutional and ecological outcomes. This model enabled continuous improvement of the capacity-building process, making it more responsive to the evolving challenges and opportunities in riverine biodiversity conservation.

Figure 11.5: Kirkpatrick Four-Level Training Evaluation Model

11.3.3 Data Analysis - Monitoring and evaluation

Monitoring and evaluation of the training programmes were conducted using the Kirkpatrick's Model (Kirkpatrick, 1959), focusing on assessing the efficacy and effectiveness of trainings conducted between 2019 and 2025. A randomized follow-up E-questionnaire survey was employed to measure post-training outcomes, particularly in terms of changes in awareness, knowledge, attitude, skill, and behaviour among participants. The evaluation covered all three phases - before, during, and after the training interventions.

The respondent sample was proportionally selected based on the number of participants from different states and districts, ensuring representative coverage across the geographical span of the training programmes. A total of 230 participants, representing approximately 30% of the total trained individuals, completed the follow-up E-questionnaire. In addition, a centralized training database, accessible through the WII-NMCG webpage, was developed to serve as a comprehensive repository of training-related information.

To gain a clear and comprehensive understanding of participant profiles, descriptive statistical methods were employed. Data were analysed with a focus on key variables such as gender, state and district-wise participation, and stakeholder group composition. Microsoft Excel was used for organizing the data and preparing visual representations, including charts and tables, to illustrate participation patterns. Frequency distributions and percentage analyses were performed to summarize and interpret the data effectively. Descriptive statistics, as foundational tools in social research, were critical in identifying trends and supporting the overall evaluation framework (Gravetter & Wallnau, 2016).

11.4 Results

11.4.1 Development of training materials

To develop the training materials, literature reviews were carried out and through training need assessment workshops, various information products were generated based on the requirement of diverse stakeholders' groups. A total of 7 training workshops for different target groups were organized in Chambal River basin for field-testing and need assessment (Table 11.1). After finalization, training programmes were delivered according to the constitution of the target groups divided at three levels as policy, implementation and execution levels and delivered in five main modules. Based on these modules, diverse training programmes were organized along the Chambal River Basin.

Table 11.1: Training needs assessment workshops with different target groups for designing of training materials at Chambal River Basin

Target Groups	States	Districts	Total No. of Workshops	Total No. of Participants
College Students	Madhya Pradesh	Morena	1	50
Forest Officials	Rajasthan	Sawai Madhopur, Kota, Jaipur, Ajmer, Dholpur	3	279
Veterinarians	Rajasthan	Sawai Madhopur, Kota, karauli, Dholpur, Bundi, Jaipur	3	129
Total	2	8	7	458

Table 11.2: List of training materials generated for capacity building programmes in Chambal River Basin

S. No.	Training Knowledge product	Category	Significance
1.	Training approach & curriculum	Booklet	This curriculum provides information about the syllabus and key approaches to developing and implementing training programmes for stakeholders in Freshwater Biodiversity Conservation.
2.	Brain Gym: River-Dependent Animals	Activity Booklet	The "Brain Gym: River Dependent Animals" Activity booklet is an engaging educational resource that introduces kids to river creatures, promoting curiosity and appreciation for river ecosystems.
3.	Life in Ganga	Brochure	This brochure provides the, rich biodiversity, featuring diverse flora and fauna, ecosystems, and species.
4.	Floral Diversity of Ganga River Basin	Brochure	Discover the vibrant floral diversity of the Ganga River Basin. This brochure highlights the rich variety of plant species found along the river's bank, showcasing their diversity, ecological importance, and cultural significance.
5.	Jal khata Abhiyan	Brochure	The brochure highlights the importance of saving rainwater through community-based accounting of the water conservation by engaging school children and local communities with an objective to proliferate the conservation practices in the Ganga Basin states.
6.	Training calendar 2025	Brochure	The brochure provides planned training activities and schedules that includes the titles of courses, target groups, dates, times, training sites, locations etc., for multiple stakeholders in different aspects of freshwater biodiversity conservation.

Designing and generating training materials for stakeholders involves a structured approach focused on identifying learning objectives, relevant content, and effective delivery methods. The process has also taken consideration of stakeholder preferences for receiving information and involve them in the design process for better alignment and engagement. Designing of training materials provides stakeholders with the necessary information to grasp the project's purpose, scope, and expected outcomes. Several awareness materials had been developed (Table 11.2) for diverse stakeholders viz. a booklet, brochures, pamphlets etc. focusing on the themes of conservation and creating awareness of Chambal Biodiversity. Several awareness posters were also generated to inculcate awareness and understanding in youth and local communities about the conservation of biodiversity of the Chambal River through the celebration of special events and days.

Distributing training materials to stakeholders is vital for the project outcome and accomplishment. It ensures target groups involved understands their roles, responsibilities, and the project's objectives, fostering alignment and reducing misunderstandings. This, in turn, increases the probability of successful project implementation and outcomes. When stakeholders are well-informed, they are more likely to actively participate, contribute their expertise, and support the conservation initiatives. Sharing training materials facilitates enhanced engagement, open communication and collaboration among stakeholders, minimizing confusion and potential conflicts. By understanding the reasons for the project and how it will impact them, stakeholders are more likely to embrace change and adapt to new processes or systems.

11.4.2 Overall participation in Capacity Building Programmes in the Chambal River basin

The capacity building programmes engaged 767 participants across the Chambal River Basin through 32 training sessions in Madhya Pradesh, Rajasthan and Uttar Pradesh (Figure 11.6). The participation data, detailed below by district, stakeholder category, and gender, highlights engagement patterns and areas for future improvement.

11.4.2.1 District-Wise Distribution

The programmes were implemented across key districts in the Chambal River Basin, targeting areas with significant ecological and socioeconomic dependence on the river, which spans approximately 960 sq.km. Table 11.3 summarizes the district-wise participation, with Madhya Pradesh 199 participants (25.9%), Rajasthan 549 participants (71.5% of the total), and Uttar Pradesh contributing 19 participants (2.4% of the total), respectively.

Table 11.3:. District-Wise Distribution of Participants

States	District	Participants	Total
Madhya Pradesh	Bhind	7	199
	Chhindwara	1	
	Datia	3	
	Dhar	4	
	Indore	3	
	Khandwa	1	
	Khargone	1	
	Mandesour	1	
	Morena	155	
	Neemuch	2	
	Ratlam	1	
	Sagar	13	
	Satna	1	
	Seoni	2	
	Shajapur	1	
	Shivpuri	1	
	Singrauli	1	
	Ujjain	1	
Rajasthan	Ajmer	1	549
	Banswara	1	
	Bharatpur	1	
	Bhilwara	11	
	Bikaner	3	

States	District	Participants	Total
Rajasthan	Bundi	10	
	Dholpur	64	
	Jaipur	205	
	Karauli	65	
	Kota	79	
	Kotputli-Behror	1	
	Pali	1	
	Sawai Madhopur	102	
	Udaipur	5	
Uttar Pradesh	Etawah	19	19
	Total		767

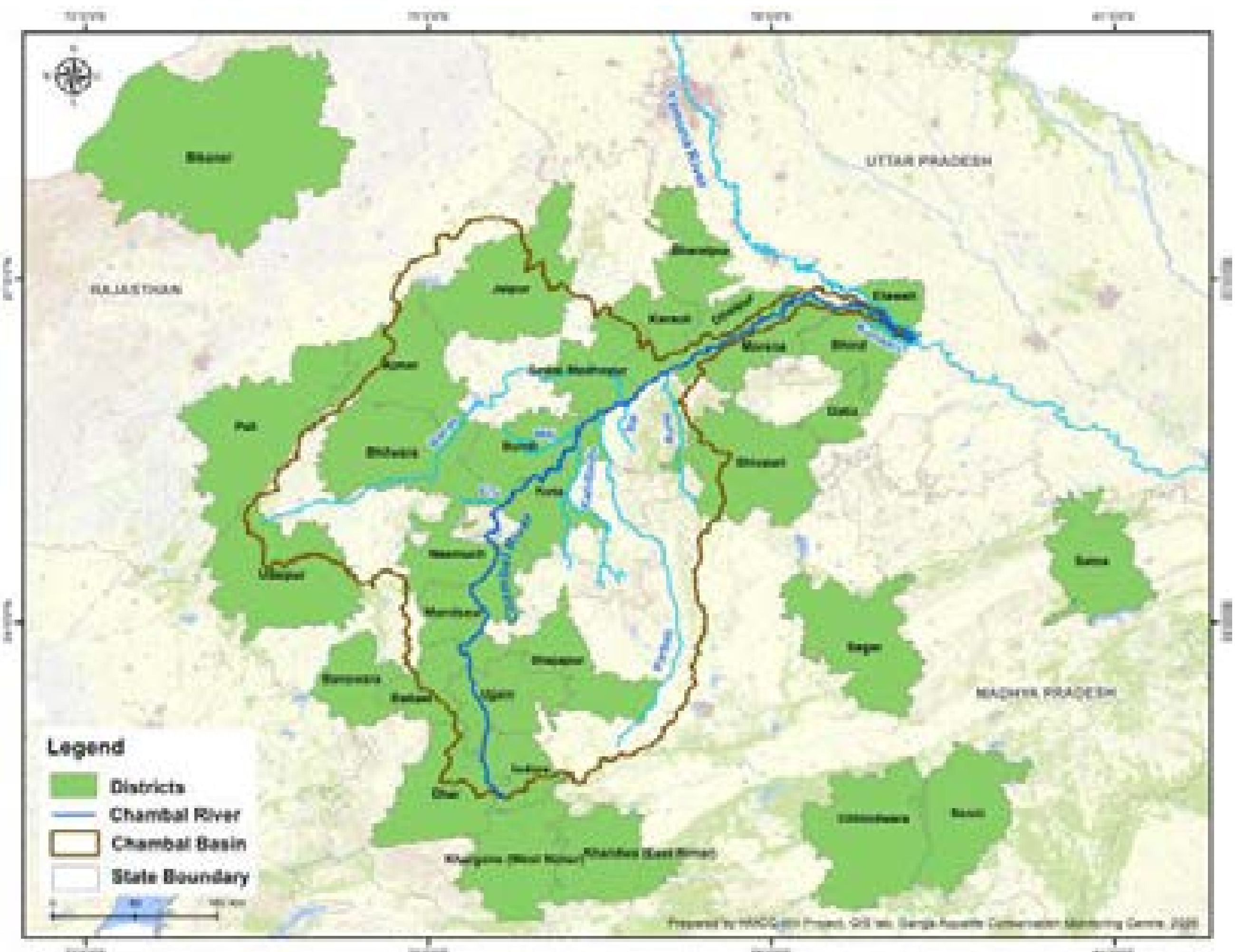


Figure 11.6: Overall participation across the Chambal River Basin

11.4.2.2 Stakeholder Category Distribution

The 32 training sessions engaged a diverse range of stakeholder categories, building a broad network for river conservation. Table 11.4. details participation across 17 groups, with Forest Officials and veterinarians' categories showing the highest involvement, aligning with NMCG's focus on grassroots participation.

Rajasthan accounted for the largest proportion of trained individuals, with 549 participants (71.5% of the total) (Table 11.3 and Figure 11.7). This high engagement reflects

Rajasthan's ecological significance in the Chambal basin and the concentration of conservation efforts in the state. The most prominent stakeholder groups in Rajasthan included forest officials (281), veterinarians (136), school students (81), NSS volunteers (11), Irrigation Dept. & Engineers (9), college professor (9), Fisheries officials (6), Line agencies (6), and Ganga Praharis (4). Additionally, contributions from school teachers (2), scientists (1), researchers (1), and ETF-GTF members (1), NGO & Volunteers (1) underscored the involvement of scientific and academic institutions.

Madhya Pradesh followed with 199 participants, contributing 26% of the total trained stakeholders. Key groups here included forest officials (104), College students (50), Fisheries Officials (3), Ganga Praharis (6), Local community (4) school teachers (5), school students (6), Participation from NSS volunteers (19), Researchers (1) and Line agencies (1) (Table 11.3 and Figure 11.7) also indicated strong institutional collaboration and community outreach in the middle stretch of the Chambal Basin. Uttar Pradesh recorded 19 participants, mainly comprising forest officials (1) and Zookeeper's (2) emphasizing local ecological stakeholders in the school teachers (3) and NSS volunteers (2), reflecting an urban-focused awareness strategy targeting the youth and educational sector. Ganga Praharis (7) and religious/community groups (4), thereby ensuring representation from key civil society stakeholders.

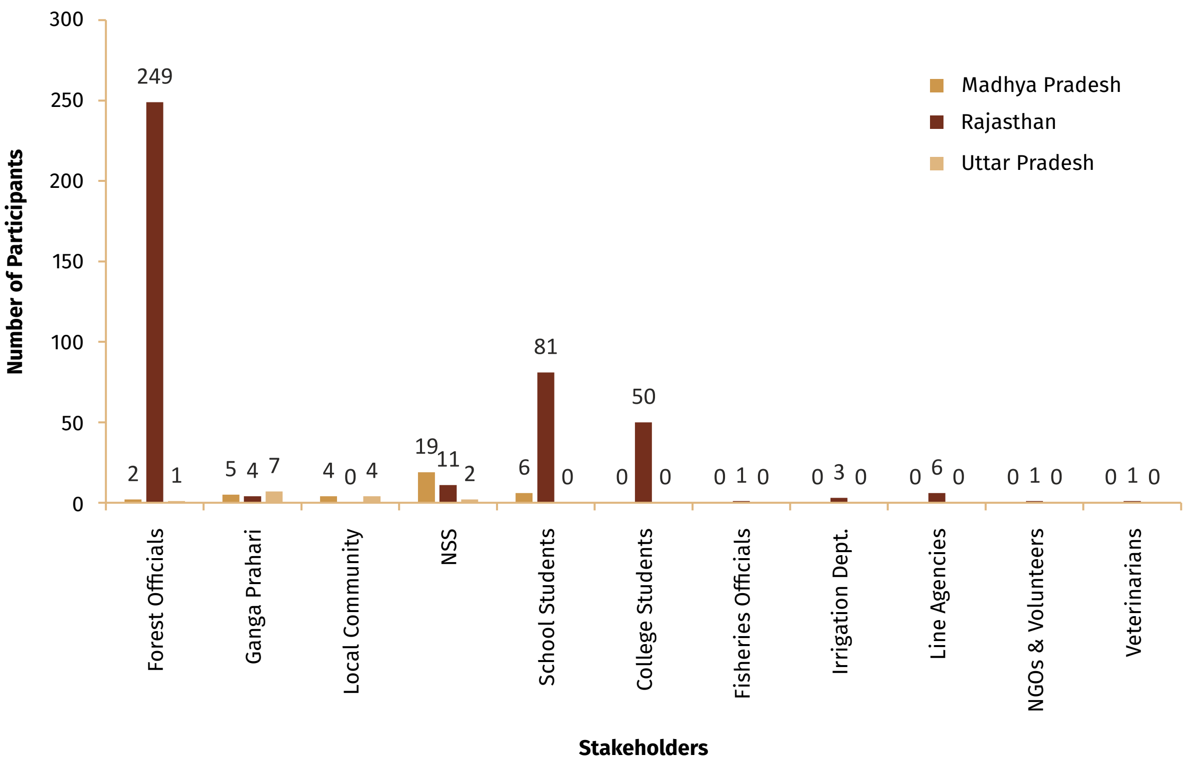


Figure 11.7: Stakeholder-Wise total Participation in Overall Trainings for Chambal River Basin

11.4.2.3 Gender Distribution

As shown in Table 11.4, participation across the 32 training sessions was male-dominated, with 518 males (67.5% of the total) and 249 females (32.4%), highlighting the need for gender-sensitive approaches to increase female involvement. In Madhya Pradesh, females accounted for 63 participants (31.6% of the state total), likely due to community-based initiatives engaging women in eco-tourism. In Rajasthan, female participation was lower at 181 (32.9%), possibly due to time constraints for women in agrarian or urban households and in Uttar Pradesh 5 participant (26.3% of the state total). Flexible training schedules and women-focused modules could address these gaps to enhance inclusivity.

Table 11.4: Gender Distribution of Participants

Gender	Madhya Pradesh	Rajasthan	Uttar Pradesh	Grand Total
Female	63	181	5	249
Male	136	368	14	518
Grand Total	199	549	19	767

11.4.3 Spearhead trainings in the Chambal River Basin

Establishment of a spearhead team is one of the vital goals under this project, which marks a strategic and collaborative effort to embed local expertise and coordinated action within the Chambal River Basin. These targeted sessions prioritized stakeholders in key districts and categories to enhance local capacity for conservation efforts. The data below, organized by district and stakeholder category, reflects participation patterns and identifies areas for improving training outreach.

11.4.3.1 District-Wise Distribution

The 11 spearhead training sessions (Figure 11.8), aimed at developing leadership skills for sustainable river management and biodiversity conservation, engaged 154 participants across the Chambal River basin and were conducted in selected districts, targeting areas critical for the Chambal's ecological health or human dependence. Table 11.5 shows the distribution, with Madhya Pradesh with 9 participants (5.8%), Rajasthan contributing 142 participants (92.2% of the total) and Uttar Pradesh 3 (1.9%), trained across Chambal River basin.

These teams have been instituted through an inclusive and consultative process, involving a series of structured dialogues, workshops, and meetings with the Forest Departments and other line agencies of Chambal River Basin states through which the Chambal and its tributaries flows. At present, these teams comprise a diverse mix of stakeholders, including forest dept. officials, researchers, professors, teachers, trained Ganga Praharis (community volunteers dedicated to river conservation), allied forces and police personnels, local club, and representatives from line agencies such as Fisheries, Animal Husbandry, irrigation departments and non-governmental organizations (NGOs) working on environmental and freshwater biodiversity conservation.

Table 11.5: District-Wise Distribution of Spearhead Training Participants

State	District	No of participate	State Total
Madhya Pradesh	Datia	1	9
	Dhar	1	
	Khandwa	1	
	Morena	5	
	Seoni	1	
Rajasthan	Banswara	1	142
	Bharatpur	1	
	Bikaner	2	
	Jaipur	91	
	Kota	18	
	Kotputli-Behror	1	
	Pali	1	
	Sawai Madhopur	22	
	Udaipur	5	
Uttar Pradesh	Etawah	3	3
	Total		154

The goal of the establishment of the Spearhead team in the Chambal River Basin was to create an in-house capacity in the State Forest Departments and other line agencies for biodiversity monitoring, conservation, and management of the riverine species along the Chambal Basin States. The objective was to (i) train the spearhead team members for each of the Chambal River Basin states in the areas of aquatic biodiversity monitoring for practical and action-oriented implementation of science-based research carried out by the WII (ii) create a pool of trainers, who would be the future trainers for other frontline staff for successful biodiversity monitoring and restoration of the Chambal River Basin and to carry forward the activities after obtaining the training programmes. By anchoring these efforts within local institutions and communities, the initiative ensures long-term stewardship of the river's ecological health and conservation of its biodiversity.

11.4.3.2 Stakeholder Category Distribution

As part of the spearhead training programmes, a total of 154 stakeholders (Figure 11.9) were trained across three states of Chambal Basin states viz. Madhya Pradesh, Rajasthan and Uttar Pradeesh respectively. These trainings aimed to build capacity and to create a pool of trainers to enhance awareness, knowledge, and collaborative action among diverse stakeholder groups who play a vital role in riverine ecosystem conservation and management. The stakeholder groups trained during these spearhead training programmes included representatives from forest officials, veterinarians, academic institutions, and allied forces government departments, civil society, local volunteers and community-based organisations.

Among the participating states, Rajasthan contributed the highest number of trained stakeholders, with 142 individuals (Table 11.6) engaged across a wide range of sectors. These included forest officials (32), college professors (9), veterinarians (85), ETF-GTF members (1), irrigation engineers (6), fisheries officials (5), scientists (1), Researchers (1), School Teachers (2). The large and diverse participation from Rajasthan reflects its ecological significance in the Chambal basin and the state's proactive approach to community-based conservation.

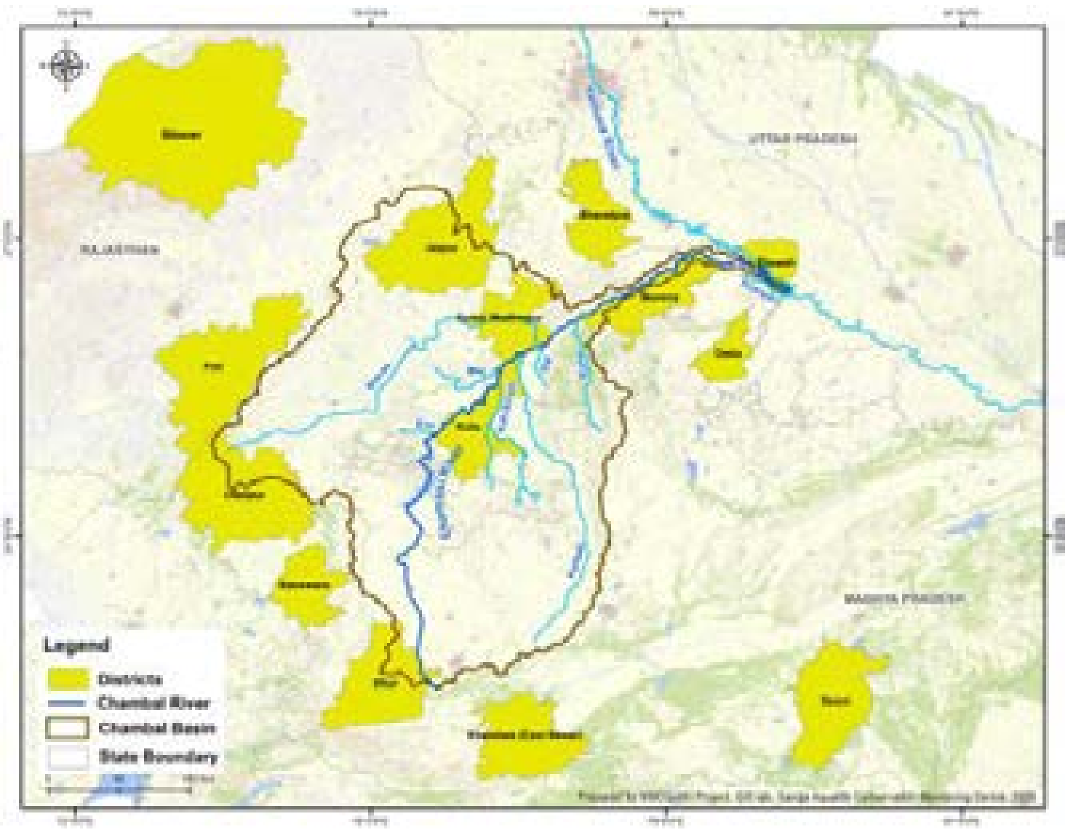


Figure 11.8: Location of trained spearhead team members in Chambal River basin

Table 11.6: Stakeholder- Wise Distribution of Spearhead Training Participants

States	Stakeholders									
	Forest Officials	College Professor	Researchers	Fisheries Officials	Irrigation Dept. & Engineers	ETF-GTF Veterinarians	School Teachers	Scientist	Ganga Praharis	Total
Madhya Pradesh				3				5	1	9
Rajasthan	32	9	1	5	6	1	85	2	1	142
Uttar Pradesh								3		3
Total	32	9	1	8	6	1	85	10	11	154

Subsequently, for the state of Madhya Pradesh followed with 9 participants, including fisheries officials (3), school Teachers (5) and Ganga Praharis (1). The state of Uttar Pradesh had fewer participants (3), but still contributed through focused involvement of academic personnel such as school teachers. This distribution highlights the importance of multi-sectoral and geographically inclusive capacity-building efforts for effective river conservation. By engaging individuals from educational institutions, technical departments, civil society, and local communities, the program strengthens the foundational framework necessary for long-term ecological stewardship of the Chambal River basin.

Across all states, the most represented stakeholder categories were veterinarians (85), forest officials (32), and School teachers (10), college professors (9), Fisheries officials (8) Irrigation Department & Engineers (6) respectively. These groups are instrumental in bridging the gap between scientific knowledge and on-ground conservation actions. Their training ensures a decentralized and well-informed network of actors capable of contributing to the protection, monitoring, and sustainable management of the Chambal River and its biodiversity.

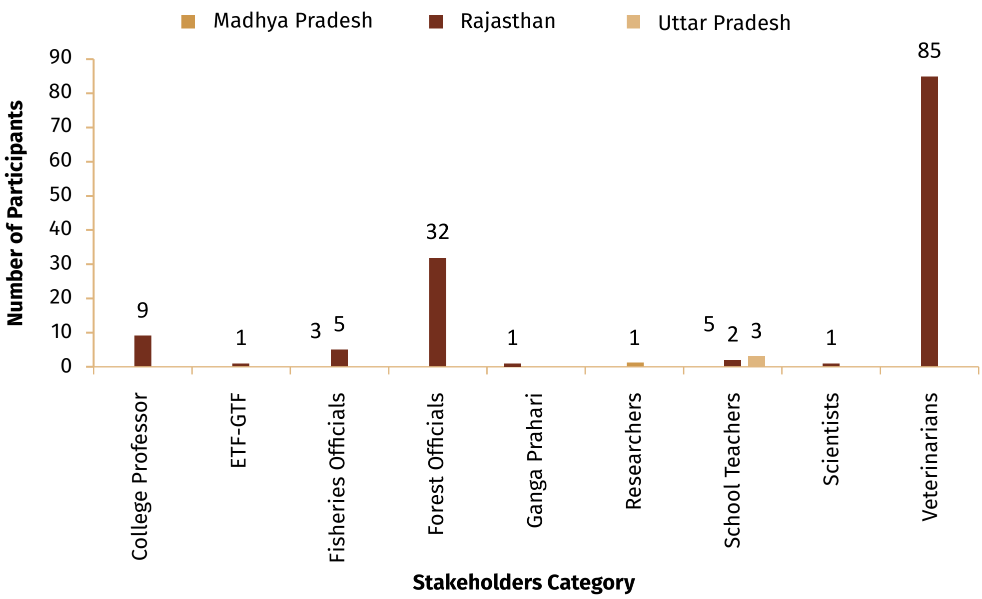


Figure 11.9: Stakeholder-Wise total Participation in Spearhead Trainings for Chambal River Basin

11.4.4 Rescue and Rehabilitation Training in the Chambal River Basin

Five rescue-specific training sessions were conducted to equip stakeholders with skills for wildlife rescue and rehabilitation in the Chambal River Basin. Focused on protecting species like the Ganges River dolphin, gharials, and freshwater turtles, the session engaged 548 participants (146 participants in 5 rescue trainings and 402 in rescue modules during other trainings) from Madhya Pradesh, Rajasthan and Uttar Pradesh including various stakeholder groups. The data below, organized by district and stakeholder category, highlights participation patterns and informs strategies for expanding future rescue training efforts.

11.4.4.1 District-Wise Distribution

Effective rescue and rehabilitation are dependent on knowledge of the species with good understanding of their biological and ecological attributes, proper planning and preparedness and availability of requisite infrastructure and a skilled professional rescue team, thus making this a concerted team effort and an inclusive process. Capacity building of professionals who can contribute to this process of efficient rescue and rehabilitation, with enhanced skills and efficiency form an integral part of the work conceptualised under Rescue and Rehabilitation training protocols.

Enhancing the capacity of personnel from forest departments, animal husbandry departments, field veterinarians, and volunteers is a crucial aspect of ensuring effective rescue and rehabilitation of macro aquatic fauna in distress. The conservation of biodiversity within the Chambal River Basin requires a well-trained workforce that can respond swiftly in managing such rescue and rehabilitation efforts, safeguard vulnerable species, and contribute to the overall health of the aquatic ecosystem. Under the Rescue and Rehabilitation training conducted across the Chambal River Basin, a cumulative total of 548 stakeholders were trained across three Chambal Basin States (Figure 11.10).

Table 11.7: District-Wise Distribution of Rescue Training Participants

State	District	No. of participants	Total
Madhya Pradesh	Bhind	6	154
	Morena	133	
	Sagar	13	
	Satna	1	
	Singrauli	1	
Rajasthan	Bharatpur	1	392
	Bikaner	3	
	Bundi	10	
	Dholpur	60	
	Jaipur	81	
	Karauli	65	
	Kota	73	
	Sawai Madhopur	96	
	Udaipur	3	
Uttar Pradesh	Etawah	2	2
	Total		**548**

Rajasthan exhibited the highest participation, accounting for 392 individuals (Table 11.7), with the majority from Sawai Madhopur (96 participants), followed by Jaipur (81), Kota (73), Karauli (65), Dholpur (60), Bundi (10), Udaipur (3), Bikaner (3), and Bharatpur (1). Madhya Pradesh contributed 154 participants, primarily from the districts of Morena (133), Sagar (13), Bhind (6), Satna (1) and Singrauli (1). Uttar Pradesh marked the beginning of stakeholder engagement under the module, with initial participation from 2 individuals trained in the Etawah district. The data reflect a geographically diverse stakeholder engagement, with Rajasthan and Madhya Pradesh emerging as the focal regions for capacity building in rescue and rehabilitation along the Chambal Basin.

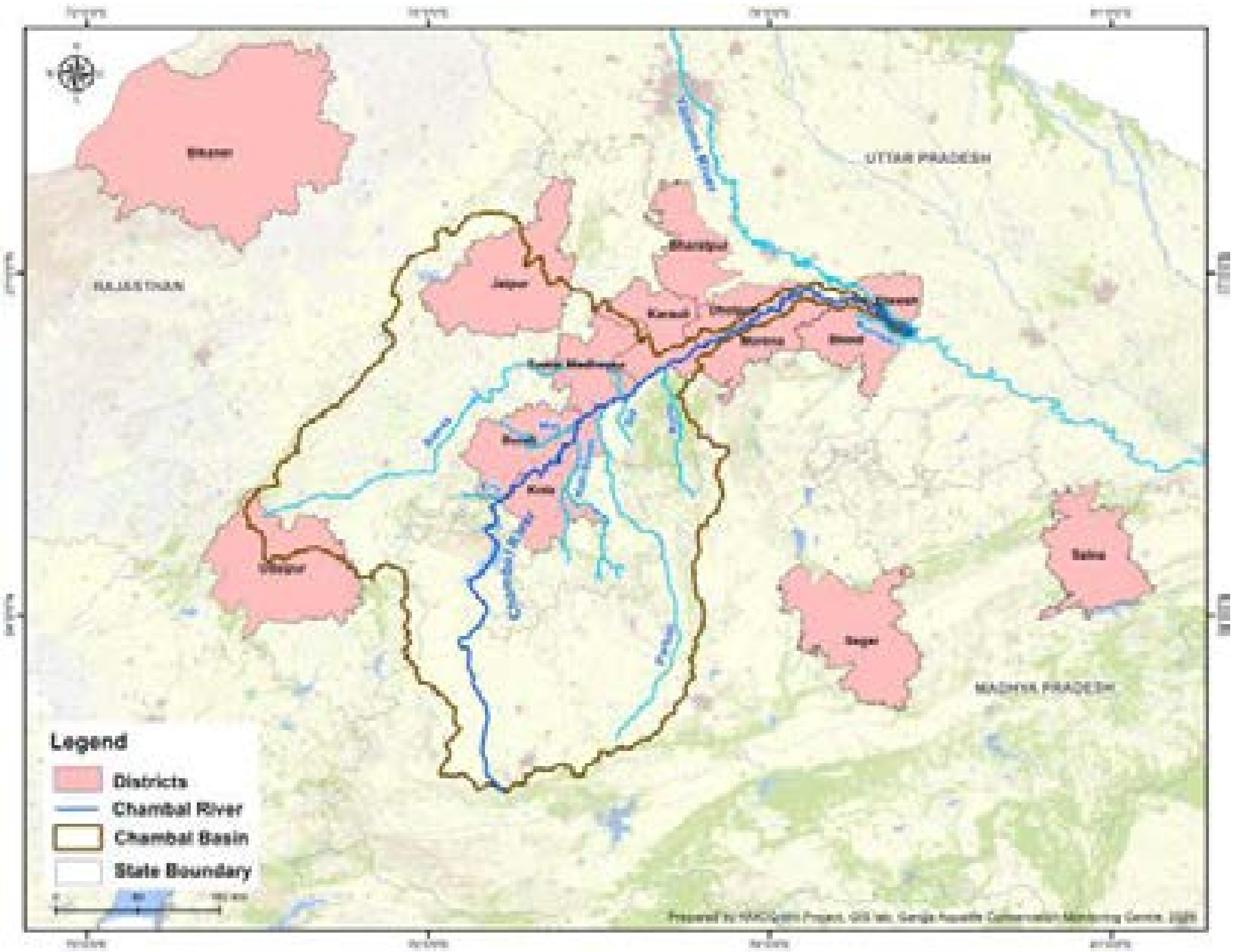


Figure 11.10: Location of trained stakeholders in Rescue and Rehabilitation Training in Chambal River Basin

11.4.4.2 Stakeholder Category Distribution

A total of 548 stakeholders were trained under the Rescue and Rehabilitation module across three states, Uttar Pradesh, Madhya Pradesh and Rajasthan (Table 11.8). This module focused on equipping participants with the necessary knowledge and skills to carry out pre-rescue, rescue, and post-rescue operations, particularly for distressed or stranded aquatic and semi-aquatic wildlife.

The highest participation was recorded in Rajasthan, with 392 stakeholders (71.5% of the total) trained. The majority of these were forest officials (252) and veterinarians (135), both of whom are critical in executing direct intervention activities during rescue missions. Additional participants included ETF-GTF members (1), college professors (3) and researchers (1) (Table 11.8), reinforcing the collaborative and inter-agency nature of rescue operations in the upper reaches of the Chambal basin.

Table 11.8: State-Wise Stakeholder Participation in Rescue and Rehabilitation Training in Chambal River Basin

States	Stakeholders								
	Veterinarians	Zookeeper & Staff	Forest Officials	ETF-GTF	College Professor	College Students	Line Agencies	Researchers	Grand Total
Rajasthan	135		252	1	3			1	392
Madhya Pradesh			102			50	1	1	154
Uttar Pradesh		2							2
Total	135	2	354	1	3	50	1	2	548

Madhya Pradesh followed with 154 trained individuals, reflecting strong engagement in the mid-Chambal stretch. A significant number of forest officials (102) were trained, along with college students (50) researchers (1) and Line agencies (1). This diversity in participation demonstrates the integration of technical expertise with community and academic engagement in field rescue efforts. Uttar Pradesh recorded smaller i.e., (2), yet these contributions were strategically important for creating linkages with enforcement and engineering departments in urban or southern basin regions. Stakeholder categories that were most represented overall included forest officials (354), veterinarians and Zoo staff (137), ETF-GTF (1), and college students/researchers (52), college professors (3).

11.4.5 Other Stakeholders Training in the Chambal River Basin

Under the capacity building initiative, focused training programmes have been conducted for other key stakeholders to engage a broader spectrum of stakeholders connected to the Chambal River basin. These include university professors, students, forest department personnel, local communities, educators, farmers, fishermen, and NGOs, media representatives etc. The objective is to build decentralized capacity and ensure the participation of maximum stakeholders in conserving the riverine biodiversity of the Chambal River Basin. These trainings were designed to enhance understanding of biodiversity of Chambal River, conservation practices, promote participatory approaches, and encourage the integration of ecological considerations into local and institutional actions.

Sixteen training sessions were conducted to engage diverse stakeholders across the Chambal River Basin in efforts to support sustainable river management and biodiversity protection. These sessions involved 457 participants from Madhya Pradesh, Rajasthan and Uttar Pradesh districts, targeting a range of stakeholder groups (Table 11.9). The table below details participation by district wise category, highlighting engagement patterns and areas for expanding future training efforts.

11.4.5.1 District-Wise Analysis

A total of 16 training sessions were conducted (Table 11.9), engaging 457 participants across twenty-three districts (Figure 11.11). Rajasthan accounted for the majority, contributing 357 participants (78.1%), with the highest participation from Jaipur district (114 participants), followed by Sawai Madhopur (70), Karauli (55), Dholpur (54), Kota (52), Bhilwara (11), and Ajmer (1). Madhya Pradesh contributed 86 participants (18.8%), with most participants coming from Morena district (67). Uttar Pradesh had 14 participants (3%), all from Etawah district.

Table 11.9 District-Wise Distribution of Participants of Other Stakeholders Training

States	Districts	Total	State total
Madhya Pradesh	Bhind	1	86
	Chhindwara	1	
	Datia	2	
	Dhar	3	
	Indore	3	
	Khargone	1	
	Mandesour	1	

States	Districts	Total	State total
Madhya Pradesh	Morena	67	
	Neemuch	2	
	Ratlam	1	
	Seoni	1	
	Shajapur	1	
	Shivpuri	1	
	Ujjain	1	
Rajasthan	Ajmer	1	357
	Bhilwara	11	
	Dholpur	54	
	Jaipur	114	
	Karauli	55	
	Kota	52	
	Sawai Madhopur	70	
Uttar Pradesh	Etawah	14	14
	Total		457

11.4.5.2 Stakeholder Category Analysis

A total of 457 individuals participated in these training programmes, representing a wide range of professional, academic, and community backgrounds (Table 11.10).

Table 11.10: Stakeholder-Wise Distribution of Other Stakeholders Training Participants

Stakeholders	Madhya Pradesh	Rajasthan	Uttar Pradesh	Total
College Students	50			50
Fisheries Officials		1		1
Forest Officials	2	249	1	252
Ganga Prahari	5	4	7	16
Irrigation Department & Engineers		3		3
Line Agencies		6		6
Local Community	4		4	8
NGOs & Volunteers		1		1
NSS	19	11	2	32
School Students	6	81		87
Veterinarians		1		1
State total	86	357	14	457

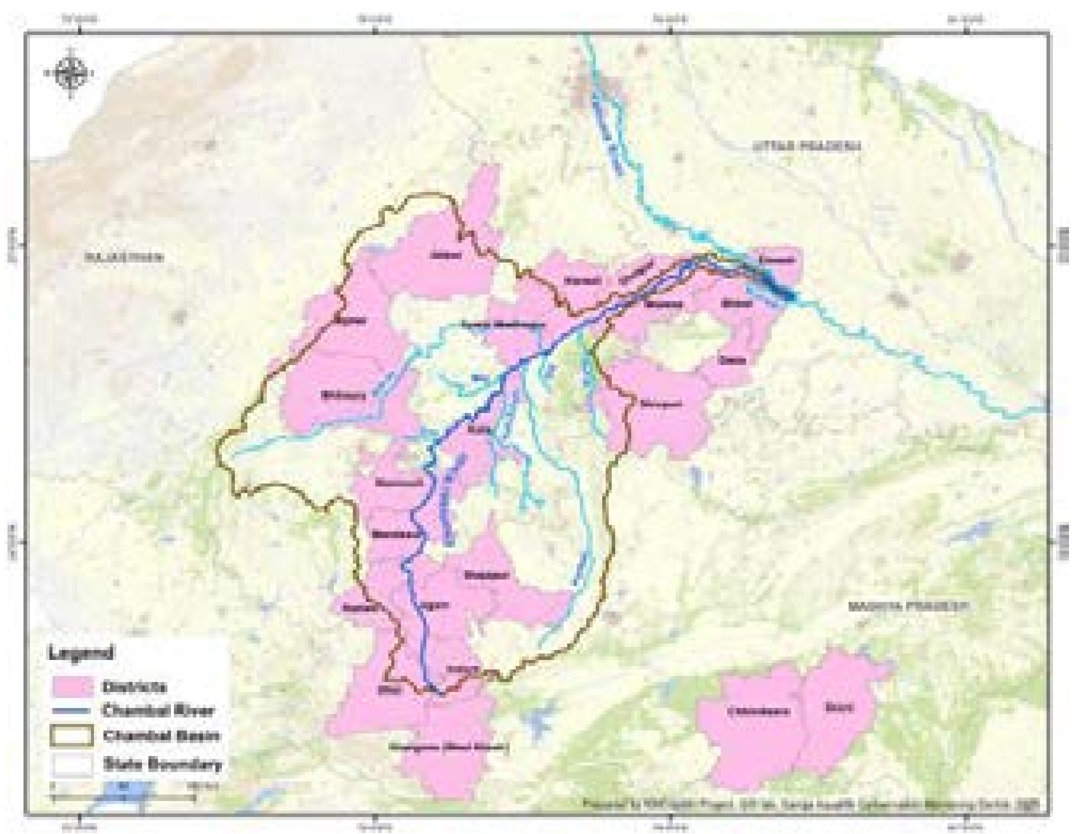


Figure 11.11: Location of multiple stakeholders trained in onsite and offsite training sites

11.4.6 Developing a Network of Riverside Local Communities Capable of Responding to Emergent Situations

Local communities play a vital role as first responders during emergent situations, often acting swiftly and decisively. Their quick action is crucial, particularly when time-sensitive rescue and rehabilitation efforts are required. Building the capacities of local communities and volunteers by investing in community-based preparedness and stewardship, this approach not only enhances ecological resilience and biodiversity conservation but also empowers local populations to play a pivotal role in safeguarding their environment.

A robust network of riverside communities has been developed, empowering them to effectively respond to various challenges through a combination of social support systems, enhanced community resilience, coordinated communication channels, and collaborative engagement with multiple stakeholders (Figure 11.12). These sessions engaged 492 participants from different districts of Madhya Pradesh, Rajasthan and Uttar Pradesh and diverse stakeholder groups (Figure 11.13). The (Table 11.11) details participation by district and stakeholder category, highlighting engagement patterns and opportunities for expanding future training efforts.

Table 11.11: District and Stakeholder Category Distribution of First Responder Training Participants

States	Districts	ETF-GTF	Forest Officials	Veterinarians	Zookeeper & Staff	Grand Total	State Total
Madhya Pradesh	Bhind		5			5	102
	Morena		82			82	
	Sagar		13			13	
	Satna		1			1	
	Singrauli		1			1	
Rajasthan	Bharatpur	1				1	388
	Bikaner			3		3	
	Bundi			10		10	
	Dholpur		50	10		60	
	Jaipur			81		81	
	Karauli		55	10		65	
	Kota		62	11		73	
	Sawai Madhopur		85	10		95	
Uttar Pradesh	Etawah				2	2	2
Grand Total		1	354	135	2		492

11.4.6.1 District-Wise Analysis

The training sessions engaged a total of 492 participants across ten districts in three states viz. Madhya Pradesh, Rajasthan, and Uttar Pradesh. Rajasthan contributed the highest number of participants, with 388 individuals (78.9% of the total), showing strong engagement from districts with active wildlife and forest management. Sawai Madhopur led with 95 participants (24.5% of Rajasthan's total), followed by Kota (73), Dholpur (60), Karauli (65), and Jaipur (81), reflecting the high concentration of forest officials and trained personnel in these areas. Participation from Bhilwara (11) and Ajmer (1) was limited. Madhya Pradesh followed with 102 participants (20.7%), largely from Morena (82), suggesting a concentrated training effort in this district. Smaller numbers were reported from Bhind (5), Sagar (13), Satna (1), and Singrauli (1), indicating a more targeted engagement in these regions (Table 11.11).

Uttar Pradesh had minimal representation, with only 2 participants (0.4%), both from Etawah district, indicating potential for expanded outreach in future training phases. The distribution pattern suggests that training efforts were focused on districts with critical wildlife habitats and higher human-wildlife conflict potential, particularly in Rajasthan and northern Madhya Pradesh.

11.4.6.2 Stakeholder Category Analysis

Participants represented four stakeholder categories essential to wildlife conservation and rapid response mechanisms. Forest officials constituted the largest group, with 354 participants (72%), reflecting their frontline role in protected area management and enforcement. Their highest representation was in districts such as Jaipur, Sawai Madhopur, and Morena. Veterinarians formed the second-largest group, with 135 participants (27.4%), significantly contributing in districts like Dholpur, Karauli, and Kota, which often deal with wildlife rescue and treatment. The inclusion of veterinarians underscores the sessions' emphasis on emergency medical response and wildlife health management. Zookeepers and support staff accounted for 2 participants (0.4%), both from Etawah district in Uttar Pradesh, indicating limited but focused engagement from zoological facilities. There were no participants recorded under the ETF-GTF category in this round of training, suggesting either a data reporting gap or that this group was not targeted in the current phase. This stakeholder composition reflects a strong operational focus on ground-level forest personnel and veterinary professionals, aligning with the training's objectives to strengthen field-based response capacities in high-priority districts.

When a wildlife rescue situation arises, trained volunteers or first responders take immediate action. Their roles include contacting relevant authorities such as the Forest Department, veterinary hospitals, NGOs, and local police, as well as managing the crowd to avoid panic. Based on the condition of the stranded species, a decision is made on whether rescue intervention is necessary. If the species is distressed, first responders provide first aid and notify the nearest rescue and rehabilitation centre. A rescue team is then dispatched to transport the species for care and eventual rehabilitation and release back into their habitat.

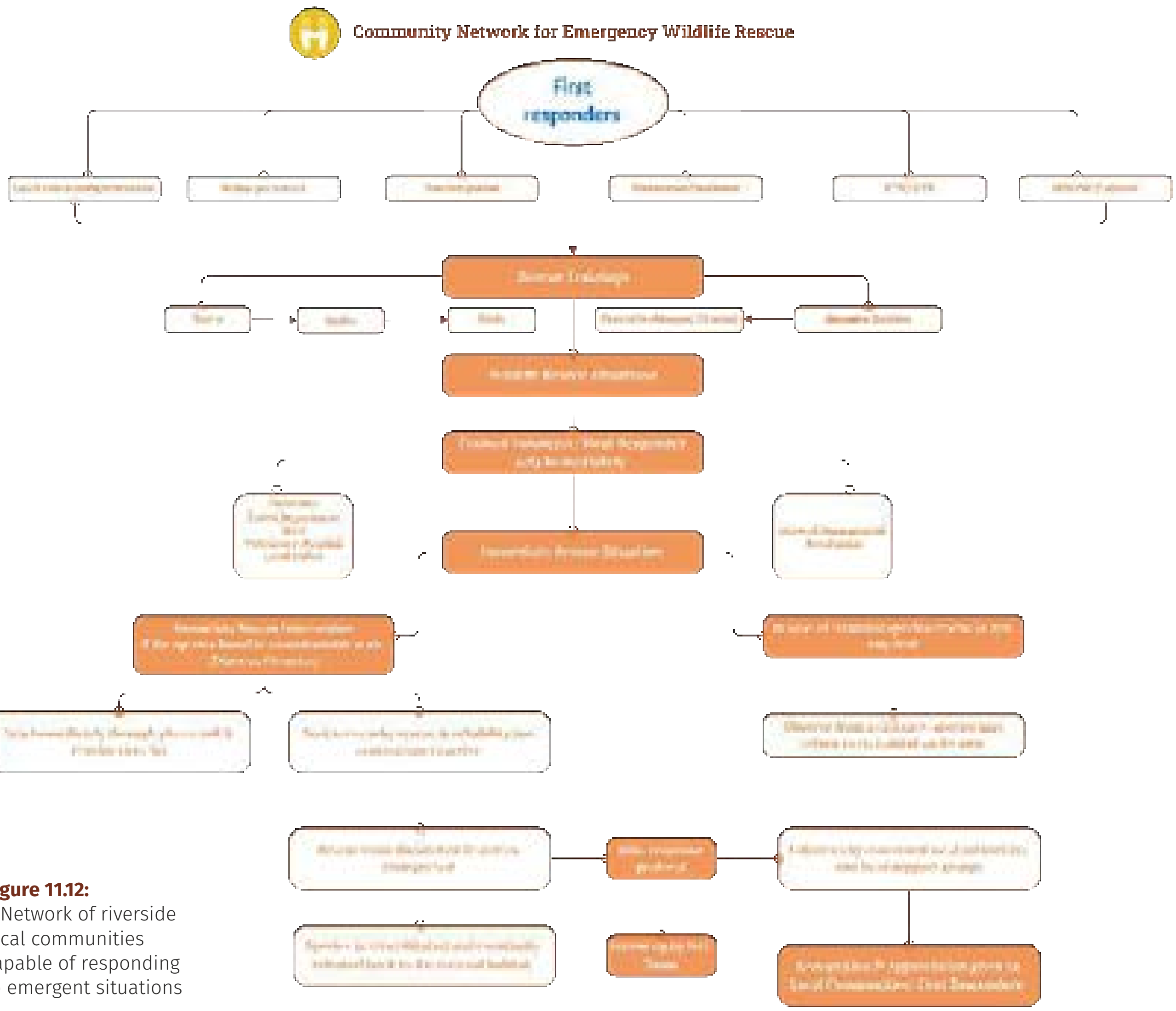


Figure 11.12: A Network of riverside local communities capable of responding to emergent situations

In situations where the species is not in distress, responders are trained to observe from a distance, allowing the species to return to its natural habitat without intervention. The process follows a joint response protocol, with subsequent follow-up by the Wildlife Institute of India (WII) team, local authorities, and community support groups. Successful interventions are acknowledged through recognition and appreciation given to the first responders and local communities, reinforcing a sense of stewardship and encouraging sustained participation in wildlife conservation efforts. The training, resources, and assistance provided by this network enable grassroots stakeholders to protect aquatic biodiversity in the Chambal River Basin and beyond, demonstrating a decentralized, community-led approach to wildlife rescue and conservation.

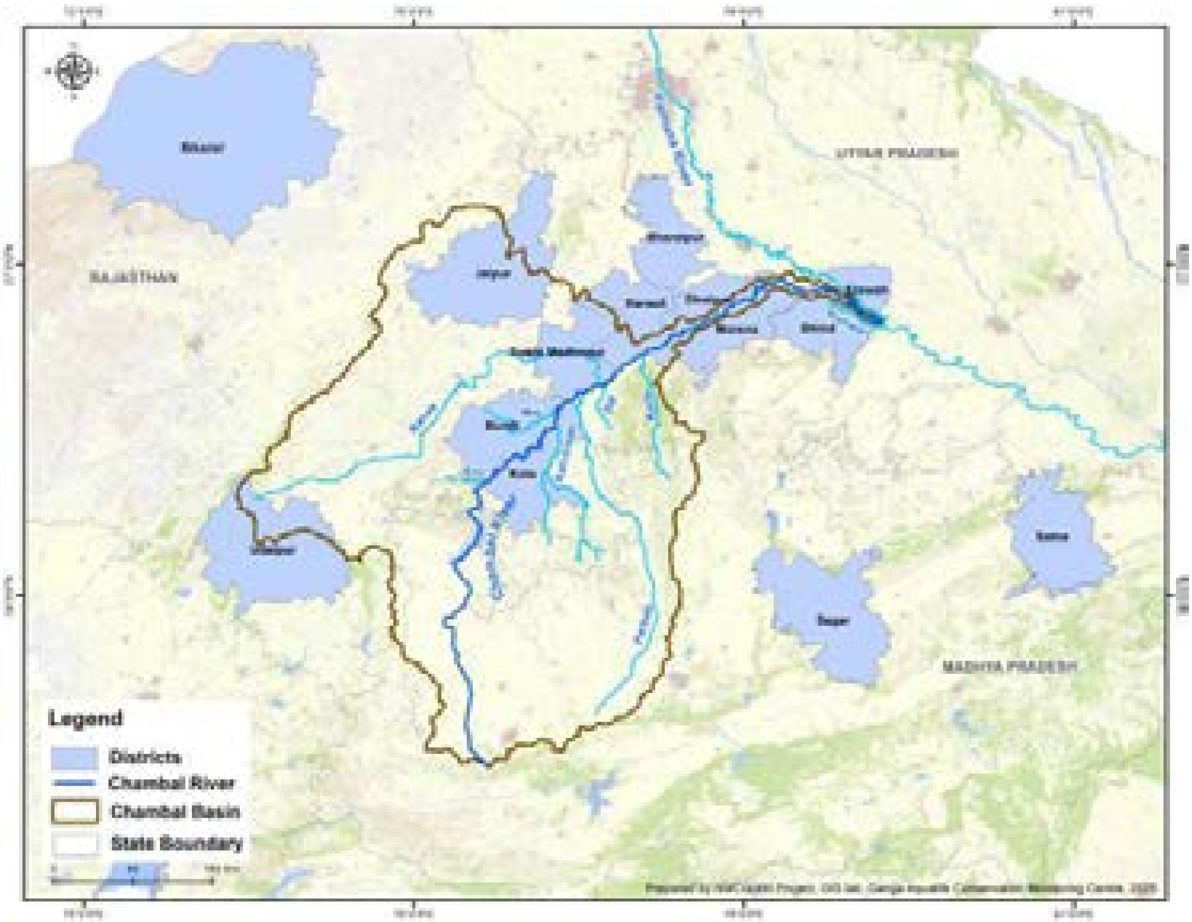


Figure 11.13: Location of first Responders trained in rescue protocols for responding to emergent situations

Figure 11.14: Training database at WII NMCG Webpage

11.4.7 Training Database Management

Management of training database is significant for networking among stakeholders for the establishment of record-keeping protocols ensuring consistency and accuracy across the training information of trainers, trainees, implementing agencies and local bodies. The training database is an online repository that provides comprehensive and compiled information of the training programmes including detailed report, programme schedule, mode of training, modules, field sessions, resource persons, number of days engaged etc. The training database can be accessed and freely download by any organizations and line agencies from https://wii.gov.in WII-NMCG Webpage at Training database 2019 to 2025 subtabs (Figure 11.14) for effective implementation of training programmes and workshops with different stakeholders in their respective areas of concerns.

11.4.8 Training records in print and social media

To ensure dissemination of the training information to a wider audience, details of the events were given extensive media coverage. Various forms of print media including newspapers, brochures and booklets, radio, and numerous social media platforms like Facebook, Instagram etc. were utilized.

Quick Links

- Website: http://www.wii.gov.in/nmcg/Training database
- http://www.wii.gov.in/nmcg/news_events
- Facebook Page: http://facebook.com/glimpsesofganga
- Instagram: http://instagram.com/glimpsesofganga

11.4.9 Carry forward activities in Chambal River Basin

The quality and effectiveness of the trainings imparted to diverge stakeholders was analysed and the outcomes of capacity building programmes were evaluated in terms of what actually happened as a result of training. This monitoring and evaluation process act as critical indicators of the past trainings while planning future activities to ensure efficacy and sustainability of the training imparted.

As part of the Chambal River biodiversity conservation initiative, the long-term impact of the training programme was evaluated through a post-training survey. Out of the 767 participants trained, a sample of 230 participants (30%) was randomly surveyed to assess their involvement in carry forward activities-independent or institutional actions undertaken after the training. The analysis, presented across three figures, provides insights into the extent of participant engagement, the nature of their follow-up actions, and the challenges faced by those who did not carry forward the activities.

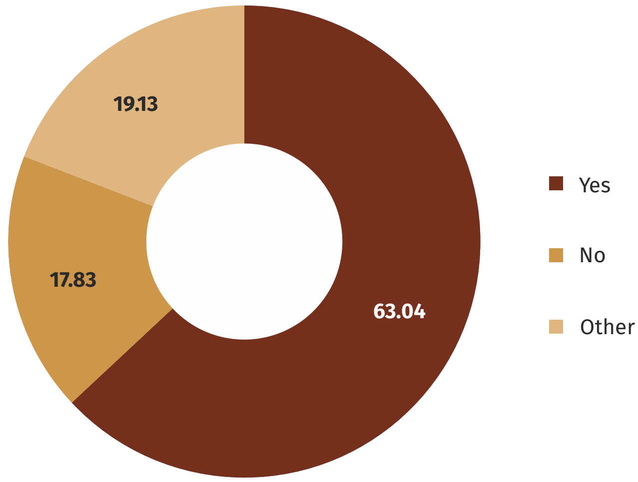


Figure 11.15: Assessment of Carry Forward Activities by Trained Participants

The responses indicated that a substantial proportion of participants demonstrated active post-training engagement. Specifically, 63.04% (n=145) reported actively undertaking carry forward activities, such as awareness campaigns, biodiversity monitoring, school sensitization, clean-up drives, and support in wildlife rescue (Figure 11.15). Meanwhile, 17.83% (n=41) reported not having conducted any follow-up activities. The reasons for non-participation were further explored in a separate analysis (see Figure 11.17). The remaining 19.13% (n=44) fell into the "Other" category (Figure 11.15), which included participants who were still in the planning stage, had only partially initiated activities, or were unsure of how to proceed. This segment represents a transitional group that could be mobilized through targeted mentoring or refresher training. Overall, nearly two-thirds of surveyed participants were actively engaged in local conservation actions, reflecting the effectiveness of the Chambal River training programme in empowering individuals and institutions to translate knowledge into sustained community-level initiatives.

Among the 145 participants who reported engaging in follow-up actions, their activities were further categorized based on the nature of their engagement. The largest proportion, 53.79% (n=78) (Figure 11.16), were involved in training more people. These individuals acted as multipliers by conducting sessions in schools, colleges, departments, or community groups, thereby extending the reach of the training programme and building a wider network of conservation advocates. Meanwhile, 25.52% (n=37) (Figure 11.16) focused on spreading awareness through community meetings, sensitization campaigns, public talks, social media engagement, and participation in local environmental events. This highlights the ripple effect of knowledge dissemination to wider community audiences.

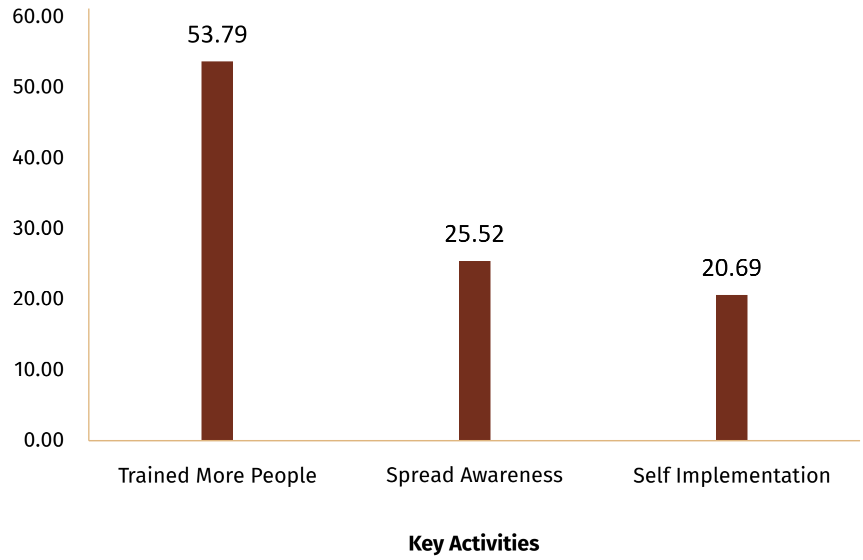


Figure 11.16: Evaluation of Various Activities Conducted by Active Participants

The remaining 20.69% (n=30) (Figure 11.16) undertook self-implementation of conservation activities, which included biodiversity surveys, participation in clean-up drives, initiating small-scale waterbody restoration efforts, and supporting wildlife rescue operations. These hands-on activities represent the direct application of training knowledge into local conservation action. Together, these results demonstrate a diversified impact of the training initiative, with participants contributing to capacity building, awareness generation, and on-ground conservation. This layered approach strengthens the long-term sustainability of conservation outcomes along the Chambal River. To understand the barriers faced by those who did not carry forward activities post-training (17.83% of the sample, n=41) (Figure 11.15), their responses were analyzed and categorized. The most frequently cited challenge, reported by 43.90% (n=18) (Figure 18), was "Inadequate Response from Target Groups." These participants expressed willingness to engage but faced difficulties in mobilizing schools, communities, or institutions to participate in conservation initiatives. This points to the need for improved facilitation and stronger community linkages. A further 19.51% (n=8) (Figure 11.17), indicated they were "Not Interested". While representing a smaller share, this group suggests the importance of reinforcing the relevance and motivational aspects of training to encourage sustained engagement.

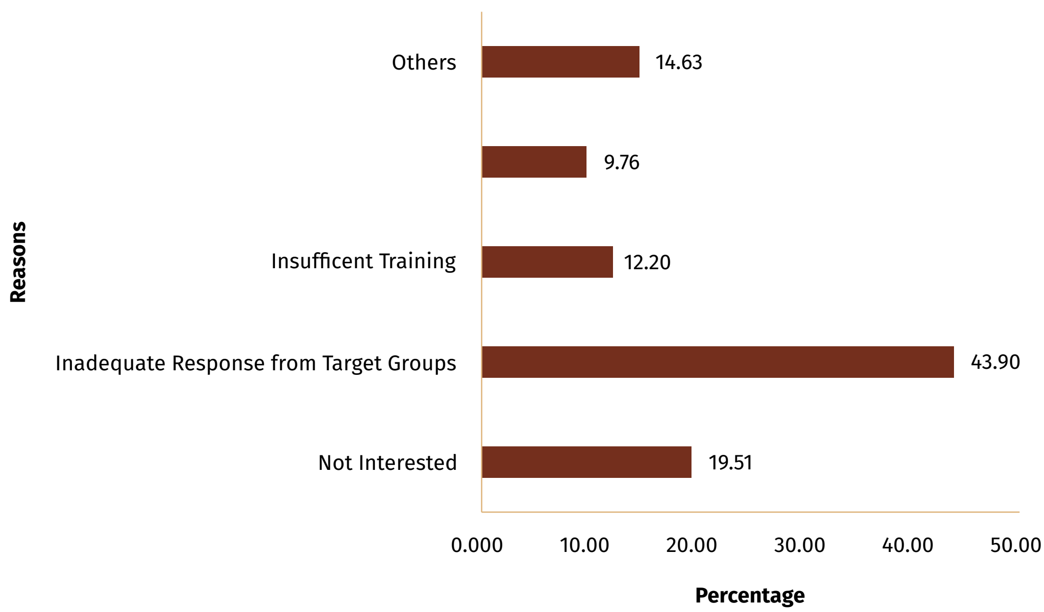


Figure 11.17: Evaluation of Reasons for No Carry Forward Activities

Meanwhile, 12.20% (n=5) (Figure 11.17), reported "Insufficient Training", feeling inadequately equipped to independently implement activities. This underscores the potential value of refresher workshops, peer mentoring, or follow-up demonstrations. Another 9.76% (n=4) identified "Lack of Resources", such as financial support, logistics, or materials, as their main constraint. The remaining 14.63% (n=6) (Figure 11.17), fell under "Other" reasons, which included personal issues, changes in professional responsibilities, or limited time since training completion to initiate actions. These findings show that non-participation is driven primarily by structural and contextual barriers rather than by disinterest alone. Addressing such limitations through institutional support, community mobilization, and continued mentoring could help convert this segment into active contributors to the Chambal River biodiversity conservation efforts.

11.5 Discussion

The capacity building efforts along the Chambal River have created meaningful opportunities for diverse stakeholder groups to engage with conservation in a structured and participatory manner. By addressing the specific roles and responsibilities of each stakeholder group, the training enhanced both technical knowledge and community awareness critical to riverine ecosystem protection. Through these initiatives, a collaborative foundation has been laid for sustained conservation action. The involvement of educational institutions, government departments, and local communities highlights a growing sense of shared responsibility towards the health and resilience of the Chambal River.

The involvement of those stakeholders who are aware and trained in field methodologies for undertaking habitat assessment, ecological monitoring, rescue and rehabilitation, environmental pollution, community participation, and conservation education. The effort is intended to build the capacity of stakeholders so that they can effectively contribute to the restoration of the ecological integrity of the Chambal River Basin. Moreover, the stakeholders would act as self-sufficient human resources capable of carrying forward the conservation activities.

The training programmes have been implemented in three states of the Chambal Basin, viz. Madhya Pradesh, Rajasthan and Uttar Pradesh, respectively. The training techniques have been implemented in an andragogy mode and competency-based methods so as to ensure the development of adequate competence among the participants. Thirty-two training sessions on need assessment workshops with different target groups were conducted to finalize the design of training materials. As part of the spearhead training programmes, a total of 154 stakeholders were trained across three states of Chambal Basin viz. Madhya Pradesh, Rajasthan and Uttar Pradesh.

These trainings aimed to build capacity and to create a pool of trainers to enhance awareness, knowledge, and collaborative action among diverse stakeholder groups who play a vital role in riverine ecosystem conservation and management. The stakeholder groups trained during these spearhead training programmes included representatives from forest officials, veterinarians, academic institutions, police personnels and allied forces government departments, civil society, local volunteers and community-based organisations.

Developing capacity of university professors and students, forest officials, local communities and other stakeholders to build decentralized capacity and ensure the participation of maximum stakeholders in conserving riverine biodiversity of Chambal River Basin. A total of 767 individuals participated in these training programmes, representing a wide range of professional, academic, and community backgrounds. The state-wise distribution of the 767 trained stakeholders across three states of the Chambal Basin, viz. Madhya Pradesh, Rajasthan and Uttar Pradesh, demonstrate the extensive geographic and institutional reach of the Chambal River biodiversity conservation programme.

Enhancing the capacity of personnel from forest departments, animal husbandry departments, field veterinarians, and volunteers is a crucial aspect of ensuring effective rescue and rehabilitation of macro aquatic fauna in distress. Under the Rescue and Rehabilitation training conducted across the Chambal River Basin, a cumulative total of 548 stakeholders were trained across three Chambal Basin States. Rajasthan exhibited the highest participation, accounting for 392 individuals.

Training local volunteers as first responders is a valuable strategy for enhancing community resilience in emergencies. The first responders include Local volunteers, Ganga Praharis, NGOs, Ganga Task Force (GTF), Eco Task Force (ETF), tourist guides. These trained volunteers can provide immediate assistance before professional help arrives, bridging the gap during the critical initial phase of a rescue situation. These individuals are trained in specific rescue modules, including turtle, bird, snake, crocodile (mugger and gharial), and Gangetic dolphin rescue techniques.

REFERENCES

Alaerts, G. J. (2008). Knowledge and Capacity Development (KCD) as tool for institutional strengthening and change. In *Water for a changing world-Developing local knowledge and capacity*, CRC Press, pp. 17-38.

Bloomfield, G., Bucht, K., Martínez-Hernández, J. C., Ramírez-Soto, A. F., Sheseña-Hernández, I., Lucio-Palacio, C. R., & Ruelas Inzunza, E. (2018). Capacity building to advance the United Nations sustainable development goals: An overview of tools and approaches related to sustainable land management. *Journal of sustainable forestry, 37*(2), 157-177.

Carr, G. (2015). Stakeholder and public participation in river basin management-an introduction. Wiley Interdisciplinary Reviews: Water, 2(4), 393-405.

Czabanowska, K., & Rodriguez Feria, P. (2024). Training needs assessment tools for the public health workforce at an institutional and individual level: a review. *European Journal of Public Health, 34*(1), 59-68.

Gravetter, F. J., & Wallnau, L. B. (2016). *Statistics for the behavioral sciences (10th ed.).* Cengage Learning, pp: 1-690.

Hussain, S.A. & Badola, Ruchi (2001). Integrated conservation planning for Chambal River Basin. Paper presented in the National Workshop on Regional Planning for Wildlife Protected Areas. August 6-8, 2001. India Habitat Centre, New Delhi, Wildlife Institute of India, Dehra Dun, 20pp.

Hamza, M. (2012). *Developing training material guide.* Swedish Civil Contingencies Agency (MSB).

Kirkpatrick, D. L. (1959). Techniques for Evaluation Training Programs. *Journal of the American Society of Training Directors, 13*, 21-26.

Leidel M., Niemann S., & Hagemann N. (2012). Capacity development as a key factor for integrated water resources management (IWRM): improving water management in the Western Bug River Basin, Ukraine. *Environmental Earth Science*, 65:1415-1426 DOI:10.1007/s12665-011-1223-5

NMCG, (2019). Annual Report 2018-19. National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India.

OECD, (2006). The Challenge of Capacity Development: Working Towards Good Practice. Paris: Organisation for Economic Co-operation and Development.

O'Keeffe, J. H. (2018). A perspective on training methods aimed at building local capacity for the assessment and implementation of environmental flows in rivers. *Frontiers in Environmental Science,* 6, 125.

UNDP, (2009). Handbook on planning, monitoring and evaluating for development results. United Nation Developments programme, United States of America.

SECTION V

CHAPTER 12

COMMUNITY-BASED CONSERVATION IN CHAMBAL RIVER BASIN

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain,
Pariva Dobriyal,
Deepika Dogra

Lead Authors
Sakshi Rana,
Abhimanyu Singh,
Rashmi Das,
Hemlata Khanduri,
Sunidhi Mishra

Contributing Authors
Amanat K. Gill,
Shraddha Mahajan, Mohit Payal,
Piyush Kumar Anuj, Vinita Sagar,
Hema Pant, Priyanka Singh,
Krishna Prakash Upadhyay

SUMMARY

The riverine communities residing in the Chambal River basin exhibit a complex and diverse socio-economic structure, with their livelihoods deeply intertwined with the Chambal's geography, ecology and history. Historically notorious for dacoity and social unrest, the ravines adjacent to the Chambal have also served as a refuge for marginalized communities. Although improved policing, administration, and socio-political organization have reduced criminal activities, the local communities residing in the basin still face socio-economic and ecological challenges.

The human population in the Chambal River basin is sparsely populated and concentrated around a few urban and suburban centres. Cities like Indore and Kota have better access to education facilities hence have better literacy rate, while rural and ecologically vulnerable areas such as Sheopur and Dhar lag behind, reflecting persistent disparities in access to resources and socio-economic advancement. Sex ratios also highlight entrenched socio-cultural biases, particularly in Bhind and Dholpur region.

As the Chambal River passes through three different states and supports an array of communities with varying needs and demands, it has a complex stakeholder setup. In Madhya Pradesh, Rajasthan, and Uttar Pradesh, over ninety key stakeholders have been identified, primary stakeholders included local administrations, forest departments, panchayats, line agencies, secondary included research institutions, armed forces, rural development departments, and tertiary stakeholders included ministries, media, NGOs. Notably, institutions such as the State Forest Departments, National Green Tribunal, Pollution Control Boards, and the

Ministry of Environment, Forest & Climate Change possess the highest influence and legitimacy. To engage the identified stakeholders in conservation of Chambal, stakeholder- and issue-specific activities were conducted i.e., awareness and sensitization, consultative meetings, participatory mapping and skill-building programmes, engaging over 1,200 participants.

Stakeholder groups mainly local people are dependent on Chambal for livelihoods and their day-to-day needs. The Chambal supports agrarian livelihoods through an extensive irrigation network-most notably the Kota Barrage and a series of dams, lift irrigation, and canal links-that underpin double cropping and agricultural diversification across the basin. Despite these interventions, rural populations remain under water stress, especially in tail-end regions where water distribution is inequitable. Livestock rearing is integral part of the local economy, complemented by fisheries in the lower basin. Reclamation of degraded ravines through anicuts, afforestation, and community watershed initiatives has tangibly improved household incomes and employment opportunities. Ecotourism and recreational use of the river, especially in protected areas like the National Chambal Sanctuary, provide additional livelihoods, empowering local residents as guides, naturalists, or homestay operators, and strengthening conservation awareness.

To ensure the community participation in Chambal conservation, interested individuals were identified and registered as Ganga Praharis (n= 122). These Ganga Praharis are trained in various aspects of conservation, such as trained volunteer plantation, stakeholder consultation, rescue and rehabilitation, sustainable tourism, ecological monitoring, and microplan development. To ensure the sustainability of the Ganga Prahari cadre and to link local livelihoods with conservation goals, the Jalaj Centre has been established at Morena, Madhya Pradesh. Needs assessments show a gender-specific preference for livelihood trainings: young men prefer toward technical and skill-based vocations; women choose activities like tailoring, food processing, and wellness-related enterprises. These findings underline the need for gender-sensitive livelihood planning. The microplanning approach and assessment revealed that the Chambal River Basin faces acute problems such as a lack of ecological awareness, illegal sand mining, unregulated riverbed farming, and limited alternative livelihoods. Issues-specific strategies were suggested to address the conservation issues, i.e., participation from all socio-economic strata in conservation and development planning, participation of all stakeholders, raising awareness, institutional strengthening, livelihood development, cleanliness and sanitation, habitat protection.

12.1 Introduction

The Chambal River passes through a total of 18 districts of three states, i.e., Rajasthan, Madhya Pradesh, and Uttar Pradesh, serving as lifeline for numerous aquatic species and the communities residing along its banks. These riverine communities exhibit a complex and diverse socio-economic structure, with their livelihoods deeply intertwined with the Chambal's geography, ecology, and history.

Chambal has been mentioned as a major tributary of the Yamuna River in ancient scriptures, the Mahabharat and the Puranas, as well as by historic scholars (Nath, 1989). In mythology, the River is said to have originated from the blood of cows offered to the Gods. The River and its area are also believed to be cursed by Draupadi, the female protagonist of the Mahabharat (Sen & Mukherjee, 2022). Historically, in Madhya Pradesh, the Chambal region was ruled by the Gupta and later by the Gurjara-Pratiharas and Kachchhapaghatas in the early medieval period, who were great patrons of art and architecture and built several temples and issued inscriptions in the Chambal basin (https://chambaldivisionmp.nic.in/en/culture-heritage).

The ravines of the Chambal River were a refuge for the most deprived castes, victims of social injustice and fugitives of law, hence witnessed dacoity, which contributed to a perception of lawlessness and underdevelopment in the region (Sen & Mukherjee, 2022). Although the incidence of dacoity has significantly declined in recent decades due to increased policing and socio-political changes, the region continues to grapple with challenges such as environmental degradation, socio-economic marginalisation, and the pressures of modernisation and conservation. Poverty remains widespread, particularly in the ravine-affected zones that are predominantly inhabited by socially and economically weaker sections. Owing to its unique geography and socio-political setup, the river has been a muse to many books, documentaries, and movies, i.e., Abhishapto

Chambal by Tarun Bhaduri, Mirrors by Galeano, and Bandit Queen by Shekhar Kapur (Sen & Mukherjee, 2022).

Agriculture forms the primary livelihood for the majority of local households, heavily dependent on the Chambal River for irrigation. However, recurrent soil erosion and the expansion of badlands, locally known as *bihads*, pose serious threats to the sustainability of farming in the region. In addition to settled agricultural communities, the landscape also supports semi-nomadic pastoralist groups such as the Rabaris and Marwadis, who traverse the basin with herds of cattle, buffalo, sheep, and goats. Other indigenous and tribal communities, including the Gujjars (traditionally cattle herders), Bhils, Sahariyas, and Minas, engage in a mix of animal husbandry and subsistence agriculture, maintaining a delicate balance with the fragile riverine ecosystem (https://whc.unesco.org/en/tentativelists/6732).

12.1.1 Human Population and Settlement Trends in the Chambal River Basin

The demographic and settlement patterns surrounding the Chambal River have been traditionally influenced by the region's difficult topography and restricted agricultural viability, primarily attributed to deep ravines, arid climate, and the infamous Chambal Dacoits. As a result, the Chambal basin, in contrast to other significant Indian river basins, remained comparatively underpopulated until the mid-20th century. In recent decades, population density has consistently risen, especially in the plains and alluvial regions of eastern Rajasthan, northern Madhya Pradesh, and southwestern Uttar Pradesh. The Census of India (2011) indicates that districts like Etawah, Bhind, and Kota have had moderate to significant population growth, primarily because of enhanced irrigation facilities, improved road connectivity, and urban expansion. Settlement patterns are predominantly rural in ravine-dominated regions, whereas urbanisation is increasingly evident in districts such as Kota and Etawah, propelled by industrial expansion and administrative progress (Jain et al., 2012). The demographic data of districts along the Chambal River basin indicate pronounced regional disparities in population characteristics. Population density ranges significantly, from as low as 104 persons/km² in Sheopur (Madhya Pradesh) to over 1,000 persons/km² in Agra (Uttar Pradesh), highlighting the contrast between ecologically vulnerable ravine areas and urbanised regions.

Urban districts such as Kota, Indore, Agra, and Etawah have higher literacy rates (exceeding 75%) and higher population density, suggesting better access to education and infrastructure and livelihood opportunities (Table 12.1; Figure 12.1). Conversely, rural and ecologically sensitive districts like Sheopur, Karauli, and Dhar have lower literacy rates (below 65%) and more challenging socio-economic conditions. The sex ratio in numerous districts is imbalanced, notably in Dholpur (846), Morena (840), and Bhind (837), indicating persistent gender inequalities, especially in rural areas (Table 12.1).

These patterns signify increasing human strain on natural resources, particularly in densely populated areas, which could lead to environmental degradation in the Chambal basin if not managed sustainably. The data underscores the necessity for equitable regional development that tackles educational disparities, gender equality, and sustainable land utilisation, particularly in environmentally fragile areas of the Chambal basin. Encroachment into ecologically sensitive areas, including riverbanks and ravines, has resulted in heightened soil erosion, habitat degradation, and conflicts with conservation goals (MoEFCC, 2020).

Table 12.1: Human population data of the Chambal River Basin (Source: Population Census, 2011)

State	District	Population	Population Density (persons/km²)	Sex Ratio	Literacy Rate (%)
Rajasthan	Bundi	11,10,906	192	925	61.52
	Chittorgarh	15,44,338	197	972	61.71
	Dholpur	12,06,516	398	846	69.08
	Jhalawar	14,11,129	227	946	61.5
	Karauli	14,58,248	264	861	66.22
	Kota	19,51,014	374	911	76.56
	Sawai Madhopur	13,35,551	297	897	65.39
Madhya Pradesh	Bhind	17,03,005	382	837	75.26
	Dhar	21,85,793	268	964	59
	Indore	32,76,697	841	928	80.87
	Mandsaur	13,40,411	242	963	71.78
	Morena	19,65,970	394	840	71.03
	Neemuch	8,26,067	194	954	70.8
	Ratlam	14,55,069	299	971	66.78
	Sheopur	6,87,861	104	901	57.43
	Ujjain	19,86,864	326	955	72.34
Uttar Pradesh	Agra	44,18,797	1,094	869	71.6
	Etawah	15,81,810	870	870	78.4

Figure 12.1: District-wise population density around the Chambal River

12.1.2 Urban and Rural Interface in Chambal River Basin

The demographic characteristics of districts next to the Chambal River exhibit a complex interaction of population growth, density, literacy rates, and gender distribution, influenced by both natural topography and socio-economic conditions. The Census of India (2011) indicates that districts like Agra (Uttar Pradesh) and Indore (Madhya Pradesh) demonstrate higher population densities of 1,093 and 839 persons/km², respectively, attributable to urbanisation and industrialisation. Conversely, Sheopur (Madhya Pradesh), has a population of merely 104 individuals/km², mainly owing to its rough ravine topography and inadequate infrastructure.

The literacy rates across these districts exhibit significant variation. Urban centres such as Indore (80.87%), Etawah (78.4%), and Kota (76.56%) exhibit high literacy rates, which correlate with superior educational resources and socio-economic advancement. Simultaneously, literacy rates are low in rural or ecologically vulnerable regions like Sheopur (57.43%) and Dhar (59%), underscoring educational inequities (Figure 12.2). The sex ratio throughout the basin is skewed, with districts such as Bhind (837) and Dholpur (846) exhibiting markedly imbalanced ratios, other districts like Chittorgarh (972) and Mandsaur (963) approximate national averages (Census of India, 2011).

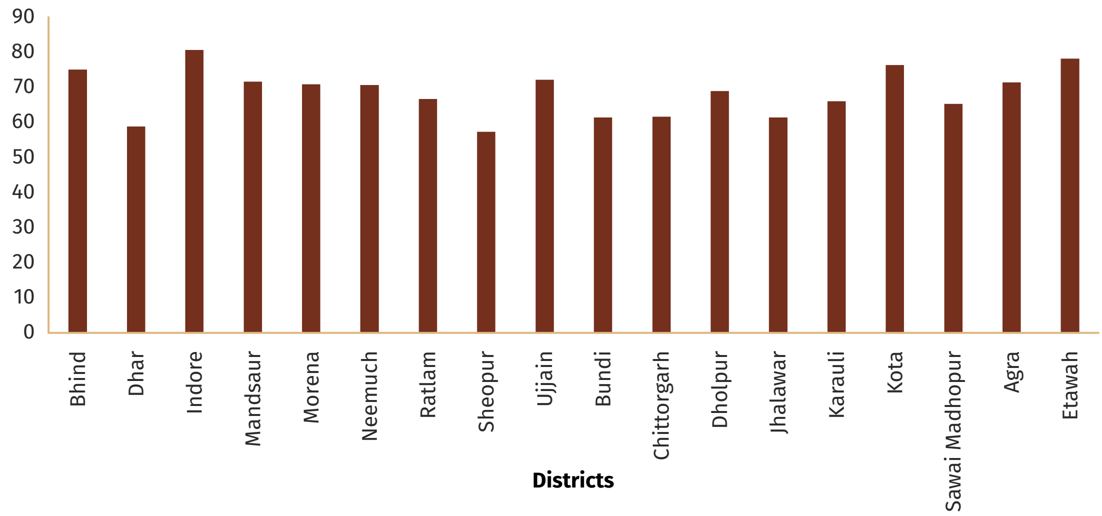


Figure 12.2: District-wise literacy rate of Chambal River Basin

The urban-rural interface along the Chambal River Basin signifies a dynamic socio-ecological transition zone, wherein traditional rural livelihoods persist and interact with escalating urban demands. The Chambal River flows through mainly rural areas, punctuated by significant urban centres such as Kota (Rajasthan), Indore (Madhya Pradesh), and Agra (Uttar Pradesh). These urban centres serve as economic and administrative hubs, exerting growing developmental impact on adjacent rural regions through infrastructural development, migration, and alterations in land use (Jain et al., 2012). Kota has experienced swift urbanisation driven by industrial development and its role as an educational hub, resulting in peri-urban sprawl along the Chambal riverbanks, frequently compromising agricultural and ecologically vulnerable areas.

In contrast, extensive areas of the Chambal basin, particularly in districts such as Sheopur, Karauli, and Dholpur, are predominantly rural, marked by low population densities, subsistence agriculture, and reliance on riverine resources for irrigation, potable water, and fishing. This interface has resulted in both possibilities and issues, including enhanced access to markets and services for rural populations, alongside escalating strain on water, land, and biodiversity owing to urban sprawl and resource extraction (CWC, 2015). Moreover, the ravine landscapes adjacent to the river function as buffer zones that have restricted urban encroachment in certain regions; nonetheless, they are currently being prioritised for afforestation, agricultural, and infrastructure development through various governmental initiatives (MoEFCC, 2020). Overseeing this interface is essential, as unregulated urban growth could compromise the ecological integrity of the Chambal River, while insufficient rural development may sustain poverty and resource dependency. Comprehensive planning that accounts for ecological sensitivity, demographic pressures, and land-use zoning is crucial for achieving sustainable cohabitation within this gradient.

12.1.3 Social, cultural, and economic significance of the Chambal River Basin

The Chambal River basin is socially, culturally, and economically important for the states of Rajasthan, Madhya Pradesh, and Uttar Pradesh. The River's name is synonymous with lawless and fearsome dacoits, unforgiving ravines, and a history as wild as its landscape. For decades, its rugged ravines served as a haven for bandits, or *dacoits*, who were often products of deep-rooted social injustices and caste-based discrimination. Figures like Phoolan Devi, Maan Singh, and Mohar Singh became legends, navigating the ravines with intimate knowledge of the landscape and evading police forces for years. While the presence of dacoits brought violence and fear to the region, it inadvertently led to the preservation of one of India's most pristine river ecosystems, the Chambal River. Due to the lawlessness and danger associated with the region, development activities remained minimal. Industrialization, urban encroachment, intensive agriculture, and large-scale infrastructure projects, which are significant threats to riverine ecosystems elsewhere, were largely absent in the Chambal River Basin for a very long time.

Despite its harsh landscape and historical ties to dacoity, the Chambal valley possesses cultural significance, as it is mentioned in the Mahabharata and is thought to have remained pristine due to a curse from Draupadi, which deters ritual bathing and thereby maintains its ecological integrity (Rao et al., 1995). According to another legend, King Rantideva performed a sacrifice, in which thousands of animals, including cows, were slaughtered and the resulting flow of blood turned into a River, *Charmanwati*. Unlike the Yamuna and the Ganga rivers, day to day and ceremonial rituals are practiced rarely on the ghats of the Chambal River. Although there are a few temples located along the Chambal, one particular temple complex of significance is the Bateshwar Temple Complex located in the Morena district of Madhya Pradesh. It is a group of about 200 ancient shrines built between the 8th and 10th centuries by the Gurjara kings (Khan et al., 2024).

Presently, the River serves as a vital resource for millions of rural residents, facilitating agriculture, cattle husbandry, and domestic water requirements in predominantly semi-arid areas. It also sustains agro-based industries, hydropower production, and fisheries, particularly in the downstream regions. The river irrigates lush plains via significant initiatives such as the Chambal Valley Project, encompassing the Gandhi Sagar, Rana Pratap Sagar, Jawahar Sagar, and Kota Barrage, collectively facilitating the irrigation of nearly 500,000 hectares across various districts (CWC, 2015). The Kota Super Thermal Power Plant in Rajasthan uses Chambal water for cooling, highlighting its industrial application (MoWR, 2020). Few large towns are situated along the Chambal, and as a result, the River has been spared the worst forms of pollution, like industrial effluents and urban sewage. The region is becoming a centre for ecotourism and wildlife tourism, especially near the National Chambal Sanctuary, which draws birdwatchers, researchers, and conservationists.

Nonetheless, the expansion of human settlements and alterations in land use, especially in ravines and floodplains, are exerting strain on the region's socio-ecological equilibrium (Jain et al., 2012). The Chambal River is a vital socio-economic foundation for central India, merging ecological significance with concrete livelihood advantages for adjacent inhabitants.

12.1.4 Global, National, and Regional Significance of Chambal River Basin

The Chambal River possesses substantial global, national, and regional importance, both biologically and hydrologically. The Chambal River is acknowledged for sustaining critically endangered species like the gharial (*Gavialis gangeticus*) and the Gangetic dolphin (*Platanista gangetica*), both of which are categorised in Appendix I of CITES and the IUCN Red List (IUCN, 2023). The National Chambal Sanctuary, a safeguarded segment of the River, is included on the Indicative World Heritage Site list under the UNESCO Natural Heritage category because of its distinctive biodiversity and ecological integrity (UNESCO WHC, 2022). It is recognized as an Important Bird Area (IBA) and also a proposed Ramsar site.

The River is essential to India's international obligations under the Convention on Biological Diversity (CBD) for the preservation of freshwater biodiversity. The Chambal River is a significant tributary of the Yamuna River, and consequently the Ganga Basin. The Chambal substantially enhances the water flow of the Yamuna, especially in arid seasons, hence aiding in the regulation of downstream hydrology (Jain et al., 2012). Additionally, the River

facilitates significant hydropower and irrigation initiatives, such as the Gandhi Sagar, Rana Pratap Sagar, and Jawahar Sagar dams, which enhance regional energy provision and agricultural output in Madhya Pradesh and Rajasthan (CWC, 2015). Historically notorious for dacoit activity, the Chambal River valley has recently emerged as a significant tourist and conservation hub, fostering sustainable development and bolstering local economies.

12.2 Drivers of Change: Natural and Anthropogenic Factors

12.2.1 Natural Drivers

The Chambal River is influenced by several natural factors that alter its hydrological regime and ecological characteristics. Climate variability is a crucial factor among these. Variations in monsoon patterns, temperature anomalies, and prolonged alterations in precipitation substantially influence the river's flow regime, silt load, and groundwater recharge. Research indicates that inter-annual and decadal fluctuations in monsoon precipitation directly affect the seasonal discharge of the Chambal River, resulting in episodic flooding or low-flow scenarios (Ghosh et al., 2010; Mishra et al., 2018). Furthermore, elevated temperatures and modified evapotranspiration rates due to climate change may intensify water stress in the basin, impacting both surface and subsurface water availability (Mall et al., 2006).

Geomorphological alterations are a significant natural factor affecting the dynamics of the Chambal River. The river traverses a semi-arid area marked by harsh topography, steep escarpments, and profound ravines, especially in the lower basin. Natural erosion processes, propelled by the river's hydraulic action and the weathering of soft alluvium and sandstone, perpetually reshape the riverbanks and valley floor (Sinha & Friend, 1994). These geomorphic processes lead to the creation of badlands, profoundly eroded gullies and ravines that modify surface runoff patterns and enhance sediment movement into the river, hence influencing its shape and water quality. Moreover, tectonic activity in the area, however minor, may cause alterations in river courses and affect drainage patterns across geological timeframes (Valdiya, 2001).

12.2.2 Human-Induced Drivers

The Chambal River, comparatively less impacted than other Indian rivers, has increasingly seen human-induced changes in recent decades. Significant infrastructures, like the Gandhi Sagar, Rana Pratap Sagar, and Jawahar Sagar dams, have profoundly modified the river's natural flow regime, disrupting sediment transport, altering aquatic habitats, and affecting downstream ecology (Ranga Reddy et al., 2001; Bhatt et al., 2012).

The proposed Parbati-Kali Sindh-Chambal link project and Eastern Rajasthan Canal Project will significantly alter the natural regimes of the Chambal basin and eastern Rajasthan, posing serious threats and challenges to ecological structure and socio-economic systems in the impacted areas.

The growth of agriculture and intensive irrigation methods in the Chambal basin further exacerbates environmental degradation. The excessive extraction of water for agriculture, particularly from tributaries and shallow aquifers, has resulted in diminishing groundwater levels and decreased base flows into the river during arid seasons (Sharma & Bharat, 2009). Moreover, the application of fertilisers and pesticides in agricultural areas leads to non-point source pollution, thereby impacting water quality and aquatic biodiversity. Singh et al. (2023) studied changes in shorelines and observed that erosion and accretion are more prevalent at the mined sites in comparison to unmined sites (Singh et al., 2023).

The Chambal region was historically marked by large ravines that fostered distinct habitats and contributed to the regulation of runoff and erosion. Recent initiatives to transform ravine areas into arable fields via levelling and afforestation under government-sponsored reclamation projects have modified the natural geomorphology and disturbed local hydrological processes (Thakur et al., 2012). Although these activities seek to enhance land productivity and mitigate erosion, they concurrently lead to habitat fragmentation and a decline in biodiversity. The extraction of sand from riverbeds for construction has surged, propelled by regional urbanisation and infrastructure development. This unsustainable activity undermines riverbanks, depletes water tables, and disrupts aquatic ecosystems, especially the breeding habitats of endangered species like the gharial and Gangetic dolphin (Nair et al., 2012; Hussain & Badola, 2010).

Local communities are perhaps the most immediately impacted stakeholders of the Chambal River. They use the river for different livelihood purposes, such as agriculture, fishing, and domestic supply. The health of the Chambal River has a direct influence on these communities, which means that their participation in decision-making is crucial to sustainable management. In summary, the Chambal River is experiencing increasing pressures from dam construction, agricultural intensification, land-use alterations, and water and sand extraction. These anthropogenic causes not only undermine the river's biological equilibrium but also jeopardise its reputation as one of the cleanest rivers in India, recognised for sustaining vital wildlife and biodiversity.

12.3 Approach used to Ensure Stakeholder Participation in the Chambal River Basin

To meet the twin goals of conservation of the riverine habitats and aquatic species, and enhancement of local communities' well-being, it is imperative to ensure their participation in conservation. Hence, the project has adopted a community based conservation paradigm, in which the riverine communities are not considered just

mere beneficiaries but co-managers and stewards of the Ganga River and its tributaries. Our approach consisted of the following five components, which are sequential yet overlapping:

12.3.1 Stakeholder identification and mobilization

A comprehensive list of stakeholders was prepared from all the states Chambal is flowing through. Stakeholders were categorized as Primary, Secondary, or Tertiary based on their functional mandates, and assessed using three key attributes: interest, power, and legitimacy. Using these three attributes, a comprehensive salience analysis was conducted to evaluate the role and influence of various stakeholders in the management and conservation of the Chambal River Basin (Figure 12.3).

Salience is the prioritization of stakeholders on the basis of their power, degree of moral legitimacy, and interest towards a claim on the resources of the Chambal River (Nastran, 2014). Scores were given to stakeholders for their level of power, legitimacy, and interest. The highest score was 3 for all the variables, while 1 was the lowest. Salience was calculated using the following formula for each stakeholder group:

$$D= \sqrt{(a^2+b^2+c^2)} \quad \text{...................... Equation (1)}$$

where D is salience, a is interest, b is power and c is legitimacy score (Figure 12.4)

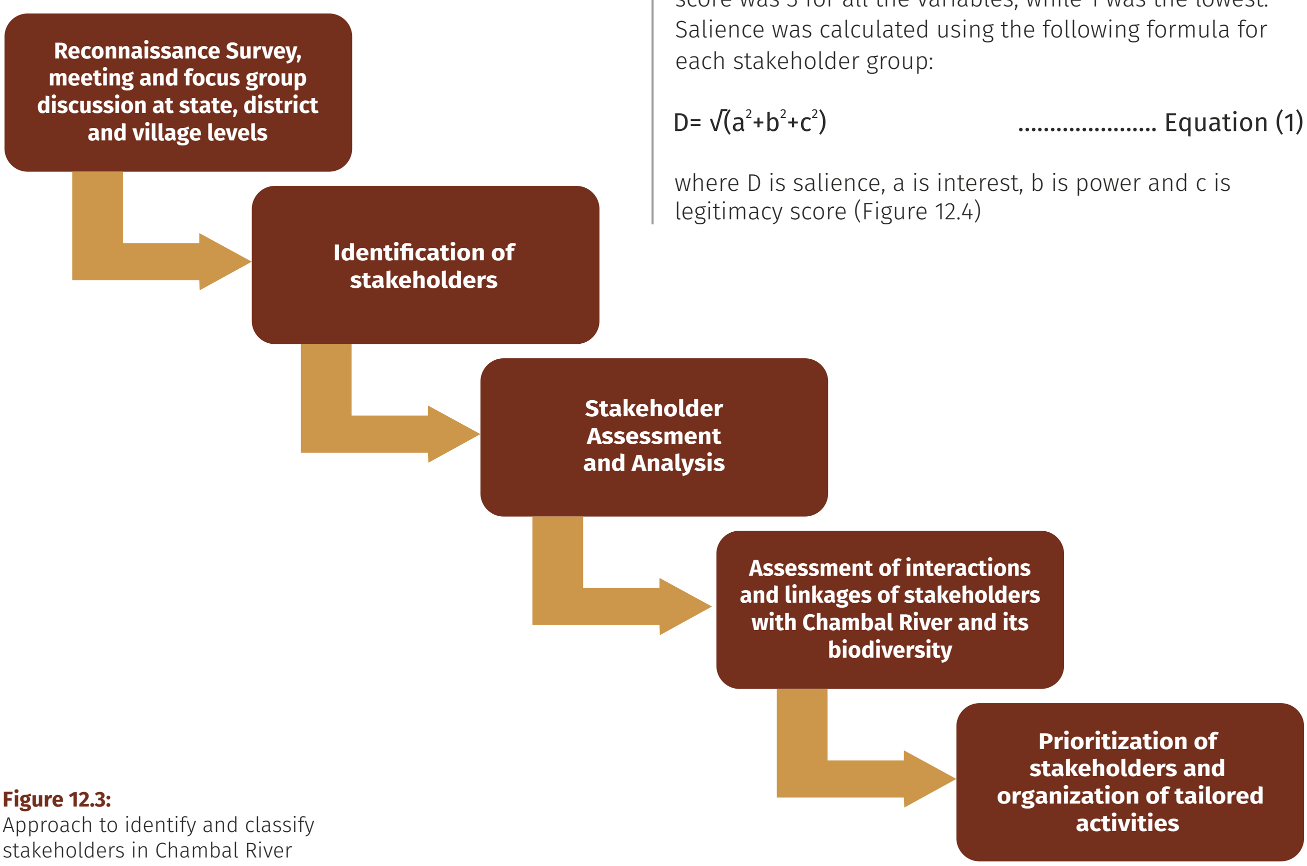


Figure 12.3:
Approach to identify and classify stakeholders in Chambal River

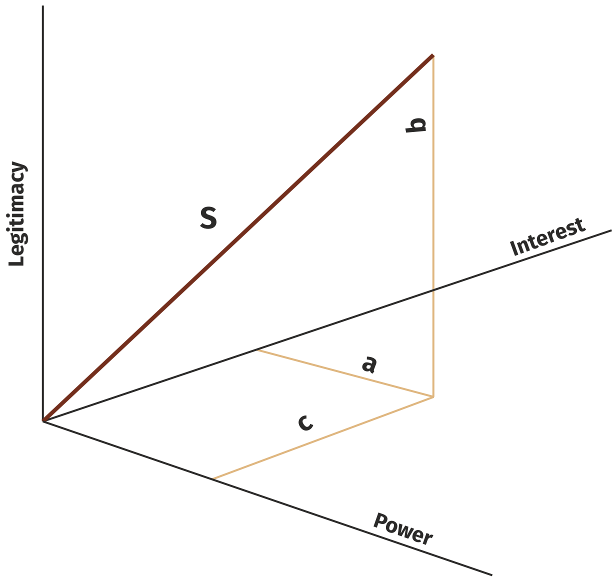


Figure 12.4: Approach to define salience of stakeholders (Nastran, 2014)

Following this, based on power, interest, and salience and our interaction with them, stakeholders were engaged through various specifically tailored activities. Awareness, sensitization, consultation, cultural activities, and workshops were aimed at the stakeholders with a developmental mandate, to mainstream conservation in their decision-making and planning. Activities like cleanliness, plantation, rescue and rehabilitation, ecological survey and monitoring involved interested volunteers from various stakeholders, especially local communities, in elicit actions for ensuring habitat restoration and conservation. The skills of these motivated and interested individuals were enhanced with regular capacity building and training workshops.

12.3.2 Understanding of social-ecological linkages in Chambal River Basin and its contribution to well-being

Through questionnaire survey and participatory mapping of ecosystem services, information on dependence of local communities on natural resources and ecosystem services of Chambal River Basin was collected. Representative villages for data collection were selected on the basis of the location of the villages, distance from river, demographic and socio-economic conditions of the villages and river stretch. Secondary data was collected from records and website of concerned departments to supplement the primary data. Households for sampling from these representative villages were randomly selected and minimum 10% of the population were targeted for the interviews.

Participatory mapping of ecosystem services was carried out to assess the grassroots level perceived dependency on the ecosystem services provided by rivers such as the biotic and abiotic resources, cultural and religious services, and dependence of agriculture, livestock and other village-level economic constituents upon the riverine resources. Villages were identified based on location and distance vis-à-vis natural and anthropogenic riverscape features, distance of village habitation from riverbank (at most 2 km from riverbank), and accessibility. Focus group discussions guided by a structured questionnaire were held in each village, wherein participants were asked to map the location and use of resources, as well as changes observed over time, including the causes. Representation from all village economic and social constituents was sought. Information not captured in maps was noted to make the mapping more contextual. A qualitative analysis of the collected data was conducted to identify the extent and trends in ecosystem service availability, drivers of change, and the impact of river development initiatives.

12.3.3 Institutionalization of community-based conservation through establishment of Ganga Prahari cadre

Following the identification and mobilization of stakeholders and assessment of their dependence on Chambal River, stakeholders especially local communities were mobilized to participate in the conservation actions. A platform was created known as Ganga Praharis to identify, register and train the interested individuals. No strict criteria were set for the selection of the Ganga Praharis, except for a drive and passion for river conservation. Site-level consultative meetings and workshops were held in select villages along the select rivers to identify Ganga Praharis (Gps). Recommendations from government departments and line agencies were also considered for potential GPs. Youth, women and social welfare groups like National Cadet Corps (NCC), National Service Scheme (NSS), Mahila Mangal Dal, Yuva Mangal Dal, Nehru Yuva Kendra Sangathan (NYKS) and Ganga Vichar Manch were also reached out to identify potential GP. Special attention was given to include women and other marginalized groups. The identified GPs were made familiar with the goals and objectives of GP programme through orientation workshops. Dedicated and thematic training workshops by NMCG-WII team made sure to improve the capacity of the GPs and keep them proactive. GPs were also involved in project activities and NMCG-WII team supported them in their initiatives, whenever possible. Through linkages with line agencies, government departments, NGOs and other organizations, opportunities to GPs were given to participate in relevant activities organized by other stakeholders and to build network (Figure 12.5).

Meeting and interactions with stakeholders (village, black and district level)

↓

Awareness and sensitization activities

↓

Identification of interested and enthusiastic individuals

↓

Assessment of understanding and knowledge regarding rivers and aquatic biodiversity

↓

Registration in Ganga Prahari cadre

↓

Orientation and trainings

Figure 12.5: Process followed to identify Ganga Praharis

12.3.4 Livelihood intervention to link livelihoods and conservation

To ensure the long-term association of Ganga Praharis to Chambal conservation and to link local livelihood issues with conservation concerns, economic incentives were introduced that make conservation a rational choice by through livelihood security and improving their capability. To identify potential themes for livelihood activities that are in tune with the local ecological and cultural settings, a need-based assessment was conducted to understand the views, needs and choices of local communities, and availability of raw material and market. Through consultative meetings and surveys, local livelihood related schemes, relevant governmental and private projects and trainers were identified in the area.

Liaising with concerned governmental departments and line agencies like state forest departments, department of rural development, block and district administration, National Rural Livelihood Mission (NRLM), NYKS, Pradhan Mantri Kaushal Vikas Yojna (PMKVY), Rural Self-employment Training Institute (RSETI), NGOs was done for collaboration in livelihood trainings and linking them with trained individuals and groups. In case of presence of established markets, market linkages were created through linkages and Jalaj initiative to ensure the sustainability of these initiatives after the training phase.

12.3.5 Microplanning for linking village development with river health

Strengthening of local institutions and decentralization of governance is the key to ensure long term success of participatory management of natural ecosystem and equitable sharing of benefits from local resources. A representative village level microplan has been developed to understand grassroots-level issues related to Chambal River biodiversity conservation and to identify practical solutions in consultation with the local community. To develop the microplan, a series of activities were undertaken in collaboration with the local community and other key stakeholders. Data was collected through a combination of participatory methods, including community meetings, stakeholder consultations, focus group discussions, and open-ended questionnaires, supplemented by various Participatory Rural Appraisal (PRA) techniques (Figure 12.6). This participatory and consultative process ensured that the microplan was tailored to the specific needs and challenges of the village, fostering community ownership and facilitating effective implementation.

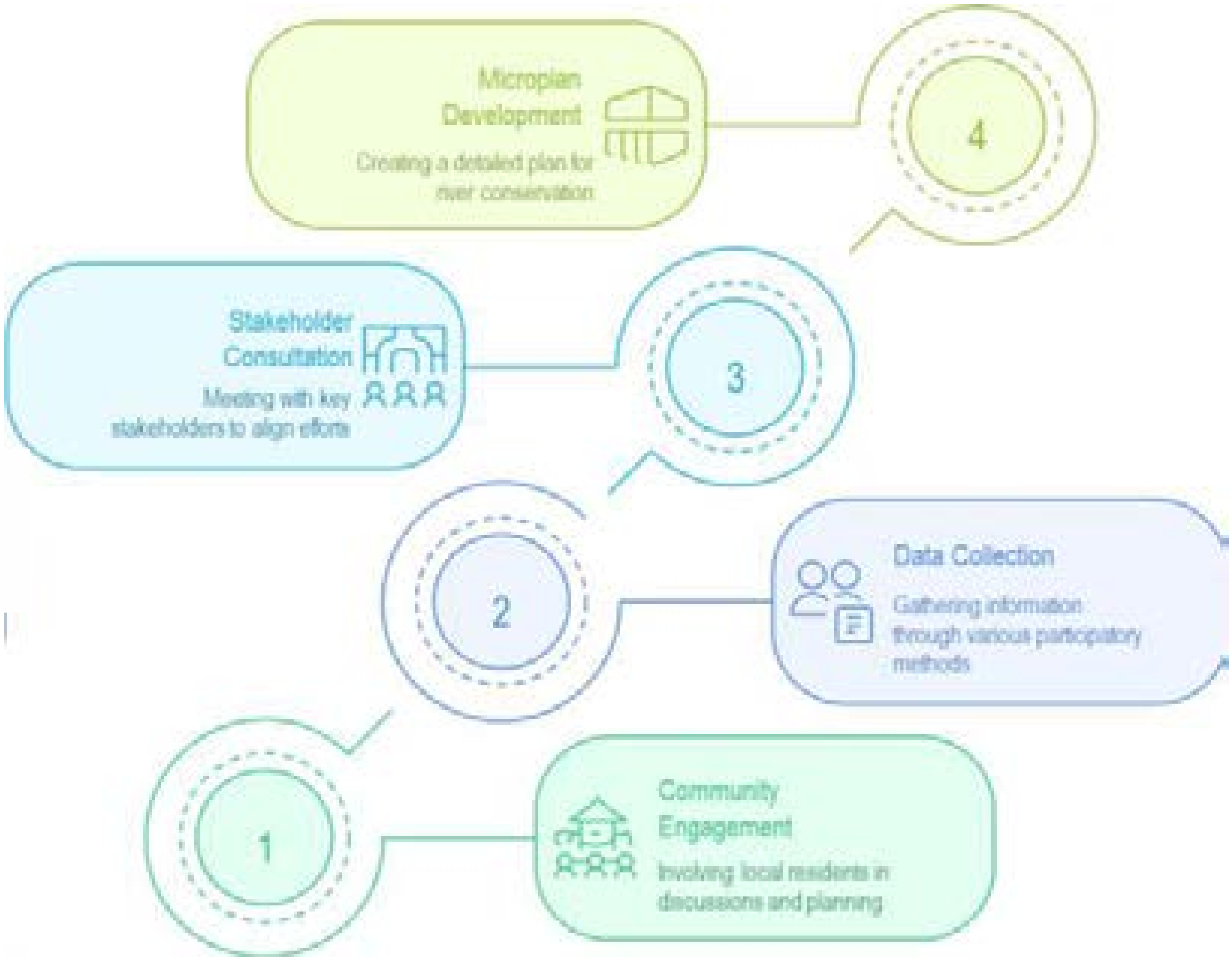


Figure 12.6: Approach for developing conservation sensitive village development planning

Following steps were followed in the microplanning process (Figure 12.7):

1. **Selection of village:** Village was selected based on the criteria of its location i.e., proximity to the river, biodiversity value and willingness of the community to participate in the program.
2. **Stakeholder engagement:** Prior to initiating microplanning activities, memorandums of agreement (MoAs) was signed with the Gram Pradhans (village heads) of Beelpur Panchayat, signifying their support and commitment to the project's implementation.
3. **Data collection:** Primary data was gathered using the participatory rural appraisal (PRA) approach. This included questionnaire surveys, stakeholder meetings, focus group discussions, transect walk, consultations and social mapping. These activities involved diverse community groups, such as Gram Panchayat and ward members, women's and youth groups, fishermen, farmers, and other stakeholders, including representatives from the forest department, rural development, and revenue departments. The collected information included village profiles, socio-economic and demographic data, and prevalent social-ecological challenges.
4. **Consultative meetings:** Meetings were held with Divisional Forest Officer, block development offices and various departments at the block and district levels to ensure a holistic design of the microplan.
5. **Biodiversity considerations:** Stakeholder consultations were conducted to assess the current status and identify threats to biodiversity. Drawing upon traditional and local knowledge, practical solutions were discussed and incorporated into the microplan. Subsequently, activities were prioritized, leading to the development of a comprehensive microplan.
6. **Approval:** A letter of consent was signed by the Gram Pradhan, indicating approval and support for the implementation of the finalized microplan.

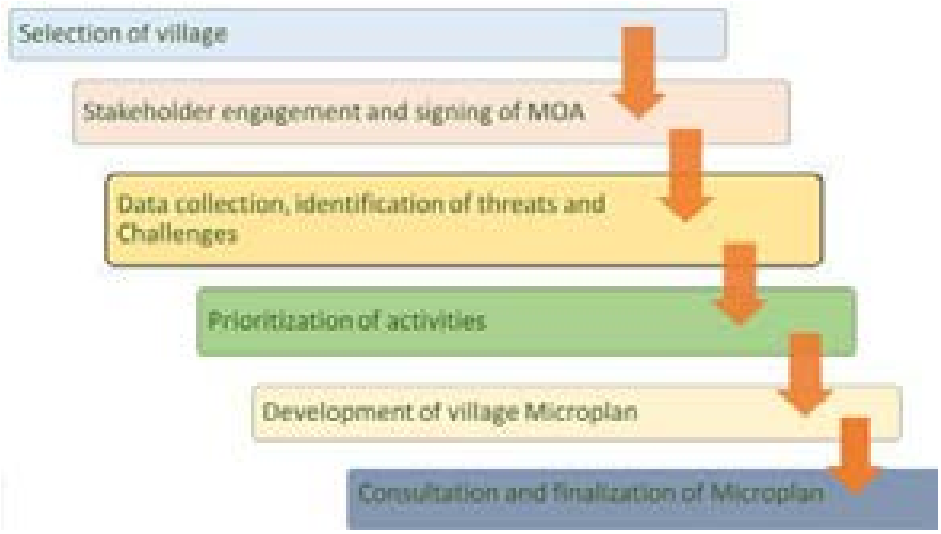


Figure 12.7: Steps followed in preparation of biodiversity sensitive village microplan

12.3.6 Policy gap analysis

The current study tries to facilitate sustainable decision-making and policy implementation by adopting a simplified approach (Figure 12.8). A critical analysis of the policies implemented under various programs in Chambal River Basin was undertaken to understand their efficiency, effectiveness and possible reasons for their limited success. The analysis included understanding needs, demands and viewpoints of multiple stakeholders, and developing and suggesting innovative strategic interventions for overcoming the identified limitations and gaps enable effective decision-making.

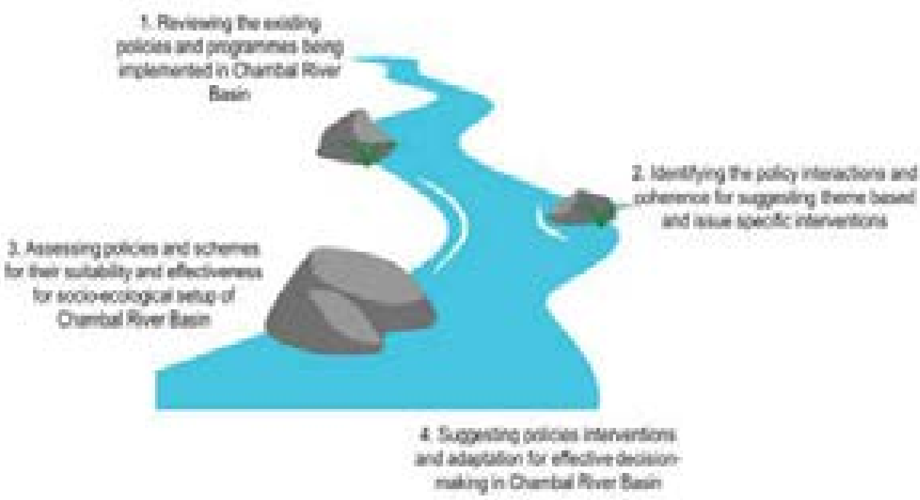


Figure 12.8: Approach adopted for analysis existing policies and schemes for their effectiveness in Chambal River Basin

12.4 Results

12.4.1 Stakeholders of Chambal River

Due to varying socio-cultural and economic background, and geographical conditions Chambal River has multiple stakeholders. A total of 36 stakeholder groups were identified in the three states based on their association with the river and its resources. Stakeholders were further divided into primary, secondary and tertiary classes based on level of interest, influence, and importance in decision making and implementation processes guiding integrated conservation planning. As all the states have their specific working and administration models, stakeholders were analysed for each state. In Madhya Pradesh, a total of 34 stakeholders has been identified, of which 19 are primary, and 11 and 04 stakeholders are secondary and tertiary, respectively (Table 12.2). In Rajasthan, a total of thirty stakeholders have been identified, of which eighteen are primary, seven and five groups of Stakeholders are secondary and tertiary, respectively. Among the highest-salience stakeholders (D = 5.20) are the Forest Department, District Ganga Committee, National Green Tribunal (NGT), Rajasthan Pollution Control Board (RPCB), National Mission for Clean Ganga (NMCG), and Ministry of Environment, Forest and Climate Change (MoEF&CC) (Table 12.3). In Uttar Pradesh, a total of thirty-six stakeholders has been identified, of which twenty-one are primary, and ten and five groups of Stakeholders are secondary and tertiary, respectively. Twelve stakeholder groups have high interest while seventeen have moderate and six groups have low interest (Table 12.4).

Table 12.2: The stakeholder attributes' estimates and their salience w.r.t. Chambal River in Madhya Pradesh

Sl. No.	Stakeholders	Type	Interest (a)	Power (b)
1	District Administration	Primary	2	3
2	Forest department	Primary	3	3
3	District Ganga committee	Primary	3	3
4	Nagar Nigam/Municipalities	Primary	2	2
5	Religious Groups	Primary	2	3
6	Village Panchayat	Primary	2	3
7	Nagar Panchayat	Primary	2	3
8	Fisheries Department	Primary	2	2
9	Agriculture Department	Primary	1	3
10	Department of Mines and Minerals	Primary	1	3
11	Local communities	Primary	3	1
12	Tourism Department	Primary	2	3
13	Irrigation Department	Primary	1	3
14	Department of water resources	Primary	3	3
15	National Green Tribunal	Primary	3	3
16	Madhya Pradesh Pollution control Board	Primary	3	3
17	Bansagar Control Board	Primary	1	3
18	NGOs (WWF, BCRF etc)	Primary	3	2
19	Local Institutions	Primary	2	3
20	Central Ground Water Board	Secondary	2	2
21	Central water commission	Secondary	2	2
22	Educational/Research Institutes	Secondary	3	2
23	Public Health Engineering Department	Secondary	2	3
24	Armed forces	Secondary	2	2
25	Training institutions	Secondary	2	2
26	Department of Rural Development	Secondary	1	1
27	State Disaster Management Authority (MP-SDMA)	Secondary	2	3
28	SRLM	Secondary	2	2
29	Asian Development Bank	Secondary	2	1
30	Major Industries (Orient Paper mill etc)	Secondary	1	2
31	MoEF&CC	Tertiary	3	3
32	NMCG	Tertiary	3	3
33	Media	Tertiary	2	3
34	Ministry of Jal Shakti	Tertiary	2	2

Legitimacy	Legitimacy score (c)	Impact	Position	Salience D= √(a²+b²+c²)
Yes	3	2	+/-	4.69
Yes	3	3	+	5.20
Yes	3	2	+	5.20
Yes	3	2	+/-	4.12
Yes/no	2	2	+/-	4.12
Yes/no	2	3	+/-	4.12
Yes/no	2	3	+/-	4.12
Yes	3	3	+/-	4.12
Yes/no	2	2	+/-	3.74
Yes	2	2	-	3.74
Yes	3	3	+/-	4.36
Yes/no	2	2	+/-	4.12
Yes/no	2	2	-	3.74
Yes	3	3	+	5.20
Yes	3	3	+	5.20
Yes	3	3	+	5.20
Yes	2	2	-	3.74
Yes/No	2	3	+	4.12
Yes/no	2	2	+/-	4.12
Yes	3	3	+	4.12
Yes/No	2	2	+	3.46
Yes	3	3	+	4.69
Yes/No	2	3	+	4.12
Yes	2	3	+	3.46
Yes	2	3	+	3.46
Yes	3	3	+	3.32
Yes	3	2	+	4.69
Yes/no	2	2	+/-	3.46
Yes/No	2	2	+/-	3.00
No	1	1	-	2.45
Yes	3	3	+	5.20
Yes	3	2	+	5.20
No	1	2	+	3.74
Yes/No	2	2	+/-	3.46

Table 12.3: The stakeholder attributes' estimates and their salience w.r.t. Chambal River in Rajasthan

Sl. No.	Stakeholders	Type	Interest (a)	Power (b)
1	District Administration	Primary	2	3
2	Forest department	Primary	3	3
3	District Ganga committee	Primary	3	3
4	NGOs	Primary	3	1
5	Religious Groups	Primary	2	1
6	Village Panchayat	Primary	2	3
7	Nagar Panchayat	Primary	2	3
8	Fisheries Department	Primary	2	2
9	Agriculture Department	Primary	1	3
10	Mining Department	Primary	1	2
11	Local communities	Primary	2	1
12	Tourism Department	Primary	2	2
13	Irrigation Department	Primary	1	3
14	National Green Tribunal	Primary	3	3
15	Rajasthan Pollution control Board	Primary	3	3
16	Department of water resources	Primary	2	3
17	Local Institutions	Primary	2	1
18	Nagar Nigam/Municipalities	Primary	2	2
19	Educational/Research Institutes	Secondary	3	1
20	Armed forces	Secondary	2	2
21	Training institutions	Secondary	2	2
22	Department of Rural Development	Secondary	2	3
23	SRLM	Secondary	2	1
24	State Disaster Management Authority	Secondary	2	2
25	Urban Development & Housing Department	Secondary	2	2
26	MoEF&CC	Tertiary	3	3
27	Media	Tertiary	2	3
28	SMCG	Tertiary	3	2
29	NMCG	Tertiary	3	3
30	Ministry of Jal Shakti	Tertiary	2	2

Legitimacy	Legitimacy score (c)	Impact	Position	Salience D= √(a²+b²+c²)
Yes	3	2	+/-	4.69
Yes	3	3	+	5.20
Yes	3	2	+	5.20
Yes/No	2	2	+	3.74
Yes/No	2	2	+/-	3.00
Yes/no	2	3	+/-	4.12
Yes/no	2	3	+/-	4.12
Yes	3	3	+/-	4.12
Yes/no	2	2	+/-	3.74
Yes	2	2	+/-	3.00
Yes	2	2	+/-	3.00
Yes/No	2	2	+/-	3.46
Yes/No	2	3	+/-	3.74
Yes	3	3	+	5.20
Yes	3	2	+	5.20
Yes	3	2	+/-	4.69
Yes	2	2	+/-	3.00
Yes	3	2	+/-	4.12
Yes	2	2	+	3.74
Yes	3	2	+/-	4.12
Yes	2	3	+	3.46
Yes/No	2	2	+/-	4.12
Yes/No	2	1	+/-	3.00
Yes/no	2	2	+/-	3.46
Yes/No	2	2	+/-	3.46
Yes	3	3	+	5.20
No	1	2	+	3.74
Yes	3	2	+	4.69
Yes	3	2	+	5.20
Yes/No	2	2	+/-	3.46

Table 12.4: The stakeholder attributes' estimates and their salience w.r.t. Chambal River in Uttar Pradesh

Sl. No.	Stakeholders	Type	Interest (a)	Power (b)
1	District Administration	Primary	2	3
2	Forest department	Primary	3	3
3	District Ganga committee	Primary	3	3
4	Nagar Nigam/Municipalities	Primary	2	2
5	Religious Groups	Primary	2	3
6	Village Panchayat	Primary	2	3
7	Nagar Panchayat	Primary	2	3
8	Fisheries Department	Primary	2	2
9	Agriculture Department	Primary	1	3
10	Directorate of Geology & Mining	Primary	1	3
11	Local communities	Primary	3	1
12	Tourism Department	Primary	1	3
13	Irrigation Department	Primary	1	3
14	National Green Tribunal	Primary	3	3
15	Uttar Pradesh Pollution control Board	Primary	3	3
16	Department of water resources, river development	Primary	3	3
17	SWaRA (State Water resource agency)	Primary	2	2
18	National Water Development agency	Primary	2	3
19	Water Resources Operation and Planning Systems	Primary	3	3
20	Uttar Pradesh Water Management & Regulatory Commission (UPWaMReC)	Primary	3	3
21	Local Institutions	Primary	2	3
22	Central Ground Water Board	Secondary	2	2
23	Central water commission	Secondary	2	2
24	Educational/Research Institutes	Secondary	3	2
25	Chambal Dolphin Mitras	Secondary	3	2
26	Armed forces	Secondary	2	2
27	Training institutions	Secondary	2	2
28	Department of Rural Development	Secondary	1	1
29	SMCG-UP	Secondary	3	2
30	SRLM	Secondary	2	2
31	State Disaster Management Authority	Secondary	2	2
32	NMCG	Tertiary	3	3
33	MoEF&CC	Tertiary	3	3
34	Major Industries (Cement, Steel, Chemical etc)	Tertiary	1	2
35	Media	Tertiary	2	3
36	Ministry of Jal Shakti	Tertiary	2	2

Legitimacy	Legitimacy score (c)	Impact	Position	Salience D= $\sqrt{(a^2+b^2+c^2)}$
Yes	3	2	+/-	4.69
Yes	3	3	+	5.20
Yes	3	2	+	5.20
Yes	3	2	+/-	4.12
Yes/no	2	2	+/-	4.12
Yes/no	2	3	+/-	4.12
Yes/no	2	3	+/-	4.12
Yes	3	3	+/-	4.12
Yes/no	2	2	+/-	3.74
Yes	2	3	-	3.74
Yes	3	3	+/-	4.36
Yes/no	2	3	+/-	3.74
Yes/no	2	2	-	3.74
Yes	3	3	+	5.20
Yes	3	3	+	5.20
Yes	3	3	+	5.20
Yes/no	2	2	+/-	3.46
Yes/no	2	2	-	4.12
Yes/no	2	2	+	4.69
Yes/no	2	2	+	4.69
Yes/no	2	2	+/-	4.12
Yes	3	3	+	4.12
Yes/No	2	2	+	3.46
Yes	3	3	+	4.69
Yes	3	3	+	4.69
Yes	2	2	+	3.46
Yes	2	3	+	3.46
Yes	3	2	+	3.32
Yes	3	2	+	4.69
Yes/no	2	2	+/-	3.46
Yes/no	2	2	+/-	3.46
Yes	3	2	+	5.20
Yes	3	3	+	5.20
Yes/no	2	1	-	3.00
No	1	2	+	3.74
Yes/No	2	2	+/-	3.46

12.4.2 Conservation activities conducted with stakeholders in Chambal River Basin

A total of 64 activities were conducted in the three states of which 14 were awareness programmes activities, 27 were consultative meetings, followed by 10 participatory mapping activities, amongst many others. A total of 1269 participants from different stakeholder groups were sensitized about the aquatic flora and fauna of the Chambal River, the issues faced by the river and the steps that can be taken to conserve the river and its biodiversity. Maximum participation was observed in awareness programmes, followed by consultative meetings and participatory mapping activities (Table 12.5). From the overall participants engaged in Chambal conservation activities in all three Chambal states, 45.07% participants belong to local communities of the targeted areas followed by educational institutions, Bal Ganga Praharis and Ganga Praharis at 12.77%, 18.29 % and 8.9%, respectively (Table 12.6).

The project involves a wide range of stakeholders at various levels- from grassroot to national. Local communities (n= 396) along with Bal Ganga Praharis (n= 232) and Ganga Praharis (n= 113) were actively engaged by WII-NMCG team in various conservation activities. Among government entities, State Forest Department (n = 68) was actively engaged. Significant involvement was also observed from educational institutions (n = 251), comprising students, faculty, and institutional staff from universities, colleges, and schools and Bal Ganga Praharis (n= 232) (Table 12.7). This multi-level institutional participation ensured vertical integration across decision-making structures and operationalised convergence between policy-level planning and site-specific execution of conservation activities. This added significantly to effective implementation of the project and its sustainable legacy of increased local capacity in generating livelihood opportunities, contributing in conservation projects and human well-being.

Table 12.5: Conservation activities conducted with stakeholders along Chambal River

Type of Activities	No. of Activities	No. of Participants
Awareness and Sensitization Activities	14	594
Cleanliness Drives	1	20
Consultative Meetings	27	127
Orientation and Training Workshops	4	116
Others	1	37
Participatory Mapping Activities	10	146
Sensitization Workshops	3	38
Socio-economic Survey	3	93
Special Occasions and Days celebration	1	98
Total	64	1269

Table 12.6: State wise conservation activities conducted along Chambal River

State	Awareness & Sensitization Activities	Cleanliness Drives	Consultative Meetings	Orientation & Training Workshops	Participatory Mapping Activities	Sensitization Workshops	Socio-economic Survey	Special Occasions & Days celebration	Others	Total
Madhya Pradesh	0	0	81	116	75	0	0	0	0	272
Rajasthan	194	20	27	0	56	0	0	0	37	334
Uttar Pradesh	400	0	19	0	15	38	93	98	0	663
Total	594	20	127	116	146	38	93	98	37	1269
%	46.81	1.58	10.01	9.14	11.51	2.99	7.33	7.72	2.92	100.00

Table 12.7: Stakeholder-wise participation in conservation-related activities conducted in three Chambal states

State	Bal Ganga Praharis	Ganga Praharis	Media	Inline Agencies	Block Administration	Educational Institutions	Local Communities	Forest Department	Panchayati Raj	Total Participants
Madhya Pradesh	0	0	81	116	75	0	0	0	0	272
Rajasthan	194	20	27	0	56	0	0	0	37	334
Uttar Pradesh	400	0	19	0	15	38	93	98	0	663
Total	594	20	127	116	146	38	93	98	37	1269
%	46.81	1.58	10.01	9.14	11.51	2.99	7.33	7.72	2.92	100.00

12.4.3 Socio-ecological interlinkages and riverine resource dependence

The Chambal River is essential for the agricultural and economic stability of districts in Rajasthan, Madhya Pradesh, and Uttar Pradesh. It supports the ravine ecology a distinctive geomorphological characteristic of north-central India, and is essential for groundwater recharge, sediment transport, and climate regulation in the semi-arid regions it crosses (Rao et al., 1995). The Chambal ravines serve as carbon sinks (Jat et al., 2022). The Chambal's comparatively unspoiled state relative to other Indian rivers establishes it as a standard for freshwater conservation and river management methods in India.

The Chambal River sustains a population over 15 million within its basin (CWC, 2015). The sustenance of local people in this semi-arid region is closely connected to the river's seasonal flow and ecological functions. The river and its tributaries are a key source for water for drinking and other domestic use and also providing irrigation services to the agriculture sector, particularly via the Chambal Valley Project, which has cultivated more than 566,000 hectares of irrigated land (WRD-MP, 2018). Non-agricultural activities, including livestock grazing and fuelwood collecting from riparian forests, augment household income, especially for Scheduled Tribes and landless labourers, who constitute a substantial segment of the Chambal population (Rathore & Dubey, 2020).

Overall, 22 key ecosystem services were identified in Chambal River Basin-12 provisioning services, six regulating and supporting services, and four cultural services. The extent of all these services was high along the river, except water purification and waste management, and heritage sites, which was medium, and water for industry, thermal power generation and transportation, and religious/spiritual value, which was low. A total of 10 villages were surveyed along the Chambal River, spanning 9 districts and three states viz., Madhya Pradesh (n=5), Rajasthan (n=4) and Uttar Pradesh (n=1). A total of 146 individuals participated in the mapping, of which 106 were males and 40 were females. Keeping the riverside communities in mind, 16 key ecosystem services were identified and assessed, viz. consumptive use of surface water and groundwater for drinking, domestic use, irrigation and livestock, biotic (fishing, fuelwood, NTFPs, grazing and fodder) and abiotic (sandmining) resource extraction, sewage disposal, soil fertility, provision of habitat for biodiversity, and cultural services like religious value and tourism.

The Chambal River plays a critical role in sustaining both ecological integrity and human well-being across its basin. It provides essential provisioning services, including drinking water and irrigation. Urban areas such as Kota and Dholpur rely on surface water, while rural populations predominantly depend on groundwater extracted via tube wells, handpumps, and traditional wells. Irrigation is facilitated through a combination of surface water (via lift and canal systems) and groundwater, supporting year-round cultivation of diverse kharif and rabi crops. However, proposed inter-basin water transfer projects and increasing groundwater dependency threaten to exacerbate river flow reduction and aquifer stress. The river corridor supports livestock rearing through access to water and grazing lands in ravines, though conservation-related restrictions have intensified human-wildlife conflict, particularly involving crocodilian species. Biotic resource use, including fishing and the extraction of fuelwood and fodder, remains locally significant but is increasingly constrained by pollution, vegetation loss, and restricted access. Illicit sand mining persists outside protected areas, degrading riverine habitats and disrupting community use. The river provides important regulating and supporting services, such as rich biodiversity, hosting endangered species like the Gangetic dolphin and gharial, and enhancing soil fertility through seasonal sediment deposition. However, altered flow regimes and agrochemical runoff are undermining these functions. Waste disposal into the river and village ponds further deteriorates water and soil quality. Culturally, the Chambal is rooted in regional mythology and heritage, supporting tourism, and heritage site conservation. Major religious sites, prehistoric rock art, and historical settlements enhance its cultural value, and community-led tourism initiatives have emerged along its course. Nonetheless, unregulated tourism growth, lacking adequate infrastructure and waste management, presents new environmental challenges.

12.4.3.1 Dependence for Agriculture

Agriculture forms the backbone of the local economy in the Chambal basin. The cropping pattern varies from district to district. Soyabean, jowar, gram, wheat and fodder crops are common crops grown in the area. Soyabean is the predominant crop covering about 30.5% of the net area sown, followed by Wheat and Gram crops covering 15.3% and 13% respectively of the net area sown (NWDA, 2024). The river provides essential irrigation, especially in areas where rainfall is erratic. Cultivation is mainly dependent upon rainfed tanks, open wells, bore wells and Nallas during Kharif. The tanks and nallas almost get dried up during summer. Hence, agriculture activities in the Rabi season are limited. Wheat, mustard, and gram flourish during the rabi season owing to reliable water discharges from the Gandhi Sagar, Rana Pratap Sagar, and Jawahar Sagar dams (Sharma & Singh, 2018). Nonetheless, diminishing flow variability resulting from upstream abstraction and unpredictable monsoons has adversely affected agricultural reliability in recent years.

Reclamation projects involving anicuts, vegetative barriers, and afforestation have shown positive results (Singh et al., 2012, Singh et al., 2018). Studies report a 156% increase in household income and improved employment in villages where ravine management was successfully implemented (Singh et al., 2018). The basin supports a dual-cropping system, due to the immense availability of irrigation water from the Chambal River and its associated distributaries. This cropping pattern reflects the agrarian dependence of the population on the seasonal flow and controlled releases from the Chambal irrigation network. Canal irrigation plays a pivotal role in sustaining both Kharif and Rabi crops. The Kota Barrage, in particular, provides regulated water releases to multiple downstream districts in Rajasthan and Madhya Pradesh. The Warabandi system, intended to ensure time-based water allocation to all farmers, often breaks down in practice, particularly in the tail-end areas where marginal farmers face significant water stress (Sisodia, 1992). The population of the Chambal basin is overwhelmingly rural and dependent on subsistence and market-oriented farming. Irrigation enables diversification into high-value crops like mustard, soyabean, and vegetables. At the same time, institutional challenges, such as underperforming Water User Associations (WUAs), limited farmer education, and poor canal maintenance restrict long-term sustainability. Efforts to promote participatory irrigation management, agroforestry on ravine margins, and crop diversification through watershed programs have been initiated but require scaling and policy support.

12.4.3.2 Dependence for Fishing

Fishing is a significant livelihood activity for riverine communities in the Chambal River Basin, across the states of Madhya Pradesh, Rajasthan, and Uttar Pradesh. The Chambal River, supports a rich diversity of freshwater fish species, contributing substantially to both local sustenance and regional fish production. The river supports more than 90 fish species, including commercially significant kinds such as Rohu, Catla, and Mrigal (CIFRI, 2017). The reliance on fish production from Chambal River basin is highest in Uttar Pradesh, which is also among the highest inland fish-producing states in India (DoF, 2023) (Figure 12.9). Madhya Pradesh and Rajasthan, though less productive by volume, sustain a large fishing community, often engaged in small-scale fishing activities. Fisheries provide direct employment and food security for numerous communities, especially in the Chambal's riparian districts. Fishing in this region is traditionally carried out by marginalized and indigenous communities using indigenous knowledge systems. However, this livelihood is under threat from several anthropogenic stressors, including dam construction, habitat fragmentation, pollution, overfishing, and fluctuating water regimes due to climate variability (Bose et al., 2019).

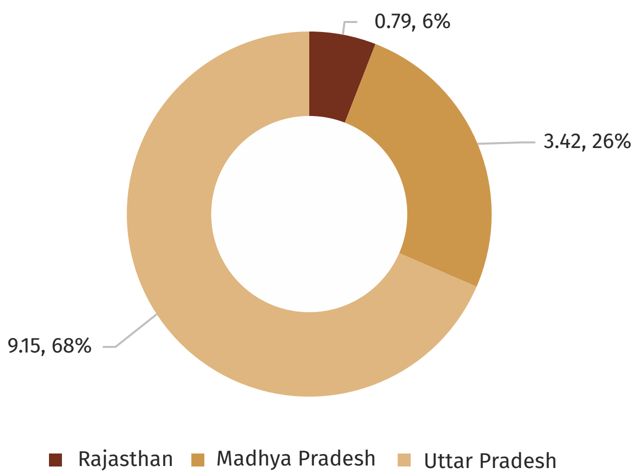


Figure 12.9: Annual inland fish-production (Lakh Tonnes) in Chambal River Basin in 2022-23 (Source: DoF, 2023)

12.4.3.3 Dependency on Water Infrastructure Projects in the Chambal River Basin

The Chambal River occupies a distinctive position within India's cultural and ecological landscape. Unlike the Ganga and Yamuna, which command pan-Indian religious reverence, the Chambal's identity is regionally rooted in mythology and historical memory. Historically known as Charmanwati, it is referenced in the Mahabharata, where Draupadi's curse-following the dice game between the Pandavas and Kauravas-led to its popular characterization as a "cursed river." The text also links its origin to animal sacrifices by King Rantideva. Despite limited mainstream ritual prominence, the riverbanks serve as cremation sites, and contemporary reverence is reflected in the 42.5-metre Chambal Mata statue at Kota Riverfront. Religious sites such as the Keshav Rai Temple (Keshoraipatan) and the Pachnada confluence reinforce its regional sacred geography.

Ecologically, the river supports significant conservation landscapes, including the National Chambal Sanctuary-India's first riverine protected area-the Mukundara Hills National Park, and major reservoirs formed by the Gandhi Sagar Dam, Rana Pratap Sagar Dam, and Jawahar Sagar Dam. These areas enable eco-tourism, wildlife observation, and community-led tourism initiatives. The river's badland topography and cinematic portrayal in Sholay and Bandit Queen further enhance tourism appeal. However, unregulated tourism, inadequate waste management, and weak visitor infrastructure pose ecological risks, necessitating community-based governance and environmentally sensitive planning to align tourism growth with long-term conservation objectives.

The Chambal River is extensively harnessed through multiple water infrastructure projects that significantly influence regional development and human livelihoods. Stretching across Madhya Pradesh, Rajasthan, and bordering Uttar Pradesh, the river serves as a vital source for hydropower generation, irrigation, and drinking water supply, forming a critical foundation for socio-economic sustenance in the basin (Table 12.8). The construction and operation of these water infrastructure projects have a multifaceted impact on local populations. They not only provide direct employment during construction and maintenance but also enable secondary livelihoods through agriculture, agro-industries, and electricity-based services. These benefits, however, are not without trade-offs, such as displacement or ecological alterations. Yet, for millions, these projects form the backbone of survival, particularly in water-stressed districts like Sheopur, Dholpur, and Morena, where Chambal waters transform arid lands into fertile plains.

Table 12.8: Types of Chambal River Projects and the purpose of the dependency

State	Chambal River Project	Type	Status	Purpose
Madhya Pradesh	Gandhi Sagar Dam	Dam	Operating	Hydropower, Storage
	Kanera Lift Irrigation	Lift	Proposed	Irrigation
Madhya Pradesh -Rajasthan	Parbati-Kalisindh-Chambal link Project	Canal	Proposed	Irrigation
Rajasthan	Rana Pratap Sagar Dam	Dam	Operating	Hydropower, Storage
	Jawahar Sagar Dam	Dam	Operating	Hydropower
	Kota Barrage	Barrage	Operating	Irrigation
	Mangrol Mini Hydel Power Station	Dam on canal	Operating	Hydropower
	Dholpur Lift Irrigation	Lift	Operating	Irrigation
	Dholpur City Drinking Water	Lift	Operating	Drinking
	Pinahat Lift Irrigation	Lift	Operating	Irrigation
	Aisha Lift Irrigation	Lift	Proposed	Irrigation

Hydropower Generation

One of the most prominent uses of the Chambal River is for hydropower production. The Gandhi Sagar Dam, Rana Pratap Sagar Dam, and Jawahar Sagar Dam, strategically constructed along the river in Madhya Pradesh and Rajasthan, collectively contribute a substantial share of renewable electricity to the grid. These projects form the core of the Chambal Valley Project, one of India's earliest major multi-purpose river valley initiatives launched post-independence. Each of these dams houses hydroelectric power stations and collectively generate 386 MW of electricity (CWC, 2015). In addition, Mangrol Mini Hydel Power Station, a smaller-scale project in Rajasthan located on a canal, also harnesses the flow of the river for localized power needs. Such hydropower generation not only supports rural electrification and industrial operations but also reduces dependency on fossil fuels, thus contributing to regional energy security (NWDA, 2024).

Irrigation

Irrigation is a core function of Chambal River projects, especially via the Kota Barrage, which supports agriculture in Rajasthan and Madhya Pradesh. The barrage enables the irrigation of 5668.01 square kilometers (566,801 hectares) through its left and right main canals (IWAI, 2017). These canals nourish some of the most agriculturally productive districts in the basin, such as Kota, Bundi, and Jhalawar, where crops like wheat, mustard, rice, and pulses dominate both the kharif and rabi seasons (Department of Agriculture & Farmers Welfare, 2024). Further, lift irrigation schemes such as the Dholpur Lift Irrigation, Pinahat, and Aisha projects are essential in semi-arid and elevated regions, allowing water to reach otherwise inaccessible fields. Proposed schemes like the Kanera Lift Irrigation and the inter-basin Parbati-Kalisindh-Chambal Link Canal project promise to further expand irrigation command areas, potentially increasing crop intensity and food security in water-deficient regions of Rajasthan and Madhya Pradesh (NWDA, 2024).

In Madhya Pradesh, districts like Ujjain (net: 506,070 ha; gross: 512,580 ha) and Dhar (net: 448,153 ha; gross: 547,742 ha) stand out with the largest irrigation footprints. In Rajasthan, Kota (net: 269,698 ha; gross: 303,092 ha) and Jhalawar (net: 331,354 ha; gross: 352,706 ha) exhibit significant irrigation due to the presence of major infrastructure like the Kota Barrage (DESAGRI ,2024). Similarly, Agra and Etawah in Uttar Pradesh depend extensively on irrigation, with Etawah recording a gross irrigated area of 207,183 ha (Figure 12.10). The high values of gross irrigated areas across the region indicate the prevalence of multi-cropping systems supported by the Chambal River and its canal networks, especially in districts under the Chambal Valley Project (Department of Agriculture & Farmers Welfare, 2024).

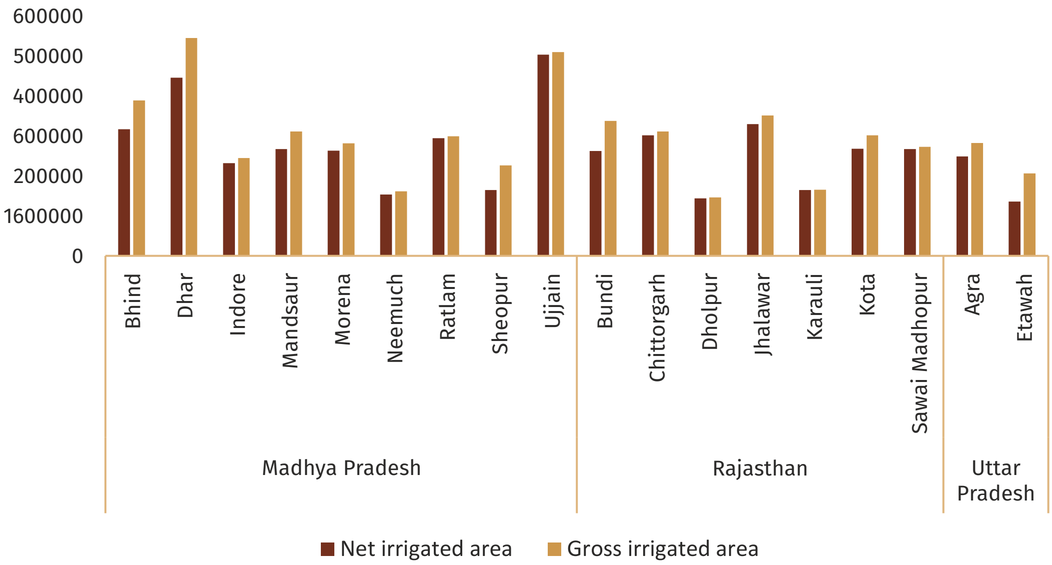


Figure 12.10: District-wise Net and Gross irrigated area of Chambal River Basin (Data Source: DESAGRI, 2024)

Drinking Water Supply

Apart from irrigation and energy, the Chambal also provides essential drinking water, especially in regions like Dholpur city, where a dedicated lift irrigation cum drinking water scheme is in operation. This is particularly vital in arid parts of eastern Rajasthan, where alternative freshwater sources are limited due to saline groundwater or seasonal rainfall variability (Table 12.8).

12.4.3.4 Recreational and Ecotourism Dependency on the Chambal River Basin

The Chambal River occupies a distinctive position within India's cultural and ecological landscape. Unlike the Ganga and Yamuna, which command pan-Indian religious reverence, the Chambal's identity is regionally rooted in mythology and historical memory. Historically known as Charmanwati, it is referenced in the Mahabharata, where Draupadi's curse—following the dice game between the Pandavas and Kauravas—led to its popular characterization as a "cursed river." The text also links its origin to animal sacrifices by King Rantideva. Despite limited mainstream ritual prominence, the riverbanks serve as cremation sites, and contemporary reverence is reflected in the 42.5-metre Chambal Mata statue at Kota Riverfront. Religious sites such as the Keshav Rai Temple (Keshoraipatan) and the Pachnada confluence reinforce its regional sacred geography.

Ecologically, the river supports significant conservation landscapes, including the National Chambal Sanctuary—India's first riverine protected area—the Mukundara Hills National Park, and major reservoirs formed by the Gandhi Sagar Dam, Rana Pratap Sagar Dam, and Jawahar Sagar Dam. These areas enable eco-tourism, wildlife observation, and community-led tourism initiatives. The river's badland topography and cinematic portrayal in Sholay and Bandit Queen further enhance tourism appeal. However, unregulated tourism, inadequate waste management, and weak visitor infrastructure pose ecological risks, necessitating community-based governance and environmentally sensitive planning to align tourism growth with long-term conservation objectives.

The Chambal River Basin plays a crucial role in supporting recreational and ecotourism-based livelihoods, especially through the National Chambal Sanctuary, which spans across Madhya Pradesh, Rajasthan, and Uttar Pradesh. The river's relatively pristine condition, in contrast to many other Indian rivers, has made it an ideal refuge for several endangered and endemic species, including the Gharial, Gangetic dolphin, and Indian skimmer (*Rynchops albicollis*). These species, along with the river's scenic landscape, have helped attract thousands of tourists each year (WWF-India, 2025).

The total number of tourists visiting the Chambal region has varied significantly over the years, reflecting both the growing interest in eco-tourism and the impact of socio-economic and environmental disruptions (Yadav et al., 2024). Tourist visits peaked in 2010-11 (4,766) and 2012-13 (4,696), while the lowest was recorded during 2020-21 (885), likely due to the COVID-19 pandemic (Figure 11). The fluctuation also highlights the fragility of tourism-dependent livelihoods and their vulnerability to external shocks. Recreational and educational tourism is also instrumental in raising awareness about biodiversity conservation, especially for species like the gharial and dolphins. Eco-tourism initiatives supported by government and non-governmental agencies have enabled community members to participate in conservation-linked livelihoods, which promotes a participatory model of river conservation.

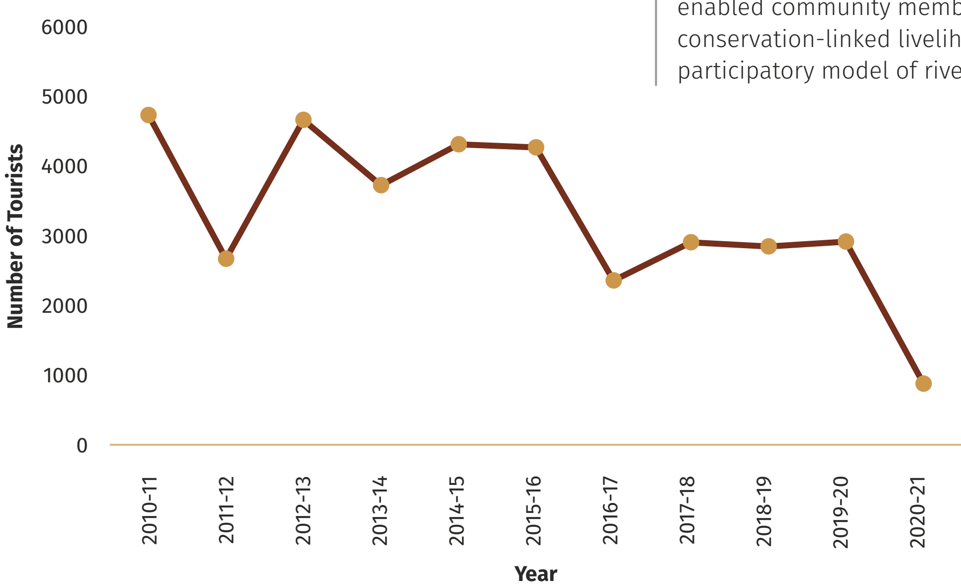


Figure 12.11: Recreational dependency of tourists in Chambal Sanctuary (Data Source: Yadav et al., 2024)

12.4.3.5 Livestock Dependency in the Chambal River Basin

Livestock rearing is a key livelihood activity across the Chambal River Basin, spanning Madhya Pradesh, Rajasthan, and Uttar Pradesh. In Madhya Pradesh, districts like Dhar and Indore report high populations. Dhar hosts 6,63,537 cattles and 279509 buffaloes, while Indore maintains around 2,39,874 cattle and 1,73,194 buffaloes. In Rajasthan, Chittorgarh and Jhalawar show similar trends, with Chittorgarh housing around 3,79,026 cattle and 4,73,245 buffaloes. Agra district in Uttar Pradesh stands out with over 1 million buffaloes and nearly 2,82,788 cattle (Department of Animal Husbandry and Dairying, 2022).

12.4.5 Ensuring people's participation through Ganga Prahari programme and livelihood development

There are a total of 122 Ganga Praharis in the Chambal River basin spanning three Indian states: Uttar Pradesh, Madhya Pradesh, and Rajasthan, consisting of 89 males and 33 females. They come from nine districts in the three Chambal states. Male engagement is evident across all 9 districts, with the highest figures recorded in Sawai Madhopur (n= 33), Morena (n= 25), and Bhind (n= 18). Female involvement is restricted to two districts: Morena, with 16 females, and Bhind, with 17, rendering Bhind the sole district where the female count almost equals that of males (Figure 12.12a & b).

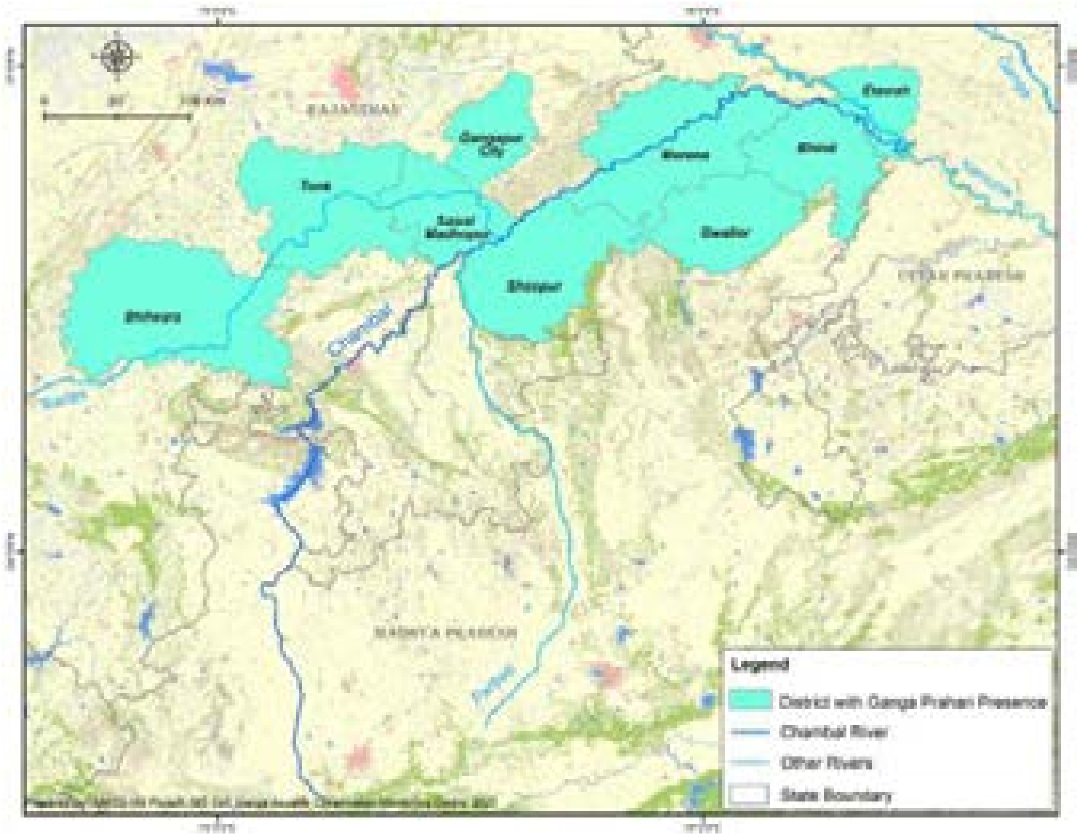


Figure 12.12a: Spatial distribution of Ganga Praharis in Chambal River Basin

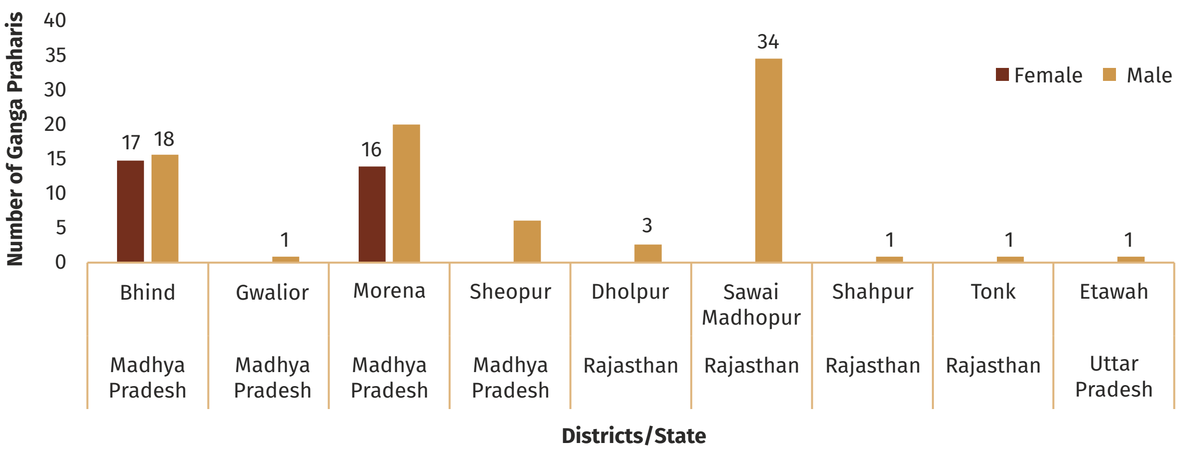


Figure 12.12b: Distribution of Ganga Praharis in Chambal River States

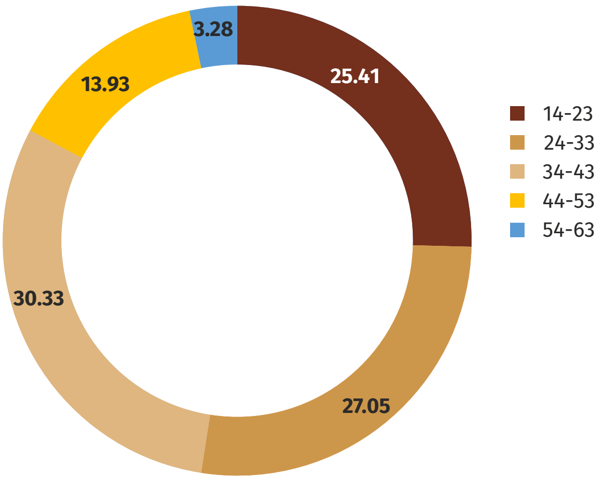


Figure 12.13: Age Distribution of Ganga Praharis in the Chambal River Region

The age distribution of Ganga Praharis provides important insights on the demographic composition of the volunteers. Their age ranges from 14-58 years with the predominant age group among Ganga Praharis is 18-35 years, therefore representing the most significant demographic category of youth (Figure 12.13). Least number of GPs belong to the older age brackets of 14-18 and 50-60 years.

About 91.8% of our Ganga Praharis are literate with majority of them studied until Higher Secondary (Figure 12.14). As Ganga Praharis, they are mainly interested in conducting awareness meetings, rescue and rehabilitation, ecological survey, plantation drive, and livelihood trainings.

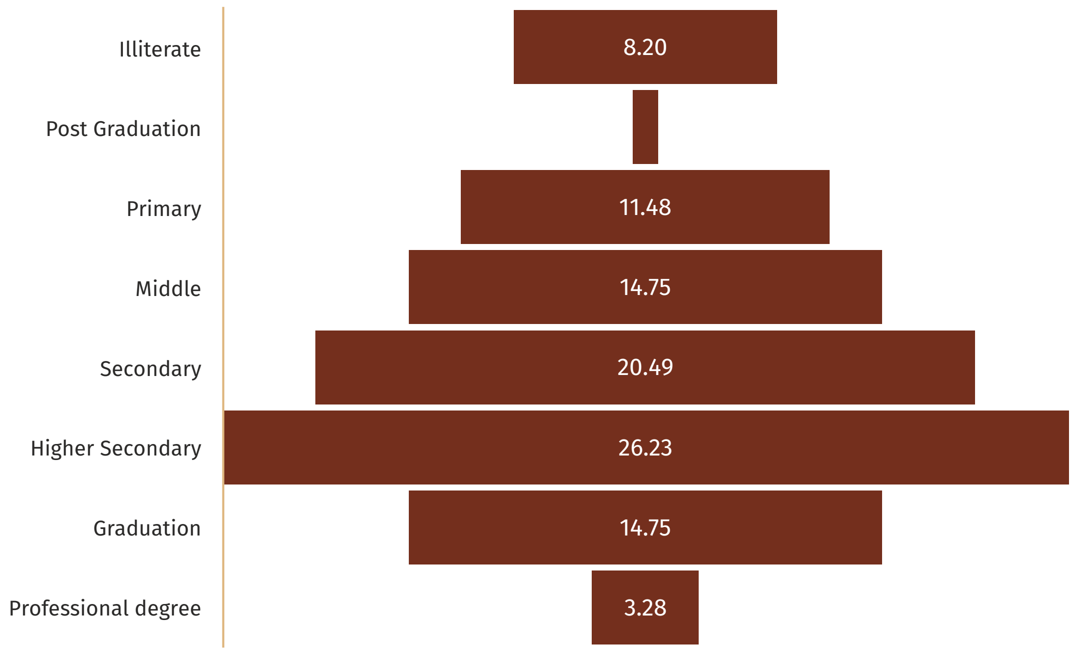


Figure 12.14: Educational profile of Ganga Praharis in the Chambal River Region

12.4.5.1. Jalaj Charmanyavati: a livelihood model in Deori, Morena to sustain conservation efforts

To ensure long-term participation of Ganga Praharsi in Chambal conservation, their livelihoods were linked with conservation actions by skill development and market linkages. To promote and encourage the Ganga Praharis and river dependent socially and economically marginalized section to participate in conservation processes, Jalaj Charmanyawati was established under the Jalaj initiative- a sister project of NMCG-WII Ganga Project. Jalaj is aimed at establishing symbiotic linkages between river and people. Jalaj models are developed with notion of local skill enhancement and environment-friendly and low impact use of natural resources for sustainable livelihood practices. At the same time, these models also act as a multidimensional platform to create awareness and mobilize stakeholders towards river conservation including local communities, pilgrims, visitors and tourists.

Assessment of social conditions in and around the select site was done to understand the needs of the local communities. Need assessment was conducted where the participants revealed their choices of trainings. It was observed that young men were interested in hands on trainings in computers, tourist guide, nursery, plumbing and electrician, which could get them employment, and women were interested in sewing and tailoring, value addition to local produce, incense stick making, fruit and food preservation and health and wellness etc.; young girls were especially interested in health and wellness training. Linkages were established with major stakeholders like forest department, district and block administration.

Jalaj Charmanyavati is located at the Gharial Centre in Deori in the Morena district of Madhya Pradesh along the Chambal River and is run in partnership with the Madhya Pradesh Forest Department (Plate 1). It aims to raise awareness among local populations and involves them in the conservation of aquatic animals, including dolphins, gharials, and water birds. This presents a chance to include stakeholders, particularly local communities, in conservation efforts. The Jalaj is connected to smaller entities, including manufacturing and training units, natural farming units, and handicraft centres in adjacent villages, establishing a self-sustaining model that can enhance the economic and ecological security of the region. Total 17 Ganga Praharis are directly linked to it.

The Jalaj is being run by WII, Ganga Praharis with kind cooperation of Madhya Pradesh Forest Department. As the Jalaj is located in a high biodiversity area, it focuses on creating awareness among local communities and engages them in the conservation of aquatic species such as dolphins, gharial, water birds, etc. The Gharial Centre in Deori, Morena is the one of its kind in Madhya Pradesh and was recently opened to the public. The centre breeds and rehabilitates Crocodiles and Gharials which are then released in the Chambal River, which is home to over 200 crocodiles and 1600 gharials. This provides an opportunity to engage stakeholders including local communities in conservation. The Jalaj is envisioned to be linked with smaller units such as production and training units, natural farming units, and handicraft centers in nearby villages creating a self-reliant model that can contribute to the economic and ecological security of the area.

Plate 12.1: Jalaj Charmanywati centre at Deori, Dist- Morena, Madhya Pradesh

12.4.6 Livelihood opportunities along Chambal River for local community

The Chambal River basin, hosts a varied spectrum of natural and socio-economic environments. Utilising the abundant local resources and distinctive physical features of the region, various sustainable livelihood options can be established to benefit local residents while safeguarding the delicate river environment. In the higher regions of the Chambal basin, namely in the Morena and Bhind districts of Madhya Pradesh, agroforestry and organic agriculture can significantly contribute to sustainable development. The ravine lands, typically regarded as wastelands, are conducive to cultivating drought-resistant and high-value crops such as custard apple, ber (*Ziziphus mauritiana*), and moringa, which necessitate minimal irrigation (Reddy et al., 2013). These can be intercropped with legumes and grasses to rejuvenate soil fertility and provide revenue variety. Organic certification and farm-to-market connections would significantly augment their profitability.

In the districts of Kota and Bundi in Rajasthan, ecotourism and community-based conservation initiatives offer an alternative opportunity. The National Chambal Sanctuary, presents considerable opportunities for wildlife tourism. Local communities can participate as naturalists, boat guides, and homestay providers. These strategies have been effective in analogous riparian habitats in India, fostering income production and conservation awareness (Sekhar, 2003; Mathur & Sinha, 2008).

Sustainable fisheries and aquaculture methods can be established in the lower basin regions of Uttar Pradesh, specifically in the Etawah and Agra districts. The Chambal's comparatively pristine waters and minimal pollution levels render it suitable for the production of indigenous fish species such as rohu, catla, and mrigal. Community fishery cooperatives can oversee seasonal harvesting while preserving natural equilibrium. The enhancement of value through fish drying, pickling, and the establishment of a cold chain might generate additional employment opportunities, especially for women (FAO, 2021).

Handicrafts and cottage businesses utilising natural resources, like bamboo, wild grasses, and riverine clay, can prosper across the basin. Artisanal pottery, bamboo weaving, and sustainable items such as baskets and mats could be advanced through skill development initiatives, bolstered by programs like the National Rural Livelihood Mission (NRLM) and the Small Industries Development Bank of India (SIDBI). Digital platforms and tourism circuits would improve the sustainability of these crafts (Kumar & Sharma, 2020). Community-based water management efforts utilising traditional methods such as johads and anicuts can facilitate groundwater recharge, improve irrigation, and bolster community cohesion across all regions. Incorporating women's self-help groups (SHGs) into these initiatives guarantees enhanced equal involvement and decision-making (Agarwal, 2001).

In summary, the Chambal River watershed offers diverse prospects for sustainable lifestyles grounded in local nature and culture. By integrating ancient wisdom with contemporary sustainability concepts and participatory governance, the region may cultivate resilient and successful communities.

12.4.7 Perceived Extent And Trend Of Ecosystem Services Availed By The Riverside Communities

12.4.7.1. Extent

Groundwater is the primary source of drinking and domestic water supply, consistently rated as high across all surveyed villages. This reflects the widespread dependence on tube wells, handpumps, and open wells. In contrast, surface water use for domestic purposes is generally rated low, with only Kohla village, reporting a moderate extent, indicating localized access.

Agricultural dependence on groundwater for irrigation is high, with most villages rating it at the maximum level. This underscores the centrality of groundwater for year-round cropping and points to intensive irrigation practices in the semi-arid landscape. Surface water irrigation, however, shows more variability, with a moderate extent in villages such as Kohla and Mathurapura but low in others. This variation likely correlates with proximity to pumping stations or canal infrastructure and suggests limited river water access in many regions.

Most villages report moderate access to water for livestock and grazing land, while fodder availability is also consistently rated at medium to high levels. Villages such as Beelpur Gher, Baroli, and Kohla reported the highest extent, likely reflecting access to ravine grasslands and protected forest patches used for open grazing and fodder collection. In terms of biomass provisioning, fuelwood collection from ravine forests is moderately prevalent, suggesting continued dependency on forested landscapes for cooking and heating needs. Non-timber forest products (NTFPs), are reported at low to medium levels, which may reflect either restricted access or degraded resource availability. Fishing activities show a limited to moderate extent across most villages, with slightly higher usage noted in Kohla and Deolimachhiya. Sand mining is highly variable, while legally restricted within protected stretches, its high extent in places like Deolimachhiya and Tighara indicates ongoing illicit extraction, which poses ecological and social risks.

Services related to pollution and waste management, such as sewage disposal, are reported at low to moderate levels, indicating that untreated wastewater discharge into the river or ponds remains a common practice. Regulation and maintenance services like soil fertility are generally perceived to be of medium extent across villages, suggesting beneficial nutrient deposition during floods, although not uniformly experienced. Provision of habitat for biodiversity is rated as high in nearly all villages, indicating widespread recognition of the ecological richness and conservation significance of the Chambal River system.

Cultural services are present to varying degrees. While religious value is generally low to moderate, aligned with the limited use of Chambal in rituals. Tourism was high in villages Kohla, Bhainsrorgarh and Palighat. The three villages reflect different models of tourism-community-driven local tourism spot in Kohla, heritage tourism in Bhainsrorgarh due to the fort, and government supported nature-based tourism (boat safari) in Palighat. These reflect scenic or heritage-related attributes and recent development initiatives that support local and regional tourism potential.

12.4.7.2. Trend

Perceived trends in ecosystem service availability and quality along the Chambal River reflect a combination of hydrological stress, ecological degradation, and socio-economic transformation. A significant finding is the widespread decline in groundwater availability, which is consistently reported across all villages. This is attributable to excessive withdrawal for both domestic use and irrigation, exacerbated by reduced recharge rates. In contrast, surface water availability for domestic use exhibits more mixed trends, stable in some locations and declining in others, reflecting site-specific infrastructural conditions and local ingenuity, and impacts from upstream diversion.

Agricultural irrigation shows differential trends based on the water source. Groundwater-based irrigation is reported to be in decline across nearly all villages, indicating increasing stress on aquifers. Surface water irrigation trends are more heterogeneous, some villages like Kohla and Mathurapura report increasing trends, likely linked to pumping infrastructure or canals (Kota Right Main Canal), while others show decline or stagnation due to limited access or unreliability.

Livestock-related services display relatively stable trends, with most villages reporting no major change in water availability, grazing access, or fodder resources. However, villages such as Bhainsrorgarh indicate declining trends, possibly due to restrictions associated with protected area boundaries or reduced vegetation cover. The availability of fuelwood and NTFPs is reported to be declining in the majority of villages surveyed. This suggests either overextraction, degradation of or limited access to ravine vegetation and forests, which are critical for meeting rural energy and livelihood needs. Fishing trends are generally stable but show signs of decline in key locations such as Deolimachhiya, where industrial effluents and thermal pollution from power plants are likely affecting aquatic biodiversity and fish availability. Sand mining, on the other hand, chiefly exhibits an increasing trend, particularly in the villages surveyed in the National Chambal Sanctuary, indicating enforcement related issues. This is highly problematic given the ecological sensitivity of the riverbed and associated breeding habitats.

Waste management-related services such as sewage disposal are reported to be stable across villages, indicating persistent but unaddressed pollution issues. There is limited evidence of improvement in waste management infrastructure at the grassroots level. Soil fertility is largely stable, with some locations noting improvement (e.g., Kohla), possibly due to beneficial floodplain sedimentation. The provision of biodiversity habitat is mostly perceived as stable or declining, depending on proximity to protected areas and the intensity of human-wildlife interactions. Declining trends are particularly reported in villages adjacent to the sanctuary, likely driven by encroachment, disturbance, or conflict.

Religious values remain mostly stable or low, reflecting the river's historically limited role in mainstream religious practice, and limited access to riverbanks. However, tourism is on the rise in selected locations such as Kohla and Palighat, driven by improved accessibility, scenic landscapes, social media promotion of local attractions, and government support. In contrast, villages with limited accessibility (far from district headquarters) or access to riverbanks (human-wildlife conflict) report stagnant or declining tourism trends, highlighting the need for targeted and inclusive tourism development strategies.

12.4.8 Village-level Microplan development for mainstreaming biodiversity conservation in local development planning

A representative village microplan for Beelpur, located in Ambah block of Morena district alongside the Chambal River, has been developed to gain a deeper understanding of grassroots-level issues related to riverine biodiversity conservation in the area. The village microplan offer a comprehensive examination of the socio-ecological challenges facing Chambal River conservation.

12.4.8.1 Issues Identified in the Chambal River through Microplanning

The village is located along a protected stretch of the National Chambal Sanctuary. Although the local community relies on the river primarily for irrigation, direct interaction with the river remains limited due to the significant presence of gharials and crocodiles, as well as the legal protection afforded to this section of the river. Nevertheless, certain indirect anthropogenic activities associated with the village continue to pose challenges to the conservation of the river's biodiversity.

Lack of Awareness

Local communities lack awareness of the ecological importance of Chambal's biodiversity, despite the existence of sanctuary protection. This lack of understanding greatly diminishes their willingness to participate in community monitoring, report illegal activities, or resist habitat degradation, perpetuating environmental damage at the grassroots level. Ignorance about the long-term consequences of pollution, and sand mining allows these threats to persist unchecked.

Illegal sand mining and soil erosion

River sand primarily deposited along the riverbanks and beds of the Chambal River, flows through Madhya Pradesh, Rajasthan, and Uttar Pradesh and preferred for construction due to its quality. Illegal sand mining is prevalent in many stretches of Chambal River. Due to lack of livelihood options and money involved in the sand business this area also has illegal sand mining issues. This is destroying the nesting sandbanks and accelerating bank erosion, severely impacting breeding sites used by gharials, turtles, and birds.

Lack of toilets and Waste Management Facility

15 households in the village lack toilet facility leading to open defecation. The village lacks liquid and solid waste collection and disposal facility. Liquid waste flows on the roads and solid waste is also dumped in the open by the villagers. Over time, these waste materials are carried into the river, leading to water pollution and disruption of the aquatic habitat.

Lack of basic infrastructure

The Panchayat lacks basic infrastructure like roads, school building and health facilities. The village roads are in a poor condition and it is very difficult to approach the village specially in monsoons making it difficult to access nearby towns or services. The local school, accommodating 150 students, operates out of just two dilapidated rooms. Basic healthcare is also unavailable nearby, with residents having to travel nearly 20km to access even primary medical care.

Use of Chemical fertilizers and pesticides in agriculture

The widespread use of chemical fertilizers and pesticides in agricultural practices in the area, poses a significant threat to the river's ecological integrity and biodiversity. People in the microplan village are mainly depend on agriculture and livestock for their livelihoods. Chemical fertilisers and pesticides are being used to increase the production, which is one of the main reasons for water pollution. Runoff from farmlands, especially during the monsoon season or irrigation cycles, carries these agrochemicals into the river system. The accumulation of chemical residues in the water can also disrupt the food chain, affecting not only aquatic life but also the health of terrestrial species that depend on the river.

Riverbed farming

Local communities are cultivating crops such as mustard in the riverbed, primarily due to the absence of alternative livelihood opportunities. While this form of riverbed farming serves as a means of subsistence, it is contributing to river pollution through the use of chemical fertilizers and pesticides. Moreover, such agricultural activities are disrupting the natural habitat of several aquatic and riparian species, posing additional challenges to biodiversity conservation.

Lack of active community-level institutions

Community-based institutions typically form with a clear purpose: to empower and represent local communities, functioning as pressure groups that support positive development. These platforms are essential for discussing village-level issues, government schemes, disseminating information, and ensuring community participation, as they remain accessible and trusted channels. Despite being located within a protected area, this panchayat lacks grassroots institutions such as Self Help Groups (SHGs), Biodiversity Management Committees (BMCs), or other participatory bodies. These institutions play critical roles by influencing decisions, livelihood, and social development-related issues, managing natural resources sustainably, and mitigating conflicts in wildlife-rich landscapes.

Human wildlife conflict

As human settlements are closer to the river and its ravine ecosystems, there are incidents of conflict between people and wildlife (Gharial, Mugger), especially during the monsoon season, which often leads to conflict. Accidental encounters often instil fear and resentment among local communities. In some cases, such tensions manifest in retaliatory actions or a decline in support for wildlife conservation efforts. Moreover, the community lacks the training and skills necessary to safely protect or rescue distressed gharials, compounding the risks for both people and animals.

12.4.8.2 Strategies suggested to address identified issues in Chambal basin

Based on the findings of the socio-economic survey and problem analysis, a set of improvement strategies was developed under seven broad thematic areas for the biodiversity conservation of the Chambal River. Within these themes, a range of activities has been proposed, including community meetings, stakeholder consultations, awareness rallies, school-based sensitization sessions, and focused discussions with farmers, school children and women. Additional initiatives include capacity-building workshops and training programs, wall paintings for public awareness, coordination with line agencies and government departments, livelihood enhancement training, sessions on wildlife rescue and rehabilitation, and the promotion of organic and natural farming practices (Table 12.9). These interventions aim to foster community engagement, enhance conservation awareness, and support sustainable livelihoods in the region. The following activities are proposed to be conducted for conservation of Biodiversity in the area:

Community Awareness

- Awareness about the importance and role of aquatic species. These sessions will be conducted in the community, schools etc.
- Placing sign boards, hoardings, slogans, wall paintings etc. in and around public places.
- Creating awareness regarding alternative livelihoods and government and non-government schemes related to the same.
- Awareness regarding cleanliness, impacts of riverbed farming and mining on river biodiversity.
- Awareness sources on pollution of river water and its impact on human, river and animal health.
- Awareness on the impact of chemical fertilisers and pesticides on human and river health.

Cleanliness and sanitation

- Creating awareness regarding pollution, plastic waste, and solid waste and their impacts on human health and river ecosystem
- Placing dustbins in the and arrangements of waste disposal and management system with the help of concerned department.
- Facilitating the construction of toilets for households lacking them, and supporting them in availing benefits under appropriate government schemes.
- Delivering sessions on the segregation of degradable and non-degradable waste.

Formation and Strengthening of Local Institutions

- Community mobilisation and facilitation of formation of community-level institutions (SHGs, Ganga Prahari cadre, Biodiversity management committee etc.) as there are no such groups in the village.

- Facilitating access for the groups to various government schemes and relevant information.
- Train institutions on sustainable alternatives to reduce pressure on the river ecosystem.
- Organize river festivals, biodiversity fairs, and school campaigns under the aegis of local institutions to promote mass engagement.
- Build platforms for regular interaction between local institutions and relevant line departments (Forest, Fisheries, Agriculture, Rural Development) to ensure convergent action on conservation priorities.

Livelihood and skill development

- Mobilisation of community to participate in alternate livelihood trainings.
- Conduct of livelihood trainings based on the local resources and traditional skills.
- Establishing coordination with officials from the National Rural Livelihood Mission (NRLM) to benefit the community. Through this collaboration, the Panchayat can facilitate the formation of Self Help Groups (SHGs), access training and financial inclusion services, and leverage livelihood promotion schemes.
- Develop linkages with the JALAJ centre for marketing of the products.

Agriculture development

- Awareness of the impacts of chemical fertilisers on human and river health.
- Coordination with the agriculture department for information on sustainable agriculture and improved tools.
- Training on the importance of organic and natural farming.
- Promoting use of organic pesticides and fertilizers.

Animal Husbandry/Livestock Development

- To establish animal husbandry as a source of livelihood, coordination with the animal husbandry department will be established for better management of the livestock.
- Training on livestock and fodder management.
- Develop farm-based fodder systems (e.g., Azolla, legumes, grasses, shrubs).
- Coordination with the concerned department to install biogas units and bio composting.

Habitat and Biodiversity Conservation Activities

- Raising awareness among local communities, institutions, and stakeholders about riverine ecosystems and their rich biodiversity. Selecting and training Ganga Praharis to lead and support biodiversity conservation efforts in the region.
- Encouraging active participation of Ganga Praharis in local institutional meetings and initiatives to integrate biodiversity conservation into everyday decision-making and practices.
- Conducting plantation drives in villages, agricultural lands, and along wetlands to restore habitat quality and improve groundwater levels.
- Supporting alternative and sustainable livelihoods through skill development for river-dependent communities, including fishers, boatmen, women, and economically weaker groups.
- Promoting environmentally friendly agricultural practices, including the use of organic fertilizers and bio-pesticides.
- Organising Rescue and rehabilitation trainings for the Ganga Praharis.
- Conduct training on topics such as River ecology and species of conservation concern, Legal provisions (Indian Wildlife (Protection) Act, 1972, Biological Diversity Act, 2002), Monitoring and patrolling techniques, Conflict resolution and community mobilization.
- Coordination with mining and forest department to regulate mining in the region.

Table 12.9: Strategies and actions proposed to address the conservation issues in Chambal River Basin

Strategy	Key Activity	Purpose & Benefits
1. Community Awareness	Sessions and interactions on aquatic species; signboards, slogans, wall art; awareness on alternative livelihoods, risks of river pollution and use of chemical fertilizer	Builds local knowledge, fosters stewardship, promotes behaviour change
2. Cleanliness & Sanitation	Waste awareness campaigns; dustbins installation; waste management; household toilets via govt schemes; segregation training, infrastructure and strategies for waste segregation and management	Reduces plastic and other pollution, improved human and ecosystem health.
3. Formation & Strengthening of Institutions	Strengthen and mobilize local institutions such as SHGs, BMCs, Ganga Praharis, Panchayats; facilitate govt scheme access; training in sustainable alternatives; community events and departmental convergence platforms.	Creates grassroots governance structures enabling participatory planning, conservation action, and government liaison.
4. Livelihood & Skill Development	Train in alternative sustainable livelihoods; establish linkages with NRLM and other such agencies for SHGs strengthening, trainings and finance, collaborate with Jalaj centre for marketing.	Reduced dependency on the river while increasing income and institutional capacity.
5. Agriculture Development	Awareness on impacts of chemical fertilizers; coordination with agriculture dept; training on organic farming; promote organic inputs in agriculture	Encourages sustainable farming practices that are beneficial for human, soil and water health.
6. Animal Husbandry/ Livestock	Coordinate with animal husbandry dept; train fodder management; create farm based fodder systems (Azolla, legumes); biogas & bio compost units.	Enhances sustainable livelihoods and converts manure to green energy.
7. Habitat & Biodiversity Conservation	Awareness among stakeholders by engaging trained Ganga Praharis; involve Ganga Praharis in institution building and strengthening; plantation of native species in villages and wetlands; support livelihoods of river dependent communities by skill development for alternative income generating resilient activities; rescue & rehabilitation training and accessibility to basic equipment and medicines for first-aid ; training on river ecology, laws, monitoring, conflict resolution, coordination with the state forest and mining departments.	Strengthens on ground biodiversity protection, monitoring, and conflict mitigation, regulates extraction activities, build trust and ownership among stakeholders and protects sensitive riverine areas.

Community participation in microplan development is key to understand the issues concerning the conservation of the river biodiversity. This process not only brings out the real concerns of the area but also helps to find solutions by merging traditional knowledge with scientific actions. By involving local stakeholders from the start, the process brings real, area-specific concerns to light-not just habitat degradation, pollution, and species status, but also the livelihoods and needs of river-dependent communities. The microplan for Beelpur integrates such community-driven approaches, aiming to foster sustainable development while conserving the river's biodiversity.

12.5 Conclusion

The Chambal River Basin stands out as both an ecological treasure and a vital economic resource, supporting millions of people who rely on its resources for drinking water, farming, fishing, livestock rearing, and other nature-based livelihoods. Despite the region's challenging semi-arid conditions and rugged ravines, local communities across Madhya Pradesh, Rajasthan, and Uttar Pradesh have close relationship with the river and its ecosystem. However, in recent years, increasing population, changes in land use, expansion of infrastructure, and shifting climate patterns have put considerable pressure on both the basin's diverse wildlife and the long-term viability of traditional village economies.

Efforts on the ground have highlighted the power of community-led conservation and collaborative planning, demonstrating how protecting the river can go hand in hand with local development goals. By bringing villagers together-strengthening groups like self-help circles and panchayats, and building skills-these projects have encouraged greater responsibility for the area's natural resources. Still, fragmentation in policies and institutions, coupled with persistent challenges to people's livelihoods, underline the urgent need for development strategies that are not only resilient and inclusive but are also tailored to the unique needs of each local community.

12.5.1 Recommendations

On the basis of our analysis and field observation following recommendations are proposed for the Chambal River Basin:

1. Create a formal tri-state coordination mechanism with regular inter-departmental meetings, shared protocols, and joint enforcement operations to address the current silo-based governance that results in uneven and fragmented conservation outcomes along the 965 km river stretch.
2. Institutionalize structured stakeholder engagement frameworks using power–interest–legitimacy mapping to prioritize interventions and participation. Ensure inclusive participation of local communities, indigenous groups, women, and marginalized populations in decision-making processes. Promote co-management models, recognizing riverine communities as co-stewards rather than beneficiaries. Facilitate continuous dialogue platforms (multi-stakeholder forums) to resolve competing resource-use conflicts.
3. Implement sustained awareness campaigns on river conservation and biodiversity values. Integrate traditional ecological knowledge with scientific approaches in management planning. Conduct capacity-building programmes for stakeholders, including government officials and communities. Develop education and outreach programmes targeting schools and local institutions.
4. Institutionalise and scale up the Ganga Prahari cadre as a formal, government-recognized community conservation force across all three states, providing Praharis with stipends, legal recognition, rescue training, and clear linkages with forest and fisheries departments moving them from voluntary to semi-professional status.
5. Mandate community representation in river governance bodies including Gram Panchayat leaders, fishermen, women's SHG representatives, and local farmers in all decision-making forums related to the Chambal River, from district-level committees to the proposed Basin Authority.
6. Adopt the village-level microplanning approach (demonstrated successfully in Beelpur village, Morena) as a standard operational tool for all gram panchayats along the river, ensuring that conservation priorities are integrated into village

development plans through participatory, evidence-based processes.

7. Empower local governance institutions (Panchayats) to implement conservation-linked development plans. Ensure bottom-up planning processes incorporating local knowledge and socio-cultural contexts. Promote equitable benefit-sharing mechanisms from conservation initiatives.

8. Formalize establishment of institutions like Biodiversity Management Committees (BMCs) in all gram panchayats adjacent to the river and National Chambal Sanctuary, as many villages currently lack such grassroots institutions, hampering conservation participation and local governance.

9. Scale up and formalize the Ganga Prahari programme as a long-term institutional mechanism for grassroots conservation. Provide financial incentives, recognition systems, and career pathways to sustain volunteer engagement. Integrate Ganga Praharis into monitoring, enforcement support, biodiversity conservation, and awareness campaigns. Expand participation of youth networks (NSS, NYKS, NCC) and local community institutions.

10. Ensure gender-inclusive participation in all community conservation programmes, as evidenced by the Ganga Prahari programme data showing gender disparities by setting minimum representation quotas for women in BMCs, SHGs, and river governance committees.

11. Invest in alternative and supplementary livelihood programmes for river-dependent communities particularly fishermen, boatmen, agricultural labourers, and women through targeted training linked to local resources, traditional skills, and market access via platforms like the Jalaj Charmanyawati Centre model piloted in Morena.

12. Link conservation programmes with existing government schemes (NRLM, PMKVY, RSETI) to enhance economic viability. Reduce dependency on ecologically harmful activities (e.g., sand mining, over-extraction) by diversifying income sources.

13. Promote sustainable and organic agriculture in the Chambal basin through coordination with agriculture departments, incentivising the phasing out of chemical fertilisers and pesticides that cause non-point source pollution into the river, especially from riverbed farming.

14. Regulate and eventually phase out riverbed farming (cultivation of mustard and other crops on exposed riverbeds during lean season), which currently threatens aquatic habitat, through alternative income support for the most vulnerable farmers practicing it.

15. Develop ecotourism as a community-linked livelihood around the National Chambal Sanctuary in a planned, low-impact manner through the mandated eco-tourism master plan, with revenue-sharing mechanisms that directly benefit local communities.

16. Implement scientifically informed land-use zoning, especially in ravine and floodplain areas, to prevent ecological degradation. Regulate ravine reclamation and agricultural expansion to avoid habitat fragmentation and erosion. Promote soil conservation, afforestation, and nature-based solutions for ravine stabilization. Integrate urban expansion planning with ecological sensitivity to manage the rural–urban interface002E.

17. Link rural communities to existing government schemes such as NRLM, PMKVY, RSETI, Jal Jeevan Mission through district and block-level facilitation, as currently there is significant underutilization of welfare schemes in ecologically vulnerable villages due to lack of awareness and institutional support.

18. Develop strategies and mechanisms to fill the policy gaps by aligning national, state, and river-specific policies into a coherent framework. Enhance implementation efficiency of existing policies through accountability mechanisms. Integrate biodiversity conservation into sectoral policies (agriculture, infrastructure, energy). Develop adaptive policy frameworks that respond to emerging challenges such as climate change and land-use transitions.

REFERENCES

Agarwal, B. (2001). Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. World Development, 29(10), 1623-1648.

Bhatt, S., Pathak, J., & Jain, A. K. (2012). Impacts of damming on water quality and aquatic biodiversity in Chambal River, India. *International Journal of Environmental Sciences, 3*(1), 43-56.

Bose, R., Bose, A. K., Das, A. K., Parashar, A., & Roy, K. (2019). Fish diversity and limnological parameters influencing fish assemblage pattern in Chambal River Basin of Madhya Pradesh, India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 89*, 461-473.

Census of India. (2011). Primary Census Abstract Data Tables. Office of the Registrar General & Census Commissioner, India.

Central Water Commission. (2015). *Integrated Hydrological Data Book*. Government of India. Retrieved from http://www.cwc.gov.in

Central Water Commission. (2015). *River Basin Planning & Management*. Government of India.

Central Water Commission (CWC). (2015). *Water and Related Statistics*. Ministry of Jal Shakti, Government of India.

CIFRI (Central Inland Fisheries Research Institute). (2017). *Status of inland fisheries in the Chambal River Basin*. Government of India.

CWC (2015). *Water and Related Statistics*. Central Water Commission, Ministry of Jal Shakti, Government of India.

Department of Agriculture & Farmers Welfare. (2024). *Agricultural statistics at a glance 2024*. Ministry of Agriculture & Farmers Welfare, Government of India.

Department of Fisheries. (2023). Handbook of Fisheries statistics 2023. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. Retrieved from https://www.dof.gov.in/documents/publications/handbook-of-fisheries-statistics-IjMxITMtQWa?pageTitle=Handbook-of-Fisheries-Statistics

DESAGRI. (2024). *Source-wise Irrigated Area Report*. Directorate of Economics and Statistics, Department of Agriculture & Farmers Welfare, Government of India. Retrieved from https://data.desagri.gov.in/weblus/lus-source-irrigated-area report-web

FAO. (2021). Small-scale fisheries and aquaculture: Livelihoods and sustainability. http://www.fao.org/fishery

Ghosh, S., Das, D., Kao, S. C., & Ganguly, A. R. (2010). Lack of uniform trends but increasing spatial variability in observed Indian rainfall extremes. *Nature Climate Change, 2*(2), 86-91.

https://www.downtoearth.org.in/environment/chambal-without-ravines-58655

Hussain, S. A., & Badola, R. (2010). Valuing ecosystem services of the Chambal River for conservation of aquatic biodiversity. *Hydrobiologia, 644*(1), 99-109.

IUCN (2023). *The IUCN Red List of Threatened Species*. Retrieved from https://www.iucnredlist.org

IWAI (Inland Waterways Authority of India). (2017). *Feasibility Study Reports for National Waterways*. Retrieved from https://iwai.nic.in/

Jain, S. K., Kumar, S., & Varghese, J. (2012). *Ecological and hydrological characterization of the Chambal River basin*. Water Resources Management, 26(8), 2327-2344.

Khan, S., Freeda Maria, S. M., & Bhattacharya, A. K. (2024). Chambal Valley: the Myth, the Curse, the Legend, the Challenges, and the Opportunities for Dark Tourism-Case Study. In *Dark Tourism: Theory, Interpretation and Attraction* (pp. 149 173). Emerald Publishing Limited.

Kumar, A., & Sharma, P. (2020). Reviving local economies through traditional handicrafts: A sustainable approach. Journal of Rural Development, 39(4), 523-535.

Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature climate change, 2*(11), 789-794.

Mall, R. K., Gupta, A., Singh, R., Singh, R. S., & Rathore, L. S. (2006). Water resources and climate change: An Indian perspective. *Current Science, 90*(12), 1610-1626.

Mathur, V. B., & Sinha, P. R. (2008). Ecotourism and biodiversity conservation: A case study of India. National Wildlife Institute of India.

Ministry of Environment, Forest and Climate Change (MoEFCC). (2020). *Annual Report 2019-20*. Government of India.

Ministry of Water Resources (MoWR). (2020). *Annual Report 2019-20*. Government of India.

Mishra, V., Aadhar, S., Asoka, A., & Ghosh, S. (2018). Annual and seasonal precipitation trends in India: 1901-2014. *International Journal of Climatology, 38*(1), 454-469.

Nair, A., Joseph, S., & Kurup, B. M. (2012). *Environmental impacts of sand mining in Chambal River: A review. Environmental Monitoring and Assessment, 184*(3), 1693-1701.

Nastran, M. (2014). Stakeholder analysis in a protected natural park: case study from Slovenia. *Journal of Environmental Planning and Management, 57*(9), 1359-1380.

Nath, M. L. (1989). *The Upper Chambal Basin: A Geographical Study in Rural Settlements*. Northern Book Centre.

National Institute of Hydrology. (2012). *Hydrological Studies in the Chambal Basin: Flood Dynamics and Watershed Behaviour*. NIH Report Series.

NWDA (National Water Development Agency). (2024). *Status of Water Resources Projects*. Retrieved from https://nwda.gov.in/

Prakash, S., & Gupta, R. (2021). *Environmental impacts of sand mining in the Chambal River Basin*. Environmental Earth Sciences, 80(12), 1-10.

Ranga Reddy, P. V., Ramakrishna, T. V., & Ramesh, R. (2001). Environmental impact of large reservoirs on river ecosystems: A case study of Chambal River. *Journal of Environmental Studies and Policy,* 4(1), 21-31.

Rao, R. J., Sharma, R. K., & Sharma, B. K. (1995). *Faunal diversity and conservation of the National Chambal Sanctuary*. Proceedings of the National Seminar on Conservation of River Ecosystems, 45-51.

Rathore, M., & Dubey, N. (2020). *Livelihood patterns among tribal communities in the Chambal region: A socio-ecological perspective*. Journal of Rural Development, 39(2), 224-238.

Reddy, S. R., Ramakrishna, Y. S., & Singh, H. P. (2013). Agroforestry: Principles and practices. Central Agroforestry Research Institute.

Sekhar, N. U. (2003). Local people's attitudes towards conservation and wildlife tourism around Sariska Tiger Reserve, India. Journal of Environmental Management, 69(4), 339-347.

Sen, S., & Mukherjee, I. (2022). Chambal as nomadic in global and local narratives on Putli and Phoolan. *Posthumanist Nomadisms across Non-Oedipal Spatiality*, 233.

Sharma, B. R., & Bharat, R. (2009). Groundwater depletion and irrigation sustainability in the Chambal basin. Indian Journal of Water Resources, 29(4), 1-9.

Sharma, R., & Singh, A. (2018). *Agricultural dependency and climate vulnerability in the Chambal River Basin*. Indian Journal of Geography and Environment, 45(1), 34-49.

Singh, R. P., Jha, M. K., & Srivastava, P. K. (2012). *Assessment of Ravine Land Degradation Using Geospatial Techniques in the Chambal Basin. Journal of Environmental Management, 109*, 92-106.

Singh, S., Meraj, G., Kumar, P., Singh, S. K., Kanga, S., Johnson, B. A., ... & Sahariah, D. (2023). Decoding chambal river shoreline transformations: a comprehensive analysis using remote sensing, GIS, and DSAS. *Water, 15*(9), 1793.

Singh, S., Singh, Y. P., Sinha, R., Singh, A. K., Dubey, S. K., & Verma, G. P. (2018). Socio-economic impact of reclamation of Chambal ravines through anicuts and afforestation. *Indian Journal of Soil Conservation, 46*(2), 225-232.

Sinha, R., & Friend, P. F. (1994). River systems and their sediment flux, Indo-Gangetic plains, northern Bihar, India. *Sedimentology, 41*(5), 825-845.

Sisodia, J. S. (1992). Performance Monitoring Study of the Warabandi System of Irrigation Management in Chambal Command Area (Madhya Pradesh). *Indian Journal of Agricultural Economics, 47*(4), 660-668.

Thakur, P. K., Aggarwal, S. P., & Garg, V. (2012). Ravine mapping and reclamation planning using remote sensing and GIS in the Chambal basin. *Geocarto International, 27*(1), 35-51.

UNESCO World Heritage Centre (2022). *Indicative List of India*. Retrieved from https://whc.unesco.org

Valdiya, K. S. (2001). Reactivation of terrane-defining boundary faults in central Indian region: Implications for intraplate seismicity. *Current Science, 81*(10), 1296-1300.

Water Resources Department, Madhya Pradesh (WRD-MP). (2018). *Chambal Valley Project Report*. Government of Madhya Pradesh.

WWF-India. (2025). *National Chambal Sanctuary: Conserving gharials, dolphins and river biodiversity*. World Wide Fund for Nature–India. https://www.wwfindia.org/?27522/WWF-India-Launches-Initiative-to-Rejuvenate-Chambal-Yamuna-Rivers

Yadav, N., Sahoo, D., & Sahu, N. C. (2024). *Assessment of recreational value of National Chambal Sanctuary: Application of Individual Travel Cost Model. Vilakshan - XIMB Journal of Management*. https://doi.org/10.1108/XJM-01-2024-0018.

CHAPTER 13

NATURE INTERPRETATION AND CONSERVATION EDUCATION

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Sangeeta Angom

Contributing Authors
Nidhi Singh, Kumari Babli, Piyush Pandey, Niraj Aswal, Sonu, Anjali Kathait, Ajay Kumar Maurya

SUMMARY

This chapter presents the implementation and outcomes of a Nature Interpretation and Conservation Education initiative conducted along the Chambal River in the states of Uttar Pradesh, Madhya Pradesh and Rajasthan, aimed at strengthening awareness and stewardship of riverine biodiversity among school students and teachers. These interventions were targeted at students aged 13-17 years in government schools located near the river. The initiative adopted a two-pronged approach: first, conducting interactive awareness and sensitization workshops covering river ecology, biodiversity, pollution, and conservation practices using participatory tools such as presentations, quizzes, games, and group discussions to simplify complex ecological concepts and encourage critical thinking; and second, establishing low-cost interpretation corners, "*Jalmala Samvaad*," within school premises to serve as permanent learning platforms displaying educational panels and artwork on riverine biodiversity and conservation themes. A total of eight awareness workshops were organized across the Chambal basin, directly sensitizing 408 students to site-specific ecological issues and conservation concerns. To ensure sustained engagement beyond one-time interventions, five Jalmala Samvaad interpretation corners were established-two each in Uttar Pradesh and Madhya Pradesh, and one in Rajasthan-which collectively reached 3,530 students and 104 in-service teachers. These interpretation spaces functioned as localized knowledge

hubs, reinforcing classroom learning and fostering continued dialogue on biodiversity conservation. The combined strategy of interactive workshops and permanent interpretation infrastructure significantly strengthened outreach and institutionalized environmental learning within participating schools.

13.1 Introduction

Conservation education is a critical approach for addressing environmental challenges by fostering knowledge, skills, attitudes, and behaviors that support the protection of natural resources and biodiversity. As environmental threats become more complex, the need for effective, inclusive, and adaptive conservation education grows, both for local communities and professionals in the field. Conservation education aims to develop environmental knowledge, values, and practical skills, preparing individuals and communities to take positive environmental action and address conservation issues directly (Ardoin et al., 2020; Fien et al., 2001). Programs seek to influence attitudes and behaviors, encouraging pro-environmental actions that can lead to tangible conservation outcomes (Schilbert & Scheersoi, 2022; Brias et al., 2022). Effective conservation education often involves collaboration with local communities, scientists, and organizations, ensuring that programs are relevant and locally grounded (Lanjouw, 2021). Many higher education programs focus on disciplinary and communication skills but often lack training in interpersonal, project management, and social science methods, which are essential for addressing modern conservation challenges (Fisher et al., 2024). Student biodiversity awareness programs are designed to increase students' understanding of biodiversity, its importance, and the need for conservation. Programs that involve direct engagement with nature, such as field observations, citizen science, and hands-on projects, transform passive learning into active, meaningful experiences. These approaches increase students' connection to biodiversity and participation in conservation activities (Davis et al., 2021; Hodges, 2016). Activities that encourage students to solve real-world biodiversity problems deepen their understanding and ability to evaluate the impacts of biodiversity loss from multiple perspectives (Ural & Dadli, 2024). Students can also greatly benefit from an interpretation programme, as it enhances their understanding of how they can actively contribute to conserving the natural resources they rely on for livelihood or subsistence. Interpretation involves communicating the significance of a place or object in a way that deepens appreciation, promotes understanding, and fosters a positive attitude toward conservation. Interpretation's goal is to enrich visitors' experiences, convey deeper symbolic meanings, and inspire shifts in attitudes and behaviors toward the natural or cultural environment (Prentice, 1996). River systems in India, which spans across various states, a singular approach for conservation education is inadequate and requires an interdisciplinary strategy. Actively involving communities that directly or indirectly depend on rivers is crucial. This was achieved through the following

1. Enhancement of students' knowledge of riverine biodiversity
2. Establishment of the Ganga Knowledge Corners as platforms for disseminating information to promote river conservation

13.2. Methods

To promote environmental awareness and biodiversity conservation along the Chambal River, Awareness and Sensitization programs were conducted. These programs were designed to target students to create sustained impact through education and engagement. Figure 13.1 outlines a comprehensive framework for "Awareness and Sensitization Programs,"

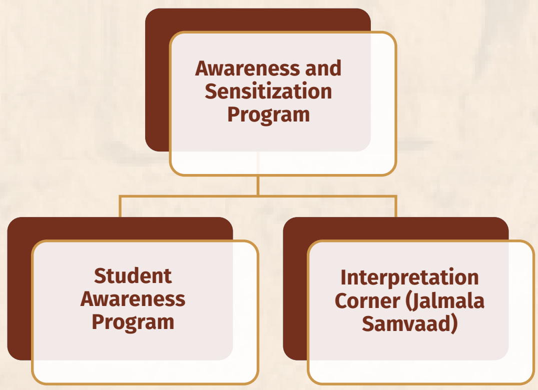


Figure 13.1: Flow chart representing approach taken for conducting awareness and sensitization programs along Chambal River

13.2.1. Student Awareness Program

Interactive awareness workshops were conducted in government schools located near the Chambal River for students aged 13 to 17 years (classes 8th to 12th). These sessions addressed key themes including river ecology, biodiversity, pollution, and conservation practices. Participatory tools such as visual presentations, games, quizzes, and group discussions were employed to simplify complex environmental concepts and promote critical thinking among students.

13.2.2. Interpretation Corners (Jalmala Samvaad)

To ensure continuous access to educational resources and learning materials, low-cost interpretation corners-*Jalmala Samvaad*-were established within the school premises. These permanent learning spaces were equipped with educational panels and artwork focusing on riverine biodiversity and conservation issues.

13.3. Results

13.3.1. School Awareness Programs

Awareness and sensitization workshops were organized in government schools situated along the Chambal River to create awareness and promote understanding of riverine biodiversity and related ecological issues. The programs were designed to address site-specific concerns within the Chambal River basin and were implemented across the states of Uttar Pradesh, Madhya Pradesh, and Rajasthan. A total of eight workshops were conducted, through which 408 school students were sensitized. (Table 13.1).

Table 13.1: Total number of awareness workshops conducted in schools along the Chambal River

S. No.	States	Number of Awareness Programs	Number of Participants
1.	Uttar Pradesh	4	205
2.	Madhya Pradesh	3	153
3.	Rajasthan	1	50
	Total	8	408

School Awareness workshop being conducted at Govt. school along Chambal River

13.3.2. Low-cost Interpretation Center "Jalmala Samvaad"

A total of five low-cost interpretation corners were established in government schools along the Chambal River to strengthen environmental education outreach (Table 13.2, Figure 13.2). These small-scale interpretation corners act as specialized galleries, equipped with educational panels, and artwork highlighting the biodiversity of Ganga and Chambal river systems. Strategically integrated within school premises, the Jalmala Samvaad corners function as permanent educational resources. These are utilized to actively involve students in celebrating the special events like Wildlife Day, World Environment Day and International Day of Biological Diversity. Through these interpretation corners along the about 3530 students and 104 school teachers were reached out.

School Awareness workshop being conducted at Govt. school along Chambal River

Table 13.2: Low-cost interpretation corners '*Jalmala Samvaad*' established along Chambal River

S.No.	State	Number of Jalmala Samvaads Established	Number of Students Sensitized	Number of Teachers Sensitized
1.	Uttar Pradesh	2	1750	32
2.	Madhya Pradesh	2	1450	55
3.	Rajasthan	1	330	17
	Total	5	3530	104

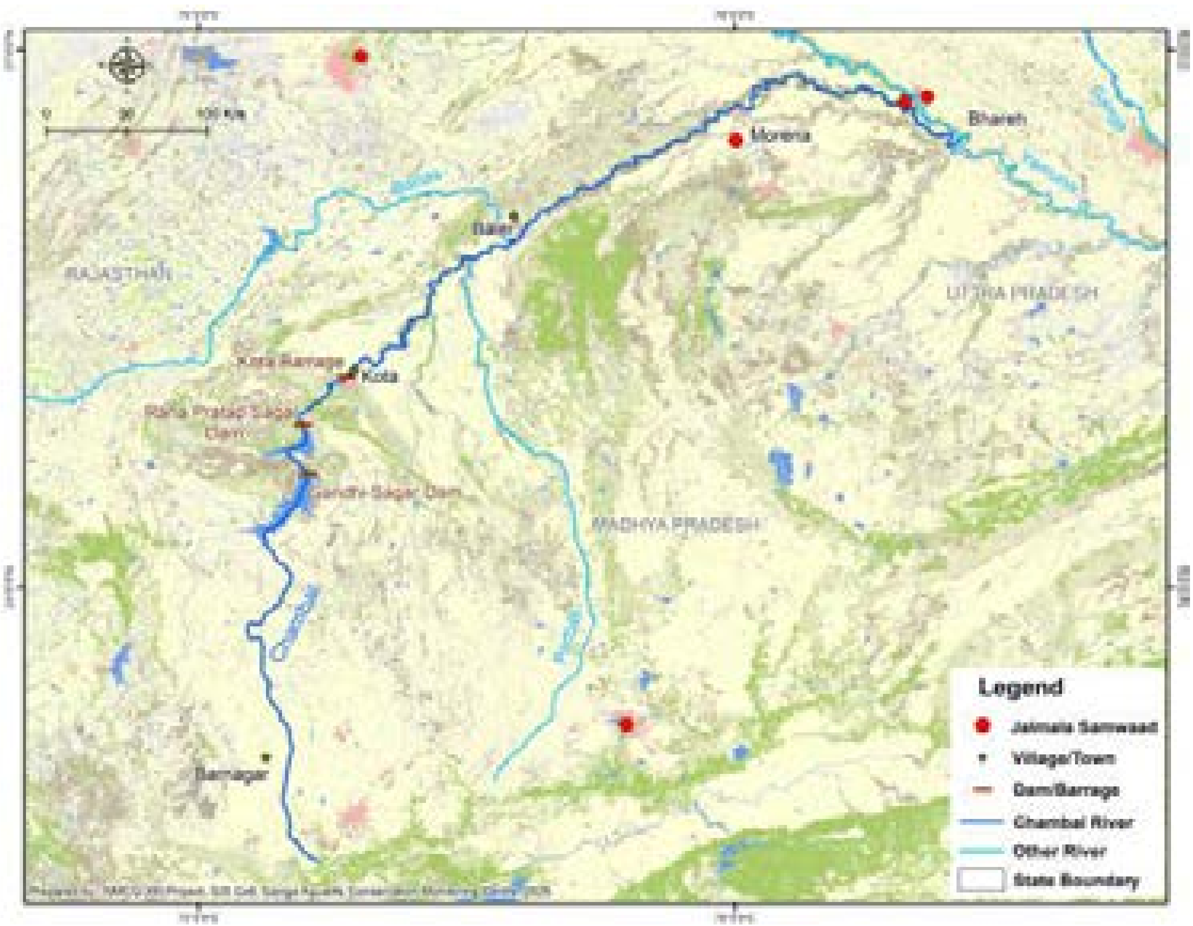


Figure 13.2: Location of *Jalmala Samvaad* along the Chambal River

Jalmala Samvaad at Govt. schools in Morena, Madhya Pradesh

13.4 Outcomes

The Nature Interpretation and Conservation Education initiative along the Chambal River generated several qualitative outcomes aligned with the objectives of enhancing environmental knowledge, fostering conservation-oriented attitudes, and institutionalizing biodiversity learning within school systems.

13.4.1. Strengthened Understanding of Riverine Biodiversity

Interactive workshops revealed a significant improvement in students' ability to identify key species and to understand their ecological significance within the River ecosystem. Participants demonstrated improved knowledge of species such as the gharial, Gangetic dolphin, and freshwater turtle species. Discussions indicated that students were able to connect biodiversity loss with anthropogenic issues such as sand mining, pollution, and habitat disturbance.

13.4.2. Shift from Passive Awareness to Active Engagement

The participatory activities-like quizzes, group discussions, and problem-solving exercises-encouraged students to move from listening to actively thinking about and discussing conservation challenges. Students engaged in dialogue about practical measures such as reducing waste disposal in river systems. Qualitative observations during sessions reflected a perceptible change in students' perception of the River-from viewing it primarily as a water resource to recognizing it as a bio-diverse ecosystem.

13.4.3. Institutionalization of Environmental Learning

The establishment of low-cost interpretation corners, "*Jalmala Samvaad*," transformed conservation education from a one-time intervention into a sustained institutional presence. These interpretation spaces functioned as localized knowledge corners, enabling repeated exposure to riverine biodiversity themes. Schools utilized these corners during environmental observance days and classroom activities, reinforcing ecological learning beyond workshop sessions.

13.4.4. Enhanced Teacher Participation

Engagement with 104 in-service teachers facilitated in merging of conservation themes across multiple classes and grade levels. Teachers demonstrated interest in incorporating river-related examples into their curriculum, thereby extending the reach of the programme beyond direct participants. This collaborative approach strengthened the program's relevance and sustainability within institutional structures.

13.5 Conclusion

The implementation of the Nature Interpretation and Conservation Education initiative along the Chambal River establishes a structured framework for facilitating environmental sensitization through a bimodal pedagogical approach. Through eight targeted school awareness workshops, 408 students were sensitized to riverine biodiversity, while five low-cost interpretation corners-Jalmala Samvaad-further expanded outreach to 3,530 students across Uttar Pradesh, Rajasthan, and Madhya Pradesh. By integrating interactive workshops with the institutionalization of interpretation corners, the program operationalizes the dissemination of site-specific ecological knowledge across regional school systems. Furthermore, the establishment of permanent interpretation infrastructure provides an accessible platform for sustained engagement, ensuring that conservation themes remain an integrated component of the academic environment. The deployment of participatory tools-such as visual presentations and group activities-served to simplify complex riverine biodiversity concepts, encouraging the evaluation of ecological issues from localized perspectives. This qualitative strategy highlights the utility of localized, issue-based interventions in creating opportunities for informed dialogue regarding the long-term stewardship of the Chambal River basin.

REFERENCES

Ardoin, N., Bowers, A., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, 241, 108224. https://doi.org/10.1016/j.biocon.2019.108224.

Brias-Guinart, A., Korhonen-Kurki, K., & Cabeza, M. (2022). Typifying conservation practitioners' views on the role of education. *Conservation Biology*, 36. https://doi.org/10.1111/cobi.13893.

Davis, M., Niemiller, K., & Niemiller, M. (2021). Addressing 'biodiversity naivety' through project-based learning using iNaturalist. *Journal for Nature Conservation*. https://doi.org/10.1016/j.jnc.2021.126070.

Fien, J., Scott, W., & Tilbury, D. (2001). Education and Conservation: Lessons from an evaluation. *Environmental Education Research*, 7, 379 - 395. https://doi.org/10.1080/13504620120081269.

Fisher, J., Keane, A., Holmes, G., & Slater, H. (2024). Mismatch between conservation higher education skills training and contemporary conservation needs. *Conservation Science and Practice*. https://doi.org/10.1111/csp2.13112.

Hodges, K. (2016). Enhancing student engagement and learning via the optional Biodiversity Challenge. *Global Ecology and Conservation*, 5, 100-107. https://doi.org/10.1016/J.GECCO.2015.11.010.

Lanjouw, A. (2021). De-colonizing conservation in a global world. *American Journal of Primatology*, 83. https://doi.org/10.1002/ajp.23258.

Prentice, R. C., *'Tourism as experience. Tourists as consumers. Insight and enlightenment'*, Inaugural Lecture Queen Margaret's College, Edinburgh (1996) p. 55

Schilbert, J., & Scheersoi, A. (2022). Learning outcomes measured in zoo and aquarium conservation education. *Conservation Biology,* 37. https://doi.org/10.1111/cobi.13891.

Ural, E., & Dadli, G. (2024). THE EFFECT OF PROBLEM-BASED LEARNING ACTIVITIES ON SECONDARY SCHOOL STUDENTS' AWARENESS OF BIODIVERSITY. *Scientific Educational Studies*. https://doi.org/10.31798/ses.1489883.

SECTION VI

CHAPTER 14

CONSERVATION IMPLICATIONS AND CONSERVATION PLANNING FRAMEWORK

Coordinating Lead Authors
Ruchi Badola,
Syed Ainul Hussain

Lead Authors
Shivani Barthwal,
Pariva Dobriyal

Contributing Authors
Surya Prasad Sharma,
Richika Sah,
Sunidhi Mishra

SUMMARY

The Chambal River, a vital tributary of the Yamuna and part of the larger Ganga River Basin, harbors significant aquatic biodiversity. The river provides refuge to several aquatic species that are rare elsewhere in the basin. Despite flowing through the Semi-arid region, the River supports over 80% of the global gharial population, a healthy population of Gangetic dolphin, and perhaps the only remaining breeding population of the Critically Endangered red-crowned roofed turtle. It is the largest and the most significant breeding ground for the Indian skimmer. The deep-rooted connection between people and the biodiversity of the region warrants stronger incorporation into formal conservation frameworks. Since 1978, 600 km of the river have been protected as the National Chambal Sanctuary. This protection, along with sustained conservation efforts, has played a pivotal role in safeguarding aquatic fauna within the Chambal River, particularly within the sanctuary. However, the river and its biodiversity are severely threatened by anthropogenic stressors and unregulated development. To preserve the ecological integrity and pristine character of the river, it is imperative to address the growing threats along its course. Analysis of the existing river-related national and state-level policies, and Chambal-specific policies, plans, and schemes, was undertaken, and these provide a legal framework for pollution control and river health. Specific sanctuary and eco-sensitive zone notifications have created regulatory buffers for biodiversity and national missions (e.g., Namami Gange, Jal Jeevan Mission),

conservation projects (e.g., Green-Ag), and inter-state mechanisms support river management, soil and catchment rehabilitation, and sustainable development. However, these policies need reformation and amendments to address the dynamic conservation-development issues of the Chambal Basin. The Chambal Basin lacks an empowered basin authority to coordinate across states and sectors. Policies and schemes have a limited focus on ecological flows, holistic river basin management, and community participation. Enforcement and monitoring are not strengthened for effective pollution control, habitat protection, and rural/urban linkages. It is also recommended that the policies need to be flexible and adaptive towards the changing climate and vulnerabilities of the Chambal Basin.

14.1 Introduction

This chapter outlines the existing policy and legislative frameworks governing the management and conservation of the Chambal River, and presents a pathway for action based on a logical framework. This framework links the river and associated freshwater ecosystems in the Chambal River Basin to practical conservation measures.

Following the formulation of an Integrated River Basin Management Plan, a comprehensive legal and policy framework was developed by synthesizing various components of conservation significance. To identify policy gaps and opportunities, relevant national and state-level policies, programs, frameworks, and schemes applicable to the Chambal River were reviewed. Based on this synthesis, policy measures were identified that directly or indirectly influence Chambal River conservation. These were evaluated for their effectiveness, implementation status, and relevance to conservation goals, using a set of predefined indicators, assumptions, and verifiable outputs.

The Integrated River Basin Management Plan was formulated through a nature-based solution lens, addressing key aspects such as the protection of indicator species, habitat restoration, sustainable fishing practices, community engagement, pollution control, and biodiversity mainstreaming in development planning. To strengthen implementation, the framework included mitigation strategies via policy and regulation, awareness-building, and mechanisms for improved monitoring of biodiversity and ecological health. Furthermore, it was harmonized with national and global biodiversity targets, thereby ensuring coherence with international conservation commitments.

This chapter presents a structured overview of the policy landscape for the Chambal River, identifying strategic entry points for enhancing conservation action. By leveraging the logical framework, it proposes actionable pathways to conserve the Chambal River and its associated freshwater ecosystems.

14.1.1 Global threat assessment

Biodiversity forms the fundamental component of an ecosystem. The richness, abundance, and conservation status of species serve as key indicators of habitat status and ecological integrity. In the case of the Chambal River, a combination of literature review and field-based ecological assessments revealed a total of 326 species, including fish, amphibians, birds, mammals, and reptiles (turtles and crocodiles).

The data highlights the Chambal River as a biodiversity hotspot, especially for riverine birds, fish, and reptiles, many of which are species of conservation concern. The presence of several threatened species, including critically endangered gharials, freshwater turtles, and endangered birds, highlights the ecological significance of this riverine habitat and necessitates urgent conservation action. Restoration efforts, pollution control, habitat protection, and community-based conservation are essential to safeguard this fragile and rich ecosystem.

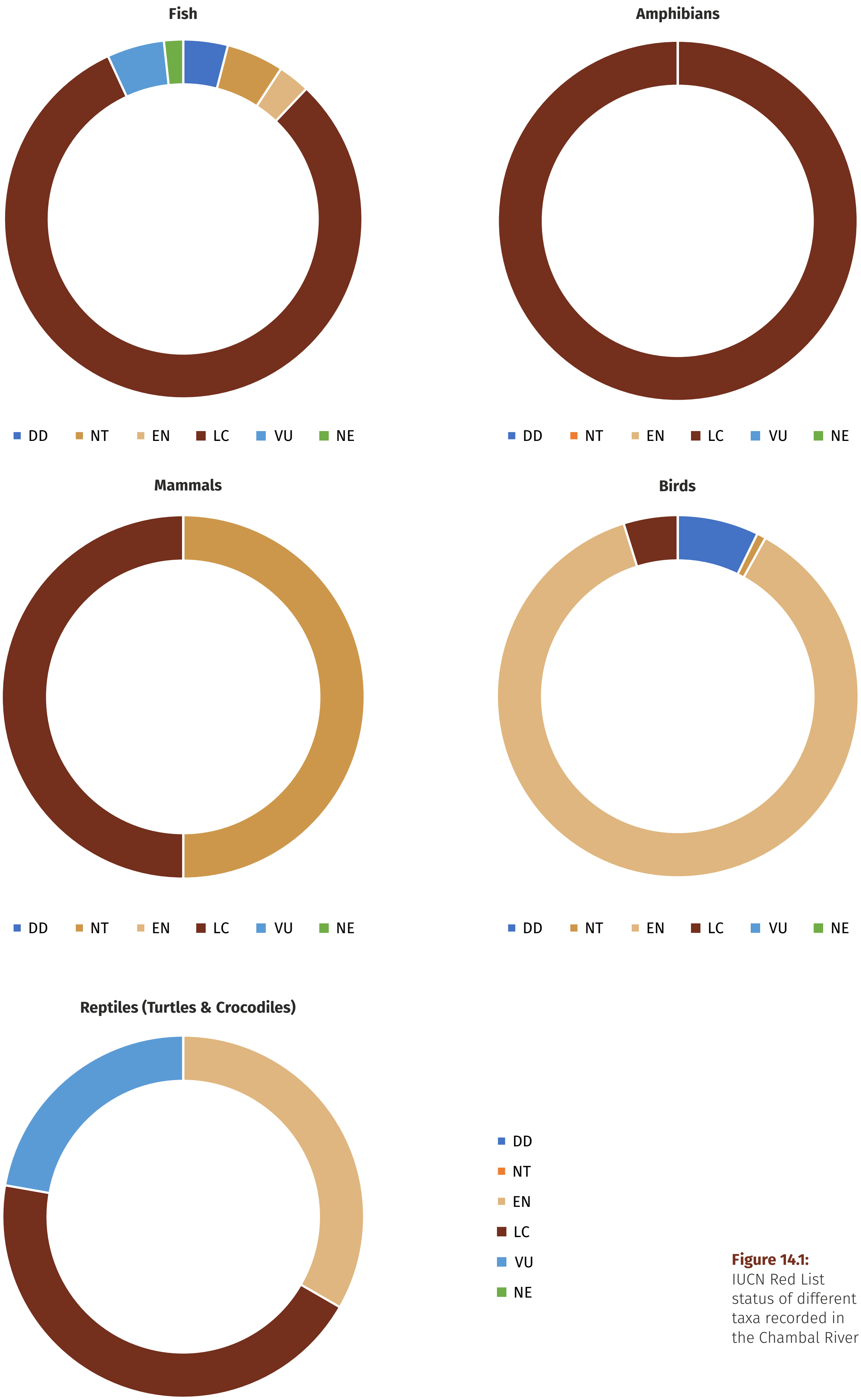


Figure 14.1: IUCN Red List status of different taxa recorded in the Chambal River

14.2 Policy Framework and Analysis

The Chambal River is the first river that was brought under the PA category as a Wildlife Sanctuary- the National Chambal Sanctuary, in 1978, and is the longest riverine protected area of the country. This conservation effort has been instrumental in conserving the aquatic biodiversity of the River. Recently, development pressures, in terms of the increase in water withdrawal and diversion infrastructure, and an increase in agricultural activities, have been noted along the River. The Chambal River has been a beacon of freshwater conservation since 1978, after the initiation of Project Crocodile. When the Sanctuary was declared, the Chambal River had lesser anthropogenic pressure in terms of agricultural activities, human settlements, and thus demand for water was consequently low. The human population growth and associated changes in the Chambal River basin mirrored the changes in the Ganga River basin, resulting in more demand for changed land uses and water. The policies of other sectors could not comprehend the changes in the aquatic diversity due to more water being diverted from the Chambal River.

Even after five decades of being notified as the first riverine Protected Area, the Chambal River lacks a dedicated and unified river basin management plan or a centralized data system for monitoring and decision-making, considering the ecological significance of the River. The River traverses multiple states - Madhya Pradesh, Rajasthan, and Uttar Pradesh, each governed by different legal frameworks, administrative mechanisms, and development priorities, creating challenges for integrated and coherent management (Crichlow, 2001). This absence of a basin-specific policy framework has led to fragmented governance, making it challenging to tackle emerging threats such as increasing pollution from industrial units in regions like Nagda in Ujjain district, unregulated sand mining, encroachments, and declining ecological flows. Despite its status as one of the least polluted rivers in India, the Chambal remains vulnerable to degradation without a structured and enforceable policy that ensures inter-state coordination, uniform monitoring protocols, stakeholder accountability, and biodiversity protection (CPCB, 2016).

Learning from global models and national programs, there is an urgent need to establish a Chambal River Basin Authority. This institution should be empowered with legal backing to oversee catchment restoration, water quality maintenance, ecological flow regulation, biodiversity monitoring, and enforcement of sustainable practices across states. Equally important is the incorporation of community participation and traditional knowledge systems, which enhance policy legitimacy and local stewardship. A well-integrated approach that aligns national initiatives like NRCP and IWRM with basin-level implementation will help reconcile development goals with river conservation, ensuring that the Chambal continues to support both ecological functions and human livelihoods over the long term.

14.2.1 National level policies

India has formulated several national policies, guidelines, and interventions aimed at the conservation, management, and development of rivers, many challenges remain in implementation, coordination, and addressing emerging threats such as climate change and pollution (Tables 14.1 and 14.2). Strengthening governance frameworks, improving data collection and monitoring, and ensuring the participation of all stakeholders are essential steps toward more effective river management.

Table 14.1: National-level policies, programmes, frameworks and schemes applicable to the Chambal River

Policy/Program/ Guidelines/Acts/ Rules/ Interventions/ Plan/Project/ Order	Description	Policy Gaps/ Suggestions	Implementing Agency/Ministry
National Water Quality Monitoring Program, 1972	Regular monitoring of the water quality of major rivers in India to assess pollution levels and water quality.	• Limited focus on smaller rivers, rural water bodies, and localised pollution hotspots. • Limited participation of local community, industries, and stakeholders	Central Pollution Control Board (CPCB)
Environmental Protection Act - 1986 & The Water (Prevention and Control of Pollution) Act – 1974	Provides a legal framework for pollution control in rivers by regulating the discharge of pollutants into water bodies and imposing penalties for non-compliance.	• Limited enforcement, especially in rural and informal sectors • Need for greater public awareness and participation. • Need for more substantial penalties for violations.	Ministry of Environment, Forest and Climate Change (MoEFCC), CPCB, State Pollution Control Board (SPCBs)
National Water Policy, 1987, Revised 2002, 2012	A comprehensive policy framework for the management and conservation of water resources, including rivers. Emphasizes sustainable water management, equitable distribution, interlinking rivers, and river basin management.	• Weak implementation and monitoring mechanisms for river basin management at the local levels and remote areas. • Climate change adaptation measures are missing. • Incoherent and sectoral water governance.	Ministry of Jal Shakti (MoJS)
National River Conservation Plan (NRCP), 1995	Focuses on cleaning and improving the quality of water in major rivers, targeting 38 rivers with a focus on sewage treatment, pollution control, and solid waste management.	• Inadequate monitoring of rural pollution due to long gaps in monitoring and maintenance. • Limited community involvement	MoJS, CPCB, SPCBs
Central Ground Water Authorit Guidelines, 1997	Guidelines to regulate groundwater extraction and prevent over-extraction, impacting river health through hydrological connectivity.	• Lack of strong enforcement and penalties for violations • Rural areas, including agriculture are neglected • Ignoring hydrological interconnectedness • Limited community involvement and lack of public awareness.	MoJS, CGWA
National Biodiversity Act, 2002, 2003	Provides for conservation of biological diversity, sustainable use, and equitable sharing.	• Poor representation of river ecosystems in the People's Biodiversity Register (PBR). • Lax implementation	National Biodiversity Authority (NBA), MoEFCC

Policy/Program/ Guidelines/Acts/ Rules/ Interventions/ Plan/Project/ Order	Description	Policy Gaps/ Suggestions	Implementing Agency/Ministry
National River Linking Project (NRLP) – 2002	Aims to interlink India's major rivers for equitable water distribution and flood and drought mitigation through dams, reservoirs, and canals.	• Inadequate addressal of the environmental concerns	MoJS
National Environment Policy, 2006	A comprehensive policy focusing on environmental protection, including river conservation and managing water quality.	• Inadequate address to the need for climate change mitigation and adaptation strategies. • Lacks robust enforcement and monitoring frameworks, leading to inconsistent implementation across states and sectors. • Limited Public Participation	MoEFCC
Flood Management and Control (FMC) Program, 2008	A program to address flood risks in river basins and improve floodplain management, particularly for flood-prone rivers.	• Inadequate addressal of upstream watershed management or river basin • Weak disaster preparedness and response	MoJS, CWC
National Aquatic Animal Declaration (Gangetic Dolphin), 2009	Declared the Gangetic dolphin a National Aquatic Animal to prioritize its protection.	• Project Dolphin is in the nascent stage.	MoEFCC
National Green Tribunal (NGT) Orders on River Protection, 2010	Orders to control pollution in rivers, including the Yamuna, through judicial directives on pollution control and enforcement.	• Lack of effective enforcement mechanisms, leading to delayed implementation. • Limited focus on holistic river ecosystem management	National Green Tribunal (NGT)
Integrated River Basin Management (IRBM) Framework, 2012	A framework to ensure integrated management of river basins, considering ecological, social, and economic aspects.	• Fragmented governance due to the lack of a centralized, coordinated approach • Insufficient involvement of local communities, industries, and other stakeholders • Absence of comprehensive data collection and real-time monitoring	MoJS, CWC
Water and Sanitation Policy, 2013	A policy to improve water and sanitation infrastructure, which has a direct impact on river water quality by addressing sewage and waste management.	• Lacks a comprehensive focus on climate resilience, equitable access in rural areas, and efficient wastewater management.	Ministry of Housing and Urban Affairs

Policy/Program/ Guidelines/Acts/ Rules/ Interventions/ Plan/Project/ Order	Description	Policy Gaps/ Suggestions	Implementing Agency/Ministry
Swachh Bharat Abhiyan (Clean India Mission), 2014	A nationwide cleanliness campaign aimed at reducing pollution, including cleaning river banks and improving sanitation near water bodies.	• Lacks a robust framework for wastewater treatment and management. • Insufficient emphasis on long-term behavioural change regarding waste management.	MoJS, MoEFCC
Namami Gange Programme – 2014	Flagship program for the rejuvenation and conservation of the Ganga River, focusing on pollution abatement, riverfront development, afforestation, and sustainable livelihoods.	• Slow infrastructure development • Need for a stringent policy regarding waste management and its compliance • Coordination issues between the central and state governments.	MoJS, NMCG
National Mission for Clean Ganga (NMCG) – 2016	Implements the Namami Gange program with a focus on wastewater treatment, pollution control, and biodiversity conservation in the Ganga Basin.	• Need consistent monitoring of water quality and treatment plants. • More focus on tributaries. • Stronger community-based governance.	MoJS, NMCG
Wetlands (Conservation and Management) Rules – 2017	Aims to conserve and manage wetlands that regulate river flows, recharge groundwater, and support biodiversity.	• Need strong guidelines to enforce conservation strategies and stringent actions • Site-specific conservation strategies needed.	MoEFCC
National Water Conservation Campaign, 2019	Promotes water conservation through rainwater harvesting, efficient use of water, and pollution reduction measures.	• Need for more comprehensive and sustained public awareness programs • Adequate monitoring of water conservation efforts and sufficient enforcement of water-saving measures across sectors.	MoJS
Jal Jeevan Mission (JJM) – 2019	Aims to provide potable water to every rural household, promoting sustainable water management and protection of river systems	• Water scarcity and quality challenges in several areas need to be addressed • Over-extraction of groundwater should be checked and penalized • Lack of climate change adaptation strategies to mitigate the loss of drinking water.	MoJS

Table 14.2. Major Concerns and Opportunities for Policy Development

Major Concerns	Description
Water Governance Framework	Lack of a centralized authority for integrated river management at the national, state, and local levels.
Integrated River Basin Management (IRBM)	IRBM application is still in the early stages; stronger coordination is needed across regions.
Climate Resilience	Policies need to address the impacts of climate change, such as erratic rainfall and changing river flows.
Public Participation	Limited involvement of local communities in river management and conservation efforts.
Ecological Flows and Biodiversity	Many policies do not prioritize maintaining the ecological flows that are crucial for aquatic ecosystems and biodiversity.

14.2.2 Chambal River- specific policies

Recognizing the ecological, economic, cultural, and social significance of the Chambal River, efforts have been made to protect its water quality and ecosystem. These initiatives focus on managing human activities such as water extraction, industrial pollution, and encroachment on riverine habitats. The goal is to ensure that the river remains a source of life for both people and wildlife, preserving its unique biodiversity while supporting sustainable development in the region. Through these combined efforts, the long-term preservation of the Chambal River is sought, ensuring its continued role as a critical natural resource (Table 14.3).

Table 14.3: Chambal River-specific policies

Policy/Program/Guidelines/Acts/Rules/Interventions/Plan/Project/Order	Description	Achievements	Policy Gaps/Suggestions	Implementing Agency/Ministry
National Chambal Sanctuary, 1979	Established as a riverine sanctuary along approximately 425 km of the Chambal River, spanning Madhya Pradesh, Rajasthan, and Uttar Pradesh, to protect the Gharial and other aquatic species.	• Supports the largest population of Gharials in the wild. • Habitat for the Gangetic dolphin and eight rare turtle species. • Home to over 320 resident and migratory bird species.	• Address inter-state coordination challenges for unified conservation efforts. • Enhance anti-poaching measures and community engagement • Implement sustainable tourism practices to minimize ecological impact.	Wildlife wings of the Forest Departments of Madhya Pradesh, Rajasthan, and Uttar Pradesh.
Tri-State Coordination Mechanism, 2010	Established to facilitate coordinated conservation efforts across Madhya Pradesh, Rajasthan, and Uttar Pradesh for the National Chambal Sanctuary.	• Development of unified strategies for species protection and habitat management.	• Regular meetings and reporting • Inclusion of local stakeholders in decision-making.	MoEFCC, Forest Departments of the three states.
Environmental Flow Assessment for Chambal River, 2011	Assessment of minimum environmental flow requirements to sustain aquatic life, focusing on species like the gharial and Gangetic dolphin.	• Provided data for informed water management decisions • Highlighted need for maintaining specific flow levels.	• Implement recommended flow regimes • Integrate findings into river basin management plans.	Wildlife Institute of India (WII); MoEFCC.
Green-Ag Project (Chambal Landscape), 2020	A project aimed at integrating biodiversity, climate resilience, and sustainable agriculture in the Chambal landscape of Madhya Pradesh.	• Implementation of sustainable agricultural practices • Community engagement in conservation efforts.	• Expand project reach • Continuous monitoring and evaluation needed to assess tangible and non-tangible ecological benefits • Strengthen community-based conservation models	Ministry of Agriculture & Farmers Welfare; Directorate of Farmer Welfare and Agriculture Development, Madhya Pradesh.
Eco-Sensitive Zone Notification, 2020	Declared an 870 sq km area around the National Chambal Sanctuary in Madhya Pradesh as an Eco-Sensitive Zone (ESZ), prohibiting polluting activities such as industries, major hydroelectric projects, mining, stone quarrying,	• Legal framework established to regulate and restrict environmentally degrading activities around the sanctuary. • Mandated the preparation of a 'zonal master plan' and an 'eco-tourism master	• Expedite the development and implementation of the zonal and eco-tourism master plans. • Strengthen monitoring and enforcement mechanisms to ensure compliance with ESZ regulations	

Policy/Program/ Guidelines/Acts/ Rules/ Interventions/ Plan/Project/ Order	Description	Achievements	Policy Gaps/ Suggestions	Implementing Agency/Ministry
	and large constructions within the 'no-go area' to conserve its unique ecology.	plan' to promote conservation and sustainable tourism.	• Promote community participation in conservation and eco-tourism initiatives.	
Parbati-Kalisindh-Chambal River Linking Project, 2024	An inter-state river linking project was initiated to provide water to the eastern districts of Rajasthan by diverting surplus monsoon water from rivers like Kalisindh and Parbati into water-deficient sub-basins. The project aims to supply drinking and industrial water to 13 districts and irrigate approximately 282,000 hectares of land.	• Initiation of a significant water resource project expected to enhance water availability for drinking, industrial use, and irrigation in eastern Rajasthan.	• Ensuring equitable water-sharing agreements between states and addressing environmental concerns related to river interlinking is critical. • Detailed environmental impact assessments and stakeholder consultations should be prioritized.	MoJS, in collaboration with the Governments of Madhya Pradesh and Rajasthan

14.2.3 State-level policies on Chambal River

Administrative priorities, ecological understanding, and regional development goals have shaped conservation efforts for the Chambal River at the state level. Each state- Madhya Pradesh, Rajasthan, and Uttar Pradesh has taken independent initiatives to manage and protect the River and its associated biodiversity. These efforts typically focus on wildlife protection, controlling human disturbances like illegal mining, and maintaining ecological balance within designated protected areas.

However, due to the River's transboundary nature, strategies tend to be fragmented. States often work in isolation, leading to inconsistencies in management practices and enforcement. While some areas benefit from focused conservation attention, others remain neglected, creating ecological imbalances along the River's length.

At the state level, these initiatives have had mixed impacts. In some stretches, especially where conservation measures have been actively enforced, there has been a noticeable recovery of flagship species such as the gharial and the Indian skimmer. Local economies have also benefited modestly through ecotourism and increased awareness. However, the lack of coordination among states, inconsistent enforcement, and varied commitment levels have limited the broader success of conservation across the entire river basin. To achieve a more substantial and lasting impact, a unified and collaborative approach among the states is essential, and the current year-long policies are described in Table 14.4.

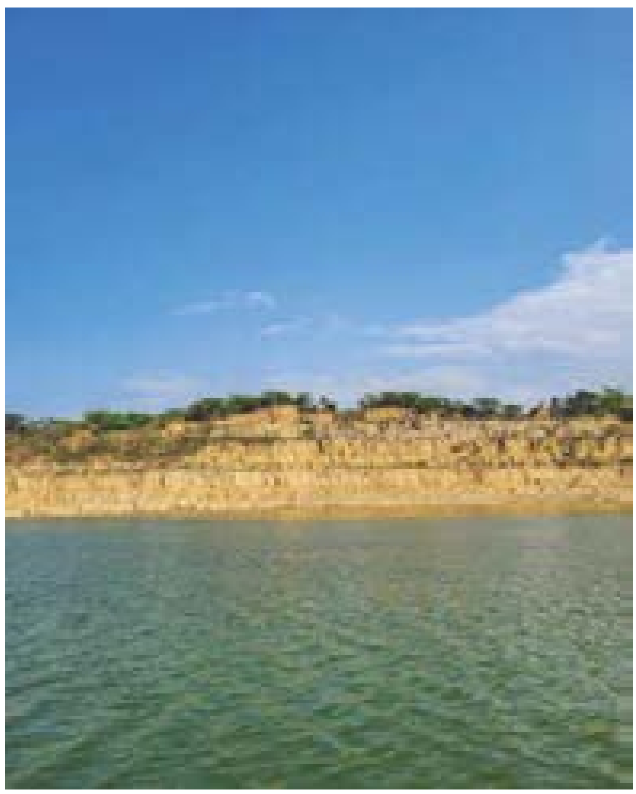


Table 14.4: State-level policies impacting the Chambal River

State	Policy/Program/ Guidelines/Acts/ Rules/ Interventions/ Plan/Project/ Order	Description	Achievements	Policy Gaps	Implementing Ministry
Rajasthan	Soil Conservation in the Catchments of River Valley Projects (RVP), 1965	• Aimed at rehabilitating catchment areas of rivers like Chambal, Mahi, and Dantiwara in Rajasthan through soil conservation measures to minimize erosion and enhance land productivity. The project also focuses on protecting and managing catchment areas to benefit water resource development, including drinking and irrigation water, by reducing sediment flow into river systems.	• Implementation of soil conservation measures in critical catchment areas has reduced erosion, improved land productivity, and increased the lifespan of reservoirs due to decreased sedimentation.	• The primary focus of RVP is soil conservation, with limited emphasis on river-specific conservation measures. • Focus is on enhancing agricultural productivity, thus there is a need to monitor the unauthorized water pumps.	Ministry of Agriculture and Cooperation, in collaboration with the Forest Department of Rajasthan
Madhya Pradesh	Action Plan for Pollution Control in Chambal River, 2018	• Initiatives to minimize pollution in the Chambal River, through sewage treatment and industrial effluent management.	• Preparation of Detailed Project Reports for sewage treatment; and proposed schemes for pollution dilution.	• Need for timely sanction and implementation of projects • Continuous monitoring needs to be undertaken	Madhya Pradesh SPCB; Municipal Councils; Water Resources Department.
Madhya Pradesh	Declaration of Eco-Sensitive Zone (ESZ) around National Chambal Sanctuary, 2020	• Area extending up to 2 kilometers around the National Chambal Sanctuary in Madhya Pradesh is declared as an Eco-Sensitive Zone to prohibit polluting activities and promote conservation.	• Establishment of regulatory measures to control industrial and developmental activities around NCS, aiding in the preservation of its unique biodiversity.	• Comprehensive and timely implementation of the zonal master plan with active involvement of local communities is essential. • Need to conduct regular assessment of the ecological impact of permitted activities within the ESZ.	MoEFCC in coordination with the Government of Madhya Pradesh

State	Policy/Program/ Guidelines/Acts/ Rules/ Interventions/ Plan/Project/ Order	Description	Achievements	Policy Gaps	Implementing Ministry
Rajasthan, Madhya Pradesh	Ramjal Setu Link Project (formerly Parbati-Kalisindh-Chambal-Eastern Rajasthan Canal Project), 2024	• An inter-state river linking project was initiated to provide water to the eastern districts of Rajasthan by diverting surplus monsoon water from rivers like Kalisindh and Parbati into water-deficient sub-basins. The project aims to supply drinking and industrial water to 13 districts and irrigate approximately 282,000 hectares of land.	• Initiation of a significant water resource project expected to enhance water availability for drinking, industrial use, and irrigation in eastern Rajasthan.	• Detailed environmental impact assessments and stakeholder consultations need to be prioritized.	Government of Rajasthan, with support from the Government of India and coordination with the Government of Madhya Pradesh

14.3 Key Policy Gaps in Chambal River Management

Managing the Chambal River comes with a range of complex challenges, many of which stem from key gaps and limitations in current policies. One major issue is the limited coordination between Madhya Pradesh, Rajasthan, and Uttar Pradesh, the three states through which the River flows. While each state has its conservation plans, the absence of a cohesive, basin-wide strategy may reduce the effectiveness of these efforts and fail to acknowledge the nature of the river as a single ecological system (WWF India, 2020). While the National Chambal Sanctuary offers some level of protection, areas beyond its jurisdiction, especially upstream and downstream, remain largely unprotected, making them vulnerable to degradation.

Strengthening the enforcement of existing environmental laws is another major concern. Despite a comprehensive regulatory framework, challenges such as illegal sand mining, poaching, and encroachment are rampant due to limited on-ground monitoring capacity and enforcement mechanisms (Divan & Rosencranz, 2022). Water regulation also poses a serious threat. The construction of dams and irrigation channels in the upstream stretch has altered the river's natural flow, and the absence of consistent policies to ensure ecological flow impacts species like the gharial and river dolphin (Choudhury et al., 2007).

Current policies tend to follow a top-down approach, with limited provisions for active community participation in decision-making processes. Therefore, it is essential to adopt a participatory approach that actively engages local communities in the design and implementation of policies. This ensures inclusion of their local knowledge and effectiveness of conservation programs (Hussain et al., 2013). Moreover, there is a significant gap in scientific data. Regular monitoring of species and habitats is lacking, making it challenging to develop well-informed conservation strategies. Hence, there is a need to strengthen the scientific basis for conservation actions through regular ecological monitoring and data-driven decision-making.

Pollution control also requires focused attention. Untreated wastewater from industries, agriculture, and households continues to flow into the river, particularly in areas outside protected areas, highlighting the need for improved implementation of pollution control measures (Central Pollution Control Board, 2020). Coordination among institutions can be further streamlined to reduce overlapping responsibilities among departments and agencies like the District and Block Administration, Forest Department, Irrigation Department, Agriculture Department, NRLM, and Pollution Control Boards to improve the efficiency of governance mechanisms. On top of all this, conservation initiatives would benefit from long-term financial planning, sustained and increased funding, and greater focus on integrating climate resilience measures, in light of increasing climate variability and resulting vulnerability observed in the Chambal basin (IPCC, 2022).

14.4 Future Action Plans

Despite these steps, challenges remain in terms of inter-state coordination, pollution control, and maintaining minimum river flow. To strengthen conservation outcomes, states are increasingly recognizing the need for a more integrated and collaborative approach. These planned actions, if implemented with commitment and collaboration, have the potential to significantly improve the ecological health of the Chambal River and ensure the long-term survival of its rare and endangered species (Figure 15).

Inter-State Coordination Mechanism: Establishing a joint river basin authority or task force to streamline policies and conservation actions across state boundaries.

Eco-sensitive Zoning and Buffer Expansion: Identifying critical habitats and expanding protection beyond current sanctuary boundaries to include upstream and downstream areas.

Community-Based Conservation Models: Increasing participation of local communities in monitoring, ecotourism, and conservation livelihoods to ensure sustainable stewardship of the river.

Scientific Monitoring and Data Sharing: Creating shared databases on water quality, species status, and human activities to support evidence-based planning.

Control of Sand Mining and Pollution: Strictly regulating unsustainable mining activities and improving wastewater management to reduce ecological stress.

Environmental Flow Management: Coordinating with water resource departments to maintain essential flow levels needed to support aquatic life.

Capacity Building and Funding Support: Enhancing training for forest and enforcement staff and securing consistent financial support through state budgets and national programs.

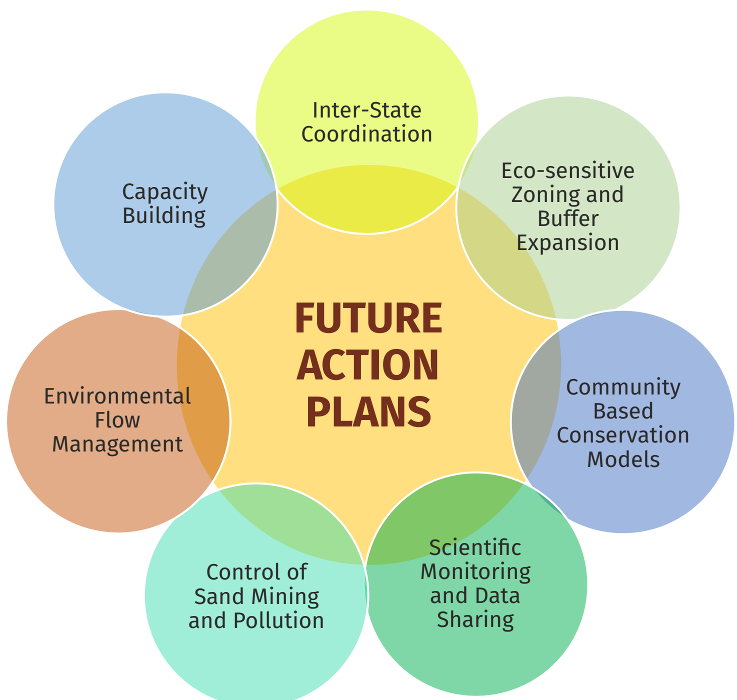


Figure 15: Future Action plans to be implemented

14.5 Conclusion and recommendations

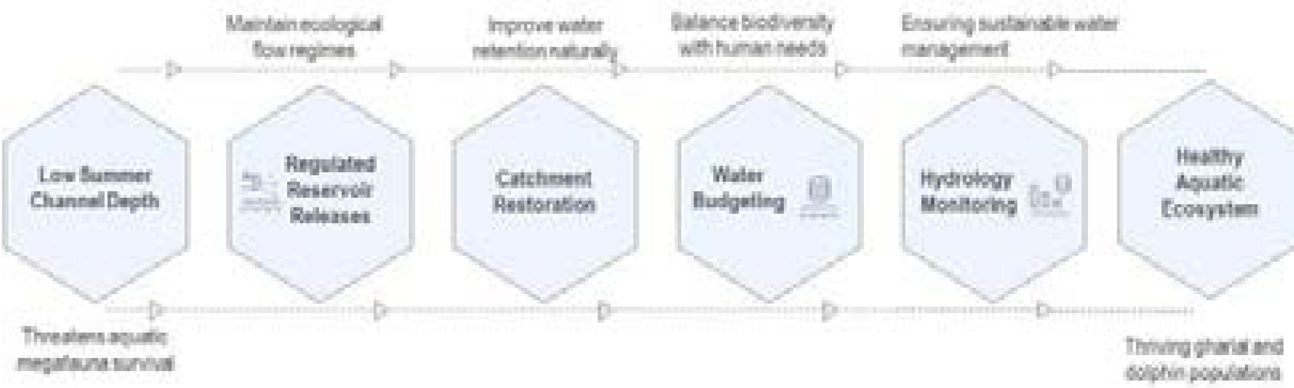
The Chambal River Basin stands out as both an ecological treasure and a vital economic resource, supporting millions of people who rely on its resources for drinking water, farming, fishing, livestock rearing, and other nature-based livelihoods. Despite the region's challenging semi-arid conditions and rugged ravines, local communities across Madhya Pradesh, Rajasthan, and Uttar Pradesh have close relationship with the river and its ecosystem. However, in recent years, increasing population, changes in land use, expansion of infrastructure, and shifting climate patterns have put considerable pressure on both the basin's diverse wildlife and the long-term viability of traditional village economies.

Historical knowledge, which is constantly updated by revisions and by the addition of new information, will be the key to a sound conservation strategy for safeguarding the future of the key aquatic species of the Chambal River as well as of the Ganga River basin. New areas of focus should involve knowledge gaps in understanding the current status of different species. The socio-economic status of the human population, dependent on the NCS, should be factored in. The importance of restoring the Chambal River needs to be highlighted to involve the local communities and garner their support.

Based on the findings of our study, we have the following recommendations for the conservation and management of key aquatic fauna in the Chambal River:

14.5.1 River Hydraulics

- Hydrological assessments indicate that suitable channel depth, particularly during summer months, is crucial for aquatic megafauna like the gharial and dolphin.
- Flow restoration through regulated releases from upstream reservoirs, combined with catchment restoration, is essential to maintain ecological flow regimes.
- Development of ecologically sound and socially equitable water budgeting for the Chambal is crucial to balance biodiversity needs with human demand.
- There should be a hydrology monitoring mechanism in place to carry out stage and discharge readings at regular intervals. The information thus gathered will help equip the forest department in determining the threshold at which the Chambal River can flow at environmentally acceptable levels. Flow monitoring is vital information in the face of growing demand for extracting water from the Chambal River for other purposes. The present study reiterates the recommendation given by WII (2011), which the National Board for Wildlife (NBWL) further endorsed in its 18th meeting of the standing committee, that no new water extraction should be allowed on the Chambal River. Water extraction from the Chambal River will irreversibly threaten the long-term survival of the key faunal species. It may alter the River's ecological function and associated services necessary for human well-being.



14.5.2 Species Restoration

- Gharial and dolphin populations in the Chambal have become increasingly isolated. Maintaining connectivity and suitable habitat is key to their recovery.
- Based on recent surveys, several biodiversity-rich zones within the Chambal have been identified, which should be prioritized for conservation and restoration.
- Crocodilians and turtles are particularly sensitive to sandbar disturbance. Illegal sand mining, bank modifications, and unsustainable riverine agriculture must be controlled.
- It is recommended that the ongoing rear and release program be discontinued by gradual scaling back for at least five years, as it will provide a chance for the population to stabilize itself naturally. Annual population counts should be supplemented by intensive population monitoring throughout the year. Considering the open landscape of the Chambal River, the use of drones should be adopted and encouraged for monitoring the populations and anthropogenic activities.
- Radio telemetry of individuals being released via the rear and release program should be encouraged. Tracking animals using telemetry will help provide better insights into the survival of captive-reared individuals in the wild. The information thus gathered can be used to amend current practices.
- Specific in-situ protection measures need to be in place to reduce nest loss. Having an active presence of field staff at all the nesting sites or guards can be employed for the entire duration of the nesting season, beginning from the trial nesting period until the hatching period (February to June). These people can patrol segments of the river to check for signs of nesting initially. Once located, these nests should be monitored daily to assess the condition of nesting sites gradually.
- Nest protection measures can also be used wherever necessary. After locating a nest, it can be covered

with a thick layer of thorny vegetation, preferably *Prosopis juliflora*. Alternatively, a wire mesh can also be used to cover the nests. These techniques can be used to reduce nest loss, as predators usually find it challenging to dig past the wire mesh or the thorny vegetation. However, nests must be detected and covered for protection, ideally within one week of the eggs being laid. Further, while protecting the nest, utmost care should be taken to ensure that none of the eggs are disturbed or removed, and the process of covering the nest should be carried out as quickly as possible, to avoid altering the environment within the nest, which is crucial for proper embryo development.

- The gharial is a highly conservation-dependent species, and translocations without assessing the genetic status of the source populations may further deteriorate the level of genetic diversity in the translocated populations. Hence, we recommend limiting the inter-population release of individuals to prevent further intermixing of the gene pool until information on the genetic status of the extant wild and captive gharial populations using an extensive dataset of mitochondrial and microsatellite markers is available.

14.5.3 Stretch-specific Implications

- Different sections of the Chambal River face varying degrees of anthropogenic pressure. While the upper and middle stretches benefit from the National Chambal Sanctuary, threats such as sand mining, altered flows, and illegal fishing persist.
- Flow regulation and maintenance are essential, particularly in the breeding zones of gharials and dolphins. Further water diversion projects would severely undermine the ecological integrity of these critical habitats.
- The downstream stretches, nearing the Yamuna confluence, suffer from reduced flow and habitat degradation, requiring restoration interventions.

14.5.4 Emergent Situations

- The sudden die-off in the Sanctuary between December 2007 and February 2008, in which at least 110 gharials died in the lower half of the Sanctuary, revealed the lack of essential rehabilitation facilities, adequate expertise, and knowledge in crocodilian health. The DGRC also experiences annual mortalities in the hatchling stock. Between December 2018 and January 2019, six juvenile gharials at the DGRC died. However, the cause of death could not be ascertained.
- A disease outbreak is likely to severely endanger both wild and captive populations. Thus, there is a pressing need to train local veterinarians in crocodilian health, physiology, disease management, and monitoring, and provide first response training to front-line forest department staff. A cadre of such trained professionals will useful for monitoring the health of captive and wild gharial populations. Additionally, capacity-building of forest staff and local stakeholders is essential to ensure effective on-ground conservation response
- Rescue and rehabilitation protocols for aquatic wildlife, particularly during flood events or stranding, are urgently needed.

14.5.5 Way Forward

- Restoration planning should begin with comprehensive historical and ecological assessments. Literature reviews and ongoing biodiversity surveys provide the foundation.
- Protected areas in the Chambal (currently the National Chambal Sanctuary) should be expanded or enhanced to cover additional biodiversity-rich stretches.
- Aquatic ecotoxicology studies are needed to assess the impact of agrochemicals and pollutants on the food web.

14.5.6 Community based conservation efforts

Efforts on the ground have highlighted the power of community-led conservation and collaborative planning, demonstrating how protecting the river can go hand in hand with local development goals. By bringing villagers together-strengthening groups like self-help circles and panchayats, and building skills-these projects have encouraged greater responsibility for the area's natural resources. Still, fragmentation in policies and institutions, coupled with persistent challenges to people's livelihoods, underlines the urgent need for development strategies that are not only resilient and inclusive but are also tailored to the unique needs of each local community. Based on our analysis and field observation, the following recommendations are proposed for the Chambal River Basin:

- Community-based conservation, including nest protection programs and awareness campaigns, should be expanded.
- Institutionalize microplanning involving all socio-economic strata and stakeholders, i.e., farmers' groups, women's collectives, youth, village panchayats, departments, government, and non-government organizations-to develop joint action plans that balance resource use with conservation.
- Prioritize inclusion of local concerns and needs in planning, mapping of natural resources, and the setting of village-level sustainability objectives, such as reducing soil erosion, managing grazing, restoring local water bodies, and sustainability of local livelihoods.

- Skill base of the local communities, especially women and youth, needs to be developed to mainstream their participation in conservation planning and actions.
- Reduce direct dependence of local communities on river resources such as fish by promoting alternative green livelihoods and employable skill sets.
- Promote agricultural diversity to attain healthy agro-systems and nutritional security, and establish market linkages for value-added and processed local produce to ensure the livelihood security of agriculture-dependent communities.
- Ganga Praharis should be involved in conservation and environment-related planning and actions. This human resource can be used in site-specific interventions such as soil and water conservation projects, community-managed rainwater harvesting, restoration of riparian buffer zones, and rescue of aquatic life in distress.
- Link Ganga Praharis with ongoing livelihood and conservation schemes such as the National Rural Livelihood Mission and local biodiversity committees for scaling up successful local initiatives.
- Facilitate farmer-producer organizations (FPOs) and local institutions and Ganga Prahari groups to access microcredit, insurance, and technical extension services essential for livelihood upgrades.
- Interstate authority should be in place to ensure conservation-sensitive development in the basin and to ensure e-flow in the mainstem Chambal River.
- Strong enforcement of the rules and regulations to minimize the disturbances, such as illicit sand mining and unsustainable water abstraction.
- Climate change poses additional threats through altered flow patterns and temperatures. Scenario-based planning and adaptive conservation strategies should be employed.
- Conservation in the Chambal must also address socio-economic realities. Programs that integrate livelihood support with conservation goals, such as eco-tourism or participatory monitoring, will help secure local cooperation and long-term ecological resilience.

14.6 Logical Framework for Conservation Planning of the Chambal River

To conserve and protect the Chambal River and its biodiversity, a series of interlinked timely actions need to be undertaken, which are provided in the table 14.4, through the logical framework. The framework emphasizes on the integration, coherence, data and knowledge sharing, among the key agencies. It also focuses on the site-specific measures and governance measures, particularly in the Chambal River states. The goal for framing the logical framework is ecological restoration of the Chambal River through integrated river basin management and planning. The Logical framework lists the objective wise task, corresponding strategies or actions, indicators, means of verification, assumptions along with a suggestive and non-exhastive list of agencies responsible and supporting organizations.

Table 14.5: Framework for conservation planning of the Chambal River

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
Objective 1: Address knowledge gaps through systematic research and monitoring			
1.1	Establish a network of institutions dedicated to conducting inter-disciplinary research and monitoring programs incorporating experts in biodiversity, aquatic ecology, habitat assessment. Ecotoxicology, socio-ecological linkages	• Number of institutions/ universities in the network • Aquatic life standards for priority contaminants/ river water quality parameters developed • Ecosystem health indices developed	• Records of network of institutions • Number of research papers published under collaborations
1.2	Conduct systematic and regular monitoring of the species and their habitat, and holistic ecological risk assessments to evaluate the impact of anthropogenic activities	• Competent organization/body for regular monitoring constituted • Number of scientific research grants • Number of Master's and Doctoral theses published	• Number of scientific and technical reports/publications • Scientific reports to support the policies for effective mitigation plans
1.3	Development of data repositories	• Regular compilation of data from reports and research papers into a common repository	• Regular updates and cross-verification from data sources • Syntheses in the form of review papers and meta-analyses
1.4	Ensuring data availability	• Number of popular articles/ news reports published • Number of open access scientific publications • Number of citations per publication	• Number of requests for data availability

Assumptions	Agencies responsible	Supporting Organizations
• Institutes are willing and/or incentivized to collaborate • Funds are mobilized by the Government for such purposes • Rules and legislation support frequent monitoring over larger sampling sites, for example Expansion of National Water Monitoring Programme, 2019	• MoJS • MoEFCC • State Forest Departments	• Central, State institutions, universities and Civil Society Organizations, including, but not limited to: • Wildlife Institute of India, • Indian Institute of Toxicological Research • IIT – Indore, and other technical universities within the Chambal River Basin • State Agriculture Universities • WWF- India • Wildlife Trust of India
• Adequately trained personnels available • Government mandate to include ECs in National monitoring Programme • Government commitment to establish, upgrade and support such studies/facilities • Incentives to early career researchers and university students	• MoJS • MoEFCC including • State Forest Departments	• Multi academic and research institutes working in the domain, including, but not limited to: Wildlife Institute of India, Dehradun • State Agriculture Universities
• Coordination between different stakeholders • Adequately trained, dedicated personnel	• MoJS • MoEFCC including • State Forest Departments	• Central and State government set up of dedicated bodies
• Legislation facilitating data sharing and availability • Adequate funds for publishing open access peer-reviewed research • Involvement of mass media and popular media	• Central, State institutions, universities	• DST • Respective research institutions and universities

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
Objective 2: To improve, restore and minimize the alteration of riverine habitats			
2.1	Make the existing & proposed Dams/ Barrages conservation friendly keeping in mind the needs of aquatic species.	• Population status distribution of dolphins, associated species and indicator species • Supportive policies and guidelines	• Numbers of existing dams/barrages/ other infrastructure which have included mitigative measures as per the ecological requirement • EIA reports of proposed dams/ barrages/ other river constructions
2.2	Design/restructure policies and guidelines for regulation of water flows from dams and barrages and maintain adequate e-flow in the river.	• Status of seasonal river depth • Status of seasonal sediment load • Status of seasonal water discharge • Status of seasonal water abstraction • Number of site-specific assessments of e-flow	• Records from CWC (central water commission), • Records of irrigation department • Records of IWAI on seasonal water discharge
2.3	Identify the hotspots/priority stretches for intensive conservation planning	• Number of hotspots identified	• Number of surveys undertaken for population, habitat and anthropogenic pressure mapping
2.4	Delineate and map the riverine habitats, including the river banks and the river islands	• Number of maps generated • LULC of each unit identified	• Spatial and seasonal database on the riverine habitat
2.5	Use NbS for restoring riverine habitats and floodplain	• Theme based NbS generated – urban areas, agriculture, wetland, waste water, forests, industries • Government orders for adoption of NbS	• Number of NbS generated • Area brought under NbS • Number of farmers adopting NbS approach • Number of urban areas adopting NbS

Assumptions	Agencies responsible	Supporting Organizations
• Compliance by agencies • State and trans-boundary river water management policies remain supportive throughout the project period	• Ministry of Jal Shakti • Ministry of New and Renewable Energy • Ministry of Environment, Forest and Climate Change • State Governments	• State Willdife Department • Wildlife Institute of India • State Jal Viduyt Nigam Ltd
• Data available for public sharing • Data collected regularly by concerned agencies	• Ministry of Jal Shakti • Ministry of Agriculture • Ministry of Industries	• State Wildlife Department • Wildlife Institute of India • State Jal Vidut Nigam Ltd
• Data on population and habitat status is available	• Ministry of Environment, Forest and Climate Change • State Forest department	• Wildlife Institute of India • Civil Society Organizations
• Funds are mobilized for such activity	• MoEFCC • MoJS	Central, State institutions, universities and Civil Society Organizations, including, but not limited to: • Wildlife Institute of India • Indian Institute of Toxicological Research • IIT Indore • State Technical and Agriculture Universities • INTACH
• NbS are acceptable by the stakeholders • All stakeholders are willing to cooperate and work together • Funds are mobilized for such activities	• MoJS • MoEFCC • State Governments • Ministry of Agriculture • Ministry of Industries	• Research Institutions • Urban local bodies • Village Panchayat • Civil Society Organizations • Industries

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
Objective 3: Reduce pollution level in the Chambal River and its tributaries			
3.1	Establish adequate functional infrastructure for treatment of industrial and municipal waste water discharge.	• Percentage of industries with functional treatment facilities • Percent of households connected to the STPs • Level of discharge of untreated waste.	• Reports of SPCBs and Municipalities • Reports on compliance management and performance evaluations such as • Operational Checks, key monitoring parameters, effluent quality testing, sludge management • Regular Water quality monitoring and risk assessment across large spatiotemporal scales
3.2	Identification, tapping, and monitoring of high priority drains in rivers - Drains in Delhi, Mathura, Vrindavan, and Agra - Drains joining the Hindon River	• Number of priority drains identified based on pollutants load and flow Interception and diversion of priority drains to STPs/ETPs • WWTPs	• Municipality Records • Water quality reports
3.3	Ensure effective functioning of above infrastructure using supportive laws and promoting good practices	• Multi-tier evaluation approach in place • Agencies identified for evaluation of effective functioning of existing and newly established infrastructure • Number of training and workshops undertaken for sensitization of different stakeholders such municipalities, state pollution control board, industrial sectors, PWD • A framework established for assessing the quality of reclaimed wastewater and sludge reuse	• Regular Audits/Monitoring Reports for status of priority pollutants in wastewater/sludge • Regular data on quantity of reclaimed wastewater/sludge • Number of industries and farmers using the reclaimed wastewater and sludge

<table>
<tr><th>Assumptions</th><th>Agencies responsible</th><th>Supporting Organizations</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Strict implementation of guidelines/protocols
Compliance with Zero Liquid Discharge Rules
Water Prevention and Control of Pollution Act 1974 and of the Environment Protection Rules of 1986
National Green Tribunal Act, 2010
Municipal Solid Waste (Management and Handling) Rules
Plastic Waste Management (Amendment) Rules, 2021, Extended Producer Responsibility (EPR)
Water Supply and Sewerage Act, 1975 and other state-based legislation</td><td>Industrial sectors such as Textile, Brass, Petrochemical, Pharmaceutical, Cement and Agrochemical industries, distilleries and tanneries etc., in each catchment
MoEFCC, Municipal agencies
Ministry of Jal Shakti
Central/State Pollution Control Board (CPCB/SPCB)
NGT</td><td>Companies involved in developing and disseminating emerging technologies for wastewater treatment</td></tr>
<tr><td>Govt. commitment to divert identified priority drains to STPs/ETPs/WWTPs
Legislation including Guidelines on Water Quality Monitoring, 2017 is functional</td><td>Ministry of Jal Shakti
MoEFCC
CPCB/UPPCB, in collaboration with multiple competent research institutions</td><td>SPPCB
IITs
Agencies (public and private) working towards advanced remediation technologies</td></tr>
<tr><td>Regular evaluation for STPs/ ETPs/ WWTPs for efficacy/ performance by multiple competent organization
Policy upgradation & implementation
Enhanced Acceptance of Using Reclaimed Wastewater and Sludge</td><td>Ministry of Jal Shakti
MoEFCC
CPCB/UPPCB, in collaboration with multiple competent research and legal organizations</td><td>State Legal Services Authority (SLSA)
National Law Universities, Lucknow
Faculty of Law, Allahabad University
Faculty of Law at IIT-BHU, Varanasi</td></tr>
</table>

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
3.4	Reduce the use of toxic pesticides and fertilizers in river bank agriculture and riverbed cultivation through adoption of green agriculture practices (organic farming, hydroponics, integrated farming)	• Number of farmers adopting green agriculture practices • Extent of area under green agriculture practices	• Agriculture department records • Survey of farmers involved in green agriculture.
3.5	Develop eco-friendly public transport electric rickshaws and buses	• Number of intra- and inter-city buses operating • Number of electric buses/rickshaws/trains operating	• Emission reports • Pollution control reports for public vehicles
Objective 4: Reduce Pollution Level in Rivers with Nature-Based Solutions			
4.1	Establish constructed wetland systems and bioremediation infrastructure Implement nature-based solutions (NbS) like constructed wetlands, floating wetlands, riparian buffer zones, urban green belts, and eco-drains for pollution filtration and nutrient trapping.	• Area covered by functional NbS units • Number of polluted drains/water bodies treated using NbS • Reduction in nutrient (N, P) and BOD levels at outlet points • Increase in biodiversity index (e.g., benthic macroinvertebrates, aquatic flora)	• GIS maps and status reports of NbS installations • Pre- and post-treatment water quality assessments • Ecological health monitoring datasets • Independent third-party performance audits
4.2	Implement floodplain restoration and ecological corridor development Restoration of natural flood retention and biodiversity corridors	• Length of floodplain area restored • Number of native species reintroduced • Increase in natural flood retention • Amount of CO_2 sequestration annually	• Satellite imagery analysis • Forest cover assessment reports • Species diversity surveys • Flood management studies • Carbon stock measurements
4.3	Promote decentralized treatment through eco-friendly STPs and DEWATS (Decentralized Wastewater Treatment Systems) in peri-urban and slum clusters draining into Yamuna.	• Number of DEWATS units installed and functional • Percent population covered by decentralized treatment • Slum areas with zero direct discharge into Yamuna	• Municipal records and project reports • Community monitoring dashboards • Slum sanitation and drain mapping reports

Assumptions	Agencies responsible	Supporting Organizations
• Govt. bodies vigilance on tracking/ controlled use of pesticides • Govt. commitment to provide subsidies on organic/ Ecofriendly Pesticides & fertilizers • Willingness of the farmers to accept/adopt ecofriendly and modern agricultural practices	• Ministry of Agriculture & Farmers Welfare • Directorate Of Plant Protection, Quarantine & Storage • Ministry of Panchayati Raj • MoEFCC	• Krishi Vigyan Kendras • State Agriculture Universities • Local Administrative dept • State Forest Department • NMCG
• Availability of adequate funds for investment in vehicles and infrastructure • Incentives for switching to eco-friendly transportation provided	• MoEFCC • CPCB/UPPCB • State Transport Department • UPSRTC • Technological Universities	• IIT Delhi • IIT-BHU, Varanasi • IIT Kanpur • State technological universities
• Land availability and public cooperation • Maintenance protocols developed • Long-term integration with urban planning	• Municipal Corporations • UP Irrigation Dept. • Ministry of Jal Shakti • CPCB/SPCBs	• Research institutes (TERI, NEERI, IITs) • NGOs working on river restoration (e.g., INTACH, CSE) • Urban planners, hydrologists
• Effective Yamuna Floodplain Zoning enforcement • Encroachment removal per NGT orders • Inter-state government coordination • Sustainable financing mechanisms	• Ministry of Environment, Forest and Climate Change • State Forest Departments • Delhi Flood Control Department • YEIDA	• World Wildlife Fund India • Yamuna Jiye Abhiyan • Forest Survey of India • ICFRE
• Inclusion of DEWATS in master plans • Behavioural change and ownership by local communities	• Urban Local Bodies • Jal Nigam / Jal Boards • NGOs facilitating community sanitation	• CSR wings of industries • International orgs (UN-Habitat, GIZ, World Bank)

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
4.4	Rejuvenate urban drains (e.g., Najafgarh drain) through nature-based remediation like bio-remediation beds, vegetated sand filters, and aquatic plant-based systems.	• Number and length of rejuvenated drains • Reduction in E. coli, BOD, COD in treated flows • Drain-to-river water quality improvement index	• Drain rejuvenation progress reports • Microbial and chemical testing results • Satellite-based land cover change detection
4.5	Integrate pollution control through policy instruments aligned with ecosystem-based river basin management (e.g., urban river management plans, blue-green infrastructure guidelines).	• Number of river zone management plans adopted • NbS components integrated into city masterplans • Budget allocation for ecosystem-based solutions	• Urban planning reports • NMCG/Smart City Mission documents • State action plans and EIA reports
4.6	Develop community managed wetland and ghat restoration programs	• Number of active community groups in restoration • Number of ghats with community-based management • Number of traditional water harvesting structures restored • Number of local employment opportunities created	• Community participation reports • Ghat management committee minutes • Employment generation statistics • Traditional knowledge documentation • Social impact assessments
Objective 5: Develop sustainable pollution abatement with a focus on plastic management			
5.1	Implementing effective plastic waste collection systems	• Reduction in plastic waste along riverbanks and in water	• Regular monitoring reports and visual inspections
5.2	Enhancing recycling programs	• Increase in the volume of plastic waste recycled	• Recycling facility records and reports
5.3	Public awareness campaigns on plastic reduction	• Increased public awareness and participation in waste reduction activities	• Surveys and feedback from community members

Assumptions	Agencies responsible	Supporting Organizations
• Continuous flow and pollutant load monitoring • Timely desludging and vegetation management	• DJB / Delhi Drainage Circle • CPCB • State Wetland Authorities	• Start-ups in bio-remediation • Botanical institutions (e.g., CSIR-NBRI)
• Cross-sector coordination • Regular policy review and stakeholder engagement	• NMCG • MoHUA • Town & Country Planning Dept.	• Policy think tanks (NIUA, CSTEP) • Urban river alliances
• Effective community mobilization • Traditional-modern practices integration • Sustainable livelihood opportunities • Cultural and religious sensitivity	• District Collectors • Panchayati Raj Institutions • Religious Committee representatives • Self-Help Group Federations	• Art of Living Foundation • Bhumi Project • Yamuna restoration Civil Society Organizations • Religious organizations
• Adequate funding and resources are available	• Central and State Governments, Policy Makers, Ministry of Jal Shakti, MOEFCC, Central/State Pollution Control Board • UP Jal Nigam	• Local Municipal Corporations, Civil Society Organizations, Community Groups
• Public participation in recycling programs	• Central and State Governments, Policy Makers, Ministry of Jal Shakti, MOEFCC, Central/State Pollution Control Board • UP Jal Nigam	• Private Recycling Companies
• Effective communication strategies and public engagement	• Central and State Governments, Policy Makers, Ministry of Jal Shakti, MOEFCC, Central/State Pollution Control Board • UP Jal Nigam	• Educational Institutions, • Media Outlets • Civil Society Organizations • Village Panchayats • District administration • Local Municipal Corporations

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
5.4	Promote the use of sustainable alternatives	• Decrease in the use of single-use plastics	• Sales data of sustainable products and reduced plastic waste in audits
5.5	Enforce regulations on plastic production and disposal	• Compliance with plastic waste management regulations	• Inspection and compliance reports
5.6	Strictly implementation of Extended Producer Responsibility (EPR) and Polluter Pays principle	• Industries take responsibility for the lifecycle of plastic products and bear the cost of pollution	• Industry compliance reports, financial records of pollution management
Objective 6: Reduce Pollution Level in Rivers with Technology Integration			
6.1	Deploy real-time water quality monitoring systems (WQMS) at strategic locations along the Yamuna River.	• Number of functional WQMS units installed • Frequency and accuracy of real-time data transmission • Parameters monitored (e.g., DO, BOD, pH, EC, heavy metals)	• IoT dashboard reports • Central monitoring system logs (e.g., CPCB portal) • Third-party calibration and maintenance reports
6.2	Integrate SCADA (Supervisory Control and Data Acquisition) systems and AI-based analytics in STPs/ETPs for operational optimization.	• Number of STPs/ETPs with SCADA/AI integration • Reduction in downtime and operational failures • Enhanced compliance with discharge standards	• Performance audit reports • Daily SCADA logs and alerts • AI system reports (e.g., fault predictions, load optimization)
6.3	Use satellite-based remote sensing and drones for pollution hotspot detection and sediment mapping.	• Number of satellite and drone surveys conducted per year • Identification and mapping of polluted stretches • Accuracy of data and correlation with field monitoring	• Remote sensing analysis reports • GIS pollution maps • Validation through field inspections
6.4	Implement automated drain flow monitoring and pollutant loading sensors in major urban drains.	• Number of drains with automated flow sensors • Daily load estimations of pollutants (e.g., BOD, COD, fecal coliform) • Data consistency and flow variability tracking	• Digital logs of drain flow systems • Pollution load estimation dashboards • Reports submitted to SPCBs/NMCG

Assumptions	Agencies responsible	Supporting Organizations
• Availability and affordability of sustainable alternatives	• Central and State Governments, Policy Makers, Ministry of Jal Shakti, MOEFCC, Central/State Pollution Control Board • UP Jal Nigam	• Manufacturers, Retailers, District administratio, Village Panchayats, Educational Institutions, Media Outlets, • Civil Society Organizations
• Strong regulatory framework and enforcement mechanisms	• Central and State Government	• Legal Bodies, Industry Associations
• Strong regulatory framework and industry cooperation	• Central and State Governments • Ministry of Jal Shakti, MOEFCC, District administration	• Civil Society Organizations • Environmental Agencies
• Availability of telecom/data network • Timely sensor calibration and maintenance	• CPCB/SPCBs • Jal Shakti Ministry • Urban local bodies	• Tech companies (e.g., Envirotech, Bosch) • Research institutions (IITs, CSIR labs)
• Skilled manpower availability • SCADA-AI systems are interoperable with legacy infrastructure	• State Jal Boards • Municipal Corporations • Private STP operators	• Industry automation partners • Digital solution providers (e.g., Tata Elxsi, IBM India)
• Access to high-resolution satellite data • Skilled GIS/digital analysts available	• ISRO • State Remote Sensing Centres • Urban planning departments	• NRSC, • IIT Roorkee, • NIC, • National Mission for Clean Ganga
• Proper sensor calibration and O&M • Integration with decision support systems	• Delhi Jal Board • UP Jal Nigam • Municipal engineering departments	• Smart City Missions • Urban tech startups GIZ/ADB-funded projects

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
6.5	Integrated ecosystem health monitoring and assessment Comprehensive AI-driven ecosystem health dashboard integrating biodiversity, water quality, and habitat conditions	• Real-time ecosystem health index (0-100 scale) • Biodiversity monitoring with species recognition AI • Habitat quality assessment using satellite and drone data • Fish population dynamics modeling and prediction • Integrated dashboard for policymakers and researchers	• Ecosystem health index reports • Species identification and counting logs • Habitat quality assessment studies • Fish population trend analysis • Dashboard usage and decision impact metrics
6.5	Intelligent waste management and illegal dumping prevention AI-powered surveillance system with computer vision for detecting and preventing illegal waste dumping activities	• Number of AI-enabled surveillance cameras installed • Real-time illegal dumping detection (95% accuracy) • Automated alert system to enforcement agencies • % reduction in illegal dumping incidents • Mobile app for citizen reporting with AI verification	• Surveillance system detection logs • Enforcement response time metrics • Illegal dumping incident reduction reports • Citizen reporting app usage statistics • AI accuracy validation studies
Objective 7 : To control the aquatic species mortality due to poaching and net entanglement			
7.1	Establish a joint protection mechanism of fisheries and forest department for river basin protection	• A cadre of joint protection force	• Number of people in the cadre. • Trainings undertaken for the cadre.
7.2	Involve the local communities and other agencies in protection and management of river ecosystem.	• Number of meetings and workshops with the local communities and institutions • Number of training workshops for local people in protection and management of river ecosystem	• Number of participants from the local communities in the meetings and workshops • Number of local institutions involved • Number of local people trained in protection and management of river ecosystem
7.3	Establish rescue and rehabilitation centres along with support systems at strategic locations for handling the individuals in distress.	• Number of rescue centres in the basin	• Operational rescue centres. • Number of rescues undertaken

Assumptions	Agencies responsible	Supporting Organizations
• Baseline ecological data establishment • Expert validation of AI-generated insights • Regular field surveys for ground-truthing • Inter-disciplinary collaboration • Long-term data consistency and quality	• Wildlife Institute of India • Zoological Survey of India • Botanical Survey of India • National Biodiversity Authority • Central Inland Fisheries Research Institute	• World Wildlife Fund • Conservation International • International biodiversity monitoring networks • Academic ecology research institutions
• Reliable camera network infrastructure • Fast enforcement response capabilities • Legal framework for AI-based evidence • Public awareness and cooperation • Regular system maintenance and updates	• Delhi Police • Municipal Corporation of Delhi • Central Industrial Security Force • State Forest Departments • District Magistrates	• Advanced surveillance systems • Indian surveillance technology companies • Computer vision AI startups • Mobile app development companies • Citizen engagement platforms

• Coordination among the participating agencies	• MoEFCC • WII • CIFRI • State forest and fishery dept.	• State Police Department • Civil Society Organizations • Local Administration
• Coordination among the participating agencies • Acceptability of the initiative among the local communities	• MoEFCC • WII • CIFRI • State forest and fishery dept.	• Local Administration
• Resource availability for establishing rescue centres	• MoEFCC • MoJS	• State forest and fishery dept. • Willdife Institute of India

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
7.4	Create necessary infrastructure for protection and monitoring.	• Number of people involved in monitoring • Number of monitoring groups established • Database created for reporting of poaching and net entanglement	• Active reporting and verification • Number of monitoring activities • Periodic reporting
7.5	Establish systems for capacity building of veterinarians, forest department, navigation, line agencies, local communities, and other stakeholders.	• Stakeholder specific modules for training developed • Number of training and workshops undertaken for build the capacity of the stakeholders to handle emergent situation	• Number of participants from each stakeholder group trained • Number of activities conducted by the trained personnel
7.6	To undertake sensitization programme for reducing net entanglement and ghost nets.	• Number of awareness material developed • Number of awareness activities, media developed	• Number of local people especially fisher folks sensitized
7.7	To promote technological interventions as deterrent, for reducing net entanglement	• Technology for reducing net entanglements developed • Number of fisher and boat folks trained in use of technology • Number of schemes promoting use of technology	• Number of people using the technology • Reduced net entanglement of aquatic species
Objective 8: Engage and empower the local communities and other stakeholders for promoting sustainable resource use in the rivers and associated water bodies			
8.1	Promote livelihood programme for fishing and related dependent communities through alternative and sustainable natural resource use.	• Number of site-specific sustainable livelihood programmes designed. • Number of sustainable livelihood development programme conducted.	• Number of livelihood centres established • Number of people trained • Number of people employed post training in sustainable livelihoods • Number of agencies participating in livelihood development

Assumptions	Agencies responsible	Supporting Organizations
• Adequate capacity among the stakeholders • Stakeholders involved are updating the database	• MoEFCC • MoJS	• State forest and fishery dept. • Local Administration
• Willingness of stakeholders	• MoEFCC • MoJS	• State forest dept., • Ministry of Ports, Shipping and Waterways, • Inland Waterways Authority of India (IWAI), Local Administrative Authority (Panchayat)
• Receptivity of local community.	• Multi departmental effort and involvement	• State forest dept., • Willdlife Institue of India • CIFRI
• Availability, accessibility and use of ease of the technology. • Actual reporting	• Dept. of Science and Technology • Ministry of Fishries, Animal Husbandary and Dairying	• State forest dept., • Willdlife Institue of India • CIFRI
• Acceptance by local communities • Adequate and timely available resources • Necessary support from concerned departments	• MoEFCC • MoJS • Ministry of Rural Development • Ministry of Agriculture • Ministry of industries	• Skill development agencies • NRLM • CSR branches of the corporates

	Strategies/Actions	Objectively verifiable indicators (OVI)	Means of verification (MOV)
8.2	Put in place a system for regulated mining practices in the river ecosystem, through supportive policy, legal and administrative framework.	• Stretches of high mining activities identified and mapped • Area under regulated mining • Number of violations	• Mining and offence records of concerned districts
8.3	Develop and incentivize sustainable, chemical-free agriculture and aquaculture practices among local farmers and fish farmers	• Number of National Programme for Organic Production (NPOP) certificates issued • Number of Aquaculture Stewardship Council (ASC) Certificates issued • Global G.A.P. Aquaculture	• Records of agriculture department • Records of fisheries department
8.4	Organize a series of awareness, sensitization and capacity building programme for local communities.	• Number of programmes conducted • Number of stakeholders sensitized • Support of local community	• Official records • Community surveys
8.5	Involve local communities and other stakeholders in protection and management of river ecosystem.	• Number of local institutions/ communities participating in river protection/ management programmes	• Official records • Community surveys
Objective 9: Develop supportive institutional mechanisms for management and developing solutions			
9.1	Establish a multitier institutional mechanism for programme implementation at State, district and local level and engaging different stakeholders.	• Effective functioning of different institutions at different level. • Government notifications and order for establishing the committee.	• Structured and tiered functional committee • Representation from the concerned Ministry/ Dept./Institution • Number of meetings held

Assumptions	Agencies responsible	Supporting Organizations
• Pplitical support • Support from concerned departments • Adequate Environmental Assessment Reviews conducted and recommendations adhered to	• MoEFCC • MoJS • Ministry of Mines • Mining corporations	• Hindustan Zinc Limited • National Mineral Development Corporation • Uttar Pradesh State Mineral Development Corporation Limited • Jaypee Group • Dalmia Bharat Group • ACC Limited • UltraTech Cement • Reliance Cement • Birla Corporation Limited
• Streamlined extension activities • Incentives and subsidies for switching to sustainable practices	• Ministry of Agriculture & Farmers Welfare, (Central and State) • Directorate Of Plant Protection, Quarantine & Storage • Krishi Vigyan Kendras • Ministry of Micro, Small & Medium Enterprises (M/o MSME)	• ICAR • State Agriculture Universities • Krishi Vigyan Kendras • Research Institutions
• Willingness of local communities to participate • Continued support from concerned local institutions	• MoEFCC • MoJS • State Biodiversity board • State Forest Department	• Wildlife Institute of India • Village panchayats
• Motivated local communities and other stakeholders are available in the region	• Ministry of Panchayati Raj, dept. • Ministry of Rural Development	• Village panchayats • Municipal bodies • Civil Society Organizations • Local Administrative
• Policy support at Centre and state level • Continued political will and funding for river management initiatives. • Adequate human and financial resources are available for its functioning	• MoEFCC • Ministry of Jal Shakti • Uttar Pradesh Jal Nigam • State Pollution Control Board • Department of Irrigation	• Wildlife Institute of India • Civil Society Organizations • Community Organizations • Urban Local Bodies

ANNEXURE I: Checklist of plant species along the Chambal River

S.no	Plant Name (Botanical name)	Family	Order	Nativity
1	*Nymphaea nouchali* Burm.f.	Nymphaeaceae Salisb.	Nymphaeales	Native
2	*Peperomia pellucida* (L.) Kunth	Piperaceae Giseke	Piperales	Exotic
3	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae Jus.	Alismatales	Native
4	*Ottelia alismoides* (L.) Pers.	Hydrocharitaceae Jus.	Alismatales	Native
5	*Vallisneria natans* (Lour.) H. Hara	Hydrocharitaceae Jus.	Alismatales	Native
6	*Najas minor* All.	Hydrocharitaceae Jus.	Alismatales	Native
7	*Najas marina* L.	Hydrocharitaceae Jus.	Alismatales	Native
8	*Sagittaria guayanensis* subsp. *lappula* (D.Don) Bogin	Alismataceae Vent	Alismatales	Native
9	*Potamogeton crispus* L.	Potamogetonaceae Rchb.	Alismatales	Native
10	*Potamogeton natans* L.	Potamogetonaceae Rchb.	Alismatales	Native
11	*Stuckenia pectinata* (L.) Börner	Potamogetonaceae Rchb.	Alismatales	Native
12	*Colocasia esculenta* (L.) Schott.	Araceae Juss.	Alismatales	Native
13	*Pistia stratiotes* L.	Araceae Juss.	Alismatales	Native
14	*Lemna minor* L.	Araceae Juss.	Alismatales	Native
15	*Lemna perpusilla* Torr.	Araceae Juss.	Alismatales	Native
16	*Spirodela polyrhiza* (L.) Schleid.	Araceae Juss.	Alismatales	Native
17	*Crinum defixum* Ker Gawl.	Amaryllidaceae J. St.-Hil.	Asparagales	Native
18	*Dioscorea bulbifera* L.	Dioscoreaceae R.Br.	Dioscoreales	Native
19	*Phoenix sylvestris* (L.) Roxb.	Arecaceae Bercht. & J. Presl	Arecales	Native
20	*Bolboschoenus maritimus* (L.) Palla	Cyperaceae Juss.	Poales	Native
21	*Bolboschoenus glaucus* (Lam.) S.G. Sm.	Cyperaceae Juss.	Poales	Native
22	*Bulbostylis barbata* (Rottb.) C.B. Clarke	Cyperaceae Juss.	Poales	Native
23	*Cyperus alulatus* J.Kern	Cyperaceae Juss.	Poales	Native
24	*Cyperus compressus* L.	Cyperaceae Juss.	Poales	Native
25	*Cyperus rotundus* L.	Cyperaceae Juss.	Poales	Native
26	*Cyperus distans* L.f.	Cyperaceae Juss.	Poales	Native
27	*Cyperus difformis* L.	Cyperaceae Juss.	Poales	Native
28	*Cyperus exaltatus* Retz.	Cyperaceae Juss.	Poales	Native
29	*Cyperus iria* L.	Cyperaceae Juss.	Poales	Native
30	*Cyperus michelianus* subsp. *pygmaeus* (Rottb.) Asch. & Graebn.	Cyperaceae Juss.	Poales	Native
31	*Cyperus polystachyos* Rottb.	Cyperaceae Juss.	Poales	Native
32	*Cyperus mindorensis* (Steud.) Huygh	Cyperaceae Juss.	Poales	Native
33	*Cyperus brevifolius* (Rottb.) Hassk.	Cyperaceae Juss.	Poales	Native
34	*Cyperus tenuifolius* (Steud.) Dandy	Cyperaceae Juss.	Poales	Native
35	*Cyperus squarrosus* L.	Cyperaceae Juss.	Poales	Native
36	*Cyperus flavidus* Retz.	Cyperaceae Juss.	Poales	Native
37	*Fimbristylis dichotoma* (L.) Vahl	Cyperaceae Juss.	Poales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Blue water lily	H	-	A	RF	LC	-
Slate pencil plant	H	-	Moist loving	-	-	-
Wterhymes	H	-	A	SUB	LC	a,c
Duck lettuce	H	-	A	SUB	LC	-
Jalil	H	-	A	SUB	LC	a
Jhangi	H	-	A	SUB	LC	-
Spiny water nymph	H	-	A	SUB	-	-
Burr Arrowhead	H	-	A	RF	LC	-
Crisp leaved pondweed	H	-	A	SUB	LC	-
Broad leaved pond weed	H	-	A	RF	LC	-
Sago pondweed	H	-	A	SUB	LC	c
Indian taro	H	-	SA	Marshy	LC	-
Water lettuce	H	-	A	FF	LC	-
Common Duckweed	H	-	A	FF	LC	-
Duckweed	H	-	A	FF	LC	-
Gaint Duckweed	H	-	A	FF	LC	-
River Crinum Lily	H	-	A	EM	-	a
Air yam	H	-	T	-		d
Indian date palm	T	-	SA	Riparian	-	-
Bayonet grass	Graminoid	Sedge	SA	Marshy	LC	-
Glaucous tuber-bulrush	Graminoid	Sedge	SA	Marshy	LC	-
Bearded Watergrass	Graminoid	Sedge	SA	Marshy	-	-
Winged Sedge	Graminoid	Sedge	SA	Marshy	LC	-
Poorland Flat Sedge	Graminoid	Sedge	SA	Marshy	LC	-
Nut grass	Graminoid	Sedge	SA	Marshy	LC	a,c,d,e
Slender cyperus	Graminoid	Sedge	SA	Marshy	LC	-
Variable flatsedge	Graminoid	Sedge	SA	Marshy	LC	-
Tall Flat Sedge	Graminoid	Sedge	SA	Marshy	LC	a
Rice flat sedge	Graminoid	Sedge	SA	Marshy	LC	d
Pygmy Sedge	Graminoid	Sedge	SA	Marshy	LC	d
Bunchy sedge	Graminoid	Sedge	SA	Marshy	LC	-
White Water Sedge	Graminoid	Sedge	SA	Marshy	LC	-
Green Water Sedge	Graminoid	Sedge	SA	Marshy	LC	-
Thinleaf Flatsedge	Graminoid	Sedge	SA	Marshy	-	-
Bearded Flatsedge	Graminoid	Sedge	SA	Marshy	LC	-
Yellow Flatsedge	Graminoid	Sedge	SA	Marshy	LC	-
Eight day grass	Graminoid	Sedge	SA	Marshy	LC	c

S.no	Plant Name (Botanical name)	Family	Order	Nativity
38	*Fimbristylis miliacea* (L.) Vahl	Cyperaceae Juss.	Poales	Native
39	*Eleocharis geniculata* (L.) Roem. & Schult.	Cyperaceae Juss.	Poales	Native
40	*Eriophorum comosum* (Wall.) Nees	Cyperaceae Juss.	Poales	Native
41	*Schoenoplectiella juncoides* (Roxb.) Lye	Cyperaceae Juss.	Poales	Native
42	*Schoenoplectiella supina* (L.) Lye	Cyperaceae Juss.	Poales	Native
43	*Apluda mutica* L.	Poaceae Barnhart	Poales	Native
44	*Arundo donax* L.	Poaceae Barnhart	Poales	Native
45	*Aristida adscensionis* L.	Poaceae Barnhart	Poales	Native
46	*Axonopus compressus* (Sw.) P. Beauv.	Poaceae Barnhart	Poales	Exotic
47	*Bambusa bambos* (L.) Voss	Poaceae Barnhart	Poales	Native
48	*Cenchrus pedicellatus* (Trin.) Morrone	Poaceae Barnhart	Poales	Native
49	*Cenchrus setigerus* Vahl	Poaceae Barnhart	Poales	Native
50	*Cenchrus ciliaris* L.	Poaceae Barnhart	Poales	Native
51	*Chloris barbata* Sw.	Poaceae Barnhart	Poales	Native
52	*Chloris virgata* Sw.	Poaceae Barnhart	Poales	Native
53	*Coix lacryma* -jobi L.	Poaceae Barnhart	Poales	Native
54	*Chrysopogon aciculatus* (Retz.) Trin.	Poaceae Barnhart	Poales	Native
55	*Chrysopogon fulvus* (Spreng.) Chiov.	Poaceae Barnhart	Poales	Native
56	*Chrysopogon zizanioides* (L.) Roberty	Poaceae Barnhart	Poales	Native
57	*Cynodon dactylon* (L.) Pers.	Poaceae Barnhart	Poales	Native
58	*Dendrocalamus strictus* (Roxb.) Nees	Poaceae Barnhart	Poales	Native
59	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae Barnhart	Poales	Native
60	*Desmostachya bipinnata* (L.) Stapf	Poaceae Barnhart	Poales	Native
61	*Dichanthium annulatum* (Forssk.) Stapf	Poaceae Barnhart	Poales	Native
62	*Digitaria stricta* Roth	Poaceae Barnhart	Poales	Native
63	*Echinochloa colona* (L.) Link	Poaceae Barnhart	Poales	Native
64	*Echinochloa crus-galli* (L.) P. Beauv.	Poaceae Barnhart	Poales	Native
65	*Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult.	Poaceae Barnhart	Poales	Native
66	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Poaceae Barnhart	Poales	Native
67	*Eragrostis ciliaris* (L.) R. Br.	Poaceae Barnhart	Poales	Native
68	*Eragrostis pilosa* (L.) P. Beauv.	Poaceae Barnhart	Poales	Native
69	*Eragrostis minor* Host	Poaceae Barnhart	Poales	Native
70	*Eriochloa procera* (Retz.) C.E. Hubb.	Poaceae Barnhart	Poales	Native
71	*Ischaemum ciliare* Retz.	Poaceae Barnhart	Poales	Native
72	*Iseilema laxum* Hack.	Poaceae Barnhart	Poales	Native
73	*Hemarthria compressa* (L.f.) R.Br.	Poaceae Barnhart	Poales	Native
74	*Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult.	Poaceae Barnhart	Poales	Native
75	*Hygroryza aristata* (Retz.) Nees ex Wight & Arn.	Poaceae Barnhart	Poales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
lesser fimbristylis	Graminoid	Sedge	SA	Marshy	-	-
Knoblike Spikesedge	Graminoid	Sedge	SA	Marshy	LC	a
Hairy Cottongrass	Graminoid	Sedge	Moist loving	Lithophytic	-	-
South-Asian Club-Rush	Graminoid	Sedge	SA	Marshy	-	-
Prostrate Club-Rush	Graminoid	Sedge	SA	Marshy	LC	-
Mauritian grass	Graminoid	Grass	SA	Marshy	-	d
Narkat	Graminoid	Grass	SA	Marshy	LC	-
Sixweeks threeawn	Graminoid	Grass	Moist loving	-	-	a,d
Broadleaf carpetgrass	Graminoid	Grass	Moist loving	-	LC	-
Giant thorny bamboo	Graminoid	Grass	Moist loving	-	-	-
Deenanath Grass	Graminoid	Grass	Moist loving	-	LC	-
Birdwood Grass	Graminoid	Grass	Moist loving	-	-	d
Buffel grass	Graminoid	Grass	Moist loving	-	LC	c,e
Swollen fingergrass	Graminoid	Grass	Moist loving	-	-	d
Feather Finger Grass	Graminoid	Grass	Moist loving	-	-	-
Job's Tears	Graminoid	Grass	SA	Marshy	-	a
Golden Beardgrass	Graminoid	Grass	Moist loving	-	-	-
Reddish-yellow beardgrass	Graminoid	Grass	Moist loving	-	-	-
Vetiver grass	Graminoid	Grass	SA	Marshy	-	c,d
Scutch grass	Graminoid	Grass	Moist loving	-	-	b,d,e
Calcutta bamboo	Graminoid	Grass	Moist loving	-	-	b,c,e
Aegyptium crowfoot	Graminoid	Grass	Moist loving	-	-	e
Dharbha, Kush	Graminoid	Grass	Moist loving	-	LC	c,d
Sheda Grass	Graminoid	Grass	Moist loving	-	-	e
Crab grass	Graminoid	Grass	Moist loving	-	-	-
Jungle rice	Graminoid	Grass	SA	Marshy	-	-
Barnyard Grass	Graminoid	Grass	SA	Marshy	-	-
Japanese lovegrass	Graminoid	Grass	Moist loving	-	-	d
Chinese Lovegrass	Graminoid	Grass	Moist loving	-	LC	-
Gophertail Lovegrass	Graminoid	Grass	Moist loving	-	-	d
Soft lovegrass	Graminoid	Grass	Moist loving	-	-	d
	Graminoid	Grass	Moist loving	-	-	-
Tropical Cupgrass	Graminoid	Grass	SA	Marshy	LC	-
Indian Muraina Grass	Graminoid	Grass	Moist loving		-	-
Musal Grass	Graminoid	Grass	Moist loving		-	-
Whip Grass	Graminoid	Grass	SA	Marshy	LC	-
Black speargrass	Graminoid	Grass	Moist loving	-	-	d
Bengal wild rice	Graminoid	Grass	A	FF	-	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
76	*Imperata cylindrica* (L.) Raeusch.	Poaceae Barnhart	Poales	Native
77	*Leptochloa panicea* (Retz.) Ohwi	Poaceae Barnhart	Poales	Native
78	*Leptochloa chinensis* (L.) Nees	Poaceae Barnhart	Poales	Native
79	*Leersia hexandra* Sw.	Poaceae Barnhart	Poales	Native
80	*Oplismenus compositus* (L.) P. Beauv.	Poaceae Barnhart	Poales	Native
81	*Oplismenus burmanni* (Retz.) P. Beauv.	Poaceae Barnhart	Poales	Native
82	*Oryza rufipogon* Griff.	Poaceae Barnhart	Poales	Native
83	*Panicum paludosum* Roxb	Poaceae Barnhart	Poales	Native
84	*Panicum miliaceum* L.	Poaceae Barnhart	Poales	Native
85	*Paspalum scrobiculatum* L.	Poaceae Barnhart	Poales	Native
86	*Paspalum dilatatum* Poir.	Poaceae Barnhart	Poales	Exotic
87	*Paspalum distichum* L.	Poaceae Barnhart	Poales	Exotic
88	*Paspalidium flavidum* (Retz.) A. Camus	Poaceae Barnhart	Poales	Native
89	*Perotis indica* (L.) Kuntze	Poaceae Barnhart	Poales	Native
90	*Phalaris minor* Retz.	Poaceae Barnhart	Poales	Native
91	*Phragmites karka* (Retz.) Trin. ex Steud.	Poaceae Barnhart	Poales	Native
92	*Polypogon monspeliensis* (L.) Desf.	Poaceae Barnhart	Poales	Native
93	*Rottboellia cochinchinensis* (Lour.) Clayton	Poaceae Barnhart	Poales	Native
94	*Saccharum spontaneum* L.	Poaceae Barnhart	Poales	Native
95	*Saccharum bengalense* Retz.	Poaceae Barnhart	Poales	Native
96	*Saccharum ravennae* (L.) L.	Poaceae Barnhart	Poales	Native
97	*Setaria glauca* (L.) P.Beauv.	Poaceae Barnhart	Poales	Native
98	*Setaria pumila* (poir.) Roem. & Schult.	Poaceae Barnhart	Poales	Native
99	*Setaria intermedia* Roem. & Schult.	Poaceae Barnhart	Poales	Native
100	*Setaria verticillata* (L.) P.Beauv.	Poaceae Barnhart	Poales	Native
101	Sporobolus diandrus (Retz.) P. Beauv.	Poaceae Barnhart	Poales	Native
102	*Urochloa ramosa* (L.) T.Q. Nguyensyn.	Poaceae Barnhart	Poales	Native
103	*Urochloa distachyos* (L.) T.Q. Nguyen	Poaceae Barnhart	Poales	Native
104	*Urochloa mutica* (Forssk.) T.Q. Nguyen	Poaceae Barnhart	Poales	Exotic
105	*Urochloa reptans* (L.) Stapf	Poaceae Barnhart	Poales	Native
106	*Themeda quadrivalvis* (L.) Kuntze	Poaceae Barnhart	Poales	Native
107	*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda	Poaceae Barnhart	Poales	Native
108	*Tetrapogon tenellus* (J.Koenig ex Roxb.) Chiov.	Poaceae Barnhart	Poales	Native
109	*Typha angustifolia* L.	Typhaceae Juss.	Poales	Native
110	*Pontederia crassipes* Mart.	Pontederiaceae Kunth	Commelinales	Exotic
111	*Pontederia hastata* L.	Pontederiaceae Kunth	Commelinales	Native
112	*Pontederia vaginalis* Burm. f.	Pontederiaceae Kunth	Commelinales	Native
113	*Commelina benghalensis* L.	Commelinaceae Mirb.	Commelinales	Native
114	*Cyanotis cristata* (L.) D. Don	Commelinaceae Mirb.	Commelinales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Cogon grass	Graminoid	Grass	SA	Marshy	LC	d
Thread Sprangletop	Graminoid	Grass	Moist loving	-	LC	-
Red sprangletop	Graminoid	Grass	Moist loving	-	-	-
Swamp rice grass	Graminoid	Grass	SA	Marshy	LC	-
Running mountain grass	Graminoid	Grass	Moist loving	-	LC	-
Wavy-Leaf Basketgrass	Graminoid	Grass	Moist loving	-	-	-
Wild rice	Graminoid	Grass	SA	Marshy	LC	-
	Graminoid	Grass	SA	Marshy	-	-
Proso millet	Graminoid	Grass	T	-	-	-
Kodo millet	Graminoid	Grass	SA	Marshy	-	-
Dallas grass	Graminoid	Grass	SA	Marshy	-	-
Water finger-grass	Graminoid	Grass	SA	Marshy	-	-
Yellow Watercrown Grass	Graminoid	Grass	SA	Marshy	LC	-
Indian comet grass	Graminoid	Grass	Moist loving	-	-	-
Small-seeded canary grass	Graminoid	Grass	Moist loving	-	-	-
Tall Reed	Graminoid	Grass	SA	Marshy	LC	-
Annual beard-grass	Graminoid	Grass	SA	Marshy	LC	-
Corngrass	Graminoid	Grass	Moist loving	-	-	-
Wild sugarcane	Graminoid	Grass	SA	Marshy	LC	d
Munj Sweetcane, Sarkanda	Graminoid	Grass	SA	Marshy	-	d
Ekra	Graminoid	Grass	SA	Marshy	LC	-
	Graminoid	Grass	Moist loving	-	-	d
Yellow foxtail	Graminoid	Grass	Moist loving	-	-	-
Chiktu	Graminoid	Grass	Moist loving	-	-	-
Bristly Foxtail	Graminoid	Grass	Moist loving	-	-	-
	Graminoid	Grass	Moist loving	-	-	a,d
Browntop Millet	Graminoid	Grass	Moist loving	-	LC	e
Creeping signal grass	Graminoid	Grass	Moist loving	-	LC	-
Buffalo grass	Graminoid	Grass	SA	Marshy	LC	e
Creeping Signal Grass	Graminoid	Grass	Moist loving		LC	-
Grader grass	Graminoid	Grass	Moist loving		-	-
Asian broom grass	Graminoid	Grass	Moist loving		-	-
Tender Finger Grass	Graminoid	Grass	T	-	-	-
Narrow leaf cattail	Graminoid	Cattail	SA	Marshy	LC	d
Common water hyacinth	H	-	A	FF	LC	c
Heart shaped false pickerelweed	H	-	A	EM	LC	-
Oval leaf pondweed	H	-	A	EM	LC	-
Bengal dayflower	H	-	Moist loving	-	-	d
Crested Dew-Grass	H	-	Moist loving	-	LC	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
115	*Cyanotis axillaris* (L.) D. Don ex Sweet	Commelinaceae Mirb.	Commelinales	Native
116	*Murdannia nudiflora* (L.) Brenan	Commelinaceae Mirb.	Commelinales	Native
117	*Murdannia spirata* (L.) G.Brückn. Subsp. *Spirata*.	Commelinaceae Mirb.	Commelinales	Native
118	*Ceratophyllum demersum* L.	Ceratophyllaceae Gray	Ceratophyllales	Native
119	*Ranunculus sceleratus* L.	Ranunculaceae Juss.	Ranunculales	Native
120	*Argemone mexicana* L.	Papaveraceae Juss.	Ranunculales	Exotic
121	*Cissampelos pareria* L.	Menispermaceae Juss.	Ranunculales	Native
122	*Tinospora cordifolia* (Thunb.) Miers	Menispermaceae Juss.	Ranunculales	Native
123	*Cocculus hirsutus* (L.) W. Theob.	Menispermaceae Juss.	Ranunculales	Native
124	*Nelumbo nucifera* Gaertn.	Nelumbonaceae A.Rich	Proteales	Native
125	*Cayrtia trifolia* (L.) Domin	Vitaceae Juss.	Vitales	Native
126	*Tribulus terrestris* L.	Zyogophyllaceae R. Br.	Zygophyllales	Native
127	*Biophytum nervifolium* Thwaites	Zyogophyllaceae R. Br.	Zygophyllales	Native
128	*Balanites roxburghii* Planch.	Zyogophyllaceae R. Br.	Vitales	Native
129	*Celastrus paniculatus* Willd.	Celastraceae R. Br.	Celastrales	Native
130	*Oxalis corniculata* L.	Oxalidaceae R. Br.	Oxalidales	Native
131	*Acalypha indica* L.	Euphorbiaceae Juss.	Malpighiales	Native
132	*Acalypha ciliata* Forssk.	Euphorbiaceae Juss.	Malpighiales	Native
133	*Croton bonplandianus* Baill.	Euphorbiaceae Juss.	Malpighiales	Exotic
134	*Euphorbia hirta* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
135	*Euphorbia heterophylla* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
136	*Euphorbia dracunculoides* Lam.	Euphorbiaceae Juss.	Malpighiales	Native
137	*Euphorbia hypericifolia* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
138	*Euphorbia serpens* Kunth	Euphorbiaceae Juss.	Malpighiales	Exotic
139	*Euphorbia thymifolia* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
140	*Euphorbia indica* Lam.	Euphorbiaceae Juss.	Malpighiales	Native
141	*Mallotus nudiflorus* (L.) Kulju & Welzen	Euphorbiaceae Juss.	Malpighiales	Native
142	*Ricinus communis* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
143	*Jatropha gossipyfolia* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
144	*Jatropha curcas* L.	Euphorbiaceae Juss.	Malpighiales	Exotic
145	*Phyllanthus emblica* L.	Phyllantaceae Martynov	Malpighiales	Native
146	*Phyllanthus niruri* L.	Phyllantaceae Martynov	Malpighiales	Native
147	*Phyllanthus reticulata* Poir.	Phyllantaceae Martynov	Malpighiales	Native
148	*Phyllanthus urinaria* L.	Phyllantaceae Martynov	Malpighiales	Native
149	*Phyllanthus virgatus* G. Forst.	Phyllantaceae Martynov	Malpighiales	Native
150	*Phyllanthus maderaspatensis* L.	Phyllantaceae Martynov	Malpighiales	Native
151	*Putranjiva roxburghii* Wall.	Putranjivaceae Meisn.	Malpighiales	Native
152	*Passiflora foetida* L.	Passifloraceae Juss. ex Roussel	Malpighiales	Exotic
153	*Salix tetrasperma* Roxb.	Salicaceae Mirb.	Malpighiales	Native
154	*Hybanthus enneaspermus* (L.) F. Muell.	Violaceae Batsch	Malpighiales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Kana	H	-	Moist loving	-	LC	-
Dove weed	H	-	Moist loving	-	-	-
Asiatic Dewflower	H	-	Moist loving	-	-	-
Coontail	H	-	A	SUB	LC	c
Celery-leaved buttercup	H	-	SA	Marshy	LC	-
Mexican prickly poppy	H	-	Moist loving	-	-	a,b,c,d,e
Velvet leaf pareira	C	-	Moist loving	-	-	-
Amrita	C	-	T	-	-	b,c,d,e
Broom Creeper	C	-	T	-	-	c,d
Lotus Sweetjuice	H	-	A	RF	DD	c
Bush grape	C	-	Moist loving	-	-	-
Gokharu	H	-	Moist loving	-	LC	c,d
Little Tree Plant	H	-	T	-	-	-
Hingalbet	T	-	T	-	LC	c
Black oil plant, Jyotishmati	S	-	T	-	-	-
Creeping woosorrel	H	-	Moist loving	-	-	b
India copperleaf	H	-	Moist loving	-	-	b,e
India copperleaf	H	-	T	-		-
Ban tulsi	H	-	Moist loving	-	-	-
Asthma plant	H	-	Moist loving	-	-	d
Mexican fireplant	H	-	Moist loving	-	LC	-
Dragon Spurge	H	-	Moist loving	-	-	d
Golden spurge	H	-	Moist loving	-	-	d
Matted sandmat	H	-	Moist loving	-	-	-
Red Caustic-creeper	H	-	Moist loving	-	-	-
Gulabi Dudhi	H	-	Moist loving	-	-	-
False white teak	T	-	SA	Riparian	LC	-
Caster bean plant	S	-	Moist loving	-	-	b,e
Bellyache bush	S	-	Moist loving	-	-	-
Physic Nut, Jatropha	S	-	Moist loving	-	LC	b,e
Amla	T	-	T	-	LC	e
Gale of wind	H	-	Moist loving	-	-	b,e
Black honey shrub	S	-	Moist loving	-	-	-
Stome breaker phyllanthus	H	-	Moist loving	-	-	-
Seed under leaf phyllanthus	H	-	Moist loving	-	-	-
Madras Leaf-Flower	H	-	Moist loving	-	LC	-
Putranjiva	T	-	Moist loving	-	LC	b,e
Stinking passionflower	C	-	Moist loving	-	-	-
Indian Willow	T	-	SA	Riparian	LC	-
Spade flower	H	-	Moist loving		-	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
155	*Bergia ammannioides* Heyne ex. Roth.	Elatinaceae Dumort	Malpighiales	Native
156	*Aeschynomene indica* L.	Fabaceae Lindl.	Fabales	Native
157	*Acacia auriculiformis* A.Cunn. ex Benth.	Fabaceae Lindl.	Fabales	Exotic
158	*Acacia catechu* (L.) Willd.,Oliv.	Fabaceae Lindl.	Fabales	Native
159	*Acacia farnesiana* (L.) Wight et Arn.	Fabaceae Lindl.	Fabales	Exotic
160	*Acacia nilotica* (L.) P.J.H. Hurter & Mabb.	Fabaceae Lindl.	Fabales	Native
161	*Acacia pennata* (L.) Willd.	Fabaceae Lindl.	Fabales	Native
162	*Acacia leucophloea* (Roxb.) Willd.	Fabaceae Lindl.	Fabales	Native
163	*Alysicarpus bupleurifolius* (L.) DC	Fabaceae Lindl.	Fabales	Native
164	*Alysicarpus moniliform* (L.) DC.	Fabaceae Lindl.	Fabales	Native
165	*Alysicarpus vaginalis* (L.) DC.	Fabaceae Lindl.	Fabales	Native
166	*Alysicarpus ovalifolius* (Schumach.) J. Léonard	Fabaceae Lindl.	Fabales	Native
167	*Alysicarpus tetragonolobus* Edgew.	Fabaceae Lindl.	Fabales	Native
168	*Alysicarpus longifolius* (Rottler ex Spreng.) Wight & Arn.	Fabaceae Lindl.	Fabales	Native
169	*Alysicarpus scariosus* (Rottler ex Spreng.) Graham	Fabaceae Lindl.	Fabales	Native
170	*Albizia lebbeck* (L.) Benth.	Fabaceae Lindl.	Fabales	Native
171	*Alhagi maurorum* Medik.	Fabaceae Lindl.	Fabales	Native
172	*Bauhinia variegata* L.	Fabaceae Lindl.	Fabales	Native
173	*Cassia fistula* L.	Fabaceae Lindl.	Fabales	Native
174	*Cajanus scarabeoides* (L.) Thouars	Fabaceae Lindl.	Fabales	Native
175	*Caesalpinia bonduc* (L.) Roxb.	Fabaceae Lindl.	Fabales	Native
176	*Crotalaria medicaginea* Lam.	Fabaceae Lindl.	Fabales	Native
177	*Crotalaria mysoriensis* Roth	Fabaceae Lindl.	Fabales	Native
178	*Crotalaria pallida* Aiton	Fabaceae Lindl.	Fabales	Native
179	*Crotalaria retusa* L.	Fabaceae Lindl.	Fabales	Native
180	*Crotalaria juncea* L.	Fabaceae Lindl.	Fabales	Native
181	*Crotalaria prostrata* Rottl ex willd.	Fabaceae Lindl.	Fabales	Native
182	*Dalbergia sissoo* Roxb.	Fabaceae Lindl.	Fabales	Native
183	*Delonix regia* (Bojer ex Hook.) Raf.	Fabaceae Lindl.	Fabales	Exotic
184	*Desmodium gangaticum* (L.) DC.	Fabaceae Lindl.	Fabales	Native
185	*Desmodium triflorum* (L.) DC.	Fabaceae Lindl.	Fabales	Native
186	*Indigofera linifolia* (L.f.) Retz.	Fabaceae Lindl.	Fabales	Native
187	*Indigofera linnaei* Ali	Fabaceae Lindl.	Fabales	Native
188	*Indigofera tinctoria* L.	Fabaceae Lindl.	Fabales	Native
189	*Indigofera trita* L.f.	Fabaceae Lindl.	Fabales	Native
190	*Indigofera cordifolia* B. Heyne ex Roth	Fabaceae Lindl.	Fabales	Native
191	*Leucaena leucocephala* (Lam.) de Wit"	Fabaceae Lindl.	Fabales	Exotic
192	*Medicago polymorpha* L.	Fabaceae Lindl.	Fabales	Exotic
193	*Medicago lupulina* L.	Fabaceae Lindl.	Fabales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Ammannia waterwort	H	-	SA	Marshy	LC	-
Indian Joint Vetch	H	-	SA	Marshy	LC	-
Earleaf Acacia	T	-	T	-	LC	-
Kher	T	-	Moist loving	-	LC	b,e
Sweet Acscia	T	-	T	-	LC	-
Gum arabic tree	T	-	Moist loving	-	LC	a,b,c,d,e
Large-Gland Acacia	C	-	Moist loving	-	-	d
White Bark Acacia	T	-	T	-	LC	c,d,e
Lanceleaf Alyce clover	H	-	Moist loving	-	LC	-
Nacklace Alyce Clover	H	-	Moist loving	-	-	d
Alyce Clover	H	-	Moist loving	-	-	-
False moneywort	H	-	Moist loving	-	-	-
Red Alyce Clover	H	-	Moist loving	-	-	d
Long-leaved alyce clover	H	-	Moist loving	-	-	-
Dry Alyce Clover	H	-	Moist loving	-	-	-
Siris	T	-	T	-	-	b,e
Camelthorn-bush	H	-	Moist loving	-	-	d
Mountain Ebony	T	-	T	-	LC	b,c,e
Amaltash	T	-	T	-	LC	b,e
Showy pigeonpea	C	-	Moist loving	-	-	-
Knicker nut	S	-	Moist loving	-	LC	-
Medick Rattlepod	H	-	Moist loving	-	-	c,d
Mysore Rattlepod	H	-	Moist loving	-	-	-
Smooth crotolaria	H	-	Moist loving	-	-	-
Rattleweed	H	-	Moist loving	-	-	-
Indian Hemp	H	-	Moist loving	-	-	-
Prostrate Rattlepod	H	-	Moist loving	-	-	-
Indin rosewood	T	-	Moist loving	-	LC	c,e
Flame Tree	T	-	T	-	LC	c
Salparni	H	-	Moist loving	-	-	-
Three-flower beggarweed	H	-	Moist loving	-	-	-
Birdsville indigo	H	-	Moist loving	-	LC	d
Nine-leaved indigo	H	-	Moist loving	-	-	d
True indigo	H	-	Moist loving	-	-	d
Asian Indigo	S	-	Moist loving	-	LC	d
Heart-Leaf Indigo	H	-	Moist loving	-	-	d
Hotse tamarind	T	-	Moist loving	-	-	e
Toothed bur clover	H	-	Moist loving	-	LC	-
Black medick	H	-	Moist loving	-	LC	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
194	*Melilotus albus* Medik.	Fabaceae Lindl.	Fabales	Exotic
195	*Melilotus indicus* (A.) All.	Fabaceae Lindl.	Fabales	Native
196	*Mimosa pudica* L.	Fabaceae Lindl.	Fabales	Exotic
197	*Mimosa hamata* Willd.	Fabaceae Lindl.	Fabales	Native
198	*Pithecellobium dulce* (Roxb.) Benth.	Fabaceae Lindl.	Fabales	Exotic
199	*Pongamia pinnata* (L.) Pierre	Fabaceae Lindl.	Fabales	Native
200	*Prosopis juliflora* (Sw.) DC.	Fabaceae Lindl.	Fabales	Exotic
201	*Senna absus* (L.) Roxb.	Fabaceae Lindl.	Fabales	Native
202	*Senna alata* (L.) Roxb.	Fabaceae Lindl.	Fabales	Exotic
203	*Senna occidentalis* (L.) Link	Fabaceae Lindl.	Fabales	Exotic
204	*Senna tora* (L.) Roxb.	Fabaceae Lindl.	Fabales	Exotic
205	*Senna sophera* (L.) Roxb	Fabaceae Lindl.	Fabales	Exotic
206	*Senna uniflora* (Mill.) H.S. Irwin & Barneby	Fabaceae Lindl.	Fabales	Exotic
207	*Sesbania sesban* (L.) Merr.	Fabaceae Lindl.	Fabales	Native
208	*Stylosanthes fruticosa* (Retz.) Alston	Fabaceae Lindl.	Fabales	Native
209	*Tamarindus indica* L.	Fabaceae Lindl.	Fabales	Exotic
210	*Tephrosia purpurea* (L.) Pers.	Fabaceae Lindl.	Fabales	Native
211	*Tephrosia strigosa* (Dalzell) Santapau & Maheshw.	Fabaceae Lindl.	Fabales	Native
212	*Tephrosia pumila* (Lam.) Pers.	Fabaceae Lindl.	Fabales	Native
213	*Teramnus labialis* (L. f.) Spreng.	Fabaceae Lindl.	Fabales	Native
214	*Trifolium resupinatum* L.	Fabaceae Lindl.	Fabales	Exotic
215	*Vicia sativa* L.	Fabaceae Lindl.	Fabales	Native
216	*Vicia hirsuta* (L.) Gray	Fabaceae Lindl.	Fabales	Native
217	*Zornia gibbosa* Span.	Fabaceae Lindl.	Fabales	Native
218	*Polygala arvensis* Willd.	Polygalaceae Hoffmanns. & Link	Fabales	Native
219	*Cannabis sativa* L.	Canabaceae Mrtinov	Rosales	Exotic
220	*Trema orientalis* (L.) Blume	Canabaceae Mrtinov	Rosales	Native
221	*Artocarpus heterophyllus* Lam.	Moraceae Gaudich.	Rosales	Native
222	*Artocarpus lacucha* Buch.-Ham.	Moraceae Gaudich.	Rosales	Native
223	*Streblus asper* Lour.	Moraceae Gaudich.	Rosales	Native
224	*Ficus amplissima* Rees.	Moraceae Gaudich.	Rosales	Native
225	*Ficus benghalensis* L.	Moraceae Gaudich.	Rosales	Native
226	*Ficus racemosa* L.	Moraceae Gaudich.	Rosales	Native
227	*Ficus heterophylla* L. f.	Moraceae Gaudich.	Rosales	Native
228	*Ficus hispida* L. f.	Moraceae Gaudich.	Rosales	Native
229	*Ficus microcarpa* L. f.	Moraceae Gaudich.	Rosales	Native
230	*Ficus palmata* ssp. *virgata* (Roxb.) Browicz	Moraceae Gaudich.	Rosales	Native
231	*Ficus religiosa* L.	Moraceae Gaudich.	Rosales	Native
232	*Ficus virens* Aiton	Moraceae Gaudich.	Rosales	Native
233	*Broussonetia papyrifera* (L.) Vent.	Moraceae Gaudich.	Rosales	Exotic

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
White Sweet Clover	H	-	Moist loving	-	LC	-
Indian Sweet Clover	H	-	Moist loving	-	-	-
Touch me not plant	H	-	Moist loving	-	LC	b,e
Hooked Mimosa	S	-	T	-	-	-
Monkeypod tree	T	-	Moist loving	-	LC	-
Karanj	T	-	SA	Riparian	LC	a,b,e
Vilayati babul	T	-	Moist loving	-	LC	a,c,d,e
Tropical Sensitive Pea	H	-	Moist loving	-	-	-
Candle Bush	S	-	Moist loving	-	-	-
Coffee senna	S	-	Moist loving	-	LC	-
Chinese senna	H	-	Moist loving	-	-	b,d,e
Sophera Senna	S	-	Moist loving	-	-	-
Oneleaf senna	S	-	Moist loving	-	-	-
Egyptian rattlepod	H	-	Moist loving	-		-
Shrubby Pencil-Flower	H	-	T	-	-	-
Tamarind tree	T	-	T	-	LC	b,e
Common tephrosia	S	-	T	-	-	b,d,e
Bristly Tephrosia	H	-	T	-	-	d
Indigo Sauvage	H	-	T	-	LC	d
Mashaparni	C	-	Moist loving	-	-	d
Persian clover	H	-	Moist loving	-	LC	-
Common Vetch	H	-	Moist loving	-	LC	-
Tiny Vetch	H	-	Moist loving	-	-	-
Grass like Zornia	H	-	Moist loving	-	-	d
Field Milkwort	H	-	Moist loving	-	-	d
Hemp	H	-	Moist loving	-	-	-
Indian Charcoal tree	T	-	Moist loving	-	LC	-
Jackfruit	T	-	T	-	-	-
Monkey jack.	T	-	T	-	-	-
Siamese rough bush	T	-	SA	Riparian	LC	-
Bat fig	T	-	Moist loving	-	-	-
Banayan tree	T	-	Moist loving	-	-	c
Gular	T	-	SA	Riparian	LC	-
Creeping fig	S	-	SA	Riparian	-	-
Opposite leaf fig	T	-	Moist loving	-	LC	c,d
Laurel Fig	T	-	Moist loving	-	LC	-
Punjab Fig	S	-	Moist loving	-	-	-
Pipal	T	-	Moist loving	-	LC	d
White fig	T	-	Moist loving	-	LC	-
Paper mulberry	T	-	Moist loving	-	LC	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
234	*Morus alba* L.	Moraceae Gaudich.	Rosales	Exotic
235	*Holoptelea integrifolia* (Roxb.) Planch.	Ulmaceae Mirb.	Rosales	Native
236	*Potentilla supina* L.	Rosaceae Juss.	Rosales	Native
237	*Ventilago denticulata* Willd.	Rhamnaceae Juss.	Rosales	Native
238	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Rhamnaceae Juss.	Rosales	Native
239	*Ziziphus mauritiana* Lam.	Rhamnaceae Juss.	Rosales	Native
240	*Ziziphus oenophlia* (L.) Mill.	Rhamnaceae Juss.	Rosales	Native
241	*Ziziphus xylopyrus* (Retz.) Willd.	Rhamnaceae Juss.	Rosales	Native
242	*Pilea microphylla* (L.) Liebm.	Urticaceae Juss.	Rosales	Exotic
243	*Pouzolzia pentandra* (Roxb.) Benn.	Urticaceae Juss.	Rosales	Native
244	*Pouzolzia zeylanica* (L.) Benn.	Urticaceae Juss.	Rosales	Native
245	*Actinostemma tenerum* Griff.	Cucurbitaceae Juss.	Cucurbitales	Native
246	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae Juss.	Cucurbitales	Native
247	*Coccinea grandis* (L.) Voigt	Cucurbitaceae Juss.	Cucurbitales	Native
248	*Cucumis maderaspatanus* L.	Cucurbitaceae Juss.	Cucurbitales	Native
249	*Ctenolepis garcinii* (Burm.f.) C.B. Clarke	Cucurbitaceae Juss.	Cucurbitales	Native
250	*Diplocyclos palmatus* (L.) C. Jeffrey	Cucurbitaceae Juss.	Cucurbitales	Native
251	*Trichosanthes cucumerina* subsp. *Cucumerina*	Cucurbitaceae Juss.	Cucurbitales	Native
252	*Trichosanthes tricuspidata* Lour.	Cucurbitaceae Juss.	Cucurbitales	Native
253	*Luffa echinata* Roxb.	Cucurbitaceae Juss.	Cucurbitales	Native
254	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae R. Br.	Cucurbitales	Native
255	*Terminalia elliptica* Willd.	Combretaceae R. Br.	Cucurbitales	Native
256	*Terminalia pendula* (Edgew.) Gere & Boatwr.	Combretaceae R. Br.	Cucurbitales	Native
257	*Combretum ovalifolium* Roxb. ex G. Don	Combretaceae R. Br.	Cucurbitales	Native
258	*Syzygium cumini* (L.) Skeels	Myrtaceae Juss.	Myrtales	Native
259	*Eucalyptus tereticornis* Sm.	Myrtaceae Juss.	Myrtales	Exotic
260	*Ammannia baccifera* L.	LythraceaeJ. St.-Hil	Myrtales	Native
261	*Ammannia multiflora* Roxb.	LythraceaeJ. St.-Hil	Myrtales	Native
262	*Ammannia auriculata* Willd.	LythraceaeJ. St.-Hil	Myrtales	Native
263	*Lagerstroemia speciosa* (L.) Martyn	LythraceaeJ. St.-Hil	Myrtales	Native
264	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne	LythraceaeJ. St.-Hil	Myrtales	Native
265	*Rotala serpyllifolia* (Roth) Bremek.	LythraceaeJ. St.-Hil	Myrtales	Native
266	*Rotala indica* (Willd.) Koehne	LythraceaeJ. St.-Hil	Myrtales	Native
267	*Trapa natans* L.	LythraceaeJ. St.-Hil	Myrtales	Native
268	*Woodfordia fruticosa* (L.) Kurz	LythraceaeJ. St.-Hil	Myrtales	Native
269	*Ludwigia adscendens* (L.) H. Hara	Onagraceae Juss.	Myrtales	Native
270	*Ludwigia octovalvis* (Jacq.) P.H. Raven	Onagraceae Juss.	Myrtales	Native
271	*Ludwigia perennis* L.	Onagraceae Juss.	Myrtales	Native
272	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae (R.Br.) Lindl.	Sapindales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
White mulberry	T	-	Moist loving	-	-	b,e
Indian elm	T	-	Moist loving	-	-	c,d
Spreading Cinquefoil	H	-	Moist loving	-	LC	-
Toothed-Leaf Red Creeper	CS	-	T	-	-	c
Jhar Beri	S	-	Moist loving	-	LC	d,e
Indian jujube	H	-	Moist loving	-	LC	b,c,e
Jackel jujube	H	-	T	-	-	d
Woody-fruited jujube	S		T	-	LC	c
Angeloweed	H	-	Moist loving	-	-	-
Narrow-lef pouzolzs bush	H	-	SA	Marshy	-	-
Graceful pouzolzs bush	H	-	SA	Marshy	-	-
Tender Ray -flower gourd	C	-	Moist loving	-	-	-
Vine of Sodom	C	-	Moist loving	-	-	-
Ivy gourd	C	-	Moist loving	-	-	d
Madras pea pumpkin	C	-	Moist loving	-	-	-
Garcins bur cucumber	C	-	Moist loving	-	-	-
Shivlingi	C	-	Moist loving	-	-	-
Snake gourd	C	-	Moist loving	-	-	-
Indrayan	C	-	Moist loving	-	-	-
Bitter spong gourd	C	-	Moist loving	-	LC	-
Arjun	T	-	SA	Riparian	-	a,b,c,e
Indian laurel	T	-	T	-	-	-
Buttontree	T	-	T	-	-	a,c
Piluki	CS	-	T	-	-	-
Jamun	T	-	SA	Riparian	-	b,e
Forest Red Gum	T	-	T	-	LC	b,e
Blistering ammannia	H	-	SA	Marshy	-	a,d
Many Flowered Ammannia	H	-	SA	Marshy	-	-
Eared Redstem	H	-	SA	Marshy	LC	-
Pride of India	T	-	T	-	LC	-
Roundleaf toothcup	H	-	A	EM	LC	-
Slender Rotala	H	-	A	EM	LC	-
Indian toothcup	H	-	A	EM	LC	-
Singhara	H	-	A	FF	LC	c
Fire Flame bush	S	-	Moist loving	-	LC	-
Water primerose	H	-	A	FF	LC	-
Willow Primrose	H	-	SA	Marshy	LC	-
Perennial water primerose	H	-	SA	Marshy	-	-
Indian ash tree	T	-	T	-	LC	c

S.no	Plant Name (Botanical name)	Family	Order	Nativity
273	*Mangifera indica* L.	Anacardiaceae (R.Br.) Lindl.	Sapindales	Native
274	*Cardiospermum halicacabum* L.	Sapindaceae Juss.	Sapindales	Native
275	*Schleichera oleosa* (Lour.) Oken	Sapindaceae Juss.	Sapindales	Native
276	*Azadirachta indica* A. Juss.	Meliaceae Juss.	Sapindales	Exotic
277	*Melia azedarach* L.	Meliaceae Juss.	Sapindales	Native
278	*Toona ciliata* M. Roem.	Meliaceae Juss.	Sapindales	Native
279	*Aegle marmelos* (L.) Correa	Rutaceae Juss.	Sapindales	Native
280	*Glycosmis pentaphylla* (Retz.) DC.	Rutaceae Juss.	Sapindales	Native
281	*Ailanthus excelsa* Roxb.	Simaroubaceae DC.	Sapindales	Native
282	*Boswellia serrata* Roxb.	Burseraceae Kunth	Sapindales	Native
283	*Abutilon indicum* (L.) Sweet	Malvaceae Juss.	Malvales	Native
284	*Abutilon pannosum* (G. Forst.) Schltdl.	Malvaceae Juss.	Malvales	Native
285	*Abutilon ramosum* (Cav.) Guill. & Perr.	Malvaceae Juss.	Malvales	Native
286	*Bombax ceiba* L.	Malvaceae Juss.	Malvales	Native
287	*Corchorus aestuans* L.	Malvaceae Juss.	Malvales	Native
288	*Corchorus capsularis* L.	Malvaceae Juss.	Malvales	Native
289	*Corchorus trilocularis* L.	Malvaceae Juss.	Malvales	Native
290	*Waltheria indica* L.	Malvaceae Juss.	Malvales	Exotic
291	*Moringa oleifera* Lam.	Moringaceae Martinov	Brassicales	Native
292	*Cleome viscosa* L.	Cleomaceae Bercht. & J. Presl	Brassicales	Native
293	*Capparis zeylanica* L.	Capparaceae Juss.	Brassicales	Native
294	*Capparis decidua* (Forssk.) Edgew.	Capparaceae Juss.	Brassicales	Native
295	*Capparis sepiaria* L.	Capparaceae Juss.	Brassicales	Native
296	*Salvadora persica* L.	Salvadoraceae Lindl.	Brassicales	Native
297	*Salvadora oleoides* Decne.	Salvadoraceae Lindl.	Brassicales	Native
298	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae Burnett	Brassicales	Native
299	*Cardamine hirsuta* L.	Brassicaceae Burnett	Brassicales	Native
300	*Lepidium didymum* L	Brassicaceae Burnett	Brassicales	Exotic
301	*Rorippa indica* (L.) Hiern	Brassicaceae Burnett	Brassicales	Native
302	*Rorippa palustris* (L.) Besser	Brassicaceae Burnett	Brassicales	Native
303	*Nasturtium officinale* W.T. Aiton	Brassicaceae Burnett	Brassicales	Exotic
304	*Moringa concanensis* Nimmo ex Dalzell & A.Gibson	Brassicaceae Burnett	Brassicales	Native
305	*Trianthema portulacastrum* L.	Aizoaceae Marinov	Caryophyllales	Native
306	*Glinus lotoides* L.	Molluginaceae Bartl.	Caryophyllales	Native
307	*Glinus oppositifolius* (L.) Aug. DC.	Molluginaceae Bartl.	Caryophyllales	Native
308	*Mollugo pentaphylla* L.	Molluginaceae Bartl.	Caryophyllales	Native
309	*Mollugo nudicaulis* Lam.	Molluginaceae Bartl.	Caryophyllales	Native
310	*Polygonum barbatum* L.	Polygonaceae Juss.	Caryophyllales	Native
311	*Polygonum glabrum* (Willd.) M. Gomez	Polygonaceae Juss.	Caryophyllales	Native
312	*Persicaria hydropiper* (L.)	Polygonaceae Juss.	Caryophyllales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Mango	T	-	T	-	DD	-
Ballon vine	C	-	Moist loving	-	LC	d
Ceylon oak	T	-	T	-	LC	-
Neem tree	T	-	T	-	LC	b,c,d,e
Chinaberry tree	T	-	T	-	LC	b,c,e
Indian mahogany	T	-	T	-	LC	-
Bel	T	-	T	-	NT	b,c,e
Gin berry	S	-	T	-	LC	-
Maharuk	T	-	T	-	-	b,e
	T	-	T	-	LC	c
Bala	S	-	T	-	-	b,d
Ragged Mallow	S	-	T	-	-	-
	S	-	T	-	-	-
Shalmali	T	-	SA	Riparian	-	-
East indian mallow	H	-	Moist loving	-	-	d
White Jute	H	-	Moist loving	-	-	-
Wild Jute	H	-	T	-	-	-
Sleepy Morning	H	-	T	-		-
Drumstick tree	T	-	T	-	LC	b,d,e
Asian spider flower	H	-	Moist loving	-	-	b,c, d
Ceylon caper	S	-	Moist loving	-	-	-
Karira	T	-	T	-	LC	a,b,c,d,e
Hedge caper	S	-	T	-	-	c,d
Toothbrush Tree	T	-	SA	Riparian	LC	d,c
Bada Peelu	T	-	Moist loving	-	DD	a,c,d
Shepherd's purse	H	-	Moist loving	-	-	-
Hairy Bitter Cress	H	-	Moist loving	-	-	-
Bitter Cress	H	-	Moist loving	-	-	-
Indian Field-Cress	H	-	SA	Marshy	-	-
Bog yellow-cress	H	-	SA	Marshy	LC	-
Yellowcress	H	-	SA	Marshy	LC	-
	T	-	T	-	-	-
Desert horse purslane	H	-	Moist loving	-	-	-
Lotus Sweetjuice	H	-	Moist loving	-	LC	b,c
Jima	H	-	Moist loving	-	LC	-
Five Leaved Carpetweed	H	-	Moist loving	-	-	-
Naked-Stem Carpetweed	H	-	Moist loving	-	-	-
Bearded knotweed	H	-	SA	Marshy	LC	-
Common marsh buckwheat	H	-	SA	Marshy	LC	-
Water pepper	H	-	SA	Marshy	LC	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
313	*Persicaria lapathifolia* (L.) Delarbre	Polygonaceae Juss.	Caryophyllales	Native
314	*Polygonum lanatum* Roxb.	Polygonaceae Juss.	Caryophyllales	Native
315	*Polygonum plebeium* R.Br.	Polygonaceae Juss.	Caryophyllales	Native
316	*Rumex dentatus* L.	Polygonaceae Juss.	Caryophyllales	Native
317	*Portulaca oleracea* L.	Portulacaceae Juss	Caryophyllales	Exotic
318	*Portulaca pilosa* L.	Portulacaceae Juss	Caryophyllales	Exotic
319	*Achyranthes aspera* L.	Amaranthaceae Juss.	Caryophyllales	Native
320	*Aerva lanata* (L.) Juss. ex Schult.	Amaranthaceae Juss.	Caryophyllales	Native
321	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthaceae Juss.	Caryophyllales	Native
322	*Alternanthera ficoidea* (L.) Sm.	Amaranthaceae Juss.	Caryophyllales	Exotic
323	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae Juss.	Caryophyllales	Exotic
324	*Amaranthus spinosus* L.	Amaranthaceae Juss.	Caryophyllales	Exotic
325	*Amaranthus viridis* L.	Amaranthaceae Juss.	Caryophyllales	Exotic
326	*Chenopodium album* L.	Amaranthaceae Juss.	Caryophyllales	Native
327	*Chenopdiastrum murale* (L.) S.Fuentes, Uotila & Borsch	Amaranthaceae Juss.	Caryophyllales	Native
328	*Digrea muricata* (L.) Mart	Amaranthaceae Juss.	Caryophyllales	Native
329	*Gomphrena serrata* L.	Amaranthaceae Juss.	Caryophyllales	Exotic
330	*Pupalia lappacea* (L.) Juss.	Amaranthaceae Juss.	Caryophyllales	Native
331	*Suaeda vermiculata* Forssk. ex J.F. Gmel.	Amaranthaceae Juss.	Caryophyllales	Native
332	*Polycarpaea corymbosa* (L.) Lam	Caryophyllaceae Juss.	Caryophyllales	Native
333	*Spergula arvensis* L.	Caryophyllaceae Juss.	Caryophyllales	Native
334	*Polycarpon prostratum* (Forssk.) Asch. & Schweinf. Syn. *Spergula prostrata* (Forssk.) D. Dietr.	Caryophyllaceae Juss.	Caryophyllales	Native
335	*Boerhavia diffusa* L.	Nyctaginaceae Juss	Caryophyllales	Native
336	*Tamarix indica* Willd.	Tamaricaceae Lnk	Caryophyllales	Native
337	*Basella alba* L.	Basellaceae Raf.	Caryophyllales	Native
338	*Trianthema portulacastrum* L.	Aizoaceae Martinov	Caryophyllales	Native
339	*Dendrophthoe falcata* (L.f.) Ettingsh.	Loranthaceae Juss.	Santalales	Native
340	*Ardisia solanacea* Roxb.	PrimulaceaeBatsch ex Borkh.	Ericales	Native
341	*Anagallis arvensis* L.	PrimulaceaeBatsch ex Borkh.	Ericales	Exotic
342	*Mimusops elengi* L.	Sapotaceae Juss	Ericales	Native
343	*Madhuca longifolia* (J.Konig) J.F. Macbr.	Sapotaceae Juss	Ericales	Native
344	*Diospyros melanoxylon* Roxb.	Ebenaceae Gürke	Ericales	Native
345	*Alangium salviifolium* (L.f.) Wangerin	Cornaceae Bercht. & J. Presl	Cornales	Native
346	*Andrographis echioides* (L.) Nees	Acanthaceae Juss.	Lamiales	Native
347	*Blepharis maderaspatensis* (L.) B. Heyne ex Roth	Acanthaceae Juss.	Lamiales	Native
348	*Blepharis integrifolia* (L. fil.) E. Mey. & Drege	Acanthaceae Juss.	Lamiales	Native
349	*Dicliptera paniculata* (Forssk.)	Acanthaceae Juss.	Lamiales	Native
350	*Eranthemum roseum* (Vahl) R. Br.	Acanthaceae Juss.	Lamiales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Pale Knotweed	H	-	SA	Marshy	LC	-
	H	-	SA	Marshy	-	-
Common knotweed	H	-	SA	Marshy	LC	b,d
Toothed dock	H	-	SA	Marshy	LC	d
Common purslane	H	-	Moist loving	-	LC	b,d
Hairy pigweed	H	-	Moist loving	-	-	-
Devils horsewhip	H	-	Moist loving	-	-	a,b,c,d,e
Mountain Knotgarss	H	-	Moist loving	-	-	b,c,d
Stalkless joyweed	H	-	SA	Marshy	-	d
Josephs goat	H	-	Moist loving	-	-	-
Alligator weed	H	-	SA	Marshy	-	-
Spiny amaranth	H	-	Moist loving	-	-	d
Green amaranth	H	-	Moist loving	-	-	d
Wild spinach	H	-	Moist loving	-	-	b,d,e
Nettle-Leaved Goosefoot	H	-	Moist loving	-	-	d
False Amaranth	H	-	Moist loving	-	-	d
Prostrate Gomphrena	H	-	Moist loving	-	-	-
Forest Burr	H	-	Moist loving	-	LC	d
Seablite	H	-	Moist loving	-	-	-
Oldmans cap	H	-	Moist loving	-	-	-
Cornspurry	H	-	Moist loving	-	-	-
Prostrate Manyseed	H	-	Moist loving	-	LC	-
Punarnava	H	-	Moist loving	-	-	d,e
Indian Tamarisk	S	-	SA	Marshy	-	-
Malabar spinach	H	-	T	-	-	d
Desert horsepurslane	H	-	Moist loving	-	-	-
Honey Suckle Mistletoe	S	-	Ephiphytic parasites	-		c
Shoebutton ardisia	S	-	T	-	-	-
The Scarlet Pimpernel	H	-	Moist loving	-	-	-
Bakul	T	-	T	-	-	-
Mahu	T	-	T	-	-	b,e
East Indian ebony	T	-	T	-	-	c
Akol	T	-	Moist loving	-	LC	-
Bugloss Chiretta	H	-	Moist loving	-	-	a
Creeping Blepharis	H	-	Moist loving	-	-	d
Narrow-Leaf Blepharis	H	-	Moist loving	-	-	-
Panicled foldwing	H	-	Moist loving	-	-	-
Rosy eranthemum	H	-	T	-	LC	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
351	*Hygrophila auriculata* (Schumach.) Heine	Acanthaceae Juss.	Lamiales	Native
352	*Hygrophila polysperma* Anderson	Acanthaceae Juss.	Lamiales	Native
353	*Hygrophila ringens* (L.) R.Br. ex Spreng.	Acanthaceae Juss.	Lamiales	Native
354	*Justicia adhatoda* L.	Acanthaceae Juss.	Lamiales	Native
355	*Rungia elegans* Dalzell & A. Gibson	Acanthaceae Juss.	Lamiales	Native
356	*Rostellularia diffusa* (Willd.) Nees	Acanthaceae Juss.	Lamiales	Native
357	*Lepidagathis trinervis* Nees	Acanthaceae Juss.	Lamiales	Native
358	*Ruellia prostrata* Poir.	Acanthaceae Juss.	Lamiales	Native
359	*Strobilanthes hirta* (Vahl) Blume	Acanthaceae Juss.	Lamiales	Native
360	*Haplophragma adenophyllum* (Wall. ex G. Don) Dop	Bignoniaceae Juss.	Lamiales	Native
361	*Dolichandrone falcata* (Wall. ex DC.) Seem.	Bignoniaceae Juss.	Lamiales	Native
362	*Anisomeles indica* (L.) Kuntze	Lamiaceae Martinov	Lamiales	Native
363	*Clerodendrum viscosum* Vent.	Lamiaceae Martinov	Lamiales	Native
364	*Clerodendrum phlomidis* L.f.	Lamiaceae Martinov	Lamiales	Native
365	*Colebrookia oppositifolia* Sm.	Lamiaceae Martinov	Lamiales	Native
366	*Hyptis suaveolens* (L.) Poit.	Lamiaceae Martinov	Lamiales	Exotic
367	*Leonotis nepetifolia* (L.) R. Br.	Lamiaceae Martinov	Lamiales	Native
368	*Leucas aspera* (Willd.) Link	Lamiaceae Martinov	Lamiales	Native
369	*Leucas biflora* (Vahl) Sm.	Lamiaceae Martinov	Lamiales	Native
370	*Leucas cephalotes* (Roth) Spreng.	Lamiaceae Martinov	Lamiales	Native
371	*Leucas martinicensis* (Jacq.) R. Br.	Lamiaceae Martinov	Lamiales	Native
372	*Ocimum americanum* L.	Lamiaceae Martinov	Lamiales	Native
373	*Ocimum tenuiflorum* L.	Lamiaceae Martinov	Lamiales	Native
374	*Pogostemon benghalensis* (Burm.f.) Kuntze	Lamiaceae Martinov	Lamiales	Native
375	*Salvia plebeia* R. Br.	Lamiaceae Martinov	Lamiales	Native
376	*Tectona grandis* L.f.	Lamiaceae Martinov	Lamiales	Native
377	*Vitex negundo* L.	Lamiaceae Martinov	Lamiales	Native
378	*Bonnaya antipoda* (L.) Druce	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
379	*Bonnaya ciliata* (Colsm.) Spreng.	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
380	*Torenia crustacea* (L.) Cham. & Schltdl.	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
381	*Lindernia dubia* (L.) Pennell	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
382	*Lindernia rotundifolia* (L.) Alston	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
383	*Lindernia procumbens* (Krock.) Philcox	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
384	*Yamazakia viscosa* (Hornem.) W.R. Barker, Y.S. Liang & Wannan	Linderniaceae Borsch, K. Müll. & Eb. Fisch.	Lamiales	Native
385	*Mazus pumilus* (Burm. f.) Steenis	Mazaceae Reveal	Lamiales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Marsh Barbel	H	-	SA	Marshy	LC	-
Dwarf hygrophila	H	-	A	EM	LC	-
Erect Hygrophila	S	-	SA	Marshy	-	-
Adulsa	S	-	Moist loving	-	LC	a,b,c,d,e
Elegant Rungia	H	-	Moist loving	-	-	-
Simple Justicia	H	-	Moist loving	-	-	-
Frilly Lepidagathis	H	-	T	-	-	-
Bell Weed	H	-	Moist loving	-	-	-
Hairy Coneflower	H	-	Moist loving	-	-	-
Karen wood	T	-	T	-	LC	-
Medhshingi	T	-	T	-	LC	-
Indian catmint	S	-	Moist loving	-	-	-
Hill glory bower	S	-	Moist loving	-	-	-
अग्निमंथा, Agnimantha	S	-	Moist loving	-	LC	d
Indian Squirrel til	S	-	Moist loving	-	-	-
American mint	S	-	Moist loving	-	-	-
Lions Ear leonotis	S	-	Moist loving	-	-	-
Common Leucas	H	-	Moist loving	-	-	d
Two-Flowered Leucas	H	-	Moist loving	-	-	a
Head leucas	H	-	Moist loving	-	-	-
Whitewort	H	-	Moist loving	-	-	-
American basil	H	-	Moist loving	-	-	b,d
Holi basil	H	-	Moist loving	-	-	-
Bengal shrub-mint	S	-	Moist loving	-	-	d
Sage Weed	H	-	Moist loving	-	-	-
Sag	T	-	T	-	LC	c
Five-leaved chaste tree	S	-	Moist loving	-	LC	b,c,d,e
Sparrow Lindernia	H	-	SA	Marshy	-	-
Fringed False Pimpernel	H	-	Moist loving	-	LC	-
Malaysian false pimpernel.	H	-	Moist loving	-	LC	-
Yellowseed Lindernia	H	-	Moist loving	-	-	-
Roundleaf Lindernia	H	-	Moist loving	-	LC	-
	H	-	Moist loving	-	LC	-
Sticky Lindernia	H	-	Moist loving	-	-	-
Japanese mazus	H	-	Moist loving	-	-	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
386	*Limnophila aquatica* (Roxb.) Alston	Plantaginaceae Juss.	Lamiales	Native
387	*Scoparia dulcis* L.	Plantaginaceae Juss.	Lamiales	Exotic
388	*Veronica anagallis-aquatica* L.	Plantaginaceae Juss.	Lamiales	Native
389	*Bacopa monnieri* (L.) Wettst.	Plantaginaceae Juss.	Lamiales	Native
390	*Mecardonia procumbens* (Mill.) Small	Plantaginaceae Juss.	Lamiales	Exotic
391	*Nanorrhinum ramosissimum* (Wall.) Betsche	Plantaginaceae Juss.	Lamiales	Native
392	*Lindenbergia indica* (L.) Vatke	Orobanchaceae Vent.	Lamiales	Native
393	*Lindenbergia muraria* (Roxb. ex D.Don)	Orobanchaceae Vent.	Lamiales	Native
394	*Striga angustifolia* (D.Don) C.J. Saldanha	Orobanchaceae Vent.	Lamiales	Native
395	*Verbascum chinense* (L.) Santapau	Scrophulariaceae Juss.	Lamiales	Native
396	*Lantana camara* L.	Verbenaceae J. St.-Hil.	Lamiales	Exotic
397	*Lippia alba* (Mill.) N.E. Br. Britton & P. Wilson	Verbenaceae J. St.-Hil.	Lamiales	Exotic
398	*Phyla nodiflora* (L.)	Verbenaceae J. St.-Hil.	Lamiales	Native
399	*Verbena officinalis* L.	Verbenaceae J. St.-Hil.	Lamiales	Native
400	*Martynia annua* L.	Martyniaceae Horaninow	Lamiales	Exotic
401	*Utricularia aurea* Lour.	Lentibulariaceae Rich.	Lamiales	Native
402	*Convolvulus arvensis* L.	Convolvulaceae Juss.	Solanales	Native
403	*Cuscuta campestris* Yunck.	Convolvulaceae Juss.	Solanales	Exotic
404	*Cuscuta reflexa* Roxb.	Convolvulaceae Juss.	Solanales	Native
405	*Distimake aegyptius* (L.) A.R. Simões & Staples	Convolvulaceae Juss.	Solanales	Exotic
406	*Distimake dissectus* (Jacq.) A.R. Simões & Staples	Convolvulaceae Juss.	Solanales	Exotic
407	*Evolvulus nummularius* (L.) L.	Convolvulaceae Juss.	Solanales	Exotic
408	*Evolvulus alsinoides* (L,) L.	Convolvulaceae Juss.	Solanales	Native
409	*Merremia hederacea* (Burm. f.) Hallier f.	Convolvulaceae Juss.	Solanales	Native
410	*Merremia emarginata* (Burm. f.) Hallier f.	Convolvulaceae Juss.	Solanales	Native
411	*Operculina turpethum* (L.) Silva Manso	Convolvulaceae Juss.	Solanales	Native
412	*Ipomoea aquatica* Forssk	Convolvulaceae Juss.	Solanales	Native
413	*Ipomoea eriocarpa* R.Br.	Convolvulaceae Juss.	Solanales	Native
414	*Ipomoea carnea* Jacq.	Convolvulaceae Juss.	Solanales	Exotic
415	*Ipomoea nil* (L.) Roth	Convolvulaceae Juss.	Solanales	Exotic
416	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae Juss.	Solanales	Native
417	*Ipomoea triloba* L.	Convolvulaceae Juss.	Solanales	Exotic
418	*Ipomoea aitonii* Lindl.	Convolvulaceae Juss.	Solanales	Native
419	*Ipomoea laxiflora* H.J. Chowdhery & Debta	Convolvulaceae Juss.	Solanales	Native
420	*Xenostegia tridentata* (L.) D.F. Austin & Staples	Convolvulaceae Juss.	Solanales	Native
421	*Datura metel* L.	Solanaceae Juss.	Solanales	Exotic
422	*Datura innoxia* Mill.	Solanaceae Juss.	Solanales	Exotic

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Water Marshweed	H	-	A	EM	-	-
Sweet broom weed	H	-	Moist loving	-	-	-
Water speedwell	H	-	SA	Marshy	LC	-
Brahmi	H	-	SA	Marshy	LC	d
Yellow flowered waterhyssop	H	-	Moist loving	-	-	-
Indian Toadflax	H	-	Moist loving	-	-	-
Indian Lindenbergia	H	-	Moist loving	-	LC	d
Wall Lindenbergia	H	-	Moist loving	-	-	-
Narrow-Leaved Witchweed	H	-	SA	Marshy	-	-
Chinese Mullein	H	-	Moist loving	-	-	-
Common lantana	S	-	Moist loving	-	-	-
Bushy lippia	S	-	Moist loving	-	-	-
Turkey tangle frogfruit	H	-	Moist loving	-	LC	d
Herb of Grace	H	-	Moist loving	-	LC	-
Devils claws	S	-	Moist loving	-	-	-
Golden Bladderwort	H		A	SUB	LC	-
Field bindweed	C	-	Moist loving	-	-	e
Golden Dodder	C	-	Ephiphytic parasites	-	-	-
Gaint dodder	C	-	Ephiphytic parasites	-	LC	c,d
	C	-	T	-	-	-
Noyau Vine	C	-	T	-	-	-
Roundleaf bindweed	H	-	Moist loving	-	-	-
Dwarf Morning Glory	H	-	Moist loving	-	-	d
Ivy rosewood	C	-	Moist loving	-	-	-
Kidney Leaf Morning Glory	H	-	Moist loving	-	-	a
Transparent wood Rose	C	-	Moist loving	-	-	-
Water morning glory	H	-	A	FF	LC	a
Tiny morning glory	C	-	Moist loving		-	-
Bush morning glory	S	-	SA	Marshy	-	a,b,c,d,e
Japanese morning glory	C	-	Moist loving	-	-	d
Obscure morning glory	C	-	Moist loving	-	-	s
Little bell morning glory	C	-	Moist loving	-	LC	-
	C	-	Moist loving	-	-	-
Indian Morning Glory	C	-	Moist loving	-	-	-
Arrow-leaf Morning Glory	C	-	Moist loving	-	-	-
Purple Thorn-Apple	H	-	Moist loving	-	-	e
Datura	H	-	Moist loving	-	-	a,b

S.no	Plant Name (Botanical name)	Family	Order	Nativity
423	*Nicotiana plumbaginifolia* Viv.	Solanaceae Juss.	Solanales	Exotic
424	*Physalis minima* L.	Solanaceae Juss.	Solanales	Exotic
425	*Physalis pruinosa* L.	Solanaceae Juss.	Solanales	Exotic
426	*Solanum nigrum* L.	Solanaceae Juss.	Solanales	Native
427	*Solanum torvum* Sw.	Solanaceae Juss.	Solanales	Exotic
428	*Solanum violaceum* Ortega	Solanaceae Juss.	Solanales	Native
429	*Solanum virginianum* L.	Solanaceae Juss.	Solanales	Native
430	*Withania somnifera* (L.) Dunal	Solanaceae Juss.	Solanales	Native
431	*Sphenoclea zeylanica* Gaertn.	Sphenocleaceae T. Baskerv.	Solanales	Native
432	*Hydrolea zeylanica* (L.) Vahl	Hydroleaceae R.Br. ex Edwards	Solanales	Native
433	*Hoppea dicotoma* B. Heyne ex Willd.	Gentianaceae Juss.	Gentianales	Native
434	*Canscora diffusa* (Vahl) R. Br. ex Roem. & Schult.	Gentianaceae Juss.	Gentianales	Native
435	*Asclepias curassavica* L.	Apocynaceae Juss.	Gentianales	Exotic
436	*Alstonia scholaris* (L.) R. Br.	Apocynaceae Juss.	Gentianales	Native
437	*Calotropis procera* (Aiton) W.T. Aiton	Apocynaceae Juss.	Gentianales	Native
438	*Calotropis gigantea* (L.) Dryand.	Apocynaceae Juss.	Gentianales	Native
439	*Cryptolepis buchananii* R. Br. ex Roem. & Schult.	Apocynaceae Juss.	Gentianales	Native
440	*Dregea volubilis* (L.f.) Benth. Ex Hook. f.	Apocynaceae Juss.	Gentianales	Native
441	*Pergularia daemia* (Forssk.) Chiov.	Apocynaceae Juss.	Gentianales	Native
442	*Pentatropis capensis* (L.f.) Bullock	Apocynaceae Juss.	Gentianales	Native
443	*Hemidesmus indicus* (L.) R. Br.	Apocynaceae Juss.	Gentianales	Native
444	*Ichnocarpus frutescens* (L.) W.T. Aiton	Apocynaceae Juss.	Gentianales	Native
445	*Oxystelma esculentum* (L.f.) Sm.	Apocynaceae Juss.	Gentianales	Native
446	*Vallaris solanacea* (Roth ex Roem. & Schult.) Kuntze	Apocynaceae Juss.	Gentianales	Native
447	*Centaurium pulchellum* L.	Gentianaceae Juss	Gentianales	Native
448	*Mitragyna parvifolia* (Roxb.) Korth.	Rubiaceae Juss.	Gentianales	Native
449	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae Juss.	Gentianales	Native
450	*Oldenlandia biflora* L.	Rubiaceae Juss.	Gentianales	Native
451	*Oldenlandia corymbosa* L.	Rubiaceae Juss.	Gentianales	Native
452	*Oldenlandia herbacea* (L.) Roxb.	Rubiaceae Juss.	Gentianales	Native
453	*Spermacoce ocymoides* Burm. f.	Rubiaceae Juss.	Gentianales	Native
454	*Spermacoce articularis* L.f.	Rubiaceae Juss.	Gentianales	Native
455	*Spermadictyon suaveolens* Roxb.	Rubiaceae Juss.	Gentianales	Native
456	*Dentella repens* (L.) J.R. Forst. & G. Forst.	Rubiaceae Juss.	Gentianales	Native
457	*Bothriospermum zeylanicum* (J. Jacq.) Druce	Boraginaceae Juss.	Gentianales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Tex-Mex tobacco	H	-	Moist loving	-	-	-
Wild cape gooseberry	H	-	Moist loving	-	-	b,d
Strawberry Tomato	H	-	Moist loving	-	LC	-
European black nightshade	H	-	Moist loving	-	-	b,e
Turkey Berry	S	-	Moist loving	-	-	-
Asian nightshade	H	-	Moist loving	-	-	-
Indian nightshade	H	-	Moist loving	-	-	a,d
Ashwagandha	S	-	Moist loving	-	DD	b,d,e
Chickenspike	H	-	SA	Marshy	LC	-
Ceylon Hydrolea	H	-	SA	Marshy	LC	-
Indian Hoppea	H	-	SA	Marshy	-	-
Spreading Canscora	H	-	SA	Marshy	-	-
Scarlet Milkweed	H	-	SA	Marshy	-	-
Blackboard tree	T	-	T	-	LC	-
Giant milkweed	S	-	Moist loving	-	-	a,b,c,d,e
Crown flower	S	-	Moist loving	-	-	-
Indian Sarsaparilla	C	-	Moist loving	-	-	-
Green milkweed climber	C	-	Moist loving	-	-	-
Trellis-vine	C	-	Moist loving	-	LC	a,b,c,d
	C	-	T	-	LC	-
Anantamul	C	-	Moist loving	-	-	b,e
Black creeper	C	-	Moist loving	-	-	-
Rosy Milkweed Vine.	C	-	SA	Marshy	LC	-
Bread flower	C	-	Moist loving	-	-	-
Lesser Centaury	H	-	Moist loving	-	LC	-
Kalamb	T	-	T	-	-	c
Kadamb	T	-	T	-	-	-
Two flower mille graines	H	-	Moist loving	-	-	-
Corymb diamond flower.	H	-	Moist loving	-	LC	-
Slender Diamond Flower	H	-	Moist loving	-	LC	-
Basil Buttonweed	H	-	Moist loving	-	-	-
Jointed Buttonweed	H	-	Moist loving	-	-	-
Forest Champa	S	-	Moist loving	-	-	-
Creeping Dentella	H	-	Moist loving	-	LC	-
	H	-	Moist loving	-	-	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
458	*Cordia dichotoma* G. Forst.	Boraginaceae Juss.	Gentianales	Native
459	*Coldenia procumbens* L.	Boraginaceae Juss.	Gentianales	Native
460	*Cynoglossum lanceolatum* Forssk.	Boraginaceae Juss.	Gentianales	Native
461	*Heliotropium indicum* L.	Boraginaceae Juss.	Gentianales	Exotic
462	*Heliotropium ovalifolium* Forssk.	Boraginaceae Juss.	Gentianales	Native
463	*Heliotropium strigosum* Willd.	Boraginaceae Juss.	Gentianales	Native
464	*Trichodesma indicum* (L.) R. Br.	Boraginaceae Juss.	Gentianales	Native
465	*Ehretia laevis* Roxb.	Boraginaceae Juss.	Gentianales	Native
466	*Artemisia vulgaris* L.	Asteraceae Bercht. & J. Presl	Asterales	Native
467	*Ageratum conyzoides* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
468	*Ageratum houstonianum* Mill.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
469	*Acmella ciliata* (Kunth) Cass.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
470	*Acmella paniculata* (Wall. ex DC.) R.K. Jansen	Asteraceae Bercht. & J. Presl	Asterales	Native
471	*Bidens pilosa* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
472	*Blumea axillaris* (Lam.) DC.	Asteraceae Bercht. & J. Presl	Asterales	Native
473	*Blumea lacera* (Burm.f.) DC.	Asteraceae Bercht. & J. Presl	Asterales	Native
474	*Blumea sinuata* (Lour.) Merr.	Asteraceae Bercht. & J. Presl	Asterales	Native
475	*Caesulia axillaris* Roxb.	Asteraceae Bercht. & J. Presl	Asterales	Native
476	*Calyptocarpus vialis* Less.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
477	*Chromolaena odorata* (L.) R.M. King & H. Rob. (L.) R.M.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
478	*Cirsium arvense* (L.) Scop.	Asteraceae Bercht. & J. Presl	Asterales	Native
479	*Cichorium intybus* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
480	*Eclipta prostrata* (L.) L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
481	*Elephantopus scaber* L.	Asteraceae Bercht. & J. Presl	Asterales	Native
482	*Erigeron bonariensis* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
483	*Enydra fluctuans* Lour.	Asteraceae Bercht. & J. Presl	Asterales	Native
484	*Echinops echinatus* Roxb.	Asteraceae Bercht. & J. Presl	Asterales	Native
485	*Eupatorium adenophorum* Spreng.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
486	*Pseudognaphalium luteoalbum* (L.) Hilliard & B.L. Burtt	Asteraceae Bercht. & J. Presl	Asterales	Native
487	*Gnaphalium pensylvanicum* Willd.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
488	*Gnaphalium polycaulon* Pers.	Asteraceae Bercht. & J. Presl	Asterales	Native
489	*Gnaphalium pulvinatum* Delile	Asteraceae Bercht. & J. Presl	Asterales	Native
490	*Grangea maderaspatana* (L.) Desf.	Asteraceae Bercht. & J. Presl	Asterales	Native
491	*Grangea minima* (L.) Dum. Cours.	Asteraceae Bercht. & J. Presl	Asterales	Native
492	*Galinsoga parviflora* Cav.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
493	*Parthenium hysterophorus* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
494	*Pluchea lanceolata* (DC.) C.B. Clarke	Asteraceae Bercht. & J. Presl	Asterales	Native

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Fragrant manjack	T	-	Moist loving	-	-	-
Creeping Coldenia	H	-	Moist loving	-	LC	-
Lanceleaf Forget-Me-Not	H	-	Moist loving	-	-	-
Indian heliotrope	H	-	Moist loving	-	-	d
Grey Leaf Heliotrope	H	-	Moist loving	-	LC	-
Bristly Heliotrope	H	-	Moist loving	-	-	-
Indian Borage	H	-	Moist loving	-	-	d
Chamror	T	-	Moist loving	-	DD	d
Common mugwort	S	-	Moist loving	-	LC	-
Goatweed	H	-	Moist loving	-	LC	-
Blueweed	H	-	Moist loving	-	-	-
Toothache Plant	H	-	Moist loving	-	-	-
Panicled Spot Flower	H	-	Moist loving	-	LC	-
Beggar's Tick	H	-	Moist loving	-	-	-
Soft Blumea	H	-	Moist loving	-	-	-
Lettuce-Leaf Blumea	H	-	Moist loving	-	-	-
Sow-Thistle Blumea	H	-	Moist loving	-	-	-
Pink node flower	H	-	SA	Marshy	LC	-
Creeping Cinderella-weed	H	-	Moist loving	-	-	-
Devil weed	H	-	Moist loving	-	-	-
Field Thistle	H	-	Moist loving	-	-	d
Chicory	H	-	Moist loving	-	LC	-
False daisy	H	-	Moist loving	-	LC	d
Prickly-leaved elephant's foot	H	-	Moist loving	-	-	e
Flaxleaf Fleabane	H	-	Moist loving	-	-	-
Buffalo Spinach	H	-	A	FF	LC	-
Indian Globe Thistle	H	-	Moist loving	-	-	d
Catweed	H	-	Moist loving	-	-	-
Weedy Cudweed	H	-	Moist loving	-	LC	-
Pennsylvania Cudweed	H	-	Moist loving	-	-	-
Many-Stemmed Cudweed	H	-	Moist loving	-	LC	-
Prostrate gnaphalium	H	-	Moist loving	-	DD	-
Madras carpet	H	-	Moist loving	-	LC	-
Spreading Sneeze Weed	H	-	Moist loving	-	-	-
Quick Weed	H	-	Moist loving	-	-	-
Carrot weed	H	-	Moist loving	-	-	a
Rasna	H	-	Moist loving	-	-	-

S.no	Plant Name (Botanical name)	Family	Order	Nativity
495	*Pulicaria undulata* (L.) C.A. Mey.	Asteraceae Bercht. & J. Presl	Asterales	Native
496	*Tridax procumbens* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
497	*Launaea procumbens* (Roxb.) Ramayya & Rajagopal	Asteraceae Bercht. & J. Presl	Asterales	Native
498	*Mikania micrantha* Kunth	Asteraceae Bercht. & J. Presl	Asterales	Exotic
499	*Oligochaeta ramosa* (Roxb.) Wagenitz	Asteraceae Bercht. & J. Presl	Asterales	Native
500	*Sigesbeckia orientalis* L.	Asteraceae Bercht. & J. Presl	Asterales	Native
501	*Soliva anthemifolia* (Juss.) Sweet	Asteraceae Bercht. & J. Presl	Asterales	Exotic
502	*Sonchus asper* (L.) Hill	Asteraceae Bercht. & J. Presl	Asterales	Exotic
503	*Sonchus oleraceus* L.	Asteraceae Bercht. & J. Presl	Asterales	Exotic
504	*Sphagneticola calendulacea* (L.) Pruski	Asteraceae Bercht. & J. Presl	Asterales	Native
505	*Sphaeranthus indicus* L.	Asteraceae Bercht. & J. Presl	Asterales	Native
506	*Xanthium strumarium* L.	Asteraceae Bercht. & J. Presl	Asterales	Native
507	*Pentanema indicum* (L.) Y. Ling	Asteraceae Bercht. & J. Presl	Asterales	Native
508	*Youngia japonica* (L.) DC.	Asteraceae Bercht. & J. Presl	Asterales	Native
509	*Laggera crispata* (Vahl) Hepper & J.R.I. Wood	Asteraceae Bercht. & J. Presl	Asterales	Native
510	*Nymphoides cristata* (Roxb.) Kuntze	Menyanthaceae Dumort.	Asterales	Native
511	*Campanula dimorphantha* Schweinf.	Campanulaceae Juss.	Asterales	Native
512	*Lobelia alsinoides* Lam.	Campanulaceae Juss.	Asterales	Native
513	*Centella asiatica* (L.) Urb.	Apiaceae Lindl.	Apiales	Native
514	*Cnidium monnieri* (L.) Cusson	Apiaceae Lindl.	Apiales	Native
515	*Hydrocotyle sibthorpioides* Lam.	Apiaceae Lindl.	Apiales	Native
516	*Oenanthe javanica* (Blume) DC.	Apiaceae Lindl.	Apiales	Native
517	*Azolla pinnata* R. Br.	Salviniaceae Martinov	Salviniales	Native
518	*Salvinia natans* (L.) All.	Salviniaceae Martinov	Salviniales	Native
519	*Marsilea minuta* L.	Marsileaceae Mirb.	Salviniales	Native
520	*Ceratopteris thalictroides* (L.) Brongn.	Pteridaceae E.D.M. Kirchn.	Polypodiales	Native

a- Chorghe et al. (2012); b- Kala et al. (2017); c- Pathak (2013); d- Sikarwar (2023); e- Uthappa et al. (2018)

Common name	Habit	Sub	Habitat category	Sub-catergory	IUCN status	Previous study
Desert Golden Daisy	H	-	Moist loving	-	-	d
Tridax daisy	H	-	Moist loving	-	-	b,d,e
Creeping Launaea	H	-	Moist loving	-	-	-
Bitter vine	C	-	Moist loving	-	-	-
Branched Sweet-Sultan	H	-	Moist loving	-	-	-
Indian-weed	H	-	Moist loving	-	-	-
Button Burrweed	H	-	Moist loving	-	LC	-
Prickly sow-thistle	H	-	Moist loving	-	-	b
Common sowthistle	H	-	Moist loving	-	-	-
Chinese Wedelia	H	-	Moist loving	-	LC	-
East Indian Globe Thistle	H	-	Moist loving	-	LC	b,d
Common cocklebur	H	-	Moist loving	-	-	b,c,d
Sonkadi	H	-	Moist loving	-	-	-
Oriental false hawksbeard	H	-	Moist loving	-	-	-
Curly Blumea	H	-	Moist loving	-	-	-
Creasted floating heart	H	-	A	FF	LC	a
Two formed bell flower	H	-	Moist loving	-	-	-
Chickweed Lobelia	H	-	SA	Marshy	LC	-
Asiatic pennywort	H	-	SA	Marshy	LC	-
Jashoshi	H	-	Moist loving	-	-	-
Water Pennywort	H	-	SA	Marshy	LC	-
Java waterdropwort	H	-	Moist loving		LC	-
Feathered mosquitofern	H	-	A	FF	LC	-
	H	-	A	FF	LC	-
Dwarf waterclover	H	-	SA	Marshy	LC	-
Water sprite	H	-	SA	Marshy	LC	-

References

Chorghe, A., Rasal, V., & Khandal, D. (2012). Riparian flora along the ravines of National Chambal Sanctuary. *ENVIS Newsletter on Wetland Ecosystems and Inland Wetlands Sarovar Saurabh, 8*(1), 8-10.

Kala, S., Meena, H. R., Rashmi, I., Prabavathi, M., Singh, A. K., & Singh, R. K. (2017). Status of medicinal plants diversity and distribution at rehabilitated Yamuna and Chambal ravine land ecosystems in India. *International Journal of Current Microbiology and Applied Sciences, 6*(3), 618-630.

Pathak, S. K. (2013). Study of vegetation and flora of Chambal region (MP). *International Journal of Scientific Research*, 2, 389.

Sikarwar, R. L. (2023). Floristic diversity of Chambal ravines of Madhya Pradesh. *Journal of Economic and Taxonomic Botany, 26*(1), 55-65.

Uthappa, A. R., Chavan, S., Ramesha, M. N., Samadharmam, K., Kumar, V., Handa, A. K., & Chaturvedi, O. P. (2018). Plant biodiversity of ravine ecosystems: Opening new vistas for enhancing productivity. In S. K. Samadharmam (Ed.), *Advances in Environmental Biology* (pp. 55-65). Springer. https://doi.org/10.1007/978-981-10-8043-2_4

ANNEXURE II: Checklist of Fish species of the Chambal River:

Family	Scientific Name	Common Name
Adrianichthyidae	*Oryzias dancena* (Hamilton, 1822)	Indian blue ricefish
Ailiidae	*Ailia coila* (Hamilton, 1822)	Gangetic ailia
	Ailiichthys punctata (Day, 1872)	Jamuna ailia
	Clupisoma garua (Hamilton, 1822)	Garua bachcha
	Eutropiichthys murius (Hamilton, 1822)	Murius vacha
	Eutropiichthys vacha (Hamilton, 1822)	Batchwa vacha
	Silonia silondia (Hamilton, 1822)	Silond catfish
Ambassidae	*Chanda baculis* (Hamilton, 1822)	Himalayan glassy perchlet
	Chanda nama (Hamilton, 1822)	Elongate glassy perchlet
	Chanda ranga (Hamilton, 1822)	Indian glassy fish
	Pseudambassis lala (Hamilton, 1822)	Highfin glassy perchlet
Amblycipitidae	*Amblyceps mangois* (Hamilton, 1822)	Indian torrent catfish
Anabantidae	*Anabas testudineus* (Bloch, 1792)	Climbing perch
Anguillidae	*Anguilla bengalensis* (Gray, 1831)	Indian mottled eel
Aplocheilidae	*Aplocheilus blockii* (Arnold, 1911)	Green panchax
	Aplocheilus lineatus (Valenciennes, 1846)	Striped panchax
	Aplocheilus panchax (Hamilton, 1822)	Blue panchax
Badidae	*Badis badis* (Hamilton, 1822)	Badis
Bagridae	*Mystus bleekeri* (Day, 1877)	Day's mystus
	Mystus cavasius (Hamilton, 1822)	Gangetic mystus
	Mystus gulio (Hamilton, 1822)	Long whiskers catfish
	Mystus tengara (Hamilton, 1822)	Tengara catfish
	Mystus vittatus (Bloch, 1794)	Striped dwarf catfish
	Rita rita (Hamilton, 1822)	Rita
	Sperata aor (Hamilton, 1822)	Long-whiskered catfish
	Sperata lamarrii (Valenciennes, 1840)	River-catfish
Belonidae	*Xenentodon cancila* (Hamilton, 1822)	Needle fish
Botiidae	*Botia birdi* (Chaudhuri, 1910)	Birdi loach
	Botia dario (Hamilton, 1822)	Bengal loach or Queen loach
	Botia lohachata (Chaudhuri, 1912)	Reticulate loach
	Botia rostrata (Gunther, 1868)	Gangetic loach
Channidae	*Channa gachua* (Hamilton, 1822)	Dwarf snakehead
	Channa marulius (Hamilton, 1822)	Bullseye snakehead or great snakehead
	Channa punctata (Bloch, 1793)	Spotted snakehead
	Channa striata (Bloch, 1793)	Striped snakehead
Cichlidae	*Oreochromis mossambicus* (Peters, 1852)	Mozambique tilapia
	Oreochromis niloticus (Linnaeus, 1758)	Nile tilapia
Clariidae	*Clarias batrachus* (Linnaeus, 1758)	Walking catfish
	Clarias gariepinus (Burchell, 1822)	North African catfish
	Clarias magur (Hamilton, 1822)	Magur

IUCN Status	Previous Studies	Present Study
LC	16,27	-
NT	16,23,27	-
DD	2,15,16	-
LC	2,6,7,11,13,15,16,21,23,25,27	+
LC	2,16	-
LC	2,6,7,8,11,13,16,18,21,22,23,25,27,30	+
LC	2,8,13,16,18,21,22,23,25,27,30	-
LC	7,16,27	+
LC	1,2,3,4,6,7,8,13,16,18,19,20,21,22,23,25,27,30	+
LC	3,5,6,7,8,13,16,17,18,20,21,22,24,25,27,29,30	-
NT	7,13	-
LC	16,27	-
LC	16,23,27	-
NT	7,10,11,16,21	-
LC	16,27	-
LC	16,27	-
LC	13	-
LC	8,16,25	-
LC	2,5,6,7,8,16,20,21,23,24,25,27,29	-
LC	3,5,6,7,8,10,11,13,16,17,20,21,23,27,29	+
LC	2	-
LC	10,11,13,16	-
LC	6,8,16,21,23,25,27	-
LC	7,8,10,11,13,15,16,18,21,22,23,25,27,30	+
LC	1,5,6,7,8,13,16,18,19,20,21,22,23,24,25,27,29,30	+
LC	1,2,3,4,5,6,7,8,10,11,12,13,16,17,18,19,20,21,22,23,24,25,27,29,30	+
LC	1,2,3,4,5,6,7,8,11,13,15,16,17,18,19,20,21,22,23,24,25,27,29,30	+
LC	16,23,27	-
LC	7	-
LC	16,23,27	-
VU	7,16,27	-
LC	5,7,8,16,21,29	-
LC	1,2,5,6,7,8,9,12,13,16,17,18,19,21,22,23,24,25,27,29,30	-
LC	1,2,5,6,7,8,9,11,12,13,16,17,18,19,21,22,23,25,27,29,30	-
LC	1,2,5,7,8,11,16,17,18,19,21,22,23,25,27,29,30	-
Exotic	2,7,16,27	-
Exotic	7,13	+
LC	5,6,11,24,29	-
LC	16,23,27	-
EN	7,16,17,21,22,23,27	-

Family	Scientific Name	Common Name
Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)	Guntea loach
Cyprinidae	*Bangana dero* (Hamilton, 1822)	Kalabans
	Bhava vittata (Day, 1865)	Greenstripe barb
	Carassius carassius (Linnaeus, 1758)	Crucian carp, Gang gad
	Chagunius chagunio (Hamilton, 1822)	Chaguni
	Cirrhinus mrigala (Hamilton, 1822)	Mrigal
	Cirrhinus reba (Hamilton, 1822)	Reba carp
	Cyprinus carpio (Linnaeus, 1758)	Common carp
	Dawkinsia arulius (Jerdon, 1849)	Arulius barb
	Garra gotyla (Gray, 1830)	Sucker head
	Garra lamta (Hamilton, 1822)	Lamta garra
	Garra mullya (Sykes, 1839)	Sucker fish
	Hypselobarbus kolus (Sykes, 1839)	Kolus
	Labeo angra (Hamilton, 1822)	Angra labeo
	Labeo bata (Hamilton, 1822)	Bata
	Labeo boga (Hamilton, 1822)	Boga labeo
	Labeo boggut (Sykes, 1839)	Boggut labeo
	Labeo calbasu (Hamilton, 1822)	Orangefin labeo
	Labeo catla (Hamilton, 1822)	Catla
	Labeo dussumieri (Valenciennes, 1842)	Common labeo
	Labeo dyocheilus (McClelland, 1839)	Boalla
	Labeo fimbriatus (Bloch, 1795)	Fringed-lipped peninsula carp
	Labeo gonius (Hamilton, 1822)	Kuria labeo
	Labeo pangusia (Hamilton, 1822)	Pangusia labeo
	Labeo rajasthanicus (Datta & Majumdar, 1970)	-
	Labeo rohita (Hamilton, 1822)	Rohu
	Oreichthys cosuatis (Hamilton, 1822)	-
	Osteobrama cotio (Hamilton, 1822)	Cotio
	Pethia conchonius (Hamilton, 1822)	Rosy barb
	Pethia gelius (Hamilton, 1822)	Golden barb
	Pethia guganio (Hamilton, 1822)	Glass-barb
	Pethia phutunio (Hamilton, 1822)	Spottedsail barb
	Pethia punctata (Day, 1865)	-
	Pethia ticto (Hamilton, 1822)	Ticto barb, Two-spot barb
	Puntius amphibius (Valenciennes, 1842)	Scarlet-banded barb
	Puntius chola (Hamilton, 1822)	Swamp barb or chola barb
	Puntius dorsalis (Jerdon, 1849)	Long snouted barb
	Puntius sophore (Hamilton, 1822)	Pool barb, spotfin swamp barb
	Systomus sarana (Hamilton, 1822)	Olive barb
	Tariqilabeo diplochilus (Heckel, 1838)	Kashmir latia
	Tariqilabeo latius (Hamilton, 1822)	Gangetic latia, Stone roller
	Tor khudree (Sykes, 1839)	Deccan mahseer

IUCN Status	Previous Studies	Present Study
LC	7,8,16,23,25,27	-
LC	2,8,13,16,25	-
LC	2,16,27	-
Exotic	16,21,23,27	-
LC	8,16,23,25,27	+
LC	1,2,3,4,5,6,7,8,10,11,12,13,16,17,18,19,20,21,24,25,27,29,30	+
LC	1,2,3,4,5,6,7,8,10,11,13,16,17,18,21,22,23,25,27,29,30	+
Exotic	2,5,10,16,17,21,22,23,24,27,29	+
EN	16,27	-
LC	1,2,3,9,13,16,18,21,23,27,29,30	-
LC	8,11,12,16,25,27	-
LC	3,6,7,16,20,23,27	+
VU	7	-
LC	11,13,16,23,27	-
LC	1,2,3,5,6,7,8,10,11,13,16,17,18,21,22,23,24,25,27,29,30	+
LC	8,16,21,23,25,27	-
LC	2,3,5,6,7,8,16,18,19,21,23,25,27,29,30	+
LC	1,2,3,4,5,6,7,8,10,11,13,16,17,18,19,21,23,24,25,27,29,30	+
LC	1,2,3,5,6,7,8,10,11,12,13,14,15,16,17,18,19,20,21,23,24,25,27,29,30	-
LC	25	-
LC	2,7,8,16,21,22,23,25,27	+
LC	1,5,11,16,21,23,27,29	-
LC	1,2,4,5,6,7,8,10,11,13,16,17,18,19,20,21,22,23,24,25,29,30	+
NT	2,6,7,13,16,19,23	-
VU	16,23	-
LC	1,2,3,5,6,7,8,10,11,12,13,14,16,17,18,19,21,23,24,25,27,29,30	-
LC	7	-
LC	2,3,4,5,6,7,8,11,13,16,18,20,21,22,23,25,27,29,30	+
LC	5,6,7,8,13,16,21,25,29	-
LC	6,7	-
LC	16	-
LC	8,16,25	-
LC	19	-
LC	1,2,3,5,6,7,8,10,16,18,19,21,22,23,25,27,29,30	+
DD	5,6,7,13,16,19,23,27,29	-
LC	7,13,16,23,27	+
LC	19	-
LC	1,2,3,5,6,7,8,10,11,12,13,16,17,19,20,21,22,23,25,27,29	+
LC	1,2,3,4,5,6,7,8,10,11,13,16,17,18,19,20,21,22,23,24,25,27,29,30	+
NE	7	-
LC	6,7,8,13,16,18,22,25,27	-
LC	2,6,7,16,23,27	-

Family	Scientific Name	Common Name
	Tor putitora (Hamilton, 1822)	Putitor mahseer
	Tor tor (Hamilton, 1822)	Tor barb, Mahseer
Danionidae	*Amblypharyngodon microlepis* (Bleeker, 1853)	Indian carplet
	Amblypharyngodon mola (Hamilton, 1822)	Mola carplet
	Barilius barila (Hamilton, 1822)	Barred baril
	Barilius modestus (Day, 1872)	Indus baril
	Barilius vagra (Hamilton, 1822)	Vagra baril
	Bengala elanga (Hamilton, 1822)	Bengala barb
	Cabdio jaya (Hamilton, 1822)	Jaya
	Cabdio morar (Hamilton, 1822)	Morari
	Chela cachius (Hamilton, 1822)	Silver hatchet chela
	Danio rerio (Hamilton, 1822)	Zebra danio
	Devario aequipinnatus (McClelland, 1839)	Giant danio
	Devario devario (Hamilton, 1822)	Sind danio
	Esomus ahli (Hora & Mukerji, 1928)	-
	Esomus danrica (Hamilton, 1822)	Indian flying barb
	Esomus thermoicos (Valenciennes, 1842)	Flying barb
	Laubuka laubuca (Hamilton, 1822)	Indian glass barb
	Opsarius barna (Hamilton, 1822)	Barna baril
	Opsarius bendelisis (Hamilton, 1807)	Indian hill trout
	Opsarius shacra (Hamilton, 1822)	Shacra baril
	Raiamas bola (Hamilton, 1822)	Trout barb
	Rasbora daniconius (Hamilton, 1822)	Slender rasbora
	Rasbora rasbora (Hamilton, 1822)	Gangetic scissortail rasbora
	Salmostoma bacaila (Hamilton, 1822)	Large razorbelly minnow
	Salmostoma balookee (Sykes, 1839)	Bloch razorbelly minnow
	Salmostoma boopis (Day, 1874)	Boopis razorbelly minnow
	Salmostoma orissaense (Banarescu, 1968)	Orissa razorbelly minnow
	Salmostoma phulo (Hamilton, 1822)	Finescale razorbelly minnow
	Salmostoma punjabense (Day, 1872)	Punjab razorbelly minnow
	Salmostoma sardinella (Valenciennes, 1844)	Sardinella razorbelly minnow
	Securicula gora (Hamilton, 1822)	Gora chela
Dasyatidae	*Himantura marginata* (Blyth, 1860)	Blackedge whipray
	Pastinachus sephen (Fabricius, 1775)	Cowtail stingray
	Urogymnus polylepis (Bleeker, 1852)	Giant freshwater whipray
Dorosomatidae	*Gonialosa manmina* (Hamilton, 1822)	Ganges river gizzard shad
	Gudusia chapra (Hamilton, 1822)	Indian river shad
	Tenualosa ilisha (Hamilton, 1822)	Hilsa shad
Engraulidae	*Setipinna phasa* (Hamilton, 1822)	Gangetic hairfin anchovy
Gobiidae	*Glossogobius giuris* (Hamilton, 1822)	Tank goby
Heteropneustidae	*Heteropneustes fossilis* (Bloch, 1794)	Asian stinging catfish
Horabagridae	*Pachypterus atherinoides* (Bloch, 1794)	Indian potasi

IUCN Status	Previous Studies	Present Study
EN	5,11,16,21,27	-
DD	3,7,8,10,11,13,16,18,19,21,22,23,25,27,28,30	-
LC	16,27	-
LC	1,3,5,6,7,8,16,17,19,20,21,23,25,27,29	-
LC	8,16,18,25,27,30	-
LC	16,27	-
LC	7,16,27	-
LC	16,27	-
LC	16	-
LC	8,16,23,25,27	+
LC	8,16,23,27	-
LC	7,8,16,23,25,27	-
LC	16,27	-
LC	2,3,6,7,8,16,18,20,21,23,25,27,30	-
LC	6,7	-
LC	7,8,16,21,23,25,27	-
LC	6,7	-
LC	5,6,7,8,16,21,25,30	-
LC	7,16,21,27	-
LC	2,7,8,16,18,21,25,27,30	-
LC	15,16	-
LC	15,16,18,21,23,25,30	-
LC	1,2,3,5,6,7,8,12,13,16,18,19,21,22,23,25,29,30	-
LC	12,16	-
LC	1,2,3,4,5,6,7,8,11,15,16,17,18,21,22,25,27,29,30	+
LC	1,18,19	-
LC	6,7	-
LC	7	-
LC	2,7,16,27	-
LC	16,27	-
LC	7	-
LC	7,8,16,23,25,27	-
DD	8,16	-
NT	16,21,26	-
EN	16,26	-
LC	2,6,7,16,20	+
LC	7,8,13,16,21,22,23,25,27	+
LC	8,11,16,21,22,25	-
LC	-	+
LC	6,7,8,13,16,18,20,21,23,25,27,30	-
LC	1,2,5,6,7,8,14,16,17,19,21,22,23,24,25,27,29	-
LC	16	-

Family	Scientific Name	Common Name
Mastacembelidae	*Macrognathus aral* (Bloch & Schneider, 1801)	One-stripe spinyeel
	Macrognathus pancalus (Hamilton, 1822)	Barred spiny eel or Indian spiny eel
	Mastacembelus armatus (Lacepede, 1800)	Zig-zag eel
Mugilidae	*Minimugil cascasia* (Hamilton, 1822)	Yellowtail mullet
	Mugil cephalus (Linnaeus, 1758)	Flathead grey mullet
	Rhinomugil corsula (Hamilton, 1822)	Corsula
Nandidae	*Nandus nandus* (Hamilton, 1822)	Gangetic leaf fish
Nemacheilidae	*Nemacheilus corica* (Hamilton, 1822)	Stone Loach
	Paracanthocobitis botia (Hamilton, 1822)	Mottled loach
	Paraschistura bampurensis (Nikolskii, 1900)	-
	Paraschistura montana (McClelland, 1838)	-
	Schistura beavani (Gunther, 1868)	Creek loach
	Schistura carletoni (Fowler, 1924)	-
	Schistura denisoni (Day, 1867)	-
	Schistura horai (Menon, 1952)	-
	Schistura multifasciata (Day, 1878)	Loach
	Schistura rupecula (McClelland, 1838)	Stone loach
	Schistura savona (Hamilton, 1822)	-
Notopteridae	*Chitala chitala* (Hamilton, 1822)	Clown knifefish, Clown featherback
	Notopterus synurus (Bloch & Schneider, 1801)	Bronze featherback
Osphronemidae	*Trichogaster fasciata* (Bloch & Schneider, 1801)	Banded gourami, striped gourami
	Trichogaster labiosa (Day, 1877)	Thick lipped gourami
	Trichogaster lalius (Hamilton, 1822)	Dwarf gourami
Pangasiidae	*Pangasianodon hypophthalmus* (Sauvage, 1878)	Striped catfish
	Pangasius pangasius (Hamilton, 1822)	Pangas catfish
Poeciliidae	*Gambusia affinis* (Baird & Girard, 1853)	Mosquitofish
	Poecilia reticulata (Peters, 1859)	Guppy
Psilorhynchidae	*Psilorhynchus balitora* (Hamilton, 1822)	Balitora minnow
Sciaenidae	*Johnius coitor* (Hamilton, 1822)	Coitor croaker
Sciaenidae	*Otolithoides pama* (Hamilton, 1822)	Pama croaker
Siluridae	*Ompok bimaculatus* (Bloch, 1794)	Butter catfish
	Ompok malabaricus (Valenciennes, 1840)	Goan catfish
	Ompok pabda (Hamilton, 1822)	Pabdah catfish
	Wallago attu (Bloch & Schneider, 1801)	Wallago
Sisoridae	*Bagarius bagarius* (Hamilton, 1822)	Goonch
	Gagata cenia (Hamilton, 1822)	Indian gagata
	Gagata itchkeea (Sykes, 1839)	Deccan nangra
	Gagata sexualis (Tilak, 1970)	Koel gagata
	Glyptothorax botius (Hamilton, 1822)	-
	Glyptothorax pectinopterus (McClelland, 1842)	River cat
	Glyptothorax telchitta (Hamilton, 1822)	Telchitta
	Gogangra viridescens (Hamilton, 1822)	Huddah nangra

IUCN Status	Previous Studies	Present Study
LC	16,27	-
LC	2,5,6,7,8,12,16,21,22,27,29	-
LC	1,2,5,6,7,8,11,12,13,16,17,18,19,21,22,24,25,27,29,30	-
LC	16,27	-
LC	16,27	-
LC	2,6,8,13,16,18,21,22,23,25,30	+
LC	2,6,8,15,16,17,18,21,23,25,27,29,30	-
LC	16,27	-
LC	1,6,7,8,9,12,13,16,18,19,21,23,25,29,30	-
NE	16,27	-
NE	16,27	-
LC	8,16,25	-
DD	16,27	-
LC	12,16,27	-
LC	16,27	-
LC	6,7	-
LC	16,27	-
LC	7	-
NT	2,5,8,15,16,21,22,23,24,25,27	-
LC	1,2,3,5,6,7,8,10,11,13,16,17,18,19,20,21,22,23,24,25,27,29,30	+
LC	16,21,23,27	-
LC	16,27	-
LC	16,27	-
Exotic	7	-
LC	7,8,15,16,21,22,25	-
Exotic	2,7	-
LC	6,7	-
LC	16,27	-
LC	-	+
DD	8,16	-
NT	1,2,4,5,6,8,11,13,16,17,18,20,21,22,23,25,27,29,30	-
LC	7	-
NT	2,7,10,11	-
VU	1,2,3,5,6,7,8,10,11,12,13,15,16,17,18,19,20,21,22,23,24,25,27,29,30	+
VU	7,8,10,11,16,18,21,22,23,25,27,30	-
LC	3,6,7,16,27	-
VU	7	-
LC	16	-
LC	8,16	-
LC	16,27	-
LC	16,25,27	-
LC	8,16,25	-

Family	Scientific Name	Common Name
	Nangra nangra (Hamilton, 1822)	Kosi nangra
	Pseudolaguvia ribeiroi (Hora, 1921)	Painted catfish
	Sisor rabdophorus (Hamilton, 1822)	Sisor catfish
Synbranchidae	*Ophichthys cuchia* (Hamilton, 1822)	Cuchia
Xenocyprididae	*Ctenopharyngodon idella* (Valenciennes, 1844)	Grass carp
	Hypophthalmichthys molitrix (Valenciennes, 1844)	Silver carp
	Hypophthalmichthys nobilis (Richardson, 1845)	Bighead carp

Previous Studies:

1- Bairwa et al. (2020); **2-** Banyal & Kumar (2015); **3-** Banyal & Kumar (2019); **4-** Banyal & Kumar (2020); **5-** Bhat & Rao (2018); **6-** Bose et al. (2019); **7-** Das et al. (2013); **8-** Dubey & Mehra (1959); **9-** Gaur et al. (2012); **10-** Gautam & Sharma (2019); **11-** Gautam & Sharma (2021); **12-** Jaiswal et al. (2010); **13-** Johnson et al. (2021); **14-** Meshram (2010); **15-** Molur & Walker (1998); **16-** Nair & Krishna (2013); **17-** Narway et al. (2019); **18-** Rao et al. (1988); **19-** Rathore et al. (2017); **20-** Ridhi et al. (2012); **21-** Saksena (2007); **22-** Sale (1982); **23-** Sharma & Choudhury (2007); **24-** Sharma & Uchchariya (2017); **25-** Sharma (2007); **26-** Sivakumar (2002); **27-** Srivastava (2007); **28-** Summarwar et al. (2021); **29-** Uchchariya et al. (2012); **30-** Vyas & Singh (2004)

References

Bairwa, V. P., Sharma, B. K., Sharma, S. K., Keer, N. R., & Vijay Kumar, V. K. (2020). Icthyofaunal diversity of Goverdhan Sagar Lake, Udaipur, Rajasthan. *Journal of Experimental Zoology India, 23*(1), 631-633.

Banyal, H. S., & Kumar, S. (2014). Fish diversity of Chambal River, Rajasthan State. In *Aquatic Ecosystem: Biodiversity, Ecology and Conservation* (pp. 271-281). New Delhi: Springer India.

Banyal, H. S., & Kumar, S. (2019). Studies on ichthyofaunal diversity of Kali Sindh river near Jetpura village, Jhalawar, Rajasthan, India. *Journal of Environment & Bio-sciences, 33*(2), 227-230.

Banyal, H. S., & Kumar, S. (2020). A preliminary study on the ichthyofaunal diversity of the Mej river in Bundi district, Rajasthan. Records of Zoological Survey of India, 120(4), 401-407.

Bhat, H., & Rao, R. J. (2018). Studies on fish diversity of Tighra reservoir Gwalior, Madhya Pradesh, India. *International Journal of Zoology Studies, 3*(2), 68-73.

Bose, R., Bose, A. K., Das, A. K., Parashar, A., & Roy, K. (2019). Fish diversity and limnological parameters influencing fish assemblage pattern in Chambal River Basin of Madhya Pradesh, India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 89, 461-473.

Das, A. K., Sharma, A. P., Jha, B. C., & Biswas, B. K. (2013). *Fishes of Madhya Pradesh*. Central Inland Fisheries Research Institute (Indian Council of Agricultural Research) Barrackpore, Kolkata, India.

Dubey, G. P., & Mehra, R. K. (1959). Fish and fisheries of Chambal River. *Proceedings of the All India Congress of Zoology*, 1, 647-665.

Gaur, K. S., Sharma, V., Verma, B. K., & Sharma, M. S. (2012). Ethnozoological study of hill stream fish inhabiting the streams and the tributaries of the Chambal River in South-Eastern Rajasthan, India. *Research & Reviews: Journal of Ecology,* 2(3), 4-10.

Gautam, H., & Sharma, M. (2019). Study of fish diversity in relation to seasonal changes of Parvati River, Baran district, Rajasthan. *Journal of Emerging Technologies and Innovative Research, 6*(2), 335-338.

Gautam, H., & Sharma, M. (2021). Biodiversity of fishes of Parvati River, Baran district, Rajasthan. *International Journal of Advanced Research in Science, Engineering and Technology, 8*(1), 16374-16385.

Jaiswal, D., Rao, C. A. N., Kumar, S., & Mond, H. (2010). Ichthyofauna. In *Fauna of Ranthambhore National Park, Conservation Area Series, 40* (pp. 145-158). Zoological Survey of India.

Johnson, J. A., George, A., Sharma, M., Kavin, D., Sreelekha Suresh, P. C., Gopi, G. V., & Hussain, S. A. (2021). *Status of wildlife between Kota Barrage and Jawahar Sagar Dam, Rajasthan,* Wildlife Institute of India, Dehradun 59p. RAPID ASSESSMENT REPORT, 4.

IUCN Status	Previous Studies	Present Study
LC	16,27	-
LC	16	-
LC	16,27	-
LC	16,21,23,27	-
Exotic	1,6,7,16,17,19,21,23,27	-
Exotic	1,2,16,17,19,21,23,27	-
Exotic	6,7,16,23,27	-

Meshram, P. K. (2010). Diversity of some fauna in National Chambal Sanctuary in Madhya Pradesh, India. *Biodiversitas, 11*(4), 211-215.

Molur, S., & Walker, S. (1998). *Report of the Workshop: Conservation Assessment and Management Plan for Freshwater Fishes of India.* Zoo Outreach Organisation & CBSG South Asia, Coimbatore, India. 156 pp.

Nair, T., & Krishna, Y. C. (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa, 5*(2), 3620-3641.

Narway, K., Chakravarty, S., Jain, A., Pailan, G. H., & Dasgupta, S. (2019). Fish diversity and fisheries of Kotwal reservoir, Morena, Madhya Pradesh. *Journal of Entomology and Zoology Studies, 7*(6), 316-323.

Rao, K. S., Kartha, K. N., Shrivastava, S., Pandya, S. S., & Choubey, U. (1988). Studies of the commercial fisheries and its fluctuations in Gandhisagar Reservoir. In *Proceedings of the National Symposium Past, Present and Future of Bhopal Lakes* (pp. 55-65). Unpublished.

Rathore, L. K., Sharma, B. K., & Dangi, P. L. (2017). Fish biodiversity and fisheries potential of reservoir Udaisagar (Udaipur, Rajasthan). *International Journal of Fisheries and Aquatic Studies, 5*(3), 587-592.

Ridhi, Jha, B. C., Parashar, A., Das, A. K., & Bose, A. K. (2012). Ichthyofaunal diversity of river Chambal in Madhya Pradesh. In B. N. Pandey, A. P. Sharma, P. N. Pandey, P. K. Katiha, & K. Jaiswal (Eds.), *Biodiversity: Issues, threats and conservation* (pp. 47-53). Narendra Publishing House.

Saksena, D. N. (2007). Fish diversity of Northern Madhya Pradesh (Gwalior and Chambal Divisions) (pp. 50-57). In W. S. Lakra & U. K. Sarkar (Eds.), *Fresh Water Fish Diversity of Central India.* National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research..

Sale, J. B. (1982). *2nd Draft. Management Plan for The National Chambal Sanctuary. First Five Year Period 1982/83 - 1986/87.* Central Crocodile Breeding and Management Institute.

Sharma, L. L., & Choudhary, C. S. (2007). Conservation and management of fish diversity in Rajasthan (pp. 110-117). In W. S. Lakra & U. K. Sarkar (Eds.), *Fresh Water Fish Diversity of Central India.* National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research.

Sharma, D. K., & Uchchariya, R. (2017). A study of ichthyofauna of Pagara dam of Morena District, Madhya Pradesh. *Indian Journal of Scientific Research, 7*(2), 51-57.

Sharma, H. S. (2007). Freshwater fishes. Zoological Survey of India. *Fauna of Madhya Pradesh (including Chhattisgarh), State Fauna Series, 15*(Part-1), 147-244.

Sivakumar, K. (2002). The rare freshwater giant stingray in the National Chambal Sanctuary: Needs more attention for conservation. *WII Newsletter, 8*(4) & 9(1), 5.

Srivastava, N. (2007). Freshwater fish diversity in Rajasthan. Fresh Water Fish Diversity of Central India. National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research, xiv+ 183pp, 142-155.

Sarkar (Eds.), *Fresh Water Fish Diversity of Central India.* National Bureau of Fish Genetic Resources, Indian Council of Agricultural Research.

Summarwar, S., Yadav, K. P., & Tailor, S. P. (2021). Genetic differentiation among Himalayan and local Mahseer populations. *International Journal of Fauna and Biological Studies, 8*(1), 08-10.

Uchchariya, D. K., Saxena, M., & Saksena, D. N. (2012). Fish biodiversity of Tighra reservoir of Gwalior, Madhya Pradesh, India. *Journal of Fisheries & Aquaculture, 3*(1), 37-43.

Vyas, R., & Singh, H. (2004). Biodiversity survey of Gandhi Sagar Reservoir, Madhya Pradesh. *Zoos' Print Journal, 19*(7), 1525-1529.

ANNEXURE III: Checklist of Amphibian species of the Chambal River:

Sr. No.	Order	Family	Common Name	Scientific Name	IUCN	Present Study	Previous study
1	Anura	Bufonidae	Asian Common Toad	*Duttaphrynus melanostictus*	LC	+	1, 2
2	Anura	Bufonidae	Indian Marbled Toad	*Duttaphrynus stomaticus*	LC	+	1, 2
3	Anura	Dicroglossidae	Skipper Frog	*Euphlyctis cyanophlyctis*	LC	+	2
4	Anura	Dicroglossidae	Boie's Wart Frog	*Fejervarya limnocharis*	LC	+	
5	Anura	Dicroglossidae	Indian Bullfrog	*Hoplobatrachus tigerinus*	LC	+	
6	Anura	Dicroglossidae	Common Cricket Frog	*Minervarya agricola*	LC	+	
7	Anura	Dicroglossidae	Pierre's wart Frog	*Minervarya pierrei*	LC	+	
8	Anura	Dicroglossidae	Terai Wart Frog	*Minervarya teraiensis*	LC	+	
9	Anura	Dicroglossidae	Indian Burrowing Frog	*Sphaerotheca breviceps*	LC	+	1, 2
10	Anura	Microhylidae	Nilphamarai Narrow-mouthed Frog	*Microhyla nilphamariensis*	LC	+	
11	Anura	Rhacophoridae	Spotted Tree Frog	*Polypedates maculatus*	LC	+	1, 2
12	Anura	Dicroglossidae	Roland's Burrowing Frog	*Sphaerotheca* rolandae	LC	-	1
13	Anura	Microhylidae	Ant Frog	*Microhyla ornata*	LC	-	1, 2
14	Anura	Microhylidae	Indian Globular Frog	*Uperodon globulosus*	LC	-	2
15	Anura	Dicroglossidae	Indian Green Frog	*Euphlyctis* hexadactylus	LC	-	2

IUCN status: LC - Least Concern; **NT** - Near Threatened; **VU** - Vulnerable; **EN** - Endangered; **CR** - Critically Endangered.

Previous Studies: 1-Ishaque & Sarsavan (2014); **2-** Kumar & Banyal (2016)

References

Ishaque, S., & Sarsavan, A. (2014). Herpetofaunal diversity in Gandhi Sagar Wildlife Sanctuary, Madhya Pradesh. *International Journal of Scientific Research in Biological Sciences.*

Kumar, S., & Banyal, H. S. (2016). Anuran diversity of Chambal River in the Rajasthan State. *Journal of Environmental Biology Science, 30*(1), 131-132.

ANNEXURE IV: Checklist of Reptile species of the Chambal River:

S. No.	Order	Family	Reptilian species	Common name	IUCN	Present Study	Previous Study
1	Crocodilia	Crocodylidae	*Crocodylus palustris* (Lesson, 1831)	Mugger	VU	+	1,7,8,13
2	Crocodilia	Gavialidae	*Gavialis gangeticus* (Gmelin, 1789)	Gharial	CR	+	1,7,8,13
3	Testudines	Geoemydidae	*Batagur dhongoka* (Gray, 1832)	Three-striped Roofed Turtle	CR		1,7,13
4	Testudines	Geoemydidae	*Batagur kachuga* (Gray, 1831)	Red-crowned Roofed Turtle	CR		1,7,13
5	Testudines	Geoemydidae	*Hardella thurjii* (Gray, 1831)	Crowned River Turtle	VU		1,7,13
6	Testudines	Geoemydidae	*Pangshura tecta* (Gray, 1830)	Indian Roofed Turtle	LC		11,13
7	Testudines	Geoemydidae	*Pangshura tentoria* (Gray, 1834)	Indian Tent Turtle	LC		1,7,13
8	Testudines	Testudinidae	*Geochelone elegans* (Schoepff, 1795)	Indian Star Tortoise	LC		8,12
9	Testudines	Trionychidae	*Lissemys punctata* (Bonnaterre, 1789)	Indian Flapshell Turtle	LC		1,7,8,13
10	Testudines	Trionychidae	Chitra indica (Gray, 1830)	Indian Narrow-headed Softshell Turtle	EN		1,7,13
11	Testudines	Trionychidae	*Nilssonia gangetica* (Cuvier, 1825)	Indian Softshell Turtle	EN		1,7,8,13
12	Testudines	Trionychidae	*Nilssonia hurum* (Gray, 1830)	Indian Peacock Softshell Turtle	EN		3
13	Squamata	Gekkonidae	*Hemidactylus brookii* (Gray, 1845)	Brooke's House Gecko	LC	-	1
14	Squamata	Gekkonidae	*Hemidactylus flaviviridis* (Rüppell, 1840)	Yellow-bellied House Gecko	LC	-	1,8,13
15	Squamata	Gekkonidae	*Hemidactylus frenatus* (Duméril & Bibron, 1836)	Common House Gecko	LC	-	1
16	Squamata	Gekkonidae	*Hemidactylus maculatus* (Duméril & Bibron, 1836)	Northern Spotted Gecko	-	-	13
17	Squamata	Gekkonidae	*Hemidactylus leschenaultii* (Duméril & Bibron, 1836)	Bark Gecko	-	-	1,13
18	Squamata	Gekkonidae	*Hemidactylus triedrus* (Daudin, 1802)	Dakota's Leaf-toed Gecko	LC	-	1
19	Squamata	Agamidae	*Calotes versicolor* (Daudin, 1802)	Oriental Garden Lizard	-	-	1,8,13
20	Squamata	Agamidae	*Sitana ponticeriana* (Cuvier, 1829)	Fan-throated Lizard	-	-	1
21	Squamata	Chamaeleonidae	*Chamaeleo zeylanicus* (Laurenti, 1768)	Asian Chameleon	LC	-	1
22	Squamata	Varanidae	*Varanus bengalensis* (Daudin, 1802)	Bengal Monitor Lizard	LC	-	1,6,8,12,13
23	Squamata	Varanidae	*Varanus griseus* (Mertens, 1954)	Indian Desert Monitor	LC	-	8

S. No.	Order	Family	Reptilian species	Common name	IUCN	Present Study	Previous Study
24	Squamata	Lacertidae	*Ophisops jerdonii* (Blyth, 1853)	Punjab-snake-eyed Lacerta	LC	-	1, 4
25	Squamata	Lacertidae	*Ophisops microlepis* (Blanford, 1870)	Small-scaled Lacerta	LC	-	2
26	Squamata	Lacertidae	*Ophisops minor nictans* (Arnold, 1989)	Indian Dwarf Lacerta	-	-	1,4
27	Squamata	Scincidae	*Eutropis carinata* (Schneider, 1801)	Keeled Grass Skink	LC	-	1,13
28	Squamata	Scincidae	*Eutropis innotata* (Blanford, 1870)	Blanford's Mabuya	-	-	4
29	Squamata	Scincidae	*Eutropis macularia* (Blyth, 1853)	Bronze Skink	-	-	1
30	Squamata	Scincidae	*Lygosoma punctata* (Gmelin, 1799)	White-spotted Supple Skink	-	-	1,13
31	Squamata	Typhlopidae	*Ramphotyphlops braminus* (Daudin, 1803)	Brahminy Blind snake	-	-	1
32	Squamata	Pythonidae	*Python molurus* (Linnaeus, 1758)	Indian Rock Python	NT	-	11,13
33	Squamata	Boidae	*Eryx johnii* (Russell, 1801)	Red Sand Boa	NT	-	1,13
34	Squamata	Boidae	*Gongylophis conicus* (Schneider, 1801)	Common Sand Boa	-	-	13
35	Squamata	Colubridae	*Coelognathus helena* (Daudin, 1803)	Common Trinket	-	-	14
36	Squamata	Colubridae	*Ptyas mucosa* (Linnaeus, 1758)	Indian Rat Snake	-	-	1,8,13
37	Squamata	Colubridae	*Platyceps ventromaculatus* (Gray, 1834)	Hardwicke's Rat Snake	LC	-	9
38	Squamata	Colubridae	*Argyrogena fasciolata* (Shaw, 1802)	Banded Racer	-	-	14
39	Squamata	Colubridae	*Spalerosophis atriceps* (Fischer, 1885)	Black-headed Royal Snake	-	-	14
40	Squamata	Colubridae	*Oligodon taeniolatus* (Jerdon, 1853)	Russell's Kukri Snake	LC	-	1
41	Squamata	Colubridae	*Oligodon arnensis* (Shaw, 1802)	Common Kukri Snake	LC	-	1,14
42	Squamata	Colubridae	*Dendrelaphis tristis* (Daudin, 1803)	Common Bronzeback Tree Snake	-	-	14
43	Squamata	Colubridae	*Lycodon striatus* (Shaw, 1802)	Barred Wolf Snake	-	-	14
44	Squamata	Colubridae	*Lycodon aulicus* (Linnaeus, 1758)	Common Wolf Snake	LC	-	1,14
45	Squamata	Colubridae	*Sibynophis subpunctatus* (Dumeril Bibron & Dumeril, 1854)	Dumeril's Black-headed Snake	LC	-	10
46	Squamata	Colubridae	*Xenochrophis piscator* (Schneider, 1799)	Chequered Keelback	LC	-	1,13,14
47	Squamata	Colubridae	*Amphiesma stolatum* (Linnaeus, 1758)	Buff Striped Keelback	LC	-	1,14
48	Squamata	Colubridae	*Macropisthodon plumbicolor* (Cantor, 1839)	Green Keelback	LC	-	14
49	Squamata	Colubridae	*Boiga trigonata* (Schneider, 1802)	Common Cat Snake	LC	-	14

S. No.	Order	Family	Reptilian species	Common name	IUCN	Present Study	Previous Study
50	Squamata	Colubridae	*Ahaetulla nasuta* (Bonnaterre, 1790)	Common Vine Snake	-	-	1,14
51	Squamata	Elapidae	*Bungarus caeruleus* (Schneider, 1801)	Common Krait	NT	-	1,8,14
52	Squamata	Elapidae	*Naja naja* (Linnaeus, 1758)	Indian Cobra	LC	-	1,14
53	Squamata	Homalopsidae	*Enhydris sieboldii* (Schlegel, 1837)	Siebold's Smooth-water Snake	LC	-	5
54	Squamata	Psammophiidae	*Psammophis leithii* (Gunther, 1869)	Leith's Sand Snake	LC	-	14
55	Squamata	Viperidae	*Daboia russelii* (Shaw & Nodder, 1797)	Western Russell's Viper	LC	-	6,13
56	Squamata	Viperidae	*Echis carinatus* (Schneider, 1801)	Saw-scaled Viper	LC	-	1,14

IUCN status: LC - Least Concern; **NT** - Near Threatened; **VU** - Vulnerable; **EN** - Endangered; **CR** - Critically Endangered.

Previous Studies:
1 - Nair & Krishna, 2013 (fieldwork in 2009 - 2010); 2 - Böhm & Richman (2010); 3 - Das et al. (2010); 4 - Molur & Walker (1998b); 5 - Murphy & Lobo (2010); 6- Nair (2009); 7- Rao (1988); 8 - Sale (1982); 9- Schätti& Schmitz (2006); 10 - Sharma (2003); 11- Vyas (2004); 12 - Vyas & Singh (2004); 13- Vyas et al. (in prep.); 14 - Nair & Krishna, 2013 (intermittent fieldwork between 2006 and 2008).

References

Nair, T. & Y.C. Krishna (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa 5*(2): 3620-3641; Field Work 2009-2010.

Böhm, M. & N. Richman (2010). *Ophisopsmicrolepis*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded on 27 April 2012.

Das, I., D. Basu & S. Singh (2010). Nilssoniahurum (Gray 1830) - Indian peacock softshell turtle. In: Rhodin, A.G.J., P.C.H. Pritchard, P.P. van Dijk, R.A. Saumure, K.A. Buhlmann, J.B. Iverson & R.A. Mittermeier (eds.). *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group.* Chelonian Research Monographs No. 5. 6pp.

Molur S. & S. Walker (eds.) (1998b). Reptiles of India. Report on Biodiversity Conservation Prioritization Project (BCPP) India Endangered Species Project, Conservation Assessment and Management Plan Workshop. Zoo Outreach Organisation & CBSG South Asia, Coimbatore, India, 175pp.

Murphy, J. & A. Lobo (2010). *Enhydris sieboldii*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded on 27 April 2012.

Nair, A.K. (2009). The status and distribution of major aquatic fauna in the National Chambal Gharial Sanctuary in Rajasthan with special reference to the Gangetic Dolphin *Platanista gangetica gangetica* (Cetartiodactyla: Platanistidae). *Journal of Threatened Taxa 1*(3): 141-146.

Rao, R.J. (1988). *Nesting Ecology of Gharial in the National Chambal Sanctuary*. Wildlife Institute of India, Dehradun, India, 105pp.

Sale, J.B. (1982). 2[nd] Draft. Management Plan For The National Chambal Sanctuary. First Five Year Period 1982/83 - 1986/87. Central Crocodile Breeding and Management Institute, Hyderabad, iii+82pp.

Schätti, B. & A. Schmitz (2006). Re-assessing *Platyceps ventromaculatus* (Gray, 1834) (Reptilia: Squamata: Colubrinae). *Revue suisse* de Zoologie113(4): 747-768.

Sharma, S.K. (2003). Presence of Dumeril's Black-headed Snake (*Sibynophis subpunctatus*) in Kumbhalgarh Wildlife Sanctuary, Rajasthan, India. Cobra 53: 17-18.

Vyas, R. & H. Singh. (2004). Biodiversity survey of Gandhi Sagar Reservoir, Madhya Pradesh. *Zoos' Print Journal 19*(7): 1525-1529.

Vyas, R., & Singh, H. (2004). Biodiversity survey of Gandhisagar Reservoir, Madhya Pradesh. *Zoos' print Journal, 19*(7), 1525-1529.

Vyas, R., R.S. Tomar & S. Singhal (in prep.) Macrofauna of National Chambal Sanctuary in Rajasthan and its conservation issues.

Nair, T., & Krishna, Y. C. (2013). Vertebrate fauna of the Chambal River basin, with emphasis on the National Chambal Sanctuary, India. Journal of Threatened Taxa, 5(2), 3620-3641.

ANNEXURE V: Checklist of Birds species of the Chambal River:

Sr. No.	Order	Family	Species
1	Galliformes	Phasianidae	*Francolinus francolinus* (Linnaeus, 1766)
2	Galliformes	Phasianidae	*Francolinus pondicerianus* (Gmelin, 1789)
3	Galliformes	Phasianidae	*Coturnix coturnix* (Linnaeus, 1758)
4	Galliformes	Phasianidae	*Coturnix coromandelica* (Gmelin, 1789)
5	Galliformes	Phasianidae	*Perdicula asiatica* (Latham, 1790)
6	Galliformes	Phasianidae	*Galloperdix spadicea* (Gmelin, 1789)
7	Galliformes	Phasianidae	*Galloperdix lunulata* (Valenciennes, 1825)
8	Galliformes	Phasianidae	*Gallus sonneratii* (Temminck, 1813)
9	Galliformes	Phasianidae	*Pavo cristatus* (Linnaeus, 1758)
10	Anseriformes	Anatidae	*Dendrocygna javanica* (Horsfield, 1821)
11	Anseriformes	Anatidae	*Anser anser* (Linnaeus, 1758)
12	Anseriformes	Anatidae	*Anser indicus* (Latham, 1790)
13	Anseriformes	Anatidae	*Sarkidiornis melanotos* (Pennant, 1769)
14	Anseriformes	Anatidae	*Tadorna ferruginea* (Pallas, 1764)
15	Anseriformes	Anatidae	*Tadorna tadorna* (Linnaeus, 1758)
16	Anseriformes	Anatidae	*Nettapus coromandelianus* (Gmelin, 1789)
17	Anseriformes	Anatidae	*Anas strepera* (Linnaeus, 1758)
18	Anseriformes	Anatidae	*Anas penelope* (Linnaeus, 1758)
19	Anseriformes	Anatidae	*Anas platyrhynchos* (Linnaeus, 1758)
20	Anseriformes	Anatidae	*Anas poecilorhyncha* (Forster, 1781)
21	Anseriformes	Anatidae	*Anas clypeata* (Linnaeus, 1758)
22	Anseriformes	Anatidae	*Anas acuta* (Linnaeus, 1758)
23	Anseriformes	Anatidae	*Anas querquedula* (Linnaeus, 1758)
24	Anseriformes	Anatidae	*Anas crecca* (Linnaeus, 1758)
25	Anseriformes	Anatidae	*Mergus merganser* (Linnaeus, 1758)
26	Anseriformes	Anatidae	*Netta rufina* (Pallas, 1773)
27	Anseriformes	Anatidae	*Aythya ferina* (Linnaeus, 1758)
28	Anseriformes	Anatidae	*Aythya nyroca* (Gldenstdt, 1770)
29	Anseriformes	Anatidae	*Aythya fuligula* (Linnaeus, 1758)
30	Podicipediformes	Podicipedidae	*Tachybaptus ruficollis* (Pallas, 1764)
31	Podicipediformes	Podicipedidae	*Podiceps cristatus* (Linnaeus, 1758)
32	Podicipediformes	Phoenicopteridae	*Phoenicopterus roseus* (Pallas, 1811)
33	Ciconiiformes	Ciconiidae	*Mycteria leucocephala* (Pennant, 1769)
34	Ciconiiformes	Ciconiidae	*Anastomus oscitans* (Boddaert, 1783)
35	Ciconiiformes	Ciconiidae	*Ciconia nigra* (Linnaeus, 1758)
36	Ciconiiformes	Ciconiidae	*Ciconia episcopus* (Boddaert, 1783)
37	Ciconiiformes	Ciconiidae	*Ephippiorhynchus asiaticus* (Latham, 1790)
38	Ciconiiformes	Ciconiidae	*Leptoptilos javanicus* (Horsfield, 1821)
39	Pelecaniformes	Threskiornithidae	*Threskiornis melanocephalus* (Latham, 1790)
40	Pelecaniformes	Threskiornithidae	*Pseudibis papillosa* (Temminck, 1824)
41	Pelecaniformes	Threskiornithidae	*Plegadis falcinellus* (Linnaeus, 1766)

Common Species	IUCN Status	Present Data	References
Black Francolin	LC	-	8
Grey Francolin	LC	+	1,2,7,8,11,12,13
Common Quail	LC	-	1,2,8,13
Rain Quail	LC	-	8
Jungle Bush-Quail	LC	-	8
Red Spurfowl	LC	-	2
Painted Spurfowl	LC	-	1,13
Grey Junglefowl	LC	-	1,2,
Indian Peafowl	LC	-	1,2,7,8,11,12,13
Lesser Whistling-Duck	LC	+	1,2,7,9,11,13
Greylag Goose	LC	+	1,8,9,12,13
Bar-headed Goose	LC	+	1,2,8,9,11,12,13
Knob-billed Duck	LC	+	1,2,7,8,9,11,13
Ruddy Shelduck	LC	+	1,2,7,8,11,12,13
Common Shelduck	LC	+	11
Cotton Pygmy-Goose	LC	-	1
Gadwall	LC	+	11,12,13
Eurasian Wigeon	LC	+	12,13
Mallard	LC	-	1,8
Indian Spot-billed Duck	LC	-	1,2,7,8,11,12,13
Northern Shoveler	LC	-	1,2,9,12,13
Northern Pintail	LC	+	1,9,11,12,13
Garganey	LC	-	1,2,7,12,13
Common Teal	LC	+	1,8,9,11,12,13
Common Merganser	LC	-	13
Red-crested Pochard	LC	+	1,2,8,9,11,13
Common Pochard	VU	-	12,13
Ferruginous Duck	NT	-	1,8,11
Tufted Duck	LC	-	1,8,12
Little Grebe	LC	-	1,2,7,8,11,12,13
Great Crested Grebe	LC	+	1,2,11
Greater Flamingo	LC	+	1,13
Painted Stork	LC	+	1,2,7,8,11,12,13
Asian Openbill	LC	+	1,2,7,8,9,11,13
Black Stork	LC	+	11,12,13
Asian Woolly-necked Stork	NT	+	1,2,7,8,11,12,13
Black-necked Stork	NT	+	1,2,8,9
Lesser Adjutant	NT	+	5
Black-headed Ibis	LC	-	1,2,7,9,11,13
Red-naped Ibis	LC	+	1,2,7,9,11,12,13
Glossy Ibis	LC	-	1,7,11,13

Sr. No.	Order	Family	Species
42	Pelecaniformes	Threskiornithidae	*Platalea leucorodia* (Linnaeus, 1758)
43	Pelecaniformes	Ardeidae	*Botaurus stellaris* (Linnaeus, 1758)
44	Pelecaniformes	Ardeidae	*Ixobrychus sinensis* (Gmelin, 1789)
45	Pelecaniformes	Ardeidae	*Ixobrychus cinnamomeus* (Gmelin, 1789)
46	Pelecaniformes	Ardeidae	*Ixobrychus flavicollis* (Latham, 1790)
47	Pelecaniformes	Ardeidae	*Nycticorax nycticorax* (Linnaeus, 1758)
48	Pelecaniformes	Ardeidae	*Butorides striata* (Linnaeus, 1758)
49	Pelecaniformes	Ardeidae	*Ardeola grayii* (Sykes, 1832)
50	Pelecaniformes	Ardeidae	*Bubulcus ibis* (Linnaeus, 1758)
51	Pelecaniformes	Ardeidae	*Ardea cinerea* (Linnaeus, 1758)
52	Pelecaniformes	Ardeidae	*Ardea purpurea* (Linnaeus, 1766)
53	Pelecaniformes	Ardeidae	*Casmerodius albus* (Linnaeus, 1758)
54	Pelecaniformes	Ardeidae	*Mesophoyx intermedia* (Wagler, 1829)
55	Pelecaniformes	Ardeidae	*Egretta garzetta* (Linnaeus, 1766)
56	Pelecaniformes	Pelecanidae	*Pelecanus onocrotalus* (Linnaeus, 1758)
57	Pelecaniformes	Pelecanidae	*Pelecanus crispus* (Bruch, 1832)
58	Pelecaniformes	Pelecanidae	*Pelecanus philippensis* Gmelin, 1789
59	Suliformes	Phalacrocoridae	*Phalacrocorax niger* (Vieillot, 1817)
60	Suliformes	Phalacrocoridae	*Phalacrocorax fuscicollis* (Stephens, 1826)
61	Suliformes	Phalacrocoridae	*Phalacrocorax carbo* (Linnaeus, 1758)
62	Suliformes	Anhingidae	*Anhinga melanogaster* (Pennant, 1769)
63	Falconiformes	Falconidae	*Falco naumanni* (Fleischer, 1818)
64	Falconiformes	Falconidae	*Falco tinnunculus* (Linnaeus, 1758)
65	Falconiformes	Falconidae	*Falco chicquera* (Daudin, 1800)
66	Falconiformes	Falconidae	*Falco subbuteo* (Linnaeus, 1758)
67	Falconiformes	Falconidae	*Falco jugger* (Gray, 1834)
68	Falconiformes	Falconidae	*Falco peregrinus* (Tunstall, 1771)
69	Accipitriformes	Accipitridae	*Pandion haliaetus* (Linnaeus, 1758)
70	Accipitriformes	Accipitridae	*Pernis ptilorhynchus* (Temminck, 1821)
71	Accipitriformes	Accipitridae	*Elanus caeruleus* (Desfontaines, 1789)
72	Accipitriformes	Accipitridae	*Milvus migrans* (Boddaert, 1783)
73	Accipitriformes	Accipitridae	*Haliastur indus* (Boddaert, 1783)
74	Accipitriformes	Accipitridae	*Haliaeetus leucoryphus* (Pallas, 1771)
75	Accipitriformes	Accipitridae	*Haliaeetus albicilla* (Linnaeus, 1758)
76	Accipitriformes	Accipitridae	*Neophron percnopterus* (Linnaeus, 1758)
77	Accipitriformes	Accipitridae	*Gyps bengalensis* (Gmelin, 1788)
78	Accipitriformes	Accipitridae	*Gyps indicus* (Scopoli, 1786)
79	Accipitriformes	Accipitridae	*Gyps tenuirostris* Gray, 1844
80	Accipitriformes	Accipitridae	*Gyps fulvus* (Hablizl, 1783)
81	Accipitriformes	Accipitridae	*Sarcogyps calvus* (Scopoli, 1786)
82	Accipitriformes	Accipitridae	*Circaetus gallicus* (Gmelin, 1788)

Common Species	IUCN Status	Present Data	References
Eurasian Spoonbill	LC	+	1,2,7,9,11,12,13
Great Bittern	LC	-	1
Yellow Bittern	LC	-	2
Cinnamon Bittern	LC	-	13
Black Bittern	LC	-	1
Black-crowned Night Heron	LC	+	1,2,7,11,13
Striated Heron	LC	-	1,2,11,12,13
Indian Pond-Heron	LC	-	1,2,7,8,11,12,13
Eastern Cattle-Egret	Not recognized	+	1,2,7,8,11,12,13
Grey Heron	LC	+	1,2,7,8,11,12,13
Purple Heron	LC	-	1,2,7,11,13
Great Egret	LC	+	2,7,11,12,13
Intermediate Egret	LC	+	1,7,11,12,13
Little Egret	LC	+	1,2,7,8,11,12,13
Great White Pelican	LC	+	11
Dalmatian Pelican	NT	+	1,2,5
Spot-billed Pelican	NT	+	1,5,8,9
Little Cormorant	LC	+	1,2,7,8,11,12,13
Indian Cormorant	LC	+	1,2,7,12,13
Great Cormorant	LC	+	1,2,7,9,11,12,13
Oriental Darter	LC	+	1,2,7,8,11,12,13
Lesser Kestrel	LC	-	5
Common Kestrel	LC	-	1,2,8,12,13
Red-necked Falcon	NT	-	1
Eurasian Hobby	LC	-	13
Laggar Falcon	NT	-	8,13
Peregrine Falcon	LC	-	1,2,13
Osprey	LC	+	1,2,7,8,11,12,13
Oriental Honey-buzzard	LC	-	2,11,13
Black-winged Kite	LC	-	1,2,7,8,11,12,13
Black Kite	LC	+	2,7,12,13
Brahminy Kite	LC	-	2
Pallas's Fish-Eagle	EN	-	3,4,6
White-tailed Eagle	LC	-	2
Egyptian Vulture	EN	+	1,2,7,8,11,12,13
White-rumped Vulture	CE	-	2,4,6,7,8,12,13
Indian Vulture	CE	-	2,4,6,7,11,12,13
Slender-billed Vulture	CE	-	12
Griffon Vulture	LC	-	7,12,13
Red-headed Vulture	CE	-	1,7,9,11,12,13
Short-toed Snake-Eagle	LC	+	1,8,11,13

Sr. No.	Order	Family	Species
83	Accipitriformes	Accipitridae	*Spilornis cheela* (Latham, 1790)
84	Accipitriformes	Accipitridae	*Circus aeruginosus* (Linnaeus, 1758)
85	Accipitriformes	Accipitridae	*Circus macrourus* (Gmelin, 1770)
86	Accipitriformes	Accipitridae	*Circus pygargus* (Linnaeus, 1758)
87	Accipitriformes	Accipitridae	*Accipiter badius* (Gmelin, 1788)
88	Accipitriformes	Accipitridae	*Accipiter nisus* (Linnaeus, 1758)
89	Accipitriformes	Accipitridae	*Butastur teesa* (Franklin, 1831)
90	Accipitriformes	Accipitridae	*Aquila pomarina* (Brehm, 1831)
91	Accipitriformes	Accipitridae	*Aquila clanga* (Pallas, 1811)
92	Accipitriformes	Accipitridae	*Aquila rapax* (Temminck, 1828)
93	Accipitriformes	Accipitridae	*Aquila nipalensis* (Hodgson, 1833)
94	Accipitriformes	Accipitridae	*Aquila heliaca* (Savigny, 1809)
95	Accipitriformes	Accipitridae	*Aquila fasciata* (Vieillot, 1822)
96	Accipitriformes	Accipitridae	*Hieraaetus pennatus* (Gmelin, 1788)
97	Accipitriformes	Accipitridae	*Nisaetus cirrhatus* (Gmelin, 1788)
98	Gruiformes	Rallidae	*Amaurornis akool* (Sykes, 1832)
99	Gruiformes	Rallidae	*Amaurornis phoenicurus* (Pennant, 1769)
100	Gruiformes	Rallidae	*Porzana pusilla* (Pallas, 1776)
101	Gruiformes	Rallidae	*Porphyrio porphyrio* (Linnaeus, 1758)
102	Gruiformes	Rallidae	*Gallinula chloropus* (Linnaeus, 1758)
103	Gruiformes	Rallidae	*Fulica atra* (Linnaeus, 1758)
104	Gruiformes	Gruidae	*Grus antigone* (Linnaeus, 1758)
105	Gruiformes	Gruidae	*Grus virgo* (Linnaeus, 1758)
106	Gruiformes	Gruidae	*Grus grus* (Linnaeus, 1758)
107	Charadriiformes	Turnicidae	*Turnix sylvaticus* (Desfontaines, 1787)
108	Charadriiformes	Turnicidae	*Turnix tanki* (Blyth, 1843)
109	Charadriiformes	Turnicidae	*Turnix suscitator* (Gmelin, 1789)
110	Charadriiformes	Burhinidae	*Esacus recurvirostris* (Cuvier, 1829)
111	Charadriiformes	Burhinidae	*Burhinus oedicnemus* (Linnaeus, 1758)
112	Charadriiformes	Recurvirostridae	*Himantopus himantopus* (Linnaeus, 1758)
113	Charadriiformes	Recurvirostridae	*Recurvirostra avosetta* Linnaeus, 1758
114	Charadriiformes	Charadriidae	*Vanellus malabaricus* (Boddaert, 1783)
115	Charadriiformes	Charadriidae	*Vanellus duvaucelii* (Lesson, 1826)
116	Charadriiformes	Charadriidae	*Vanellus indicus* (Boddaert, 1783)
117	Charadriiformes	Charadriidae	*Vanellus leucurus* (Lichtenstein, 1823)
118	Charadriiformes	Charadriidae	*Charadrius dubius* (Scopoli, 1786)
119	Charadriiformes	Charadriidae	*Charadrius alexandrinus* (Linnaeus, 1758)
120	Charadriiformes	Rostratulidae	*Rostratula benghalensis* (Linnaeus, 1758)
121	Charadriiformes	Jacanidae	*Hydrophasianus chirurgus* (Scopoli, 1786)
122	Charadriiformes	Jacanidae	*Metopidius indicus* (Latham, 1790)
123	Charadriiformes	Scolopacidae	*Gallinago gallinago* (Linnaeus, 1758)
124	Charadriiformes	Scolopacidae	*Limosa limosa* (Linnaeus, 1758)

Common Species	IUCN Status	Present Data	References
Crested Serpent-Eagle	LC	-	2,11,12,13
Western Marsh Harrier	LC	+	1,2,7,8,11,12,13
Pallid Harrier	NT	-	8,11,13
Montagu's Harrier	LC	-	12
Shikra	LC	+	1,2,7,11,12,13
Eurasian Sparrowhawk	LC	-	11
White-eyed Buzzard	LC	-	8,12,13
Indian Spotted Eagle	VU	-	1
Greater Spotted Eagle	VU	-	1,3,4,5,6,13
Tawny Eagle	VU	-	2,8
Steppe Eagle	EN	-	2
Imperial Eagle	VU	-	5,12,13
Bonelli's Eagle	LC	+	13
Booted Eagle	LC	-	1,2
Changeable Hawk-Eagle	LC	-	1,2,8
Brown Crake	LC	+	1,11,13
White-breasted Waterhen	LC	-	1,2,12,13
Baillon's Crake	LC	-	1
Grey-headed Swamphen	Not recognized	-	1,2,7,13
Common Moorhen	LC	-	13
Eurasian Coot	LC	+	1,2,7,11,12,13
Sarus Crane	VU	-	1,2,3,4,5,6,7,8,9,12,13
Demoiselle Crane	LC	-	13
Common Crane	LC	+	9,12
Small Buttonquail	LC	-	1
Yellow-legged Buttonquail	LC	-	12,13
Barred Buttonquail	LC	-	8
Great Thick-knee	NT	+	1,2,9,11,12,13
Indian Thick-knee	LC	-	1,2,8,13
Black-winged Stilt	LC	+	1,2,7,8,11,12,13
Pied Avocet	LC	+	(R1115s8 Vy1s, p5rs.
Yellow-wattled Lapwing	LC	-	1,2,7
River Lapwing	NT	+	1,2,7,11,13
Red-wattled Lapwing	LC	+	1,2,7,8,11,12,13
White-tailed Lapwing	LC	+	1,7,12
Little Ringed Plover	LC	+	1,2,7,8,11,12,13
Kentish Plover	LC	+	1,11,12,13
Greater Painted-Snipe	LC	-	1,13
Pheasant-tailed Jacana	LC	-	1,11,13
Bronze-winged Jacana	LC	-	13
Common Snipe	LC	-	12,13
Black-tailed Godwit	NT	+	1,7,11,12,13

Sr. No.	Order	Family	Species
125	Charadriiformes	Scolopacidae	*Numenius arquata* (Linnaeus, 1758)
126	Charadriiformes	Scolopacidae	*Tringa erythropus* (Pallas, 1764)
127	Charadriiformes	Scolopacidae	*Tringa totanus* (Linnaeus, 1758)
128	Charadriiformes	Scolopacidae	*Tringa stagnatilis* (Bechstein, 1803)
129	Charadriiformes	Scolopacidae	*Tringa nebularia* (Gunnerus, 1767)
130	Charadriiformes	Scolopacidae	*Tringa ochropus* (Linnaeus, 1758)
131	Charadriiformes	Scolopacidae	*Tringa glareola* (Linnaeus, 1758)
132	Charadriiformes	Scolopacidae	*Actitis hypoleucos* (Linnaeus, 1758)
133	Charadriiformes	Scolopacidae	*Calidris minuta* (Leisler, 1812)
134	Charadriiformes	Scolopacidae	*Calidris temminckii* (Leisler, 1812)
135	Charadriiformes	Scolopacidae	*Philomachus pugnax* (Linnaeus, 1758)
136	Charadriiformes	Glareolidae	*Cursorius coromandelicus* (Gmelin, 1789)
137	Charadriiformes	Glareolidae	*Glareola pratincola* (Linnaeus, 1766)
138	Charadriiformes	Glareolidae	*Glareola lactea* (Temminck, 1820)
139	Charadriiformes	Laridae	*Larus cachinnans* (Pallas, 1811)
140	Charadriiformes	Laridae	*Larus ichthyaetus* (Pallas, 1773)
141	Charadriiformes	Laridae	*Larus brunnicephalus* (Jerdon, 1840)
142	Charadriiformes	Laridae	*Larus ridibundus* (Linnaeus, 1766)
143	Charadriiformes	Laridae	*Sterna aurantia* (Gray, 1831)
144	Charadriiformes	Laridae	*Sterna albifrons* (Pallas, 1764)
145	Charadriiformes	Laridae	*Sterna acuticauda* (Gray, 1832)
146	Charadriiformes	Laridae	*Chlidonias hybrida* (Pallas, 1811)
147	Charadriiformes	Laridae	*Rynchops albicollis* (Swainson, 1838)
148	Pterocliformes	Pteroclididae	*Pterocles exustus* (Temminck, 1825)
149	Pterocliformes	Pteroclididae	*Pterocles indicus* (Gmelin, 1789)
150	Columbiformes	Columbidae	*Columba livia* (Gmelin, 1789)
151	Columbiformes	Columbidae	*Streptopelia orientalis* (Latham, 1790)
152	Columbiformes	Columbidae	*Streptopelia tranquebarica* (Hermann, 1804)
153	Columbiformes	Columbidae	*Streptopelia decaocto* (Frivaldszky, 1838)
154	Columbiformes	Columbidae	*Stigmatopelia senegalensis* (Linnaeus, 1766)
155	Columbiformes	Columbidae	*Stigmatopelia chinensis* (Scopoli, 1786)
156	Columbiformes	Columbidae	*Treron phoenicopterus* (Latham, 1790)
157	Psittaciformes	Psittacidae	*Psittacula eupatria* (Linnaeus, 1766)
158	Psittaciformes	Psittacidae	*Psittacula krameri* (Scopoli, 1769)
159	Psittaciformes	Psittacidae	*Psittacula cyanocephala* (Linnaeus, 1766)
160	Columbiformes	Cuculidae	*Clamator jacobinus* (Boddaert, 1783)
161	Columbiformes	Cuculidae	*Cuculus varius* (Vahl, 1797)
162	Columbiformes	Cuculidae	*Cuculus canorus* (Linnaeus, 1758)
163	Columbiformes	Cuculidae	*Eudynamys scolopaceus* (Linnaeus, 1758)
164	Columbiformes	Cuculidae	*Phaenicophaeus leschenaultii* (Lesson, 1830)
165	Columbiformes	Cuculidae	*Centropus sinensis* (Stephens, 1815)
166	Strigiformes	Tytonidae	*Tyto alba* (Scopoli, 1769)

Common Species	IUCN Status	Present Data	References
Eurasian Curlew	NT	-	11,12,13
Spotted Redshank	LC	-	12
Common Redshank	LC	-	1,7,8,11,12,13
Marsh Sandpiper	LC	+	12
Common Greenshank	LC	+	1,7,11,12,13
Green Sandpiper	LC	-	1,11,12,13
Wood Sandpiper	LC	-	1,2,7,11,12,13
Common Sandpiper	LC	+	1,2,7,8,11,12,13
Little Stint	LC	+	1,7,8,11,12,13
Temminck's Stint	LC	+	12,13
Ruff	LC	-	1,7,8,12,13
Indian Courser	LC	-	1
Collared Pratincole	LC	+	1,13
Small Pratincole	LC	-	1,7,8,10,11,13
Caspian Gull	LC	-	11,13
Pallas's Gull	LC	+	1,11,12,13
Brown-headed Gull	LC	-	1,8,9,11,12,13
Black-headed Gull	LC	-	11,12,13
River Tern	VU	+	1,2,7,8,11,12,13
Little Tern	LC	+	1,7,10
Black-bellied Tern	EN	+	1,7,11,12,13
Whiskered Tern	LC	+	1,7,8,11,12,13
Indian Skimmer	EN	+	1,2.3.4,5,6,7,9,10,11,13
Chestnut-bellied Sandgrouse	LC	-	1,7,8,13
Painted Sandgrouse	LC	-	11
Rock Pigeon	LC	+	1,2,7,8,11,12,13
Oriental Turtle-Dove	LC	-	1,2
Red Collared-Dove	LC	+	1,2,7,13
Eurasian Collared-Dove	LC	-	1,2,7,11,12,13
Laughing Dove	LC	-	1,2,7,11,12,13
Spotted Dove	LC	-	1,2,7,11,12,13
Yellow-footed Green-Pigeon	LC	-	2,11,12,13
Alexandrine Parakeet	NT	-	2,11,13
Rose-ringed Parakeet	LC	+	1,2,7,8,11,12,13
Plum-headed Parakeet	LC	-	1,2,7,11,12,13
Pied Cuckoo	LC	-	2,8,13
Common Hawk-Cuckoo	LC	-	1,13
Common Cuckoo	LC	-	2
Asian Koel	LC	-	1,2,7,8,11,12,13
Sirkeer Malkoha	LC	+	1,13
Greater Coucal	LC	-	1,2,7,11,12,13
Eastern Barn Owl	LC	-	1,13

Sr. No.	Order	Family	Species
167	Strigiformes	Strigidae	*Otus sunia* (Hodgson, 1836)
168	Strigiformes	Strigidae	*Otus bakkamoena* (Pennant, 1769)
169	Strigiformes	Strigidae	*Bubo bengalensis* (Franklin, 1831)
170	Strigiformes	Strigidae	*Bubo coromandus* (Latham, 1790)
171	Strigiformes	Strigidae	*Ketupa zeylonensis* (Gmelin, 1788)
172	Strigiformes	Strigidae	*Glaucidium radiatum* (Tickell, 1833)
173	Strigiformes	Strigidae	*Athene brama* (Temminck, 1821)
174	Strigiformes	Strigidae	*Ninox scutulata* (Rafles, 1822)
175	Strigiformes	Strigidae	*Asio flammeus* (Pontoppidan, 1763)
176	Caprimulgiformes	Caprimulgidae	*Caprimulgus indicus* (Latham, 1790)
177	Caprimulgiformes	Caprimulgidae	*Caprimulgus macrurus* (Horsfield, 1821)
178	Caprimulgiformes	Caprimulgidae	*Caprimulgus asiaticus* (Latham, 1790)
179	Caprimulgiformes	Caprimulgidae	*Caprimulgus affinis* (Horsfield, 1821)
180	Apodiformes	Apodidae	*Cypsiurus balasiensis* (Gray, 1829)
181	Apodiformes	Apodidae	*Apus affinis* (Gray, 1830)
182	Coraciiformes	Coraciidae	*Coracias benghalensis* (Linnaeus, 1758)
183	Coraciiformes	Alcedinidae	*Pelargopsis capensis* (Linnaeus, 1766)
184	Coraciiformes	Alcedinidae	*Halcyon smyrnensis* (Linnaeus, 1758)
185	Coraciiformes	Alcedinidae	*Alcedo atthis* (Linnaeus, 1758)
186	Coraciiformes	Alcedinidae	*Ceryle rudis* (Linnaeus, 1758)
187	Coraciiformes	Meropidae	*Merops orientalis* (Latham, 1802)
188	Coraciiformes	Meropidae	*Merops philippinus* (Linnaeus, 1766)
189	Bucerotiformes	Upupidae	*Upupa epops* (Linnaeus, 1758)
190	Bucerotiformes	Bucerotidae	*Ocyceros birostris* (Scopoli, 1786)
191	Piciformes	Ramphastidae	*Megalaima zeylanica* (Gmelin, 1788)
192	Piciformes	Ramphastidae	*Megalaima haemacephala* (Mller, 1776)
193	Piciformes	Picidae	*Jynx torquilla* (Linnaeus, 1758)
194	Piciformes	Picidae	*Dendrocopos nanus* (Vigors, 1832)
195	Piciformes	Picidae	*Dendrocopos mahrattensis* (Latham, 1801)
196	Piciformes	Picidae	*Picus xanthopygaeus* (Gray & Gray, 1846)
197	Piciformes	Picidae	*Dinopium benghalense* (Linnaeus, 1758)
198	Piciformes	Picidae	*Chrysocolaptes festivus* (Boddaert, 1783)
199	Passeriformes	Campephagidae	*Tephrodornis pondicerianus* (Gmelin, 1789)
200	Passeriformes	Campephagidae	*Coracina macei* (Lesson, 1831)
201	Passeriformes	Aegithinidae	*Aegithina tiphia* (Linnaeus, 1758)
202	Passeriformes	Campephagidae	*Pericrocotus cinnamomeus* (Linnaeus, 1766)
203	Passeriformes	Campephagidae	*Pericrocotus erythropygius* (Jerdon, 1840)
204	Passeriformes	Campephagidae	*Pericrocotus ethologus* (Bangs & Phillips, 1914)
205	Passeriformes	Laniidae	*Lanius isabellinus* (Ehrenberg, 1833)
206	Passeriformes	Laniidae	*Lanius cristatus* (Linnaeus, 1758)
207	Passeriformes	Laniidae	*Lanius vittatus* (Valenciennes, 1826)
208	Passeriformes	Laniidae	*Lanius schach* (Linnaeus, 1758)

Common Species	IUCN Status	Present Data	References
Oriental Scops-Owl	LC	-	2
Collared Scops-Owl	LC	-	1,2
Indian Eagle-Owl	LC	-	1,2,7,11,13
Dusky Eagle-Owl	LC	-	13
Brown Fish-Owl	LC	-	1,11,13
Jungle Owlet	LC	-	11
Spotted Owlet	LC	-	1,2,8,11,12,13
Brown Boobook	LC	-	1
Short-eared Owl	LC	-	13
Grey Nightjar	LC	-	1,2
Large-tailed Nightjar	LC	-	2
Indian Nightjar	LC	-	1,7,12,13
Savanna Nightjar	LC	+	2
Asian Palm Swift	LC	-	1,11
House Swift	LC	-	1,2,8,12,13
Indian Roller	LC	-	1,2,7,8,11,12,13
Stork-billed Kingfisher	LC	-	2,13
White-throated Kingfisher	LC	+	1,2,7,8,11,12,13
Common Kingfisher	LC	-	1,2,7,11,12,13
Pied Kingfisher	LC	+	1,2,7,8,11,12,13
Asian Green Bee-eater	LC	-	1,2,7,12,13
Blue-tailed Bee-eater	LC	-	2,7,12,13
Eurasian Hoopoe	LC	-	1,2,8,11,13
Indian Grey Hornbill	LC	-	1,2,13
Brown-headed Barbet	LC	-	2
Coppersmith Barbet	LC	-	2,7,11,13
Eurasian Wryneck	LC	-	11,13
Brown-capped Pygmy Woodpecker	LC	-	2
Yellow-crowned Woodpecker	LC	-	2,11,13
Streak-throated Woodpecker	LC	-	2
Black-rumped Flameback	LC	-	1,2,11,13
White-naped Woodpecker	LC	-	2
Common Woodshrike	LC	-	1,2,13
Indian Cuckooshrike	LC	-	13
Common Iora	LC	-	2,11,13
Small Minivet	LC	-	2,7,13
White-bellied Minivet	LC	-	2
Long-tailed Minivet	LC	-	1
Isabelline Shrike	LC	-	11
Brown Shrike	LC	-	1,11
Bay-backed Shrike	LC	-	1,2,7,11,13
Long-tailed Shrike	LC	-	1,2,7,11,13

Sr. No.	Order	Family	Species
209	Passeriformes	Laniidae	*Lanius excubitor* (Linnaeus, 1758)
210	Passeriformes	Oriolidae	*Oriolus oriolus* (Linnaeus, 1758)
211	Passeriformes	Dicruridae	*Dicrurus macrocercus* (Vieillot, 1817)
212	Passeriformes	Dicruridae	*Dicrurus leucophaeus* (Vieillot, 1817)
213	Passeriformes	Dicruridae	*Dicrurus caerulescens* (Linnaeus, 1758)
214	Passeriformes	Rhipiduridae	*Rhipidura aureola* (Lesson, 1830)
215	Passeriformes	Monarchidae	*Terpsiphone paradisi* (Linnaeus, 1758)
216	Passeriformes	Corvidae	*Dendrocitta vagabunda* (Latham, 1790)
217	Passeriformes	Corvidae	*Corvus splendens* (Vieillot, 1817)
218	Passeriformes	Corvidae	*Corvus macrorhynchos* (Wagler, 1827)
219	Passeriformes	Corvidae	*Corvus corax* (Linnaeus, 1758)
220	Passeriformes	Paridae	*Parus major* Linnaeus, 1758
221	Passeriformes	Hirundinidae	*Riparia paludicola* (Vieillot, 1817)
222	Passeriformes	Hirundinidae	*Hirundo concolor* (Sykes, 1832)
223	Passeriformes	Hirundinidae	*Hirundo rustica* (Linnaeus, 1758)
224	Passeriformes	Hirundinidae	*Hirundo smithii* (Leach, 1818)
225	Passeriformes	Hirundinidae	*Hirundo daurica* (Linnaeus, 1771)
226	Passeriformes	Hirundinidae	*Hirundo fluvicola* (Blyth, 1855)
227	Passeriformes	Alaudidae	*Mirafra cantillans* (Blyth, 1844)
228	Passeriformes	Alaudidae	*Mirafra assamica* (Horsfield, 1840)
229	Passeriformes	Alaudidae	*Mirafra erythroptera* (Blyth, 1845)
230	Passeriformes	Alaudidae	*Ammomanes phoenicura* (Franklin, 1831)
231	Passeriformes	Alaudidae	*Calandrella brachydactyla* (Leisler, 1814)
232	Passeriformes	Alaudidae	*Galerida cristata* (Linnaeus, 1758)
233	Passeriformes	Alaudidae	*Alauda gulgula* (Franklin, 1831)
234	Passeriformes	Alaudidae	*Eremopterix griseus* (Scopoli, 1786)
235	Passeriformes	Cisticolidae	*Cisticola juncidis* (Rafinesque, 1810)
236	Passeriformes	Cisticolidae	*Prinia hodgsonii* (Blyth, 1844)
237	Passeriformes	Cisticolidae	*Prinia gracilis* (Lichtenstein, 1823)
238	Passeriformes	Cisticolidae	*Prinia sylvatica* (Jerdon, 1840)
239	Passeriformes	Cisticolidae	*Prinia socialis* (Sykes, 1832)
240	Passeriformes	Cisticolidae	*Prinia inornata* (Sykes, 1832)
241	Passeriformes	Pycnonotidae	*Pycnonotus leucotis* (Gould, 1836)
242	Passeriformes	Pycnonotidae	*Pycnonotus cafer* (Linnaeus, 1766)
243	Passeriformes	Sylviidae	*Orthotomus sutorius* (Pennant, 1769)
244	Passeriformes	Sylviidae	*Acrocephalus stentoreus* (Ehrenberg, 1833)
245	Passeriformes	Sylviidae	*Phylloscopus collybita* (Vieillot, 1817)
246	Passeriformes	Sylviidae	*Phylloscopus griseolus* Blyth, 1847
247	Passeriformes	Sylviidae	*Phylloscopus humei* (Brooks, 1878)
248	Passeriformes	Sylviidae	*Hippolais rama* (Sykes, 1832)
249	Passeriformes	Sylviidae	*Sylvia curruca* (Linnaeus, 1758)
250	Passeriformes	Sylviidae	*Sylvia hortensis* (Gmelin, 1789)

Common Species	IUCN Status	Present Data	References
Great Grey Shrike	LC	-	2,7,11,13
Eurasian Golden Oriole	LC	-	2,7,12,13
Black Drongo	LC	-	1,2,7,11,12,13
Ashy Drongo	LC	-	1,2,
White-bellied Drongo	LC	-	2,12,13
White-browed Fantail	LC	-	12,13
Indian Paradise-Flycatcher	LC	-	2,12,13
Rufous Treepie	LC	-	1,8,11,12,13
House Crow	LC	-	1,2,7,8,11,12,13
Large-billed Crow	LC	-	1,2,7,11,12,13
Common Raven	LC	-	13
Cinereous Tit	Not recognized	-	1,2,7,13
Grey-throated Martin	LC	-	1,2
Dusky Crag-Martin	LC	-	1,11,12,13
Barn Swallow	LC	-	1,2,7,11,12,13
Wire-tailed Swallow	LC	+	1,11,12
European Red-rumped Swallow	Not recognized	-	1,2,11,12,13
Streak-throated Swallow	LC	-	1,7,11,13
Singing Bushlark	LC	-	12,13
Rufous-tailed Lark	LC	-	1
Indian Bushlark	LC	-	1,7,12,13
Rufous-tailed Lark	LC	-	2,7,8,13
Greater Short-toed Lark	LC	-	1
Crested Lark	LC	-	1,7,11,12,13
Oriental Skylark	LC	-	1,2
Ashy-crowned Sparrow-Lark	LC	-	1,2,7,8,11,12,13
Zitting Cisticola	LC	-	2
Grey-breasted Prinia	LC	-	1
Delicate Prinia	Not recognized	-	2
Jungle Prinia	LC	-	11
Ashy Prinia	LC	-	1,7,11,13
Plain Prinia	LC	-	7,11,13
White-eared Bulbul	LC	-	1,2,7,11,13
Red-vented Bulbul	LC	-	1,2,7,11,12,13
Common Tailorbird	LC	-	2,7,11,13
Clamorous Reed Warbler	LC	-	13
Common Chiffchaff	LC	-	12,13
Sulphur-bellied Warbler	LC	-	13
Hume's Warbler	LC	-	2
Sykes's Warbler	LC	-	1
Lesser Whitethroat	LC	-	11,12,13
Eastern Orphean Warbler	LC	-	13

Sr. No.	Order	Family	Species
251	Passeriformes	Timaliidae	*Chrysomma sinense* (Gmelin, 1789)
252	Passeriformes	Timaliidae	*Turdoides caudata* (Dumont, 1823)
253	Passeriformes	Timaliidae	*Turdoides malcolmi* (Sykes, 1832)
254	Passeriformes	Timaliidae	*Turdoides striata* (Dumont, 1823)
255	Passeriformes	Zosteropidae	*Zosterops palpebrosus* (Temminck, 1824)
256	Passeriformes	Sturnidae	*Acridotheres tristis* (Linnaeus, 1766)
257	Passeriformes	Sturnidae	*Acridotheres ginginianus* (Latham, 1790)
258	Passeriformes	Sturnidae	*Sturnus pagodarum* (Gmelin, 1789)
259	Passeriformes	Sturnidae	*Sturnus roseus* (Linnaeus, 1758)
260	Passeriformes	Sturnidae	*Sturnus contra* (Linnaeus, 1758)
261	Passeriformes	Sturnidae	*Sturnus vulgaris* (Linnaeus, 1758)
262	Passeriformes	Muscicapidae	*Luscinia svecica* (Linnaeus, 1758)
263	Passeriformes	Muscicapidae	*Copsychus saularis* (Linnaeus, 1758)
264	Passeriformes	Muscicapidae	*Saxicoloides fulicatus* (Linnaeus, 1766)
265	Passeriformes	Muscicapidae	*Phoenicurus ochruros* (Gmelin, 1774)
266	Passeriformes	Muscicapidae	*Saxicola torquatus* (Linnaeus, 1766)
267	Passeriformes	Muscicapidae	*Saxicola caprata* (Linnaeus, 1766)
268	Passeriformes	Muscicapidae	*Oenanthe picata* (Blyth, 1847)
269	Passeriformes	Muscicapidae	*Oenanthe deserti* (Temminck, 1825)
270	Passeriformes	Muscicapidae	*Oenanthe isabellina* (Temminck, 1829)
271	Passeriformes	Muscicapidae	*Cercomela fusca* (Blyth, 1851)
272	Passeriformes	Muscicapidae	*Monticola solitarius* (Linnaeus, 1758)
273	Passeriformes	Muscicapidae	*Muscicapa dauurica* (Pallas, 1811)
274	Passeriformes	Muscicapidae	*Ficedula parva* (Bechstein, 1792)
275	Passeriformes	Muscicapidae	*Ficedula superciliaris* (Jerdon, 1840)
276	Passeriformes	Muscicapidae	*Eumyias thalassinus* (Swainson, 1838)
277	Passeriformes	Muscicapidae	*Cyornis tickelliae* (Blyth, 1843)
278	Passeriformes	Muscicapidae	*Culicicapa ceylonensis* (Swainson, 1820)
279	Passeriformes	Nectariniidae	*Nectarinia asiatica* (Latham, 1790)
280	Passeriformes	Passeridae	*Passer domesticus* (Linnaeus, 1758)
281	Passeriformes	Passeridae	*Passer hispaniolensis* (Temminck, 1820)
282	Passeriformes	Passeridae	*Passer montanus* (Linnaeus, 1758)
283	Passeriformes	Passeridae	*Petronia xanthocollis* (Burton, 1838)
284	Passeriformes	Ploceidae	*Ploceus benghalensis* (Linnaeus, 1758)
285	Passeriformes	Ploceidae	*Ploceus manyar* (Horsfield, 1821)
286	Passeriformes	Ploceidae	*Ploceus philippinus* (Linnaeus, 1766)
287	Passeriformes	Estrildidae	*Amandava amandava* (Linnaeus, 1758)
288	Passeriformes	Estrildidae	*Amandava formosa* (Latham, 1790)
289	Passeriformes	Estrildidae	*Lonchura malabarica* (Linnaeus, 1758)
290	Passeriformes	Estrildidae	*Lonchura punctulata* (Linnaeus, 1758)
291	Passeriformes	Estrildidae	*Lonchura malacca* (Linnaeus, 1766)
292	Passeriformes	Motacilidae	*Motacilla alba* (Linnaeus, 1758)

Common Species	IUCN Status	Present Data	References
Yellow-eyed Babbler	LC	-	12,13
Common Babbler	LC	-	1,2,7,11,13
Large Grey Babbler	LC	-	1,7,11,12,13
Jungle Babbler	LC	-	1,2,7,11,12,13
Indian White-eye	LC	-	2,7,13
Common Myna	LC	-	1,2,7,11,12,13
Bank Myna	LC	+	1,2,7,11,12,13
Brahminy Starling	LC	-	1,2,7,11,13
Rosy Starling	LC	-	1,2,11,13
Indian Pied Starling	LC	-	1,2,7,11,12,13
Common Starling	LC	-	2
Bluethroat	LC	-	11,13
Oriental Magpie-Robin	LC	-	1,2,7,11,13
Indian Robin	LC	-	1,2,7,11,12,13
Black Redstart	LC	-	1,11,12,13
Siberian Stonechat	Not recognized	-	1,2,11,12,13
Pied Bushchat	LC	+	1,2,11,12,13
Variable Wheatear	LC	-	11,12
Desert Wheatear	LC	-	11
Isabelline Wheatear	LC	-	12,13
Brown Rock Chat	LC	-	1,2,7,11,12,13
Rufous-tailed Rock-Thrush	LC	-	11,13
Asian Brown Flycatcher	LC	-	2,13
Red-breasted Flycatcher	LC	-	12,13
Ultramarine Flycatcher	LC	-	2
Verditer Flycatcher	LC	-	13
Yellow-throated Sparrow	LC	-	2,13
Grey-headed Canary-Flycatcher	LC	-	12,13
Purple Sunbird	LC	-	1,2,7,11,12,13
House Sparrow	LC	-	1,2,7,11,12,13
Spanish Sparrow	LC	-	13
Eurasian Tree Sparrow	LC	-	1
Yellow-throated Sparrow	LC	-	1,7,12,13
Black-breasted Weaver	LC	-	2
Streaked Weaver	LC	-	1
Baya Weaver	LC	-	1.2,7,11,13
Red Munia	LC	-	13
Green Munia	VU	-	14
Indian Silverbill	LC	-	1,11,12,13
Scaly-breasted Munia	LC	-	1,2
Tricoloured Munia	LC	-	1,2
White Wagtail	LC	+	1,8,12,13

Sr. No.	Order	Family	Species
293	Passeriformes	Motacilidae	*Motacilla maderaspatensis* (Gmelin, 1789)
294	Passeriformes	Motacilidae	*Motacilla citreola* (Pallas, 1776)
295	Passeriformes	Motacilidae	*Motacilla flava* (Linnaeus, 1758)
296	Passeriformes	Motacilidae	*Motacilla cinerea* (Tunstall, 1771)
297	Passeriformes	Motacilidae	*Anthus rufulus* (Vieillot, 1818)
298	Passeriformes	Motacilidae	*Anthus campestris* (Linnaeus, 1758)
299	Passeriformes	Motacilidae	*Anthus trivialis* (Linnaeus, 1758)
300	Passeriformes	Motacilidae	*Anthus hodgsoni* (Richmond, 1907)
301	Passeriformes	Motacilidae	*Anthus spinoletta* (Linnaeus, 1758)
302	Passeriformes	Fringillidae	*Carpodacus erythrinus* (Pallas, 1770)
303	Passeriformes	Emberizidae	*Melophus lathami* (Gray, 1831)
304	Passeriformes	Emberizidae	*Emberiza stewarti* (Blyth, 1854)
305	Passeriformes	Emberizidae	*Emberiza buchanani* (Blyth, 1844)
306	Passeriformes	Emberizidae	*Emberiza melanocephala* (Scopoli, 1769)
307	Passeriformes	Emberizidae	*Emberiza bruniceps* (Brandt, 1841)
308	Accipitriformes	Accipitridae	*Buteo rufinus* (Cretzhshmar, 1829)
309	Ciconiiformes	Ciconiidae	*Ciconia episcopus* (Boddaert, 1783)

IUCN status: LC - Least Concern; NT - Near Threatened; VU - Vulnerable; EN - Endangered; CR - Critically Endangered.

Previous Studies:

1- Nair & Krishna, 2013 (fieldwork in 2009 - 2010); **2-** Nair & Krishna, 2013 (intermittent fieldwork between 2006 and 2008); **3-** BirdLife International (2012a); **4-** BirdLife International (2012b); **5-** Islam & Rahmani (2002); **6-** Islam & Rahmani (2004); **7-** Nair (2009); **8-** Sale (1982); **9-** Sharma et al. (1995); **10-** Sundar (2004); **11-** Tigerwatch (2009); **12-** Vyas & Singh (2004); **13-** Vyas et al. (in prep.); **14-** BirdLife International (2012c)

References

Nair, T. & Y.C. Krishna (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa 5*(2): 3620-3641; Field Work 2009-2010.

Nair, T. & Y.C. Krishna (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa 5*(2): 3620-3641; doi:10.11609/JoTT.o3238.3620-41; Field Work 2006-2008.

BirdLife International (2012a). *Important Bird Areas factsheet: National Chambal Wildlife Sanctuary (Agra/Etawah) (part of National Chambal River Gharial Sanctuary AZE).* Downloaded from http://www.birdlife.org on 06/05/2012.

BirdLife International (2012b). *Important Bird Areas factsheet: National Chambal Wildlife Sanctuary (Bundi/Kota) (part of National Chambal River Gharial Sanctuary AZE).* Downloaded from http://www.birdlife.org on 06/05/2012.

Islam, M.Z. & A.R. Rahmani (2002). Threatened birds of India. *Buceros7*(1&2). Compiled from Threatened Birds of Asia - BirdLife International Red Data Book (2001). BirdLife International, Cambridge, U.K.

Islam, M.Z. & A.R. Rahmani (2004). *Important Bird Areas in India: Priority Sites for Conservation.* Indian Bird Conservation Network: Bombay Natural History Society and BirdLife International (UK), xviii+1133pp.

Nair, A.K. (2009). The status and distribution of major aquatic fauna in the National Chambal Gharial Sanctuary in Rajasthan with special reference to the Gangetic Dolphin *Platanista gangetica gangetica* (Cetartiodactyla: Platanistidae). *Journal of Threatened Taxa 1*(3): 141-146.

Common Species	IUCN Status	Present Data	References
White-browed Wagtail	LC	+	1,2,7,8,11,12,13
Citrine Wagtail	LC	-	11
Western Yellow Wagtail	LC	-	1,2,7,11,13
Grey Wagtail	LC	-	1,2,7,11,12,13
Paddyfield Pipit	LC	-	1,2,11,12,13
Tawny Pipit	LC	-	2
Tree Pipit	LC	-	2
Olive-backed Pipit	LC	-	13
Water Pipit	LC	-	12
Common Rosefinch	LC	-	1,11
Crested Bunting	LC	-	2.7,13
White-capped Bunting	LC	-	11
Grey-necked Bunting	LC	-	11,13
Black-headed Bunting	LC	-	13
Red-headed Bunting	LC	-	13
Long-legged Buzzard	LC	+	
Asian Woolly-necked Stork	NT	+	

Sale, J.B. (1982). 2nd Draft. Management Plan ForThe National Chambal Sanctuary. First Five Year Period 1982/83 - 1986/87. Central Crocodile Breeding and Management Institute, Hyderabad, iii+82pp.

Sundar, K. G. (2004). Observations on breeding Indian Skimmers *Rynchops albicollis* in the National Chambal Sanctuary, Uttar Pradesh, India. Forktail, 20, 89-90.

Sharma, R.K., R. Mathur & S. Sharma (1995). Status and distribution of fauna in National Chambal Sanctuary, Madhya Pradesh. *Indian Forester 121*(10): 912-916.

Tigerwatch (2009). The Gharial expedition - December 2009 - A survey of Gharial populations in one segment of the National Chambal Sanctuary, Rajasthan. Tigerwatch, Ranthambore, India, 37pp.

Vyas, R., & Singh, H. (2004). Biodiversity survey of Gandhisagar Reservoir, Madhya Pradesh. *Zoos' Print Journal, 19*(7), 1525-1529.

Vyas, R., R.S. Tomar & S. Singhal (in prep.) Macrofauna of National Chambal Sanctuary in Rajasthan and its conservation issues.

BirdLife International (2012c). *Species factsheet: Amandavaformosa.* Downloaded from http://www.birdlife.org on 05/05/2012.

ANNEXURE VI: Checklist of Mammalian Species of the Chambal River:

leschenaultii

Sr. No.	Order	Family	Mammalian species
1	Primates	Cercopithecidae	*Macaca mulatta* (Zimmermann, 1780)
2	Primates	Cercopithecidae	*Semnopithecus entellus* (Dufresne, 1797)
3	Rodentia	Sciuridae	*Funambulus pennantii* (Wroughton, 1905)
4	Rodentia	Muridae	*Tatera indica* (Hardwicke, 1807)
5	Rodentia	Muridae	*Millardia meltada* (Gray, 1837)
6	Rodentia	Muridae	*Mus musculus* (Linnaeus, 1758)
7	Rodentia	Muridae	*Rattus rattus* (Linnaeus, 1758)
8	Rodentia	Muridae	*Bandicota bengalensis* (Gray, 1835)
9	Rodentia	Hystricidae	*Hystrix indica* (Kerr, 1792)
10	Lagomorpha	Leporidae	*Lepus nigricollis* (F. Cuvier, 1823)
12	Eulipotyphla	Erinaceidae	*Hemiechinus collaris* (Gray, 1830)
13	Eulipotyphla	Erinaceidae	*Paraechinus micropus* (Blyth, 1846)
14	Eulipotyphla	Soricidae	*Suncus murinus* (Linnaeus, 1766)
16	Chiroptera	Pteropodidae	*Rousettus leschenaulti* (Desmarest, 1820)
17	Chiroptera	Pteropodidae	*Pteropus giganteus* (Brünnich, 1782)
18	Chiroptera	Pteropodidae	*Cynopterus sphinx* (Vahl, 1797)
19	Chiroptera	Rhinopomatidae	*Rhinopoma microphyllum* (Brünnich, 1792)
20	Chiroptera	Rhinopomatidae	*Rhinopoma hardwickii* (Gray, 1831)
21	Chiroptera	Hipposideridae	*Hipposideros fulvus* (Gray, 1838)
22	Chiroptera	Megadermatidae	*Megaderma lyra* (É. Geoffroy, 1810)
23	Chiroptera	Rhinolophidae	*Rhinolophus lepidus* (Blyth, 1844)
24	Chiroptera	Emballonuridae	*Taphozous longimanus* (Hardwicke, 1825)
25	Chiroptera	Emballonuridae	*Taphozous melanopogon* (Temminck, 1841)
26	Chiroptera	Emballonuridae	*Taphozous perforatus* (É. Geoffroy, 1818)
27	Chiroptera	Emballonuridae	*Taphozous nudiventris* (Cretzschmar, 1830)
28	Chiroptera	Molossidae	*Tadarida aegyptiaca* (É. Geoffroy, 1818)
29	Chiroptera	Vespertilionidae	*Scotophilus heathii* (Horsfield, 1831)
30	Chiroptera	Vespertilionidae	*Scotophilus kuhlii* (Leach, 1821)
31	Chiroptera	Vespertilionidae	*Pipistrellus coromandra* (Gray, 1838)
32	Chiroptera	Vespertilionidae	*Pipistrellus tenuis* (Temminck, 1840)
33	Chiroptera	Vespertilionidae	*Scotozous dormeri* (Dobson, 1875)
34	Philodota	Manidae	*Manis crassicaudata* (É. Geoffroy, 1803)
35	Carnivora	Felidae	*Felis chaus* (Schreber, 1777)
36	Carnivora	Felidae	*Felis lybica ornata*
37	Carnivora	Felidae	*Prionailurus bengalensis* (Kerr, 1792)
38	Carnivora	Felidae	*Prionailurus viverrinus* (Bennett, 1833)
39	Carnivora	Felidae	*Caracal caracal* (Schreber, 1776)
40	Carnivora	Felidae	*Panthera pardus* (Linnaeus, 1758)
41	Carnivora	Felidae	*Panthera tigris* (Linnaeus, 1758)
42	Carnivora	Viverridae	*Paradoxurus hermaphroditus* (Pallas, 1777)
43	Carnivora	Viverridae	*Viverricula indica* (É. Geoffroy Saint-Hilaire, 1803)

Common Species	IUCN Status	Present Study	Previous Study
Rhesus Macaque	LC	-	1,2,11,15
Hanuman Langur	LC	-	1,2,10,11,15
Five-striped Palm Squirrel	LC	-	1,2,15
Indian Gerbil	LC	-	1,2,7,15
Soft-furred Rat	LC	-	2
House Mouse	LC	-	1,2,7
Black Rat	LC	-	2,11
Lesser Bandicoot Rat	LC	-	2
Indian Crested Porcupine	LC	-	10,11,15
Indian Hare	LC	-	1,2,10,11,15
Indian long-eared hedgehog	LC	-	7
Indian Hedgehog	LC	-	15
Asian House Shrew	LC	-	1,11
Leschenault's Rousette	LC	-	2
Indian Flying Fox	LC	-	1,2,15,8
Greater short-nosed Fruit Bat	LC	-	1,2,
Greater Mouse-tailed Bat	LC	-	8
Lesser Mouse-tailed Bat	LC	-	1*,8
Fulvous Leaf-nosed Bat	LC	-	2,8
Greater False vampire Bat	LC	-	1,8
Blyth's Horseshoe Bat	LC	-	8
Long-winged Tomb Bat	LC	-	8
Black-bearded Tomb Bat	LC	-	2
Egyptian Tomb Bat	LC	-	1,2
Naked-rumped Tomb Bat	LC	-	8
Egyptian Free-tailed Bat	LC	-	1,8
Greater Asiatic Yellow Bat	LC	-	8
Lesser Asiatic Yellow House Bat	LC	-	1
Indian Pipistrelle	LC	-	2,15
Indian Pygmy Bat	LC	-	8
Dormer's Bat	LC	-	8
Indian Pangolin	NT	-	3
Jungle Cat	LC	-	9,11,15
Asiatic Wildcat	LC	-	5,10,15
Leopard Cat	LC	-	11,12
Fishing Cat	EN	-	15
Caracal	LC	-	6
Common Leopard	NT	-	11,15
Tiger	EN	-	11
Asian Palm Civet	LC	-	1,2,15
Small Indian Civet	LC	-	1,2,15

Sr. No.	Order	Family	Mammalian species
44	Carnivora	Herpestidae	*Herpestes edwardsii* (É. Geoffroy Saint-Hilaire, 1818)
45	Carnivora	Herpestidae	*Herpestes javanicus* (É. Geoffroy Saint-Hilaire, 1818)
46	Carnivora	Herpestidae	*Herpestes smithii* (Gray, 1837)
47	Carnivora	Hyaenidae	*Hyaena hyaena* (Linnaeus, 1758)
48	Carnivora	Canidae	*Canis lupus pallipes* (Linnaeus, 1758)
49	Carnivora	Canidae	*Canis aureus* (Linnaeus, 1758)
50	Carnivora	Canidae	*Cuon alpinus* (Pallas, 1811)
51	Carnivora	Canidae	*Vulpes vulpes pusilla* (Linnaeus, 1758)
52	Carnivora	Canidae	*Vulpes bengalensis* (Shaw, 1800)
53	Carnivora	Ursidae	*Melursus ursinus* (Shaw, 1791)
54	Carnivora	Mustelidae	*Mellivora capensis* (Schreber, 1776)
55	Carnivora	Mustelidae	*Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826)
56	Artiodactyla	Suidae	*Sus scrofa cristatus* (Linnaeus, 1758)
57	Artiodactyla	Bovidae	*Antilope cervicapra* (Linnaeus, 1758)
58	Artiodactyla	Bovidae	*Gazella gazella* (Pallas, 1766)
59	Artiodactyla	Bovidae	*Boselaphus tragocamelus* (Pallas, 1766)
60	Artiodactyla	Bovidae	*Tetracerus quadricornis* (de Blainville, 1816)
61	Artiodactyla	Cervidae	*Axis axis* (Erxleben, 1777)
62	Artiodactyla	Cervidae	*Rusa unicolor* (Kerr, 1792)
63	Artiodactyla	Platanistidae	*Platanista gangetica* (Roxburgh, 1801)

Previous Studies:

1- Nair & Krishna, 2013 (fieldwork in 2009 - 2010); **2-** Nair & Krishna, 2013 (intermittent fieldwork between 2006 and 2008); **3-** Chauhan & Narain (2001); **4-** Choudhury et al. (2008); **5-** Driscoll & Nowell (2009); **6-** Khudsar (2004); **7-** Molur et al. (2005); **8-** Molur et al. (2002); **9-** Nair (2009); **10-** Rao (1988); **11-** Sale (1982); **12-** Sanderson et al. (2008); **13-** Sharma et al. (1995); **14-** Vyas (2004); **15-** Vyas et al. (in prep.)

REFERENCES

Nair, T. & Y.C. Krishna (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa 5*(2): 3620-3641; Field Work 2009-2010.

Nair, T. & Y.C. Krishna (2013). Vertebrate fauna of the Chambal River Basin, with emphasis on the National Chambal Sanctuary, India. *Journal of Threatened Taxa 5*(2): 3620-3641; doi:10.11609/JoTT.o3238.3620-41; Field Work 2006-2008.

Chauhan, R. & S. Narain (2001). The Indian Pangolin (*Manis crassicaudata*) in the Chambal ravines of Etawah. *Zoos' Print Journal 16*(5): 501.

Choudhury, A., C. Wozencraft, D. Muddapa & P. Yonzon (2008). *Herpestes smithii*. In: IUCN 2010. 2010 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 06 September 2010.

Driscoll, C., & Nowell, K. (2011). Felis silvestris. IUCN Red List of Threatened Species v, 1.

Khudsar, F.A. (2004). Sighting of caracal in the Chambal ravines of Bhind District, Madhya Pradesh. *Journal of the Bombay Natural History Society 101*(1): 149.

Molur, S., C. Srinivasulu, B. Srinivasulu, S. Walker, P.O. Nameer & L. Ravikumar (2005). Status of South Asian Non-volant Small Mammals: Conservation Assessment and Management Plan Workshop Report. Zoo Outreach Organisation & CBSG-South Asia, Coimbatore, India, 618pp.

Molur, S., G. Marimuthu, C. Srinivasulu, S. Mistry, A.M. Hutson, P.J.J. Bates, S. Walker, K. Padma Priya & A.R. Binu Priya (eds.) (2002). Status of South Asian Chiroptera: Conservation Assessment and Management Plan Workshop Report. Zoo Outreach Organisation, CBSG South Asia & WILD, Coimbatore, India, viii+320pp.

Common Species	IUCN Status	Present Study	Previous Study
Indian Grey Mongoose	LC	-	1,2,11,15
Small Indian Mongoose	LC	-	1,2,15
Ruddy Mongoose	LC	-	2,4
Striped Hyaena	NT	-	1,2,10,11,15
Indian Gray Wolf	LC	-	10,11,15
Golden Jackal	LC	-	1,2,9,10,11,15
Dhole	EN	-	11
Desert Fox	LC	-	11
Bengal Fox	LC	-	10,11
Sloth Bear	VU	-	11,15
Honey Badger	LC	-	11
Smooth-coated otter	VU	-	1,2,13,14,10,11,15
Wild Boar	LC	-	1,10,11,15
Blackbuck	NT	-	1,11,15
Chinkara	VU	-	11,15
Nilgai	LC	-	1,10,11,15
Four-horned Antelope	VU	-	11
Chital	LC	-	10,11
Sambar	VU	-	1,10,11
Gangetic River Dolphin	EN	+	1,2,13,14,9,10,11,15

Nair, A.K. (2009). The status and distribution of major aquatic fauna in the National Chambal Gharial Sanctuary in Rajasthan with special reference to the Gangetic Dolphin *Platanista gangetica gangetica* (Cetartiodactyla: Platanistidae). Journal of Threatened Taxa 1(3): 141-146.

Rao, R.J. (1988). *Nesting Ecology of Gharial in the National Chambal Sanctuary.* Wildlife Institute of India, Dehradun, India, 105pp.

Sale, J.B. (1982). 2nd Draft. Management Plan ForThe National Chambal Sanctuary. First Five Year Period 1982/83 - 1986/87. Central Crocodile Breeding and Management Institute, Hyderabad, iii+82pp.

Sanderson, J., S. Sunarto, A. Wilting, C. Driscoll, R. Lorica, J. Ross, A. Hearn, S. Mukherjee, J.A. Khan, B. Habib & L. Grassman (2008). *Prionailurus bengalensis.* In: IUCN 2010. 2010 IUCN Red List of Threatened Species. <www.iucnredlist.org>.

Sharma, R.K., R. Mathur & S. Sharma (1995). Status and distribution of fauna in National Chambal Sanctuary, Madhya Pradesh. *Indian Forester 121*(10): 912-916.

Vyas, R. &H. Singh. (2004). Biodiversity survey of Gandhi Sagar Reservoir, Madhya Pradesh. *Zoos' Print Journal 19*(7): 1525-1529.

Vyas, R., R.S. Tomar & S. Singhal (in prep.) Macrofauna of National Chambal Sanctuary in Rajasthan and its conservation issues.

Ministry of Environment,
Forest and Climate Change

NMCG

National Mission for Clean Ganga,
Department of Water Resources,
River Development & Ganga
Rejuvenation, Ministry of Jal Shakti,
Major Dhyan Chand Stadium, India
Gate, New Delhi - 110001

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Wildlife Institute of India
Chandrabani, PO Box #18,
Dehradun-248001, Uttarakhand
t.: +91135 2640114-15,+91135 2646100
f.: +91135 2640117
wii.gov.in/nmcg/national
-mission-for-clean-ganga

GACMC/NCRR

Ganga Aqualife Conservation
Monitoring Centre/
National Centre for River Research
Wildlife Institute of India, Dehradun
nmcg@wii.gov.in