नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

SOCIO-ECOLOGICAL STATUS OF GOMTI RIVER FOR CONSERVATION PLANNING

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This document is an output of the project "Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in theGanga River Basin for a Clean Ganga", sponsored by the National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India, New Delhi.

ISBN: XXXX

Citation
WII-GACMC (2026). Socio-Ecological Status of the Gomti River for Conservation Planning. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehradun, India. Pp. 320.

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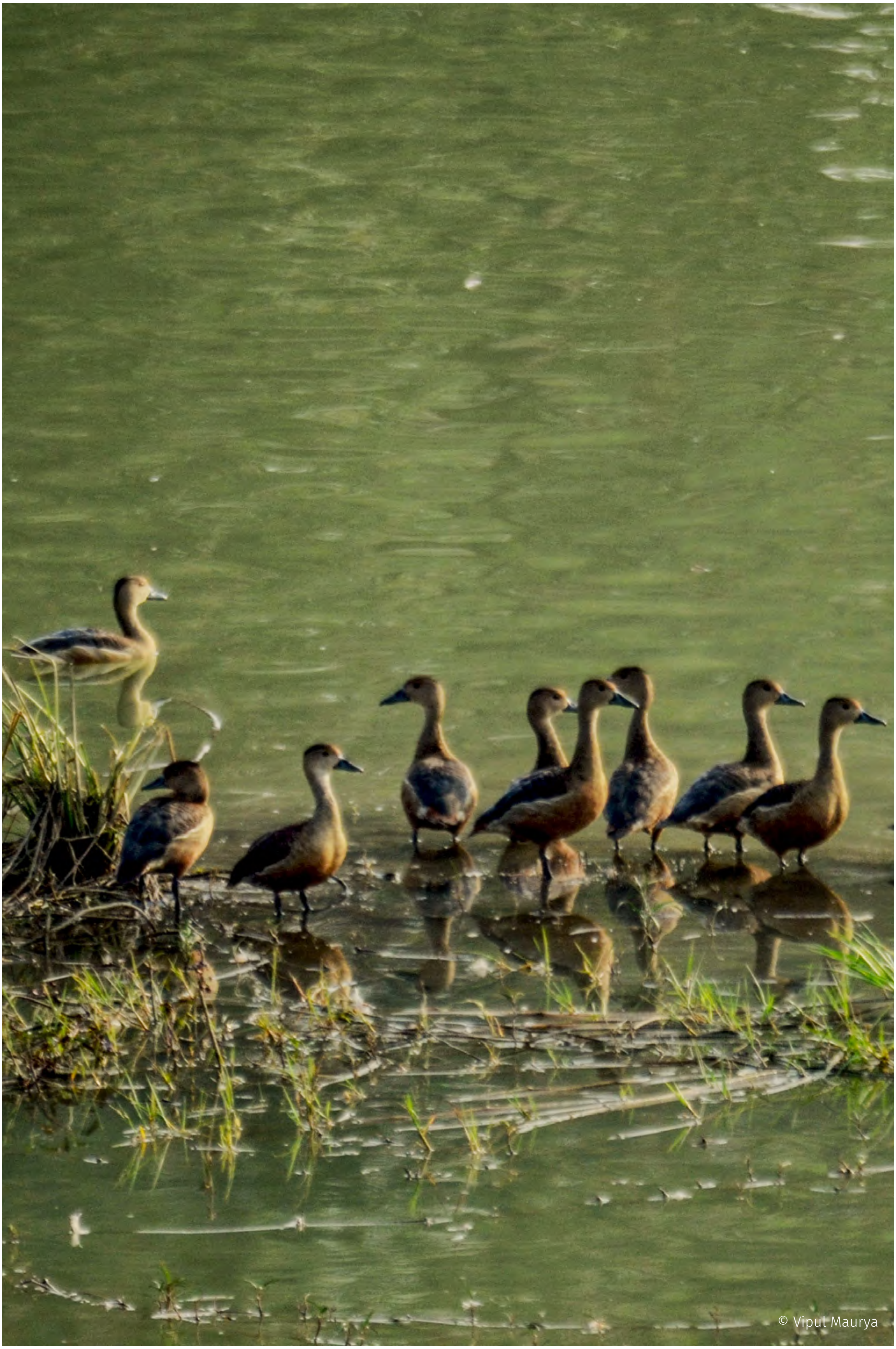
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EXECUTIVE SUMMARY

The Gomti River, a key left bank tributary of the Ganga River known for its cultural and ecological importance, flows exclusively through Uttar Pradesh, spanning approximately 930 km from its source at Gomat Tal in Pilibhit district to its confluence with the Ganga River at Kaithi in Ghazipur district. This report offers a detailed evaluation of the river's physical, biological, and socio-economic attributes, along with an examination of the human pressures, the conservation implications for the River and recommendations.

The basin covers an area of 30,435 km² within the Ghaghara-Ganga interfluve region of the Gangetic Plain. The river is typically segmented into three longitudinal parts: an upper stretch of 354 km crossing the terai landscape, a middle stretch of 344 km flowing through the densely populated corridor including Lucknow, and a lower stretch of 232 km extending to its confluence with the Ganga. Each segment displays distinct hydrological, geomorphic, and ecological characteristics. The Gomti River basin lies within the Upper Gangetic Plain biogeographic zone and forms part of the Terai-Arc Landscape, a globally significant biodiversity corridor in South Asia. The basin landscape is characterised by alluvial plains predominantly composed of loamy soils and falls under a humid subtropical climate, experiencing hot dry summers, monsoon-driven rainfall accounting for nearly three-quarters of annual precipitation, and cool dry winters. Agricultural land constitutes the largest share of the basin, exceeding 76 per cent, while forest cover is largely confined to the upper reaches and represents only around five per cent of the total area. Between 2008–09 and 2018–19, agricultural and built-up areas expanded measurably, while water bodies and wastelands contracted, reflecting intensifying land-use pressures. This report provides the first systematic, multi-year survey of aquatic and semi-aquatic mammals across the entire 930 km length of the Gomti River.

Ecological assessments were undertaken in the Gomti River to ascertain occurrence and distribution of the key aquatic species in the River. The comprehensive literature review and multiple biodiversity assessments were undertaken in the Basic/Biodiversity Evaluation Units (BEU) demarcated along the length of the River. A total of 186 BEUs were demarcated and the River was also divided into upper, middle and the lower zones

for analysis. The multiple ecological assessments recorded a total of 517 species, of which 408 were angiosperm plant taxa, 41 were freshwater fish species, 10 were amphibian species, five were freshwater turtle species, one crocodile, 51 were waterbird species, and the first confirmed record of smooth-coated otter. Flagship threatened species documented include the Indian skimmer, sarus crane, river tern, painted stork, *Clarias magur* (an Endangered fish), and the crowned river turtle; the critically endangered three-striped roofed turtle appears to have declined to functional local extinction from its last known sites in the river. Of the 517 species recorded, the majority of fall under Least Concern (LC), totalling 255 (49.2%). About 241 species (46.5%) remain Not Evaluated (NE), largely comprising flora, which limits any comprehensive threat assessment for this taxon. Of the evaluated 109 faunal species, 11 species are threatened: five Endangered (EN) — distributed across fish, herpetofauna, and avifauna — and six Vulnerable (VU), spanning herpetofauna, avifauna, and mammals. Four species are Near Threatened (NT) and five are Data Deficient (DD), the latter flagging significant gaps in available population data. Collectively, these figures underscore the urgent need for targeted monitoring of threatened fauna, particularly freshwater fish and reptiles, and systematic Red List evaluation of the basin's extensive floral diversity, which remains largely unassessed.

A total of 408 angiosperm taxa representing 31 orders, 86 families, and 299 genera were documented. The most abundant families were Asteraceae (40 species), Fabaceae, and Poaceae (37 species each), followed by Amaranthaceae and Lamiaceae. Semi-aquatic species were the most abundant ecological category (234 species), followed by terrestrial (148 species) and aquatic plants (26 species). The herbaceous flora dominated in terms of life form (231 species), followed by trees (58 species), grasses (52 species), shrubs (42 species), and climbers (25 species). Native species comprised around 86% of the flora, with the most diversity found in meandering regions and tributary junctions. Fish samples were collected at 11 sampling sites along the Gomti River during the post-monsoon season in January 2024. A total of 193 individuals representing of 41 fish species belonging to 9 orders, 17 families, and 31 genera were recorded during the post-monsoon period in January 2024, from Gomat

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Taal to Kaithi across the Gomti River. Out of 41 species, 39 species were native and two were non-native. The highest species richness (23 species) was recorded in the middle and lower zones, while the lowest species richness (11 species) was recorded in the upper zone. Surveys along the Gomti River revealed significant herpetofaunal diversity, which included ten amphibian species, five turtle species and mugger crocodile. The amphibians were represented by four families (Bufonidae, Dicroglossidae, Microhylidae, and Rhacophoridae), with adaptable species like the Indian bullfrog, Asian common toad, and Indian marbled toad widely distributed across agricultural and semi-modified riverbanks. The mugger crocodile was identified as the sole crocodilian species in reptile surveys, with higher sightings during the pre-monsoon season, indicating seasonal habitat use patterns. Five freshwater turtle species from the families Geoemydidae and Trionychidae were documented over four seasons, with Indian roofed turtles and Pangshura species being the most common. Notably, the Critically Endangered three-striped roofed turtle, previously recorded from the Gomti River, was missing, implying a steady decline or local extinction. Distribution of turtles was mainly limited to the middle stretch of the Gomti River.
The avifaunal diversity was represented by 51 bird species, 44 of which are classified as water and water-associated species, spanning eight orders and 15 families. Geographically, the Middle Zone had the greatest species richness, probably due to enhanced habitat variability and favorable hydrological conditions, whereas the upper and lower zones had less diversity, possibly due to habitat changes and changing flow regimes. Generalist species, such as the little cormorant, black-winged stilt, Indian cormorant, and common moorhen, were more frequently observed, whereas habitat specialists like bitterns and night herons were less prevalent. Carnivorous species predominated in the feeding guild study, indicating continued support for aquatic insectivorous and piscivorous birds. The survey undertaken to record presence of aquatic and semi-aquatic mammals revealed absence of the Gangetic dolphin and a single confirmed sighting of the smooth-coated otter. These findings are ecologically significant not merely as species records but as indicators of the river's overall ecological condition. Interpreted together, they reveal a river system in advanced stages of habitat degradation, yet one that retains residual ecological value in its less disturbed reaches. The fate of the Gangetic dolphin and the smooth-coated otter in the Gomti River exemplifies a general pattern seen in degraded river systems worldwide, where large, specialised freshwater mammals with narrow ecological tolerances, such as river dolphins, are extirpated first and most completely, whereas more adaptable semi-aquatic species, such as otters, may persist in residual habitat patches long after apex predators have disappeared.

The study provides a longitudinal assessment of disturbances along the Gomti River, emphasizing variations between the upper, middle, and lower zones. The upper zone is characterized by severe hydrological changes and agricultural encroachment, with parts of the river drying during non-monsoon months due to reduced channel width and floodplain connection caused by agricultural conversion.
Water extraction and ferry activities demonstrate an increased reliance on the river for irrigation and transportation. The middle zone has the highest cumulative pressure of urban growth; sewage discharge, water withdrawal for agriculture, and industrial runoff have a significant influence on water quality. In the middle zone, which includes the city of Lucknow, there is significant untreated wastewater flow, which contributes to organic and chemical contamination. Concentrated fishing, livestock presence, and human activities, as well as localised sand mining, severely impact sediment dynamics.
Overall, the middle zone is the most ecologically stressed segment of the Gomti River. The lower zone, while subject to fewer direct disturbances, is significantly affected by pollutants and altered flow regimes transmitted from upstream reaches.

survival floor across the Lucknow corridor. Heavy metals dominate by mass in all three matrices. River-wide mean concentrations are 20,723 ng/L in surface water, 75,440 μg/kg in sediment, and 25,835 μg/kg in fish muscle tissue. Phthalates dominate the emerging fraction across all matrices, with 2024 to 2025 outliers reaching 19000 to 27000 ng/L. BPA increased five-fold in 2024. Ecological Risk Assessment classifies 17% of the corridor as Critical, 42% High, 42% Moderate, no stretch as Low. Bioaccumulation rises systematically downstream: organochlorine pesticides 27-fold from Upper to Lower Zone despite prohibition in India; steroidal endocrine disruptors detected in Lower Zone biota but below detection in the Upper, indicating trophic transfer of the Lucknow pharmaceutical-endocrine plume into fish in the human consumption chain across Amethi, Azamgarh and Jaunpur. The samples collected during two time periods, viz., 2021 and 2025, show that heavy metals declined 79%, coinciding with CETP enforcement, OCEMS deployment, and ZLD verification on the Sitapur and Jagdishpur clusters. Personal care products declined 90%, coinciding with post-pandemic triclosan normalisation and STP capacity commissioned 2017 to 2022. Pharmaceuticals and steroidal EDCs show no significant change; organochlorines persist despite the ban regime. However, phthalates rebounded 55% above 2021; BPA increased five-fold; PCBs and OPPs crossed detection limits for the first time, with candidate sources including end-of-life transformer leakage and informal e-waste clusters in Lucknow and Jaunpur and chlorpyrifos-malathion substitution in the Sitapur-Hardoi-Lakhimpur Kheri belt conveyed by the Sarayan.

To spatially delineate the Conservation Priority Stretches (CPS) along the 930 km of the Gomti River, spanning the state of Uttar Pradesh a systematic, multispecies framework was used. A species distribution modelling approach based on Maximum Entropy (MaxEnt) was applied using occurrence records of six indicator taxa-the Gangetic dolphin (*Platanista gangetica*), gharial (*Gavialis gangeticus*), black-bellied tern (*Sterna acuticauda*), Indian skimmer (*Rynchops albicollis*), river lapwing (*Vanellus duvaucelii*), and river tern (*Sterna aurantia*) in conjunction with sixteen ecologically relevant bioclimatic, hydro-morphological, and anthropogenic variables. Predicted habitat suitability was classified into three conservation priority categories (CPS I: ≥0.70; CPS II: 0.61-0.70; CPS III: 0.51-0.60) and

Restoration Zones (RZ: <0.50). No river segments met the threshold for CPS I, indicating widespread habitat degradation and fragmentation along the river. Approximately 150 km (15.59%) of the river was identified as Conservation Priority Stretches-II (CPS-II). Additionally, around 230 km (25.27%) were categorised as Conservation Priority Stretches-III (CPS-III). Complementing these priority stretches, approximately 550 km (59.14%) of the river was identified as restoration zones. The Gomti River has undergone a drastic transition due to surmounting anthropogenic stressors, which has resulted in the predominance of moderately and low suitable habitats. Relatively higher suitability in the middle reaches contrasts with substantial restoration needs in both upstream regulated and downstream heavily modified sections, consistent with patterns observed in river systems globally.

The Gomti basin supports nearly 66 million people across 18 districts, with population densities ranging from 524 per km² in Lakhimpur Kheri to over 2,390 per km² in Varanasi. Agriculture accounts for over 90 per cent of total water use, and groundwater reserves in Lucknow are being depleted at an estimated rate of 0.5 to 1 meter per year. The average Human Development Index of 0.543 conceals significant disparities between urbanised and rural areas. Regarded in Hindu mythology as the daughter of Sage Vashistha, the river is central to the livelihoods of fishing communities, irrigated farmers, artisans, and pilgrims, and hosts numerous sacred ghats and seasonal festivals, including Kartik Purnima and Chhath Puja. To address these compounding challenges, the NMCG-WII project has implemented a series of conservation and outreach programmes. Capacity building plays a pivotal role in river and biodiversity conservation. A systematic and multistakeholder approach was adopted to empower a diverse group of stakeholders to carry forward the conservation initiatives and play a proactive role in the conservation and rejuvenation of the Gomti River. To build capacity, training modules were developed as a first step, which was followed by stakeholder identification and need assessment, which were carried out simultaneously. A total of 45 training programmes engaged 1,610 participants, categorised into 13 spearhead trainings, 4 rescue-specific sessions, and 28 broader thematic programmes. Stakeholder groups included forest officials, college students, Ganga Praharis, ETF-GTF members, zookeepers, veterinarians, police, and local communities. Gender analysis revealed a significant disparity, with female participants comprising only 25.71% of the total. Post-training evaluation showed that 54.62% actively undertook carry-forward conservation activities, while 37.86% reported no follow-up, citing institutional and logistical barriers. The capacity building initiatives have built a foundation of skilled, motivated conservation practitioners across the Gomti basin. Considering that the Gomti River passes through one of the most densely populated states of India, and this population is heavily dependent on the River for their livelihood and also for cultural and spiritual needs, it is critical to understand socio-ecological dependencies and governance dynamics. Thus, a comprehensive stakeholder assessment was conducted that identified 37 key stakeholders representing government agencies, civil society organisations, academic institutions, and local communities. Participatory mapping exercises conducted in five villages across Pilibhit and Jaunpur districts highlighted the extent of community dependence on the river and its associated ecosystems. The River provides a wide range of provisioning, regulating, and cultural ecosystem services that are central to local livelihoods and social identity. Community-based conservation emerged as a central strategy for addressing these challenges and strengthening local stewardship of river ecosystems. A network of 303 trained Ganga Praharis was established across eight districts of the Gomti River Basin to support conservation actions, monitoring, and community engagement. Women constituted about 82% of the Ganga Prahari cadre, demonstrating strong female participation in conservation efforts. The programme was also strongly youth-oriented and community-driven, with students, homemakers, and local residents forming the majority of participants. Collectively, the Ganga Praharis organized and implemented 59 conservation activities involving 1,349 participants. These activities included awareness campaigns, river cleanliness drives, ecological monitoring initiatives, and community outreach programmes. The initiative has received national recognition for its contributions to conservation leadership and community participation.

Recognizing that long-term conservation outcomes depend on livelihood security and community incentives, the programme also promoted conservation-linked livelihood development. Specific livelihood trainings were developed in line with local resources, markets and skill sets, and were organised across the basin, benefiting more than 500 individuals. Training activities focused on locally relevant and market-oriented skills, including sewing, incense-stick production, millet value addition, bag making, basket weaving, and textile-based enterprises, which sought to diversify income opportunities while strengthening community engagement in conservation activities. The Jalaj initiative further expanded these efforts through market integration, formation and strengthening of self-help groups, ecotourism opportunities, local product development, and skill enhancement programmes. To institutionalize conservation planning at the village level, a biodiversity-sensitive microplan was developed for Rajepur village in Jaunpur district. The microplan addressed several locally identified environmental challenges, including riverbed farming that affects turtle nesting habitats, excessive use of chemical fertilizers, inadequate sanitation infrastructure, unsustainable fishing practices, extraction of riparian vegetation, and limited awareness regarding biodiversity conservation. Through the low-cost interpretation centres, “Jalmala Samvaad” reached more than 24,000 school students and 324 teachers across six districts along the Gomti River, through permanently installed interpretation corners in government schools

Governance gaps that continue to constrain effective river conservation and restoration include inadequate sewage treatment infrastructure and maintenance, weak management of non-point agricultural pollution, the absence of Gomti-specific ecological flow standards, limited protection of wetlands and riverine biodiversity, insufficient real-time environmental monitoring systems, weak enforcement mechanisms, and inadequate integration of climate resilience considerations into river management frameworks. Policy analysis found that while recent initiatives such as the Gomti River Rejuvenation Mission provide positive momentum, the long-term restoration of the river will require integrated basin-scale planning, stronger governance, community-centred conservation approaches, and scaling up of successful models such as Ganga Praharis, Jalaj centres, and village-level microplanning. These efforts provide a practical framework for balancing ecological restoration, livelihood security, and sustainable development across the Gomti River Basin. On the basis of periodic ecological assessments across various taxa, ecotoxicological analysis, community engagement, stakeholder and policy analysis, this study proposes a coherent framework for the ecological recovery of the Gomti River. The study identifies, six overarching conservation priorities, viz. (i) restore and maintain environmental flows; (ii) control point-source and diffuse pollution; (iii) protect and restore floodplain and riparian habitats; (iv) implement species-specific conservation actions for globally threatened taxa; (v) regulate fishing, sand mining, and water abstraction; and (vi) establish a long-term, standardised biodiversity monitoring programme. These priorities are grounded in the systematic baseline data generated by this study and need to be implemented through an integrated, basin-scale management approach that spans sectoral boundaries and engages communities, local governance institutions, and state and national policy frameworks. This report advocates for an integrated, basin-scale management framework that harmonises ecological restoration with livelihood security, governance strengthening, and sustained community participation along the Gomti River.

SECTION- I

INTRODUCTION

CHAPTER 01

RIVER PROFILE

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SUMMARY

The Gomti River originates at Gomat tal (Fulhar Jheel) in the piedmont zone of the Gangetic Plain in Pilibhit district and runs southeast for roughly 930 km through 14 districts until reaching the Ganga River near Kaithi village of Ghazipur district in Uttar Pradesh. The basin lies within the Ghaghra-Ganga interfluve area (Doab) of the Gangetic Plain. The river is geomorphologically categorized into three zones: Upper, Middle, and Lower, each with various geomorphic surfaces such as active floodplains, river valley terraces, and upland terraces. These surfaces have micro-geomorphic characteristics such as ponds, lakes, oxbow lakes, paleochannels, and meander scars. Water availability and quality are impacted by the Gomti River's seasonal discharge patterns, which peak during the monsoon and decrease during the dry seasons. Sukheta, Chuha, Kathana, Sarayan, Kukrail, Behta Nalas, and Sai are some of its tributaries that contribute to its distinct, winding features, especially in lower stretches. The soils of the basin are mostly clayey and loamy, with very few sandy soils. The climate encompasses hot and dry summers to warm, humid monsoons and cold winters.

Being located in the Upper Gangetic Plain biogeographic zone the Gomti River basin is primarily characterized by agricultural land use, which occupies over three-quarters of the area. Decadal LULC comparisons show growth in agricultural and build-up areas, with declines in wastelands and water bodies. Forest cover is predominantly found in the basin's upper zone, accounting for 5% of the total

area and the key species include *Shorea robusta, Acacia spp., Butea monosperma, Terminalia arjuna, Prosopis cineraria,* and *Dalbergia sissoo.* Ecologically, the river supports diverse aquatic and riparian fauna, including key protected species such as the smooth-coated otter (*Lutrogale perspicillata*), mugger crocodile (*Crocodylus palustris*), freshwater turtles, and several threatened waterbirds such as Indian skimmer (*Rynchops albicollis*), sarus crane (*Antigone antigone*), painted stork (*Mycteria leucocephala*), river tern (*Sterna aurantia*), and river lapwing (*Vanellus duvaucelli*), as well as fish species like magur (*Clarias magur*), clown knifefish (*Chitala chitala*), and helicopter catfish (*Wallago attu*). Many of these species receive legal protection under the Indian Wildlife (Protection) Act, 1972. Conservation efforts in the basin include protected areas such as Shaheed Chandra Shekhar Azad and Samaspur bird sanctuaries, parts of Pilibhit and Kishanpur wildlife sanctuaries, along with a designated Biodiversity Heritage Site, namely, Gharial Rehabilitation Centre at Kukrail, Uttar Pradesh. The basin has 18 districts with a population of about 66 million with high population densities ranging from 524 to 2,395 people per km². The river is vital for irrigation, drinkable water supply, fisheries, and the livelihoods of populations along its banks. The average Human Development Index across the basin is 0.543. The Gomti River has mythical, cultural, historical, archeological, and ecological significance in the region. The Gomti River faces critical threats like pollution and habitat loss driven by urbanization, industry, agricultural encroachment. Because ecological and socio-economic systems are deeply linked, the study advocates for integrated, sustainable management to balance the river's complex environmental needs with human development.

THE GOMTI RIVER

The Gomti River is a major tributary of the Ganga River, fed by groundwater and rain (Tangri et al., 2018). It is a tremendously meandering river, particularly in its lower reaches. The river's meandering nature (ghumati) may have contributed to the origin of the name Gomti (Upadhyay, 2019). It originates in the piedmont zone of the Gangetic Plain in the Pilibhit district and traverse about 930 km through 14 districts of Uttar Pradesh to confluence with the Ganga River in the Ghazipur district. The Gomti River basin is located in the Ghaghara–Ganga interfluve region (Doab) in the Gangetic Plain and lies between longitudes 79° 59′ to 83° 14′ E and latitudes 25° 25′ to 28° 40′ N (India-WRIS, 2014; Tangri et al., 2018). It covers a total area of 30,435 km², which is about 3.53% and 12% of the total landmass of the Ganga River basin and Uttar Pradesh, respectively. About 23 tributaries contributes to the Gomti River (Tangri et al., 2018), while the major tributaries include Gachai, Sai, Reth, Sarayan, Chuha, Pili and Kalyani (India-WRIS, 2014: Figure 1.2).

The Gomti River possesses significant mythological, cultural, historical, and archaeological significance. As per mythological belief, the Gomti River is Sage Vashistha's daughter. Devotees bathe in the Gomti River during a solar eclipse, considering it spiritually equivalent to bathing in the river at Kurukshetra, a historic city, revered in Hindu belief as a Dharmakshetra – field of righteousness (Tangri et al., 2018). The key pilgrimage places (including mythical connection) along the Gomti River are (1) Naimisharanay (or Neemsar) and Rudravart Mahadev Temple in the Sitapur district, (2) Chandrika Devi Temple in the Kathvara village, near the Lucknow City and Gomeshwar Mahadev Temple in Daliganj, Lucknow district, and (3) Markandey Mahadev Temple near the confluence of the Gomti River with the Ganga River at Kaithi Village, Ghazipur district, Uttar Pradesh. Archaeological explorations along the paleo-channels of the Gomti River, identified presence of about 90 prehistoric and historic sites, dating back to Mesolithic Age. These sites are mostly concentrated in the Ghazipur, Varanasi and Jaunpur districts of Uttar Pradesh along the Gomti River (Upadhyay, 2019). These sites were associated with the pre-Northen Black Polished Ware (pre-NBPW) period to medieval period (Upadhyay, 2019). Lucknow, the capital of Uttar Pradesh, is also located along the banks of the Gomti River. The major characteristics of the Gomti River are provided in Table 1.1.

Table 1.1. Characteristics of the Gomti River.

Type	Perennial river
Origin	Gomat tal (formerly known as Fulhar Jheel) near the Madho Tanda town of Pilibhit district, Uttar Pradesh
Length (km)	930
Discharge (BCM)*	113.5 (including Ghaghra River)
Basin area (km^2)	30,435
Altitude of the basin	267 to 49 m amsl
Passage through states	Uttar Pradesh
Basin states	Uttar Pradesh
No. of districts in the basin	18
No. of sub-basins**	33
Major tributaries*	Gachai, Sai, Reth, Sarayan, Chuha, Pili, Kalyani
No. of barrages on the river	1
No. of barrages in basin	1
No. of dams in the basin	0
Human Population in the basin***	66,386,894
Human population density of the districts in the basin (persons/km^2)***	886
Biogeographic zones	Gangetic Plain: Upper (7A)
Forest cover in basin**** (km^2)	2966.16
Total irrigated area in basin^	About 85% of the gross cropped area (24,800 km^2)
Riparian flora	408 taxa (angiosperms) including tree, shrubs, herbs, grasses, and climbers
Mammals	Smooth-coated otter (*Lutrogale perspicillata*)
Birds	69 species. Threatened species include Sarus Crane (*Antigone Antigone*), Painted Stork (*Mycteria leucocephala*), River Tern (*Sterna aurantia*), and River Lapwing (*Vanellus duvaucelli*).
Reptiles	Mugger, Freshwater turtles including Indian Roofed Turtle (*Pangshura tecta*), Indian tent Turtle (*Pangshura tentoria*), Crowned River Turtle (*Hardella thurjii*), Indian soft-shell turtle (*Nilssonia gangetica*), and Indian Flap-shell turtle (*Lissemys punctata*)
Amphibians	10 species
Fish	115 species including threatened species viz., Magur (*Clarias magur*), Clown knifefish (*Chitala chitala*), Helicopter catfish (*Wallago attu*)
Protected Areas in the basin	Pilibhit WLS#, Kishanpur WLS#, Nawabganj WLS, Samaspur WLS

*India-WRIS (2014); **Das et al. (2021); ***Census of India (2011); ****for the year 2018-19 (NRSC data); ^Mali et al. (2018); #A small area of the PAs come under the Gomti River basin

1.1. COURSE OF THE RIVER

The Gomti River originates from Gomat tal (also known as Fulhar Jheel), at an elevation of 185 m. The Gomat tal is located in the fringe area of Pilibhit Tiger Reserve near the Madho Tanda town (about 30 km east of Pilibhit town) of Pilibhit district, Uttar Pradesh (Figure 1.1; Upadhyay, 2019). This part of the Gomti River basin falls under the terai-Arc landscape. The Gomti River flows northwest to southeast-ward after its origin and traverses about 930 km through 14 districts in the state of Uttar Pradesh before joining the Ganga River at Kaithi village in the Ghazipur district (Figures 1.1 and 1.2). Naimisharanay (or Neemsar) and Rudravart Mahadev Temple in the Sitapur district, Chandrika Devi Temple in the Kathvara village near the Lucknow City, Gomeshwar Mahadev Mandir in Daliganj, Lucknow, and Markandey Mahadev Temple near the confluence of Gomti River with Ganga River are the major pilgrimage sites on the bank of the Gomti River. The major cities and towns situated on the river bank are Lucknow, Sultanpur, and Jaunpur (Figure 1.1).

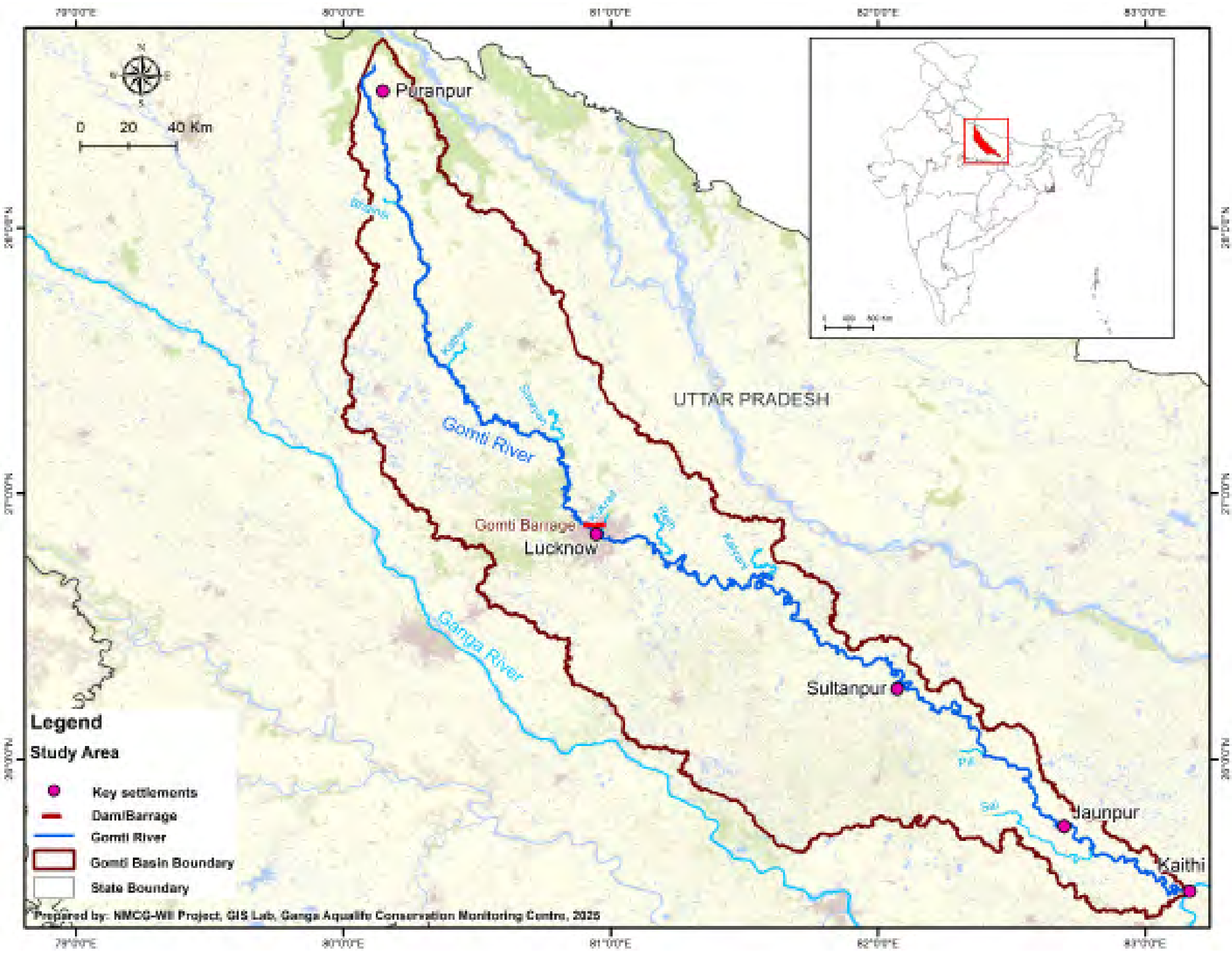


Figure 1.1. Map showing the Gomti River basin and the course of Gomti River.

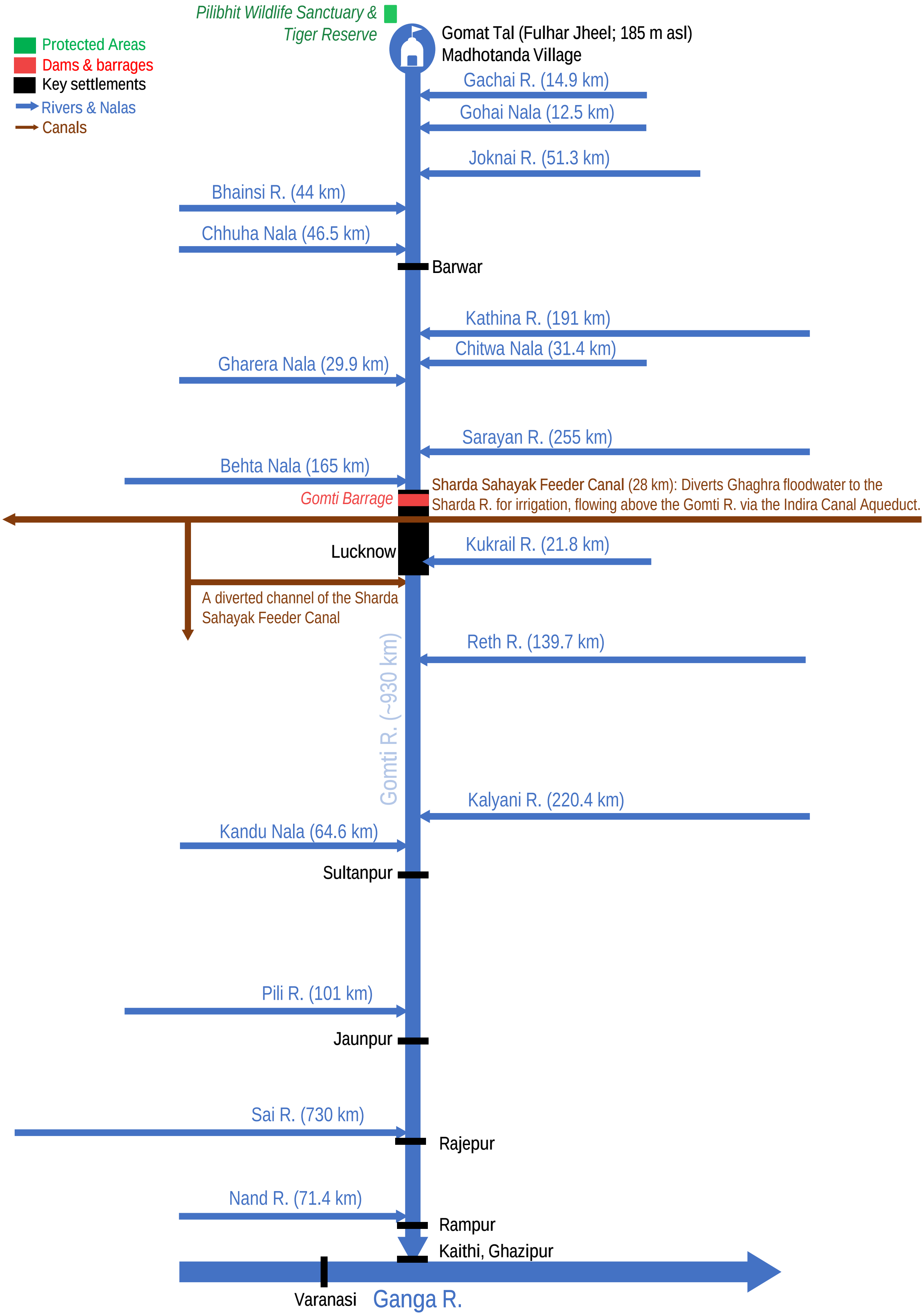


Figure 1.2. Schematic diagram of the course of the Gomti River.

The course of river can be divided into three zones (A) Upper zone, (B) Middle zone, and (C) Lower zone based on geology, channel morphology and flow barriers (Figures 1.3 and 1.4).

Upper zone: The 354 km long river stretch in the terai landscape from the origin of the Gomti River to the confluence with the Surayan River near Sitapur can be classified as the upper zone. This zone has very low water flow, and consists of scattered distribution of small water pools.

Middle zone: The 344 km long river stretch from the confluence point of Surayan and Gomti rivers to Sultanpur can be classified as middle zone. In this zone, the Gomti River is fed by multiple tributaries including the Kukrail, the Reth, and the Kalyani. Lucknow, the capital city of Uttar Pradesh is located in this stretch and water is diverted at Gomti barrage near Lucknow for the purpose of agriculture.

Lower zone: The 232 km long river stretch from Sultanpur to the confluence point with the Ganga River at Kaithi can be classified as the lower zone. The Sai River, a major tributary of Gomti, joins in the downstream of Jaunpur town in this stretch.

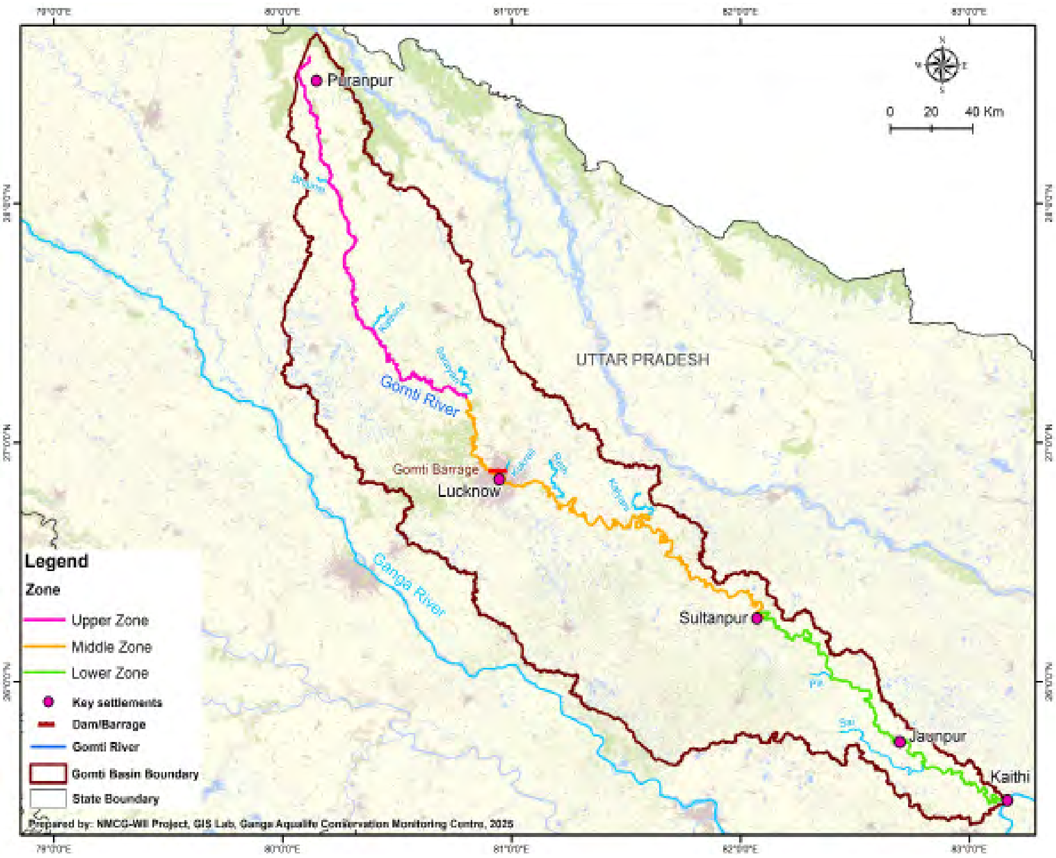


Figure 1.3. Map showing division of the Gomti River stretches into upper, middle and lower zones.

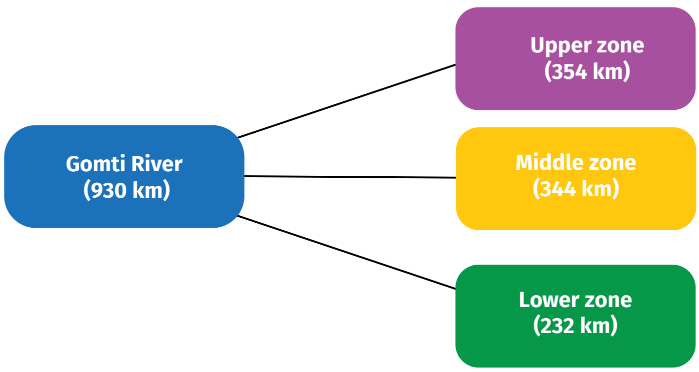


Figure 1.4. Length of the Gomti River stretches divided into the upper, middle, and lower zones.

1.2. GEOLOGY AND GEOMORPHOLOGY

The Gomti river basin is situated in the doab region formed by the Ganga and Ghaghra rivers, and characterized by the Ganga alluvium plain, geologically (Prakash et al., 2017; Das et al., 2021). The northern-most portion of the basin is primarily piedmont. It refers to debris deposited by moving streams. This piedmont region has significant infiltration capability and serves as the primary recharging area due to the presence of coarser materials (Das et al., 2021). This highlights its importance in hydrology. The basin is composed of unconsolidated sediments resulting from the erosion, redistribution, and weathering of Himalayan and Ganga Alluvial Plain material. Muddy and sandy interfluve deposits are found in the basin area and also dominate the Ganga plain's late Quaternary River deposits' stratigraphy (Singh, 1996; Prakash et al., 2017).

According to Tangri et al. (2018), the basin has three distinct geomorphic surfaces: (1) active floodplain surface, (2) river valley terrace surface, and (3) upland terrace surface. The micro-geomorphic characteristics present on the geomorphic surfaces of basins include ponds, lakes, oxbow lakes, palaeo-channels, and meander scars (Prakash et al., 2017; Tangri et al., 2018). The Gomti river's active channel has crescent-shaped point bar deposits with varied diameters. In the lower stretch of the River, bar deposits increase in frequency and size (Tangri et al., 2018). The River slope fluctuates between 55 and 11 cm/km from its upper to lower reaches (Kumar et al., 2025). The elevation of the basin ranges from 49 to 267 m amsl as shown in Figure 1.5.

1.3. LAND USE LAND COVER (LULC)

In the Gomti River basin, LULC is predominantly characterized by agriculture, which accounts for 76.11% of the basin area for the year 2018-19. Other contributing LULC classes in the basin include forested areas (9.75%), wasteland (5.88%), built-up areas (4.98%), and water bodies (3.28%) (Figures 1.6 and 1.7). Between 2008-09 and 2018-19, there was a 3.12% increase in agricultural land and a 1.22% rise in built-up areas, while wasteland decreased by 3.82% and water bodies reduced by 0.54% within the Gomti River basin (Figure 1.7). Lucknow, the capital of Uttar Pradesh, is the most populated city and plays a significant role in contributing to the built-up area of the Gomti River basin.

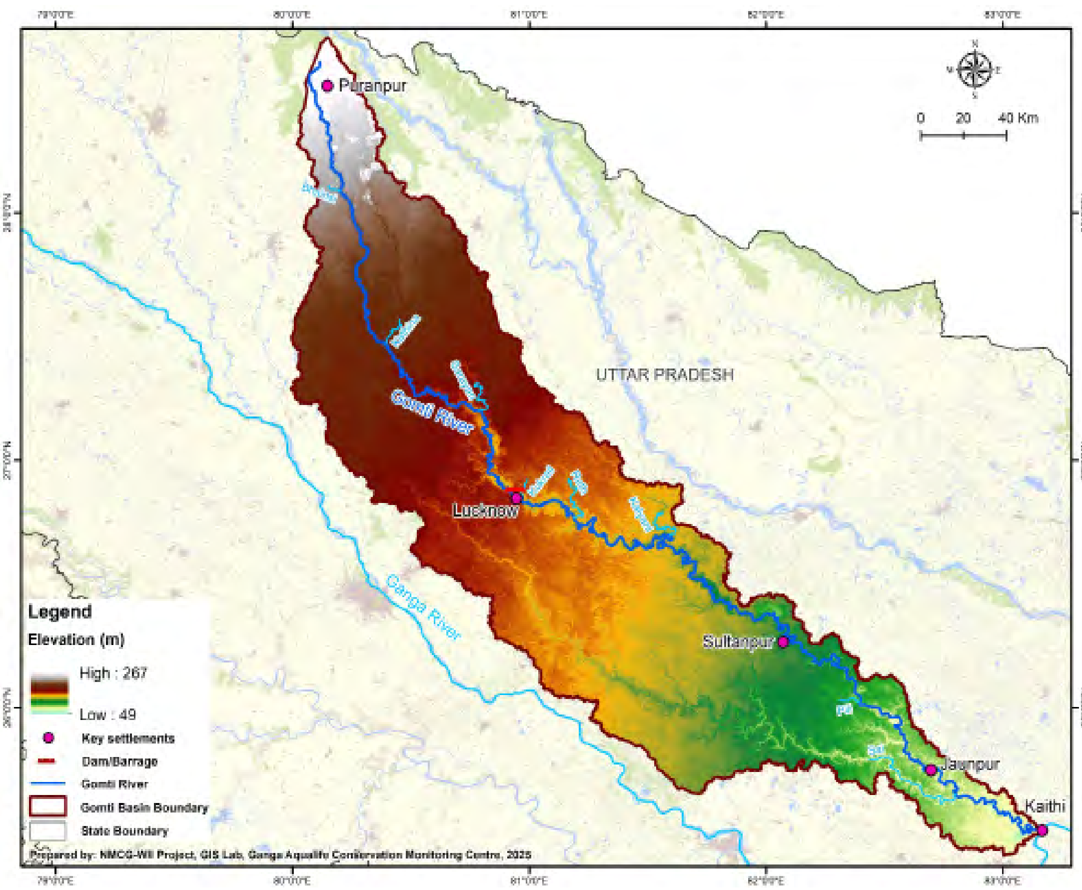


Figure 1.5. The digital elevation model (DEM) map showing elevation ranges in the Gomti River basin.

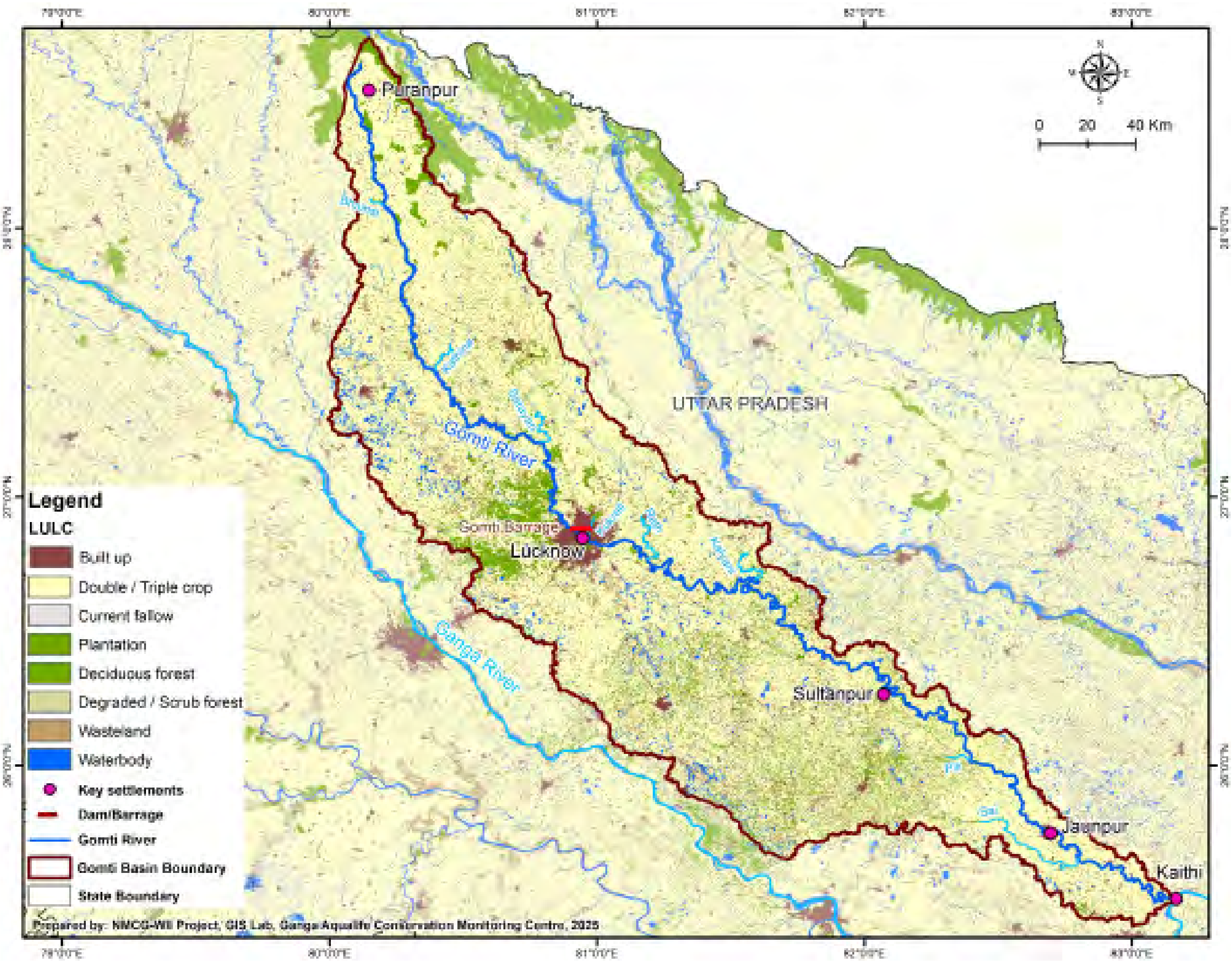


Figure 1.6. Map showing land use land cover in the Gomti River basin for the year 2018-19.
Data source: NRSC

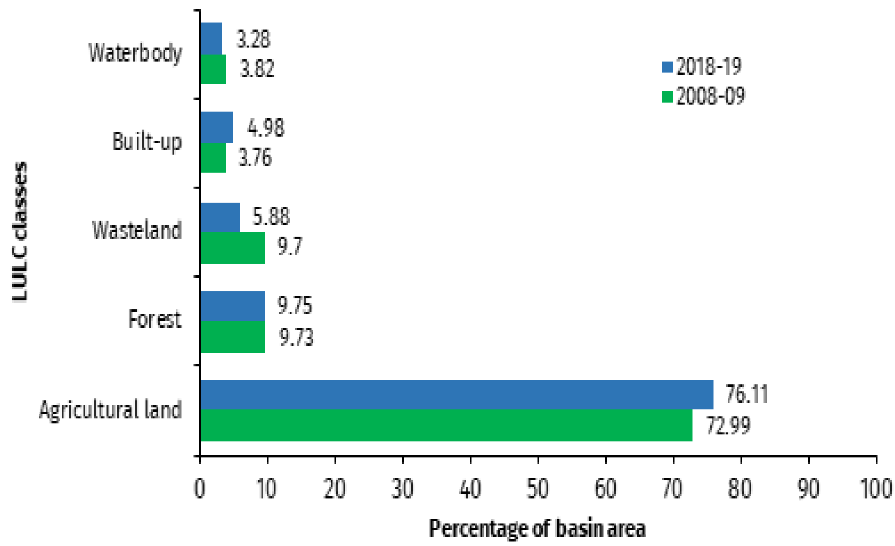


Figure 1.7. Land use land cover changes in the Gomti River basin between 2008-09 and 2018-19.
Data source: NRSC

1.4. SOIL TYPE

The Gomti basin predominantly has two varieties of alluvium: the older alluvium (Bangar) and the younger alluvium (Khadar) (Singh, 1996). These alluvium soils are derived from Himalayan sources, which are transported by the tributaries of the Gomti River. The Fluvisols, young soils, are confined to floodplain of the main channel of the Gomti River. The basin is composed of three types of soil textures, with major contribution of loamy soils (86.38% of basin area) followed by clayey (12.69%) and sandy (0.64%) (Figures 1.8 and 1.9). The coarser sandy loam is found along the main channel of the River, while finer loam and clay loam soils are found along the interfluve. The primary attribute of loamy soil is its water availability. It is appropriate for the cultivation of wheat and rice, comprising a blend of sand, silt, clay, and organic materials (Das et al., 2021).

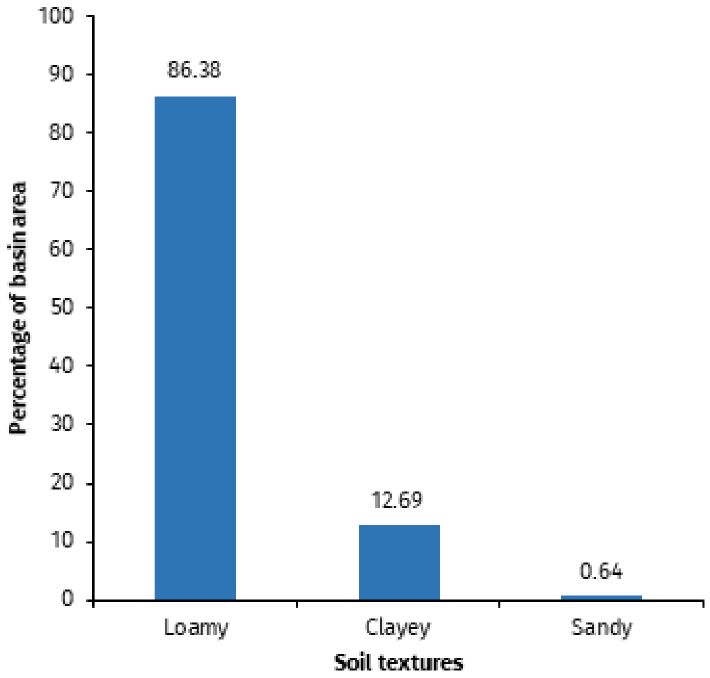


Figure 1.8. Area coverage of different soil textures in the Gomti River basin.
Data source: ICAR-NBSS&LUP (https://bhoomigeoportal-nbsslup.in/)

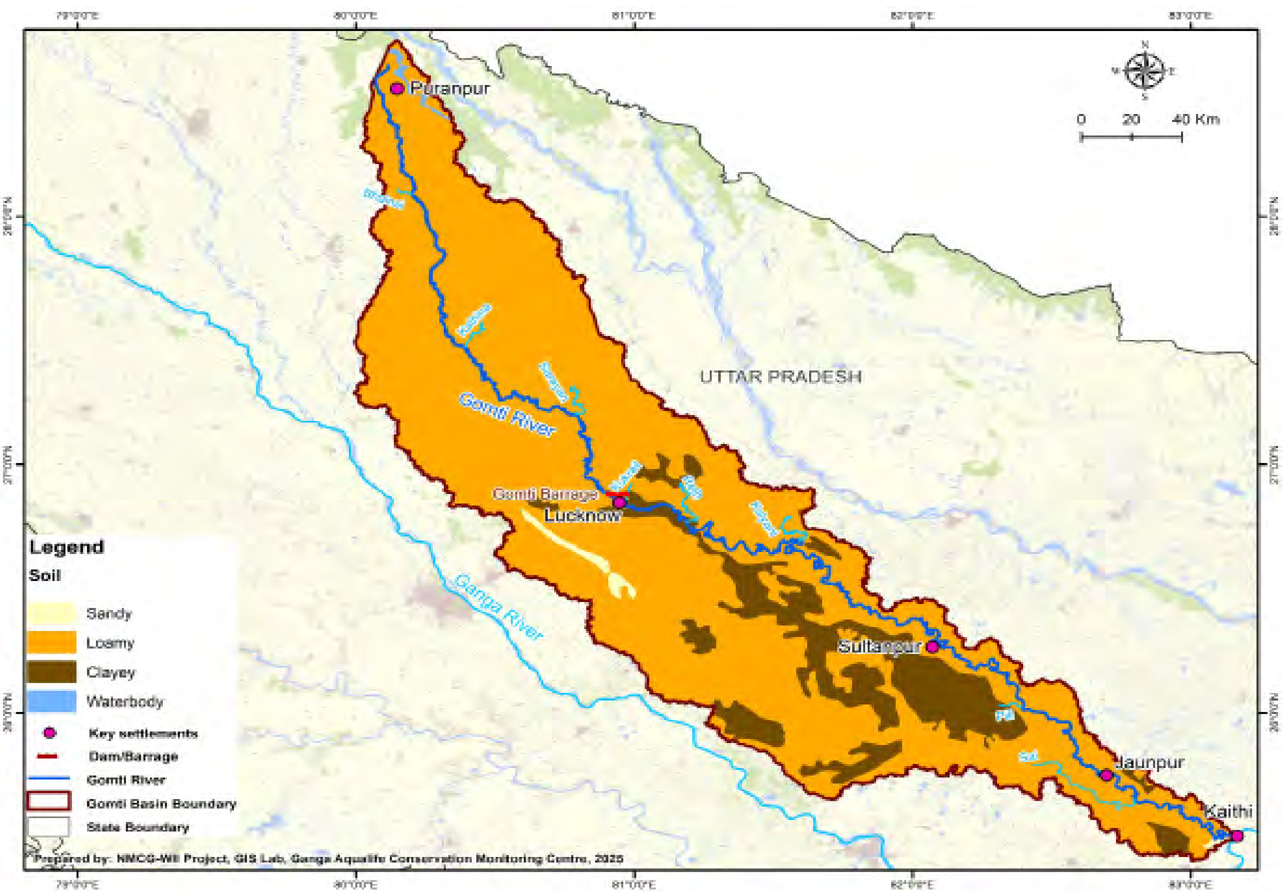


Figure 1.9. Map showing different soil textures in the Gomti River basin. Data source: ICAR-NBSS&LUP (https://bhoomigeoportal-nbsslup.in/)

1.5. CLIMATE

According to the Köppen climate classification system, the Indo-Gangetic Plain, including the Gomti River basin is classified as humid subtropical. The basin mainly experiences hot and dry climate during summer, warm, humid and frequent rainfall during monsoon, and cold wind with little rain during winter. The temperature ranges between 2 to 22°C in the winter (November to February), while the summer (March to early June) temperature ranges between 28 to 44 °C (Tangri et al., 2018). The average annual rainfall in the basin is between 850 and 1,100 mm. The south-west monsoon accounts for approximately 75% of total yearly rainfall from June to September (Rai et al., 2009). According to Abeysingha et al. (2014) Kheri and Pilibhit districts in the upstream region of the basin experience the maximum rainfall of 301.18 and 303.47 mm in the month of August, respectively. While the districts: Lucknow, Sultanpur, and Jaunpur in mid and downstream experience maximum rainfall of 220.3, 256.2, and 236.18 mm in the month of July, respectively (Figure 1.10).

1.6. DRAINAGE AND HYDROLOGY

The Gomti river drains the region situated between the Ramganga and Sharda rivers in the upper zone and between the Ganga and Ghaghra rivers in the middle and the lower zones (Figure 1.11). The total drainage area of the river is 30,435 km^2 (NIH, 1998). Except during monsoon and post-monsoon seasons, the river flow is slow (<100 m^3/s). The annual discharge of river is about 7,390 X 106 m^3 (Rao, 1975). The monsoon and post-monsoon seasons contribute 75% of total annual discharge, whilst summer contributes about 5%. Agricultural irrigation water demand restricts the river's flow during the winter and summer. High summer air temperatures (>40°C) enhance evaporation and diminish river discharge (Kumar et al., 2025).

The Gomti River has about 23 tributaries throughout its course and major tributaries include Gachai, Sai, Reth, Sarayan, Chuha, Pili and Kalyani (India-WRIS, 2014; Tangri et al., 2018; Figure 1.2). After 20 km from the

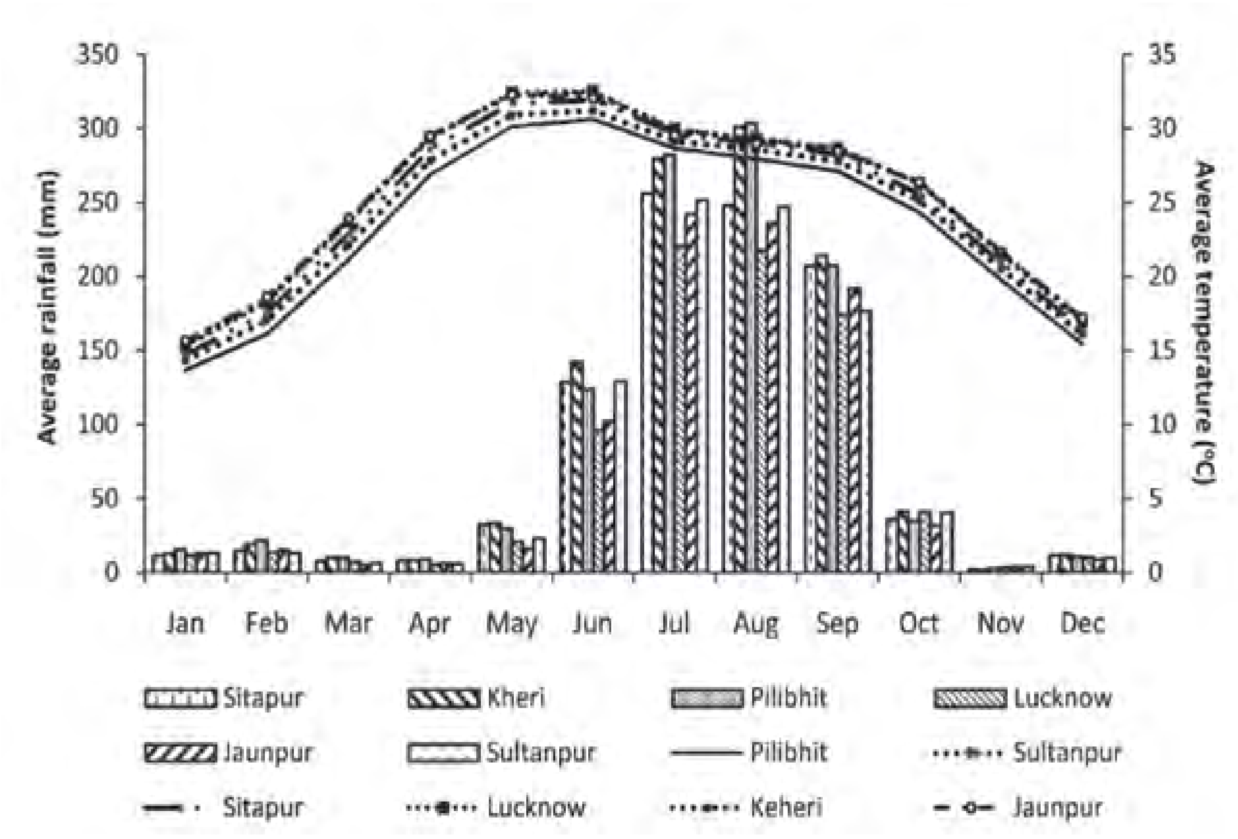


Figure 1.10. Average monthly precipitation and temperature in key districts of the Gomti River basin. Ex-tracted from Abeysingha et al. (2014).

origin, the Gomti River is joined by a small tributary Gachai, from left bank in the Pilibhit district. Thereafter the Gomti River remains a narrow stream for approximately 80 km till it is joined by tributaries, namely Sukheta, Chuha, and Andhra Chuha, at the Mohammadi Kheri Tehsil of Lakhimpur Kheri district. After confluence with these tributaries, the Gomti River's channel becomes well formed. Thereafter, Kathana and Sarayan rivers join the Gomti River at Lucknow, and the Sai River at Rajepur in Jaunpur district join the Gomti River (Tangri et al., 2018). The other tributaries of Gomti include Jomkai, Barna, Saryu, Bhainsi, Gon, Kalyani, Reth, Pili and Nand rivers. The Sai River is the main tributary of the Gomti River, it drains one-third of the basin and 33 micro-basins. Gomti River sub-basins are drained by small alluvial channels with a drainage density of 0.44 to 1.04 km/km^2 and a basin relief of 10 to 44% (Thakur, 2008; Kumar et al., 2025).

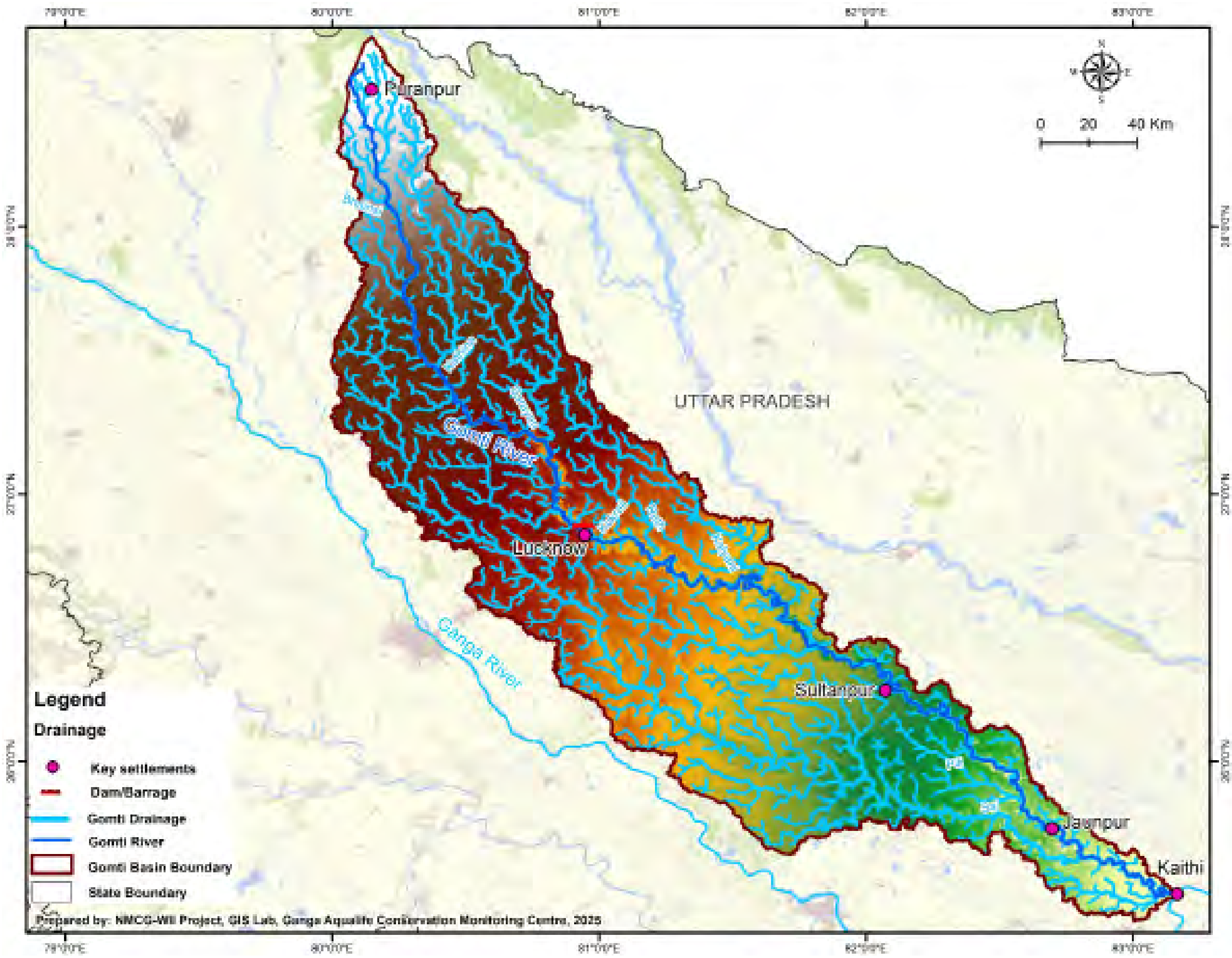


Figure 1.11. Map showing drainage structure of the Gomti River.

1.7. BIOGEOGRAPHY, FLORA AND FAUNA

The Gomti River basin falls under the Gangetic plain biogeographic zone (Upper Gangetic Plain – 7A) (Figure 1.12; Rodgers et al., 2000). The Upper Zone of the basin is part of the Terai-Arc Landscape, a landscape with significant conservation significance as it provides connectivity corridor to the adjoining protected areas in the Terai landscape of India and Nepal.

The forest cover in the Gomti River basin is limited to the Upper zone only. The forest of the basin is broadly composed of tropical dry deciduous forest, which include *Shorea robusta, Acacia* spp., *Butea monosperma, Terminalia arjuna, Prosopis cineraria,* and *Dalbergia sissoo* as dominating species (Champion & Seth, 1968; Singh & Chaturvedi, 2017). Duthie (1903) was first to compile the information on flora of the Gomti River. The riparian vegetation is composed of trees, shrubs, herbs, grasses, and climbers, which is further described in detail in chapter 3. Key aquatic species recorded from the Gomti River are smooth-coated otter (*Lutrogale perspicillata*), mugger (*Crocodylus palustris*), Freshwater turtles, threatened waterbirds such as Indian skimmer (*Rynchops albicollis*), sarus crane (*Antigone antigone*), painted stork (*Mycteria leucocephala*), river tern (*Sterna aurantia*), and river lapwing (*Vanellus duvaucelli*), and threatened fish species including magur (*Clarias magur*), clown knifefish (*Chitala chitala*), helicopter catfish (*Wallago attu*). The faunal assemblage from the Gomti River is least studied, except for the fish taxa. Chapters 4 to 7 describe in detail the faunal assemblage based on ecological assessment carried along the entire stretch of the Gomti River.

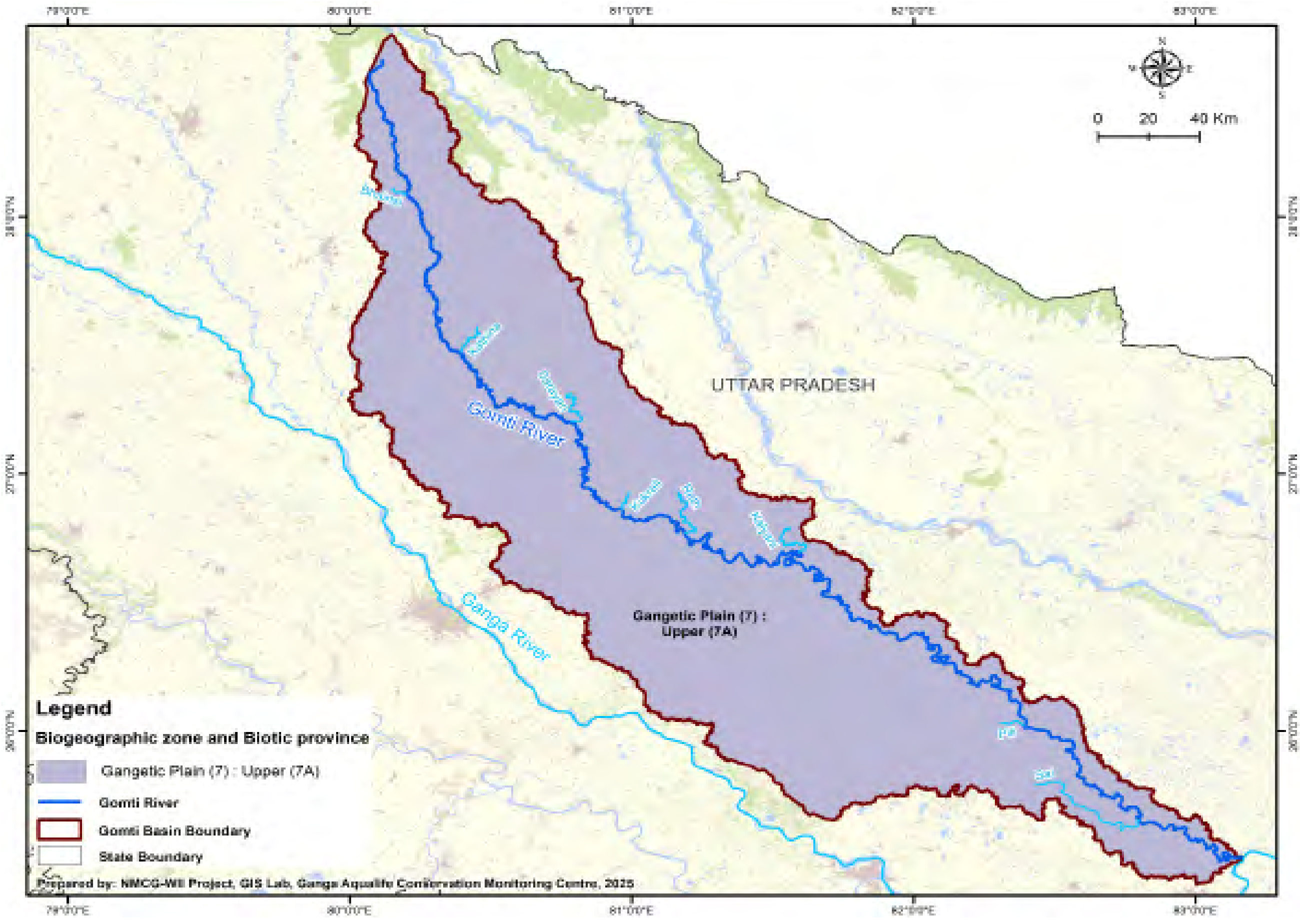


Figure 1.12. Map showing biogeographic zone for the Gomti River basin.

1.8. FOREST TYPE AND COVER

The forests in the Gomti River basin are limited to Pilibhit and Kheri districts only (Dutta et al., 2015). According to the Forest Survey of India (2019), approximately 5% of the Gomti basin area has forest cover, comprising a major contribution from the open forest class (3.48%), while the remaining area is classified as non-forest (95%), with a negligible area of scrubland (Table 1.2; Figure 1.13). The forest is broadly represented by tropical moist and dry deciduous forests (Champion & Seth, 1968). Northern tropical dry deciduous forest with dominant species like *Shorea robusta*, Northern dry mixed deciduous forest with *Acacia catechu*, General edaphic dry deciduous forests with *Butea monosperma* and *Acacia arabica*, Dry tropical riverine forest with *Terminalia arjuna, Acacia catechu,* and *Dalbergia sissoo*, and Northern tropical thorn forests with *Acacia leucophloea*, *Acacia arabica,* and *Prosopis cineraria* are found in the basin (Singh & Chaturvedi, 2017).

Table 1.2. Forest cover statistics in the Gomti River basin for the year 2019. Data source: FSI (2019)

S. N.	Forest cover classes	Area (km²)	% of basin
1	Very dense forest	223.18	0.73
2	Moderately dense forest	264.45	0.87
3	Open forest	1,058.45	3.48
4	Scrub	23.03	0.08
5	Non forest	28,865.89	94.84
	Total	30,435	100

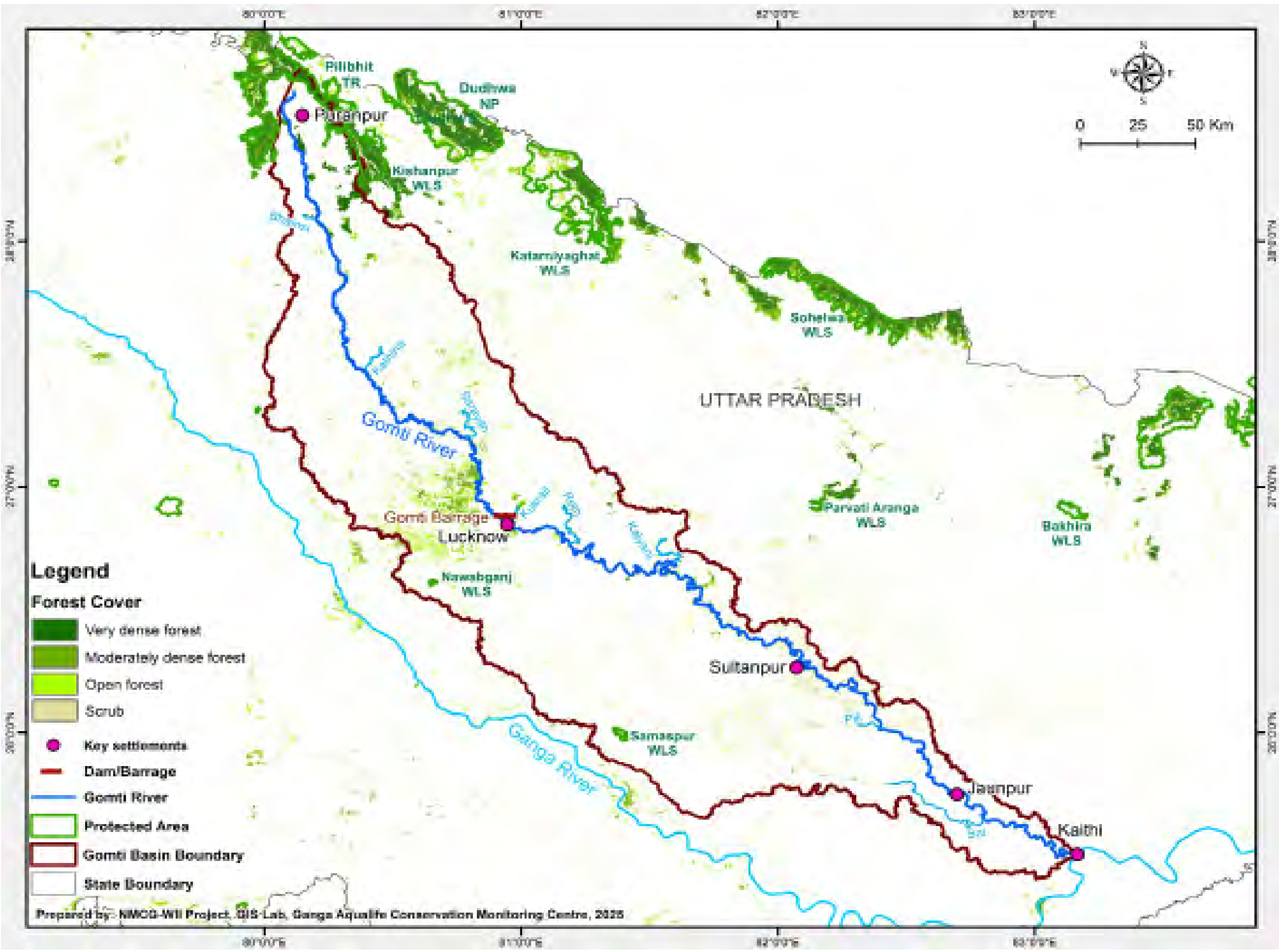


Figure 1.13. Map showing the forest cover for the year 2019 along with protected areas (PAs) in the Gomti River basin for the year 2019. Data source: FSI (2019)

1.9. CONSERVATION STATUS OF GOMTI RIVER BASIN

Mainly, two protected areas (PAs) are located in the basin covering only 10.24 km^2 area namely, Shaheed Chandra Shekhar Azad bird sanctuary (formerly Nawabganj bird sanctuary) and Samaspur bird sanctuary, which are also designated as Ramsar sites, wetlands of international importance (Table 1.3; Figure 1.12). While Kishanpur and Pilibhit wildlife sanctuaries (WLS) share the boundary with the Gomti River basin and minimal area of these two PAs is part of the Gomti basin (Figure 1.12). To date, there are no PAs along or on the Gomti River. These conservation areas are also designated as Important Bird and Biodiversity Areas (IBAs) due to their significance for the conservation of avian species and other biodiversity (Rahmani et al., 2016).

The Gomti River basin has one Biodiversity Heritage Site viz. Gharial Rehabilitation Centre, Kukrail nearby Lucknow, which was established for the conservation of Gharials in 1975 and it also plays a major role in the freshwater turtle conservation (DoEFCC, GoUP & NMCG, 2023; UPSBDB, 2015). This Biodiversity Heritage Site was declared in 2015 under Section 37 of Biological Diversity Act, 2002. Key aquatic species of the Gomti River viz. smooth-coated otter (*Lutrogale perspicillata*), mugger (*Crocodylus palustris*), freshwater turtles, Indian skimmer (*Rynchops albicollis*), river tern (*Sterna aurantia*), and sarus crane (*Antigone antigone*), are protected under the Schedule I of the Indian Wild Life (*Protection*) Amendment Act, 2022. While painted stork (*Mycteria leucocephala*), and river lapwing (*Vanellus duvaucelli*) are protected under Schedule-II of the Indian Wild Life (Protection) Act, 1972.

Table 1.3. Status of protected area (PA) and other designated sites in the Gomti River basin. Data source: National Wildlife Database, WII; https://rsis.ramsar.org/; Rahmani et al. (2016); https://www.keybiodiversityareas.org/; UPSBDB, 2015

Name of the site	PA category	Other designations	Area (km^2)	Key biodiversity
Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	Wildlife Sanctuary	Ramsar site, IBA, Part of Dudhwa TR	2.25	Mammal: Jungle Cat (*Felis chaus*). Birds: More than 200 bird species including Egyptian Vulture (*Neophron percnopterus*), Lesser Adjutant (*Leptoptilos javanicus*), Asian Woolly-necked Stork (*Ciconia episcopus*), Sarus Crane (*Grus antigone*)
Samaspur Bird Sanctuary	Wildlife Sanctuary	Ramsar site, IBA, KBA	7.99	Birds: More than 110 bird species including 14 duck species, 13 wader species, four stork species, and 10 raptor species. Key species include Egyptian Vulture (*Neophron percnopterus*), Pallas's Fish-eagle (*Haliaeetus leucoryphus*), Greater Spotted Eagle (*Clanga clanga*), Sarus Crane (*Grus antigone*), Ferruginous Duck (*Aytha nyroca*).
Kishanpur*	Wildlife Sanctuary	IBA, KBA	227	Mammals: Royal bengal Tiger (*Panthera tigris*), Barasingha (*Rucervus duvaucelii*), Hog Deer (*Axis porcinus*), Cheetal (*Axis axis*), Sambar (*Cervus unicolor*), and Wild Boar (*Sus scrofa*). Birds: More than 250 bird species including White-rumped Vulture (*Gyps bengalensis*), Red-headed Vulture (*Aegypius calvus*), Bengal Florican (*Houbaropsis bengalensis*), Black-bellied Tern (*Sterna acuticauda*), Lesser Florican (*Sypheotides indicus*), Sarus Crane (*Grus antigone*).
Pilibhit*	Wildlife Sanctuary	IBA, KBA, Part of Pilibhit TR	602.80	Mammals: Royal bengal Tiger (*Panthera tigris*), five species of deer (including Barasingha (*Rucervus duvaucelii*), Hispid Hare (*Caprolagus hispidus*), Sloth Bear (*Melursus ursinus*). Birds: More than 330 species including key species such as Bengal Florican (*Houbaropsis bengalensis*), Swamp Francolin (*Francolinus gularis*), Egyptian Vulture (*Neophron percnopterus*), Sarus Crane (*Grus Antigone*).
Gharial Rehabilitation Centre, Kukrail, Lucknow	Biodiversity Heritage Site	Reserve Forest	0.1	Birds: 46 species Reptiles: Gharial (*Gavialis gangeticus*), Mugger (*Crocodylus palustris*), 13 Freshwater Turtles species, Indian Star Tortoise (*Geochelone elegans*).

*Very negligible area of the PA comes under the Gomti River basin

1.10. DEMOGRAPHY AND HUMAN DEVELOPMENT INDEX

Eighteen districts of Uttar Pradesh partly or fully contribute to the Gomti River basin with a population of 66.39 million people and a human density of 886 persons/km² (Table 1.4; Figure 1.14; Census of India, 2011). The population density of the districts ranges from 524 persons/km² in Kheri to 2,395 persons/km² in Varanasi (Table 1.4). The average Human Development Index (HDI) of the 18 districts is 0.543, and the highest HDI of 0.638 is recorded for the Lucknow district, while the minimum HDI of 0.500 is recorded for the district Shahjahanpur. Sitapur district has the highest education index (0.712), followed by Hardoi (0.684), Pratapgarh (0.659), Azamgarh (0.651), and Kheri (0.649). The highest health index of 0.783 and standard of living index of 0.537 are recorded for the district of Lucknow (Table 1.4; Maurya et al., 2016). Table 1.4 provides the detailed demographic profile and HDI for the districts in the Gomti River basin.

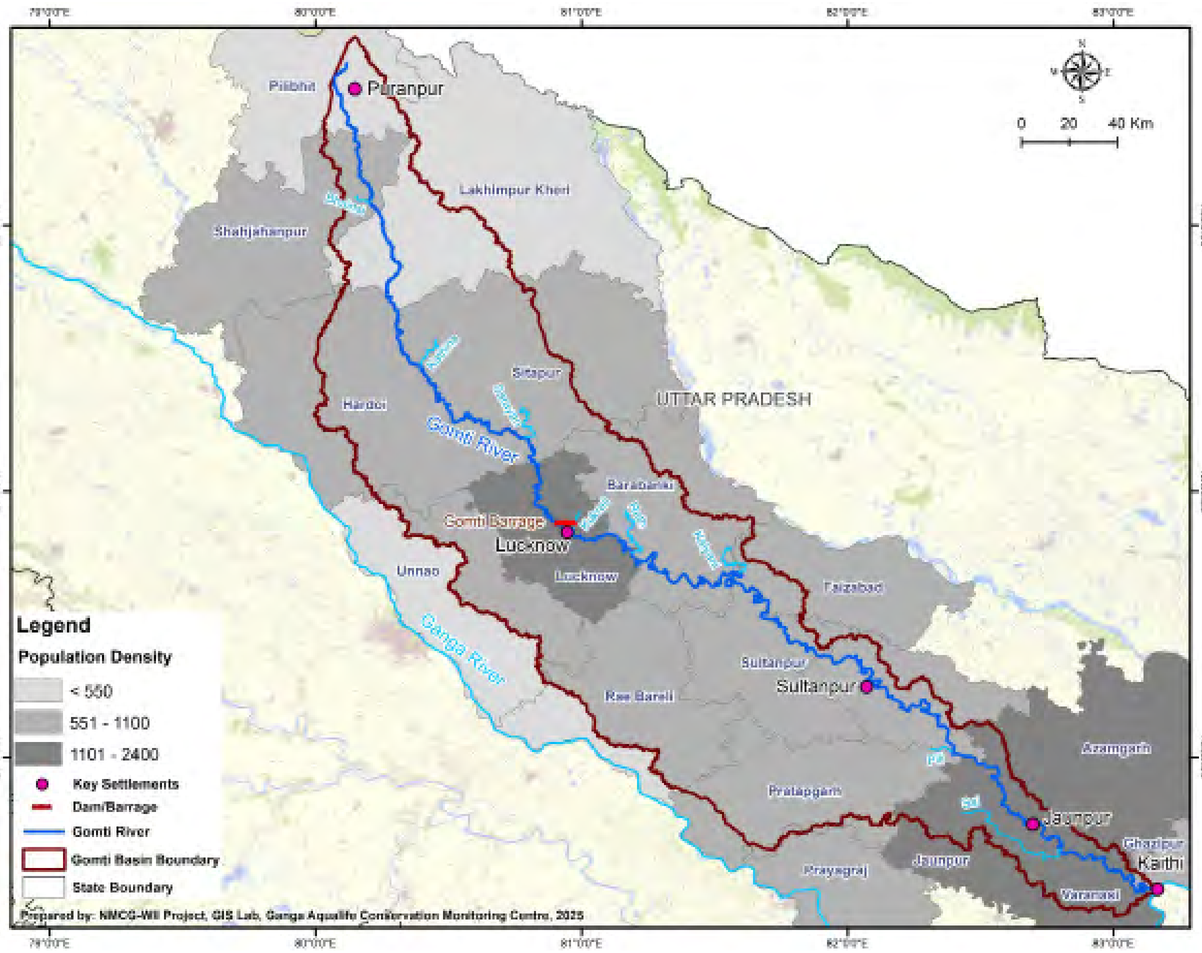
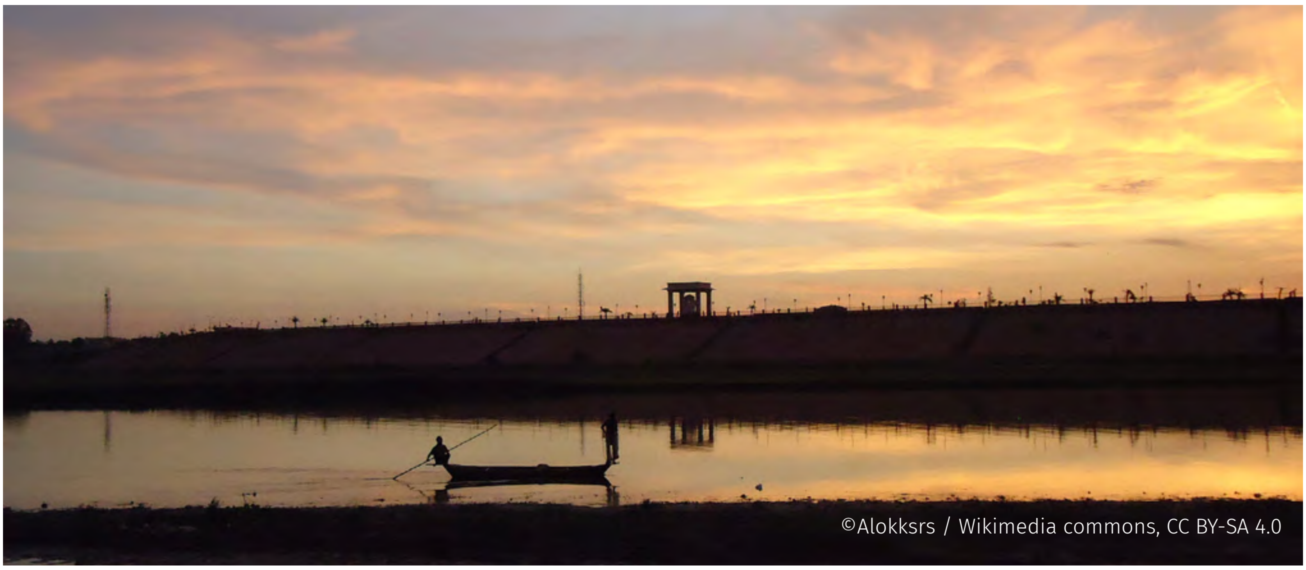


Figure 1.14. Map showing human density of the districts situated in the Gomti River basin.

Table 1.4. Demographic profile and Human Development Index (HDI) for districts situated in the Gomti River basin. Source: Maurya et al. (2016); Census of India (2011).

State	District Name	Area (km²)	Population (Census 2011)	Population Density	Education Index	Health Index	Std. of living Index	HDI
Uttar Pradesh	Lakhimpur Kheri*~	7,680	4.02	524	0.649	0.548	0.420	0.539
	Pilibhit*~	3,686	2.03	551	0.562	0.517	0.448	0.509
	Unnao*	4,558	3.11	682	0.576	0.651	0.429	0.552
	Hardoi*~	5,986	4.09	684	0.684	0.535	0.388	0.535
	Shahjahanpur*~	4,388	3.01	685	0.587	0.485	0.427	0.500
	Rae Bareli*	4,609	3.41	739	0.574	0.717	0.381	0.557
	Bara Banki*~	4,402	3.26	741	0.566	0.638	0.385	0.530
	Sitapur*~	5,743	4.48	781	0.712	0.550	0.398	0.553
	Sultanpur~	4,436	3.80	856	0.612	0.725	0.404	0.580
	Pratapgarh*~	3,717	3.21	863	0.659	0.580	0.341	0.526
	Ayodhya*~	2,341	2.47	1,056	0.609	0.592	0.410	0.537
	Ghazipur**~	3,377	3.62	1,072	0.612	0.621	0.363	0.532
	Prayagraj**	5,482	5.95	1,086	0.580	0.564	0.432	0.526
	Amethi*~	2,329	2.55	1,095	#	#	#	#
	Jaunpur*~	4,038	4.49	1,113	0.631	0.580	0.345	0.519
	Azamgarh*	4,054	4.61	1,138	0.651	0.665	0.336	0.551
	Lucknow~	2,528	4.59	1,816	0.595	0.783	0.537	0.638
	Varanasi*~	1,535	3.68	2,395	0.569	0.650	0.427	0.549
Total / Average for index columns		74,889	66.39	886	0.613	0.612	0.404	0.543

*Partly located in the basin, **Districts contribute a very minimal area to the basin, ~Districts through which the river traverse, #Indexes for Amethi district is included with Sultanpur and Rae Bareli districts.



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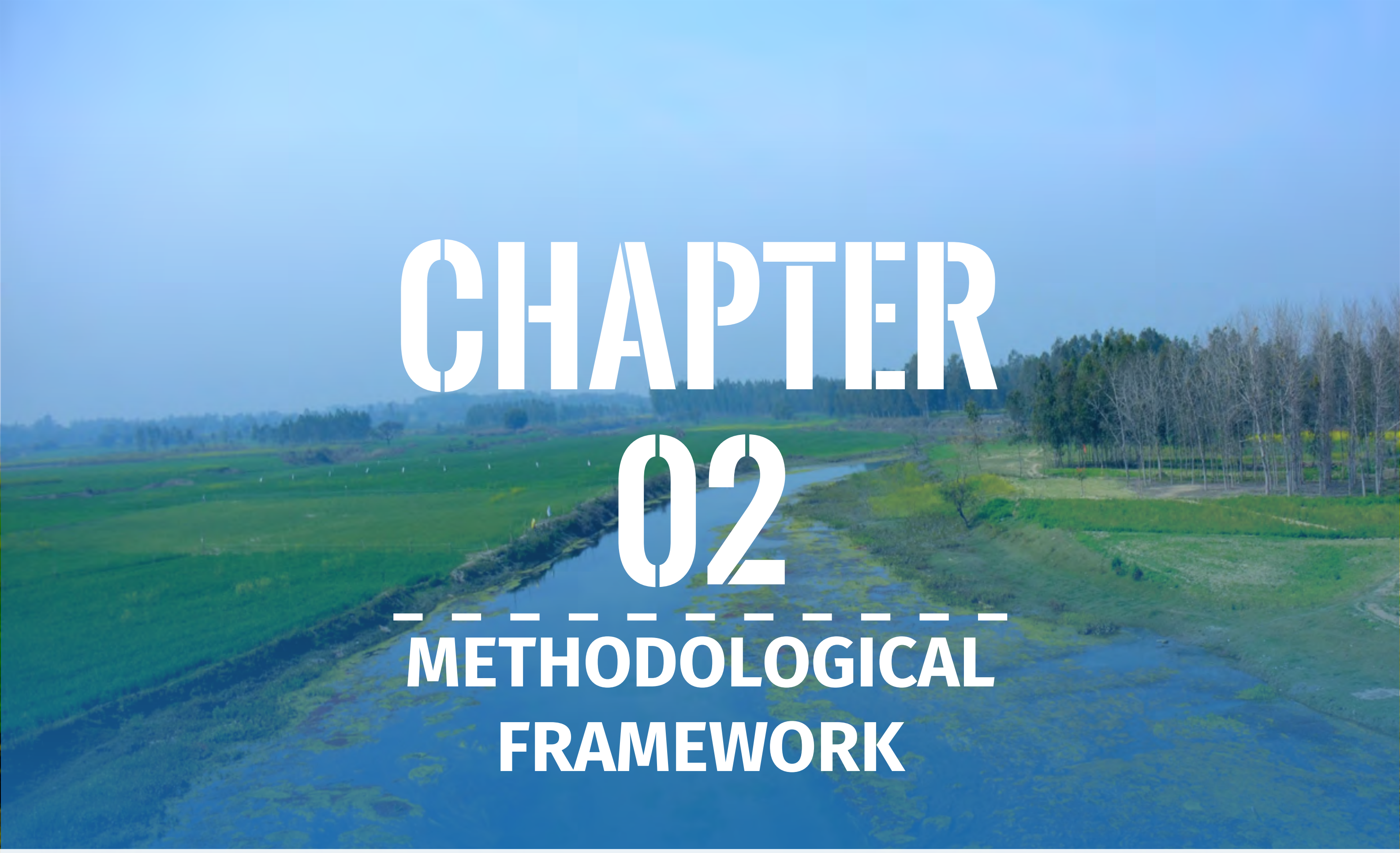

CHAPTER 02

METHODOLOGICAL FRAMEWORK

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The study was conducted through a combination of methods to assess the current as well as past ecological conditions of the Gomti River and its basin. Figure 2.1, briefly describes the process followed for the study. The ecological systems are closely connected and shaped by the socio-economic structures, and hence information on the socio-economic and policy dimensions were also examined, including the stakeholders.

2.1. REVIEW OF LITERATURE

An extensive literature review was carried out to assess the status of key aquatic species of the Gomti River and its basin. Online search engines and databases like Google Scholar (https:// scholar. google.com/), JSTOR (https://www.jstor. org/) and OpenAlex (Priem et al., 2022) were used for the collection and compilation of the information based on the peer-reviewed articles, books, technical reports. Information on the historical and current distribution of species, especially within the context of the Gomti River, was compiled through a comprehensive literature review using suitable keywords of the different taxa. The checklists of flora, fish, reptiles, amphibians, birds, and aquatic and semi-aquatic mammals are given in annexures I to V.

2.2. FIELD SAMPLING

Field surveys were carried out focusing on different taxa viz., flora, fish, amphibian, reptile, bird, and aquatic and semiaquatic mammals. Considering the variety of taxa and length of the river, a methodological framework was conceived to monitor different elements of biodiversity in the Gomti 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, were 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 winters, 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 summer. Taxa-wise detailed methods have been provided in the individual chapters. In addition, the hydrological profile of the Gomti River required a zone-specific sampling approach, two different types of approaches were adopted in terms of monitoring of aquatic reptiles, birds and mammals. Discontinuous flow and fragmentation of river remained an issue at most of the stretches owing to various reasons in the upper zone of the river from Gomat tal to Sitapur, thus vehicle and foot survey were adopted focusing the BEUs and point data was collected on the different taxa.

Seasonal variations in species occurrence and detectability were incorporated into the sampling design. Winter migratory waterbird species were monitored during the winter season, whereas breeding and nesting observations, particularly for island and riparian bird species, were undertaken during the summer months. Taxa-wise detailed methodologies have been provided in the respective chapters. Concurrently, physiochemical parameters, including electrical conductivity, salinity, turbidity, pH, and water temperature, were recorded using portable digital instruments. Surface water, sediment, and fish samples were collected from designated sampling sites along the Gomti River in accordance with standard sampling protocols and established guidelines.

2.3. SPATIAL ANALYSIS

Spatial analysis tools and software were used for delineating and visualizing the Gomti River and its associated stretches. Data collected on species occurrence, habitat characteristics, and associated anthropogenic pressures across different sections of the river, facilitated a comprehensive understanding of spatial patterns in biodiversity and environmental conditions along the Gomti River. In addition, spatial datasets were utilized to understand patterns in land use and to support the interpretation of ecological and socioenvironmental dynamics of the Gomti River. Spatial analysis tools such as MaxEnt were also used for identification of the Conservation Priority Stretches.


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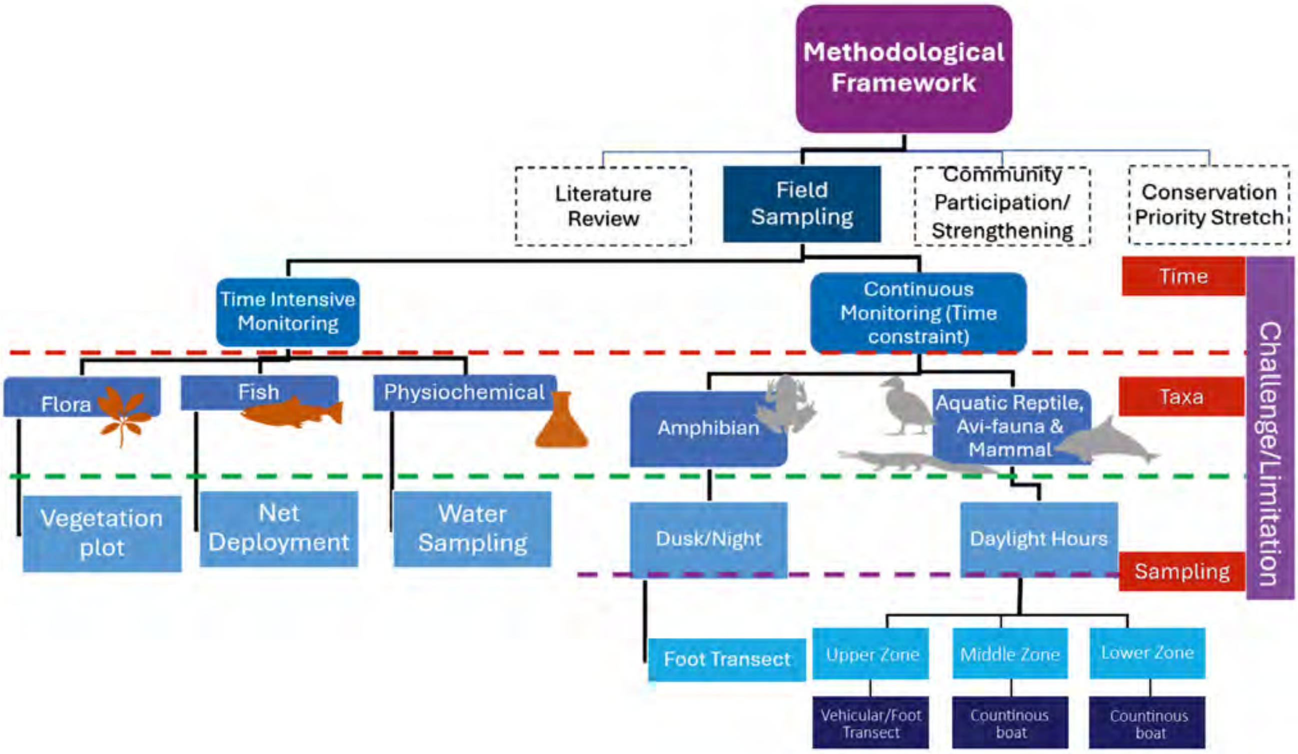

Figure 2.1. Methodological framework for the Field Sampling of the Gomti River.

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SECTION- II

ECOLOGICAL CONDITIONS

CHAPTER 03

FLORAL ASSEMBLAGE

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SUMMARY

Riparian vegetation forms a critical ecological interface between terrestrial and aquatic ecosystems, regulating hydrological processes, stabilizing riverbanks, supporting biodiversity, and maintaining overall river health. This study presents the first thorough floristic assessment of the Gomti River in Uttar Pradesh, exploring plant diversity across aquatic, semi-aquatic, and terrestrial categories across various spatial gradients.

The Gomti River, a major left-bank Ganga tributary, travels mostly through an extensive agricultural landscape. Despite significant anthropogenic stresses, the riparian environment continues to host a variety of plant groups. This research was undertaken on riparian vegetation along the Gomti River from Puranpur to Rasoolpur during the post-monsoon season of 2023. To capture gradients of hydrological effect and land-use intensity, vegetation samples were collected along systematic transects established at three distances from the riverbank—1 m, 500 m, and 1000 m. Standard ecological methods were used to describe species composition, calculate Shannon Diversity Index (H'), determine abundance, and construct the Importance Value Index (IVI) of tree species. A total of 408 angiosperm taxa representing 31 orders, 86 families, and 299 genera were documented. The most abundant families were Asteraceae (40 species), Fabaceae, and Poaceae (37 species each), followed by Amaranthaceae and Lamiaceae. Semi-aquatic species were the most abundant ecological category (234 species), followed by terrestrial (148 species)

and aquatic plants (26 species). The herbaceous flora dominated in terms of life form (231 species), followed by trees (58 species), grasses (52 species), shrubs (42 species), and climbers (25 species). The tree communities along the river gradient displayed significant spatial variation, with 58 species documented, primarily from the Fabaceae and Moraceae families. Native species comprised around 86% of the flora, with the most diversity found in meandering regions and tributary junctions. There was less diversity and dominance of invasive species like Populus and Eucalyptus in agricultural zones. According to IVI study, *Dalbergia sissoo* and others dominated at 1 m distance, whereas agroforestry species predominated at increasing distances. Shrub and grass communities showed a distance-driven gradient, with higher diversity near the river, but lower diversity due to agricultural expansion at 500 m and significant homogenization at 1000 m. Herbaceous flora varied greatly, with richness peaking in semi-natural habitats, and around 26% of species being exotic, including invasive species like *Pontederia crassipes*.

The riparian vegetation along the Gomti River serves as crucial biodiversity refuge in an agricultural landscape, with abundant native species near the riverbanks owing to hydrological connection and natural disturbance instances. Species diversity decline with distance from the river, greatly impacted by agriculture activity, monocultures, as well as habitat fragmentation. Areas with hydrological complexity and cultural value have greater ecological stability. This research emphasizes the relationship between river health and land use, highlighting the need of native species restoration, minimizing exotic monocultures, protecting ecosystem mosaics, and conserving buffer zones along the Gomti River. The present study provides a detailed floristic assessment, which will be used as crucial ecological baseline for future biodiversity monitoring and restoration activities along the Gomti River in Uttar Pradesh.

3.1. INTRODUCTION

Riparian flora, or river bank vegetation, is highly dynamic and ecologically significant. It links terrestrial and aquatic habitats, growing along rivulet and riverbanks to form the riparian zone (Dutta et al., 2011). Riparian vegetation, defined by the diverse plant communities in and along the waterways, is crucial to aquatic systems and performs various social and ecological functions (Malanson, 1993; National Research Council, 2002). This vegetation influences the physical and ecological health of streams by maintaining the balance of oxygen, nutrients, and sediments, and providing habitat and food for micro and macrofauna. Tree stems, plant debris, and large branches in the water channel provide stability, reduce stream velocity, and offer habitat for invertebrates and fish (Harmon et al., 1986). Without riparian vegetation, stream banks are often unstable and prone to erosion, as plants strengthen the soil with their root systems (Griffiths, 1980; Hupp and Simon, 1986; Sagir et al., 2018). The main forest types in the basin are Tropical Semi Evergreen (0.21%), Tropical Moist Deciduous (19.68%), Tropical Dry Deciduous (50.66%), Tropical Thorn (4.61%) and Littoral and Swamp forests (2.35%) (Champion & Seth, 1968). Initial studies on taxonomy and distribution of flora in the upper Gangetic plain can be accessed from Duthie (1903). Recently, Singh et al., (2020) studied diversity of aquatic/wetland plant species in and around Lucknow district, a total of 1263 aquatic flora recorded was divided into six categories i.e. (a) Free-floating, (b) Suspended, (c) Submerged attached, (d) Attached with floating leaves, (e) Amphibious, and (f) Wetland. Dominating species found by Singh et al., (2020) were *Ceratophyllum demersum, Utricularia stellaris var. inflexa, Hydrilla verticillata, Ottelia alismoides, Potamogeton crispus, P. nodosus*. Summary of previous plant studies in the Gomti River basin is described in Table 3.7 and annexure I provides the complete list of plants recorded during the present study. However, comprehensive floristic investigations along the Gomti River catchment are limited, and a thorough assessment of floral diversity across the entire river stretch is still lacking. The primary objective of this study was to assess, and document the floristic diversity comprehensively in and along the Gomti River.


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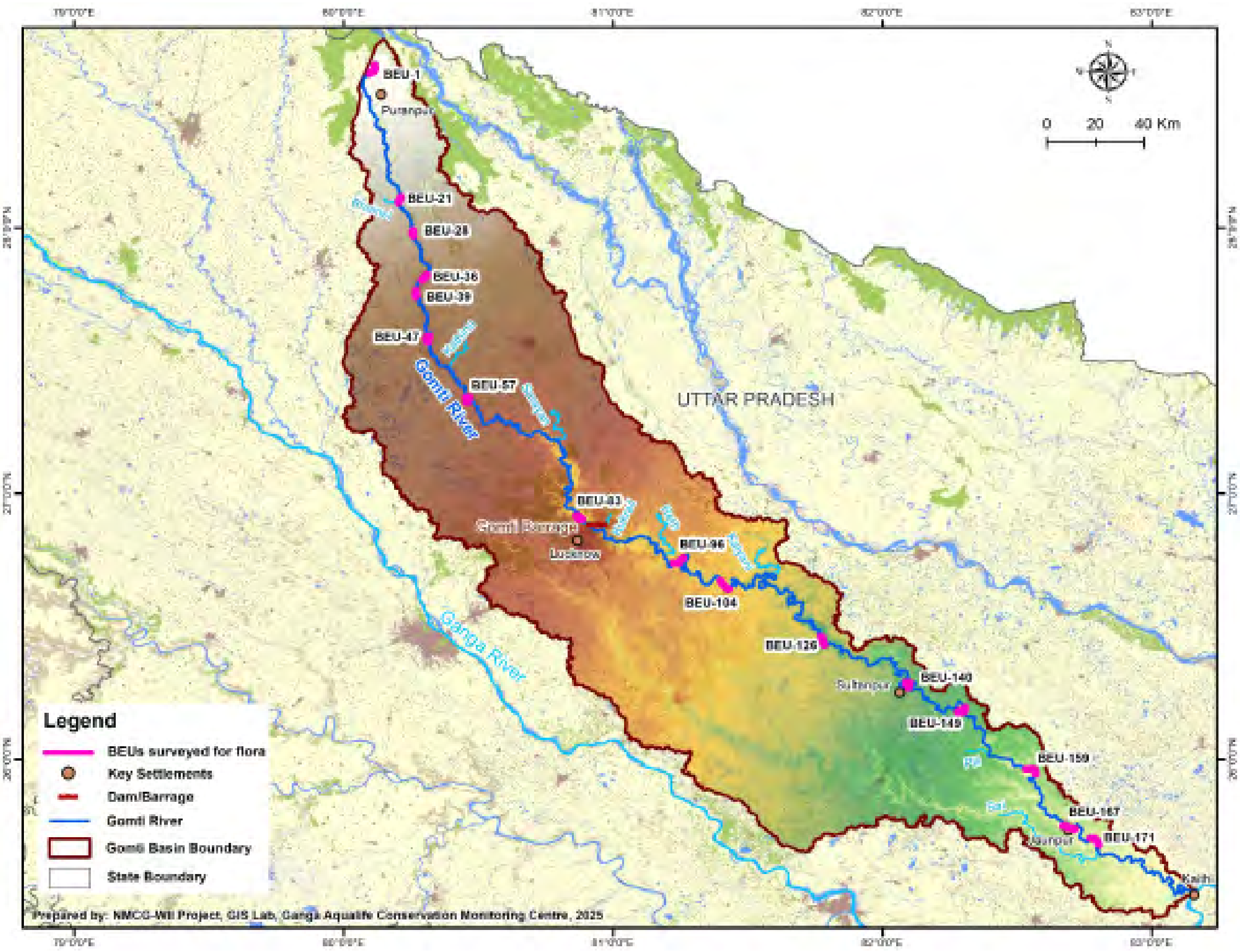

Figure 3.1. BEUs assessed to evaluate riparian vegetation along the Gomti River.

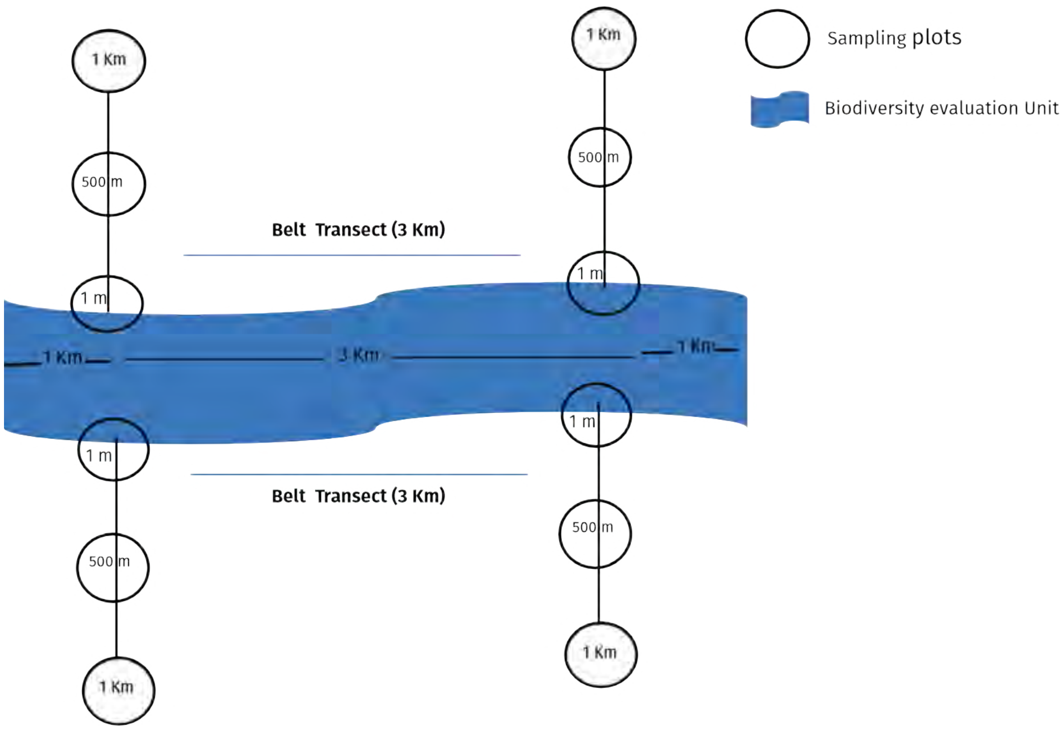

Figure 3.2. Methodology adopted to sample riparian vegetation along the Gomti River.

3.2. METHODS

The study was carried out in post-monsoon 2023 to survey vegetation along the Gomti River. A total of 16 BEUs were assessed, ranging from Puranpur to Rasoolpur of Uttar Pradesh, to evaluate the riparian plant communities (Figure 3.1). In each Biodiversity or Basic Evaluation Unit (BEU), six transects were established: four perpendicular transects, each extending 1 km from the river, and two parallel transects, each spanning 3 km along the river (Figure 3.2). In the perpendicular transects, circular plots (radius 20m for trees, 5m for shrubs and four quadrats of 1x1m for herbs) were established at distances of 1 m, 500 m, and 1000 m from the riverbank to document and collect plant species (Mishra, 1968; Kent, 2012).

Species Richness and diversity indices such as Shannon Diversity Index (H'), were calculated (using percentage cover of shrubs and grasses), to indicate species diversity in a community, it accounts for both species' richness and evenness. The 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).

The 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/). The families of the plants follow APG IV (Angiosperm Phylogeny Group, 2016).
For calculating tree abundance, three 20 m radius plots were established in each perpendicular transect (at 1 m, 500 m and 1000 m) (Figure 3.2). In each circular plot, the number of individuals for each tree species was recorded. IVI for plant species was also calculated.

Box 1: Formulas Used in Vegetation Analysis

• Shannon Index (H') – Biodiversity Index
$H' = -\sum (p_i \times \ln p_i)$
Where:
H' = Shannon diversity index
p_i = Proportion of individuals of species i = n_i / N
n_i = Number of individuals of species i
N = Total number of individuals of all species
S = Total number of species
• Frequency (%) = (Number of quadrats in which the species occurs / Total number of quadrats) × 100
• Abundance = Total number of individuals of a species / Number of quadrats in which the species occurs
• Density = Total number of individuals of a species / Total number of quadrats studied
• Relative Frequency (RF) (%) = (Frequency of a species / Sum of frequencies of all species) × 100
• Relative Abundance = Number of individuals of a species / Total number of individuals of all species
• Relative Density (RD) (%) = (Density of a species / Sum of densities of all species) × 100
• Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Abundance


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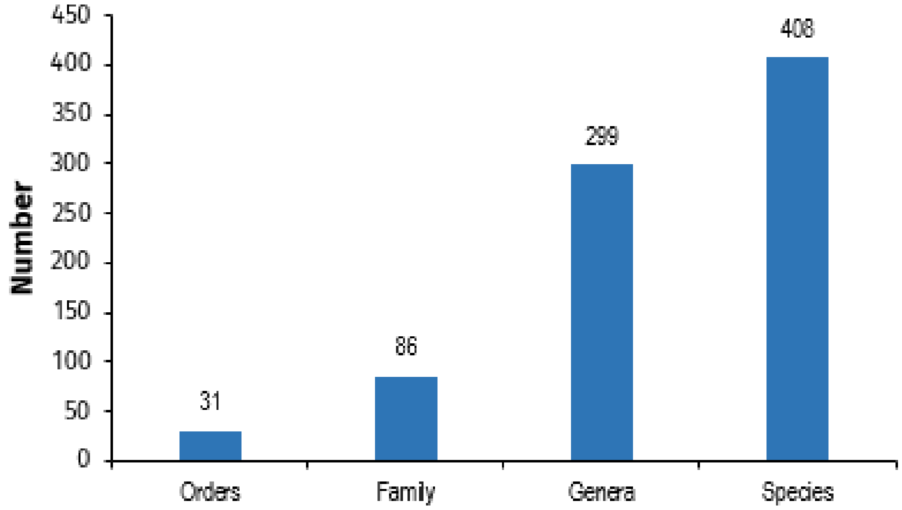

Figure 3.3. Taxonomic classification of plants recorded along the Gomti River.

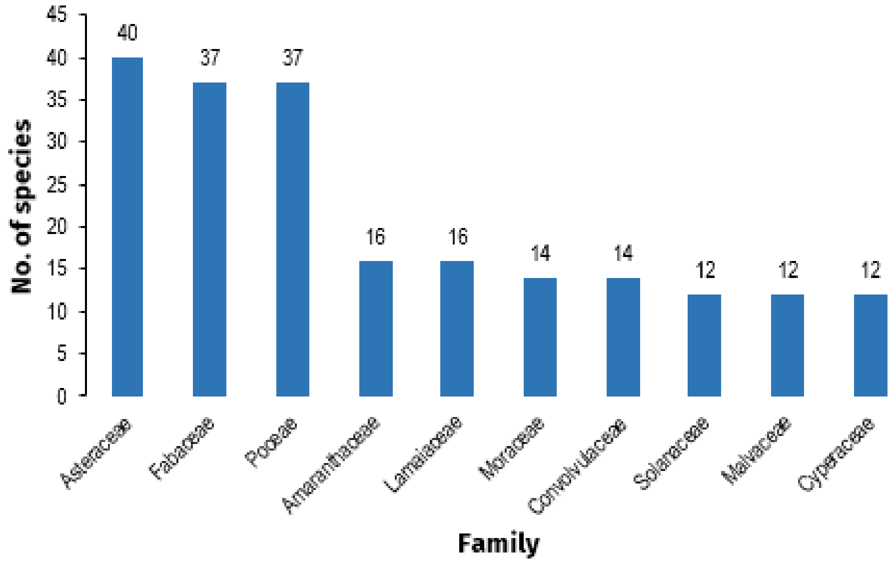

Figure 3.4. Family-wise number of plant species recorded along the Gomti River.

3.3. RESULTS

Based on field surveys conducted and forest types recorded in and along the Gomti River, the dominant families representing riparian flora were Asteraceae, Fabaceae, Poaceae, Amaranthaceae, Lamiaceae, Euphorbiaceae, Moraceae, Convolvulaceae, Solanaceae, Malvaceae, Cyperaceae, Rubiaceae. A total of 408 angiosperm taxa belonging to 31 orders, 86 families, and 299 genera were recorded during the present survey along the river Gomti (Figure 3.3; Annexure 1). Among them, Asteraceae was the most dominant family (40 spp.) followed by Fabaceae and Poaceae (37 spp. each), Amaranthaceae and Lamiaceae (16 spp. each), Moraceae and Convolvulaceae (14 spp. each), Solanaceae, Malvaceae and Cyperaceae (12 spp. each) (Figure 3.4). Most of the recorded species in the survey are semi-aquatic (234 spp.), followed by terrestrial (148 spp.) and aquatic (26 spp.) (Figure 3.5). While the life form (habit) of the recorded species is dominated by herbaceous flora (231 spp.), followed by trees (58 spp.), grasses (52 spp.), shrubs (42 spp.) and climbers (25 spp.) (Figure 3.6).

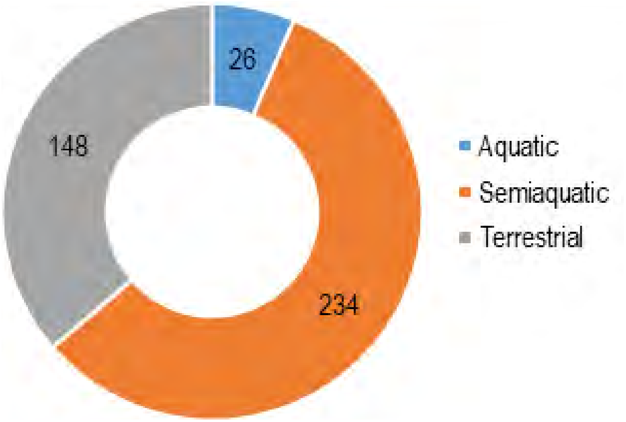

Figure 3.5. Habit-wise number of recorded plant species along the Gomti River.

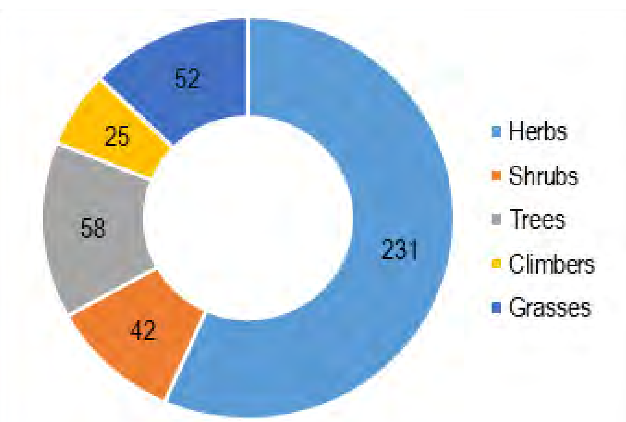

Figure 3.6. Habitat-wise number of recorded plant species along the Gomti River.

Moderate to high species richness of 79 to 118 species was observed in the surveyed transects along the 16 BEUs of the Gomti River, with native species consistently dominating (Figure 3.7). Higher richness in sites like Katghara Gaon (n=118) and Bahadur Nagar (n=114) reflected the presence of semi-natural or mixed-use habitats supporting diverse flora. In the BEUs 1 to 39, located in the upper zone, richness is largely contributed by aquatic, semi-aquatic, and weedy species near the river (1m from the river), while areas farther away were dominated by monoculture agriculture, reducing diversity. From BEU 57 onwards, increased river meandering sustained riparian habitats even at 500–1000m, supporting varied vegetation including avenue and ornamental trees. Exotic species make up 20 to 28% of total richness in the surveyed respective BEUs (Figure 3.7). Proximity to dense urban areas introduced pressures such as effluent discharge and habitat fragmentation, promoting the spread of exotic and opportunistic species.

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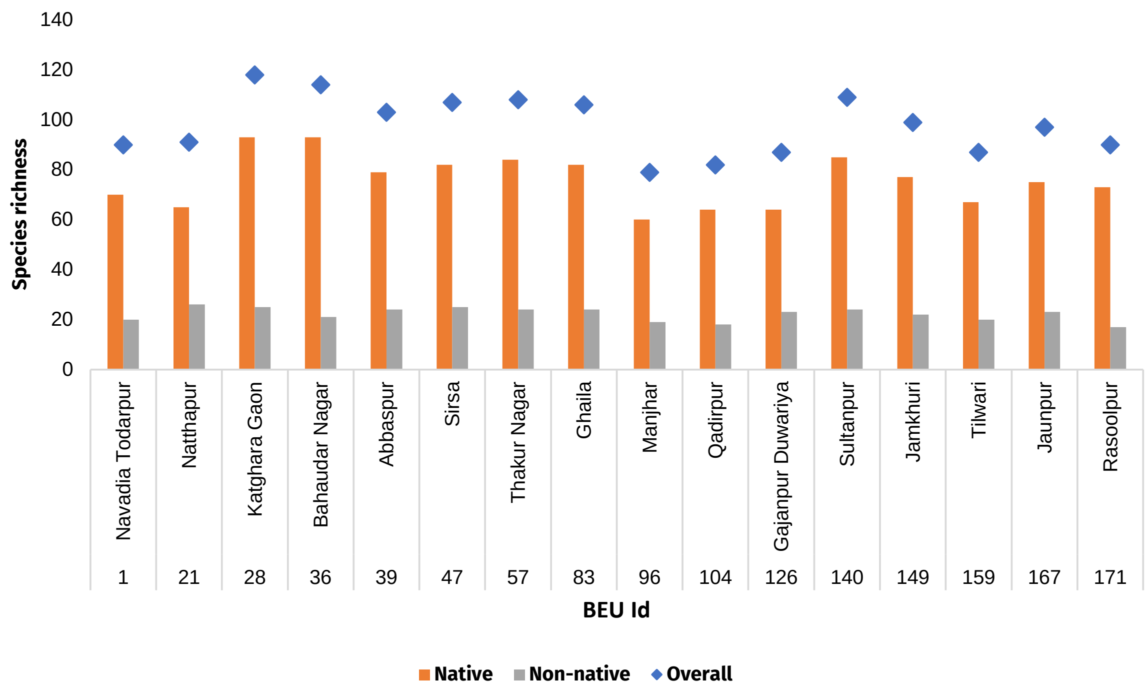

Figure 3.7. BEU-wise species richness and nativity of flora recorded along the Gomti River.

Table 3.1. Habit-wise classification of plants recorded along the Gomti River during the present survey.

Plant group	Trees	Shrubs	Herbs	Climbers	Grasses
Order	14	21	24	7	1
Family	29	21	55	7	4
Genus	47	36	164	24	37
Species	58	42	231	25	52
Aquatic	0	0	23	0	2
Semi-aquatic	0	13	151	5	48
Terrestrial	58	29	59	20	2

3.3.1. Trees

Richness and diversity

Tree species reported along the river Gomti during the survey are represented by 58 species belonging to 14 orders, 29 families, and 47 genera. Dominant families are the Fabaceae (11 spp.) and Moraceae (10 spp.) (Table 3.1.). Dominant tree species recorded were *Dalbergia sissoo*, *Tectona grandis*, *Terminalia arjuna*, *Cassia fistula*, *Acacia catechu*, *A. nilotica*, *Azadirachta indica*, *Ficus religiosa*, *F. benghalensis*, *Bombax ceiba*, *Butea monosperma*, *Madhuca longifolia*, *Pithecellobium dulce, Trewia nudiflora*, *Melia azedarach*. The BEU 57 at Thakur Nagar has the highest species richness of tree (35 spp.), followed by BEU 96, 104, and 159 (33 spp. each) and BEU 149 (30 spp.). While the lowest richness was recorded in the BEU 21 at Natthapur (3 spp.) followed by BEU 1 (6 spp.) (Figure 3.8). The Shannon diversity index (H') was recorded highest in the BEU 39 at Abbaspur (H'=2.63), while the lowest diversity was recorded in the BEU 21 at Natthapur (H'=1.09) (Figure 3.8).

Tree richness and diversity varied widely across BEUs along the Gomti River. Lowest values were observed in BEUs such as 1 and 21, where natural vegetation was nearly absent and exotic plantations like Eucalyptus dominated. In contrast, BEUs around meandering stretches and tributary junctions (28, 36, 39, and 57) supported higher richness and diversity, with native species such as *Ficus religiosa* and *Dalbergia sissoo* persisting. Urban BEUs like Jaunpur (167) showed moderate to high diversity due to older avenue plantations, while some BEUs such as 96 and 104 recorded high richness but low diversity, reflecting species dominance by a few exotics.

Abundance

Dalbergia sissoo and *Mallotus nudiflorus* were the most abundant tree species found at the transects 1 m distance from the Gomti River. While, *Acacia nilotica, Pithecellobium dulce, Holoptelea integrifolia, Dalbergia sissoo,* Populus spp. and Eucalyptus spp. were found to be abundant at a distance of 500m from the Gomti River. *Tectona grandis, Mallotus nudiflorus* with the addition of *Mangifera indica, Moringa oleifera,* Populus spp. and Eucalyptus spp. were most abundant tree species observed at a distance of 1,000 m from the river. Additionally, species like *Morus alba, Toona ciliata, Tectona grandis* and *Moringa oleifera* were observed in the plantation areas. These species play a significant role in the landscape, serving as shelterbelts to reduce wind erosion, timber sources for commercial use, and stabilizers for riverbanks.

Dominance of plant 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.

IVI at 01 m from the river

In the plots located at 1 m distance from the Gomti River, *Dalbergia sissoo*, *Mallotus nudiflorus,* and *Holoptelea integrifolia* were the dominant tree species across multiple BEUs, demonstrating significantly higher IVI values, with *Holoptelea integrifolia* recording a maximum IVI value of 232.5 in BEU 159. The frequent dominance of *Dalbergia sissoo* (BEUs 1, 149, 167) and *Mallotus nudiflorus* (BEUs 47, 96, and 126) were recorded. In contrast, BEUs like 36, 57, and 104 exhibit more evenly distributed IVI patterns, where secondary contributors such as *Pongamia pinnata*, *Ficus religiosa*, *Mangifera indica*, and *Cassia fistula* play significant co-dominant roles (Table 3.2).

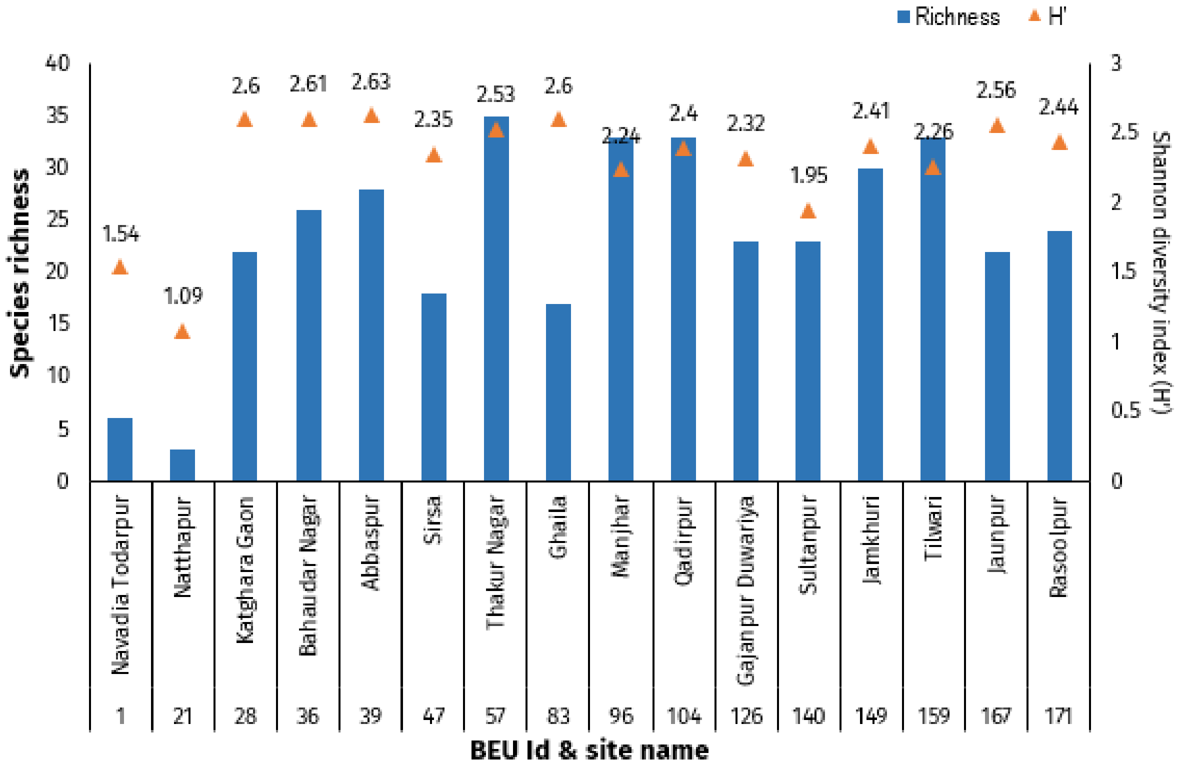

Figure 3.8. Species richness and Shannon diversity index (H') of trees recorded along the surveyed BEUs in the Gomti River.

Table 3.2. Dominant tree species and IVI value in BEU-wise surveyed plots one meter from the Gomti River.

S.N.	BEU Id	Dominant tree species at 1 m distance from the river	IVI values	Other contributing tree species
1	1	*Dalbergia sissoo, Acacia nilotica*	150	-
2	21	*Acacia nilotica, Phoenix sylvestris*	150	-
3	28	*Pongamia pinnata, Toona ciliata, Barringtonia acutangula*	50	-
4	36	*Ficus religiosa*	85.23	*Pongamia pinnata, Dalbergia sissoo*
5	39	*Dalbergia sissoo*	67.14	*Alangium salvifolium, Ficus benghalensis*
6	47	*Mallotus nudiflorus, Tectona grandis*	91.66	*Acacia catechu, Morus alba*
7	57	*Terminalia arjuna*	63.38	*Dalbergia sissoo, Mangifera indica*
8	83	*Acacia nilotica*	66.86	*Morus alba, Azadirachta indica, Mallotus nudiflorus*
9	96	*Mallotus nudiflorus*	95	*Cassia fistula, Pithecellobium dulce, Mangifera indica*
10	104	*Alangium salvifolium*	63.29	*Mallotus nudiflorus, Ficus racemosa*
11	126	*Mallotus nudiflorus*	73.81	*Holoptelea integrifolia*, Eucalyptus spp., *Acacia nilotica*
12	140	*Alangium salvifolia, Mangifera indica*	150	-
13	149	*Dalbergia sissoo*	90.47	*Pithecellobium dulce, Pongamia pinnata*
14	159	*Holoptelea integrifolia*	232.5	*Ficus religiosa*
15	167	*Dalbergia sissoo, Bombax ceiba*	66.66	*Ficus virens, Streblus asper*
16	171	*Dalbergia sissoo*	95	*Bombax ceiba, Ficus virens*

IVI at 500 m from the river

At 500 m distance from the river, *Pithecellobium dulce, Borassus flabellifer, Dalbergia sissoo,* and *Populus* spp. emerged as dominant species across several BEUs, with high IVI values in BEUs 96, 171, 140, and 1 respectively (Table 3.3). BEU 1 showed co-dominance of Populus and Eucalyptus, reflecting agroforestry practices in agricultural matrices, while BEU 171's Borassus dominance highlighted its cultural and boundary planting role. In contrast, BEUs 28, 36, and 39 showed balanced IVI patterns, where *Terminalia arjuna, Mangifera indica*, and *Pithecellobium dulce* shared dominance with species like *Bombax ceiba* and *Ficus benghalensis*. Other sites, such as BEUs 47, 57, and 104, supported moderately structured communities with dominants like *Madhuca latifolia* and *Holoptelea integrifolia* alongside co-dominants such as *Artocarpus lacucha* and *Tectona grandis* (Table 3.3).

IVI at 1,000 m from the river

At 1,000 m distance from the river, species like *Azadirachta indica, Dalbergia sissoo, Phoenix sylvestris,* and *Leucaena leucocephala* emerged as dominants in BEUs 21, 104, 47, and 96, respectively, with exceptionally high IVI values. Transitional or structurally complex assemblages were observed in BEUs 28, 36, 39, and 57, with *Ficus racemosa, Tectona grandis, Streblus asper,* and *Mallotus nudiflorus* sharing co-dominance. Other BEUs such as 83, 140, 149, and 159 supported moderately dominant natives like *Mangifera indica* and *Moringa oleifera* interspersed with culturally important species, while urban BEU 167 displayed a mix of large natives and planted species. BEUs 126 and 171 showed low dominance but retained hardy, culturally valued species such as *Borassus flabellifer* and *Aegle marmelos* (Table 3.4).

Table 3.3. Dominant tree species and IVI value in BEU-wise surveyed plots 500 m from the Gomti River.

S.N.	BEU	Dominant tree species at 500 m distance from the river	IVI values	Other contributing tree species
1	1	Populus sp., Eucalyptus sp.	91.66	*Acacia nilotica, Ziziphus mauritiana*
2	21	-	-	-
3	28	*Terminalia arjuna, Dalbergia sissoo*	66.66	*Acacia nilotica, Bombax ceiba, Pithecellobium dulce*
4	36	*Mangifera indica*	80.55	*Azadirachta indica, Ficus benghalensis,* Eucalyptus sp.
5	39	*Pithecellobium dulce*	72.64	*Trewia nudiflora, Ficus benghalensis, Bombax ceiba*
6	47	*Madhuca latifolia, Mangifera indica*	70	*Artocarpus lacucha, Morus alba*
7	57	*Dalbergia sissoo*	67.61	*Azadirachta indica, Ficus racemosa,*
8	83	*Acacia nilotica*	72.54	Eucalyptus spp., Ziziphus sp, *Syzygium cumini*
9	96	*Pithecellobium dulce*	83.33	*Phoenix sylvestris, Trewia nudiflora*
10	104	*Holoptelea integrifolia*	62.22	*Ficus religiosa, Borassus flabellifer, Tectona grandis*
11	126	*Acacia nilotica*	76.85	*Holoptelea integrifolia, Dalbergia sissoo*
12	140	*Dalbergia sissoo*	85.11	*Mangifera indica, Streblus asper,*
13	149	*Pithecellobium dulce*	94.38	*Holoptelea integrifolia, Dalbergia sissoo*
14	159	*Holoptelea integrifolia*	60.34	*Mangifera indica, Azadirachta indica, Tectona grandis*
15	167	*Ehretia aspera, Ficus religiosa*	66.66	*Ficus virens, Toona ciliata, Aegle marmelos*
16	171	*Borassus flabellifer*	93.91	*Alangium salvifolium*


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Table 3.4. Dominant tree species and IVI value in BEU-wise surveyed plots 1000 m from the Gomti River.

S.N.	BEU	Dominant tree species at 1000 m distance from the river	IVI values	Other contributing species
1	1	Eucalyptus spp.	108.33	*Acacia nilotica, Dalbergia sissoo,* Populus spp.
2	21	*Azadirachta indica*	300	-
3	28	*Ficus racemosa*	95	*Ehretia aspera*
4	36	*Tectona grandis, Streblus asper*	77.14	*Morus alba, Cassia fistula, Toona ciliata*
5	39	*Tectona grandis*	105.71	*Toona ciliata, Cassia fistula, Streblus asper*
6	47	*Phoenix sylvestris*	133.33	*Ficus religiosa, Mimusops elengi*
7	57	*Mallotus nudiflorus*	108.35	*Ficus racemosa, Phoenix sylvestris, Holoptelea integrifolia*
8	83	*Mangifera indica*	71.21	*Trema orientale, Melia azedarach, Dalbergia sissoo*
9	96	*Leucaena leucocephala*	112.3	*Borassus flabellifer, Phoenix sylvestris, Mallotus nudiflorus*
10	104	*Dalbergia sissoo*	176.98	*Morus alba, Mallotus nudiflorus*
11	126	*Borassus flabellifer, Ehretia acuminata, Aegle marmelos*	60	-
12	140	*Streblus asper*	83.33	*Mangifera indica, Putranjiva roxburghii, Syzygium cumini*
13	149	*Moringa oleifera, Tectona grandis*	58.73	*Azadirachta indica, Oroxylum indicum, Pithecellobium dulce*
14	159	*Toona ciliata*	83.33	*Morus alba, Mallotus nudiflorus*
15	167	*Ficus benghalensis, Mallotus nudiflorus*	93.33	*Moringa oleifera, Ficus religiosa*
16	171	*Moringa oleifera*	64.28	*Ehretia acuminata, Ehretia aspera, Aegle marmelos*

3.3.2. Shrubs and Grasses

Richness and diversity

Shrubs reported during the survey along the Gomti River are represented by 42 species belonging to 21 orders, 21 families, and 36 genera (Table 3.1.). Lamiaceae being the dominant family in shrubs with eight species. A total of 52 species of grasses reported during the survey along the Gomti River belonging to four families (including grasses, sedges, rushes and cattails) and 37 genera (Table 3.1.). Poaceae was found to be the dominant family in grasses with a total of 37 species.

The Shannon's Diversity Index (H') patterns observed at 01 m, 500 m, and 1000 m from the Gomti River, revealed a consistent trend of ecological simplification driven by agricultural expansion and human settlement. The diversity for grasses is highest near river meanders and wetland-like zones, reflecting the influence of hydrological complexity and occasional remnant vegetation patches at sampling plots 1 m distance from the river. However, shrub diversity is generally lower due to limited woody cover, sometimes not supported by sandy banks at 1 m from the Gomti River. At 500 m, diversity declines further, particularly for shrubs, as agricultural dominance intensifies and native vegetation becomes fragmented, though pockets of moderate diversity persist near micro-wetlands or less intensively managed fields. At a distance of 1000 m from the Gomti River, the landscape is largely homogenized, natural vegetation is scarce, and diversity (especially shrub diversity) drops remarkably in many BEUs, while grass diversity is largely supported by disturbance-tolerant species. Nonetheless, a few areas, such as Qadirpur (BEU 104) and Sultanpur (BEU 140) maintained relatively high diversity at all distances, due to semi-natural field margins or retained vegetation structure. These patterns underscored the strong influence of land use on biodiversity gradients and highlighted the urgent need for restoration, particularly in zones where natural hydrology and remnant habitats are still persisting. At a distance of 1 m from the Gomti River, diversity patterns of shrubs and grasses are strongly site-dependent. High grass diversity at Navadia, Todarpur (BEU 1, H' = 2.42) and shrub diversity at Natthapur (BEU 21, H' = 2.23) were recorded due to remnant riparian vegetation and wetland conditions (Figures 3.10 and 3.11). Balanced diversity at Katghara Gaon (BEU 28) and Ghaila (BEU 83) reflects habitat complexity, which created by flooding and sediment deposition. In contrast, Abbaspur (BEU 39) and Tilwari (BEU 159) showed low values due to intensive disturbance and bank modification. These results highlight the role of microhabitats and reduced human pressure in sustaining native diversity even within narrow riparian zones.

At a distance of 500 m from the Gomti River, the shrub and grass diversity declined overall as agriculture dominated. Low shrub and grass diversity were recorded at Navadia Todarpur (BEU 1) and Natthapur (BEU 21) with Shannon's diversity index (H') less than 0.8 (Figures 3.10 and 3.11). While, sites such as Qadirpur (BEU 104) and Sultanpur (BEU 140) exhibit significant diversity in shrubs, with Shannon's diversity index (H') values of 2.17 and 1.78, respectively, and in grasses, with indices of 1.55 and 2.08, respectively, indicating the impact of wetlands and reduced land use intensity (Figures 3.10 and 3.11). Urban areas such as Jaunpur (BEU 167) and Rasoolpur (BEU 171) also register high shrub diversity, though largely from exotics or planted species. These results indicated that, despite local changes in hydrology and land-use mosaics occurring 500 meters from the Gomti River, it still sustains considerable plant diversity. At the 1,000 m distance from the Gomti River, again agriculture with human settlements dominated the landscape, leading to generally low shrub diversity and only moderate grass diversity.

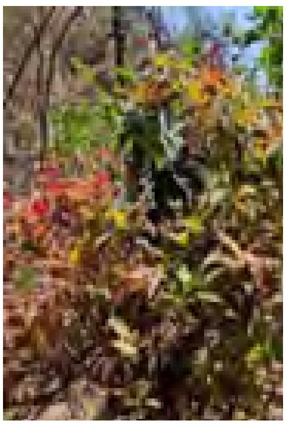
Navadia Todarpur (BEU 1) shows complete loss of shrub diversity, reflecting intensive land conversion. In contrast, Qadirpur (BEU 104) and Sultanpur (BEU 140) retain relatively high values (H' of both shrubs and grasses is more than 1.5), suggesting persistence of semi-natural field margins or residue vegetation. Jaunpur (BEU 167) and Rasoolpur (BEU 171) also maintain high shrub diversity (H'~ 1.9), though largely supported by exotic or planted species. Overall, while biodiversity declines markedly at this distance, localized habitat heterogeneity still sustains pockets of diversity.


Terminalia arjuna (Roxb. ex DC.) Wight & Arn.


Bombax ceiba L.


Dalbergia sissoo Roxb. ex DC.


Vachellia nilotica (L.) P.J.H.Hurter & Mabb.


Ficus virens Aiton


Mallotus nudiflorus (L.) Kulju & Welzen


Pithecellobium dulce (Roxb.) Benth.

Plate 3.1. Some of the dominant trees recorded during survey along the Gomti River.

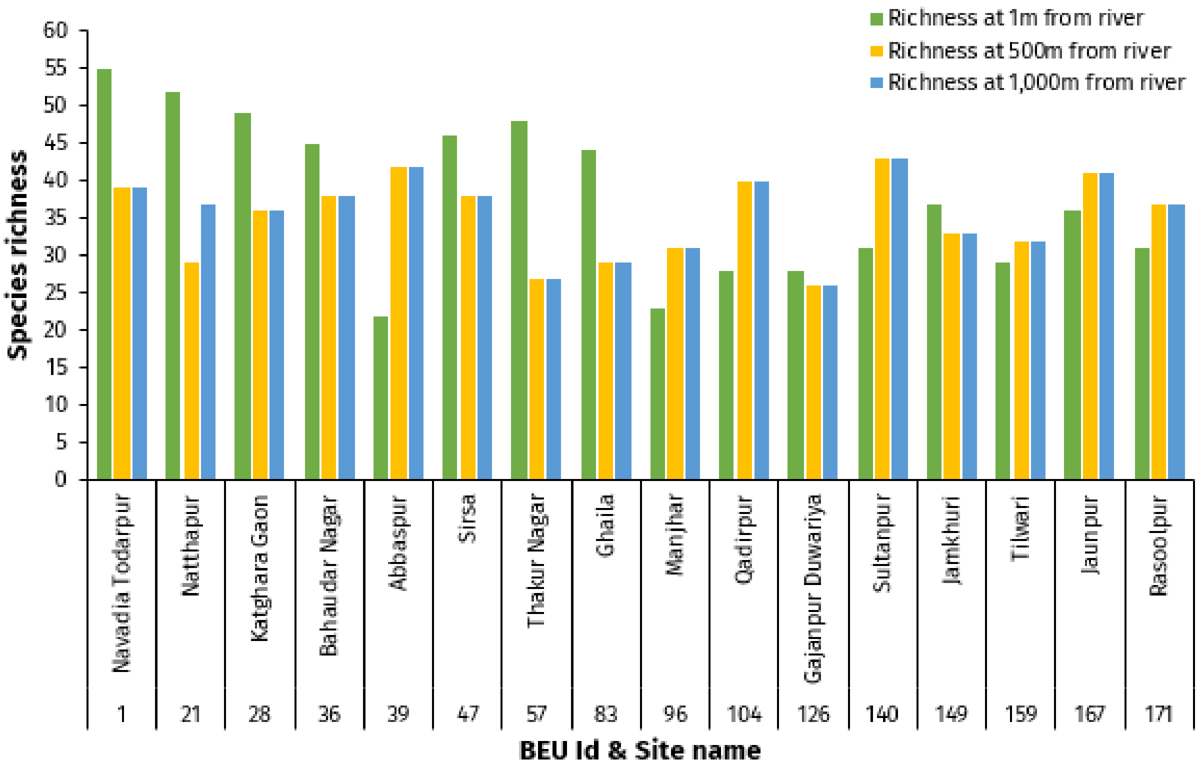


Figure 3.9. Richness of shrubs and grasses recorded along 1m, 500m and 1,000m distance from the Gomti River.

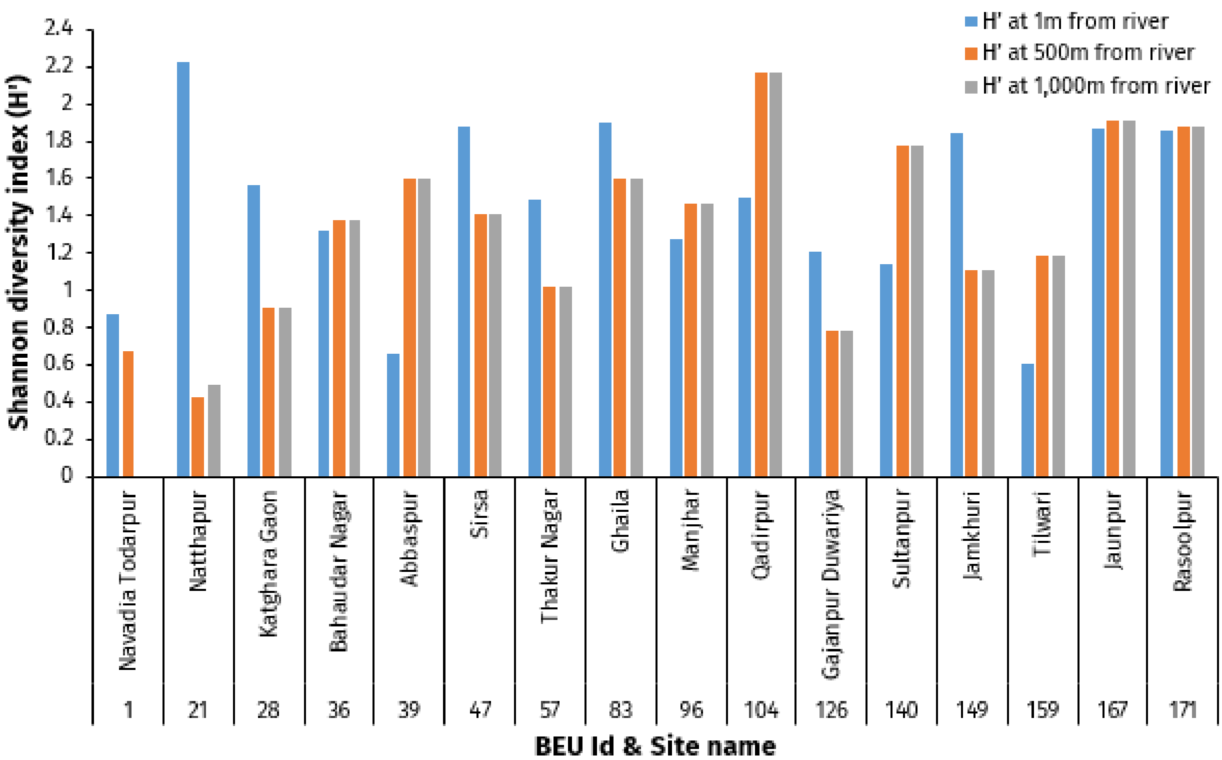


Figure 3.10. Shannon diversity index (H') for shrubs recorded along 1m, 500m and 1,000m distance from the Gomti River.

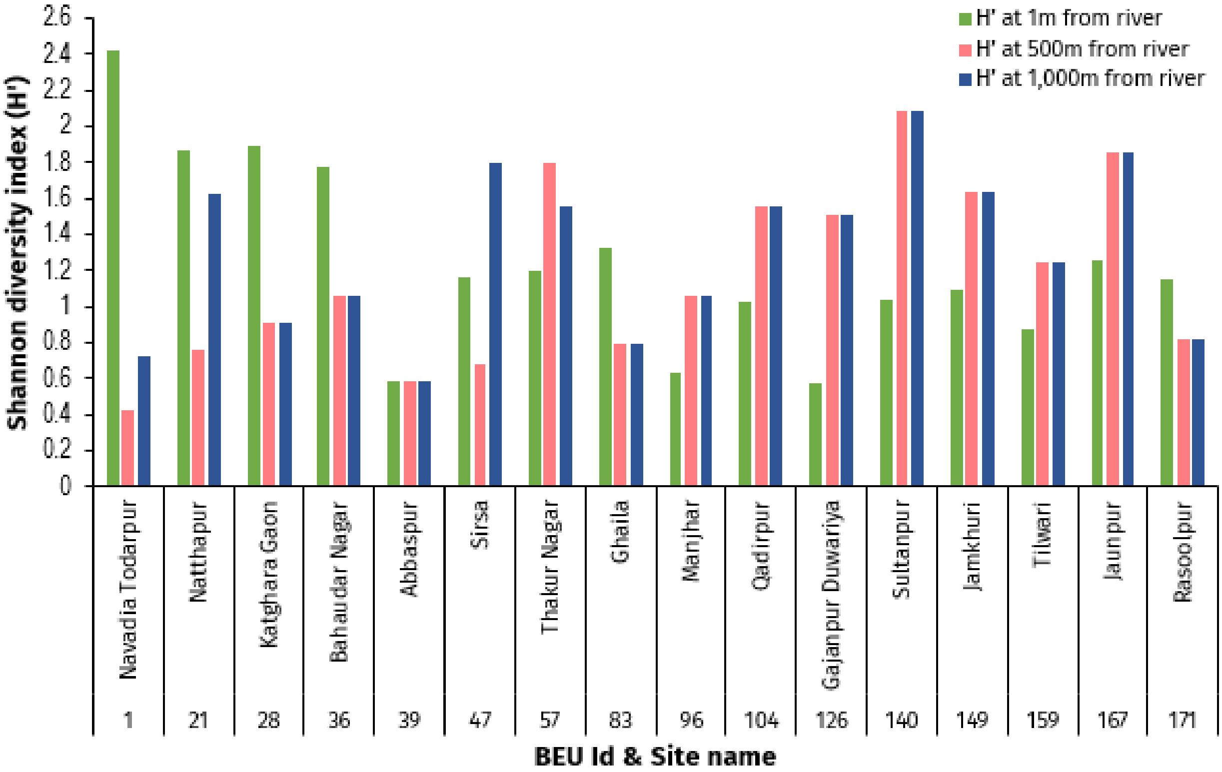


Figure 3.11. Shannon diversity index (H') for grasses recorded along 1m, 500m and 1,000m distance from the Gomti River.

Dominant shrubs and grasses

Dominant shrubs recorded during the survey are *Ipomoea carnea, Calotropis procera, Ricinus communis, Lippia alba, Abutilon indicum, Clerodendrum infortunatum, Lantana camara, Urena lobata, Murraya koenigii, Tamarix ericoides.* While, the dominant grass species include *Saccharum benghalensis, S. spontaneum, Typha anugustifolia, Phragmites karka, Vetiveria zizanioides, Cynodon dactylon, Cyperus rotundus, Fimbristylis* spp., *Schoenoplectiella juncoides, Juncus bufonius, Arundo donax, Bambusa bambos.* Based on percentage coverage, the dominant shrubs and grasses recorded are provided in table 3.5.

Table 3.5. Dominant shrubs and grasses recorded in the surveyed plots along the Gomti River.

Group	Dominant species
Shrubs	*Calotropis procera, Abutilon indicum, Clerodendrum viscosum, Phyllanthus reticulatus,* Ficus spp., Ziziphus spp., etc.
Shrubby weeds	*Ricinus communis, Lippia alba, Lantana camara,* etc.
Grasses	*Cynodon dactylon, Dichanthium annulatum, Sachharum benghalensis, S. spontaneum, Typha aungustifolia, Phragmites karka,* etc.


Abutilon indicum (L.) Sweet


Capparis zeylanica L.


Ficus heterophylla L.f.


Tamarix ericoides Rottler & Willd.


Ipomoea carnea Jacq.


Clerodendrum infortunatum L.

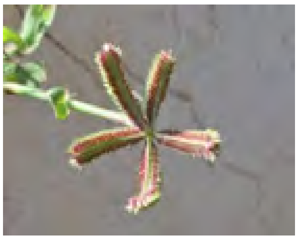

Glycosmis pentaphylla (Retz.) DC.

Plate 3.2. Some of the dominant shrubs recorded during survey along the Gomti River.

3.3.3. Herbs

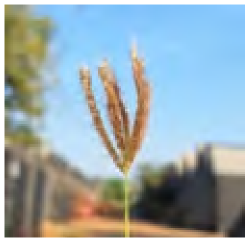
Herbs reported during the survey in the Gomti River basin are represented by 24 orders, 55 families, 164 genera and 231 species. Asteraceae (38 spp.) is the most dominant family, followed by Fabaceae (21 spp.), Amaranthaceae (16 spp.). Of the total herbaceous species recorded, 22 are aquatic, 151 species are semi-aquatic and 59 species are terrestrial. About 26% (60 spp.) of the total herbs recorded are found introduced. Dominant herb species along the Gomti River include *Grangea maderaspatana, Parthenium hysterophorus, Cannabis sativa, Tridax procumbens, Gnaphalium luteoalbum, Sphaeranthus indicus, Cirsium arvense, Blumea lacera, Ageratum conyzoides*, Solanum spp., *Nicotiana plumbaginifolia, Phyla nodiflora, Lindernia dubia, Basella alba.*

Species richness of herbs across the BEUs shows considerable variation. The highest richness of herbs is recorded at Thakur Nagar (BEU 57) with 74 species, followed by Katghara Gaon (BEU 28, 71 species), and Sultanpur (BEU 140, 69 species). While the lowest richness of herbs is recorded at Qadirpur (BEU 104) with 41 species, followed by Rasoolpur (BEU 171, 44 species), and Manjhar (BEU 96, 46 species) (Figure 3.12).


Dactyloctenium aegyptium (L.) Willd.


Cynodon dactylon (L.) Pers.


Cenchrus pedicellatus (Trin.) Morrone


Chloris barbata Sw.


Saccharum bengalense Retz.


Phragmites karka (Retz.) Trin. ex Steud.


Typha angustifolia L.

Plate 3.3. Some of the dominant grasses recorded during survey along the Gomti River.


Hydrilla verticillata (L.f.) Royle


Ottelia alismoides (L.) Pers.

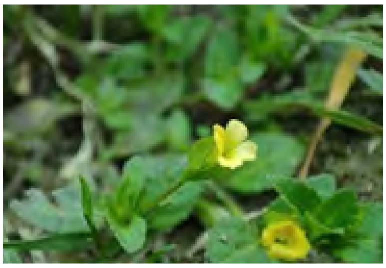

Potamogeton crispus L.


Alternanthera ficoidea (L.) P. Beauv.


Eichhornia crassipes (Mart.) Solms


Najas minor All.


Argemone mexicana L.


Mecardonia procumbens (Mill.) Small


Tribulus terrestris L.

Plate 3.4. Some of the dominant herbs recorded during survey along the Gomti River.

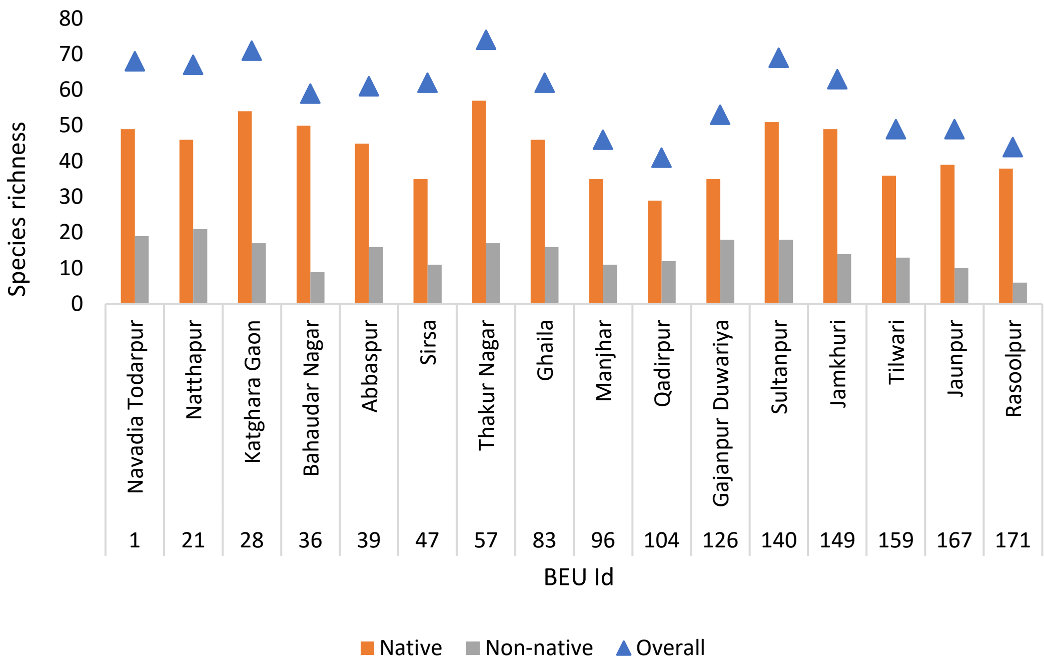


Figure 3.12. Richness and Nativity of herbaceous plants recorded at distance of 1m, 500m and 1,000m from the Gomti River.

3.3.4. Climbers

A total of 25 species of climbers are reported during the survey along the Gomti River belonging to 7 orders, 7 families (Table 3.1). Dominant families are Cucurbitaceae (9 spp.), Apocynaceae (7 spp.). 23 species are native and 02 species are introduced. Dominant climber species *Actinostemma tenerum, Coccinia grandis, Cucumis maderaspatanus, Momordica charantia, Trichosanthes cucumerina.*

3.3.5. Dominant hydrophytes

Aquatic species that are dominating the main river streams and seasonal rivulets are *Pontederia crassipes, Pistia stratiotes, Lemna minor, Spirodela polyrhiza, Azolla pinnata, Hydrilla verticillata, Ceratophyllum demersum, Ipomoea aquatica, Potamogeton crispus, Vallisneria natans, Ludwigia adscendens*, Polygonum spp, *Nelumbo nucifera* and Nymphaea spp.

3.3.6. Invasive and Non-native species

Of the 408 plant species recorded, 20.09% plants are found to be non-native. The majority of non-native species were found in the herbs, totaling 60 species (~26% of total herb species recorded during sampling) (Figure 3.13). Highest number of non-native plants were recorded in the Asteraceae family (18 species), followed by Fabaceae (13 species), Solanaceae, and Amaranthaceae (8 species each). Grasses and climbers are showing the highest nativity (over 90%), indicating minimal exotic introductions in these groups. Trees also maintain a strong native representation with ~86% nativity. Overall, the vegetation retains strong native dominance, though the presence of nearly one-fifth exotics suggests anthropogenic influence on community composition (Figure 3.13).

The BEU-wise trend shows that exotic species are consistently present across all sites, though their abundance varies with disturbance and site condition. Locations such as Nathapur (BEU 21), Katghara Gaon (BEU 28), and Abbaspur (BEU 39) record the highest exotic loads, while Bahadur Nagar, Rasoolpur, and Jaunpur retain relatively stronger native dominance. Herbs contribute the largest share of exotics across BEUs, reflecting their opportunistic and weedy nature, whereas shrubs and grasses play a comparatively smaller role. When examined along the river gradient, exotic species are lowest at the river's edge, increase sharply at 500 meters, and then decline again by 1,000 meters. This pattern suggests that the mid-distance zone is most vulnerable to invasion, likely due to its transitional position where both influence of riverine habitat and human activities such as grazing, cultivation, and settlement overlap, while the river edge and distant uplands maintain comparatively more native vegetation (Figure 3.14).

Major weeds encountered during the survey were *Pontederia crassipes, Alternanthera philoxeroides, Mikania micrantha, Ipomoea carnea, Mecardonia procumbens, Nicotiana plumbaginifolia, Urochloa mutica, Senna occidentalis, Lantana camara, Lippia alba, Ageratum conyzoides, Leucaena leucocephala, Pithecellobium dulce*. Species like *Pontederia crassipes* and *Pistia stratiotes* were seen forming dense mats on water surface thus choking the waterways. Dominant exotic species recorded along the Gomti River are presented in table 3.6.

Table 3.6. Habit-wise dominant Invasive and Non-native species recorded along the Gomti River during the present survey.

Habit-wise Plant group	Dominant exotic species
Tree	*Morus alba, Azadirachta indica, Pithecellobium dulce, Solanum erianthum, Leucaena leucocephala, Acacia auriculiformis* etc.
Shrub	*Hyptis suaveolens, Ipomoea carnea, Jatropha gossypiifolia, Lantana camara, Lippia alba*
Herb	*Ageratum conyzoides, Alternanthera pungens, Alternanthera ficoidea, Bidens pilosa, Cannabis sativa, Croton bonplandianus* etc.
Grass	*Paspalum distichum, Paspalum dilatatum, Urochloa mutica*

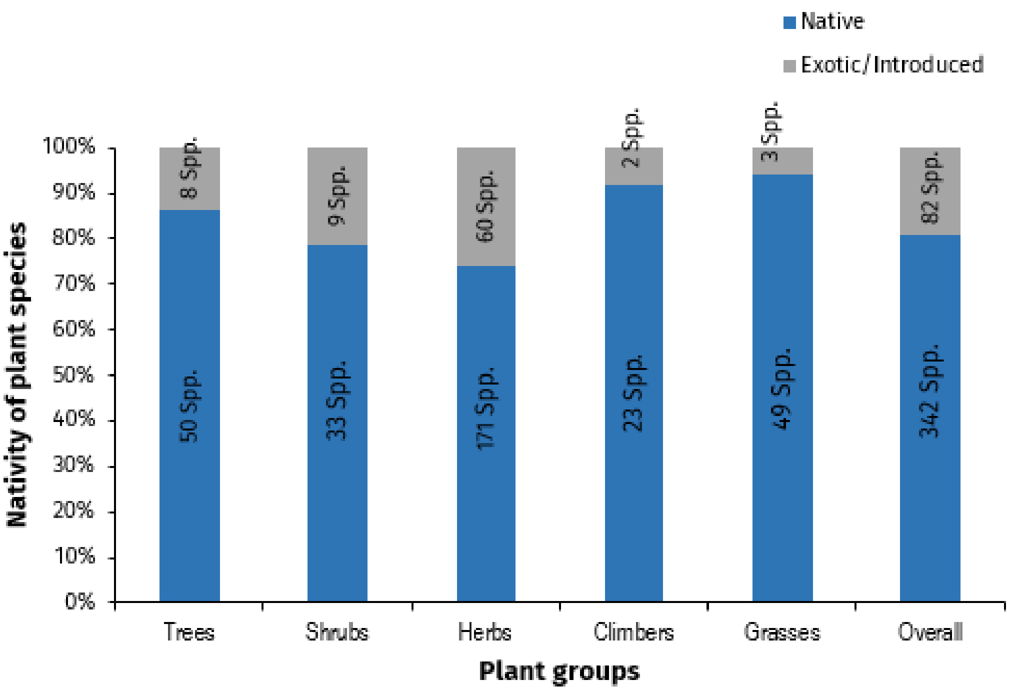


Figure 3.13. Nativity of plant species recorded along the Gomti River during the present survey.

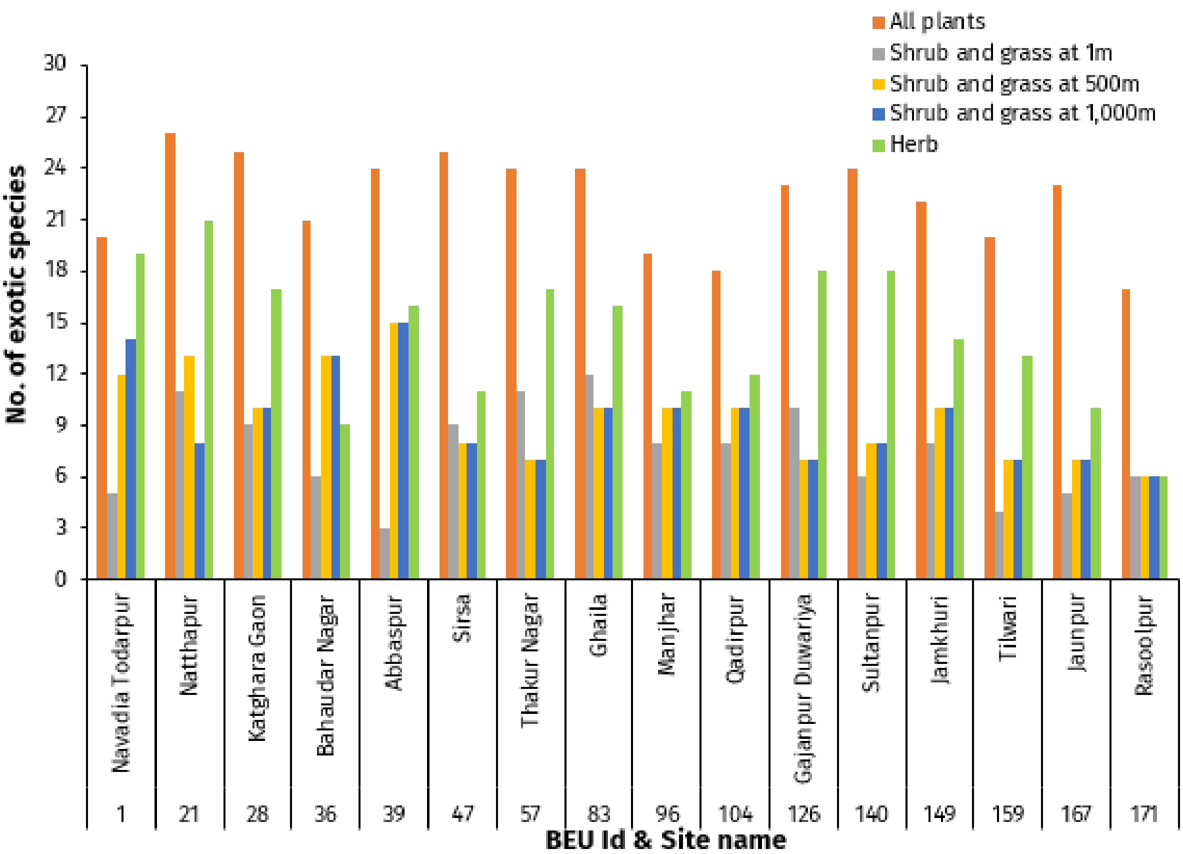


Figure 3.14. BEU-wise number of exotic species recorded along the Gomti River.

Plate 3.5. *Eichhornia crassipes* and *Pistia stratiotes* form dense mats over water surface choking the waterways in the Gomti River.

3.4. DISCUSSION

The Gomti River is a dynamic ecological system influenced by both natural processes and extensive human activity. Flowing through a largely agricultural landscape, the river is not highly prone to flooding but does experience seasonal variations during the monsoon, which alter its flow regime and impact riparian habitats. Research on the aquatic and associated plant communities along the Gomti River has primarily focused on specific stretches, for instance, Maheshwari and Tomar (1983) contributed to the baseline data for wetland flora of Sitapur district reporting 147 species belonging to 54 families. Mishra and Maurya (2002) studied Phyto-diversity of two wetlands from Jaunpur district i.e., Kunwarpur wetland and Gujar wetland reporting 36 and 66 species, respectively. Mishra and Narain (2014) reported 201 species belonging to 115 genera of 50 families from wetlands and marshy habitats of eastern Uttar Pradesh. Singh et al. (2013) recorded diversity of aquatic and wetland habitats of Lucknow district, reporting 210 species divided into six different habitats. The noteworthy plant studies in and around the Gomti River basin are represented in Table 3.7.

Our current intensive biodiversity study in and along the Gomti River focuses on the habits including trees, shrubs, grasses and herbs revealed vegetation patterns as the tree richness and diversity along the river showed strong interplay between land use, hydrology, and human disturbance. Sites dominated by agriculture and exotic plantations (e.g., Eucalyptus, Populus) specifically at the 500 m and 1000 m transects showed low diversity and monodominance, while meandering stretches and tributary junctions supported higher richness and structurally diverse communities, often anchored by native species like *Dalbergia sissoo, Ficus religiosa,* and *Terminalia arjuna*. Soil substrate at a distance of 1 m from the river was sandy which restricted establishment of new plants to a few hardy dominants and many other contributing species resulting in balanced IVI distributions. Whereas at 500 m and 1000 m, species composition reflected gradients of human influence from plantation-driven or culturally valued dominants (*Azadirachta indica, Borassus flabellifer, Leucaena leucocephala*) to semi-natural mosaics with IVI value distributed between few dominating species. Urban BEUs retained moderate diversity through older avenue and institutional plantations, while scattered multipurpose species persisted in agrarian zones.

The diversity of shrubs and grasses with their nativity reflecting again a clear distance-driven gradient. At a distance of 1 m, proximity to the river sustained localized richness, especially where wetland conditions and riparian microhabitats supported native shrubs and grasses. At a distance of 500 m from river bank, agricultural expansion and habitat simplification dominated, though scattered wetlands and land-use heterogeneity allowed certain BEUs to retain moderate diversity. At a distance of 1000 m from the river bank, intensive cultivation drives sharp declines in shrub richness, with diversity maintained only in pockets linked to field margins, plantations, or semi-natural remnants. The variation in richness and nativity of herbs across the locations were also shaped by differences in land-use intensity, habitat continuity, and human disturbance. Low richness coincided with areas of habitat fragmentation and conversion for agriculture, whereas higher richness aligned with remainder vegetation patches, community-managed green spaces, and agricultural buffer zones.

Similarly, non-native species dominance reflected anthropogenic pressures such as urban encroachment, roadside vegetation change, and field-edge disturbances, while balanced native–non-native compositions showed stronger ecological stability and less intensive land modification. Together, these results highlight the riverbank as a critical biodiversity refuge, with diversity diminishing as land-use pressures increase away from the river. Overall, the Gomti River’s riparian tree, shrub, grass, and herb communities changed from simple, human-modified stands to more ecologically complex patches in places that were culturally and hydrologically important. This shows how important it is to restore ecosystems using native species.

Table 3.7. Plant studies conducted in and around Gomti River basin, Uttar Pradesh.

Studies	Study area	No. of species
Duthie (1903-1929) (3 volumes)	Upper Gangetic plains in Uttar Pradesh and Uttarakhand	2,400
Reddy et al. (2007)	Raebareili	149
Singh et al. (2013)	Lucknow district	210
Garg & Joshi (2015)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	219
Garg & Joshi (2018)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	243
Singh et al. (2020)	Lucknow district	1,263
Singh et al. (2020)	Lucknow district	102
Prajapati & Singh (2024)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	28
Avishek et al. (2025)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	22
Sonkar et al. (2025)	Pilibhit Tiger Reserve	123
Verma et al. (2025)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	254
Present study	Along the Gomti River	408

3.5. CONCLUSION

The findings from this study highlight that the Gomti River and its riparian corridor continue to serve as a crucial biodiversity refuge, despite significant human pressures. Tree, shrub, grass, and herb vegetation patterns showed that species richness and nativity were highest near the river and in semi-natural or hydrologically buffered habitats. In certain transects, exotics dominated, highlighting anthropogenic change, while native species provided ecological stability in less damaged areas.

The present study, therefore, holds unique significance as the first comprehensive floristic assessment conducted across the entire stretch of the Gomti River in Uttar Pradesh, encompassing aquatic, semi-aquatic, and riparian vegetation along its length. These results emphasize that the ecological integrity of the Gomti is tightly linked to land-use practices and riparian management. Protecting and restoring native vegetation, reducing exotic monocultures, and conserving semi-natural mosaics along the river would be essential steps toward maintaining biodiversity and ecosystem services. Strengthening such conservation efforts will not only enhance riverine health but also support community livelihoods, water quality, and the broader goals of river rejuvenation.

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CHAPTER 04

ICHTHYOFAUNA OF GOMTI RIVER

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SUMMARY

Freshwater fish are crucial to aquatic ecosystems, human health, and local economies. They maintain ecological equilibrium by enabling nutrient cycling and controlling trophic dynamics, thereby enhancing the overall productivity of the freshwater ecosystems. There are around 3,532 identified fish species in India, with freshwater environments accounting for 30% of the total. Hamilton (1822) described 272 fish species from the Ganga and its tributaries, with 177 being accepted as valid today. The Gomti River, which is a tributary of the Ganga River, harbours a relatively rich and diverse array of freshwater fish, including several species of conservation concern. Numerous ichthyological investigations have been undertaken in Uttar Pradesh's Gomti River and its tributaries, with fish species ranging from 6 to 83. The current study focused on the current state of ichthyofaunal diversity, distribution, and abundance, as well as the assessment of Hydro-morphology and physicochemical parameters in the sampling sites of the Gomti River.

Fish samples were collected at 11 sampling sites in the Gomti River during the post-monsoon season in January 2024. A total of 193 individuals representing 41 fish species belonging to 9 orders, 17 families, and 31 genera were recorded during the post-monsoon period in January 2024, between Gomat Tal and Kaithi across the Gomti River. Out of 41 species, 39 species are native and two species are non-

native. The most dominant order was Cypriniformes, which contributed 21 species. Family Cyprinidae contributed the highest number of species (13) followed by Danionidae (7) and Bagridae (4). The highest species richness (23 species) was recorded in the sampling points situated in the middle and lower zones, while the lowest species richness (11 species) was recorded in the sampling sites situated in the upper zone. The highest Shannon diversity was recorded at sampling Site-11 at Kaithi (H' =2.74) and the lowest was recorded in Jalalpur (H'=0.93), The highest catch per unit effort for fish (number of fish individuals recorded per panel hour) was recorded at Jalalpur 36.33 individuals per panel hour) and the lowest was recorded at Sultanpur (0.75 individuals per panel hour). The analysis of relative abundance indicated a dominance of small indigenous species, including *Pethia ticto* (48.19%), *Cabdio morar* (3.63%), *Puntius sophore* (3.63%), *Devario devario* (3.11%), *Labeo bata* (2.59%), *Laubuka laubuca* (2.59%), *Chanda baculis* (2.59%), *Esomus danrica* (2.07%) etc.

Among the 41 fish species recorded in the current survey of the Gomti River, *Clarias magur* was in Endangered (EN), *Ompok bimaculatus* is Near Threatened (NT) and *Sperata lamarri* is Not Evaluated (NE) categories of IUCN redlist. Whereas, 36 species were Least Concern (LC) in the IUCN Red List. Presence of two alien species, *Cyprinus carpio* and *Oreochromis niloticus*, is, however, a cause of concern due to their possible ecological impacts on indigenous fish populations. Environmental characteristics, such as average flow, had the largest positive link with fish diversity, emphasizing the necessity of maintaining natural hydrological regimes. Human-induced pressures, including high pollution from urban and agricultural runoff, habitat change, water diversion, invasive species introduction, and destructive fishing methods, all pose a substantial threat to fish diversity in the Gomti River. Preserving biodiversity requires immediate action. Priorities should include habitat restoration, invasive species control, and fishing regulations. Increasing community engagement, improving water quality, and enhancing water flow during dry seasons will support the long-term survival of fish populations in this tributary of the Ganga River.

4.1. INTRODUCTION

Freshwater fish are crucial to the functioning of aquatic ecosystems, human well-being, and local economies. They are essential for sustaining ecological equilibrium by facilitating nutrient cycling and regulating trophic dynamics, thereby enhancing the overall productivity of freshwater ecosystems (Mota et al., 2014). Freshwater fish are essential elements of food webs, sustaining many aquatic and terrestrial predators, underscoring their ecological importance.

Currently, approximately one-third of freshwater fish species face extinction due to several threats, including river damming, wetland drainage, excessive water abstraction for irrigation, discharge of untreated waste, unsustainable fishing practices, introduction of invasive and non-native species. These threats are exacerbated under the intensifying effects of climate change (Hughes, 2021). Enhancing conservation initiatives for freshwater fish is crucial, not only for safeguarding species but also for maintaining the ecosystem functions that both nature and humans depend upon.

The fish fauna is one of the largest vertebrate groups, with more than 36,640 known species described globally. Remarkably, about 51% of them are found in freshwater ecosystems (Fricke et al., 2025; Hughes, 2021). In India, there are about 3,532 recognised fish species, with approximately 30% residing in freshwater ecosystems (Chandra et al., 2017; Kosygin et al., 2024). Hamilton (1822) documented 272 fish species from the Ganga and its tributaries, emphasising that "the list is far from complete". In that study, Hamilton (1822) recorded 260 species new to science, of which 177 species are recognised as valid currently (Chandra et al., 2017). Later on, Talwar & Jhingran (1991) reported a total of 375 fish species from the Ganga main stem. A total of 153 fish species have been recorded from the state of Uttar Pradesh (Kosygin et al., 2024). Numerous ichthyological studies have been conducted in the Gomti River and its tributaries in Uttar Pradesh over the years, documenting fish species ranging from 6 to 83 (Table 4.2). Previous investigations revealed that a total of 115 valid fish species have been recognized as inhabiting the Gomti River and its tributaries (Annexure II). The present study focused on the current status of ichthyofaunal diversity, distribution, abundance and the assessment of the environmental variables that influence the fish diversity in the Gomti River.

4.2. METHODS

Fish were sampled at 11 sampling sites along the Gomti River during the post-monsoon season during January-February 2024 (Figure 4.1). The sampling sites and their geographical coordinates and hydro morphology are given in the table below (Table 4.1). Fish samples were collected at selected sites along the Gomti River course from Gomat Tal to Kaithi using standard fishing gear and nets. Cast nets, drag nets, and monofilament gill nets with varying mesh sizes (0.5 to 5 inches) were strategically deployed with the help of fishermen during the survey. A gill net measuring 50x1 meters, with a 0.5-inch mesh dimension was used at minimal depths for up to 30 minutes to minimize unintended fish captures. An average of 2 hours of net effort was applied at each sampling site. Fish samples were collected during morning (06:00-08:00hrs) and evening (16:00-18:00hrs) sessions. Habitat parameters such as river width were measured with a range finder, depth was recorded using a Hondex depth sounder Model-PS-7, and flow was measured with the Geopack Advanced River Pack digital flow meter. Physicochemical parameters were 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 (2010), Talwar and Jhingran (1991), and the electronic version of FishBase (Froese & Pauly, 2025).

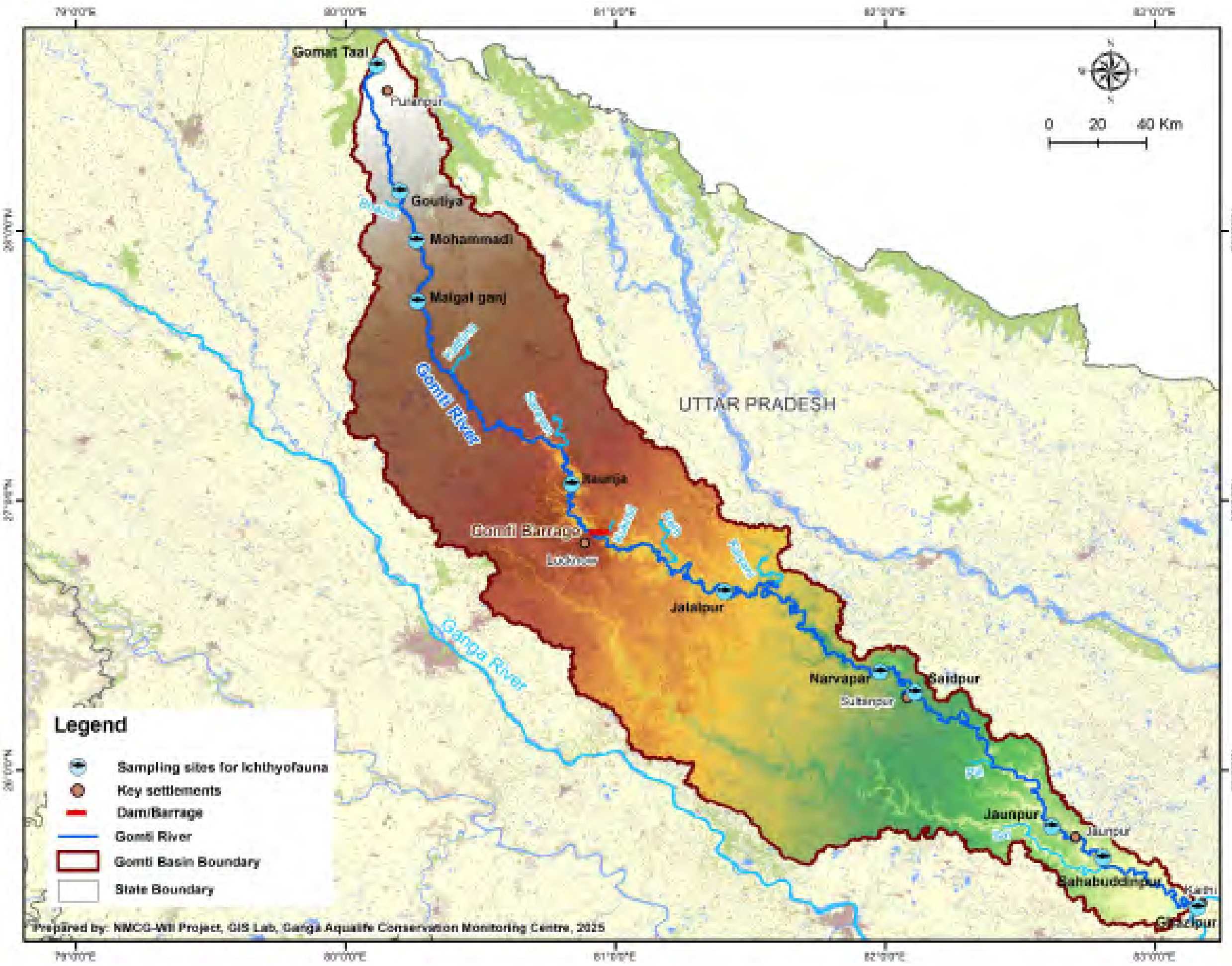


Figure 4.1. Ichthyofauna sampling sites along the Gomti River, Uttar Pradesh, India.

Table 4.1. Hydro-morphology and physicochemical parameters of water were recorded at the fish sampling sites in the Gomti River during the survey.

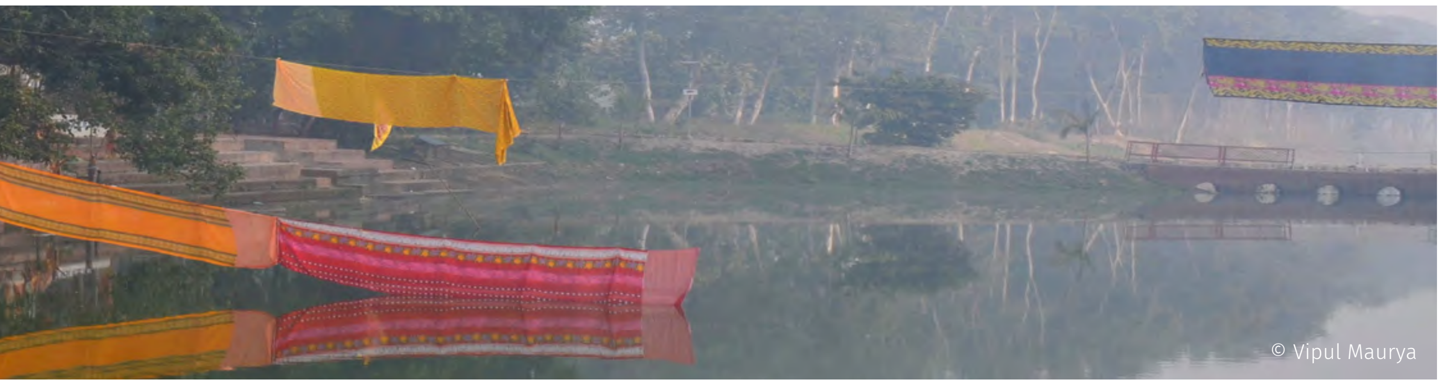
Site No.	Site Name	Average Width (m)	Average Depth (m)	Elevation (m)	Average Flow (m/s)	Water Temp (°C)	Conductivity (µs/cm)	TDS (ppm)	pH
1	Gomat Tal	35	1.17	176	0.63	12.1	133	77	7.24
2	Goutiya	36.67	1.83	138	0.43	13.4	125	74	8.13
3	Mohammadi	56.67	1.0	114	0.42	13.8	127	75	7.86
4	Maigal Ganj	83.33	2.3	114	0.41	15.9	125	73	8.31
5	Itaunja	71.67	2.07	99	0.6	13.9	128	77	8.41
6	Jalalpur	107.67	1.53	134	0.46	18.5	117	70	7.44
7	Narvapar	105	1.0	109	0.47	18.5	126	76	8.2
8	Sultanpur	111.67	0.83	105	0.35	14.3	124	73	7.78
9	Jaunpur	105	1.0	109	0.47	14.6	122	73	7.7
10	Sahabuddinpur	104	2.23	92.95	0.48	16.6	123	74	8.02
11	Kaithi, Ghazipur	201.67	1.67	96.46	0.63	17.3	116	70	8.06

4.3. RESULTS

4.3.1. Species richness and diversity

A total of 41 fish species belonging to 9 orders, 17 families, and 31 genera were recorded from the 11 sampling sites in the Gomti River during the post-monsoon period in January 2024, as compared to a total of 115 species belonging to 12 orders, 37 families, and 77 genera recorded from the river to date (Annexure II). The Cypriniformes was the most abundant order with 21 species followed by Siluriformes (7 species), Anabatiformes (4 species), and Mugiliformes (4 species) in the present survey (Figure 4.2). The Cyprinidae was the most dominant family with 13 species, followed by Danionidae (n=7) and Bagridae (n=4) recorded during the present survey (Figure 4.3).

The sampling sites in the middle zone of the Gomti River from Sitapur to Sultanpur and lower zone from Sultanpur to the confluence point of the river with the Ganga recorded the highest number of species (n=23), while the sampling points in the upper zone from the origin to Sitapur had the lowest species richness (n=11) (Figure 4.4). The sampling site-11 at Kaithi had the most incredible diversity of fish species with a Shannon's Diversity Index (H') value of 2.74, followed by site-5 at Itaunja (H' = 2.37), Site-10 at Sahabuddinpur (H' = 2.28), site-1 at Gomat Tal (H' = 2.01), site-9 at Jaunpur (H ' = 1.89), site-8 at Sultanpur (H' = 1.89), site-3 at Mohammadi (H' = 1.81), site-7 at Narvapar (H' = 1.63), site-2 at Goutiya (H' = 1.58), site-4 at Maigal ganj (H' = 1.57), and site-6 at Jalalpur (H' = 0.93) respectively (Figure 4.5).



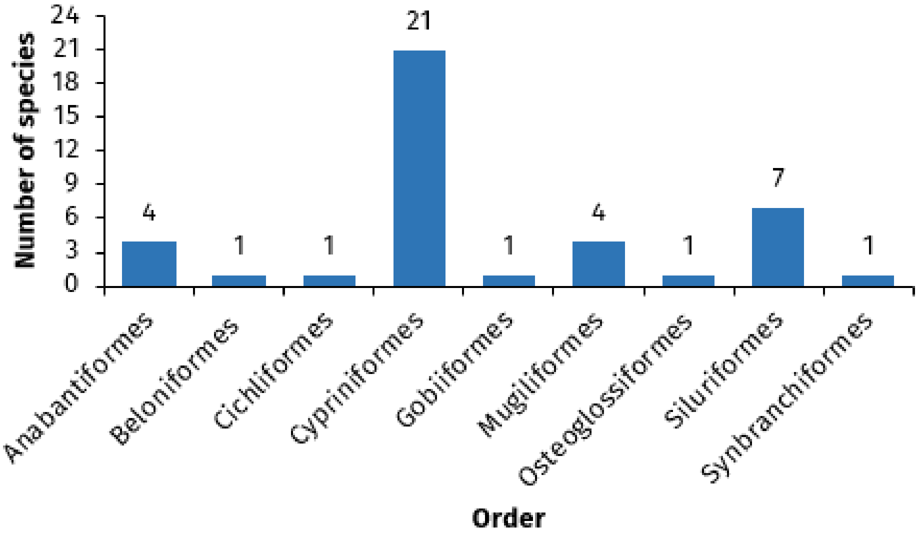


Figure 4.2. Order-wise number of fish species recorded from the 11 sampling sites in the Gomti River.

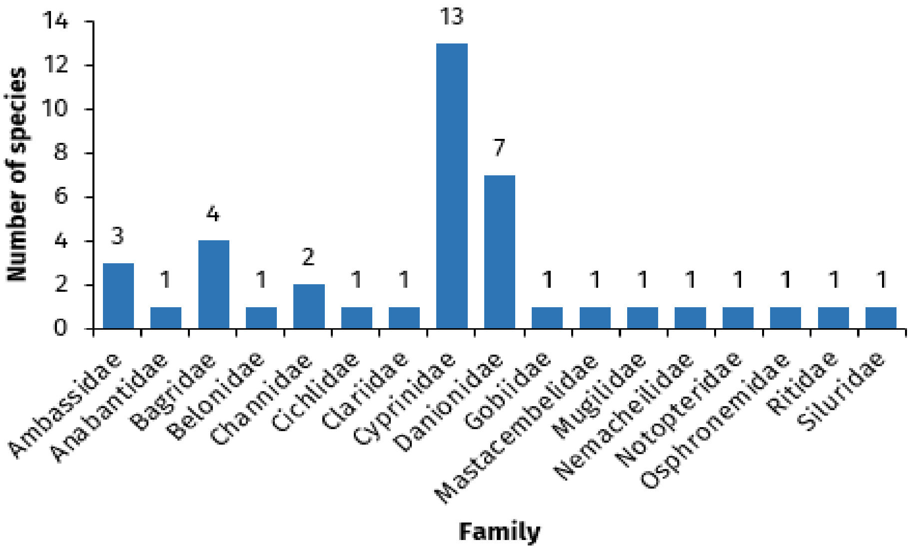


Figure 4.3. Family-wise number of fish species recorded from the 11 sampling sites in the Gomti River during January 2024.

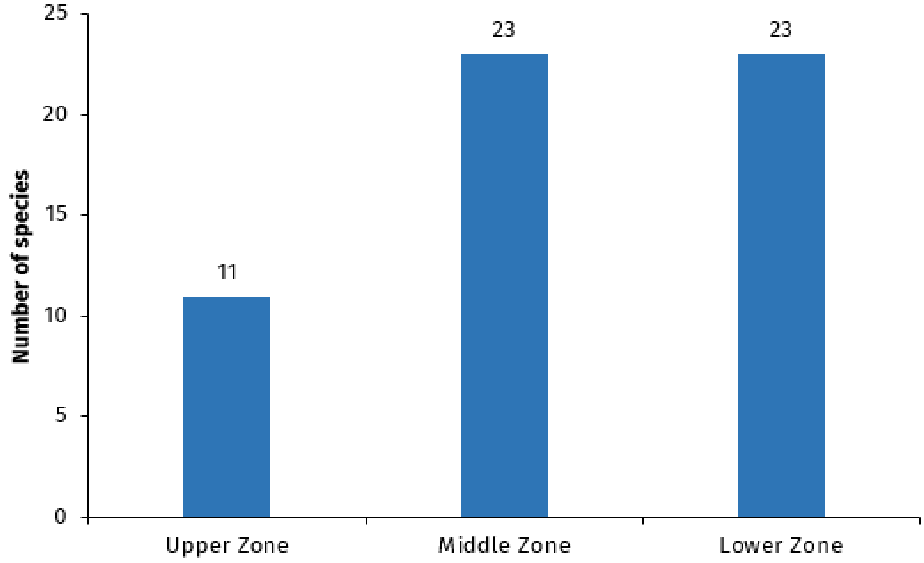


Figure 4.4. Zone-wise species richness of fish recorded from the 11 sampling sites in the Gomti River during January 2024.

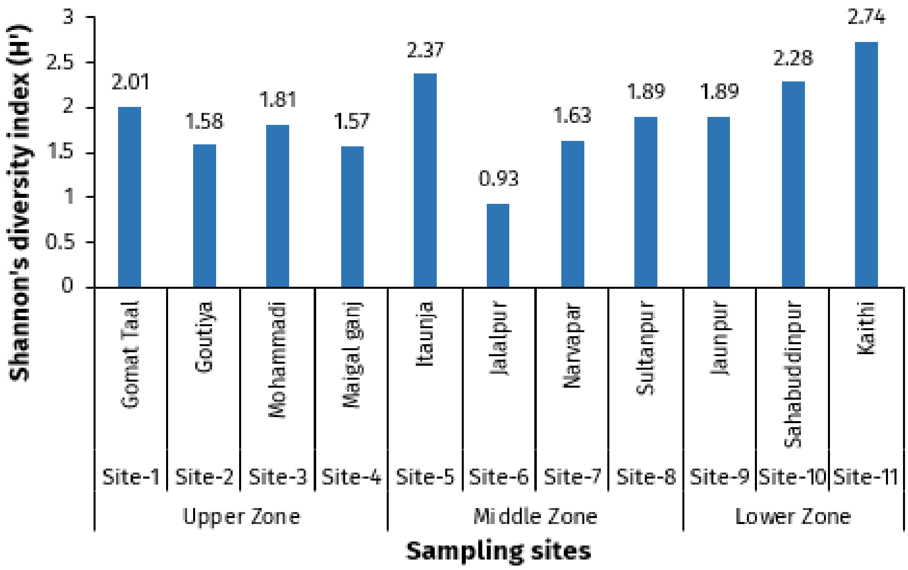
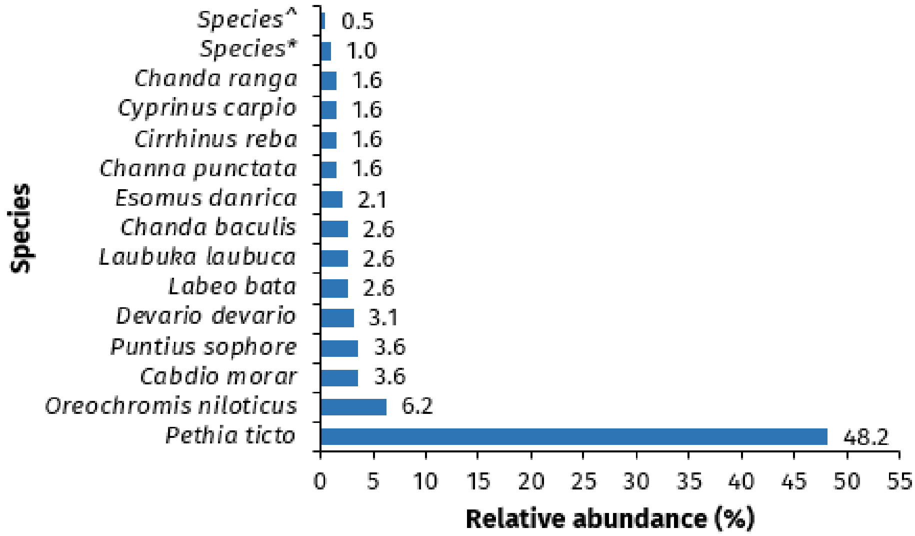


Figure 4.5. Shannon's diversity index (H') of fish community for the 11 sampling sites in the Gomti River, surveyed during January 2024.



Species Chagunius chagunio, Labeo gonius, Osteobrama cotio, Puntius chola, Rita rita, Salmostoma bacaila, Sperata lamarrii, Trichogaster fasciata,* and *Xenentodon cancila*

Species^ Amblypharyngodon mola, Anabas testudineus, Chanda nama, Channa striata, Cirrhinus mrigala, Clarias magur, Glossogobius giuris, Labeo calbasu, Macrognathus pancalus, Mystus bleekri, Mystus cavasius, Notopterus synurus, Ompok bimaculatus, Paracanthocobitis botia, Pethia conchonius, Rasbora daniconius, Rhinomugil corsula, Sperata aor, and *Tariquilabeo latius*

Figure 4.6. Relative Abundance of the fish species recorded at the 11 sampling sites in the Gomti River.

4.3.2. Relative Abundance

Relative abundance was highest for the species *Pethia ticto* (48.19%) among the 41 species recorded during the post-monsoon period in January 2024, which was followed by the species *Oreochromis niloticus* (6.2%), *Cabdio morar* (3.6%), *Puntius sophore* (3.6%), and *Devario devario* (3.1%), respectively. At the same time, the lowest relative abundance of 0.5% was calculated for 19 species provided in Figure 4.6.

4.3.3. Catch Per Unit Effort (CPUE)

The highest catch per unit effort for fish (number of fish individuals recorded per panel hour) was recorded at Jalalpur (36.33 individuals per panel hour), followed by Goutiya (6 individuals per panel hour), Mohammadi (5.33 individuals per panel hour), Gomat Tal (5 individuals per panel hour) and Maigal ganj (4.67 individuals per panel hour). The lowest CPUE were recorded at Sultanpur (0.75 individuals per panel hour) and Narvapar (0.83 individuals per panel hour) along the river course of Gomti River (Table 4.7).

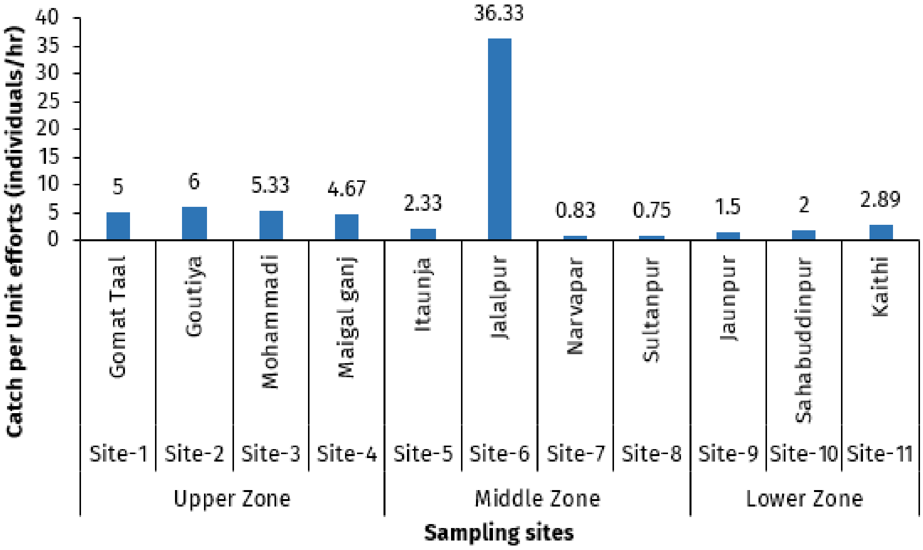


Figure 4.7. Catch Per Unit Effort (CPUE) of fish recorded at 11 sites along the Gomti River in January 2024.

4.3.4. Status of species with conservation significance

Of the 41 fish species recorded during the present survey from the Gomti River, *Clarias magur* and *Ompok bimaculatus* are listed as Endangered (EN) and Near Threatened (NT), respectively, in the IUCN Red List of Threatened Species. While 87.80% (n=36) of the recorded native species are Least Concern (LC) and one species is Not Evaluated (NE) in the IUCN Red List (Figure 4.8). Species such as *Chitala chitala, Cirrhinus mrigala, Wallago attu, Labeo bata, Labeo rohita, Sperata lamarrii, Sperata aor,* and *Channa punctata* are the indicators of a river's health. They are considered to have significant value for conservation. The presence of these species is a reflection of the river's habitat condition as well as overall ecological stability. For instance, *Chitala chitala* is a top predator, influencing the population dynamics of smaller fish and maintaining balance within the aquatic community. Similarly, species like *Labeo rohita* and *Cirrhinus mrigala* are essential for controlling algae and other aquatic plants, which helps prevent overgrowth that can choke the river.

4.3.5. Status of invasive species

A total of 10 exotic species have been recorded from the Gomti River to date. Of which, two exotic species, namely *Cyprinus carpio* and *Oreochromis niloticus,* were recorded during our present survey from the river in January 2024, which are invasive to India (Plate 4.2). *O. niloticus* was recorded from the three sampling sites viz., Belawon bridge, Sahabuddinpur, and Kaithi, while *C. carpio* was recorded from Mohammadi, Jalalpur and Kaithi. *O. niloticus* was the widely distributed invasive species during the survey, with a relative abundance of 6.22%, while *C. carpio* has 1.55%.

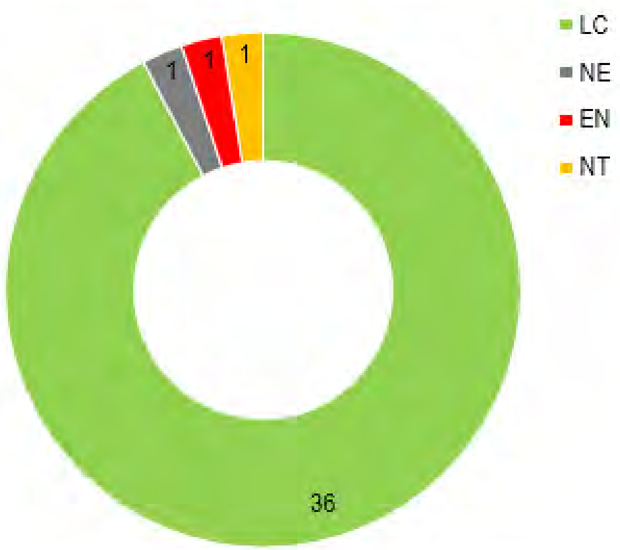


Figure 4.8. IUCN status of native fish species recorded from the Gomti River.

I. *Wallago attu*

II. *Labeo rohita*

III. *Chitala chitala*

IV. *Labeo bata*

Plate 4.1. Fish species with conservation significance recorded from the Gomti River.

I. *Cyprinus carpio*

II. *Oreochromis niloticus*

Plate 4.2. Invasive fish species were recorded from the Gomti River during the present survey in January 2024.

4.4. DISCUSSION

The present study recorded 35.65% of the total fish species recorded in the Gomti River and its tributaries. The 41 species recorded in the present study are comparable to those reported in previous studies: Kumar & Rao (2009) recorded 64 fish species, Sarkar et al. (2010) recorded 56 species, Gupta & Tripathi (2017) documented 61 species from the Lucknow reach of the Gomti River, and Kumar et al. (2023) reported 56 species from the middle stretch of the Gomti River. The summary of previous studies in the Gomti River and its tributaries is presented in Table 4.2. Similarly, Sarkar et al. (2007) documented 46 species from the Samaspur Bird Sanctuary (also a Ramsar site) situated in the Gomti River basin, indicating a comparable richness to the present findings.

The spatial distribution of fish species in the Gomti River demonstrates clear ecological trends. The higher elevations have low species richness, perhaps due to diminished flow, seasonal water constraint, and a restricted catchment area. Conversely, the downstream segments demonstrate increased habitat variability, characterized by fluctuations in depth and flow, which facilitate higher species richness via a broader array of ecological niches (Guegan et al., 1998; Oberdorff et al., 1993; Aarst & Nienhuis, 2003). Variations among sites were apparent, with the Kaithi sampling site exhibiting the highest diversity (H' = 2.74), while Jalalpur recorded the lowest (H' = 0.93). Notably, Jalalpur recorded the highest catch per unit effort (36.33 individuals per panel hour), indicating the prevalence of a limited number of opportunistic or disturbance-tolerant species. Conversely, Sultanpur, with the lowest CPUE (0.75 Individuals per panel hour), likely signifies a habitat under stress due to poor quality or resource constraints. The fish community predominantly comprised of small-sized native species, including *Pethia ticto*, *Puntius sophore*, *Cabdio morar*, *Laubuka laubuca, and Chanda baculis. Multiple species of conservation significance*, *namely Ompok bimaculatus*, *Notopterus synurus*, *Cirrhinus reba*, *Sperata aor*, and *Rita rita*, were documented, underscoring the ecological value of the Gomti River. A major concern is the invasion by non-native species, including *Cyprinus carpio* and *Oreochromis niloticus*. These two species were observed in significant numbers at multiple sites. Their increasing presence, indicated by juvenile specimens, poses a serious threat to native fish populations through competitive exclusion and ecological disruption. Previous research (Gupta, 2011; Sarkar et al., 2012; Kumar et al., 2023) has also documented their presence in the river. Despite these pressures, several native species, such as *Pethia ticto* (48.19%), *Puntius sophore* (3.63%), and *Devario devario* (3.11%), remain, demonstrating resilience to environmental changes and remaining viable candidates for conservation efforts.

Of the total species recorded from the Gomti River, six Near Threatened (NT) species, two Vulnerable (VU) species, one Endangered (EN) species namely *Clarias magur*, and one Critically Endangered (CR) species namely *Pinniwallago kanpurensis* were found in the IUCN Red List (Annexure II). But the present survey recorded only one Endangered and one Near Threaten species from the Gomti River (Figure 4.8; Annexure II). Low number of threatened species recorded from the present study underscores the need of intensive survey in the Gomti River.

Among environmental variables, average flow showed the strongest positive correlation with fish diversity, highlighting the importance of preserving natural hydrological regimes. Tiwari (2014) noted that pollution-tolerant species dominated due to poor water quality, especially in the Jaunpur segment of the Gomti River. Several human-induced stresses pose a significant threat to the fish diversity in the Gomti River. These include heavy pollution from urban and agricultural runoff, habitat alteration, water diversion, introduction of invasive species, and harmful fishing methods, such as using toxins and fine mesh nets. The deliberate killing of brooders and juveniles further worsens population decline. The use of pesticides, particularly endosulfan, has led to substantial fish mortality and ecological decline (Sheela & Brat, 2021).

Immediate conservation actions are vital to prevent further biodiversity loss. Priorities should include habitat restoration, control of invasive species, and enforcement of fishing regulations. Increasing community engagement, improving water quality, and enhancing water flow during dry seasons will be crucial for maintaining the long-term health of fish populations in this important tributary of the Ganga River.

Table 4.2. Summary of ichthyofaunal diversity documented in the Gomti River and its tributaries from previous studies.

Previous studies	Study area	No. of Species
Srivastava (1995) *	Lohanipur, Rajghat, Munshiganj, Dariyapur, Jagdishpur & Behta khurd from Sai River	54
Singh (2006)	Gomti River	23
Kumar and Rao (2009)	Gomti River in Faizabad and Sultanpur District	64
Sarkar et al. (2010)	Gomti River at Sitapur, Lucknow, Haidergarh, Sultanpur and Jaunpur sites	56
Singh (2010) *	River Gomti and Gujartal in Jaunpur	46
Singh (2011)	Gomti River at Sahipul	42
Gupta (2011)	Gomti River at Pilibhit, Sitapur, Lucknow, Haidergarh and Jaunpur sites	62
Sarkar et al. (2012)	Gomti River at Pilibhit, Sitapur, Lucknow, Sultanpur and Jaunpur sites	5
Singh et al. (2013)	Gomti River	6
Srivastava and Singhal (2015)	Gomti River at Lucknow	70
Verma et al. (2015)	Gomti River at Lucknow	83
Bano and Serajuddin (2016)	Gomti River at Lucknow	56
Gupta and Tripathi (2017)	Gomti River at Lucknow	61
Rani and Kumar (2020) *	Sai River, tributary of Gomti River	22
Mishra and Mishra (2021)	Gomti River in Sultanpur and Jaunpur Districts	52
Mishra et al. (2021)	Gomti River at Sultanpur and Jaunpur	56
Yadav and Mishra (2021)	Gomti River	62
Krishna (2022)	Gomti River in Sultanpur district	41
Kumar et al. (2023)	Middle stretch of Gomti River	56
Sahu et al. (2024)	Gomti River at Daliganj, Lucknow, Mehndi Ghat, Lucknow, Golaghat, and Sultanpur sites	76
Present study	Gomti River at Gomat Tal, Goutiya, Mohammadi, Maigal ganj, Itaunja, Jalalpur, Saidpur, Narvapar, Chhunchha Bridge, Belawon bridge, Kaithi	41

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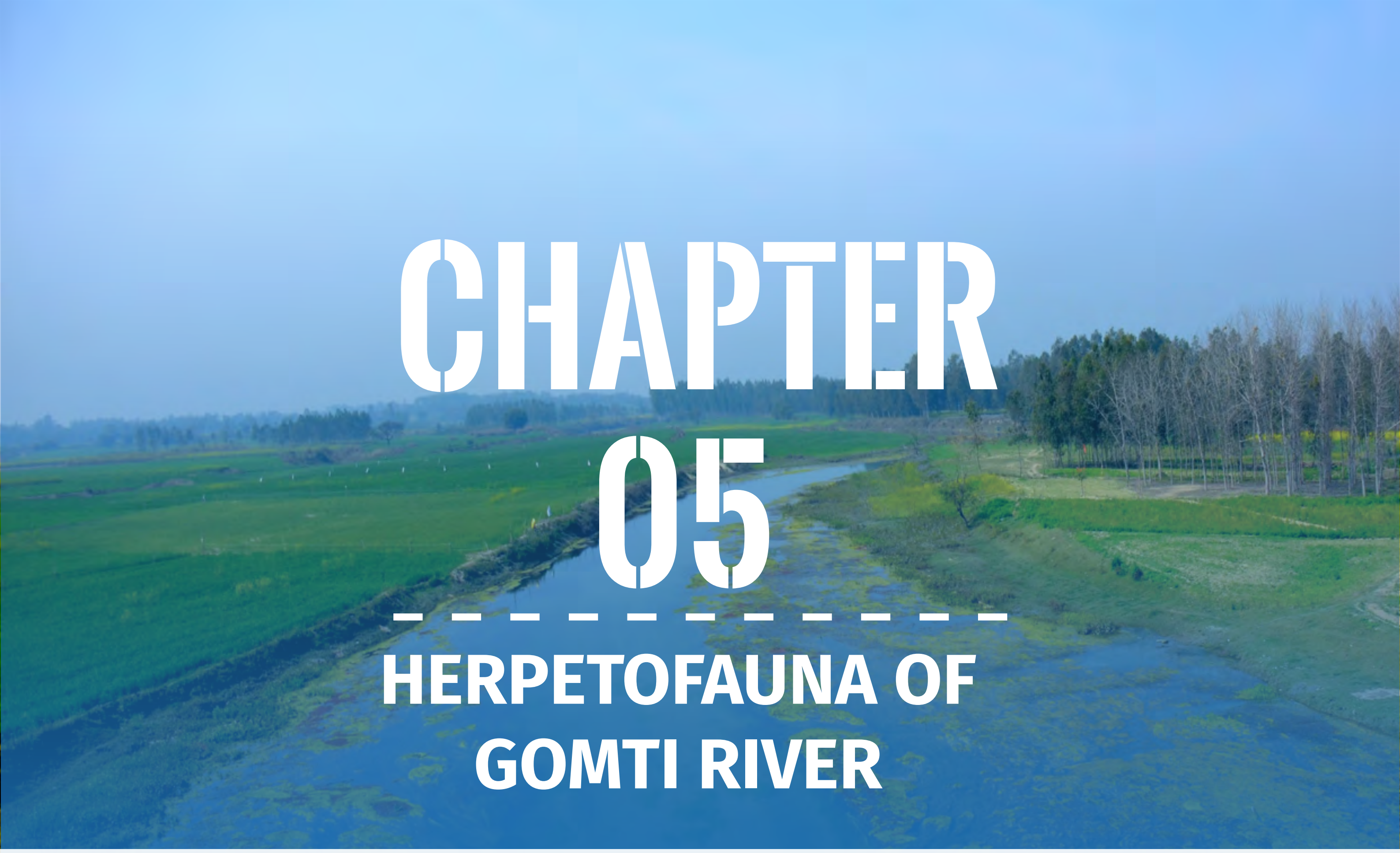

CHAPTER 05

HERPETOFAUNA OF GOMTI RIVER

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SUMMARY

Herpetofauna plays important ecological role in freshwater environments, functioning as predators, scavengers, nutrient recyclers, bioindicators, and ecosystem engineers. Amphibians are among the most endangered vertebrate groups in the world, while many reptile species, particularly freshwater turtles and crocodilians, face substantial threats from habitat loss and human disturbance. Understanding the ecological significance of the Gomti River within the Ganga basin requires comprehensive data on its herpetofaunal diversity, which this study aims to provide by collecting baseline information on species diversity, distribution, and abundance over its ~930 km length. This chapter presents assessment of herpetofaunal diversity along the Gomti River, with a focus on amphibians (Anura), crocodilians, and freshwater turtles.

Surveys along the Gomti River revealed significant herpetofaunal diversity, including ten amphibian species from four families (Bufonidae, Dicroglossidae, Microhylidae, and Rhacophoridae), with adaptable species like the Indian bullfrog, Asian common toad, and Indian marbled toad widely distributed across agricultural and semi-modified riverbanks. Species richness varied spatially, with Phulhar having the highest richness and sites such as Makaria Kalan having relatively even species distribution; overall, the findings significantly expand earlier localized records and highlight the ecological importance of

the river's riparian habitats within the Gangetic Plain. The mugger crocodile was identified as the sole crocodilian species in reptile surveys, with higher sightings during the pre-monsoon season, indicating seasonal habitat use patterns; however, increasing anthropogenic pressures pose threats to its habitat and may intensify human-wildlife interactions. Furthermore, five freshwater turtle species from the families Geoemydidae and Trionychidae were documented over four seasons, with Indian roofed turtles and Pangshura species being the most common, while crowned river turtles, Indian softshell turtles, and Indian flapshell turtles were less common. Notably, the Critically Endangered three-striped roofed turtle, previously recorded from the Gomti River, was missing, implying a steady decline or local extinction. Overall, these data show that, while the Gomti River continues to support diverse amphibian and reptilian communities, however, uneven distribution patterns and decreased observations of vulnerable species highlight the importance of ongoing monitoring and focused conservation efforts. Spatial presentation of turtle distribution revealed that some BEUs had significant turtle sightings, highlighting the importance of specific river sections for basking and habitat suitability. The presence of threatened species highlights the Gomti River's conservation value as an important freshwater refuge in a profoundly changed landscape. This study provides essential information for amphibians, crocodilians, and turtles in the Gomti River. It demonstrates that despite rising anthropogenic pressures, the river continues to support diverse herpetofaunal groups. However, the scarcity of sightings of certain threatened species indicates the ecosystem's vulnerability. The findings highlights the need for regular assessments, improved habitat protection, human activity regulation, and focused conservation planning to ensure the long-term survival of herpetofauna in the Gomti River ecosystem.

5.1. INTRODUCTION

Herpetofauna encompasses both reptile and amphibian species, which are poikilothermic in nature. Herpetofauna are considered extremely diverse in terms of ecology, morphology, and genetics due to their widespread distribution in nature and profound adaptability to terrestrial, aquatic, arboreal, and saxicolous habitats (Karthik et al., 2018; Ranjan et al., 2021). They can thrive in various environmental conditions, from moist forest floors to high-altitude streams. For example, research has revealed that in tropical rainforests, amphibian species occupy distinct microhabitats based on moisture levels, canopy cover, and elevation (Pough et al., 2016). Amphibians are considered the most threatened vertebrate group globally (Stuart et al. 2004; Sodhi et al. 2008). Their presence in different niches is a testament to the intricate interplay between their morphology, behaviour, and habitat preferences. Turtles clean organic debris, indicate environmental health, and support biodiversity and river conservation. They also aid decomposition, restore water quality, enhance seed germination, and facilitate nutrient transfer (Santori et al., 2020).

Crocodilians act as both ecosystem engineers and apex predators, regulating prey populations and maintaining ecological balance through their trophic interactions. Additionally, they serve as bioindicators of ecosystem health, with changes in their populations reflecting habitat integrity and signalling potential ecosystem degradation (Ross, 1998; Somaweera et al., 2020). Over 8,200 amphibian species are known worldwide, with nearly 41% facing extinction (Amphibian Survival Alliance, 2025). While comprehensive assessments of reptiles report 10,196 species worldwide, about 21% (n=1,829 species) of them are at risk of extinction (Böhm, 2013). The herpetofauna diversity of India comprises about 889 reptile species (Butler, 2023) and 472 amphibians (Gosavi et al., 2021). Riparian habitats play a crucial role in shaping the community structure of aquatic ecosystems (Gomi et al., 2006). Of the total herpetofauna recorded in India, 46 reptile species and 275 amphibian species inhabit the freshwater ecosystem (Chandra et al., 2017). The Indian Gangetic Plains supports 174 herpetofauna species, comprising 38 amphibians and 136 reptiles (Chandra et al., 2022) and the state of Uttar Pradesh accounts for 69 reptilian species and 29 amphibian species (Mohapatra et al., 2024; Dinesh et al., 2024). Major studies on the herpetofauna in the Gangetic Plain include Chanda (1991), Sharma (1991), Bashir et al. (2012), Boruah et al. (2020), Chandra et al. (2022), Debnath et al. (2022) and Yadav & Kakavipure (2023) (Table 5.4). The freshwater turtle assemblage studied by Singh et al. (2024) and faunal diversity study at Saroj Barewar region of Jaunpur district by Yadav & Kakavipure (2023) are the only published studies on herpetofauna from the Gomti River. The present study examines the diversity, abundance and distribution of amphibians (Anura) and reptiles (Crocodylia and Testudines) in the Gomti River.

5.2. METHODS

5.2.1. Amphibians (Anura)

The survey was carried out at the 12 randomly selected sites along the river in August 2024 (Figure 5.1). The Visual Encounter Survey method was employed for recording amphibian species (Crump & Scott, 1994). Study sites along the Gomti River were mainly agricultural fields and settlement areas. The fieldwork was carried out between 19:00 and 12:00 by walking approximately one kilometre on 5m wide transects searching along both banks of the river and documenting all the amphibian species encountered in the sampling sites. Species were identified using field guides, viz., Smith (1935, 1943), Schleich & Kastle (2002), Dutta (1997), Chanda (2002), and Das & Das (2017). Amphibian nomenclature and taxonomic arrangement were followed according to Frost (2018).

5.2.2. Reptiles

A reconnaissance survey was carried out to assess the feasibility of the Gomti River for survey in the post-monsoon season during 2019-20. Then, the overlaid Basic/Biodiversity Evaluation Units (BEUs) across the Gomti River were surveyed for three consecutive years from 2021 to 2023 (Table 5.1).

Crocodilians

The data was collected during daylight between 1000 and 1600 hrs and subject to suitable weather conditions for 2020 and 2021 in prescribed BEUs using standardized protocol (WII-NMCG, 2019; Panda et al., 2023). The upper zone of the Gomti River was found to have discontinuous flow of water, so a combination of vehicular and foot survey was utilised to survey BEUs. Boat based visual encounter surveys were carried out for Crocodilians by two observers maintaining a boat speed of 8-10 km/ hr for middle and lower zones from Sitapur to Kaithi in the Gomti River during February and March months of 2022 (Table 5.1). Mugger presence was confirmed by direct observations in the Gomti River based upon its physical characteristics (Madireddi, 2011). The number of individuals and size class were recorded for every mugger encounter, along with habitat variables and GPS coordinates.

Turtles

The total count method was employed to monitor turtles at every 5 km BEU along the river shorelines, river islands, snags during daylight hours (0700-1700 hrs), spending 15-20 minutes at each sampling location and using both boat and vehicle surveys (WII-NMCG, 2019). Survey was carried out every year between 2020 and 2023. All the BEUs were surveyed by teams of 2-3 observers across three post-monsoon and one pre-monsoon seasons (Table 5.1). Turtle species were identified using 10×50 binoculars and verified with the field guide by Talukdar et al. (2019).

Table 5.1. Summary of crocodilian and turtle survey in the Gomti River.

Surveyed stretch	Length of the stretch (km)	Survey method	Season	Year	Month
Gomat tal in Pilibhit district to Kaithi, Ghazipur district, Uttar Pradesh	~930	Vehicular and foot (reconnaissance survey)	Post-monsoon	2019-20	December, January, February
		Vehicular and foot	Pre-monsoon	2021	June, July
		Vehicular and foot in the upper zone from Gomat tal to Sitapur, Boat (middle and lower zone from Sitapur to Kaithi)	Post-monsoon	2022	February, March
		Vehicular and foot	Post-monsoon	2023	February, March

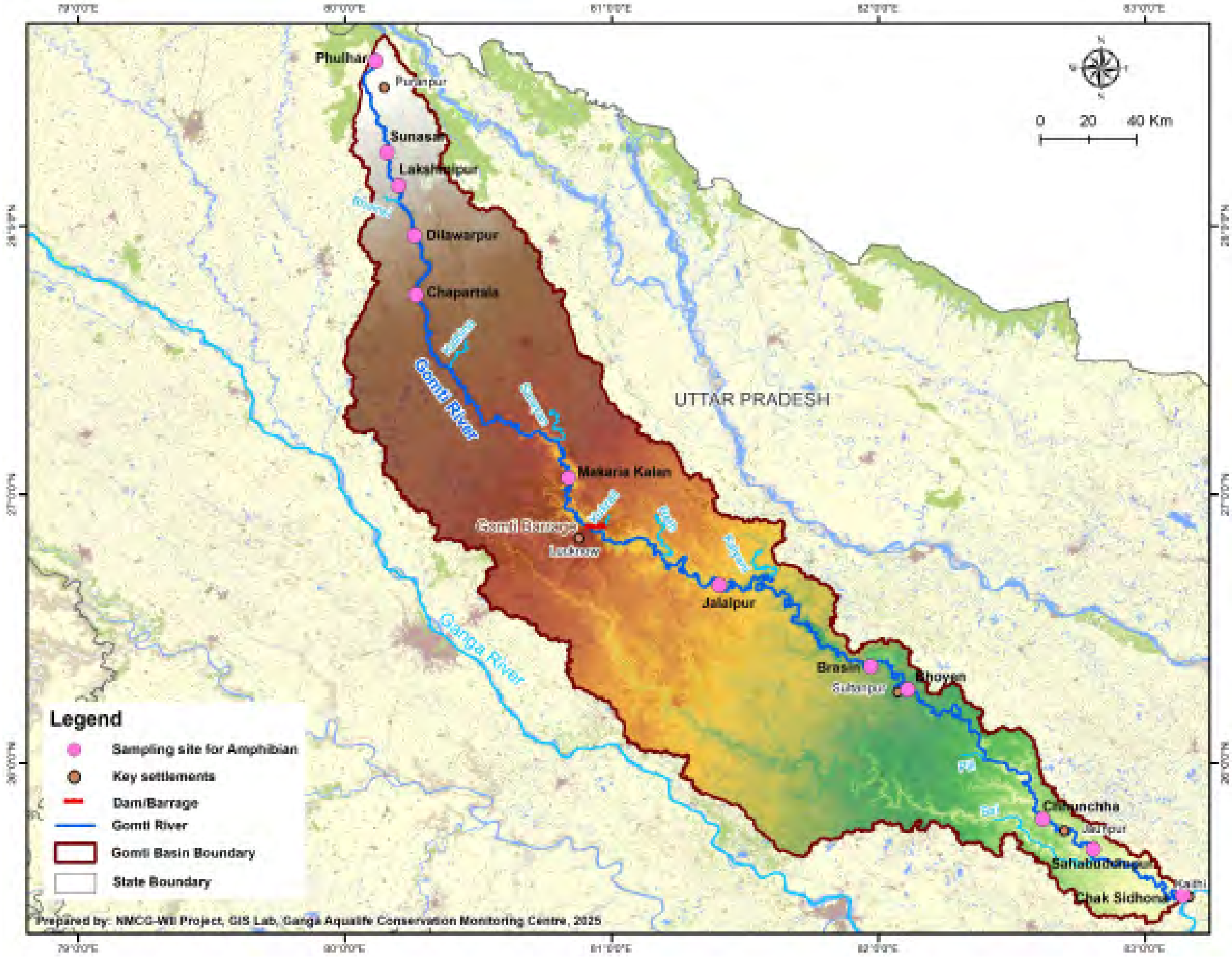


Figure 5.1. Amphibian sampling sites along the Gomti River.

5.3. RESULTS

5.3.1. Amphibians (Anura)

The amphibian survey along the Gomti River recorded a total of 10 species belonging to four families viz., Bufonidae, Dicroglossidae, Microhylidae, and Rhacophoridae (Table 5.2). The most frequently recorded species were the Indian bullfrog (*Hoplobatrachus tigerinus*), the Asian common toad (*Duttaphrynus melanostictus*), and the Indian marbled toad (*Duttaphrynus stomaticus*). In contrast, Jerdon's bullfrog (*Hoplobatrachus crassus*) and the Bengal tree frog (*Polypedates taeniatus*) were among the least frequently documented, occurring at only two or three locations. Among the surveyed sites, Phulhar in Uttar Pradesh exhibited the highest species richness, with seven species and the lowest in Chhunchha in Uttar Pradesh with only four species (Figure 5.2). The species diversity was also comparable across the surveyed sites. Makaria Kalan in Uttar Pradesh had the highest Shannon's diversity index (H'=1.71), followed by Phulhar (H'=1.64), indicating a well-distributed and diverse amphibian community. Meanwhile, Sahabuddinpur recorded the lowest diversity index (H'=1.11) (Figure 5.2). The anuran community was dominated by Dicroglossidae family (54.78%), followed by Bufonidae family (40.72%), together comprising the majority of recorded species. Microhylidae and Rhacophoridae families were the least encountered, accounting for only 2.64% and 1.86%, respectively. At the species level, *Duttaphrynus melanostictus* was very common and highly encountered species with a relative abundance of 28.72%, reflecting strong ecological adaptability, while *Hoplobatrachus crassus* and *Uperodon systoma* were the least encountered, with a relative abundance each of 0.79% (Figure 5.3).

Table 5.2. List of amphibian species encountered along the Gomti River.

Family	Common name	Scientific name	Phulhar	Sunasar	Dilawar-pur	Chapartala
Bufonidae	Asian common toad	*Duttaphrynus melanostictus*	+	+	+	+
	Indian marbled toad	*Duttaphrynus stomaticus*	+	-	+	-
Dicroglossidae	Indian bullfrog	*Hoplobatrachus tigerinus*	+	+	-	-
	Jerdon's bullfrog	*Hoplobatrachus crassus*	+	-	-	+
	Indian burrowing frog	*Sphaerotheca breviceps*	+	+	+	+
	Indian cricket frog	*Minervarya agricola*	+	+	+	+
	Indian skittering frog	*Euphlyctis cyanophlyctis*	-	+	+	+
Rhacophoridae	Bengal whipping frog	*Polypedates taeniatus*	-	+	+	+
Microhylidae	Ornate narrow-mouthed frog	*Microhyla ornata*	-	-	-	-
	Marbled balloon frog	*Uperodon systoma*	-	-	-	-

Abbreviation: + Presence, - Absence

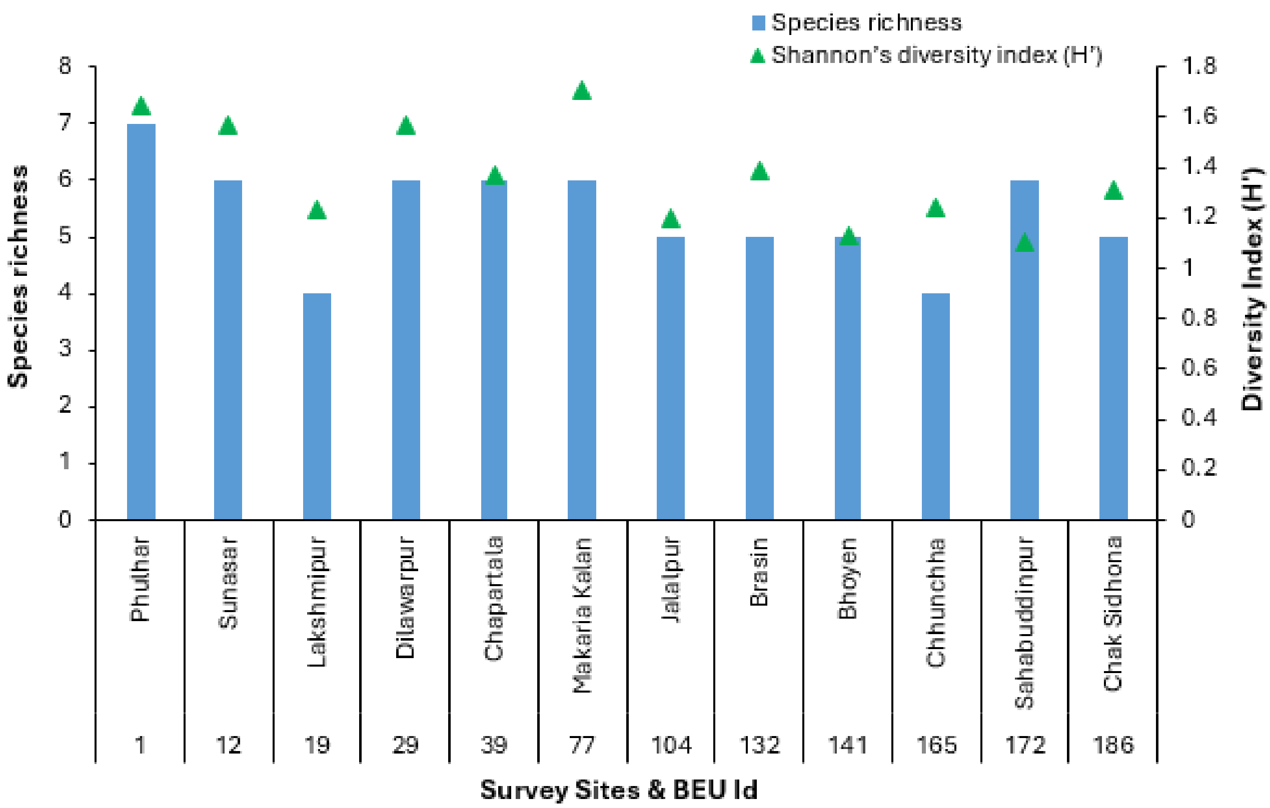


Figure 5.2. Species richness and Shannon's diversity index (H') of amphibians recorded along the Gomti River.

Sampling sites							
Makaria Kalan	**Jalalpur**	**Brasin**	**Bhoyen**	**Chhunchha**	**Sahabuddinpur**	**Chak Sidhona**	**Lakshmipur**
+	+	+	+	-	+	+	+
+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+
-	-	-	-	-	-	-	-
-	+	-	+	+	+	-	-
+	-	-	-	-	-	+	+
+	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
+	-	+	-	-	+	+	-
-	+	+	+	+	+	-	-

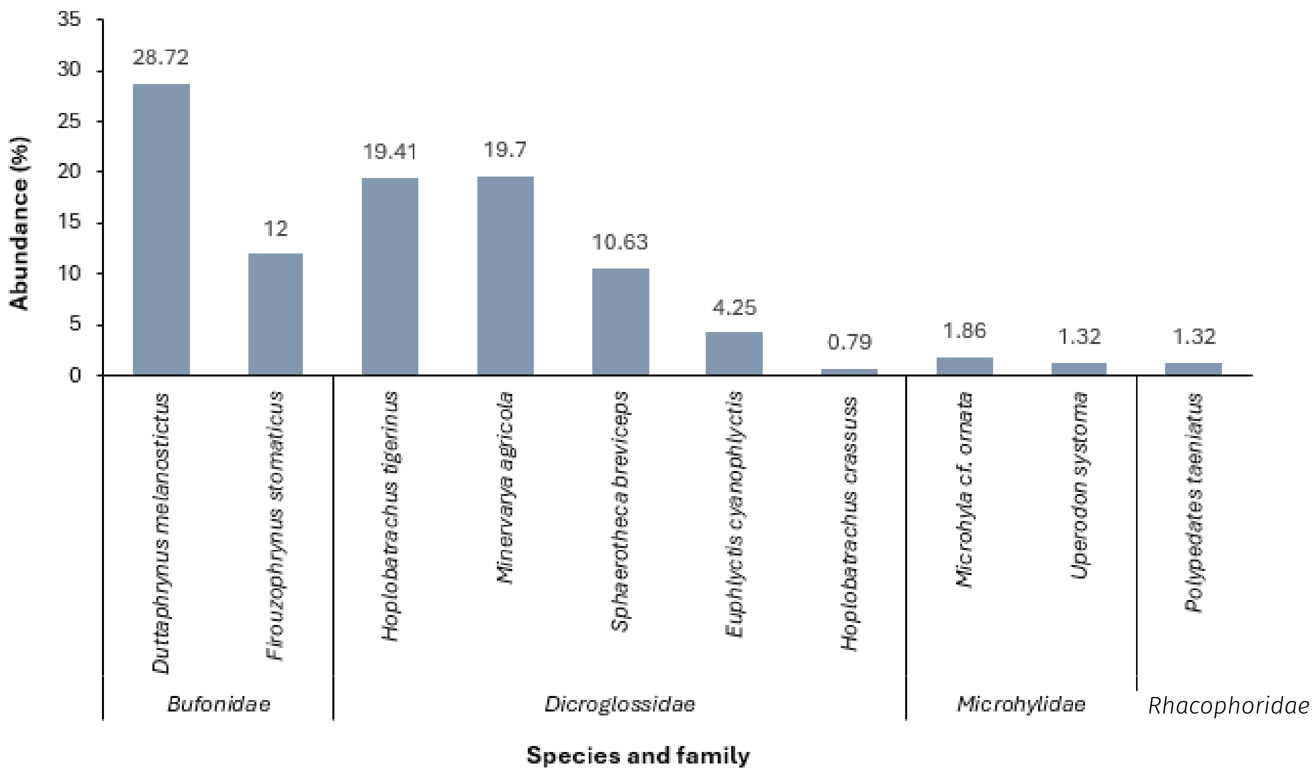


Figure 5.3. Relative abundance of amphibians recorded along the Gomti River.

5.3.2. Reptiles

Mugger

A total of eight BEUs recorded mugger individuals during the survey along the Gomti River (Figure 5.4). Most of the individuals were recorded in the clay islands and sandbars in proximity to agricultural land. A total of five individuals of mugger were sighted during the reconnaissance survey in 2020, out of which three were recorded near Sadarpur in the upstream of the Mohammadi at BEU-9, while two individuals were sighted at BEU-115 and BEU-175 in the downstream of Lucknow. During the pre-monsoon survey of 2021, a total of 11 mugger individuals were recorded along the Gomti River. The maximum sightings of mugger (n=4) were recorded nearby Fatuhabad village at BEU-30, followed by two individuals each at BEU-9 (nearby Sadarpur) and BEU-52 (in the upstream area of Dadhnamau). BEU-wise distribution of muggers is represented in figure 5.4 and the spatial distribution is represented in Figure 5.5.

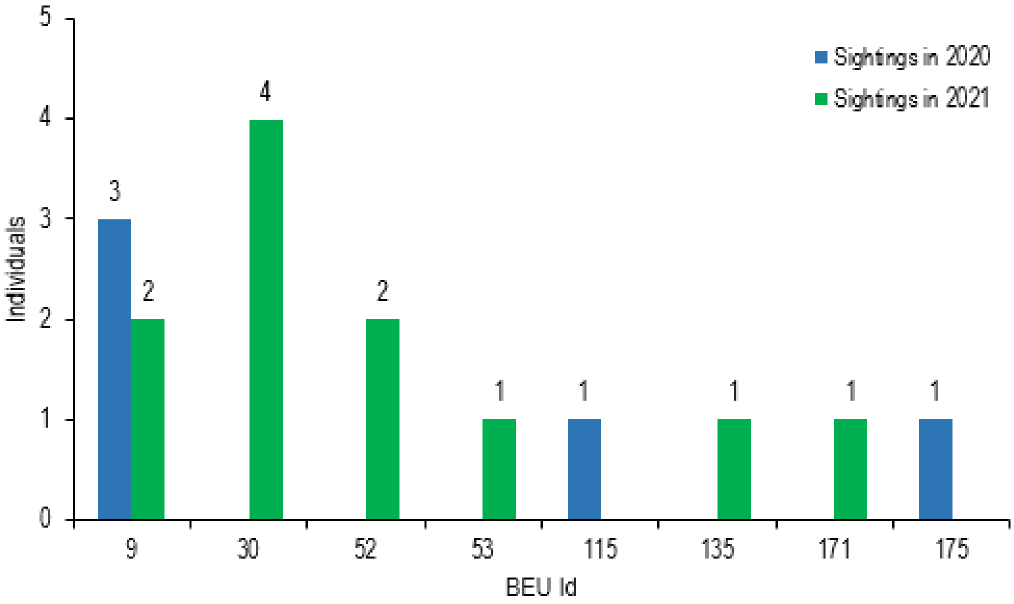


Figure 5.4. BEU-wise distribution of muggers along the Gomti River during the survey.

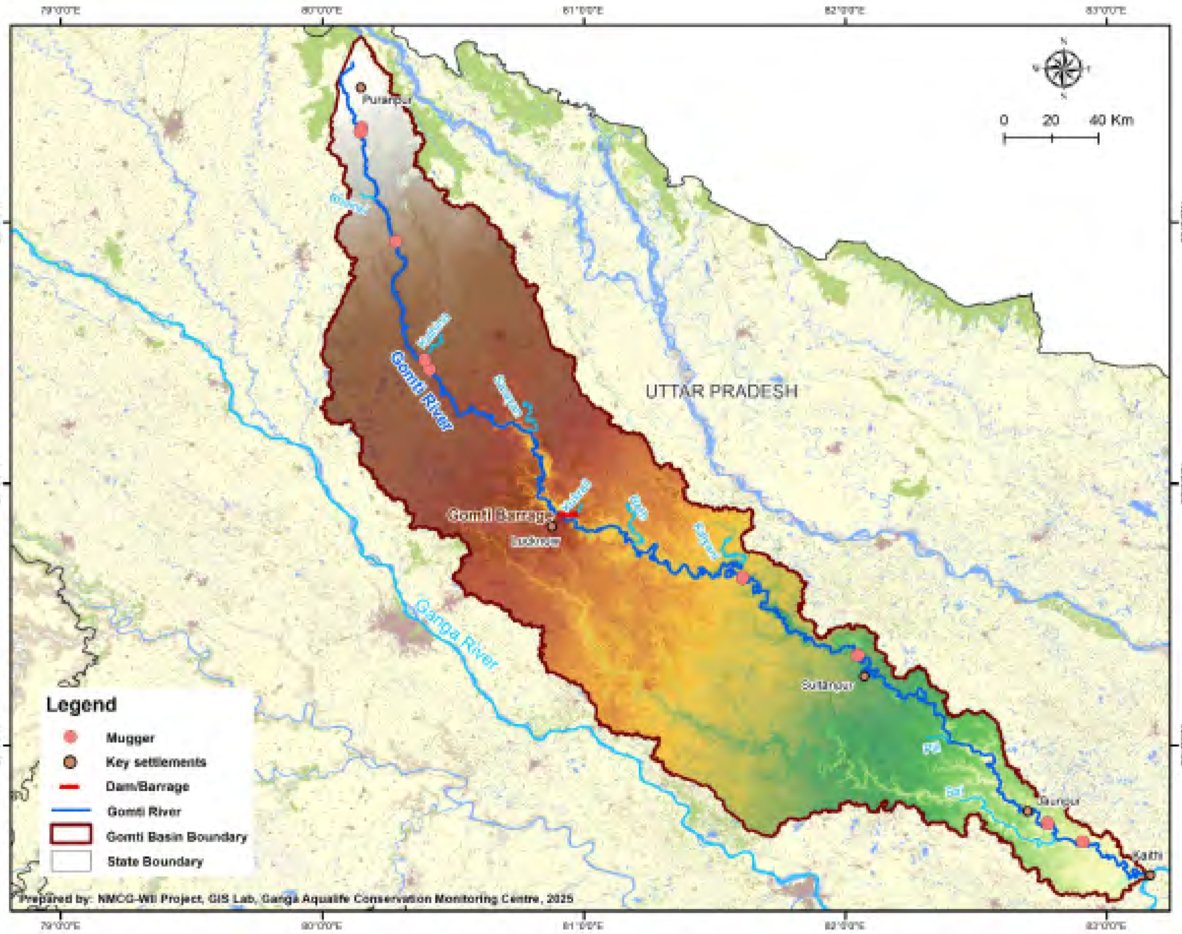
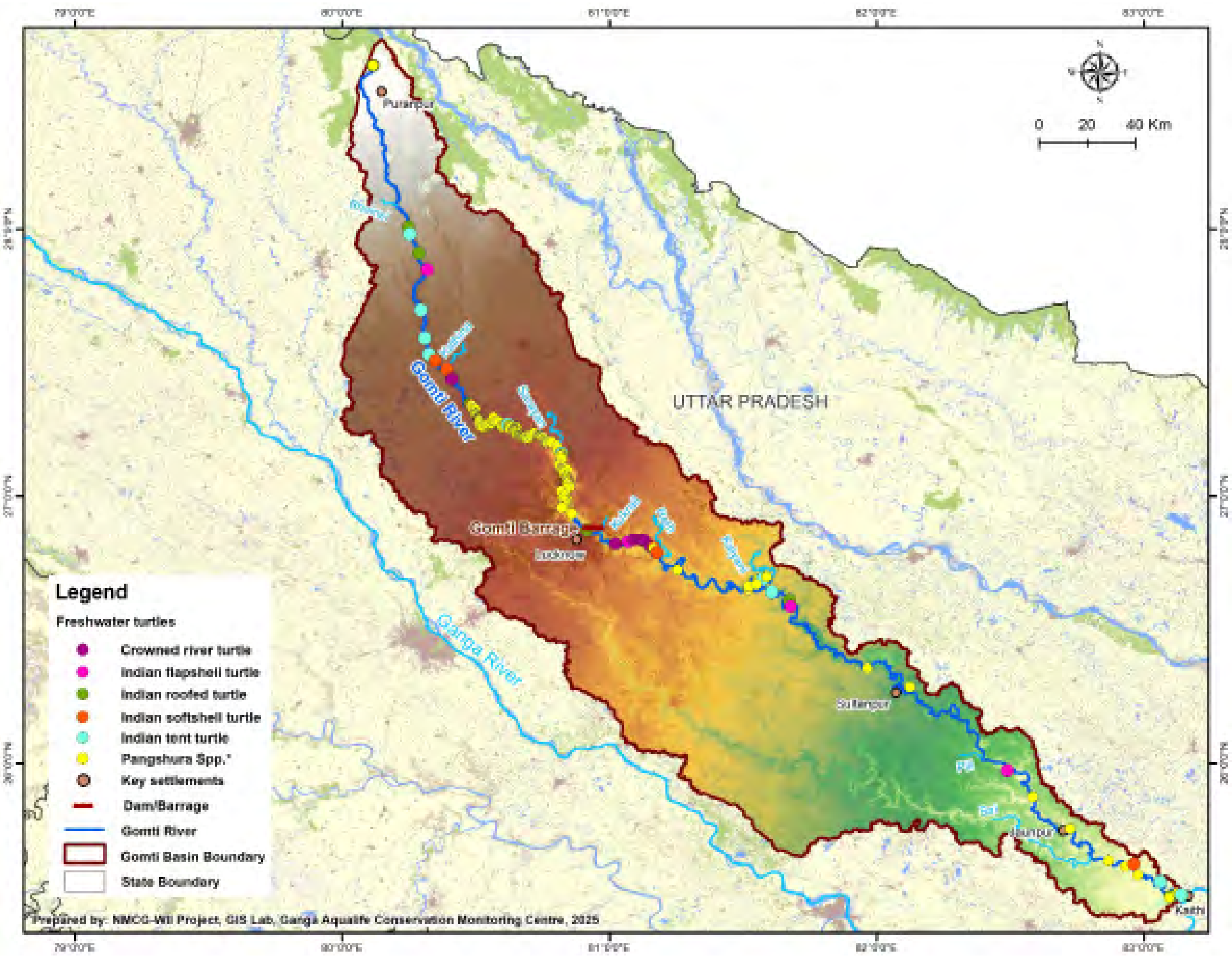


Figure 5.5. Spatial distribution of muggers along the Gomti Rive .

Turtles

A total of five turtle species belonging to two families, viz., Geoemydidae and Trionychidae were recorded from the Gomti River during four survey seasons between 2020 and 2023 (Table 5.3; Figure 5.6). A total of 18 individuals of turtles were sighted during reconnaissance survey in 2020. While during pre-monsoon survey in 2021, a total of 51 individuals were recorded with maximum 31 individuals of Indian roofed turtle, followed by other species. The pre-monsoon survey in 2022 recorded a maximum 558 individuals of turtle, of which 553 individuals belonged to Pangshura spp., followed by crowned river turtle (n=5) and Indian softshell turtle (n=2). In addition, 21 Pangshura spp. were observed at two BEUs in the Gomti River during 2023. With a sighting of four individuals, Indian flapshell turtle was the least sighted species among the turtles, followed by crowned river turtle (n=8) and Indian softshell turtle (n=8). BEU-1 recorded the maximum sighting of 76 individuals of turtles over the period 2020 to 2023, followed by BEU-69 (n=55), BEU-67 (n=50), BEU-66 (n=45), and BEU-60 (n=43) (Figure 5.7). The year-wise sightings of turtle individuals are represented in Table 5.3.



*Could not be identified up to species level

Figure 5.6. Spatial distribution and species composition of turtles in the Gomti River, Uttar Pradesh.

Table 5.3. Year-wise sighting of turtles during the present survey in the Gomti River, Uttar Pradesh

Freshwater turtles	Scientific name	2020	2021	2022	2023
Crowned River Turtle	*Hardella thurjii*	1	2	5	-
Indian Flapshell Turtle	*Lissemys punctata*	1	3	-	-
Indian Roofed Turtle	*Pangshura tecta*	8	31	-	-
Indian Softshell Turtle	*Nilssonia gangetica*	1	5	2	-
Indian Tent Turtle	*Pangshura tentoria*	7	10	-	-
-	*Pangshura* spp.*	-	-	553	21

*could not be identified up to species level

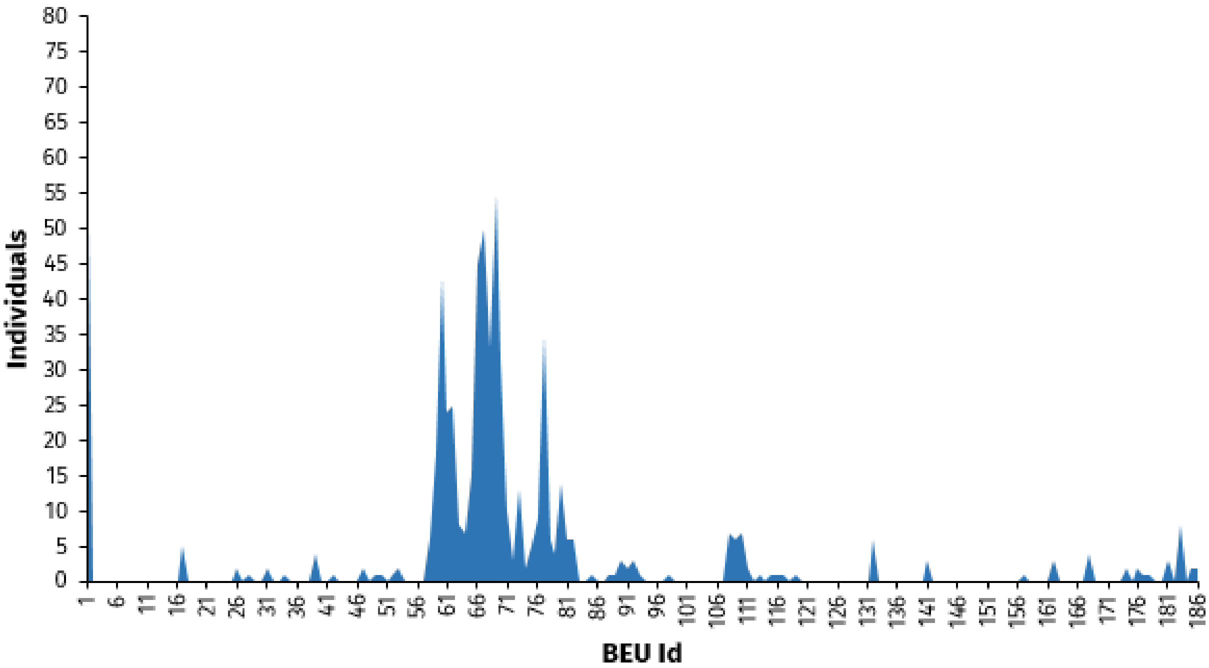


Figure 5.7. BEU-wise sighting of turtles in the Gomti River, Uttar Pradesh.

5.4. DISCUSSION

The present study provides one of the first comprehensive assessments of amphibian diversity along the Gomti River, documenting 10 species, accounting for 26.3% of the total amphibian species that are found in the Gangetic plain (Chandra et al., 2022), comparable to findings from other studies (Chanda, 1991; Boruah et al., 2020; Tripathi et al., 2025) (Table 5.4). Previously, only three amphibian species were reported at Saroj Barewar village of Jaunpur district along the banks of Gomti River (Yadav & Kakavipure, 2023), but the present study has generated baseline data on amphibians with 10 species from the 12 sampling sites along the Gomti River from its origin to confluence with the Ganga River. *Duttaphrynus melanostictus* followed by *Hoplobatrachus tigerinus*, and *Minervarya agricola* were very common and highly encountered species, reflecting strong ecological adaptability, while *Hoplobatrachus crassus* and *Uperodon systoma* were the least encountered species, indicating either habitat specificity or a naturally restricted range. Despite being a top predator in the river ecosystem, no previous research has been conducted on crocodilian species in the Gomti River. The present study also provides baseline data on the distribution of mugger in the Gomti River, which would be critical for decision making, management planning and conservation of this vulnerable species in the Gomti River. Muggers and gharials have also been recorded from the Dudhwa Tiger Reserve (Tripathi et al., 2025), which is near the Gomti River basin. Mugger sightings were concentrated near the river banks with agriculture practice in Sultanpur, Pindra, Rampura, and Fatuhabad. Encroachment of the river banks constitutes a primary threat to crocodilian habitats, which has led to negative interactions between local people and mugger along the Gomti River (Trivedi et al., 2022; Chavan & Borkar, 2022). Sensitization programmes and awareness campaigns about muggers and their behaviour should be carried out for local communities in order to prevent negative interactions with muggers. People should avoid crocodile habitats, especially during twilight hours, and promptly inform the Forest Department in case of a sighting or if rescue assistance is required.

Singh et al. (2024) studied three turtle species, including the three-striped roofed turtle, crowned river turtle, and Indian tent turtle from the Gomti River in the Hardoi district of Uttar Pradesh. The present study reported five turtle species except the three-striped roofed turtle across the entire length of the Gomti River (Table 5.3). According to the IUCN Red List, the three-striped roofed turtle is Critically Endangered. Its population was estimated to be 180 ± 46 individuals from the Daranga and Dunandiya pools of the Gomti River in 1992 (Singh et al., 2024). No sightings of the species have been reported since 1992, including the surveys conducted by Singh et al. (2024) in 2003 at both the surveyed pools, as well as in the entire length of the Gomti River during the present survey. Singh et al. (2024) captured 314 individuals of the Endangered crowned river turtle during 1992, later only 29 individuals of the species were captured in 2003 from the Daranga and Dunandiya pools of the Gomti River in the Hardoi district, Uttar Pradesh. The present survey recorded rare sightings of crowned river turtle including one individual in the downstream of Lucknow in 2020, two individuals nearby Barra Sarain in Hardoi district in 2021, and five individuals downstream of Lucknow during 2022. The Gomti River recorded good number of turtle sighting with maximum sighting of Pangshura spp. during the present survey. The baseline information on threatened and Schedule-I turtle species generated by the present study highlights the ecological importance of the Gomti River for turtle populations. The present study provides a crucial baseline on Gomti River amphibians, crocodilians, and turtles, demonstrating the river's ecological importance and the need for conservation. Crucial insights into the species richness, distribution patterns, and population losses of vulnerable taxa in this study will be very much helpful to drive future research, management measures, and evidence-based conservation planning to protect herpetofauna of Gomti River.

Table 5.4. Summary of Studies on Herpetofauna Diversity in the Upper Gangetic Plain.

Study	Study area	Focused group	No. of Species
Chanda (1991)	Upper Ganga	Amphibians	12
Sharma (1991)	Upper Ganga	Lizard, Snakes	8
Bashir et al. (2012)	Upper Ganga (Bijnor-Narora)	Lizard, Snakes	8
Boruah et al. (2020)	Ganga Stretch	Amphibians	16
		Snakes, Lizards	22
Chandra et al. (2022)	Gangetic Plain Biogeographic Zone	Amphibians	38
		Reptiles	136
Debnath et al. (2022)	Lower Ganga Canal (Narora)	Snakes, Lizards, Crocodiles	4
		Turtles	13
Yadav & Kakavipure (2023)*	Gomti River at Saroj barewar Village, Jaunpur district, Uttar Pradesh	Snakes, Lizards	9
		Amphibians	3
Singh et al. (2024)*	Gomti River, Hardoi District of Uttar Pradesh	Turtles	3
Tripathi et al. (2025)*	Dudhwa TR, Uttar Pradesh	Amphibians	15
		Snakes, Lizards, Crocodiles	31
Present study*	Gomti River	Amphibians	10
		Crocodilians	1
		Turtles	5

*Studies carried out in and around Gomti River basin.

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CHAPTER 06

AVIFAUNA OF GOMTI RIVER

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SUMMARY

Birds play an important role in freshwater habitats by promoting ecological balance through predation, scavenging, seed dissemination, and nutrient cycling. The wetlands and rivers of Uttar Pradesh are vital for waterbirds, including numerous migratory and endangered species. Many avifaunal studies have been undertaken along the wetlands and stretches of the Gomti River, yet a comprehensive study covering the entire length of the Gomti River is lacking. This chapter aims to fill this gap by carrying out the first comprehensive study of avifauna along the Gomti River, from its source to its confluence with the Ganga, covering ~930 km. The surveys undertaken between 2019 and 2023 used standardized methodology across established Biodiversity Evaluation Units (BEUs), using both vehicular and boat-based counts dependent on hydrological conditions. During daylight, total count methods were employed to record water and water-associated birds. The collected data was analysed to understand species richness, diversity indices, relative abundance, feeding guilds, and residential status.

A total of 51 bird species were recorded, 44 of which were water and water-associated species, spanning eight orders and 15 families. Geographically, the Middle Zone had the greatest species richness, probably due to enhanced habitat variability and favorable hydrological conditions, whereas the upper and lower zones were less diverse, possibly due to habitat changes and changing flow regimes. Generalist species, such as the little cormorant, black-winged stilt, Indian cormorant, and common moorhen, were more frequently observed, whereas habitat specialists like bitterns and night herons were less prevalent.

Carnivorous species predominated in the feeding guild study, indicating continued support for aquatic insectivorous and piscivorous birds. The majority of reported species were residents with local migrants, with a smaller group consisting of winter migrants, underscoring the river's importance in supporting diverse species as both a breeding and foraging site. Several globally threatened species were also recorded in the Gomti River, including the Endangered Indian skimmer and Egyptian vulture, as well as vulnerable species such as the sarus crane and river tern. Notably, observations of Indian skimmers on sandy islands suggest potential breeding grounds, while anthropogenic activities such as sand mining, fishing, animal grazing, and water extraction pose threats to successful nesting. The existence of these conservation-priority species emphasizes the ecological value of non-protected riverine ecosystems outside recognized sanctuaries. This study provides a long-term, systematic baseline of water and water-associated bird diversity over the entire stretch of the Gomti River. The findings show that the river supports both resident and migratory birds, as well as revealing ecological stress caused by human activities. Continuous monitoring, habitat conservation, extractive activity restriction, and restoration initiatives are essential to sustaining bird diversity and maintaining the ecological integrity of the Gomti River ecosystem.

6.1. INTRODUCTION

Birds are vital components of freshwater ecosystems, valued for their ecological, recreational, and economic importance (Ormerod & Tyler, 1993; Das et al., 2014). They occupy nearly all trophic levels and play essential roles in food webs across both terrestrial and aquatic habitats (Whelan et al., 2016). Functioning as carnivores, herbivores, seed dispersers, pollinators, scavengers, and ecosystem engineers (Whelan et al., 2008), birds significantly contribute to ecosystem processes. Additionally, migratory species enhance connectivity across broad geographical and temporal scales (Meshram, 2010).

India harbours a remarkable avifaunal diversity, with 1,332 recorded species, representing about 6% of global avifauna (Praveen et al., 2020). Among the 871 waterbird species worldwide, India is home to over 240, including 33 migratory and 44 threatened waterbird species (Venkatraman & Sivaperuman, 2017; Gopi & Hussain, 2014; IUCN, 2014). Uttar Pradesh, the fourth-largest state in the country, is a key region for bird conservation, hosting about 546 bird species (Maheswaran & Alam, 2024). The wetlands and protected areas in the state are recognized as ecologically significant habitats (Javed & Rahmani, 1998; Iqubal et al., 2003; Khan et al., 2013; Kumar & Kanaujia, 2016; Mishra et al., 2020). Seasonal fluctuations have a strong impact on wetland bird diversity and abundance, with species richness and density peaking during migration (Lee & Kang, 2019; Nagarajan & Thiyagesan, 1996; Khan, 2010; Pandiyan et al., 2010). Globally, about 23% of waterbird populations are declining due to habitat loss, pollution, hunting, invasive species, and climate change (Wang et al., 2018; Wetlands International, 2012). Studying water and water-associated birds and their habitats is essential to promote conservation and ensure the overall well-being of the Earth. The Ganga River basin and its tributaries support diverse aquatic and avian fauna (WII-NMCG, 2019).

Previous surveys in and around the Gomti River basin have documented notable avifaunal richness, including up to 200 species at Nawabganj, 110 at Samaspur, 105 at Sandi, and more than 250 species recorded at Kishanpur Wildlife Sanctuary (Kumar et al., 2013; Rahmani et al., 2016). Recent records from Lucknow and adjacent wetlands further underscore the basin's ecological significance (Srivastava et al., 2022; Parveen et al., 2023).

Key findings from published studies of the Gomti River basin include the documentation of the Bengal Florican from the Dudhwa Tiger Reserve and transboundary landscapes, including Pilibhit (Kumar, 2013; Jha et al., 2018). Significant populations of the Asian openbill (1,054 individuals) were observed at Nawabganj (Kumar & Kanaujia, 2016), and the region is also recognized as critical habitat for the sarus crane (Rahmani et al., 2019). Additionally, the white-tailed Lapwing has been reported from Nawabganj Bird Sanctuary (Kumar et al., 2018b). Wetland flora serves as vital food resources for numerous waterbird species (Prajapati & Singh, 2024).Freshwater habitats in the Gomti River basin support several threatened species, including the Bengal florican, Indian skimmer, Egyptian vulture, sarus crane, common pochard, and river tern. The detailed information of published studies and bird diversity in and around Gomti River basin is provided in Table 6.2 and Annexure IV. Most studies on the avifauna of the Gomti River basin have been conducted in protected wetlands, sanctuaries, or focused on specific species. Existing research does not provided information on the water and water-associated birds along the Gomti River, with the exception of a couple of studies from smaller stretches of the Gomti River along the Lucknow city. This study aims to fill that gap by systematically surveying the water and water-associated birds and generating baseline data along ~930 km of the Gomti River, from its source to its confluence with the Ganga River.

6.2. METHODS

A reconnaissance survey was conducted to access the feasibility of surveying the Gomti River during the post-monsoon season of 2019-20. Subsequently, the overlaid Biodiversity Evaluation Units (BEUs) along the Gomti River were surveyed over three consecutive years, from 2021 to 2023 (Table 6.1). The total count method was used to survey waterbirds at every 5 km river segment during daylight hours (0700-1700 hrs) for periods of 15-20 minutes. Multiple observers (2-3) conducted the surveys using a combination of boat and vehicular methods (Bibby et al., 1992; WII-NMCG, 2019). Bird identification was performed using 10×50 binoculars, and when necessary, further identification was aided by the field guide by Grimmett et al. (2012). A comprehensive checklist of reported bird species was created, based on guild-specific criteria (Kumar et al., 2005) and IUCN Red List status (BirdLife International, 2025; Praveen & Jaypal, 2025).

6.3. RESULTS

6.3.1. Water and water-associated bird species Richness and diversity

During the surveys conducted in 2019–20, 2021, 2022, and 2023, a total of 5,611 individual birds belonging to 51 species were recorded, of which 44 species were water and water-associated birds. The water and water-associated bird species were further taken into consideration for the detail analysis and which were represented by eight orders and 15 families. The Pelecaniformes and Charadriiformes were the most dominant orders with 28.26% and 26.08% of recorded water and water-associated bird species, respectively (Figure 6.1). While Ardeidae was the most dominant family with 23.91% of recorded species (Figure 6.2). The highest overall Shannon–Wiener diversity index (H') value of 3.01 was recorded in 2022, as compared to H' value of 2.83 in 2021, 2.49 in 2023, and 2.02 in 2019–20. The highest species richness of 36 was also recorded in 2022 survey as compared to richness of 31 in 2021, 22 in 2023, and 12 in 2019-20 (Figure 6.3). The Middle Zone recorded the highest species diversity with Shannon-Wiener's diversity index (H') of 3.08 and species richness of 37, as compared to the upper zone (H' = 2.85; species richness = 30) and lower zone (H' = 2.81; species richness = 24) (Figure 6.4).

Among the recorded bird species, two species viz., Indian skimmer (*Rynchops albicollis*) and Egyptian vulture (*Neophron percnopterus*) were classified as endangered. The river tern (*Sterna aurantia*) and sarus crane (*Antigone antigone*) were listed as vulnerable, while the Asian woolly-necked Stork (*Ciconia episcopus*) and river lapwing (*Vanellus duvaucelii*) were categorized as near threatened in the IUCN Red List, indicating their conservation significance. The distribution of threatened species along the Gomti River is provided in Figure 6.5.

Table 6.1. Summary of avifauna survey along the Gomti River.

Surveyed stretch	Length of the stretch (km)	Survey method	Season	Year	Month
Gomat tal in Pilibhit district to Kaithi, Ghazipur district, Uttar Pradesh	~930	Vehicular (reconnaissance survey)	Post-monsoon	2019-20	December, January, February
		Vehicular	Pre-monsoon	2021	June, July
		Vehicular in the upper zone from Gomat tal to Sitapur, Boat (middle and lower zone from Sitapur to Kaithi)	Post-monsoon	2022	February, March
		Vehicular (BEUs at 1 m, 500 m and 1,000 m from the river)	Post-monsoon	2023	February, March

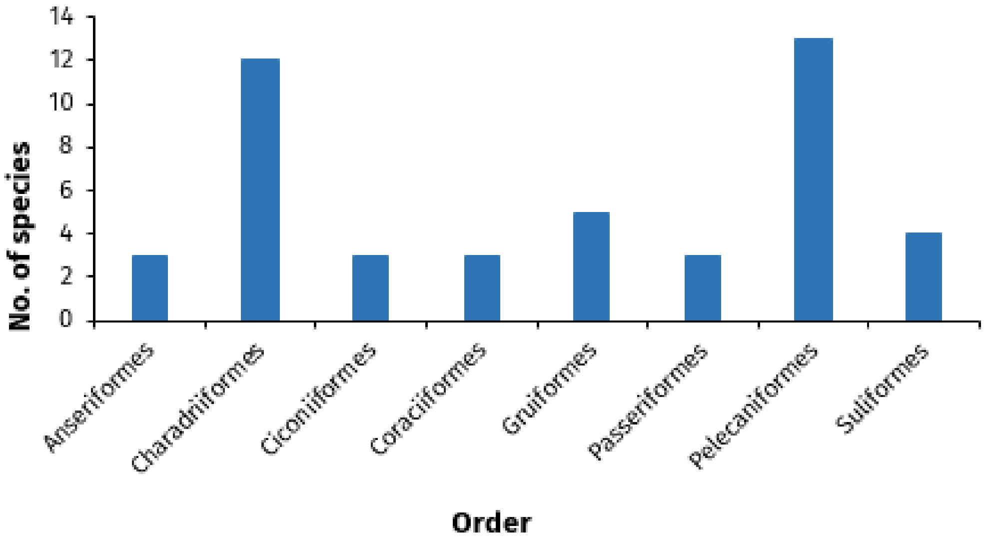

Figure 6.1. Order-wise distribution of water and water-associated bird species along the Gomti River.

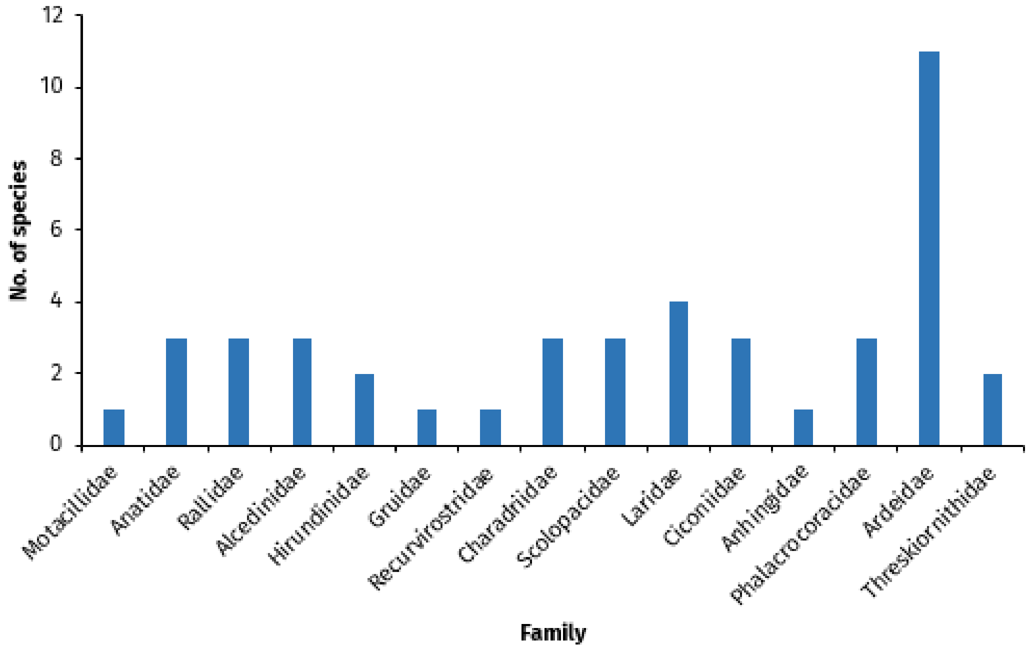

Figure 6.2. Family-wise distribution of water and water-associated bird species along the Gomti River.

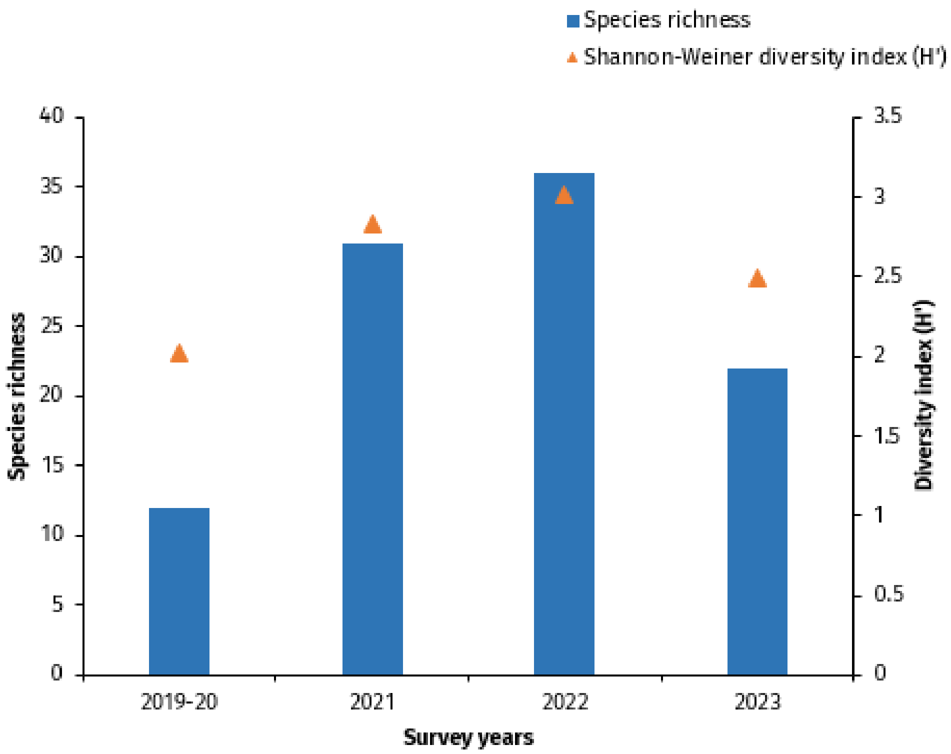

Figure 6.3. Year-wise species richness and Shannon-Wiener's Diversity index (H') of water and water-associated birds along the Gomti River.

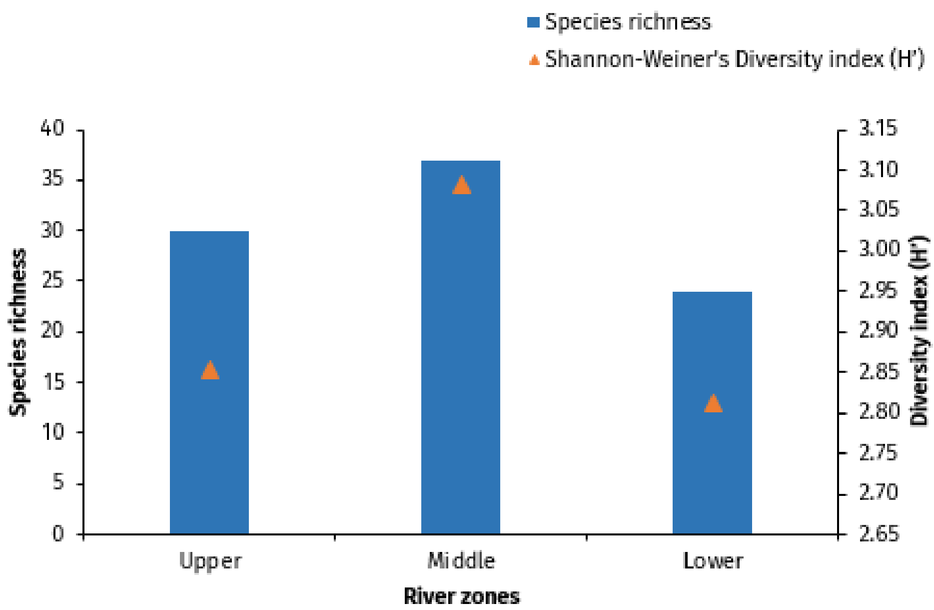

Figure 6.4. Zone-wise species richness and Shannon-Wiener's Diversity index (H') of water and water-associated birds along the Gomti River.

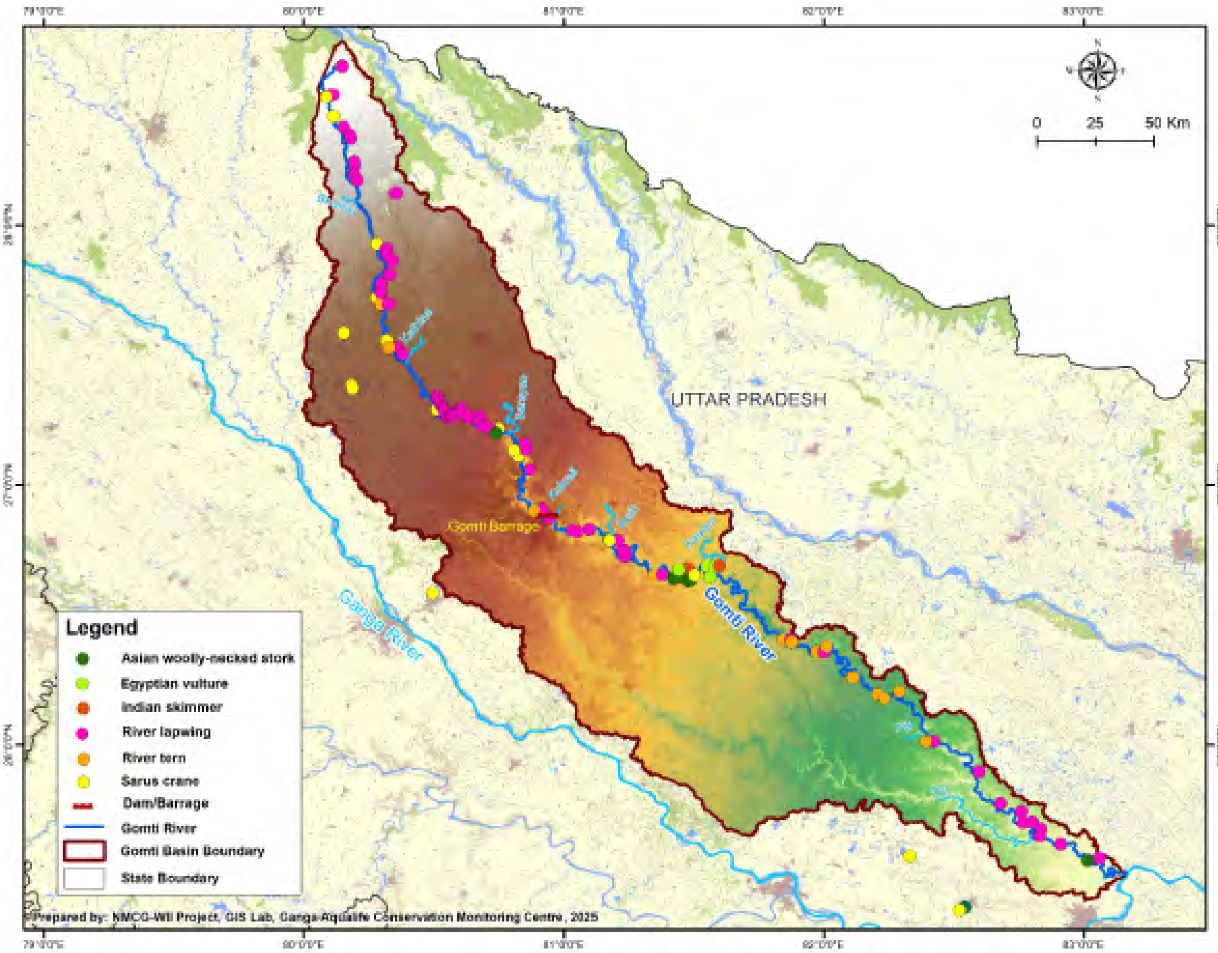

Figure 6.5. Distribution of globally threatened birds along the Gomti River.

Relative abundance

Little cormorant was the most abundant species with a relative abundance of 10.64%, followed by black-winged stilt (*Himantopus himantopus*) (8.21%), Indian cormorant (*Phalacrocorax fuscicollis*) (7.76%), and common moorhen (*Gallinula chloropus*) (6.27%) among the water and water-associated birds along the Gomti River. In contrast, black-crowned night heron (*Nycticorax nycticorax*), cinnamon bittern (*Botaurus cinnamomeus*), and yellow bittern (*Botaurus sinensis*) were found to be least abundant (Figure 6.6).

During the 2019-20 reconnaissance survey, little cormorant (*Microcarbo niger*), river tern (*Sterna aurantia*), and river lapwing (*Vanellus duvaucelii*) were the most dominant species along the Gomti River with a relative abundance of 25.37%, 22.38%, and 14.55%, respectively. These results are comparable to relative abundance of dominant species recorded in subsequent surveys, viz. river lapwing (*Vanellus duvaucelii*) (16.30%), little cormorant (*Microcarbo niger*) (12.36%) and white-breasted waterhen (*Amaurornis phoenicurus*) (9.8%) during 2021 survey; Indian cormorant (*Phalacrocorax fuscicollis*) (11.27%), black-winged stilt (*Himantopus himantopus*) (10.92%), common moorhen (*Gallinula chloropus*) (9.1%), and little cormorant (*Microcarbo niger*) (8.12%) during the 2022 survey; and red-wattled lapwing (*Vanellus indicus*) and little cormorant (*Microcarbo niger*) (19% each), Eastern cattle-egret (*Ardea coromanda*) (10.55%), and painted stork (*Mycteria leucocephala*) (9.15%) during the 2023 survey.

In the upper zone of the Gomti River from the origin point to Sitapur, little cormorant (*Microcarbo niger*) was the dominant species with a relative abundance of 18.4%, followed by the common moorhen (*Gallinula chloropus*) (11.86%) and river lapwing (*Vanellus duvaucelii*) (10.45%). In the middle zone of the Gomti River from Sitapur to Sultanpur, Indian cormorant (*Phalacrocorax fuscicollis*) was the most abundant species with relative abundance of 13.03%, followed by black-winged stilt (*Himantopus himantopus*) (12.84%), common sandpiper (*Actitis hypoleucos*) (7.69%). In the lower zone of the Gomti River from Sultanpur to confluence point, little cormorant (*Microcarbo niger*) was the most abundant species with a relative abundance value of 15.6%, followed by the Eurasian coot (*Fulica atra*) (9.41%) and river lapwing (*Vanellus duvaucelii*) (9.2%).

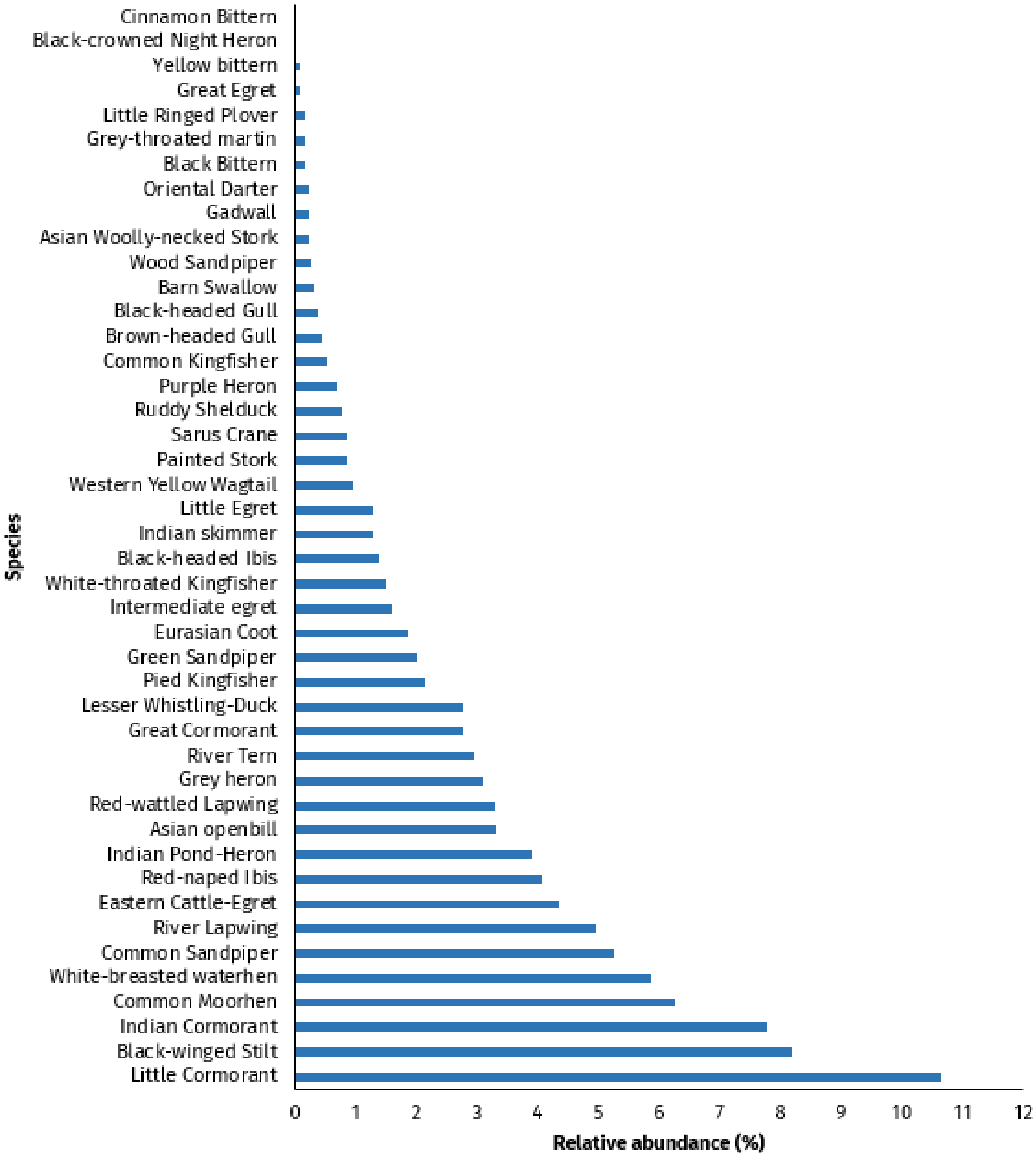

Figure 6.6. Relative abundance of water and water-associated birds recorded along the Gomti River.

Feeding guilds and residential status

The feeding guilds and residential status of recorded water and water-associated species along the Gomti River are vital for effective conservation planning of species as well as habitat. Carnivores constituted the most dominant (77.27%) among the feeding guilds, followed by herbivore/carnivores (9.09%), omnivores (6.82%),and insectivores (4.55%) (Figure 6.7). Of the recorded water and water-associated species 52.27% were resident with local movement, followed by winter migratory residents (22.73%), residents (13.64%). Winter migratory species contributed 4.55% of the total recorded water and water-associated species (Figure 6.8).

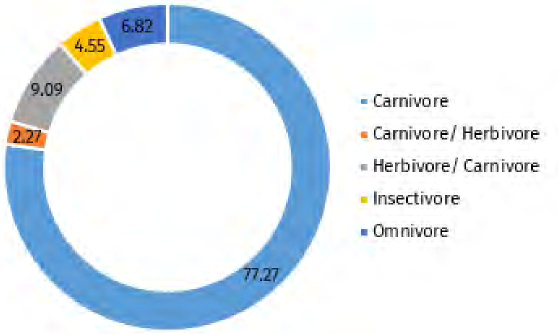

Figure 6.7. Feeding-guild composition of water and water-associated birds along the Gomti River.

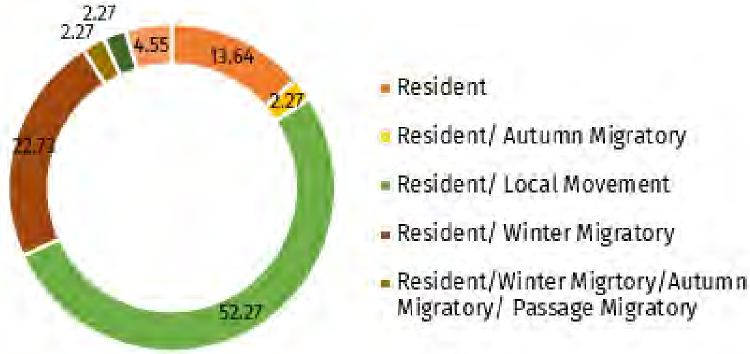

Figure 6.8. Residential status of water and water-associated birds along the Gomti River.

6.4. Discussion

Riverine habitats are vital for avifauna, supporting around 60 specialist species and serving as key habitats for nearly 23% of all bird species that depend on freshwater systems throughout their life cycles (Buckton, 1998; Buckton & Ormerod, 2002; Ormerod & Tyler, 1993). About 930 km stretch from origin to confluence of the Gomti River was surveyed, encompassing diverse and unprotected habitats. This is the first baseline study on water and water-associated birds throughout the entire length of the Gomti River. A total of 51 bird species, including 44 water and water-associated species were recorded along the Gomti River, comparable to those recorded at other sites, viz. 70 species in Lucknow district (Kanaujia et al., 2015), 78 species in Samaspur Bird Sanctuary (Kumar & Kanaujia, 2015), and 17 species in wetlands surrounding Ekana Stadium, Lucknow (Parveen et al., 2023).

Other studies from the basin conducted at Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary, Samaspur Bird Sanctuary, Kishanpur Wildlife Sanctuary, and Pilibhit Tiger Reserve documented overall bird species richness. However, these efforts were largely site-specific and sanctuary or IBA-focused, with some studies targeting single taxa such as the Bengal florican (Kumar, 2013; Jha et al., 2018) and sarus crane (Rahmani et al., 2019). The summary of number of species recorded in respective research studies in and around the Gomti River basin is provided in table 6.2. Variations in species richness and Shannon–Wiener diversity indices across years and river zones reflect the dynamic ecological processes of the Gomti River. The highest diversity observed in the Middle Zone (H'=3.08) suggests that favourable hydrological conditions and habitat heterogeneity supported richer bird assemblages. The reduced diversity in the lower zone is likely attributable to degraded habitat. Habitat degradation and anthropogenic pressures such as pollution, sand mining, and altered flow regimes negatively impact waterbird diversity (Pandiyan et al., 2010; Wang et al., 2018). Low diversity in the upper zone as compared to middle zone is also likely due to habitat degradation, anthropogenic stressors, land use pattern change, and altered flow regimes. Despite its richness, the Gomti's waterbird community shows signs of ecological stress. Dominance by generalists suggests detoriated habitat conditions due to fragmentation, pollution, and resource extraction (Khan et al., 2013; Wang et al., 2018). Earlier investigations provided only limited, short-term observations, our systematic, replicable, multi-year surveys furnish a robust baseline for sustained avian monitoring along the Gomti River. Our observations extend bird's distribution in unprotected riverine habitats, underscoring the Gomti's role in supporting both breeding and migratory populations along the Central Asian Flyway (Meshram, 2010). Taxonomic composition was dominated by Pelecaniformes, Charadriiformes, and families such as Ardeidae and Anatidae, consistent with the Gomti floodplain's shallow waters, mudflats, and emergent vegetation. Abundant and adaptable species such as little cormorant (*Microcarbo niger*), black-winged stilt (*Himantopus himantopus*), and Indian cormorant (*Phalacrocorax fuscicollis*) exhibit ecological flexibility, allowing them to thrive in environments altered by human activity (Whelan et al., 2016). In contrast, rarer specialists such as bitterns and woolly-necked Storks indicate that ongoing habitat alteration favour generalists while restricting habitat-specialist taxa. Feeding guild analysis revealed dominance of carnivorous taxa, indicating that the Gomti sustains robust populations of piscivorous and aquatic invertebrate feeders, consistent with patterns in other Indian freshwater systems (Mukhopadhyay & Mazumdar, 2019; Mishra et al., 2020). In contrast, insectivores and omnivores were comparatively scarce, unlike in wetlands where vegetation creates broader foraging niches (Prajapati & Singh, 2024). This underscores the distinct ecological nature of flowing river habitats in structuring avian communities.

The presence of threatened species including the Endangered Indian skimmer (*Rynchops albicollis*) and Egyptian vulture (*Neophron percnopterus*), communities. and Vulnerable sarus crane (*Antigone antigone*) and river tern (*Sterna aurantia*) highlights the Gomti River's critical conservation value. A flock of 57 Indian skimmers was observed resting on a small sandy island of the Gomti River near Palauli during our survey in February 2022; the flock was observed in the same location over three consecutive days (Figure 6.5). Small shallow depressions were also observed on the ground, potentially indicating their attempts at breeding. Further downstream, 14 km away, a single individual of Indian skimmer was observed gliding over the water surface near Devait. Therefore, it is plausible that comparable islets exist along the river, which could offer suitable breeding sites. The Gomti River flows through an agricultural landscape, where water extraction, fishing, cattle grazing, sand mining, and other activities were noted. Due to considerable human and livestock disturbance, riverine nesting birds have limited opportunities for successful breeding (SoIB, 2023). Further research is needed to determine Indian skimmer breeding in the Gomti River.

Overall study provided a comprehensive assessment of waterbird diversity, abundance, distribution, and ecological status along the Gomti River. Our findings demonstrate the river's significance as a habitat for resident, migratory, and globally threatened species, while underscoring the urgent need for conservation interventions beyond sanctuary boundaries. Sustained monitoring and targeted habitat management are essential to safeguard the ecological integrity of the Gomti River and its avian communities.

Table 6.2. Summary of avifaunal diversity documented in and around the Gomti River basin, Uttar Pradesh.

Previous studies	Study area	Targeted group/species	No. of Species
Kumar (2013)	Dudwa Tiger Reserve, Uttar Pradesh	Bengal florican	1
Kumar et al. (2013)	Sandi Bird Sanctuary, Hardoi, Uttar Pradesh	All birds	105
Jha (2015)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary, Uttar Pradesh	All birds	61
	Samaspur Bird Sanctuary, Uttar Pradesh	All birds	109
	Sandi Bird Sanctuary, Hardoi, Uttar Pradesh	All birds	105
Kanaujia et al. (2015)	Lucknow district, Uttar Pradesh	Waterbirds	70
Kumar & Kanaujia (2015)	Samaspur Bird Sanctuary, Rae Bareli District, Uttar Pradesh	Waterbirds	78
Kumar & Kanaujia (2016)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary, Uttar Pradesh	Asian Open bills (Population size=1,054)	1
Rahmani et al. (2016)	Kishanpur Wildlife Sanctuary, Uttar Pradesh	All birds	>250
	Pilibhit Tiger Reserve	All birds	>330
	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	All birds	>200
	Samaspur Bird Sanctuary, Rae Bareli District, Uttar Pradesh	All birds	>110
	Sandi Bird Sanctuary, Hardoi, Uttar Pradesh	All birds	40
Jha et al. (2018)	Trans boundary study in India and Nepal including Pilibhit region of Uttar Pradesh	Bengal florican	1
Kumar et al. (2018a)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	Five new avifauna record for the sanctuary	5
Kumar et al. (2018b)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary	New sighting record of white-tailed Lapwing	1
Rahmani et al. (2019)	Northen part of Uttar Pradesh	Saras crane	1
Verma et al. (2019)	Dudwa Tiger Reserve, Uttar Pradesh	Bengal Florican	1
Srivastava et al. (2022)	Lucknow zone of North Indian Plain	All birds	35
Parveen et al. (2023)	Surrounding Wetlands of Ekana Stadium, Lucknow	Waterbirds	17
Prajapati & Singh (2024)	Nawabganj (Shaheed Chandra Shekhar Azad) Bird Sanctuary, Uttar Pradesh	Wetland flora as natural food source for avifauna	22
Safi et al. (2024)	Pilibhit Tiger Reserve	All birds	236
Present study	Gomti River (Gomat Tal to Kaithi ~930 km), Uttar Pradesh	Waterbirds and water-associated birds	44
		Terrestrial birds	7

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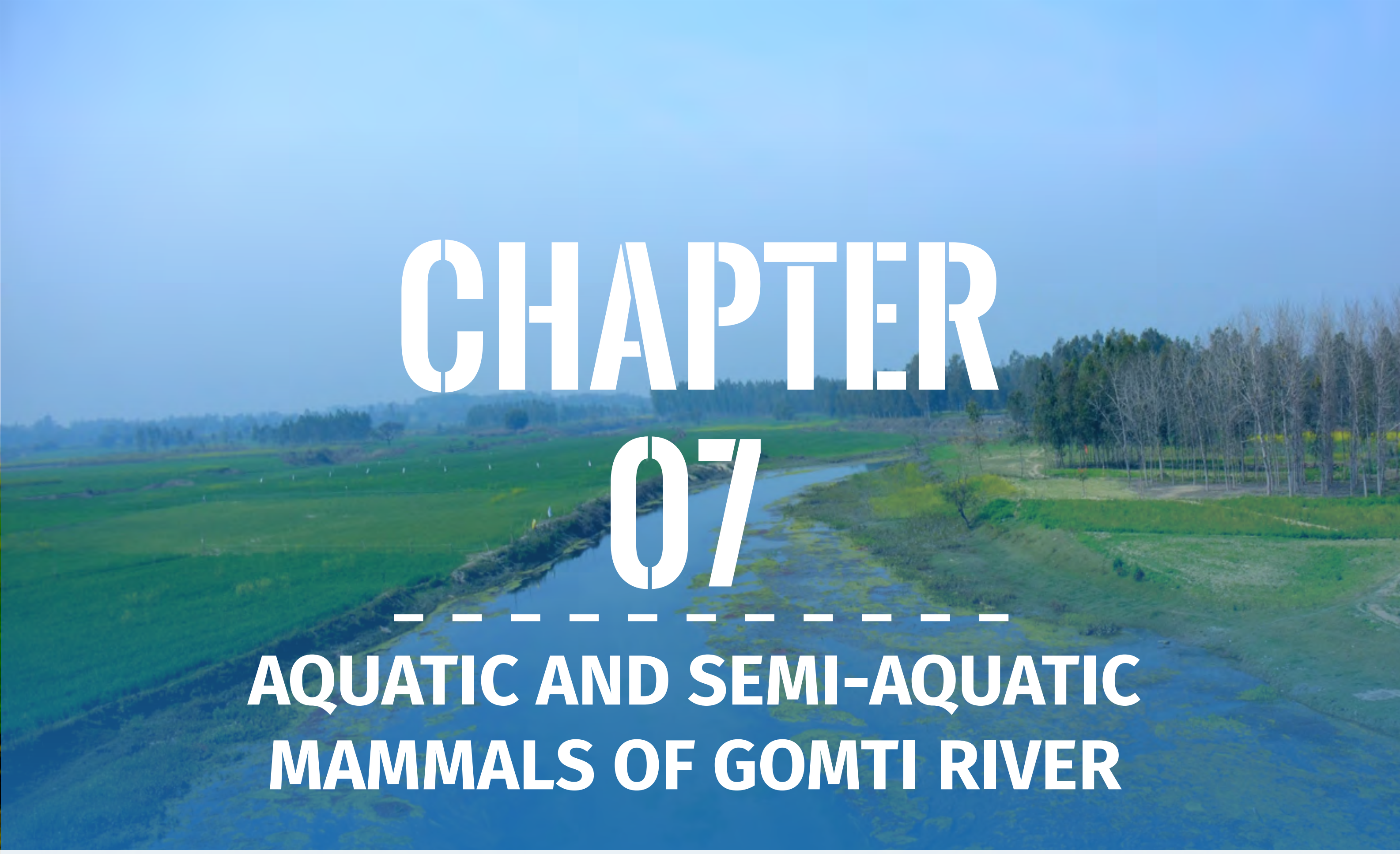

CHAPTER 07

AQUATIC AND SEMI-AQUATIC MAMMALS OF GOMTI RIVER

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SUMMARY

Freshwater ecosystems harbour a rich biodiversity, including a significant portion of vertebrate species despite covering a small fraction of the Earth's surface. In India, seven mammalian species are associated with freshwater habitats. The key species such as the Gangetic dolphin, smooth-coated otter, Eurasian otter, and Asian small-clawed otter have been recorded from the Ganga River basin. However, human activities including as dam construction, pollution, and unsustainable resource extraction pose a threat to these species. The Gangetic dolphin, which was formerly documented from the Gomti River, appears to have locally extinct, and there were no confirmed reports of otters prior to this study, indicating a significant knowledge gap.

This study aimed to determine the present distribution and abundance of aquatic and semi-aquatic animals along a 930 km stretch of the Gomti River in Uttar Pradesh. Initial reconnaissance in 2019-2020 preceded systematic surveys in 2021, 2022, and 2023, which used a variety of approaches according to hydrological circumstances and navigability. The data confirmed the absence of the Gangetic dolphin, which is consistent with earlier studies of its local extinction, while also revealing that dolphins may periodically move upstream during monsoon seasons. Notably, a single sighting of a smooth-coated otter was reported, marking the species' first scientific record from the Gomti River, implying that some

populations likely persist. The absence of the Gangetic dolphin implies substantial habitat degradation, but the proven existence of the smooth-coated otter indicates stretches of the Gomti River with relatively intact habitat and ecological value. This study provides a crucial baseline for future monitoring and conservation measures, highlighting the importance of sustaining environmental flows, maintaining the quality of water, safeguarding habitats, and improving river management to conserve freshwater mammals in the region.

7.1. INTRODUCTION

Freshwater ecosystems cover only a small portion of the Earth's surface and are home to roughly one-third of all vertebrate species (Dudgeon et al., 2006). Freshwater mammals inhabit all continents except Antarctica; some species are widely dispersed, while several possess quite restricted ranges (Veron et al. 2008). India's freshwater system harbour a total of seven mammalian species (Chandra et al., 2017). The river systems in the Ganga basin provide habitat to key mammalian species such as Gangetic dolphin (*Platanista gangetica*), Asian small-clawed otter (*Aonyx cinerea*), Eurasian otter (*Lutra lutra*), and Smooth-coated otter (*Lutrogale perspicillata*). As top predators, these freshwater mammals play a vital role in the river ecosystem and its overall health by imposing top-down control in the food web (Yodzis, 2001; Gomez-Salazar et al., 2012; Peterson & Schulte, 2016). These riverine ecosystems are increasingly jeopardized by anthropogenic alterations, including dam development, pollution, excessive water extraction, which lead to habitat fragmentation, degradation and loss. These alterations severely degrade aquatic biodiversity, placing freshwater habitats among the most imperiled ecosystems globally (Dudgeon et al., 2006; Vörösmarty et al., 2010). Conservation initiatives are essential to alleviate these effects and safeguard the distinctive biodiversity seen in freshwater ecosystems.

Previous studies have highlighted the historical presence of the Gangetic dolphin (*Platanista gangetica*) in the Gomti River during the 1870s (Anderson, 1878; Sinha & Kannan, 2014). The Conservation Action Plan for the dolphin (2010–2020) identified the Gomti River as one of the areas requiring systematic and scientific surveys for this species (Sinha et al., 2010). Subsequently, Sinha and Kannan (2014) compiled available population data of Gangetic dolphin (*Platanista gangetica*) from across India and produced a distribution map for the year 2009, which indicated the local extinction of the species from the Gomti River. Additionally, no documented evidence has been found regarding the presence or distribution of any otter species in the Gomti River. Based on the existing knowledge gap, the key objectives of this study were (i) to determine the current distribution of aquatic and semi-aquatic mammal species, and (ii) to assess their abundance in the Gomti River.

7.2. METHODS

A reconnaissance survey was carried out to assess the feasibility of the Gomti River for survey in the post-monsoon season during 2019-20. Then, the BEUs overlaid across the Gomti River were surveyed for three consecutive years 2021 to 2023 (Table 7.1). Boat-based visual encounter method was followed to record freshwater mammals throughout the BEUs except for upper zone in the Gomti River in 2022 (Smith & Reeves, 2000). The upper zone of the Gomti River was found to have discontinuous flow of water, so vehicular and foot survey was implemented to survey BEUs. A 25 hp inflatable rubber boat/country boat was used during daylight hours, specifically between 0800–1200 hours and 1500–1700 hours in the middle and lower zone of the river in 2022 during the post-monsoon season (Table 7.1). The boat speed was maintained between 6 and 10 km/h to minimize the risk of missing surfacing individuals. A team of four trained observers was equipped with binoculars, GPS device, and rangefinder to simultaneously record aquatic mammals along with associated habitat features. The observers were positioned at the bow of the vessel in case of boat survey following Smith et al. (2006).

7.3. RESULTS

Gangetic dolphin

There was no sighting of Gangetic dolphin (*Platanista gangetica*) during the BEU surveys in the Gomti River.

Otters

A single sighting of a smooth-coated otter (*Lutrogale perspicillata*) was recorded from the Gomti River near Gayabar village (at BEU 59) in Sitapur district, Uttar Pradesh on March 5, 2023 (Figure 7.1; Plate 7.1).

7.4. DISCUSSION

The present study provides the first systematic, multi-year survey of aquatic and semi-aquatic mammals across the entire 930 km length of the Gomti River. The findings — absence of the Gangetic dolphin and a single confirmed sighting of the smooth-coated otter — are ecologically significant not merely as species records but as indicators of the river's overall ecological condition. Interpreted together, they reveal a river system in advanced stages of habitat degradation, yet one that retains residual ecological value in its less disturbed reaches.

The absence of the Gangetic dolphin (*Platanista gangetica*) in the Gomti River, across all sampling years is consistent with the observation by Sinha & Kannan (2014). The map created by Sinha & Kannan (2014), indicates the extinction of the species' local population in this river. However, according to anecdotal records, the species is known to migrate into the Gomti River from the Ganga mainstem during high flow in monsoon season. The observation of the Vulnerable smooth-coated otter (*Lutrogale perspicillata*) represents the first confirmed record of the species in the Gomti River. Intensive studies with special focus on the smooth-coated otter would be essential to determine the distribution range, population, and ecology of the species, as well as for its conservation in the Gomti River.

The fate of the Gangetic dolphin and the smooth-coated otter in the Gomti River exemplifies a general pattern seen in degraded river systems worldwide, where large, specialised freshwater mammals with narrow ecological tolerances, such as river dolphins, are extirpated first and most completely, whereas more adaptable semi-aquatic species, such as otters, may persist in residual habitat patches long after apex predators have disappeared (Dudgeon et al., 2006; Vörösmarty et al., 2010). The results of the survey are ecologically important, as they suggest a river that has already crossed a threshold of degradation sufficient to eliminate its most sensitive freshwater mammal, yet it still contains ecological refugia capable of supporting less specialised species. The Sitapur reach, where the otter was sighted, could be one such refugium – relatively upstream, less industrially impacted and perhaps benefitting from higher flow and lower concentrations of pollutants compared to the middle and lower zones.

In the context of the confirmed local extinction of the Gangetic dolphin and the vulnerable status of the smooth-coated otter, there is a compelling need to adopt a new paradigm of river management that unequivocally integrates ecological flow requirements, pollution abatement and bycatch mitigation as essential conservation imperatives. Adequate environmental flows are needed, especially during the pre-monsoon and non-monsoon periods when the upper zone has intermittent flows, to maintain the ecological integrity of the river and to provide opportunity for natural recolonization by dolphins from the mainstem Ganga.

Table 7.1. Summary of aquatic and semi-aquatic mammal survey in the Gomti River.

Surveyed stretch	Length of the stretch (km)	Survey method	Season	Year	Month
Gomat tal in Pilibhit district to Kaithi, Ghazipur district, Uttar Pradesh	~930	Vehicular and foot (reconnaissance survey)	Post-monsoon	2019-20	December, January, February
		Vehicular and foot	Pre-monsoon	2021	June, July
		Vehicular and foot in the upper zone from Gomat tal to Sitapur, Boat (middle and lower zone from Sitapur to Kaithi)	Post-monsoon	2022	February, March
		Vehicular and foot	Post-monsoon	2023	February, March

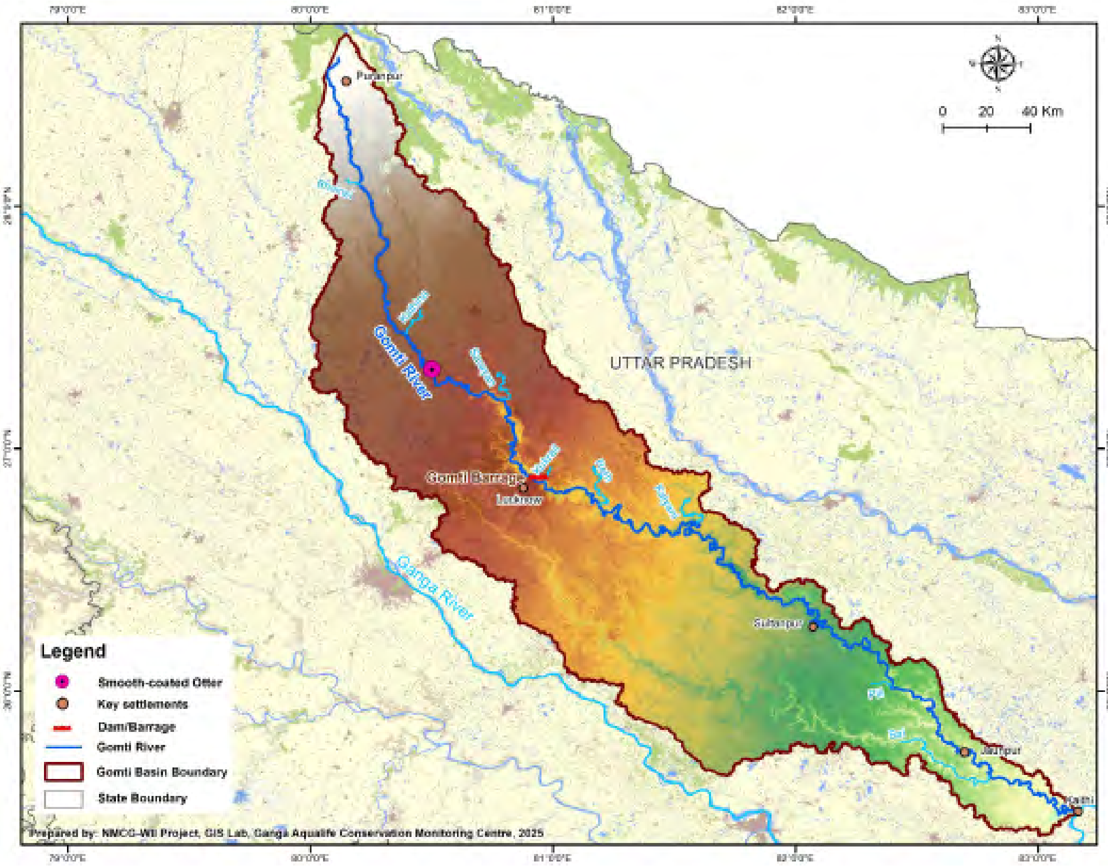

Figure 7.1. Map showing distribution of Smooth-coated otter in the Gomti River near Gayabar village in Sitapur district, Uttar Pradesh.

Plate 7.1. Smooth-coated otter in the Gomti River near by Gayabar village in the Sitapur district of Uttar Pradesh.

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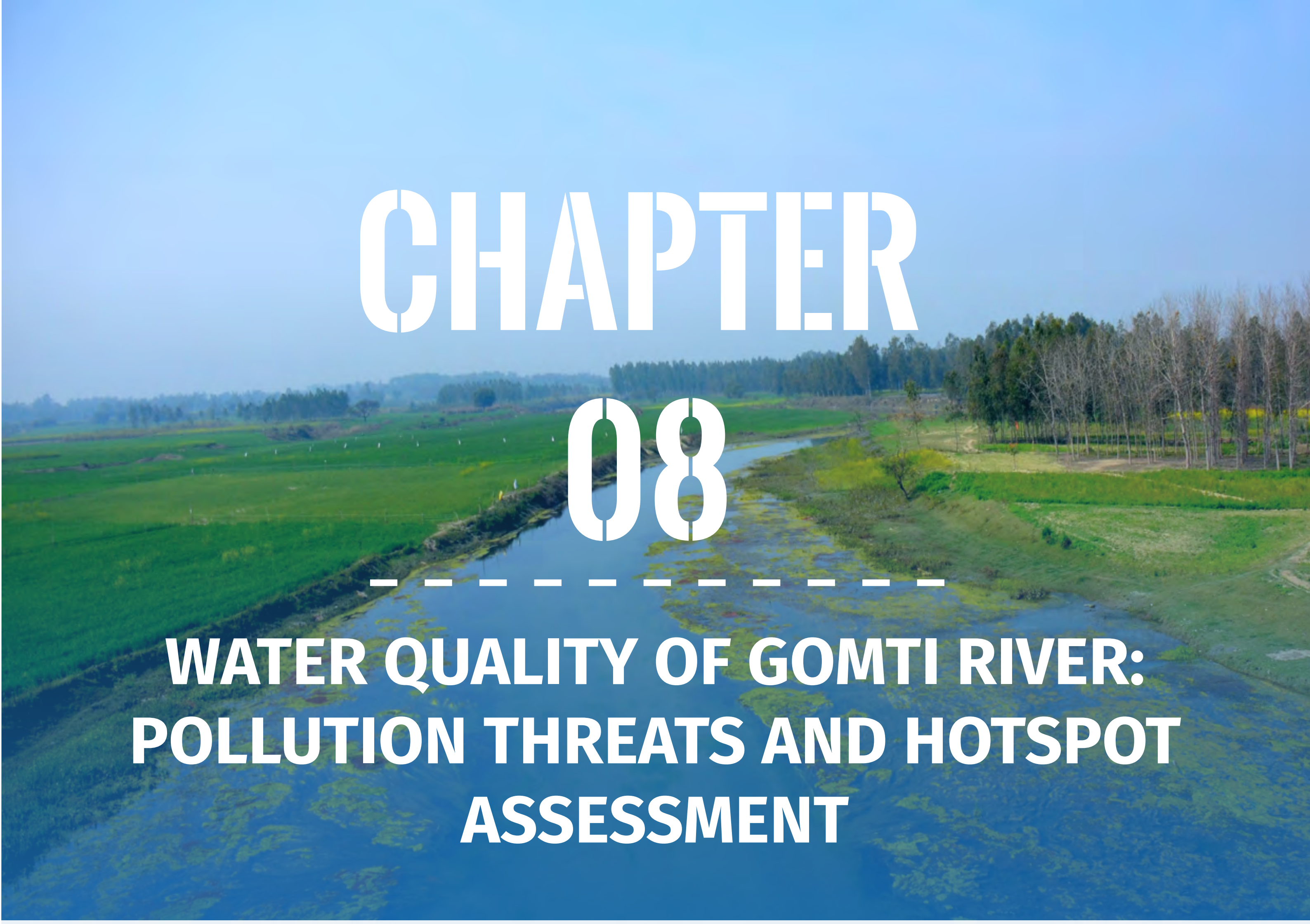

CHAPTER 08

WATER QUALITY OF GOMTI RIVER: POLLUTION THREATS AND HOTSPOT ASSESSMENT

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SUMMARY

The Gomti is hydrologically extant, conventionally polluted, and emerging-contaminant compromised at a level its regulatory framework does not measure. The river supplies drinking water to over 3.5 million people across Lucknow, Jaunpur, Sultanpur and Lakhimpur Kheri and discharges into documented Gangetic dolphin (*Platanista gangetica*) habitat at Kaithi. The 2021 to 2025 assessment, three matrices (water, sediment, biota) and four monitoring years documents a contaminant flux that includes pharmaceuticals, steroidal endocrine disruptors, plasticisers, heavy metals, and a newly detected fraction of polychlorinated biphenyls and organophosphate pesticides. Sustaining conventional compliance will not address this flux; addressing the flux will not displace the conventional programme.

Results are reported at two nested spatial scales, river-wide and zone-wide (Upper, Middle, Lower), with the 2025 annual mean defining current status and 2021 to 2025 trends distinguishing parameters

responding to mitigation from those of continuing concern. Surface water exceeds aquatic-life thresholds at 67% of observations. Dissolved oxygen fails the 5 mg/L survival floor across the Lucknow corridor. Heavy metals dominate by mass in all three matrices. River-wide mean concentrations are 20,723 ng/L in surface water, 75,440 µg/kg in sediment, and 25,835 µg/kg in fish muscle tissue. Phthalates dominate the emerging fraction across all matrices, with 2024 to 2025 outliers reaching 19000 to 27000 ng/L. BPA increased five-fold in 2024. Pharmaceutical residues anchor across the Lucknow corridor. India presently prescribes no ambient, discharge or monitoring standards for any of these emerging classes.

Ecological Risk Assessment classifies 17 % of the corridor as Critical, 42 % High, 42 % Moderate, no stretch as Low. Bioaccumulation rises systematically downstream: organochlorine pesticides 27-fold from Upper to Lower Zone despite Indian prohibition; steroidal endocrine disruptors detected in Lower Zone biota but below detection in the Upper, indicating trophic transfer of the Lucknow pharmaceutical-endocrine plume into fish in the human consumption chain across Amethi, Azamgarh and Jaunpur.

Four operational priorities define the basin. Sarayan Confluence carries a chlorpyrifos-phthalate signature associated with the Sitapur-Hardoi sugarcane belt and ten Sitapur catchment industries. U/S and D/S Lucknow are co-Critical, wherein the largest treatment assets are either not-achieving compliance, or are non- operational, and ten of Lucknow's 33 drains carry approximately 50 mg/L BOD daily. Amethi carries the plume amplified by the Kadu Drain from the Jagdishpur Industrial Area. Jaunpur and Azamgarh deliver the fish bioaccumulation peak into the Ganga at Kaithi. Four NGT-flagged towns (Sitapur, Barabanki-Nawabganj, Amethi-Jagdishpur, Kerakat) remain at zero STP capacity seven years on.

The 2021 to 2025 trend record is bifurcated. Heavy metals declined 79%, coinciding with CETP enforcement, OCEMS deployment, and ZLD verification on the Sitapur and Jagdishpur clusters. Personal care products declined 90%, coinciding with post-pandemic triclosan normalisation and STP capacity commissioned 2017 to 2022. Pharmaceuticals and steroidal EDCs show no significant change; organochlorines persist despite the ban regime. Four signals are newly emerging in 2024 to 2025: phthalates rebounded 55% above 2021; BPA increased five-fold; PCBs and OPPs crossed detection limits for the first time, with candidate sources including end-of-life transformer leakage and informal e-waste clusters in Lucknow and Jaunpur (the inventory under India's Stockholm NIP is incomplete) and chlorpyrifos-malathion substitution in the Sitapur-Hardoi-Lakhimpur Kheri belt conveyed by the Sarayan.

Closing the documented gaps requires four sequenced priority tiers, extending NMCG's existing instruments to contaminant classes and pathways currently outside its scope, and addressing enforcement, performance, coverage, and structural reform in sequence.

Priority 1-Immediate (0 to 6 months). Water Act 1974 compliance order against Bharwara with 90-day remediation; commission the five Lucknow STPs under construction; interception-and-diversion for the ten high-load Lucknow drains; source-point fish-tissue biomonitoring at Lucknow; permanent NWMP nodes at the Sarayan, Sai and Kukrail confluences.

Priority 2 - Near-term (6 to 24 months). Performance-based STP contracts in the Lucknow corridor with effluent-linked payment; NWMP parameter expansion to the eight ERA contaminant groups; STPs in the four zero-STP NGT-flagged towns; OCEMS expansion to heavy metals for metal-finishing, electroplating and dyeing units in Lucknow and Jagdishpur; designate the National Centre for River Research, WII Dehradun, as the formal Gomti reference laboratory.

Priority 3 - Medium-term (2 to 4 years). Notify ambient criteria for emerging contaminants under the Water Act 1974; reclassify Gomti's CPCB priority status from BOD-only to multi-contaminant; mandate tertiary treatment at the four largest Lucknow STPs; source-apportionment for the BPA-phthalate rebound and PCB-OPP emergence; complete end-of-life transformer and e-waste inventory under Stockholm NIP; integrated pest management in the Sarayan sub-catchment.

Priority 4 - Long-term (4 to 10 years). Integrated Gomti Basin Council under the Ministry of Jal Shakti chaired at Secretary level, treating the main stem and the Sarayan, Sai and Kukrail as a single management unit; integrate Lower Gomti into the dolphin critical conservation corridor (Prayagraj to Bhagalpur); contaminant-aware species management plans for dolphin and gharial-and-turtle conservation, with the Kukrail Gharial and Turtle Rehabilitation Centre as Middle Zone co-management anchor; institutionalise the WII Dehradun monitoring network as a permanent NMCG programme with public dashboard.

8.1. INTRODUCTION

Freshwater ecosystems face escalating pressure from chemical pollution, climate change, species invasions and habitat degradation, with these stressors threatening approximately 27% of all freshwater species in the IUCN Red List (Tickner et al., 2020). Legacy pollutants (heavy metals, endocrine disruptors, persistent organic pollutants) accumulate in sediments and biota over decadal timescales, while emerging contaminants (pharmaceuticals, personal care products, plasticisers) pose complex risks through continuous discharge and biological activity at trace concentrations (Kümmerer, 2009). Together, these classes impair water quality, erode biodiversity and disrupt ecosystem functioning across all trophic levels, from primary producers to fish and aquatic mammals.

The Gomti supports the health and livelihoods of riparian communities across its 930 km course, serving as the primary drinking water source for over 3.5 million people in Lucknow, Jaunpur, Sultanpur and Lakhimpur Kheri, sustaining inland fisheries, and providing irrigation for sugarcane, paddy, wheat, barley and pulses across the basin. Over recent decades, the anthropogenic pressure has intensified sharply. The Sitapur-to-Sultanpur reach traverses an agro-industrial corridor of sugar mills, paper and plywood industries, where effluents combine with agricultural runoff and urban waste to generate severe contamination loads (Dutta et al., 2011). The transformation of Lucknow into a dense urban centre has further increased inflows of untreated sewage, industrial effluents and municipal waste enriched in heavy metals, hydrocarbons and emerging contaminants (Inland Waterways Authority of India, 2018; Kushwah et al., 2023), while basin land use (65.5% agriculture, 13.3% settlements) delivers nitrates, phosphates and pesticide residues alongside riverbank encroachment and inadequate waste management (Das et al., 2024). The Gomti discharges directly into the Ganga at Kaithi, a documented habitat of the Gangetic dolphin (*Platanista gangetica*, IUCN Endangered), making its contamination assessment directly relevant to both Ganga main-stem water quality and dolphin conservation under the Namami Gange Mission of the Ministry of Jal Shakti.

This chapter provides an integrated, evidence-based assessment of the Gomti River across three contamination matrices (surface water, sediment, fish biota), two seasons (pre- and post-monsoon) and four monitoring years, linking contamination patterns to ecological risk and abatement priorities for aquatic species conservation under the Namami Gange framework.


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8.2. METHODS

Surface water, sediment and fish samples were collected from designated sites along the Gomti River (Figure 8.1, Table 8.2) following standard protocols and established guidelines, during pre-monsoon (April–June) and post-monsoon (October–December) campaigns in 2021, 2022, 2024 and 2025. The assessment covers four components: current contamination status (2025 surveys) across water, sediment and biota; temporal trends to evaluate intervention effectiveness and emerging risks; pollution hotspot identification based on contamination intensity and ecological vulnerability; and targeted, tiered interventions aligned with pollution type, institutional responsibility and implementation timeline.

Results are presented at two nested spatial scales (river-wide and zone-wise), with the river divided into three contiguous zones reflecting catchment character: the Upper Zone (354 km, origin to Sarayan confluence), Middle Zone (344 km, Kukrail confluence to Sultanpur), and Lower Zone (230 km, Azamgarh to the Ganga confluence). This structure supports both basin-scale policy and site-specific operational decisions for restoration and conservation planning within the broader Ganga Basin.

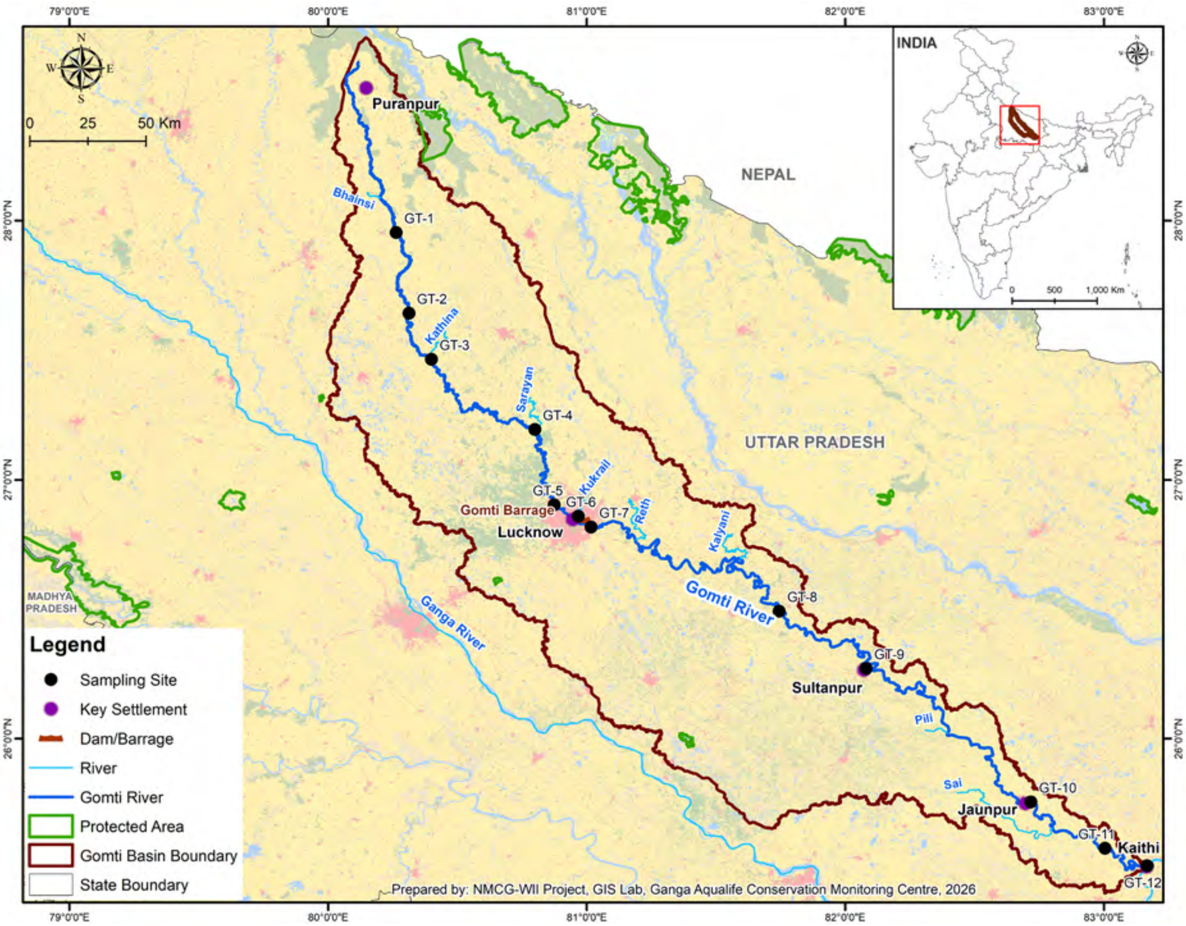

Figure 8.1. Spatial distribution of Sampling Sites along the Gomti River.

Table 8.1. Details of Sampling locations in Gomti River.

River Zones	Site Name	State	District	Latitude	Longitude
Upper Zone	D/S Origin	Uttar Pradesh	Kheri	27.9489	80.3935
	Maholi	Uttar Pradesh	Sitapur	27.6422	80.3125
	Dadhnamau	Uttar Pradesh	Sitapur	27.4641	80.3996
	Sarayan River Confl.	Uttar Pradesh	Hardoi	27.1928	80.7990
Middle Zone	U/S Lucknow City	Uttar Pradesh	Lucknow	26.9030	80.8741
	Kukrail River Confl	Uttar Pradesh	Lucknow	26.8590	80.9673
	D/S Lucknow City	Uttar Pradesh	Lucknow	26.81722	81.01694
	Amethi	Uttar Pradesh	Sultanpur	26.4919	81.7449
	Sultanpur	Uttar Pradesh	Sultanpur	26.2703	82.0811
Lower Zone	Jaunpur	Uttar Pradesh	Jaunpur	25.7540	82.7181
	Azamgarh	Uttar Pradesh	Jaunpur	25.5750	83.0050
	U/s Ganga Conf	Uttar Pradesh	Ghazipur	25.5077	83.1679
Area of concerns (%)	Solid Waste (88%), Bridges (88%), Agricultural Runoff (75%), Domestic/Industrial Effluents (63%), Cremation Activities (63%), Community Bathing (50%), Fishing Activities (50%), National Highways (50%), Washing Activities (38%), Motor Boats (25%), Recreational Activity (13%)				

Physical-chemical parameters of surface water were measured in situ using a ProDSS Multiparameter Digital Water Quality Meter (YSI, USA). At each site, 4–5 grab samples of surface water and sediment were collected at 0–15 cm depth and bulked into composite samples in pre-cleaned amber glass bottles (water) and aluminium zip-locks (sediment), preserved at 4°C, and processed within 48–72 hours. Biological samples comprised 23 freshly caught fish species obtained from local fishermen during routine activities in the 2024 post-monsoon season; individual total length and weight were recorded on-site, and specimens were identified, sealed, transported on ice and stored at –50°C until processing.

Sample preparation followed established in-house validated methods for the contaminant classes assessed (Sah et al., 2024a, 2024b). Extracts were quantified by 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) . Analytical quality assurance comprised standard operating procedures, calibration with certified standards, reagent blanks, recovery checks against Standard Reference Materials (SRMs) and analytical replicates. Target chemicals monitored are listed in Table 8.2.

Table 8.2. Target chemical groups monitored.

Category	Number of analytes (61)
Plastics Additives	6 Phthalate Esters (PAEs) + BPA
Polychlorinated Biphenyls (PCBs)	7 (Priority Congeners)
Pesticides	20 organochlorines (OCP) + 6 organophosphates (OPP)
Steroids/Hormones	3 natural + 2 synthetics
Personal care products (PCPs)	Anti-microbial (Triclosan+Triclocarban)
Pharmaceuticals (Pharma)	5 (analgesic, NSAID, CNS stimulant, anti-inflammatory, antibiotic)
Heavy Metals (HMs)	Mercury, Cadmium, Lead, Arsenic, Chromium, Cobalt, Zinc, Nickel, Copper

8.3. RESULTS AND DISCUSSION

8.3.1. Water Quality Assessment of the Gomti River

Six pollution indicators were assessed across nine Gomti sites (Figure 8.2 and Table 8.3). On annual mean, 33% of the river met good water quality criteria; 67% was poor. The Lucknow corridor (U/S to D/S Lucknow City) and Azamgarh are the focal points for priority monitoring and abatement. Conductivity was the most widespread failure (67% exceedance; 628.6 ± 49.56 µS/cm). Nitrate exceeded the 10 mg/L limit at 33% of observations (8.75 ± 1.90 mg/L; peak 36 mg/L at Dadhnamau). TDS exceeded 500 mg/L at 33% (426 ± 34.96 mg/L;). pH breached the 6.5 to 8.5 range at 33%, consistently alkaline (8.30 ± 0.10). Dissolved oxygen (DO) failed the 5 mg/L survival threshold at 17% (7.42 ± 0.69 mg/L) of observations, all confined to the sampling sites in Lucknow. Salinity was fully compliant (100%; 0.09 ± 0.04 ppt). Seasonally, conductivity, TDS and DO fail in the pre-monsoon under low-flow concentration; nitrate showed the opposite pattern, peaking post-monsoon through fertiliser flushing and ammonia nitrification (Figure 8.3).

The three zones carried distinct signatures. The Upper Zone was nitrate-driven, with the river's highest spike at Dadhnamau and Sarayan confluence, consistent with fertiliser runoff from the rice-wheat headwater belt. The Middle Zone across the Lucknow corridor was the most oxygen-degraded, with DO at 1.4 mg/L at D/S Lucknow City, well below survival levels for fish; the collapse began immediately downstream of Kukrail confluence, which simultaneously delivered the river's highest conductivity (1180 µS/cm) and a corridor nitrate peak of 31 mg/L. The Lower Zone carried the most consistent ionic burden, with conductivity of 575 to 776 µS/cm at every site, TDS reaching 503 mg/L at U/S Ganga confluence, and Azamgarh's pH at 9.02 signalling nutrient-driven primary productivity.

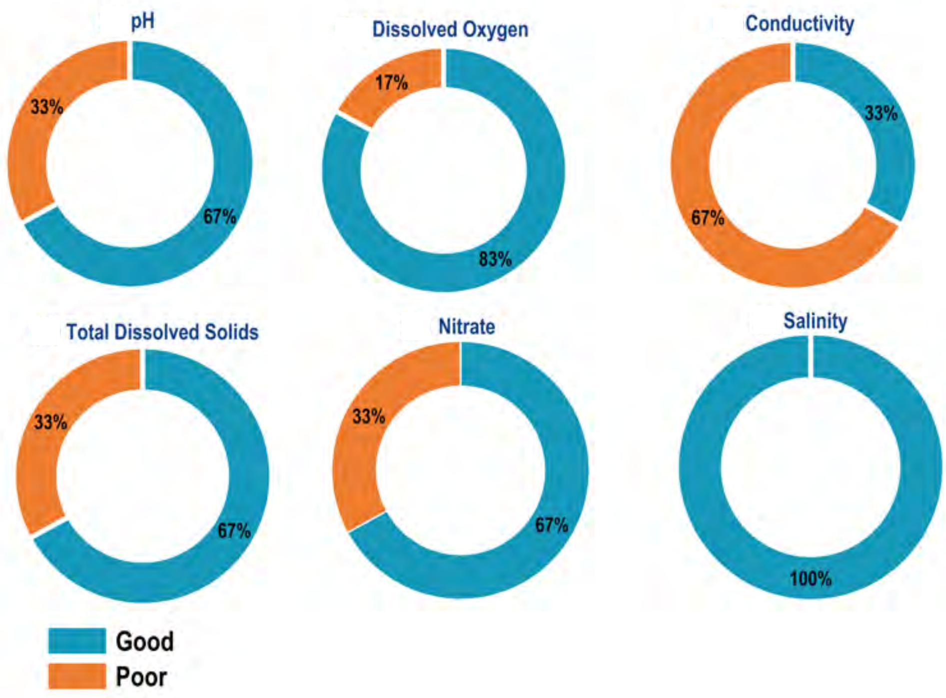

Figure 8.2. Compliance of Gomti surface water against aquatic-life thresholds for key parameters (2025 annual mean).

Table 8.3. Zone-wide assessment of physical-chemical parameters based on 2025 Annual Mean.

Category	Zones			River Wide (Mean ± SEM)
	Upper Zone	Middle Zone	Lower Zone	
DO (mg/L)	6.66 - 8.14	2.89 - 9.21	7.90 - 10.63	7.42 ± 0.69
pH	7.99 - 8.61	7.71 - 8.82	8.37 - 8.54	8.30 ± 0.10
TDS (mg/L)	273 - 384	258 - 627	376-503	426 ± 34.96
Salinity (ppt)	<0.01 - 0.29	<0.01 - 0.40	<0.01	0.09± 0.04
Cond (µS/cm)	405 - 592	399 - 892	575 - 776	628± 49.56
Nitrate (mg/L)	0.33 - 18.38	7.29 - 15.91	1.79 - 5.81	8.75 ± 1.9
Water-Quality Stress	Moderate-High (21%)	Very High (40%)	Moderate-High (28%)	Moderate-High (67%)
Priority Pollution Sites	Sarayan River Confl.	U/S Lucknow City, Kukrail Confl., D/S Lucknow City	Azamgarh	-

Aquatic Life Threshold: DO ≥5 mg/L; pH: 6.5–8.5; TDS<500 mg/L; Salinity≤0.5 ppt; Conductivity≤500 µS/cm; Nitrate<10 mg/L

Figure 8.3. Seasonal variation of physical-chemical parameters across Gomti sites (pre- and post-monsoon 2025).

8.3.2. Surface Water and Sediment Contamination Status of Gomti River.

The Gomti carries three source-driven contamination signatures: sewage-derived emerging contaminants in the Lucknow corridor, agricultural pesticides and fertiliser legacy in the Upper Zone, and heavy-metal depositional sinks at Sarayan confluence, Sultanpur and Jaunpur. PCBs were below detection across the river, confirming successful national phase-out. Four operational targets define the abatement priority: the Lucknow corridor (Kukrail to D/S Lucknow City) for sewage interception, Sarayan confluence for agricultural runoff control, Sultanpur and Jaunpur for sediment-bound legacy metals, and U/S Ganga confluence as the cumulative transfer point into the Ganga mainstem.

In surface water (Table 8.4, Figures 8.4 and 8.5), the contaminant rank by mean ± SEM was ΣHMs (20723 ± 1967 ng/L) > ΣPAEs (4308 ± 1399) > ΣPharma (99.94 ± 52.9) > BPA (90.49 ± 29.26) > ΣOCPs (8.92 ± 2.24) > ΣOPPs (7.29 ± 2.22) > ΣPCPs (5.65 ± 2.25) > ΣSteroids (1.81 ± 0.76), with heavy metals dominating by three orders of magnitude. Heavy metals, phthalates, pharmaceuticals and BPA followed Middle Zone > Lower Zone > Upper Zone, peaking at D/S Lucknow City, Kukrail confluence (4× river mean), D/S Lucknow City (caffeine, diclofenac, ciprofloxacin) and U/S Lucknow City respectively. Personal care products and steroidal hormones peaked at Kukrail confluence, with EE2 driving a steroidogenic-endocrine signal across the corridor. Legacy organochlorines reversed this trend (Lower Zone > Upper Zone > Middle Zone), while current-use organophosphates followed Upper Zone > Middle Zone > Lower Zone. The Lucknow corridor is the principal dissolved-phase source of sewage-derived emerging contaminants, with Kukrail confluence and D/S Lucknow City as the operational intervention points. Earlier studies on heavy metal contamination of the Gomti (Gupta et al., 2014; Singh et al., 2005) and recent multivariate water-quality assessments (Kushwah et al., 2023) provide the baseline. Earlier water-pollution syntheses for the Gomti are reviewed in Ravichandran and Yadav (2021).

Seasonal dynamics in surface water showed two opposing patterns (Figure 8.5). Legacy and low-flow-concentrated contaminants (ΣHMs, ΣPAEs, ΣOCPs) peaked pre-monsoon, with ΣPAEs 5-fold higher under reduced flow. Current-use contaminants (ΣPharma, ΣOPPs, ΣSteroids, ΣPCPs) peaked post-monsoon through runoff flushing, with ΣPharma rising 3-fold and ΣOPPs 4-fold. BPA showed minimal seasonal variation, indicating continuous sewage-plastic input independent of flow. Year-round monitoring is therefore required, with season-specific intervention planning rather than episodic campaigns.

In surface sediment (Table 8.5, Figures 8.4 and 8.6), the contaminant rank by mean ± SEM was ΣHMs (75440 ± 14067 µg/kg) > ΣPAEs (2669 ± 813) > BPA (93.17 ± 36.18) > ΣOPPs (14.13 ± 4.15) > ΣPharma (12.57 ± 2.68) > ΣOCPs (7.09 ± 1.58) > ΣPCPs (4.28 ± 2.02) > ΣSteroids (0.36 ± 0.13), with heavy metals dominating by a smaller margin than in water. Heavy metals followed Upper Zone ≈ Lower Zone > Middle Zone, the inverse of the dissolved-phase trend, peaking at Sultanpur and Sarayan confluence; cadmium was distinctly elevated at Jaunpur. Phthalates, organophosphates and steroidal hormones followed Upper Zone > Middle Zone > Lower Zone, peaking at Sarayan confluence and identifying the Sitapur-Hardoi headwater belt as the active pesticide and fertiliser source. BPA, organochlorines, pharmaceuticals and personal care products followed Middle Zone > Upper Zone > Lower Zone, peaking at Kukrail confluence and D/S Lucknow City as urban-EDC sediment sinks. The two matrices showed systematically inverted patterns: Middle Zone urban hotspots carried the lowest sediment heavy-metal loads (21284 to 32000 µg/kg) due to scouring, but the highest dissolved EDC and metal loads, while Upper Zone and downstream slack-water sites acted as depositional sinks accumulating both legacy metals and bound EDCs.


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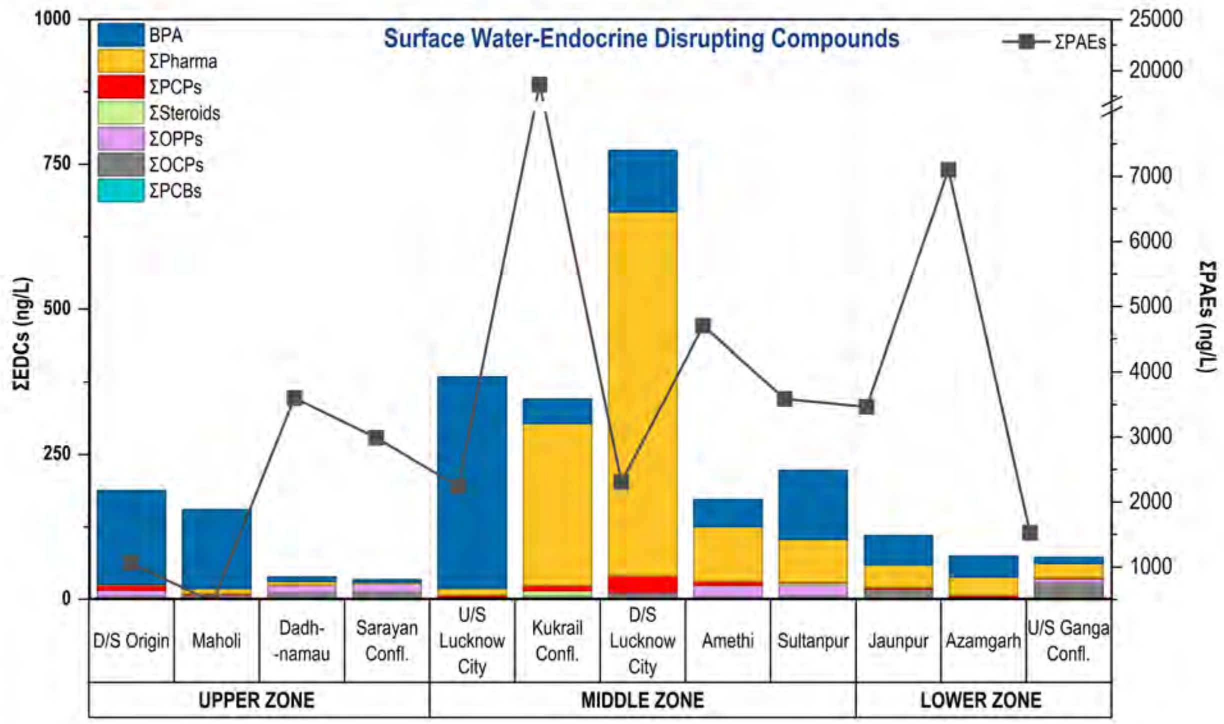


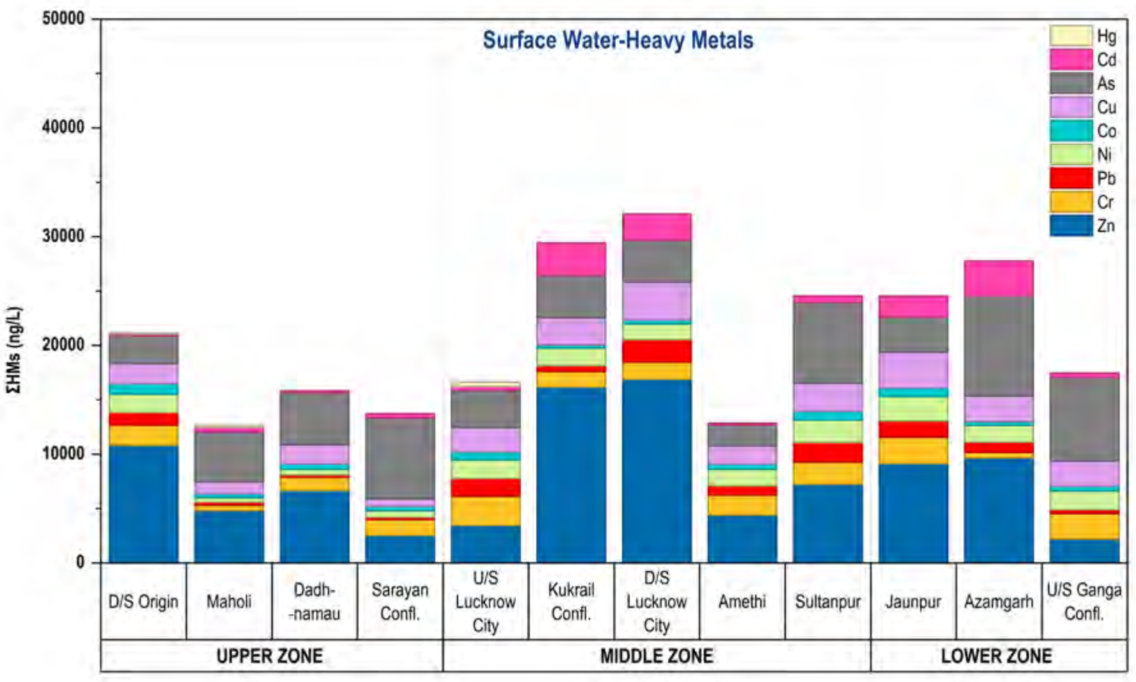
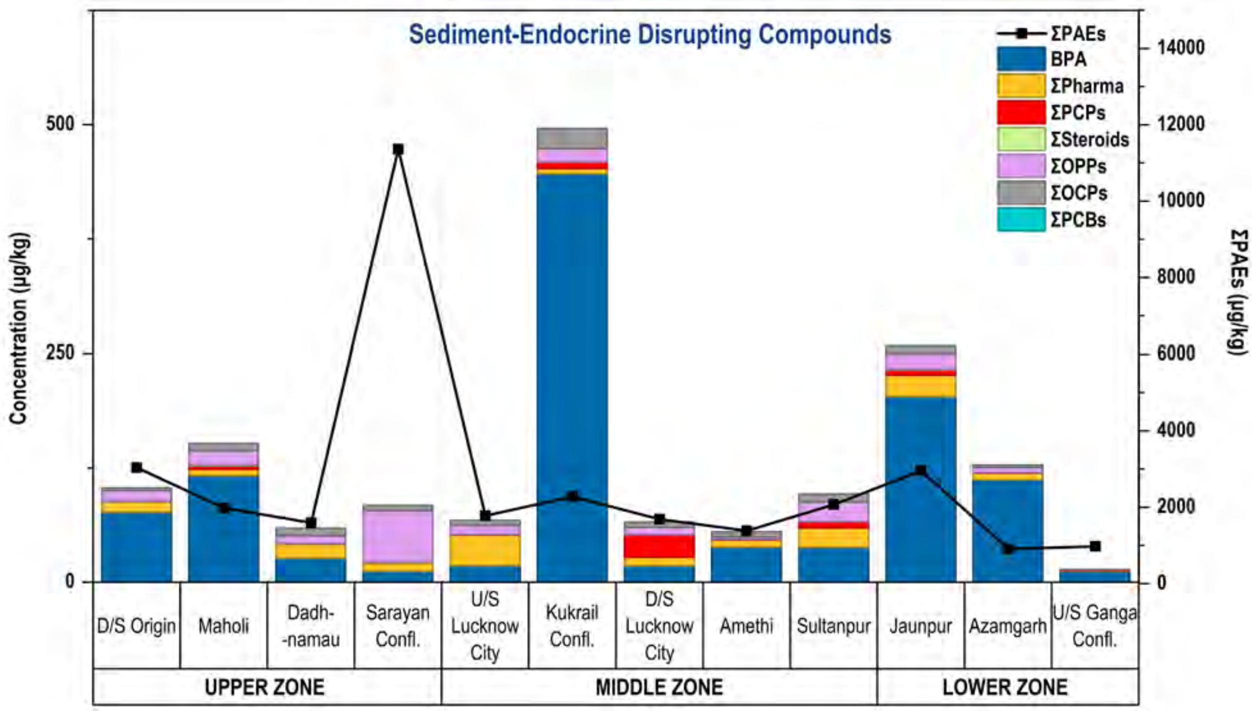


Figure 8.4. Endocrine-disrupting compounds and heavy metals in Gomti surface water and sediment (2025 annual mean, ng/L).


Sediment-Endocrine Disrupting Compounds
Concentration (µg/kg)
ΣPAEs (µg/kg)
ΣPAEs
BPA
ΣPharma
ΣPCPs
ΣSteroids
ΣOPPs
ΣOCPs
ΣPCBs
0
250
500
0
2000
4000
6000
8000
10000
12000
14000
D/S Origin
Maholi
Dadh- -namau
Sarayan Confl.
U/S Lucknow City
Kukrail Confl.
D/S Lucknow City
Amethi
Sultanpur
Jaunpur
Azamgarh
U/S Ganga Confl.
UPPER ZONE
MIDDLE ZONE
LOWER ZONE

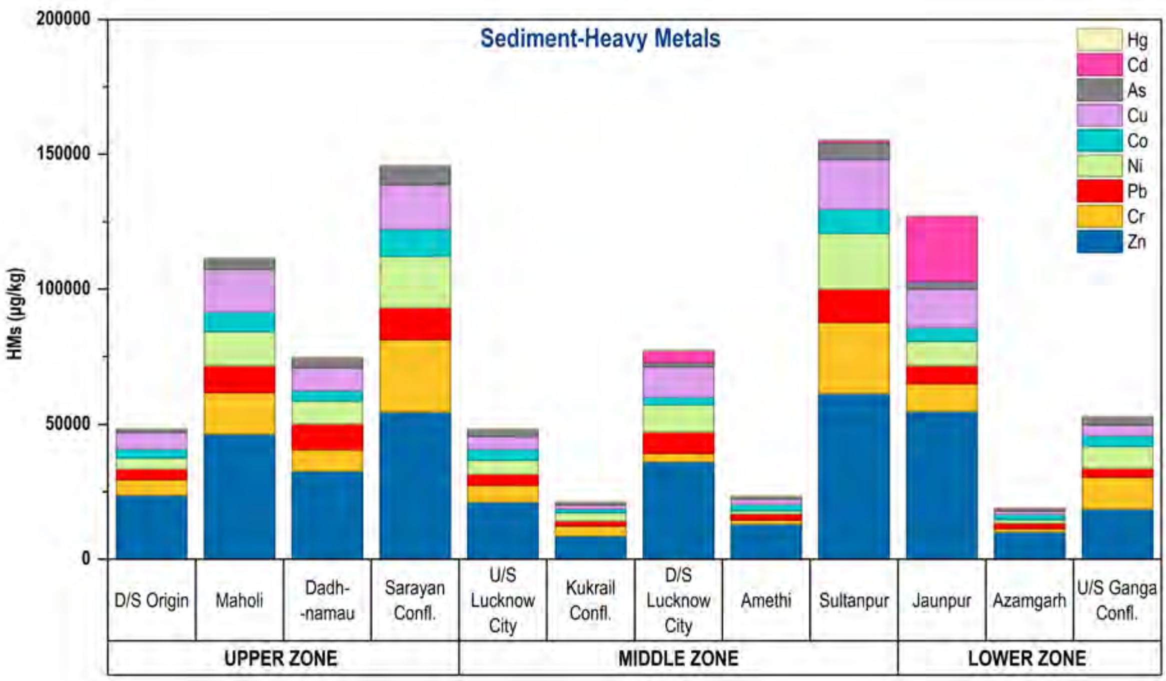

Sediment-Heavy Metals
HMs (µg/kg)
0
50000
100000
150000
200000
Hg
Cd
As
Cu
Co
Ni
Pb
Cr
Zn
D/S Origin
Maholi
Dadh- -namau
Sarayan Confl.
U/S Lucknow City
Kukrail Confl.
D/S Lucknow City
Amethi
Sultanpur
Jaunpur
Azamgarh
U/S Ganga Confl.
UPPER ZONE
MIDDLE ZONE
LOWER ZONE

Table 8.4. Zone-Wide Contamination Status of surface water (ng/L) based on 2025 Annual Mean.

Analyte	Zones			River Wide (Mean ± SEM)
	Upper Zone	Middle Zone	Lower Zone	
ΣHMs	12671 - 21142	12851 - 32095	17453 - 27764	20723 ± 1967
ΣPAEs	466 – 3600	2239 - 18653	1524 - 7099	4308 ± 1399
BPA	4.65 – 162	41.96 – 364	10.55 - 36.26	90.49 ± 29.26
ΣPharma	1.48 - 8.88	11.44 – 627	24.4 - 31.43	99.94 ± 52.9
ΣPCPs	0.08 - 8.88	1.11 - 28.45	1.79 - 3.41	5.65 ± 2.25
ΣSteroids	<DL - 0.74	<DL - 8.55	0.53 - 3.49	1.81 ± 0.76
ΣOCPs	5.66 - 12.14	0.13 - 10.19	<DL- 27.81	8.92 ± 2.24
ΣOPPs	1.55 - 15.17	<DL - 19.04	<DL- 7.34	7.29 ± 2.22

Table 8.5. Zone-Wide Contamination Status of Sediment (µg/kg) based on 2025 Annual Mean.

Analyte	Zones			River Wide (Mean ± SEM)
	Upper Zone	Middle Zone	Lower Zone	
ΣHMs	48385 - 145880	21284 - 155300	19061 - 127213	75440 ± 14067
ΣPAEs	1594 - 11363	1383 - 2281	911 - 2960	2669 ± 813.26
BPA	12.16 - 116.47	18.04 – 446	12.16 - 203	93.17 ± 36.18
ΣPharma	6.9 - 15.18	5.76 - 33.81	0.89 - 23.45	12.57 ± 2.68
ΣPCPs	0.26 - 3.82	0.26 - 24.78	0.32 - 5.68	4.28 ± 2.02
ΣSteroids	0.52 - 1.22	<DL - 0.27	<DL - 0.57	0.36 ± 0.13
ΣOCPs	2.96 - 8.42	5.71 - 22.26	0.06 - 8.77	7.09 ± 1.58
ΣOPPs	8.11 - 55.56	2.66 - 21.52	0.18 - 16.51	14.13 ± 4.15

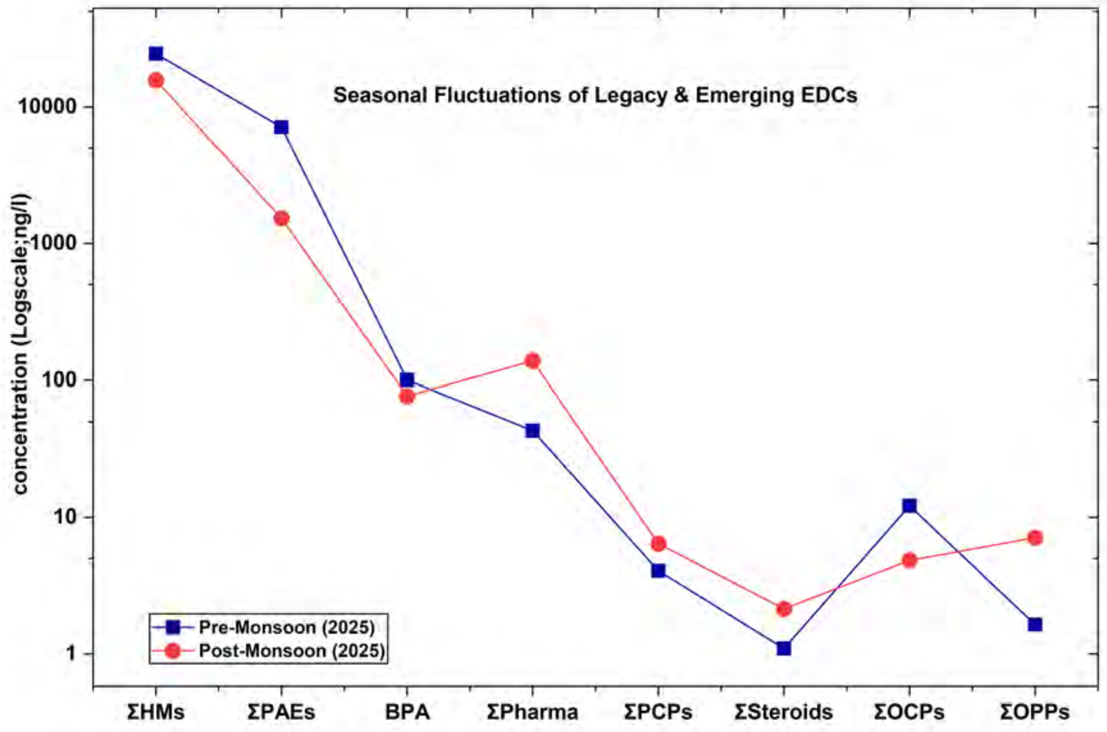


Figure 8.5. Seasonal fluctuation of legacy and emerging endocrine-disrupting chemicals in Gomti surface water (pre- vs post-monsoon 2025, log scale).

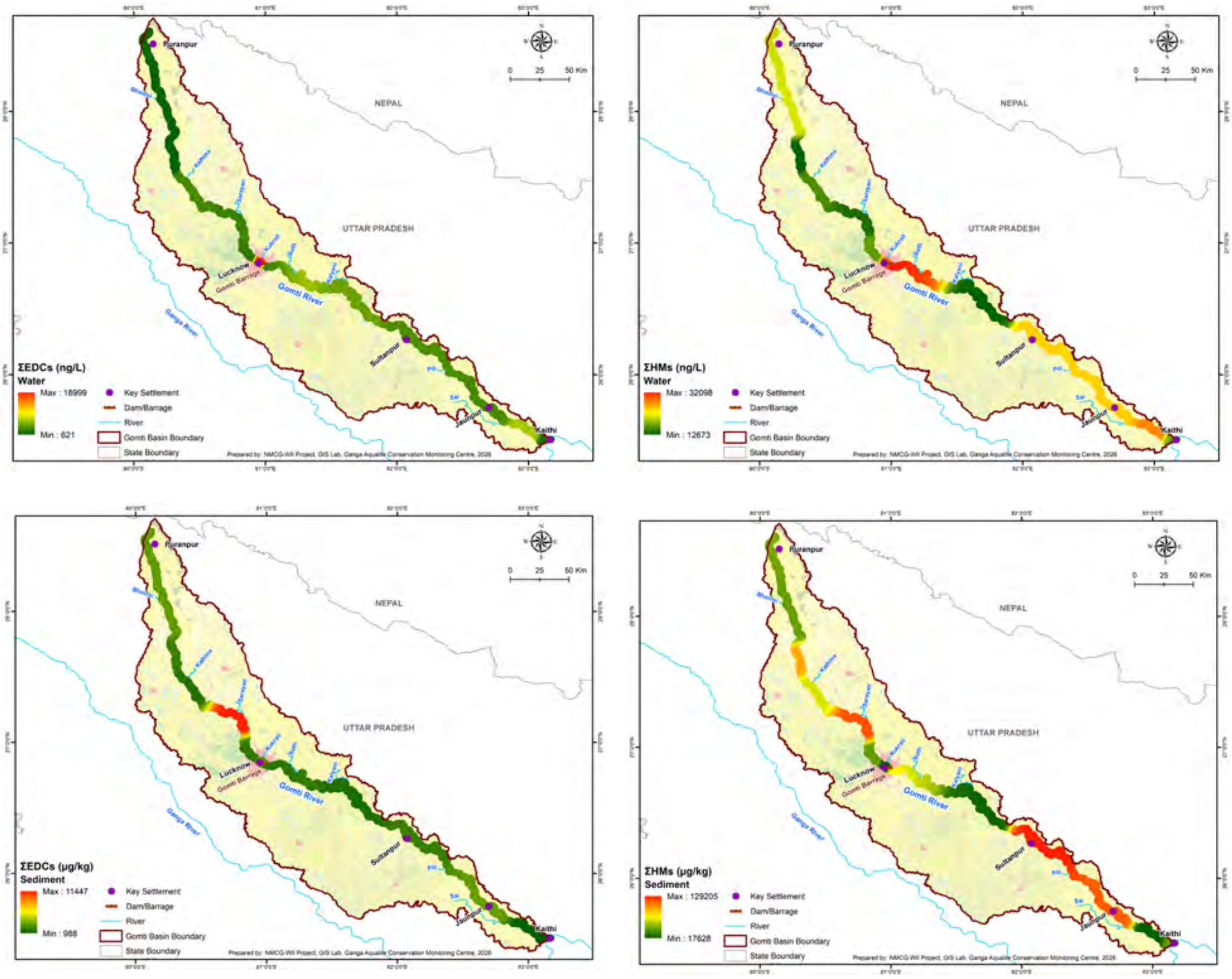


Figure 8.6. Spatial distribution of EDCs and heavy metals in Gomti surface water and sediment (2025 annual mean, ng/L).

8.3.3. Bioaccumulation Profiles of EDCs And Heavy Metals in Fish Biota from Gomti River

Fish biota integrates dissolved- and sediment-bound contamination in the Gomti and form the principal pathway through which pollutants reach the apex predators such as Gangetic dolphin (*Platanista gangetica*) and the riparian human population through fish consumption. Fish tissue analysis across 15 species sampled from five sites along the Gomti continuum confirms that the contamination signature documented in water and sediment is translating into the food web. Heavy metals are the dominant tissue burden (river mean 25835 µg/kg), with Zn, Cu, Cr, Hg and Pb detected in every sample across all three zones (Figure 8.7 and Table 8.6).

In Upper Zone, Heavy metals dominate the tissue burden (22045 µg/kg) at near-basin-mean concentration, with ΣPAEs at 203 µg/kg and trace ΣPharma (0.71 µg/kg) detected. ΣOCPs are low, and ΣSteroids, ΣPCPs, ΣOPPs, and BPA are below detection limits. The Upper Zone biota represents the basin's defensible baseline, consistent with the Moderate water-column ERA classification (Figure 8.7 and Table 8.6).

In the Middle Zone (Figure 8.7 and Table 8.6), Heavy metals remain near basin-mean (22478 µg/kg) and ΣPharma is the highest recorded across zones (0.79 µg/kg), with ΣSteroids newly detected (0.79 µg/kg) confirming downstream transfer of the Lucknow-origin pharmaceutical-endocrine plume into biota. The Middle Zone burden documented at Amethi is therefore a downstream proxy, not a direct measurement at the point of emergence. Sentinel-species biomonitoring at Lucknow Corridor (framework Objective 8.2) is overdue.

In the Lower Zone, bioaccumulation peaks across multiple contaminant groups (Figure 8.7 and Table 8.6). Heavy metals are the highest of all zones (28,606 µg/kg), driven by Cr exceeding 10,000 µg/kg in B. dero at Jaunpur and elevated Cu and Pb across *B. bagarius*, *O. niloticus*, and *R. rita* at

Azamgarh. ΣOCPs show a 27-fold elevation over the Upper Zone (12.76 µg/kg), concentrated in *Sperata* sp., *O. niloticus*, *B. dero*, and *C. carpio*, despite India's prohibition of these compounds under the Insecticides Act and Stockholm Convention. ΣPAEs reach their highest tissue concentrations (408 µg/kg), with peaks in *O. niloticus* and *C. carpio*. ΣSteroids persist at detectable concentrations (0.06 µg/kg). The zone overlaps documented Gangetic dolphin (*Platanista gangetica*) habitat. Contaminants the basin's STPs cannot remove are now in the muscle tissue of fish in the human consumption chain across Amethi, Azamgarh, and Jaunpur, and in Schedule I species habitat. This is a public health and conservation concern requiring the tertiary-treatment mandate, industrial source-control enforcement, and tributary-level interventions in the framework. The absence of Lucknow sampling is itself a finding: the Lower Zone burden shows the signal is already in the food web; direct source-point measurement under Objective 8.2 (Table 8.9) must be initiated immediately.

Table 8.6. Zone-wide endocrine-disrupting chemical and heavy metal concentrations in Gomti fish biota (µg/kg; mean ± SEM).

Analyte	Upper Zone	Middle Zone	Lower Zone	River Range (Mean ± SEM)
ΣHMs	22045 ± 4928	22478 ± 10913	28606 ± 8672	25835 ± 5210
ΣPAEs	203 ± 73.57	182 ± 162	408 ± 163	333 ± 101
BPA	<DL	<DL	<DL	<DL
ΣPharma	0.71 ± 0.15	0.79 ± 0.45	0.19 ± 0.12	0.42 ± 0.11
ΣPCPs	<DL	<DL	<DL	<DL
ΣSteroids	<DL	0.79 ± 0.79	0.06 ± 0.01	0.11 ± 0.08
ΣOCPs	0.47 ± 0.18	0.96 ± 0.96	12.76 ± 5.55	7.54 ± 3.39
ΣOPPs	<DL	<DL	<DL	<DL

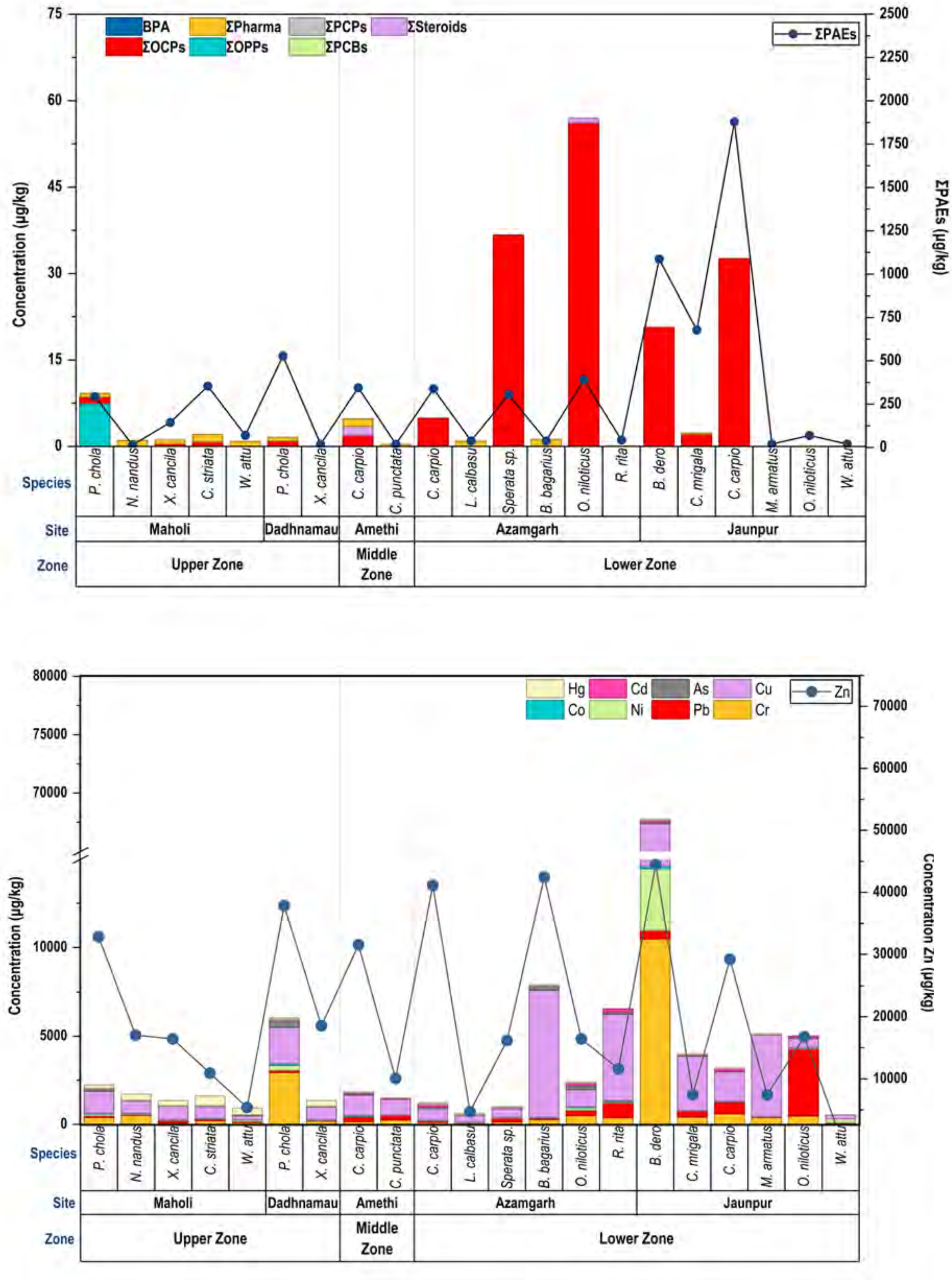


Figure 8.7. Endocrine-disrupting compound and heavy metals bioaccumulation in Gomti fish biota (µg/kg).

8.3.4. Temporal Patterns of the Gomti River (2021-2025)

The 2021 to 2025 monitoring record reveals a bifurcated trajectory across the Gomti contaminant profile (Figure 8.8 and Table 8.7).
Two interventions have demonstrably worked. Heavy metals declined by 79 % (97923 ng/L in 2021 to 20769 ng/L in 2025; $p < 0.001$), tracking to CETP enforcement, OCEMS deployment, and ZLD verification on the Sitapur and Jagdishpur industrial clusters. Personal care products declined by 90 % (33.24 to 3.16 ng/L; $p < 0.001$), with a two-stage attribution: the 2021 elevation was triclosan-dominated, reflecting sustained pandemic-era antibacterial-product consumption, while the post-2022 plateau reflects demand normalisation combined with the operational capacity of STPs commissioned between 2017 and 2022. Pharmaceuticals and steroidal endocrine disruptors show no significant temporal change ($p > 0.05$). Organochlorine pesticide residues persist at a low baseline despite India's prohibition under the Insecticides Act and Stockholm Convention obligations, reflecting sediment-bound legacy contamination and the limited ongoing DDT footprint under the national vector-control exemption. The proximate cause is common: the Shahjahanpur unit and the Lucknow Bharwara, City Park, and Hathi Park STPs are independently verified by UPPCB as Not Achieving or non-operational, and no basin STP carries tertiary capacity rated for micropollutant removal (ethinylestradiol, estradiol, ibuprofen, caffeine). The basin's treatment base has not yet been challenged against demand-stable micropollutant pressure; the post-2022 PCP performance cannot be read as evidence of competence for the wider micropollutant load. Four signals are newly emerging in 2024 to 2025, all outside the current regulatory scope: phthalates rebounded to 5,703 ng/L (55 % above 2021) and BPA spiked five-fold to 155 ng/L, reflecting plastic-waste and packaging pressure; PCBs and organophosphate pesticides crossed detection limits for the first time, tracing to end-of-life transformer-oil leakage and informal e-waste clusters in Lucknow and Jaunpur (incompletely inventoried under India's National Implementation Plan) and to chlorpyrifos and malathion substitution in the Sitapur-Hardoi-Lakhimpur Kheri sugarcane belt conveyed by the Sarayan tributary.

Three lines of action follow. First, consolidation of demonstrated gains: sustain industrial enforcement on the Lucknow clusters, extend equivalent compliance monitoring to the Jagdishpur Industrial Area in Amethi, complete the five Lucknow STPs under construction (CG City 19, Hathi Park 1.5, GH Canal 120, Barikala 3.5, Daulatganj 39 MLD), and intercept the ten high- BOD load Lucknow drains (Sarkata, Mohammadi, Nagariya, Pata, Gomti Nagar and others) that discharge into Gomti, to absorb any future consumption rebound at source. Second, remediation of the tertiary-treatment deficit: mandate tertiary upgrade at the four largest Lucknow STPs for micropollutant removal and initiate statutory action against the Bharwara unit under the Water Act. Third, pre-emptive source control for the emerging contaminant signals: commission a source-apportionment study for the BPA and phthalate rebound, an inventory of end-of-life transformers and informal e-waste clusters under the Stockholm NIP for PCB control, and an integrated pest management programme for the Sarayan sub-catchment for OPP control.


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Table 8.7. Temporal trend of legacy and emerging contaminants in Gomti surface water (2021 to 2025).

Contaminant Category	Parameters	Mean±SEM		Status	p-value
		2021	2025		
Emerging (Not-regulated	Phthalate Esters	3675 ± 465	5703 ± 1934	↑	0.85
	BPA	106 ± 14.45	39.65 ± 13.08	↓	0.04
	Pharmaceuticals	79.14 ± 44.80	68.79 ± 32.15	≈	0.68
	Personal care products	33.24 ± 10.87	3.16 ± 1.12	↓	0.01
	Steroids	3.81 ± 0.93	2.15 ± 1.06	≈	0.11
Legacy (Regulated)	Organochlorine Pesticides	12.32 ± 4.78	10.67 ± 3.11	≈	0.17
	Organophosphorus Pesticides	<DL	3.76 ± 2.33	↑	-
	Polychlorinated Biphenyls	<DL	2.99 ± 1.13	↑	-
	Heavy Metals	97923 ± 28259	20769 ± 2314	↓	0.01

SEM: Standard Error Mean; Temporal trend testing was not performed for OPPs and PCBs because the majority of samples returned values below the analytical detection limit, precluding statistically meaningful comparison across years.

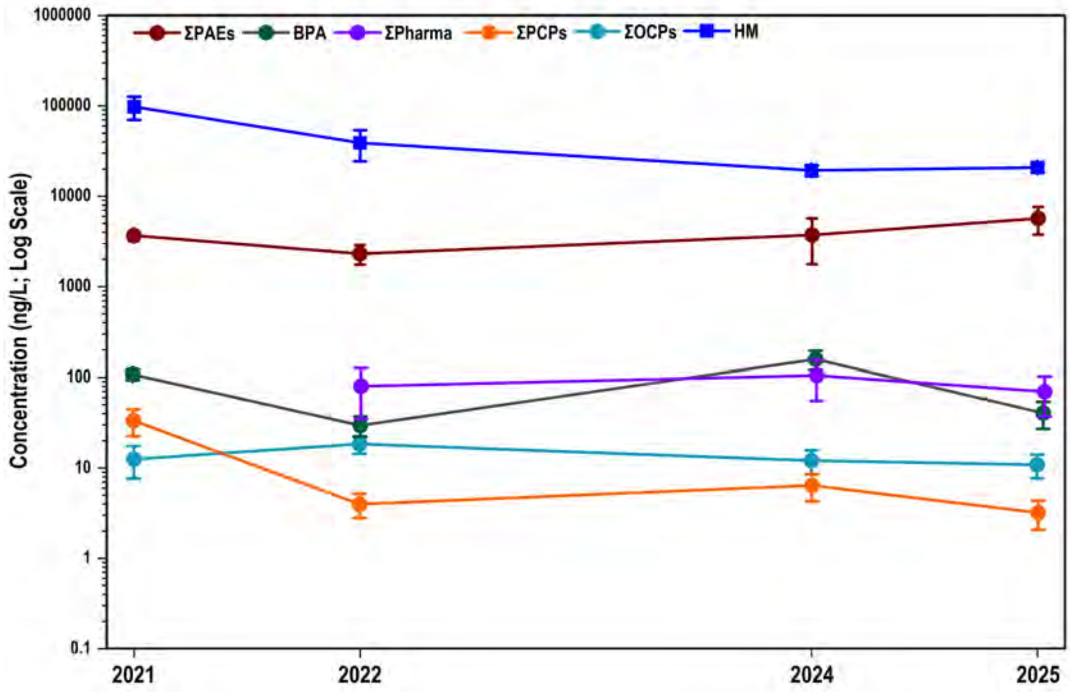

Figure 8.8. Temporal trend of legacy and emerging contaminants in Gomti surface water (2021 to 2025, log scale).

8.3.5. Identification of Threats and Pollution Hotspot Assessment

Conventional river monitoring in India relies on single-parameter compliance assessment (BOD, DO, faecal coliform) and fails to capture the cumulative ecological burden at sites exposed to multiple contaminant classes simultaneously. The Ecological Risk Assessment (ERA) framework in this chapter addresses this gap by integrating multi-contaminant risk into a single, site-specific, conservation-weighted priority score built on four dimensions: On this basis, every monitoring station is stratified into one of four threshold-defined priority categories: CRITICAL (multiple high-weight contaminant groups at ecological risk within conservation-sensitive habitat; immediate intervention required), HIGH (two or more contaminant groups at risk, or single high-weight exceedances amplified by conservation tier; targeted remediation priority required), MODERATE (typically single-compound exceedance; enhanced monitoring and source control required), and LOW (routine baseline surveillance required).
Pollution hotspots along the Gomti are delineated in Figures 8.9 and 8.10 and Table 8.8. The ERA framework resolves a longitudinally stratified signature: 42% High, 17 % Critical, 42 % Moderate, no sites qualify as Low. The Critical classification concentrates at U/S and D/S Lucknow and is independently corroborated by seven years of UPPCB monitoring at the "D/S After meeting of STP Bharwara" station (highest basin BOD, lowest DO, highest faecal coliform), confirming a chronic pollution emergency.
Zone-wise ecological risk assessment highlights:
Upper Zone (Origin to Sarayan Confluence, 354 km). Moderate-risk dominates (90 %); the 10 % High stretch at the Sarayan Confluence is driven by industrial wastewater from the Sitapur catchment and diffuse pesticide runoff from the Sitapur-Hardoi sugarcane-wheat belt conveyed by the Sarayan tributary.
Middle Zone (Sarayan Confluence to Sultanpur, 344 km). Highest ecological stress (41% Critical, 40% High). Defined by a pharmaceutical-endocrine emergency at Lucknow with the basin's single largest ERA exceedance; the plume amplifies at Amethi through the Jagdishpur Industrial Area via the Kadu Drain.
Lower Zone (D/S Sultanpur to U/S Ganga Confluence, 232 km). High-risk dominates (91%). Conventional-quality partially recovers but the micropollutant ERA does not, indicating secondary impact from the Lucknow plume compounded by untapped drains at Jaunpur and Kerakat. The zone overlaps documented Gangetic dolphin habitat, making metal-estrogen co-exposure a direct Schedule I species risk.
Zone-wise priority sites, district mapping, threats, and zone-specific actions are summarised in Table 8.8.

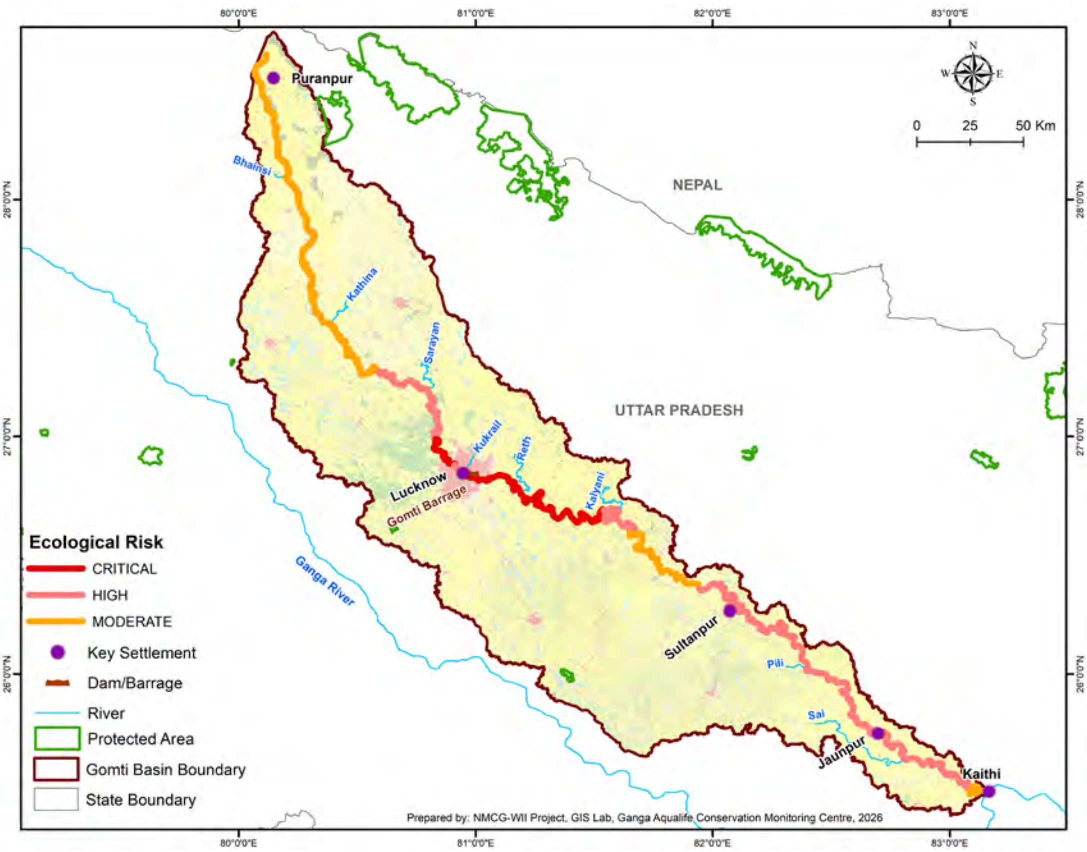

Figure 8.9. Ecological risk distribution across Gomti River.

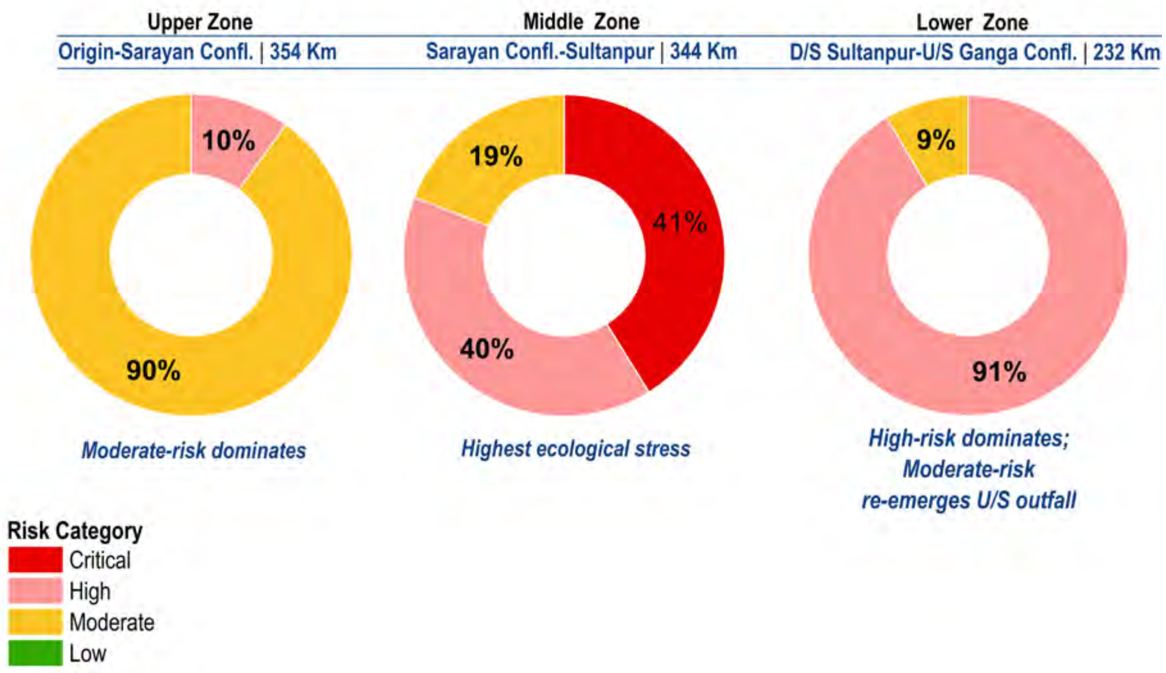

Figure 8.10. Ecological risk distribution across Upper, Middle and Lower zone of Gomti River.

Table 8.8. Pollution hotspot and threats across zones along the Gomti River.

Zone	Upper Zone	Middle Zone	Lower Zone
Priority Sites	Sarayan Confluence Dadhnamau	Critical Risk: U/S Lucknow D/S Lucknow, Kukrail Confluence High Risk: Amethi; Sultanpur	Jaunpur; Azamgarh
District	Hardoi Sultanpur	Sitapur Lucknow	Jaunpur
Threats	Plasticiser-EDC baseline from un-sewered habitations. Sarayan tributary delivers wastewater from 10 Sitapur catchment industries (Dalmia and Oudh distilleries plus sugar units, Kamlapur Chini, Madhu India Deco, JB Daruka paper, Aasan / Madhu India / Mohd Aafaq yarn dyeing) and diffuse chlorpyrifos runoff from the Sitapur-Hardoi sugarcane-wheat belt.	Pharmaceutical-endocrine emergency centred on Lucknow corridor. Driven by 8 of Lucknow's 32 drains, principally Kukrail (60-100 MLD bypassing Bharwara 345 MLD STP directly to Gomti, carrying CP Milk 900 KLD and HAL Faizabad Road 1,766 KLD), GH Canal (71-80 MLD direct overflow; carrying Eveready and Lucknow Producer Cooperative Milk Union), Gomti Nagar 30 MLD raw, Sarkata 12 MLD overflow. Bharwara verified Not Achieving by UPPCB Dec 2023. Amethi amplified by Kadu Drain from Jagdishpur Industrial Area (BHEL 150 KLD, HAL Korwa 1,900 KLD, Indogulf Fertilizer 12,000 KLD, basin's largest single discharger	Persistent metal-endocrine residue: Jaunpur and Azamgarh. Lower Zone functions as secondary impact pathway for the Lucknow-origin pharmaceutical plume while receiving fresh metal inputs from Jaunpur's 14 small untapped drains and Kerakat's 7 untapped drains (8.7 MLD). UPPCB shows partial conventional-quality recovery but micropollutant does not recover.
Action Required (Table 8.9)	Cross-reference Framework Objectives 5.4, and 9.2	Cross-reference framework Objectives 2.3, 3.1 to 3.2, 4.1	Cross-reference framework Objectives 8.1, 8.2, 9.3, and 2.3

The zonal threat profile and site-specific evidence summarised above translate into a structured pollution abatement framework for the Gomti, presented in the Table. The framework is organised around nine strategic objectives spanning conservation-tier prioritisation, conventional infrastructure delivery, tertiary-treatment mandate for micropollutant removal, industrial source control with continuous emission monitoring, agricultural and emerging-contaminant source control, solid waste and EPR enforcement, ERA-integrated monitoring and adaptive management, conservation-integrated river management for the Gangetic dolphin, and tributary and sub-basin integration covering the Sarayan, Sai, and Kukrail. Each objective is operationalised through a Logical Framework Matrix specifying actions, objectively verifiable indicators, means of verification, assumptions, lead agencies, and supporting organisations, with delivery phased across short, medium, and long-term horizons aligned to the Namami Gange Programme.

Table 8.9. Framework for Sustainable Pollution Abatement of River Gomti.

#	Strategies / Actions	Objectively Verifiable Indicators (OVI)
Objective 1: Zone-differentiated, ERA-prioritised pollution abatement		
1.1.	Adopt ERA zonation (Upper, Middle, Lower) as the basin's official planning unit; reflect in all Namami Gange 2.0 sanctions for Gomti.	ERA zonation in NMCG DPR-appraisal criteria. Zone-specific sanction allocations notified.
1.2.	Issue site-specific intervention prescriptions for 2 Critical sites (D/S Lucknow, U/S Lucknow) and 6 High sites (Sarayan Confl., Dadhnamau, Kukrail Confl., Sultanpur, Jaunpur, Azamgarh).	Site-specific intervention plans notified for all 8 priority sites.Intervention class, timeline, budget per site.
1.3.	Embed Gangetic dolphin conservation-tier multiplier in Lower Zone management and sanction prioritisation.	Dolphin-tier weighting in Lower Zone criteria. Critical Conservation Corridor integration documented.
Objective 2: Conventional infrastructure delivery (STPs, drains, sewer connectivity)		
2.1.	Complete 5 Lucknow STPs under construction: CG City 19 MLD; Hathi Park 1.5 MLD; GH Canal 120 MLD; Barikala 3.5 MLD; Daulatganj 39 MLD.	All 5 units commissioned by Secretary-notified milestone date.All Achieving MoEFCC norms (BOD <10, FC <1000).
2.2.	Initiate STP DPRs for 4 zero-STP towns flagged by 2019 UPPCB Action Plan: Sitapur; Barabanki-Nawabganj; Amethi-Jagdishpur; Kerakat.	DPRs submitted to NMCG within Secretary-notified window.Sanction-to-commissioning timeline in approval orders
2.3.	Intercept and divert 10 high-load Lucknow drains to nearest STP catchment under I&D: Sarkata, Mohammadi, Nagariya, Pata, Gomti Nagar, Faizullaganj U/S, Sahara Shahar, Maheshganj, Gaughat, Gomti Nagar Vistar.	All 10 drains tapped to STP catchment. Combined diverted load reported quarterly. Conveyed BOD reduced by ~11,500 kg/day.
2.4.	Field-gauge unquantified high-BOD drains: Daliganj-2 (BOD 108 mg/L), Mohan Meakins (BOD 84 mg/L).	Flow gauging completed. Daily load published.
2.5.	Expand sewer connectivity in 4 zero-STP towns and non-Lucknow stretches; current household connectivity data missing for ~98% of basin towns.	Household sewer-connectivity ratio reported for all basin towns.Notified minimum coverage threshold met.

Means of Verification (MOV)	Assumptions	Agencies Responsible	Supporting Organisations
NMCG sanction orders. DPR appraisal documents.	NMCG accepts ERA-based prioritisation. Namami Gange guidelines amended. Water Act 1974; NGT Act 2010.	NMCG Ministry of Jal Shakti	WII CPCB UPPCB
Published intervention plans. UP Government notifications. NMCG sanction orders.	Funding under Namami Gange 2.0. UPPCB-NMCG-UPJN coordination. Site-specific feasibility completed.	NMCG UPPCB UP Jal Nigam	WII IIT-BHU CSIR-IITR Lucknow
Critical Conservation Corridor plan. NMCG biodiversity-vertical reports.	WPA Schedule I and IUCN Endangered status. Project Dolphin operational continuity	NMCG (Aviral and Biodiversity) WII	UP Forest Department Project Dolphin
UPPCB compliance monitoring rounds. NMCG quarterly progress reports. UPJN delivery dashboard.	Concessionaire delivery (HAM). Land and statutory clearances. Water Act 1974; CPCB STP norms 2017	UP Jal Nigam NMCG	UPPCB HAM Concessionaires
NMCG sanction orders. UPJN dashboard	Closure of 7-year NGT non-delivery backlog. Land allocation by ULBs. NGT OA 673/2018 compliance.	UP Jal Nigam NMCG	UPPCB ULBs of 4 towns
UPPCB drain monitoring. UPJN I&D completion certificates.	STP catchment capacity adequate post-2.1. Lucknow city engineering integration	UP Jal Nigam Lucknow Municipal Corporation	NMCG UPPCB
UPPCB next monitoring round publication	UPPCB analytical capacity available. Guidelines on Water Quality Monitoring 2017.	UPPCB	CPCB UPJN
JJM-UP and Census-linked reporting. ULB-wise dashboards.	AMRUT and JJM funds available. UP Water Supply and Sewerage Act 1975.	UP Jal Nigam ULBs	UPPCB UP Urban Development Department

#	Strategies / Actions	Objectively Verifiable Indicators (OVI)
Objective 3: Tertiary-treatment mandate for micropollutant removal		
3.1.	Mandate tertiary treatment (AC, ozonation, MBR) at 4 largest Lucknow STPs: Bharwara; Daulatganj; Awas Vikas; GH Canal (on commissioning).	DPR revisions with tertiary stage notified. Tertiary-stage performance verified for EE2, E2, ibuprofen, caffeine removal.
3.2.	Initiate statutory action against Bharwara 345 MLD UASB STP under Water Act 1974; UPPCB Dec 2023 verifies Not Achieving (BOD 15.4, FC 7,900).	Closure or remediation notice issued. Recommissioning timeline notified.
3.3.	Establish hospital and pharmaceutical effluent management protocol for Lucknow; on-site pre-treatment for hospitals above notified bed-capacity threshold.	Notified protocol. Pre-treatment compliance audit for all hospitals above threshold.
3.4.	Designate the National Centre for River Research, Wildlife Institute of India, Dehradun, established under the NMCG project, as the reference laboratory for routine micropollutant and microplastics quantification in the Gomti basin; the Centre is already equipped with LC-MS/MS, GC-MS/MS, LDIR, and ICP-MS instrumentation and operational analytical capacity.	Reference laboratory formally designated for the Gomti basin under NMCG notification. Routine sampling schedule and analyte panel notified. Method validation reports for the six micropollutants published.
Objective 4: Verified industrial source control with continuous emission monitoring		
4.1.	Sustain CETP-grade enforcement on Lucknow industrial cluster: Eveready Industries Aishbagh (170 KLD, GH Canal); HAL Faizabad Road (1,766 KLD); CP Milk Kursi Road (900 KLD, Kukrail); Banaskantha CG City (1,000 KLD); Lucknow Producer Cooperative Milk Union CG City (300 KLD).	OCEMS connectivity verified for all named units. 12-month rolling compliance reported. Annual CETP enforcement audit completed.
4.2.	Extend compliance monitoring to Amethi-Jagdishpur cluster (BHEL, HAL Korwa, Indogulf Fertilizer 12,240 KLD via Kadu Drain) and Sitapur catchment (Dalmia and Oudh distilleries + sugar units; Kamlapur Chini; Madhu India Deco; JB Daruka paper; Aasan / Madhu India / Mohd Aafaq yarn dyeing units via Sarayan).	OCEMS coverage extended to all named units. Third-party ZLD verification for Sitapur distilleries and sugar mills.
4.3.	Audit residual Cd, Cu, Cr, Ni signal in sediment at Kukrail outfall, GH Canal outfall, Kadu Drain confluence at Amethi against OCEMS effluent record.	Sediment audit report published with industry-level source apportionment.
4.4.	Mandate OCEMS parameter expansion beyond pH/COD/BOD to include Cd, Cu, Cr, Ni for metal-finishing, electroplating, dyeing units.	OCEMS expanded-parameter notification issued. Deployment timeline notified.

Means of Verification (MOV)	Assumptions	Agencies Responsible	Supporting Organisations
NMCG DPR appraisal records. UPPCB tertiary-stage monitoring.	NMCG funding for tertiary upgrade. LC-MS/MS capacity per 3.4.CPCB micropollutant norms developed.	NMCG UP Jal Nigam	CPCB CSIR-NEERI IIT-BHU
UPPCB statutory action records. NGT compliance reporting.	UPPCB statutory authority exercised. Water Act 1974 enforcement vigour.	UPPCB	NGT (jurisdictional) MoEFCC
UPPCB hospital-effluent inspection records. UP Health Department reports.	Inter-departmental coordination. Bio-Medical Waste Rules 2016 alignment.	UPPCB UP Department of Health	MoEFCC Ministry of Health and Family Welfare
NMCG / UPPCB reference-lab notifications. Published methods at the National Centre for River Research, WII Dehradun.	National Centre for River Research, WII Dehradun, continues under NMCG support. NWMP 2019 parameter expansion approval. Sample-chain-of-custody protocols established between UPPCB monitoring teams and WII reference laboratory.	NMCG National Centre for River Research, WII Dehradun UPPCB	CSIR-CDRI ICMR CSIR-IITR Lucknow
UPPCB OCEMS dashboard. CPCB consolidated annual report.	OCEMS uptime maintained. CPCB directive enforcement. Water Act 1974; EPA 1986.	UPPCB CPCB	NMCG MoEFCC
UPPCB inspection reports. Third-party ZLD audit reports.	Industry cooperation. ZLD norms applicable. Polluter Pays Principle.	UPPCB	CPCB MoEFCC
UPPCB / NMCG biomonitoring publication. Peer-reviewed sediment audit.	Sediment sampling and analytical protocols standardised. Inter-laboratory comparison.	UPPCB WII	CSIR-NEERI IIT-BHU
CPCB and UPPCB notifications. Industry-level compliance reports.	Sensor technology available for HM in OCEMS. Funding for instrumentation upgrade.	CPCB UPPCB	MoEFCC

#	Strategies / Actions	Objectively Verifiable Indicators (OVI)
Objective 5: Agricultural and emerging-contaminant source control in catchment		
5.1.	Launch IPM and chlorpyrifos-malathion substitution programme in Sarayan sub-catchment: Sitapur, Hardoi, Lakhimpur Kheri sugarcane-wheat belt.	Hectarage converted to IPM reported. Pesticide-use volumes tracked. Chlorpyrifos and malathion off-take volumes reported.
5.2.	Establish riparian buffer-zone restoration along Sarayan tributary and Gomti main stem in Sitapur-Hardoi reach.	Length of buffer zone established (km). Vegetation survival audit at 12 and 24 months.
5.3.	Track and report residual DDT footprint under WHO Annex B vector-control exemption (Lucknow, Sitapur municipal health programmes).	DDT use volume reported annually by municipal health departments.Environmental detection cross-referenced with UPPCB monitoring.
5.4.	Commission source-apportionment study for 2024-2025 BPA and phthalate rebound (phthalate mean 5,703 µg/L in 2025; BPA spike 155 µg/L in 2024).	Source-apportionment report identifying named industries and solid-waste sources.
Objective 6: Solid waste, plastic, and e-waste source control under EPR and Stockholm NIP		
6.1.	Commission MSW processing capacity in 5 gap districts: Sitapur, Hardoi, Amethi, Pilibhit, Sultanpur.	MSW plants commissioned with notified TPD capacity per district. Aligned to projected 2030 generation.
6.2.	Mandate plastic-waste interception under Namami Gange 2.0 in Lucknow-to-Sultanpur stretch (trash booms, floating-debris removal).	Number of trash booms installed. Tonnage of recovered plastic reported quarterly.
6.3.	Strengthen EPR enforcement on plastic-packaging producers in basin; PWM Rules 2021 compliance audit.	Number of producers audited.EPR compliance ratio on CPCB EPR portal.
6.4.	Commission inventory of end-of-life transformers and informal e-waste clusters in Lucknow (Aishbagh, Naka) and Jaunpur under Stockholm NIP for PCB control.	Inventory completed. Transformer-disposal protocol notified. Informal e-waste cluster mapping published.
Objective 7: ERA-integrated monitoring, data systems, and adaptive management		
7.1.	Expand CPCB NWMP on Gomti to include priority legacy and emerging contaminant groups (organochlorines, phthalates, BPA, pharmaceuticals, steroidal EDCs, antimicrobials, heavy metals, organophosphate pesticides).	Number of monitoring stations covering ERA groups. Analytical capacity notified at designated reference lab.

Means of Verification (MOV)	Assumptions	Agencies Responsible	Supporting Organisations
KVK records. UP Agriculture Department dashboards.	Insecticides Act 1968 enforcement. Subsidies for IPM substitution. Farmer willingness.	UP Agriculture Department Ministry of Agriculture and Farmers Welfare	KVKs ICAR State Agricultural Universities
UP Forest Department records. NMCG afforestation reports.	Land availability with landowner consent. Forest Conservation Act 1980 alignment. Community engagement.	UP Forest Department NMCG	Panchayats Civil society
UP Department of Health reports. UPPCB monitoring. Stockholm NIP annual updates.	Stockholm Convention Annex B compliance. Inter-departmental data sharing.	UP Department of Health MoEFCC	National Vector Borne Disease Control Programme
NMCG-funded study report. Peer-reviewed publication.	PMF/CMB modelling capacity available. Industry cooperation for source sampling	NMCG WII	IIT Kanpur CSIR-IITR Lucknow
ULB compliance reports. UP Urban Development dashboards. SWM Rules 2016 reporting.	Solid Waste Management Rules 2016. Swachh Bharat Mission funding	ULBs UP Urban Development Department	UPPCB MoEFCC
NMCG Jan Ganga reports. Lucknow Municipal Corporation records.	Plastic Waste Management (Amendment) Rules 2021. Community participation.	NMCG Lucknow Municipal Corporation	NGOs Civil society
CPCB EPR portal records. UPPCB audit reports.	EPR portal operational. Producer cooperation. Polluter Pays Principle.	CPCB MoEFCC	UPPCB Producer associations
MoEFCC / CPCB NIP progress reports. State Electricity Board records.	Stockholm Convention NIP implementation. E-Waste Management Rules 2016.	MoEFCC CPCB	UPPCB State Electricity Boards
CPCB NWMP reports. UPPCB monitoring publications.	NWMP 2019 parameter expansion approval. Reference lab capacity per 3.4.	CPCB UPPCB	WII NCRR/Ganga Aqua Labs IITs

#	Strategies / Actions	Objectively Verifiable Indicators (OVI)
7.2.	Establish real-time public dashboard for Gomti integrating STP compliance, drain interception, OCEMS, ERA monitoring.	Dashboard live with verified data feed. Quarterly updating frequency notified.
7.3.	Publish annual State of River Gomti report integrating ERA, STP compliance, OCEMS	Annual report tabled before NGT and Ministry. Public release accompanies tabling.
7.4.	Cross-tributary learning between Gomti, Sai, Sarayan and other Ganga tributaries (Ramganga, Ghaghara) using common framework template.	Tributary learning workshops convened annually. Framework portability documented.
Objective 8: Conservation-integrated river management for Gangetic dolphin and otter		
8.1.	Integrate Lower Gomti formally as feeder reach into Critical Conservation Corridor (Prayagraj-Bhagalpur) of the Namami Gange dolphin programme.	Lower Gomti incorporated into corridor plan. Habitat boundaries and intervention prescriptions notified.
8.2.	Establish quarterly biomonitoring for OCs, EDCs, heavy metals, PCBs in sentinel species (fish, otter spraint, dolphin tissue where available) in Lower Zone.	Quarterly biomonitoring reports published. Sentinel-species panel notified. Tissue-level contaminant burden tracked over time.
8.3.	Conduct Gomti-specific Gangetic dolphin occupancy survey using methodology applied to other smaller Ganga tributaries.	Occupancy estimate published with confidence intervals. Survey methodology documented. Population trend baseline established.
8.4.	Apply environmental flow (e-flow) considerations in any new abstraction or barrage proposal on the Gomti, with conservation-tier weighting.	E-flow notification for Gomti issued, consistent with the main-stem Ganga e-flow notification of 9 October 2018.
Objective 9: Tributary management and sub-basin integration (Sarayan, Kukrail, and other)		
9.1.	Establish dedicated water-quality monitoring network on Gomti tributaries: 3 stations on Sarayan (upper, mid, Gomti confluence); Cover the priority legacy and emerging contaminants plus conventional BOD-DO-FC at quarterly frequency.	Monitoring stations notified and operational on all four tributaries. Quarterly data published. Tributary-specific ERA scores computed annually.

Means of Verification (MOV)	Assumptions	Agencies Responsible	Supporting Organisations
NMCG / UPPCB portal. MoJS Digital cell records.	Data protection compliance. Inter-agency data sharing protocol.	NMCG UPPCB	MoJS Digital Cell
Published annual report. NGT compliance reporting.	Dedicated reporting cell. Inter-agency data integration.	NMCG	WII CPCB UPPCB
NMCG annual reports. Workshop proceedings.	Inter-tributary coordination via NMCG. Cross-state cooperation.	NMCG	WII IIT-BHU
NMCG Project Dolphin programme document. Corridor management plan.	Project Dolphin operational continuity. WPA Schedule I protection sustained. Wildlife Protection Act 1972.	NMCG (Biodiversity) Project Dolphin	National Centre for River Research, WII Dehradun UP Forest Department
Publications from the National Centre for River Research, WII Dehradun. NMCG quarterly reports.	Non-invasive sampling protocols approved. WPA permissions for tissue sampling. Analytical capacity at Dehradun adequate.	National Centre for River Research, WII Dehradun	NMCG UP Forest Department
Peer-reviewed publication. Technical report from the National Centre for River Research, WII Dehradun.	Field-survey capacity available. Funding under Project Dolphin / NMCG. Seasonal coverage in dry and monsoon periods.	National Centre for River Research, WII Dehradun	NMCG Project Dolphin
MoJS notification. Central Water Commission assessment reports.	E-flow precedent (Ganga 2018) applicable. Hydrological data adequate. Inter-departmental coordination (MoJS, CWC).	Ministry of Jal Shakti	Central Water Commission National Centre for River Research, WII Dehradun
UPPCB / CPCB monitoring publications. NMCG quarterly reports. Analytical reports from the National Centre for River Research, WII Dehradun.	NWMP 2019 expansion accommodates tributary stations. Analytical capacity at Dehradun adequate. Inter-state coordination not required (all tributaries within UP).	CPCB UPPCB	National Centre for River Research, WII Dehradun IIT-BHU

#	Strategies / Actions	Objectively Verifiable Indicators (OVI)
9.2.	Implement integrated source control on the Sarayan tributary: enforce ZLD on 10 Sitapur catchment industries discharging via Sarayan (Dalmia and Oudh distilleries + sugar units, Kamlapur Chini, Madhu India Deco, JB Daruka paper, yarn dyeing units); complete IPM substitution programme in the Sarayan sub-catchment (Sitapur, Hardoi, Lakhimpur Kheri); establish riparian buffer along Sarayan; intercept and treat municipal drains from Sitapur town.	OCEMS coverage of 10 named Sitapur industries verified. IPM hectarage in Sarayan sub-catchment reported. Sarayan riparian buffer length notified. Sitapur municipal drains tapped to STP catchment.
9.3.	Initiate dedicated Sai sub-basin Action Plan covering municipal sewage, agricultural runoff, and industrial source control; map drain inventory and STP gap for Sai-bank towns; integrate Sai tributary management with the Lower Zone Critical Conservation Corridor planning for dolphin habitat protection at the Sai-Gomti confluence near Jaunpur.	Sai sub-basin Action Plan notified. Drain and STP inventory for Sai-bank towns published. Sai-Gomti confluence reach incorporated into Critical Conservation Corridor plan.
9.5.	Implement integrated urban tributary rehabilitation of the Kukrail in Lucknow: (a) divert CP Milk 900 KLD, HAL 1,766 KLD, and municipal sewage to tertiary-capable STP catchments (linked to Objective 3); (b) ecological restoration of the Kukrail channel between the Kukrail forest reserve and the Gomti confluence; (c) co-management with the Kukrail Gharial and Turtle Rehabilitation Centre to ensure downstream contaminant loads do not compromise Schedule I species habitat.	Industrial discharges to Kukrail diverted with timeline notified. Kukrail channel restoration length reported. Gharial Centre water-quality compliance audit completed. ERA score at Kukrail Confluence reduced from current 2.13.
9.6.	Constitute an Integrated Gomti Basin Council under the Ministry of Jal Shakti, with the main stem and the Sarayan, Sai, Kukrail tributaries treated as a single management unit. Quarterly tributary-wise compliance reporting to Secretary-level review.	Council constituted by Ministry notification. Tributary-wise compliance reporting integrated into quarterly Secretary review. Sub-basin coordination protocols notified.

References: Uttar Pradesh Jal Jeevan Mission (n.d.); National Mission for Clean Ganga (2025); Uttar Pradesh Pollution Control Board (2019)

Means of Verification (MOV)	Assumptions	Agencies Responsible	Supporting Organisations
UPPCB inspection reports. KVK records. UP Forest Department records. UPJN I&D completion certificates.	Sitapur STP DPRs operational. Industrial cooperation. IPM substitution funded. Insecticides Act 1968 enforcement.	UPPCB UP Agriculture Department UP Forest Department UP Jal Nigam	CPCB NMCG KVKs ICAR
UPPCB / NMCG Sai sub-basin documentation. UPJN drain inventory. NMCG biodiversity-vertical reports.	NGT framework extends to Sai (analogous to 2019 Gomti Action Plan). Inter-departmental coordination. Conservation-tier weighting applied.	NMCG UPPCB UP Jal Nigam	National Centre for River Research, WII Dehradun UP Forest Department Project Dolphin
UPPCB OCEMS dashboard. UPJN I&D completion certificates. UP Forest Department reports. Biomonitoring publication from the National Centre for River Research, WII Dehradun.	Industrial cooperation (CP Milk, HAL). Lucknow Municipal Corporation engineering. UP Forest Department coordination for Kukrail forest reserve. Wildlife Protection Act 1972 (Schedule I).	UPPCB UP Jal Nigam Lucknow Municipal Corporation UP Forest Department	NMCG National Centre for River Research, WII Dehradun Project Crocodile (gharial component)
MoJS notification. Council meeting minutes. Quarterly compliance dashboards.	Inter-departmental coordination at Ministry level. UP State Government cooperation. NMCG secretariat support.	Ministry of Jal Shakti NMCG	UPPCB UP Jal Nigam UP Forest Department National Centre for River Research, WII Dehradun

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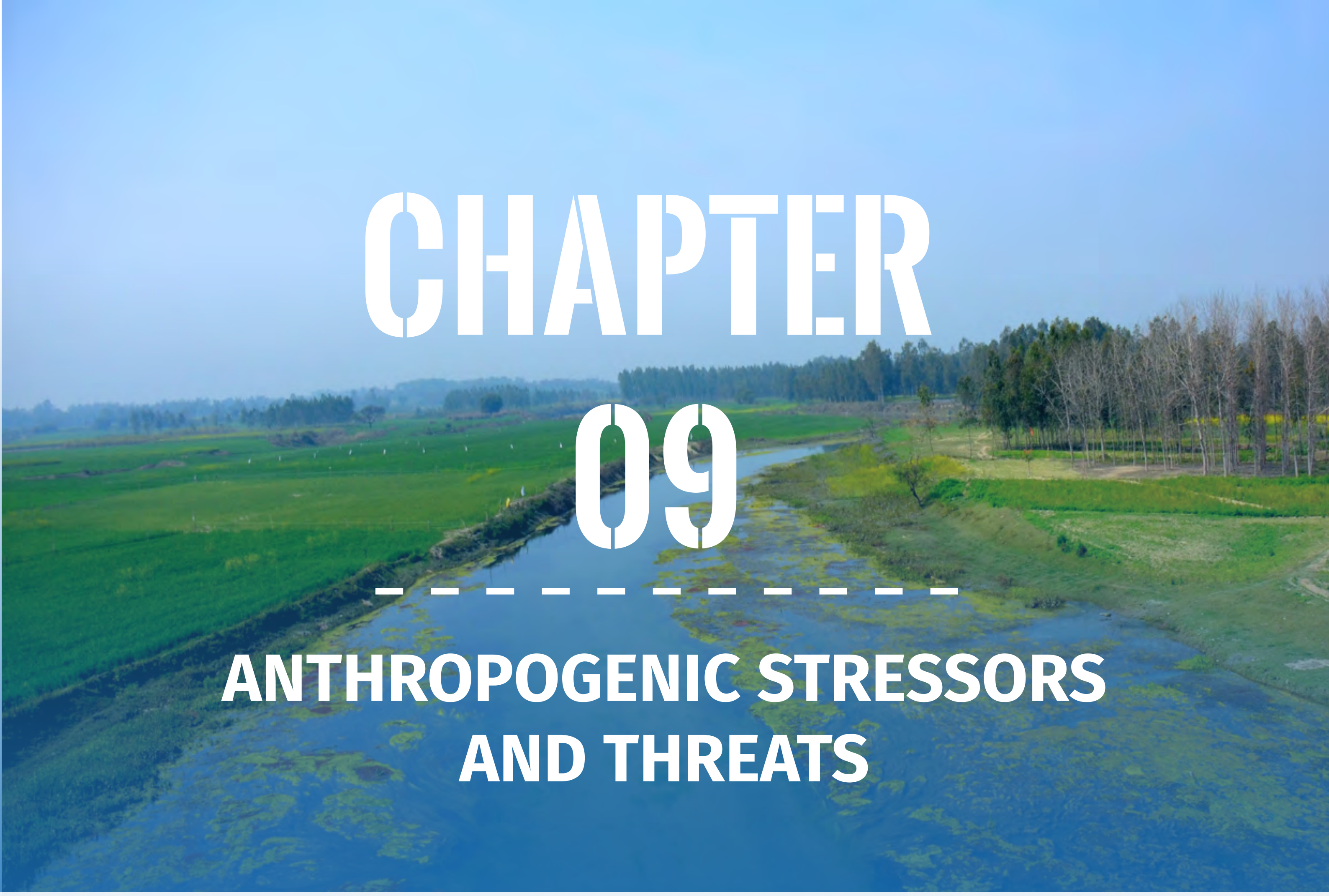

CHAPTER 09

ANTHROPOGENIC STRESSORS AND THREATS

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SUMMARY

Freshwater ecosystems are crucial yet critically endangered, providing key ecological functions and ecosystem services. Urbanization, agricultural development, industrial discharge, and climate change have all contributed to the deterioration of river systems across the world. In India, this is most acute in the Ganga River Basin, where ecological stress is increasing due to land use changes and population growth. The Gomti River, a key tributary, faces multiple anthropogenic stressors along its 930 km length in Uttar Pradesh. This chapter investigates these stressors by examining the Gomti River, which is divided into 5 km Biodiversity Evaluation Units (BEUs) using GIS tools and analysis. Anthropogenic activities such as dams, sewage discharges, agricultural encroachment, water extraction, fishing, ferry or boat operations, sand mining, livestock, and the presence of human and free-ranging dogs were documented in pre-monsoon (2021) and post-monsoon (2022) surveys, demonstrating the extent of human impact on the ecosystem. The study provides a longitudinal assessment of disturbances along the Gomti River, emphasizing variations between the upper, middle, and lower zones. The upper zone is characterized by severe hydrological changes and agricultural encroachment, with parts of the river drying during non-monsoon

months due to reduced channel width and floodplain connection caused by agricultural conversion. Water extraction and ferry activities demonstrate an increased reliance on the river for irrigation and transportation. The middle zone, has the highest cumulative pressure of urban growth, sewage discharge, water withdrawal for agriculture and industrial runoff have a significant influence on water quality. In the middle zone, which includes the city of Lucknow, there is significant untreated wastewater flow, which contributes to organic and chemical contamination. Concentrated fishing, livestock presence, and human activities, as well as localized sand mining, severely impact sediment dynamics. Overall, the middle zone is the most ecologically stressed segment of the Gomti River. The lower zone experiences lesser direct disturbances but is impacted by upstream processes such as changed flow regimes and pollution transmission. This demonstrates the interdependence of river systems, in which the biological status of downstream areas is dependent on upstream management and practices.

The study emphasizes the need of using stretch-specific management options rather than broad conservation measures. Protecting source areas of the river, sustainable water extraction, managing sewage and industrial discharges, restoring floodplain connectivity, and supervising fishing and sand mining operations are all important steps toward improving ecological security. Maintaining biodiversity and ecological services in the Gomti River requires an integrated basin-scale management approach that includes flow regulation, pollution control, and habitat restoration. This chapter details anthropogenic stressors throughout the 930 km stretch of the Gomti River, providing a comprehensive baseline for evaluating ecological risks and shaping future conservation and river restoration actions along the river as well as basin.

9.1. INTRODUCTION

Freshwater ecosystems are hotspots for biodiversity, host around one-third of vertebrates species and account for 9.5% of all known animal species on Earth (Dudgeon et al., 2006; Balian et al. 2008; Dudgeon, 2019). Multiple factors threaten freshwater biodiversity in the Anthropocene and rivers are among the most threatened ecosystems in the world (Dudgeon, 2019; George et al., 2022). Managing freshwater as a common resource has led to decreased human water security and significant threats to biodiversity worldwide (Vörösmarty et al., 2010). The river and its floodplain provide several ecosystem services and require a comprehensive strategy for their protection and restoration. Human actions have been impacting ecological processes along with land-atmosphere interactions, which impact river basin's hydrology and geomorphology, affecting the riverine landscapes and complicating the assessment of ecological security (Poff et al., 1997; Wohl, 2005; Sinha et al., 2013; Baral et al., 2014). Human-induced stressors include industrialization, urbanization, agricultural activities, mining, and deforestation. Agricultural runoff from chemical intensive farming techniques induces eutrophication, depleting oxygen and reducing biodiversity (Smith et al., 1999). Natural hydrology is changed by urbanization, which increases chemical contamination and sedimentation (Paul & Meyer, 2001). Climate change exacerbates these effects by increasing temperatures and modifying precipitation patterns (Poff et al., 2012). Damming and water extraction also disrupt ecological connectivity and flow regimes (Nilsson et al., 2005). Bycatch mortality of aquatic species is also caused by entanglement in fishing nets (Dewhurst-Richman et al., 2020; Larocque et al., 2020; Sindha et al., 2020).

The ecological integrity of river ecosystems relies on their inherent dynamic nature; nevertheless, planners and land developers typically perceive rivers just as longitudinal channel networks. Human activities have modified all large and minor river-floodplain ecosystems in India to varying degrees (Sinha et al., 2012). Ganga River basin (GRB) is experiencing significant water stress, mostly because of population growth and the increase in agricultural activities. Substantial alterations have occurred in the GRB recently and are ongoing (Dutta et al., 2015b). The Gomti River, a major tributary of the Ganga River, is facing severe levels of pollution, especially in the Lucknow and Jaunpur area due to industrial and sewage outlets.

Anthropogenic pressures including industrial activities, discharge of sewage effluents, garbage dumping on the river bed, congestion of the river, encroachment, and agricultural runoff pose significant threats to the ecological integrity of the Gomti River (Dutta et al., 2015b; Kumar, 2019; SwaRA, 2019; Jain, 2024;Zareen, 2025).

Assessing anthropogenic stressors on a broad scale can enhance conservation effectiveness for watersheds and improve the management capabilities of administrators, thereby contributing positively to the integrated management of these watersheds (Fore et al., 2014). Several studies on pollution have been conducted in the major towns along the Gomti River; however, comprehensive

Table 9.1. Summary of survey that documented anthropogenic pressures and threats in the Gomti River.

Surveyed stretch	Length of the stretch (km)	Survey method	Season	Year	Month
Gomat tal in Pilibhit district to Kaithi, Ghazipur district, Uttar Pradesh	~930	Vehicular and foot	Pre-monsoon	2021	June, July
		Vehicular and foot in the upper zone from Gomat tal to Sitapur, Boat (middle and lower zone from Sitapur to Kaithi)	Post-monsoon	2022	February, March

baseline data for the entire Gomti River is insufficient to evaluate ecological hazards and to prioritize conservation efforts for the river and its biodiversity. This study aims to assess anthropogenic threats that influence biodiversity and river ecosystem of the Gomti River, throughout the 930 km stretch from its origin to confluence, in Uttar Pradesh.

9.2. METHODS

The Gomti River was segmented into 5 km sections designated as BEU in ArcGIS 10.2 (ESRI, Redlands, USA) (Figure 9.1). Data on anthropogenic stressors were gathered at each sampling location, which included presence of fishing activities, the number of fishing boats and nets, agricultural practices on banks and islands, the presence of sand mining, modes of transportation and extraction (including the number of trucks, earth movers, and boats), the number of ferries, drains, sewage and industrial outlets, as well as the number of dams and barrages were also documented. Furthermore, the presence of predators, livestock, and characteristics associated with human occupancy were documented within each BEU. The summary of the survey is provided in Table 9.1.

9.3. RESULTS

9.3.1. Dams and barrages

Gomti Barrage is situated on the Gomti River at Lucknow city (Figures 9.1 and 9.3). The Barrage was built to divert water for the local paper industries and to manage the river water levels in Lucknow during the summer months (Maurya, 2008; Maurya, 2013).

9.3.2. Drains – industrial and sewage

The Gomti River receives approximately 450,000 m^3 of untreated domestic wastewater daily from Lucknow city (Singh et al., 2005a). Additionally, it is contaminated by effluents from several industries, including distilleries, sugar mills, and chemical plants, which are discharged directly into the river (Singh et al., 2005b). One industrial outlet near Daulatpur (BEU-36) as well as six sewage drains in the upper zone and 20 sewage drains in the middle zone of the Gomti River were recorded during our survey (Figure 9.1). The maximum number of sewage outlet (n=13) were recorded in BEU-84 near the Daudnagar village of Lucknow district (Figures 9.1 and 9.3).

9.3.3. Agriculture activity on river bank and island

The upper zone of the Gomti River is encroached by agriculture and water flow is severely impacted. During the survey, the highest incidences of agriculture activity was recorded in the upper zone (n=67) of the Gomti River, followed by middle zone (n=52) and lower zone (n=38) (Figures 9.1 and 9.3).

9.3.4. Water extraction

Water extraction for the purpose of irrigation was recorded from the Gomti River. Maximum number of water pumping incidences (n=316) were observed in the middle zone of the river from Sitapur to Sultanpur, while a moderate (n=87) and low incidences (n=4) were recorded from upper and lower zones, respectively (Figures 9.1 and 9.3).

9.3.5. Fishing

Maximum fishing activity were recorded in the middle zone of the Gomti River with total counts of 158 fishing nets and 202 fishing boats followed by the upper zone (total 61 counts each of fishing net and boat). While the lower zone recorded less fishing activities as compared to both middle and upper zone in the Gomti River (Figures 9.1 and 9.3).

9.3.6. Ferry

Country boats and some motor boats were observed at various locations. These were being used for crossing the river and tourism purpose. Maximum

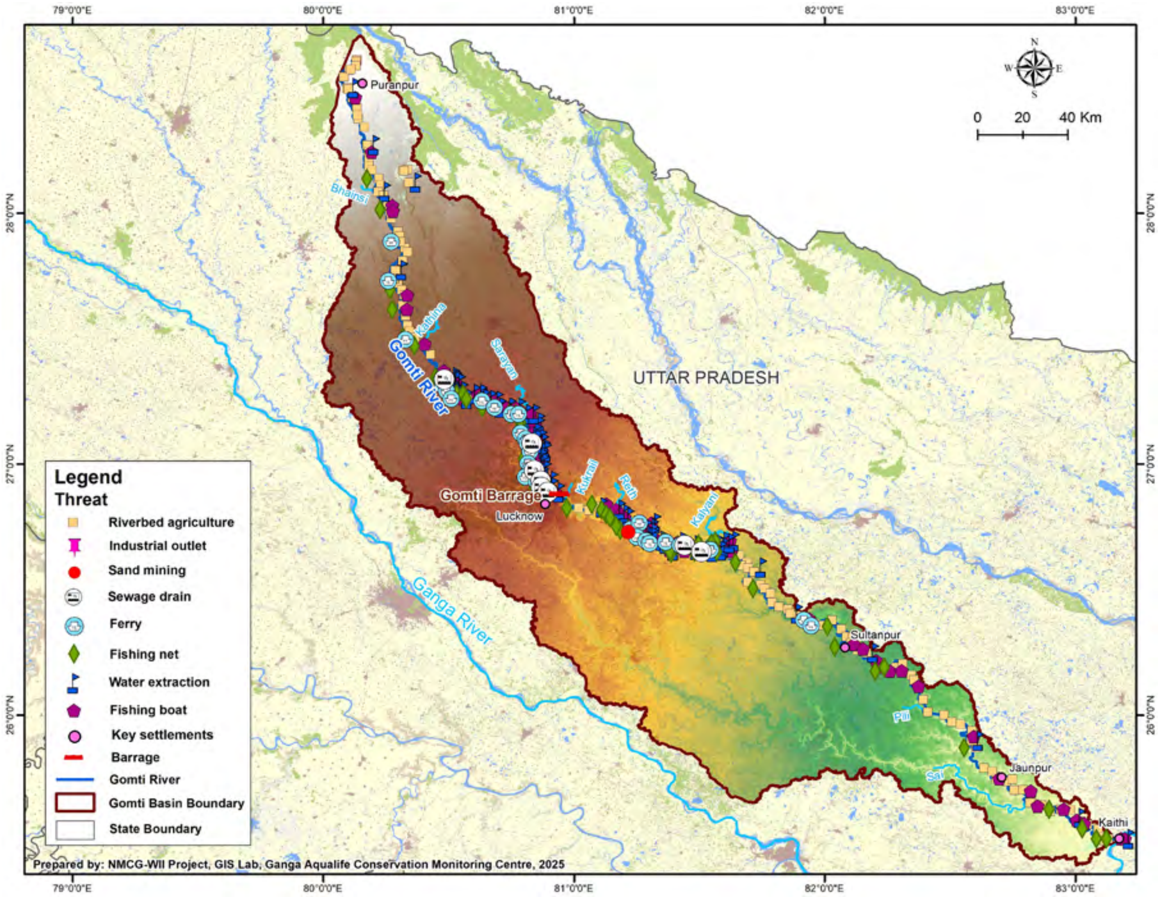

Figure 9.1. Anthropogenic stressors documented along the Gomti River.

65 ferries or small boats were recorded in the upper zone, while the middle zone recorded a total of 35 ferries or small boats (Figures 9.1 and 9.3).

9.3.7. Sand mining

Sand mining was recorded at three locations near Chaksar village within the BEU-95 of the middle zone of the Gomti River (Figures 9.1 and 9.3).

9.3.8. Human presence

Human presence was recorded while they were engaged in agricultural practice, fishing, boating, crossing river, cultural, and tourism purpose along the Gomti River. Maximum human presence was recorded in the middle zone (n=1,056), followed by the upper zone (n=713). Less human presence was recorded in the lower zone (n=87) as compared to the upper and middle zone of the river (Figures 9.2 and 9.3).

9.3.9. Free-ranging dog

Maximum number of free-ranging dogs were recorded in the middle zone along the Gomti River with a total count of 65 as compared to 24 individuals each in upper and lower zones of the river (Figures 9.2 and 9.3).

9.3.10.Livestock

Maximum livestock were recorded in the middle zone (n=1,499), followed by the upper zone (n=521) and lower zone (n=25) along the Gomti River (Figures 9.2 and 9.3).

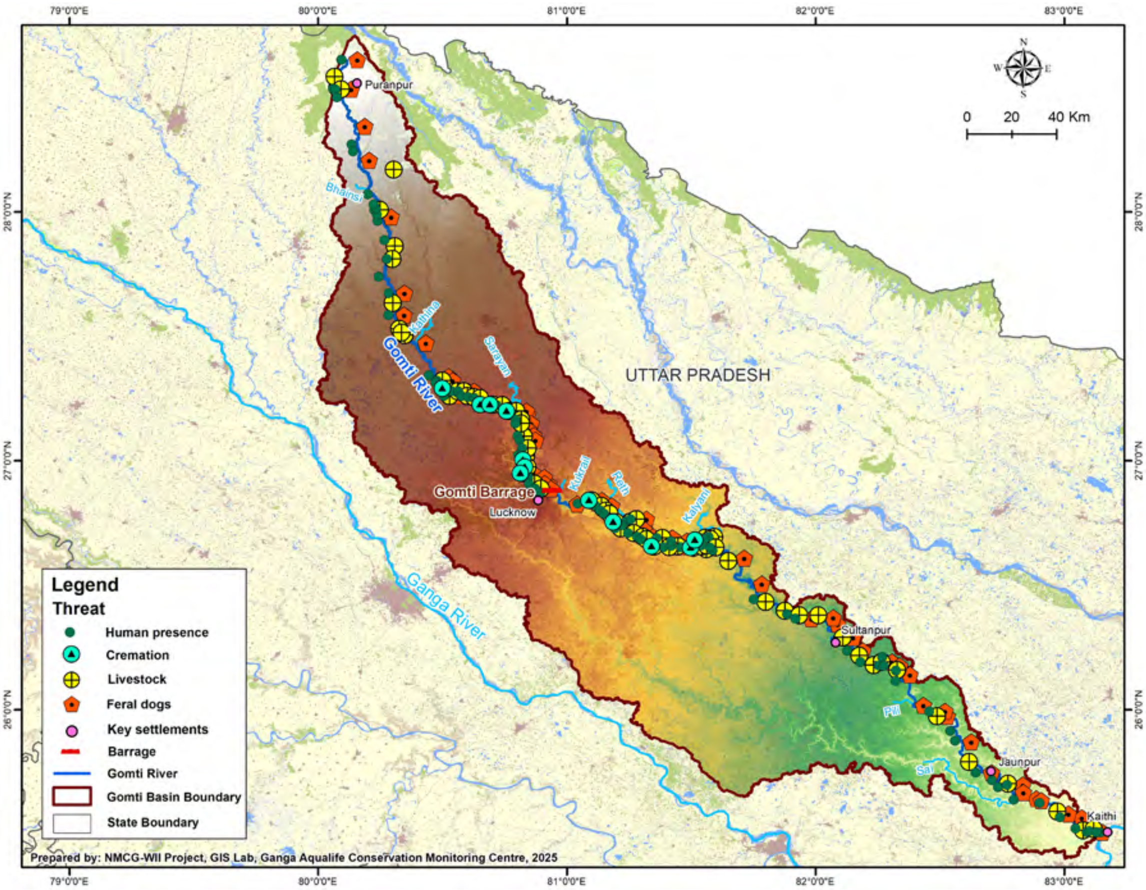

Figure 9.2. Additional stresses documented along the Gomti River.

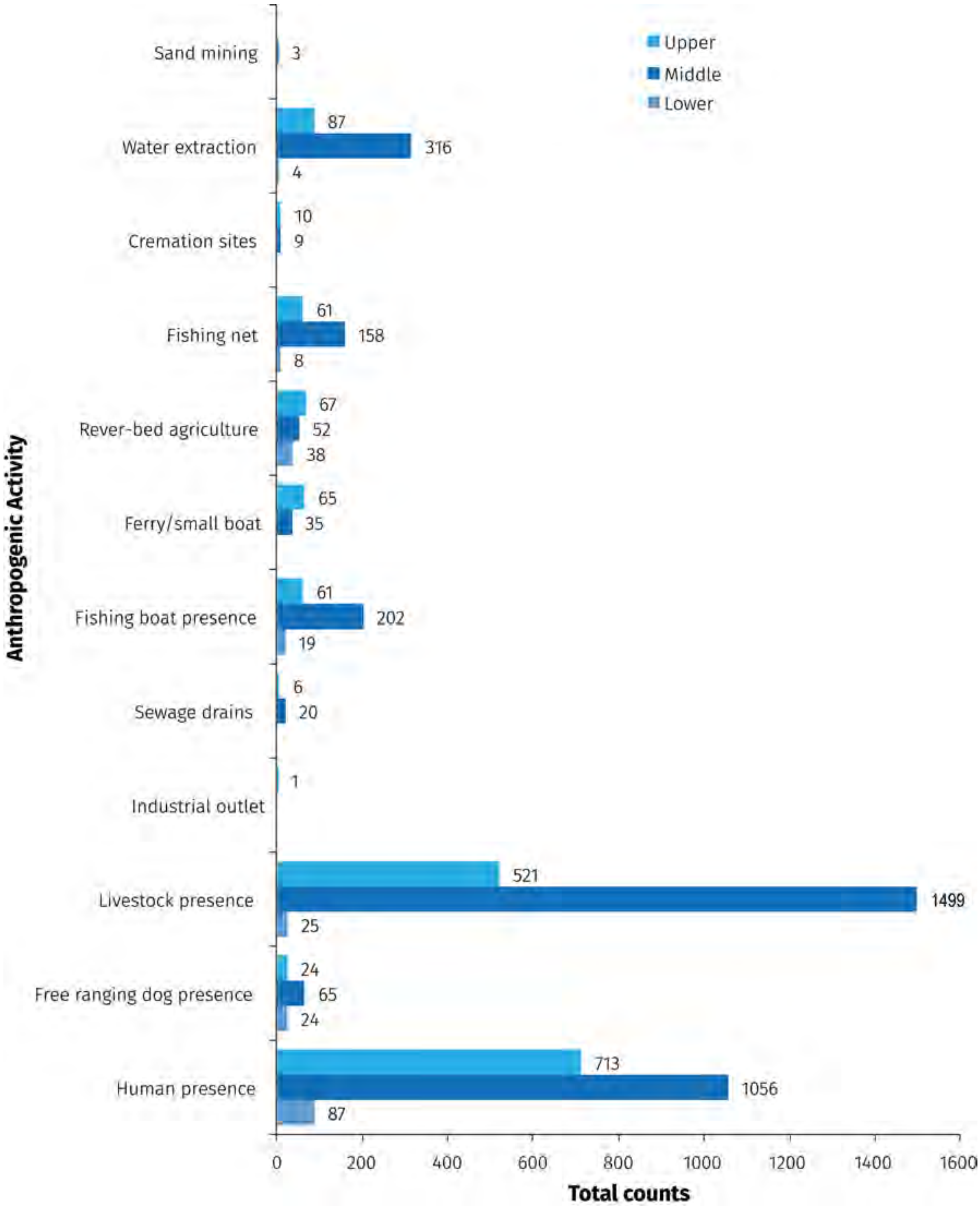

Figure 9.3. Total count of anthropogenic stressors along the Gomti River.

9.4. DISCUSSION

This study highlights the extensive effect of anthropogenic pressures on the Gomti River throughout its course, with distinct regional variations in the intensity and the type of disturbances. Human activities such as agriculture, encroachment, congestion of river, urbanization, pollution, sewage effluents, and resource exploitation have altered the river's hydrology, habitat structure, and ecological functioning (Dutta et al., 2011; Dutta et al., 2015a; Dutta et al., 2015b; Kumar, 2019; SwaRA, 2019; Jain, 2024; Zareen, 2025). The uneven distribution of these stressors underscores the importance of stretch-specific management over uniform river conservation efforts. For clarity and management purposes, the Gomti River's anthropogenic activity intensity and effects can be broadly categorized into upper, middle, and lower zones.

9.4.1. Upper Zone

The upper course of the Gomti River remains intermittent for approximately 60 kilometers, attaining perennial flow only downstream of its confluence with the Joknai River at Ekkotarnath. During the non-monsoon season, this upstream segment frequently lacks flow, with numerous dry stretches. The riverbed has been heavily silted and encroached upon by farmers, who cultivate crops for several months when the channel is dry, particularly near Dhimapur Bridge and along the Puranpur-Khuthar road (Dutta et al., 2011). Our survey recorded high agricultural activity in the upper zone as compared to the middle and lower zones. According to revenue records, encroachment into the river and floodplain has left only a few fields in the name of the Gomti river in each village in the upper reaches, with no land in Navadia Todarpur, Biharipur M. Rampur Fukire, Navdia Maksudpur, Panchpera Prahladpur, and Udaiksanpur.

Approximately 90% of the river's channel is converted to Gram samaj land (a village body) or agricultural road (Dutta et al., 2015a). This legal and physical encroachment has two consequences that compound each other: it reduces the channel's cross-sectional area, diminishing its capacity to convey flood flows and recharge groundwater, while simultaneously eliminating the riparian buffer zone that would otherwise intercept agricultural runoff, stabilise banks, and provide terrestrial habitat continuity for riparian fauna (Paul & Meyer, 2001; Smith et al., 1999). The result is a severely constricted and hydrologically impaired upper river in which the ecological preconditions for biodiversity — stable flows, connected floodplains, and intact riparian vegetation — have been progressively dismantled. Thus the most ecologically fundamental stressor in the upper zone is the hydrological failure. Intermittency eliminates aquatic habitat continuity, disrupts longitudinal connectivity for fish and other aquatic organisms, and renders the upper channel functionally unsuitable for most obligate freshwater fauna during dry months (Poff et al., 1997).

9.4.2. Middle Zone

The middle zone of the Gomti River receives the cumulative pressure, owing mostly to urban development. Uttar Pradesh's capital, Lucknow is also situated along the Gomti River in this zone. The concentration of sewage drains, industrial outputs and runoff including legacy and current-use agrochemicals along this stretch causes significant organic and chemical pollution, deteriorating water quality, and risking aquatic species (Verma, 2025; Khan et al., 2021; Singh, 2016). High fishing intensity, combined with increased human and livestock presence, exacerbates ecological stress by disrupting habitat, depleting biological resources. Even minor sand mining activities observed in this zone may have localized but considerable effects on channel shape and sediment dynamics.

9.4.3. Lower Zone

In contrast, the lower zone shows relatively lower direct human pressure, with fewer instances of agriculture, water extraction, and human presence. However, its ecological condition remains dependent on upstream processes and downstream confleunce, including altered flow regimes and pollutant transport, underscoring the interconnected nature of river systems.

Taken in aggregate, the data from this study characterise a river whose ecological security — defined as the capacity of the ecosystem to maintain its structure, function, and resilience under external stressors (Graham et al., 1991; Wang et al., 2003) — has been severely compromised across all three zones, albeit through different dominant mechanisms. Ecological security frameworks provide a useful conceptual basis for integrating the diverse stressor types documented here into a unified assessment that can inform management prioritisation. In applying such a framework to the Gomti, it is evident that the river currently fails to meet the conditions for ecological security in any zone: the upper zone lacks the hydrological continuity required for ecosystem function; the middle zone is chemically and biologically degraded beyond natural assimilative capacity; and the lower zone is ecologically dependent on upstream conditions that are themselves severely impaired. A particularly important finding of this study is the spatial heterogeneity of stressor distribution across zones, which has implications for how conservation resources should be allocated. The temptation in river management to focus remediation efforts on the most visibly degraded reach — in the Gomti's case, the Lucknow urban stretch — risks neglecting the source-reach processes in the upper zone that ultimately govern the hydrological template of the entire river. As Poff et al. (1997) demonstrated, the natural flow regime is the master variable controlling ecological integrity in river systems; without adequate flows, improvements in water quality or habitat structure deliver limited ecological benefit. Restoring hydrological function in the upper zone — through groundwater management, floodplain repossession, and environmental flow provision — is therefore a prerequisite for, rather than an alternative to, pollution control in the middle zone.

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SECTION- III

CONSERVATION PLANNING

CHAPTER 10

CONSERVATION PRIORITY STRETCHES

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SUMMARY

This chapter presents a systematic, multispecies framework for the spatial delineation of Conservation Priority Stretches (CPS) along the 930 km of the Gomti River, spanning the state of Uttar Pradesh. A species distribution modelling approach based on Maximum Entropy (MaxEnt) was applied using occurrence records of six indicator taxa-the Gangetic dolphin (*Platanista gangetica*), gharial (*Gavialis gangeticus*), black-bellied tern (*Sterna acuticauda*), Indian skimmer (*Rynchops albicollis*), river lapwing (*Vanellus duvaucelii*), and river tern (*Sterna aurantia*)-in conjunction with sixteen ecologically relevant bioclimatic, hydro-morphological, and anthropogenic variables. Field data were collected through boat-based visual encounter surveys (2020- 2021) and analysed using 5 km Biodiversity Evaluation Units (BEUs). Predicted habitat suitability was classified into three conservation priority categories (CPS I: ≥0.70; CPS II: 0.61-0.70; CPS III: 0.51-0.60) and Restoration Zones (RZ: <0.50). No river segments met the threshold for CPS I, indicating widespread habitat degradation and fragmentation along the river. Approximately 150 km (15.59%) of the river was identified as Conservation Priority Stretches-II (CPS-II). Additionally, around 230 km (25.27%) were categorized as Conservation Priority Stretches-III (CPS-III). Complementing these priority

stretches, approximately 550 km (59.14%) of the river was identified as restoration zones. The Gomti River has undergone drastic transition due to surmounting anthropogenic stressors, which has resulted in the predominance of moderately and low suitable habitats. Relatively higher suitability in the middle reaches contrasts with substantial restoration needs in both upstream regulated and downstream heavily modified sections, consistent with patterns observed in river systems globally. This chapter provides a robust, spatially explicit basis for prioritizing conservation and restoration interventions along the Gomti River. It emphasizes the need for integrated river basin management, targeted habitat restoration, and strengthened policy measures to enhance ecological integrity and biodiversity conservation, while aligning with global frameworks.

10.1. INTRODUCTION

Freshwater ecosystems are among the most imperilled ecosystems worldwide, experiencing intense pressures from interconnected drivers which range from pollution, overexploitation of resources, and climate change (Reid et al., 2019; Schneider et al., 2013). Altered natural flow regimes, species range reduction, change in water quality, loss of aquatic habitats are some of the impacts of the drivers (Dudgeon, 2006; Grimm et al., 2008; Echols et al., 2009). Climate change further compounds these impacts by modifying water temperature, flow patterns, and precipitation, thereby affecting species distributions and ecosystem resilience. The combined influence of these stressors has resulted in widespread declines in freshwater biodiversity. As a consequence, many freshwater species are now threatened with extinction. In the context of the Gomti River, the smooth-coated otter (*Lutrogale perspicillata*), and riverine specialist birds, including black-bellied tern (*Sterna acuticauda*) and Indian skimmer (*Rynchops albicollis*) are particularly vulnerable to these environmental changes. Their decline signals a broader crisis threatening freshwater biodiversity and ecosystem integrity (Dudgeon, 2006; Strayer & Dudgeon, 2010; Reid et al., 2019; IUCN, 2023).

In response to the global decline in freshwater ecosystems, six priority actions were identified to bend the curve of freshwater biodiversity decline (Tickner et al., 2020). Among those priorities, protecting and restoring critical habitats, managing exploitation of riverine species and aggregates, preventing and controlling invasive species, and safeguarding and restoring freshwater connectivity translate into identifying Conservation Priority Stretches (CPS) —ecologically significant regions requiring urgent action (Margules et al., 2002; Bonn & Gaston, 2005). Conservation prioritization helps identify the crucial areas (spawning grounds, refugia, headwaters, connectivity), allocate limited resources where conservation could yield maximum ecological return and trade-offs could be managed, to align with human well-being (Howard et al., 2018; Reid et al., 2019).

A systematic conservation prioritization framework integrates spatial modeling tools, species distribution data, and connectivity assessments (Moilanen et al., 2009; Nel et al., 2009). Approaches such as MaxEnt (Maximum Entropy Modeling), AHP (Analytical Hierarchy Process), and WOA (Weighted Overlay Analysis) provide a robust basis for identifying high-priority conservation areas and guiding sustainable river basin management (Balmford, 2002; Albuquerque & Beier, 2015; Howard et al., 2018). Species distribution modeling (SDM) links occurrence records with environmental variables to predict suitable habitats (Ma & Sun, 2018). MaxEnt, particularly suited to presence-only data, is especially useful in freshwater systems where absence data are limited (Elith et al., 2006; Beery et al., 2021). Since identifying conservation priority stretches is a complex task (Knight et al., 2011; Tambosi et al., 2014; Perring et al., 2015), species distribution and habitat conditions are valuable for determining high-biodiversity stretches (Darwall & Vié, 2005).

In the context of the Gomti River, which provides habitat to some of the globally endangered species, conservation prioritization enables the identification of habitats for indicator species. This chapter focuses on the prioritization of stretches along the Gomti River. Establishing CPS can enhance gene flow, seasonal migration, and stabilize populations of threatened species (Kumar, 2021). Using a multispecies framework and advanced conservation planning tools, we identified CPS to strengthen biodiversity conservation and ecosystem services. Delineating and managing these priority areas aligns with national and global conservation targets, which would help curb biodiversity loss and enhance ecological sustainability (Strassburg et al., 2020). By mapping the key habitats of multiple indicator species, this study provides a robust scientific basis for identifying conservation priority areas and implementing targeted management interventions necessary to maintain the ecological integrity of the mainstem Gomti River.

10.2. METHODOLOGY

10.2.1. Data collection

We conducted boat-based visual encounter surveys to assess the ecological conditions of the 22 rivers in the Ganga River basin, including the Gomti River, by examining the presence of key indicator species between 2020 and 2021. The surveyed river stretch was divided into 5 km segments referred to as the Biodiversity Evaluation Unit (BEUs) using ArcGIS 10.2 (ESRI, Redlands, USA). Bioclimatic, hydro-morphological, and anthropogenic variables were compiled across the current and historical ranges of these species to predict potential habitat suitability and identify priority areas within the basin. Information on hydro-morphological and anthropogenic variables was collected at 1 km intervals and averaged for each BEU. Climatic variables were downloaded from WorldClim version 2 at a spatial resolution of 2.5 arc minutes (~4.5 km²) (Fick & Hijmans, 2017) and resampled at 5 km² to have a uniform spatial resolution. A total of 29 environmental variables initially taken were based on published literature for species distribution modelling using MaxEnt (e.g. Kelkar et al., 2010; Choudhary et al., 2006; Paudel et al., 2015).

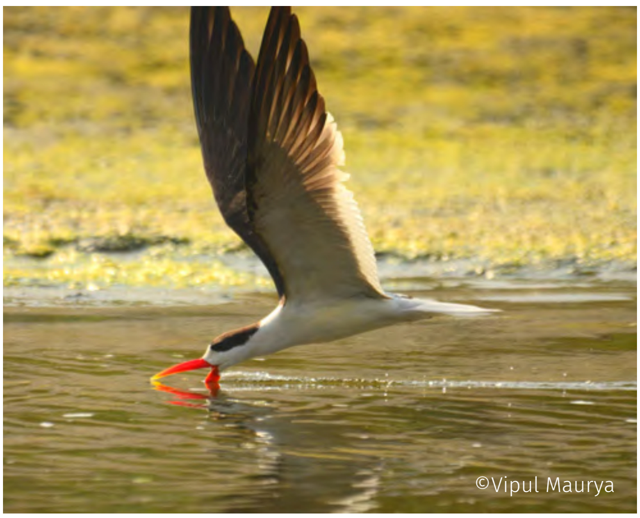
Surveys were conducted during the post-monsoon season (November–February). Field surveys were carried out during daylight between 8:00 hrs and 12:00 hrs and 15:00 and 17:00 hrs using an inflatable rubber (25 hp)/country boat following thalweg (the deepest part of the river channel) (Oliveira et al., 2017). The boat speed was kept constant at 6-8 km h^{-1} to minimize the chances of missing sightings of surfacing dolphins and other freshwater faunas. Hydro-morphological parameters recorded within each BEU included channel width (m), channel depth (m), water flow ($m^3 s^{-1}$), river slope (degree), and channel morphology. Field observations were made using binoculars (NIKON 8×42), GPS (GARMIN e-Trex 30), depth sounder (HONDEX PS7), range finder (HAWKE Endurance LRF-1000). Additional variables such as number of meanders (me), fishing intensity (fn), sand mining intensity (mining boats/BEU), and other anthropogenic factors were also recorded.

10.2.2. Data Analysis

A MaxEnt model was used to predict the potential distribution and identify priority stretches for the conservation of indicator species across the Ganga River basin, and the results were subsequently extracted and analysed for the Gomti River. MaxEnt is based on the principle of maximum entropy and is extensively used to model species distributions using presence-only occurrence data and environmental variables (Phillips et al., 2006; Clements et al., 2012; Kramer-Schadt et al., 2013). The approach is widely recognized as an effective method, particularly where absence data are lacking (Elith et al., 2006), and for identifying areas of high habitat suitability that can be used to delineate conservation priority stretches.

Species distribution modelling using MaxEnt was conducted for six key indicator species: Gangetic dolphin (*Platanista gangetica*), gharial (*Gavialis gangeticus*), black-bellied tern (*Sterna acuticauda*), Indian skimmer (*Rynchops albicollis*), river lapwing (*Vanellus duvaucelii*), river tern (*Sterna aurantia*). The analysis was carried out across 22 rivers in the Ganga River basin, including the Gomti River. Bioclimatic, hydro-morphological, and anthropogenic variables were checked for multicollinearity, and highly correlated (Pearson correlation ≥0.70) variables with low ecological influences were removed from the modelling (Zuur et al., 2009). Presence records of six indicator species, together with 16 ecologically meaningful and uncorrelated variables (bioclimatic =7, hydro-morphological =5, and anthropogenic =4) were used to predict the suitable habitat of the species in MaxEnt software v3.4.4 (Phillips et al., 2017).

The predicted probability outputs generated by MaxEnt were exported as ASCII raster files, imported into ArcGIS 10.6, and reclassified to generate habitat suitability maps. The resulting spatial layers were subsequently clipped for the Gomti River extent for BEU-level analysis and discussion. River stretches with probability values greater than 0.50 were identified as potential distribution areas. This midpoint threshold was applied to distinguish suitable from unsuitable habitats and to convert the continuous probability surface into a binary habitat suitability map for spatial analysis. These stretches were further categorized into three CPS classes: ≥ 0.70 CPS I (High Conservation Priority), 0.61–0.70 CPS II (Moderate Conservation Priority), and 0.51–0.60 CPS III (Low Conservation Priority). River stretches with suitability scores below 0.50 were classified as Restoration Zones (RZ).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10.3. RESULTS

The MaxEnt model classified river stretches into different CPS categories based on habitat suitability scores. No segment of the Gomti River met the threshold for CPS I (≥0.70). Approximately 150 km (15.59%) of the river was identified as Conservation Priority Stretches-II (CPS-II). Additionally, around 230 km (25.27%) were categorized as Conservation Priority Stretches-III (CPS-III). Complementing these priority stretches, approximately 550 km (59.14%) of the river has been identified as restoration zones (Figures 10.1, 10.2 and Table 10.1). Across different river stretches or zones, about 65.41% of the Gomti River's middle zone was identified as CPS, compared with 32.49% and 17.24% in the lower and upper zones, respectively (Figure 10.2). These CPS are distributed along the source of the Gomti River, upstream and downstream of the Gomti barrage and at confluence with the Ganga River, near Kaithi.

Table 10.1. Detailed information on identified Conservation Priority Stretches (CPSs) along the Gomti River.

State	District	From		To		Length (km)	CPS Category
		Place	GPS coordinates	Place	GPS coordinates		
Uttar Pradesh	Pilibhit	Gomat Tal, Phulhar	28.61218N, 80.116452E	Laukahi	28.545245N, 80.069976E	10	III
	Hardoi	Ragoia	27.590886N, 80.319896E	Rahimpur	27.540377N, 80.32061E	10	III
	Sitapur, Hardoi	Ismail Ganj	27.236132N, 80.722014E	Amberpur	27.178306N, 80.804248E	15	II
	Sitapur, Hardoi	Amberpur	27.178306N, 80.804248E	Jansapur	27.135134N, 80.818716E	10	III
	Lucknow, Bara Banki	Jansapur	27.135134N, 80.818716E	Kathwara, Chandrika Devi Temple	27.031858N, 80.848801E	20	II
	Lucknow	Kathwara, Chandrika Devi Temple	27.031858N, 80.848801E	Raitha	26.989068N, 80.831327E	10	III
	Lucknow	Raitha	26.989068N, 80.831327E	Gopramau	26.971036N, 80.829529E	5	II
	Lucknow	Gopramau	26.971036N, 80.829529E	Ghaila	26.915645N, 80.862492E	10	III
	Lucknow	Ghaila	26.915645N, 80.862492E	Nishatganj	26.860464N, 80.945504E	15	II
	Lucknow, Bara Banki	Nishatganj	26.860464N, 80.945504E	Sureya Mau	26.834887N, 81.124715E	25	III
	Lucknow, Bara Banki	Sureya Mau	26.834887N, 81.124715E	Ghuskar	26.773215N, 81.18641E	15	II
	Bara Banki	Ghuskar	26.773215N, 81.18641E	Ibraheembad	26.75859N, 81.261299E	15	III

State	District	From		To		Length (km)	CPS Category
		Place	GPS coordinates	Place	GPS coordinates		
Uttar Pradesh	Bara Banki	Ibraheembad	26.75859N, 81.261299E	Bhetaura	26.673782N, 81.368081E	30	II
	Bara Banki	Bhetaura	26.673782N, 81.368081E	Mansara	26.67268N, 81.398393E	5	III
	Bara Banki	Mansara	26.67268N, 81.398393E	Bajpura Ghat	26.64003N, 81.430235E	5	II
	Bara Banki	Subeha	26.643573N, 81.499005E	Selhaur	26.692193N, 81.54001E	10	II
	Ayodhya	Sharifabad	26.672446N, 81.557176E	Devait	26.66078N, 81.576159E	10	II
	Sultanpur	Basantpur	26.369332N, 81.985712E	Arjunpur	26.184267N, 82.213236E	65	III
	Sultanpur	Sabsukhpur	26.195653N, 82.306906E	Katsari	26.159611N, 82.323679E	10	III
	Sultanpur, Pratapgarh, Jaunpur	Aniraula	26.13802N, 82.341094E	Ramnipur	25.963348N, 82.532128E	35	III
	Jaunpur	Gopalapur	25.946124N, 82.568995E	Narauli	25.893727N, 82.573286E	10	III
	Jaunpur	Pasewan	25.644127N, 82.843036E	Saidkhanpur	25.618702N, 82.94837E	15	III
	Varanasi, Ghazipur	Niyardiha	25.536432N, 83.076826E	Kaithi Ghat, Gazipur	25.507883N, 83.169283E	25	II


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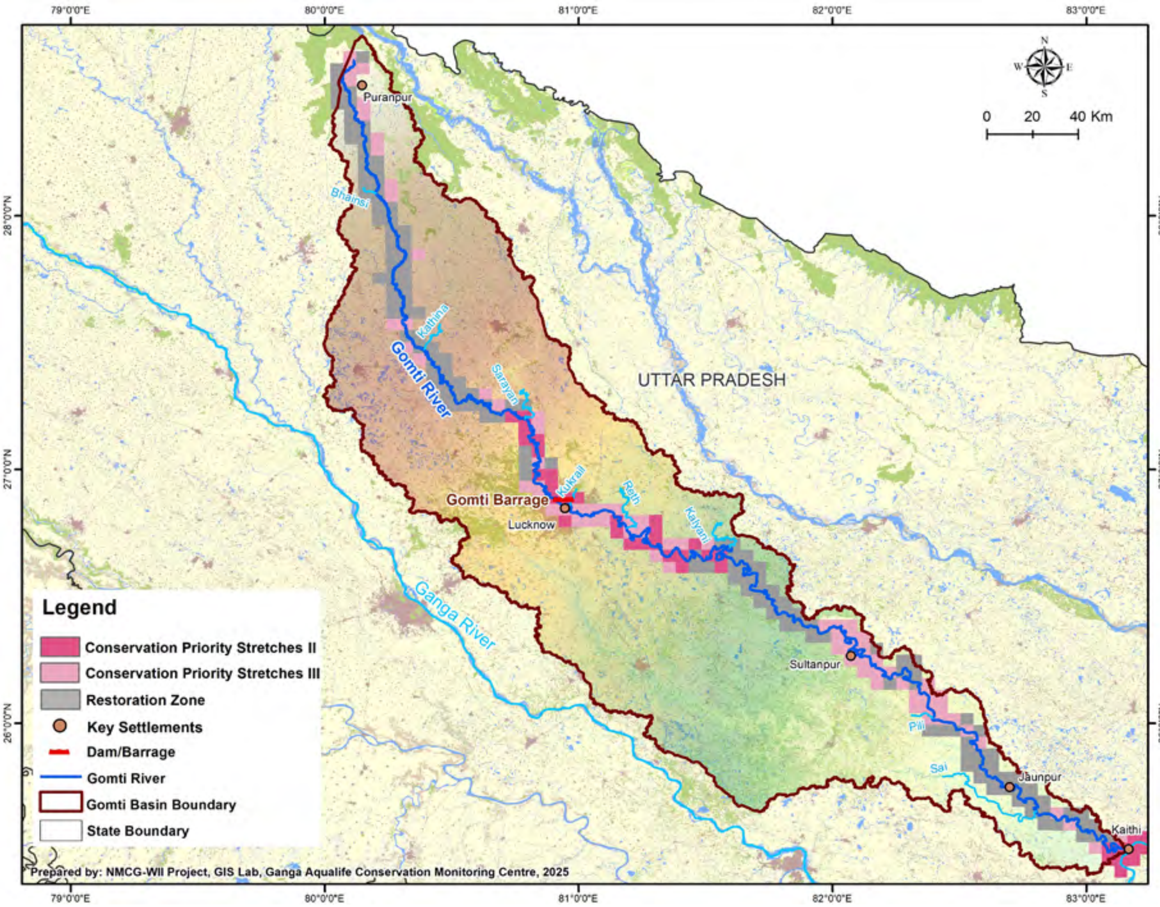

Figure 10.1. Conservation Priority Stretches (CPS) along the Gomti River, identified using key indicator species.

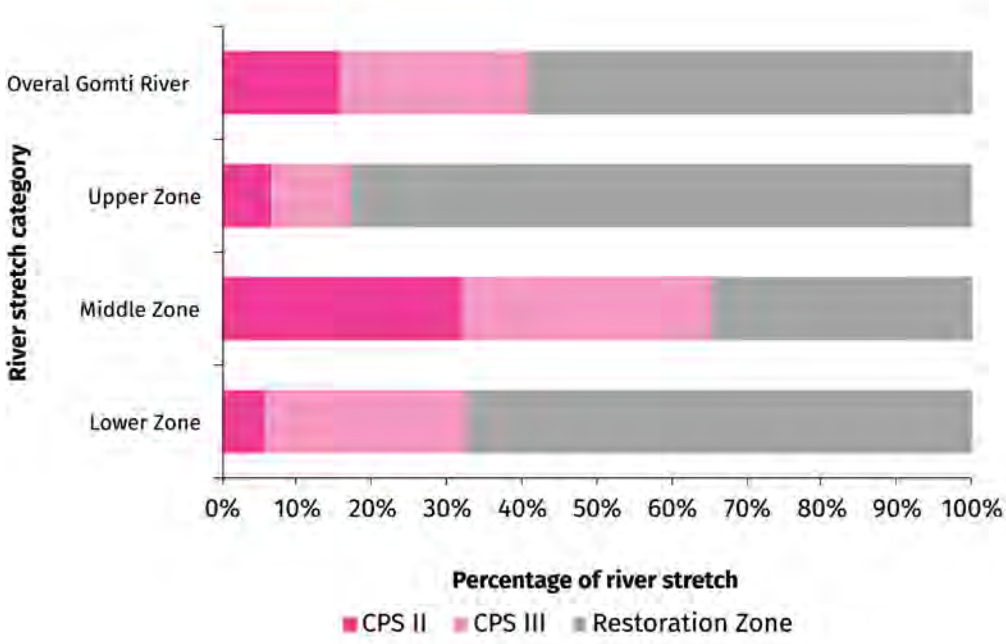

Figure 10.2. Identified Conservation Priority Stretches (CPS) in different zones of the Gomti River

10.3. DISCUSSION

Rivers' dynamic hydrological, morphological, and physicochemical characteristics feature a high level of habitat diversity, which is essential for species presence and overall biodiversity (Allan et al., 2021; Tockner et al., 2009; Ward, 1998). Nevertheless, many rivers within the Ganga River basin are now extensively regulated, made uniform, and increasingly affected by human activities such as agriculture, fishing, and sand mining, making them less suitable for biodiversity conservation (Pradhan et al., 2023; Das et al., 2022; Haidvogl, 2018). River ecosystems are particularly susceptible to competing resource demands and land use pressures, with these effects being notably significant in smaller river systems (Ledger et al., 2023; Dudgeon, 2000). In this situation, identifying conservation priority areas in these rivers is vital for safeguarding local ecosystems and preserving the ecological integrity of the entire basin.

Six key indicator species were used to identify Conservation Priority Stretches (CPSs) across 22 rivers in the Ganga River basin. Of these, three species, viz., Indian skimmer (*Rynchops albicollis*), river lapwing (*Vanellus duvaucelii*), and river tern (*Sterna aurantia*), were recorded from the Gomti River during our surveys and primarily shape the identified CPSs. Other key freshwater species found in the Gomti River, viz., smooth-coated otter (*Lutrogale perspicillata*), mugger (*Crocodylus palustris*), and turtles, were not incorporated in this analysis. Consequently, six out of eight BEUs with mugger sightings and approximately 50% of BEUs with turtle sightings fall outside the identified CPSs, as does the single BEU with a smooth-coated otter sighting.

Over 80% of the identified CPSs face high threats (CPS II: 86.66%; CPS III: 82.60%), compared to 89.09% in the restoration zone. Most CPSs along the Gomti River lie in the middle zone, stretching from the confluence of the Surayan and Gomti Rivers to Sultanpur — an area that faces a wider range and higher levels of threats than the upper and lower zones. This zone is also among the most densely populated regions in Uttar Pradesh, encompassing Lucknow, the state capital.

The identification of Conservation Priority Stretches provides a scientific basis for spatially standardised conservation planning along the Gomti River. Special attention must be given to the middle zone, where human activity is a primary source of multiple threats across the identified CPSs. Given that some key species were not included in the analysis, the actual area requiring conservation attention along the river is likely more extensive than what this study indicates. The inclusion of the smooth-coated otter (*Lutrogale perspicillata*), mugger (*Crocodylus palustris*), and turtles in future assessments would expand the currently identified CPSs. Nevertheless, these findings highlight the prioritized key habitats of the Gomti River for conservation and restoration. These CPSs can contribute to regional and global environmental targets, such as the Kunming-Montreal Global Biodiversity Framework, Freshwater Challenge, and can be considered under the Other Effective Area Based Conservation Measures (OECMs), which go beyond the conventional Protected Areas. Collective engagement, coordinated action, and long-term planning involving local communities, conservation organisations, and policymakers will be crucial for the conservation of key biodiversity and river ecosystems, based on the priorities identified through the CPSs along the Gomti River.


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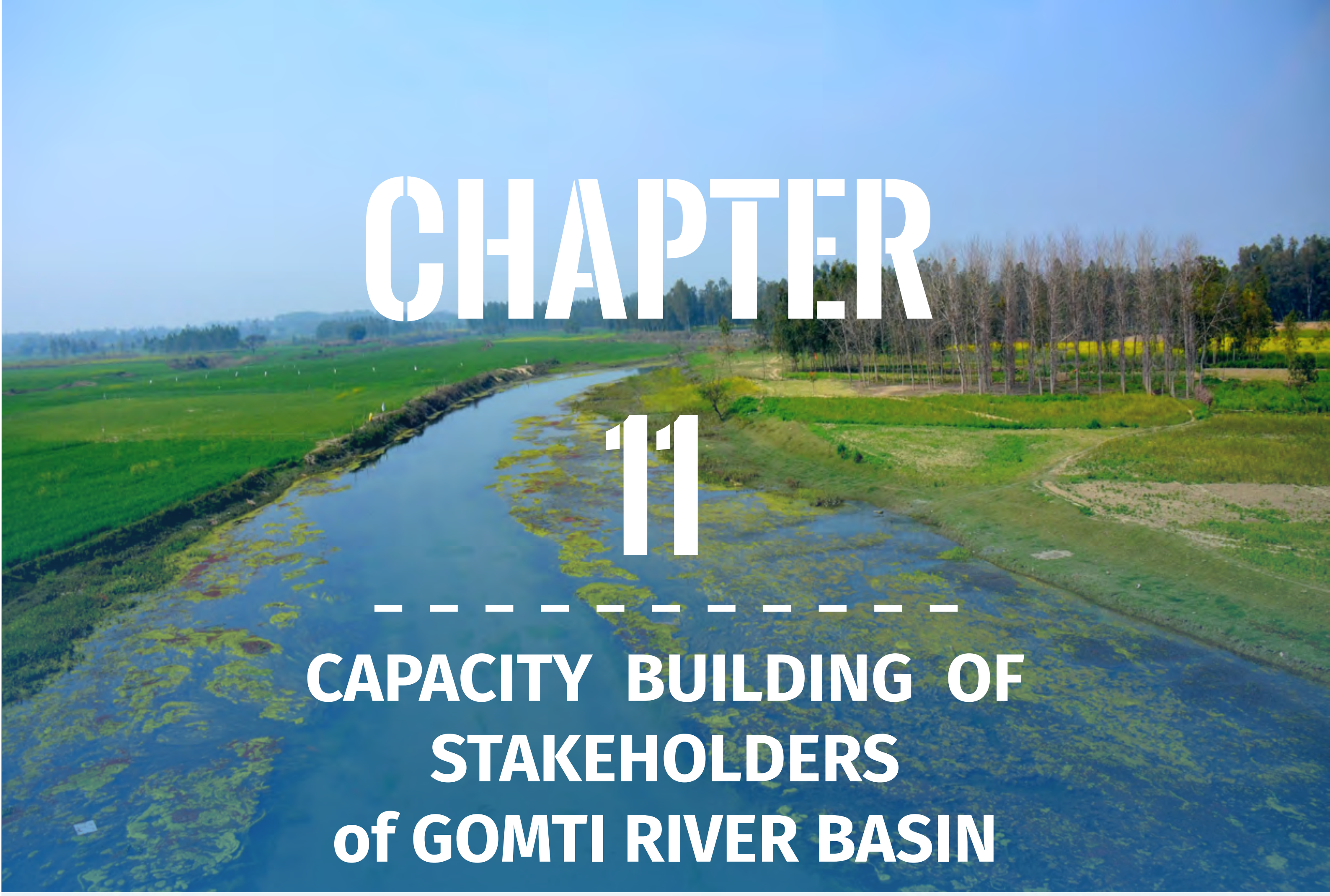
SECTION-IV

CAPACITY BUILDING



CHAPTER 11

CAPACITY BUILDING OF STAKEHOLDERS of GOMTI RIVER BASIN

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SUMMARY

Recognizing the importance of stakeholder participation, the Wildlife Institute of India (WII), under the NMCG project, implemented extensive capacity-building programmes across the basin. A structured, multi-tiered framework comprising five stages- stakeholder identification, training needs assessment, module design, implementation, and evaluation- was undertaken for capacity-building. Five thematic training modules were developed covering biodiversity monitoring, wetland management, rescue and rehabilitation, participatory management, and conservation education. A total of 45 training programmes engaged 1,610 participants across districts of Uttar Pradesh, categorised into 13 spearhead trainings, 4 rescue-specific sessions, and 28 broader thematic programmes. Stakeholder groups included forest officials, college students, Ganga Praharis, ETF-GTF members, zookeepers, veterinarians, police, and

local communities. Gender analysis revealed a significant disparity, with female participants comprising only 25.71% of the total. Post-training evaluation of a 150-person sample showed that 54.62% actively undertook carry-forward conservation activities, while 37.86% reported no follow-up, citing institutional and logistical barriers. A publicly accessible training database on the WII website, along with print and social media dissemination, ensured programme visibility and replicability. The chapter concludes that these initiatives have built a foundation of skilled, motivated conservation practitioners across the Gomti basin.

11.1. INTRODUCTION

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 aimed at empowering forest officials, field veterinarians, researchers, NGOs, entrepreneurs, school teachers, college professors, university students, and volunteers to act as proactive contributors in biodiversity monitoring and species conservation across the Ganga and its tributaries. The approach is designed to promote knowledge exchange, strengthen institutional coordination and foster collaborative decision-making among stakeholders involved in freshwater ecosystem management.

The approach emphasises 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 Gomti 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 Gomti River Basin and carry forward the awareness-generation activities individually or at the institutional level.

The overall approach would assist in developing and strengthening the participants' skills, instincts, abilities, processes and resources that organisations 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. Special focus is placed on experiential learning through field demonstrations, species identification protocols, habitat assessment techniques, and the use of scientific tools for conservation planning.

11.1.1. Key elements of capacity building

The foundational principle of this programme is that long term stakeholder engagement and sustained institutional support are vital for achieving durable conservation 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, institutional coordination and community -based stewardship. 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 evaluation processes comprise pre- and post-training assessments, structured participant feedback, field performance reviews and follow-up mentoring to ensure knowledge retention and practical application. These interlinked stages are visually represented in Figure 11.1., which illustrates the core elements of capacity building adopted under the NMCG initiative. The capacity building framework comprises five essential components: (i) Identification of target groups and engagement of stakeholders through meetings, correspondence, workshops, (ii) Identification of training and capacity needs (iii) Formulation of context-specific capacity development programmes (iv) Implementation through structured delivery mechanisms (v)

Evaluation, feedback and adaptive refinement. Together, these components constitute the core management framework necessary for planning, implementation, monitoring, evaluation and continual improvement of freshwater biodiversity conservation initiatives across the Ganga River and its tributaries.

11.1.2.Building the base - Implementation and logistics

As highlighted by Alaerts (2008), organizing successful training programmes requires seamless 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. This tailored approach ensures that the knowledge delivered remains relevant and directly applicable to participants' operational responsibilities.

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.

11.1.3. 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 and integrated river basin management across the Gomti 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 Gomti River Basin (Figure 11.3).

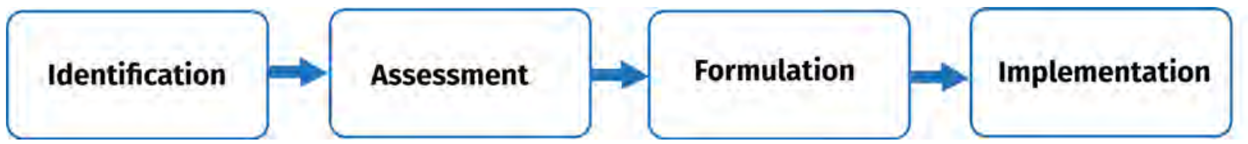

Figure 11.1. Core Elements of Capacity Building Programme for River Conservation

For developing the contents of the training curriculum, a comprehensive process of literature review, consultations, stakeholder mapping, needs assessment exercises, and communication was undertaken with the forest department and other stakeholders of Gomti Basin states. Training and capacity building workshops were designed and delivered according to the categorisation of target groups divided into three levels, viz. policy, implementation and execution levels. This tiered structure ensured that the content was appropriately contextualised to address strategic planning, operational implementation and field-level execution requirements.

The capacity building process begins with the identification of target groups. These include a diverse range of stakeholders, such as forest and fisheries department personnel, academic professionals and students, frontline staff, veterinarians, and community volunteers, representatives from line departments, local governance institutions and civil society organisations. 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). These interactions also help in establishing trust, identifying collaborative opportunities and facilitating institutional ownership of conservation interventions.

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. This strategic planning enhances participation, minimizes operational constraints and ensures efficient utilization of institutional and field-level resources.

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.

Figure 11.2. Stages of Capacity Building Initiative

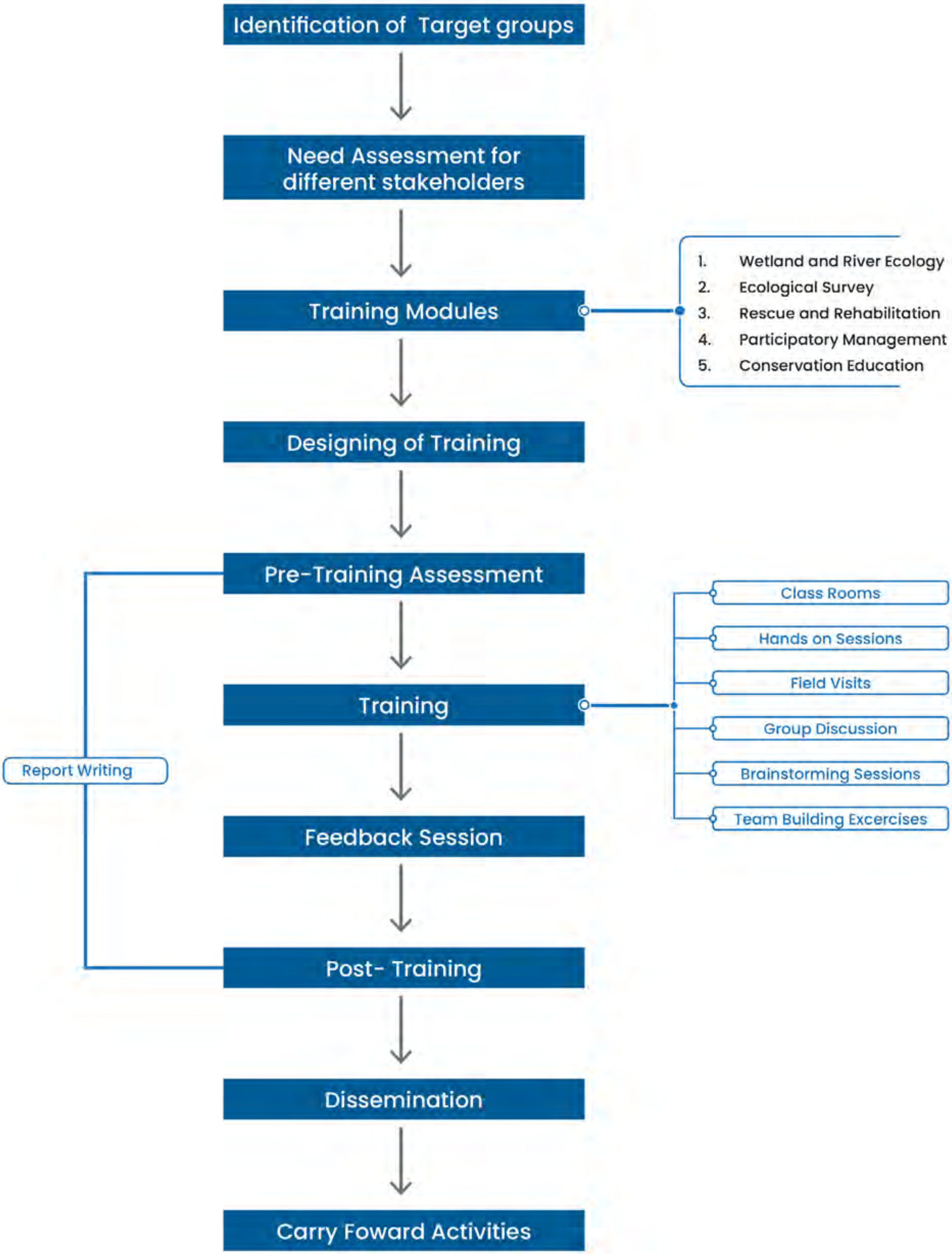

Figure 11.3. Capacity Building Framework.

11.1.4. Training needs

Following the identification of diverse stakeholder groups engaged in the Gomti 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, forms the foundation of a scientifically designed and strategically targeted capacity-building initiative.

In the context of Gomti 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 the mechanisms through which these activities can be aligned with biodiversity conservation objectives. 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 strengthening community stewardship through conservation-linked sustainable livelihoods practices.

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). Prioritisation of training needs was carried out through consultative processes involving relevant departments and institutional stakeholders. This participatory prioritisation 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. It also enabled the identification of knowledge gaps, operational constraints and opportunities for strengthening cross-sectoral coordination among stakeholders. 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 Gomti River Basin requires the involvement of multiple stakeholders equipped with specialised knowledge, practical skills and institutional competencies. To address the existing gaps in technical expertise and institutional capacity, five comprehensive training modules were developed:

(1) Biodiversity monitoring of macro aquatic species of the Gomti River and its tributaries; (2) Conservation and management of wetlands and associated habitats; (3) Rescue and Rehabilitation of macro aquatic
animals in distress; (4) Participatory Management; and (5) Conservation Education (Figure 11.4).

Together, these modules are essential for strengthening institutional roles and ensuring coordinated, informed action for long-term biodiversity conservation and ecosystem health in the Gomti River Basin. Based on these training modules, the capacity building programmes were designed and implemented for multiple stakeholders in the Gomti River basin. This modular structure also provides flexibility for adaptation across different stakeholder groups, allowing training content to be customized according to operational roles, technical requirements, and local conservation priorities.


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Figure 11.4. Capacity Building Module.

11.2. OBJECTIVES

The aim was to enhance the institutional and individual capacities of stakeholders involved in freshwater biodiversity conservation across the Gomti River Basin, focusing on equipping them with the knowledge, skills, and tools necessary for the effective implementation of conservation strategies, adaptive ecosystem management, and long-term ecological management. The study had following objectives

1. To develop and disseminate context-specific training materials and knowledge products targeting different stakeholder groups engaged in freshwater biodiversity conservation.

2. To expand and strengthen spearhead teams across the Gomti Basin states and build their technical capacity in monitoring macro aquatic species of conservation significance, wetland management planning, rescue and rehabilitation protocol, and ecological monitoring techniques.

3. To enhance the capacities of university professors, students, forest officials, local communities and other relevant stakeholders in aquatic species monitoring, rivers and wetland management planning, ecological assessment and community-based conservation practices.

4. To enhance capacity of the personnel of the forest departments, animal husbandry departments, field veterinarians, and volunteers in rescue, rehabilitation, emergency response and post-release monitoring of aquatic fauna in distress.

5. To build capacity of local communities, including the Ganga Praharis for timely reporting, coordinated response and effective management of emergent ecological and wildlife related situations in the Gomti River basin.

11.3. METHODOLOGY

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 the Gomti River Basin. Given their varying roles, exposure levels, and technical backgrounds, a flexible training strategy and methods of andragogy were adopted, rooted in adult learning principles and designed to meet identified knowledge and skill gaps.

The training methodology emphasized experiential, participatory and competency based learning approaches to maximize knowledge transfer and facilitate practical application in real-world conservation settings. 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 basin 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 Gomti 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.

At the first level, participants' immediate responses to the training programmes were collected through structured feedback forms and open-ended responses. These captured their perceptions of the content quality, delivery methods, relevance to their roles, and the overall learning environment. Special attention was paid to whether participants felt the sessions were practical, engaging, and reflective of their on- ground realities. This feedback served as a critical input for refining training modules and improving facilitation styles in future sessions. The second level focused on assessing the extent of knowledge and skill enhancement achieved through the training. This was done through structured pre- and post-training assessments, which measured improvements in participants' understanding of key concepts, policies, species identification, ecological processes, monitoring techniques, and stakeholder roles in conservation. These assessments enabled a quantitative comparison of learning gains and helped identify areas requiring additional attention.

Beyond knowledge acquisition, the third level assessed whether participants applied their learning in their professional or social environments. This was evaluated through systematic follow- up interactions, observational reports from nodal officers, and feedback from institutional supervisors. Examples included forest officials initiating community engagement programmes for riverine Biodiversity conservation, fisheries officers applying habitat assessment and ecological monitoring techniques, and volunteers organising awareness activities in schools, colleges and their surroundings within their respective capacities.

The final level of evaluation focused on measuring the broader outcomes of the training at the institutional and community levels. This involved analysing whether the capacity-building interventions contributed to strengthened conservation planning, timely response to wildlife emergencies, integration of biodiversity concerns into development schemes, and enhanced collaboration across departments. Documented instances of cross-sectoral initiatives, biodiversity documentation efforts, species rescue operations, and informed participation in conservation policy discussions reflected tangible programme-level impacts. These results demonstrated that the training programmes had not only enhanced individual competencies but also contributed to institutional readiness and multi-stakeholder collaboration in line with the objectives of the National Mission for Clean Ganga (NMCG).

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 360 participants 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 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. RESULT

11.4.1. Development of training materials

To develop the training materials, literature reviews were conducted and through training needs assessment workshops, various information products were generated based on the requirement of diverse stakeholders' groups. A total of 10 training workshops involving different target groups were organized across the Gomti River basin for field-testing and needs assessment (Table 11.1). After finalization, the training programmes were delivered according to the categorization of target groups into three levels -policy, implementation and execution -and were structured into five core modules. Based on these five modules, diverse training programmes were organized along the Gomti River and its adjacent tributaries.

The design and development of training materials for stakeholders involved a structured approach focused on identifying learning objectives, relevant content and effective delivery methods. The process has also considered stakeholder preferences for receiving information and actively incorporated their inputs into the design process for better alignment and engagement. 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, including booklets, brochures, pamphlets, focusing on conservation and awareness creation regarding the ecological significance of Gomti Biodiversity.

Several awareness posters were also generated to promote awareness and enhance understanding among youth and local communities about the conservation of biodiversity of Gomti River through celebration of special events and commemorative days.

The distribution of training materials among stakeholders was vital for project outcome and ensuring effective implementation. It ensured that target groups clearly understood their roles, responsibilities, and the project's objectives, thereby fostering alignment and reducing misunderstandings. This, in turn, increased the probability of successful project implementation and desired conservation 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 improved conservation practices and management systems.

Table 11.1. Training needs assessment workshops with different target groups for designing training materials at Gomti River Basin.

Target Groups	States	Districts	Total No. of Workshops	Total No. of Participants
Forest Officials	Uttar Pradesh	Ayodhya, Barabanki, Pratapgarh	3	179
Ganga Prahari	Uttar Pradesh	Ayodhya, Gorakhpur, Lucknow, Prayagraj	2	49
Police Personnel	Uttar Pradesh	Ayodhya	1	55
ETF-GTF	Uttar Pradesh	Prayagraj	2	59
Zookeeper & Staff	Uttar Pradesh	Gorakhpur, Lucknow	1	39
NCC	Uttar Pradesh	Gorakhpur, Lucknow, Prayagraj	1	16
Total	1	6	10	397

Table 11.2. List of training materials generated for capacity building programmes in Gomti River Basin.

S. No.	Training Knowledge product	Category	Significance
1	Training approach and 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 showcases the rich biodiversity of the Ganga River, featuring its diverse flora, fauna, ecosystems, and species.
4	Floral Diversity of Ganga River Basin	Brochure	This brochure highlights the vibrant floral diversity of the Ganga River Basin, showcasing the wide variety of plant species found along the river’s bank and emphasizing their 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 across the Ganga Basin states.
6	Training calendar 2025	Brochure	The brochure provides detail of planned training activities and Schedules, including course titles, target groups, dates, timings, training sites and locations etc., designed for multiple stakeholders across various aspects of freshwater biodiversity conservation.

11.4.2. Overall Participation in Capacity Building Programmes in the Gomti River Basin

The capacity building programmes under the National Mission for Clean Ganga (NMCG), engaged 1610 participants across the Gomti River Basin through 45 training sessions in Uttar Pradesh. These programmes, aimed at promoting sustainable river management and biodiversity conservation, targeted diverse groups to support the ecological restoration of the Gomti, which spans approximately 18,750 km² (CWC, 2020). The participation data, detailed below by district, stakeholder category, and gender, highlights engagement patterns and areas for future improvement. The capacity building process initiates with a diverse range of stakeholders such as forest and fisheries department personnel, academic professionals and students, frontline staff, veterinarians, and community volunteers, and line agencies (Figure 11.6).

The training and outreach programmes along the Gomti River Basin were implemented across key districts in Uttar Pradesh, where the river traverses approximately 960 km, influencing diverse ecological zones and densely populated agricultural landscapes. The basin spans several central and eastern Uttar Pradesh districts that are socioeconomically dependent on the river for irrigation, domestic water use, and cultural activities.

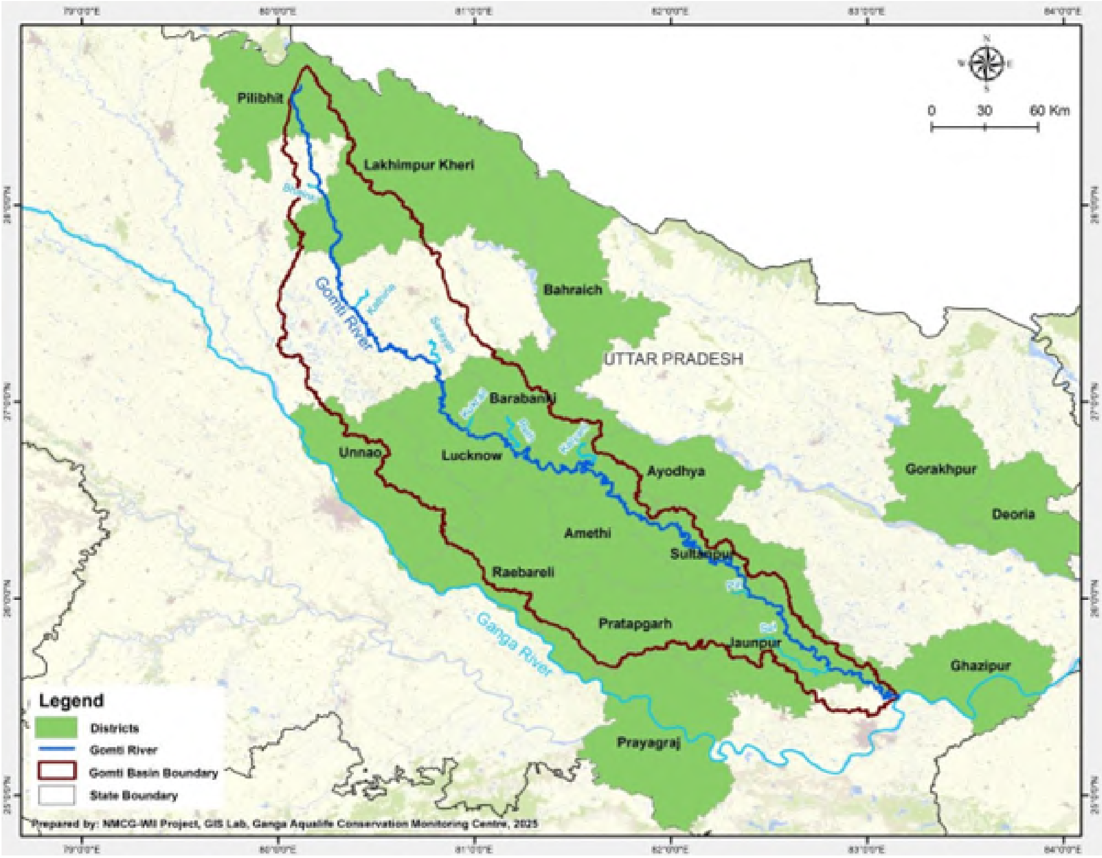
A total of 1,610 participants took part in the district-level programmes, reflecting strong community and institutional engagement across the basin and overall participation is represented on the map (Figure 11.7). The highest participation was recorded from Gorakhpur (563, 35%), followed by Ayodhya (291, 18.1%) and Lucknow (254, 15.8%), which together accounted for nearly 69% of total participation (Figure 11.8). This concentration of participants corresponds to areas where extensive riverine ecosystems and urban settlements coexist, necessitating robust outreach for pollution control, biodiversity protection, and sustainable water management.

Districts such as Prayagraj (235, 14.6%), Barabanki (72, 4.5%), and Lakhimpur Kheri (48, 3%) showed moderate participation, reflecting growing awareness and active involvement of forest and academic institutions in riparian management. These districts also serve as key nodes for river connectivity and aquatic species movement within the Ganga basin network.

Lower participation was observed in Jaunpur (28), Pilibhit (29), Pratapgarh (60), and Ghazipur (11) districts located along the river's smaller tributaries or terminal stretches where access and institutional networks may be limited. Amethi (2), Unnao (2), Raebareli (1), Sultanpur (5), Bahraich (4), and Deoria (5) recorded minimal engagement, suggesting potential logistical or awareness gaps. These areas would benefit from targeted capacity- building interventions and strengthened coordination among line departments, NGOs, and community volunteers.

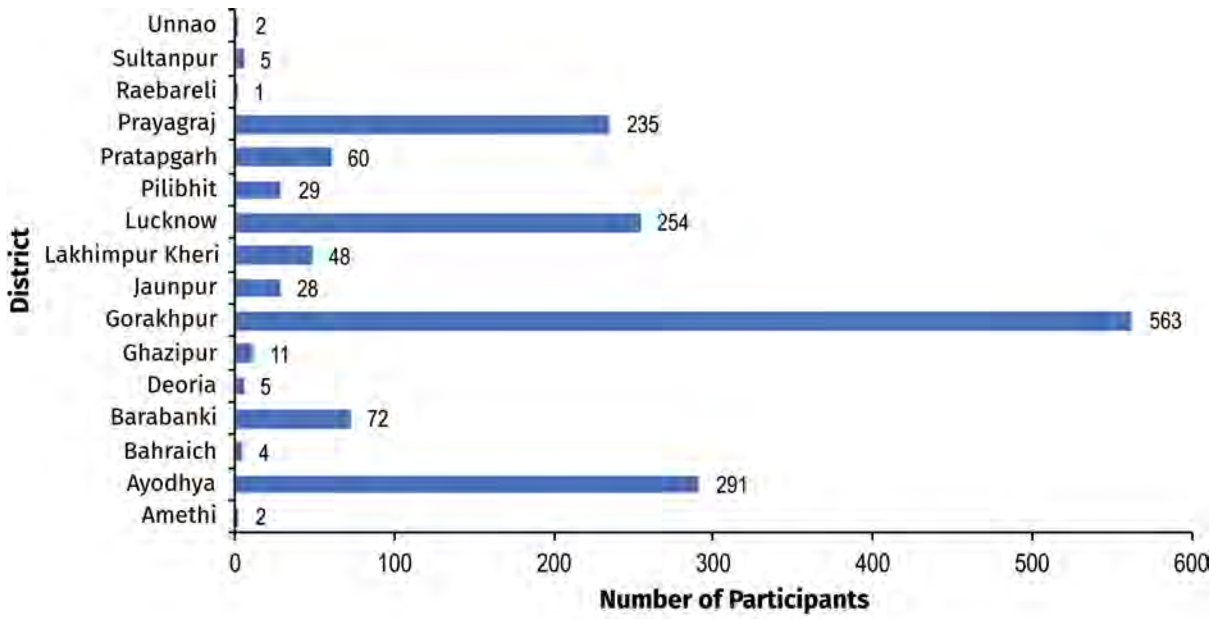
Overall, the district-wise distribution indicates that participation intensity aligns with both population density and proximity to the main river channel. Urban centres such as Lucknow and Ayodhya demonstrated strong institutional involvement, while downstream districts like Ghazipur and Deoria exhibited comparatively lower engagement due to reduced river flow volume, ecological degradation and weaker institutional outreach mechanisms.

Figure 11.6. List of Stakeholders reached.



Note: Stakeholder participation for both the Gomti and Ghaghra River basins.

Figure 11.7. Overall participation by the different stakeholder groups.



Note: Stakeholder participation for both the Gomti and Ghaghra River basins.

Figure 11.8. District-Wise Distribution of Participants.

The 45 training sessions engaged a diverse range of stakeholder categories, building a broad network for river conservation. Figure 11.9 presents the stakeholder category-wise participation in the Gomti River Basin, highlighting engagement across 19 stakeholder groups with a total of 1,610 participants. The distribution reflects the multi-sectoral approach emphasizing the inclusion of academic institutions, community groups, government departments, and conservation networks.

Among all categories, college students formed the largest group with 499 participants (31.0%), underscoring the programme's strong focus on youth engagement and environmental education. Their participation aligns with NMCG's strategy to promote future stewardship through experiential learning and citizen science activities along the river. Similarly, forest officials represented a significant proportion, with 398 participants (24.7%), reflecting active involvement of the State Forest Department in biodiversity monitoring, rescue, and rehabilitation training.

The Ganga Prahari network, a flagship community-based initiative, accounted for 182 participants (11.3%), demonstrating consistent engagement of local custodians in riparian conservation, habitat protection and awareness outreach activities. ETF (Eco-Task Force), GTF (Ganga Task Force) members (139, 8.6%) and local community participants (77, 4.8%) also contributed meaningfully, indicating strong collaboration between institutional task forces and grassroots stakeholders.

Other contributors included NSS (59, 3.7%), college professors (33, 2.0%), zookeeper and staff (74, 4.6%), and police personnel (55, 3.4%), reflecting a blend of academic, enforcement, and operational perspectives in ecosystem management. Tourist guides (22, 1.4%), NGOs and volunteers (15, 0.9%), and NCC cadets (16, 1.0%) supported public outreach and field logistics during training and awareness drives (Figure 11.9).

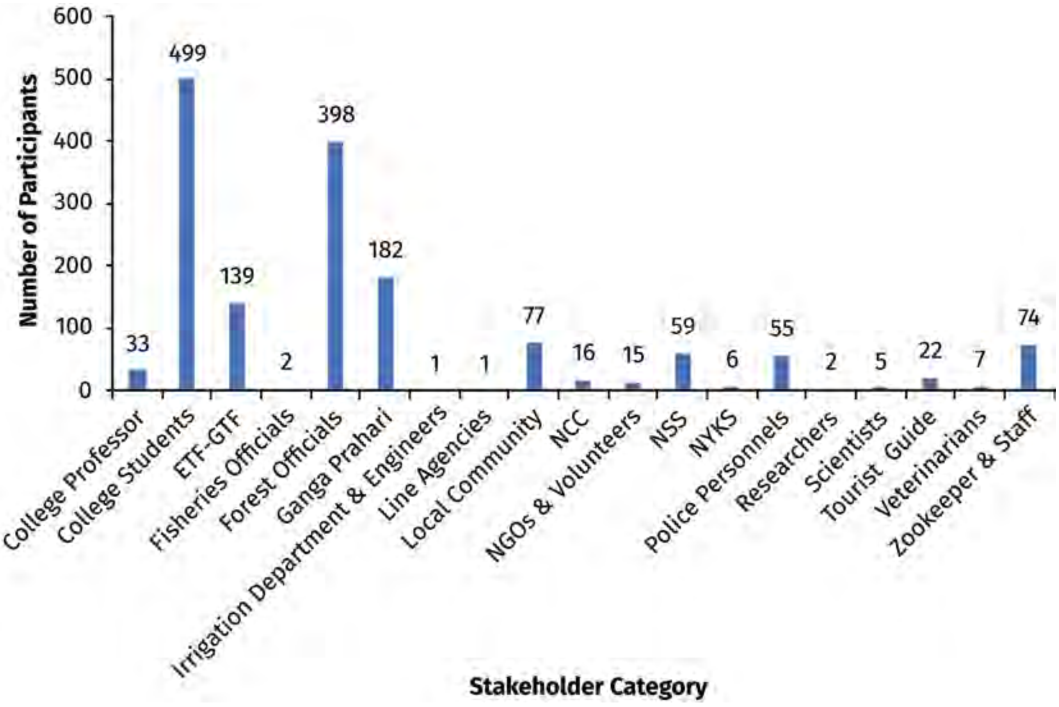
Participation from specialized sectors such as veterinarians (7, 0.4%), researchers (2, 0.1%), scientists (5, 0.3%), fisheries officials (2, 0.1%), line agencies (1, 0.06%), and irrigation engineers (1,0.06%) (Figure 11.9) remained comparatively low, suggesting the need for greater cross- departmental integration in future programmes. Overall, the Gomti River stakeholder profile reveals balanced representation from institutional, community, and youth sectors, with pronounced engagement from education and forest management stakeholders. This pattern reflects a growing recognition of collaborative conservation. However, future interventions should strategically enhance participation from technical, research, and water resource departments to establish a more holistic, multi-disciplinary river basin management framework.

The gender-wise distribution of participants across the 45 training programs conducted in Uttar Pradesh revealed notable disparities in representation. Out of the total 1,610 participants, 1,196 were male and 414 were female. This corresponds to 74.29% male participation and 25.71% female participation. This indicates a substantial gender gap, with male representation being nearly three times higher than that of females (Figure 11.10). This pattern emphasizes the opportunity to further enhance gender inclusivity by encouraging and facilitating greater participation of women in future training and stakeholder engagement activities. Flexible training schedules and women-focused modules could address these gaps to enhance inclusivity (WWF, 2022).

11.4.3. Training of spearhead teams in freshwater biodiversity conservation

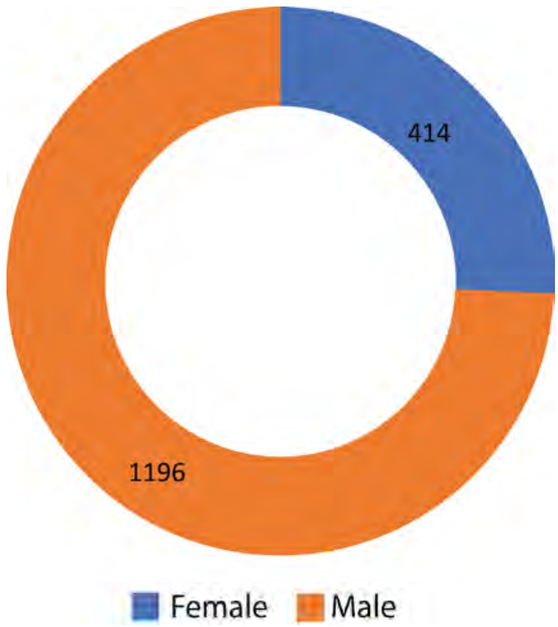
The 13 spearhead training sessions, aimed at developing leadership skills for sustainable river management and biodiversity conservation, engaged 94 participants across the Gomti River Basin. These targeted sessions prioritized stakeholders in key districts and categories to enhance local capacity for conservation efforts. The data below, organized by district and stakeholder category, reflects participation patterns and identifies areas for improving training outreach.

The 13 spearhead training sessions (Figure 11.11) were organized across selected districts of Uttar Pradesh, focusing on areas along the Gomti River that are vital for ecological health and community engagement. As shown in Table 11.3, a total of 94 participants attended these sessions, representing diverse districts with varying levels of participation. Gorakhpur recorded the highest attendance with 42 participants (44.7% of the total), highlighting its active involvement and strategic importance in regional conservation initiatives. Prayagraj followed with 25 participants (26.6%), reflecting strong institutional and community engagement. Lucknow contributed 16 participants (17%), likely due to its administrative significance and proximity to key program coordination centres. Other districts such as Ayodhya (4 participants), Bahraich (2), and Ghazipur, Lakhimpur Kheri, Pratapgarh, Raebareli, and Unnao (1 participant each) showed limited representation, suggesting potential areas for strengthening outreach and participation in future programs, and the incorporation of mobile or virtual training formats to improve participation in underrepresented district (WWF, 2022) (Table 11.3).



Note: Stakeholder participation for both the Gomti and Ghaghra River basins

Figure 11.9. Stakeholder-wise participation in the overall trainings.



Note: Stakeholder participation for both the Gomti and Ghaghra River basins

Figure 11.10. Gender-wise distribution of participants

11.4.4.Develop the capacity of university professors and students, forest officials, local communities and other stakeholders

Under the capacity building initiative, 28 focused training programmes were conducted across the Gomti River Basin to engage a wide spectrum of stakeholders associated with riverine ecosystems. These sessions aimed to strengthen decentralised capacity for aquatic biodiversity conservation and promote participatory approaches involving forest officials, academic representatives, local communities, NGOs, and volunteers. The primary objectives were to enhance understanding of the Gomti River's biodiversity, improve conservation practices, and integrate ecological considerations into institutional and community-level decision-making. A total of 1,324 participants attended these 28 training programmes conducted across 15 districts of Uttar Pradesh (Table 11.5). The highest participation was recorded in Gorakhpur district (423 participants; 31.9%), reflecting strong engagement from field personnel and forest divisions. Ayodhya followed with 230 participants (17.4%), indicating effective mobilization from both institutional and local community stakeholders. Lucknow recorded 202 participants (15.2%), highlighting significant participation from academic and administrative groups.

Other major districts included Prayagraj (209; 15.8%), Barabanki (72, 5.4%), and Pratapgarh (59, 4.5%), demonstrating notable representation from central and downstream regions of the basin. Moderate participation was observed from Lakhimpur Kheri (47, 3.5%), Pilibhit (29; 2.2%), and Jaunpur (28, 2.1%), while smaller yet important contributions were made by Ghazipur (10), Deoria (5), Sultanpur (5), Amethi (2), Bahraich (2), and Unnao (1).

Table 11.5. District-wise participation of the other stakeholders in the training programmes

States	Districts	Participants
Uttar Pradesh	Amethi	2
	Ayodhya	230
	Bahraich	2
	Barabanki	72
	Deoria	5
	Ghazipur	10
	Gorakhpur	423
	Jaunpur	28
	Lakhimpur Kheri	47
	Lucknow	202
	Pilibhit	29
	Pratapgarh	59
	Prayagraj	209
	Sultanpur	5
	Unnao	1
	Total	1324

Note: Includes participants from both the Gomti and Ghaghra River basins

The extensive coverage of districts and high stakeholder turnout underscore growing regional awareness and collective commitment to the conservation of the Gomti River. These training programmes significantly strengthened local stewardship capacities and fostered inter-departmental collaboration for sustaining aquatic biodiversity and improving river ecosystem health (WWF, 2022).

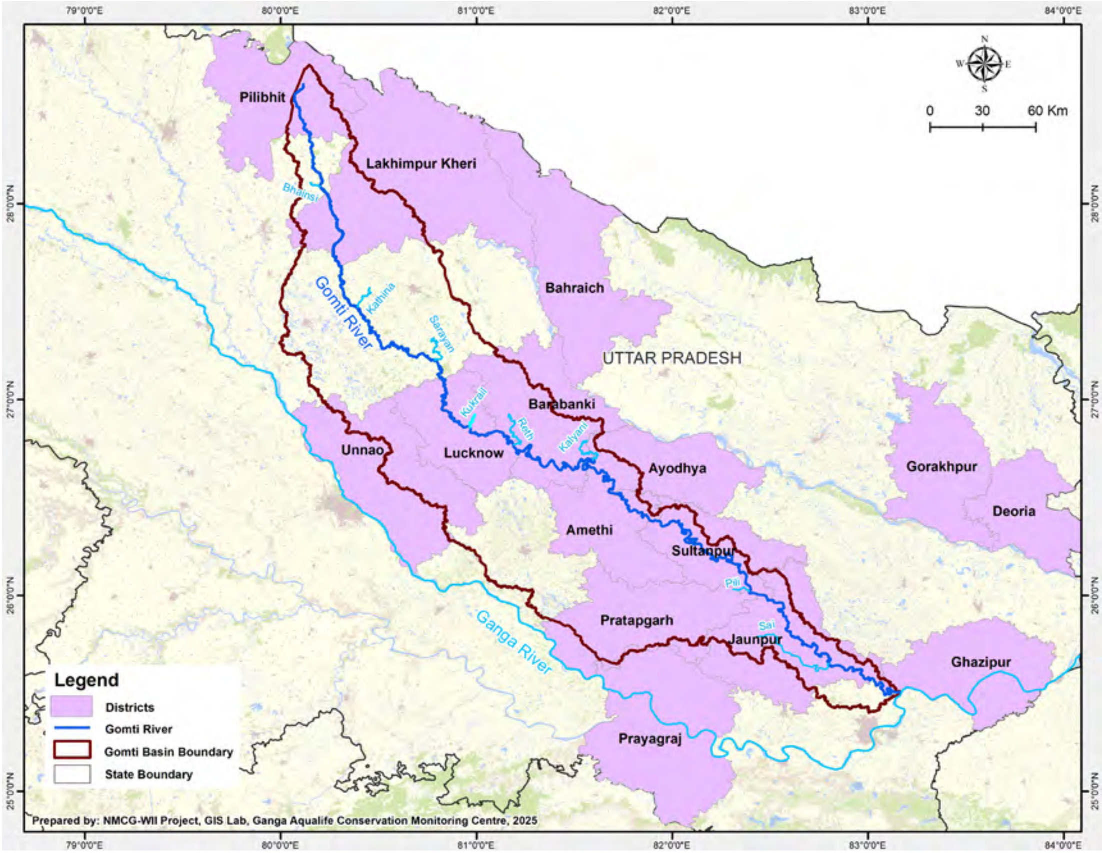
A total of 1,324 stakeholders participated in 28 training sessions (Figure 11.13) conducted under the biodiversity conservation and awareness module across the Gomti River basin in Uttar Pradesh. These sessions were designed to strengthen participants' capacities in aquatic species conservation, promote eco-friendly practices, and enhance inter-agency collaboration for effective river basin management.

The highest participation was recorded among college students (499, 37.7%), reflecting strong academic engagement and youth-driven outreach in environmental stewardship. Forest officials (357, 26.9%) represented a major share of participants, highlighting their critical operational role in implementing biodiversity protection, enforcement, and habitat management initiatives across the basin. Ganga Prahari (164, 12.4%) emerged as a vital bridge between communities and conservation programs, actively supporting awareness generation and citizen-based ecological monitoring along key stretches of the Gomti. Similarly, ETF-GTF members (130, 9.8%) contributed technical insights and field-based expertise in habitat assessment and species rescue activities. Other notable contributors included the NSS (54; 4.1%), local community members (44, 3.3%), and college professors (22, 1.7%), indicating meaningful collaboration between academic, social, and institutional stakeholders. Tourist guides (22, 1.7%), NCC cadets (16, 1.2%), and NGOs & volunteers (9, 0.7%) also played key roles in expanding conservation awareness and public engagement in urban and rural areas. Specialized participation from veterinarians (2, 0.15%), researchers (2, 0.15%), and zookeepers & staff (2, 0.15%) provided valuable technical support for wildlife rescue, rehabilitation, and health assessment. Overall, the 28 training sessions conducted across multiple districts of Uttar Pradesh underscore a comprehensive and inclusive effort in the Gomti River basin— effectively integrating institutional, academic, and community participation for sustainable aquatic biodiversity conservation and river ecosystem rejuvenation (Table 11.6).

Table 11.6. Stakeholder-wise distribution of the other stakeholders in the training programmes.

Stakeholders	Uttar Pradesh
College Professor	22
College Students	499
ETF-GTF	130
Forest Officials	357
Ganga Prahari	164
Line Agencies	1
Local Community	44
NCC	16
NGOs & Volunteers	9
NSS	54
Researchers	2
Tourist Guide	22
Veterinarians	2
Zookeeper & Staff	2
Total	1324

Note: Includes participants from both the Gomti and Ghaghra River basins



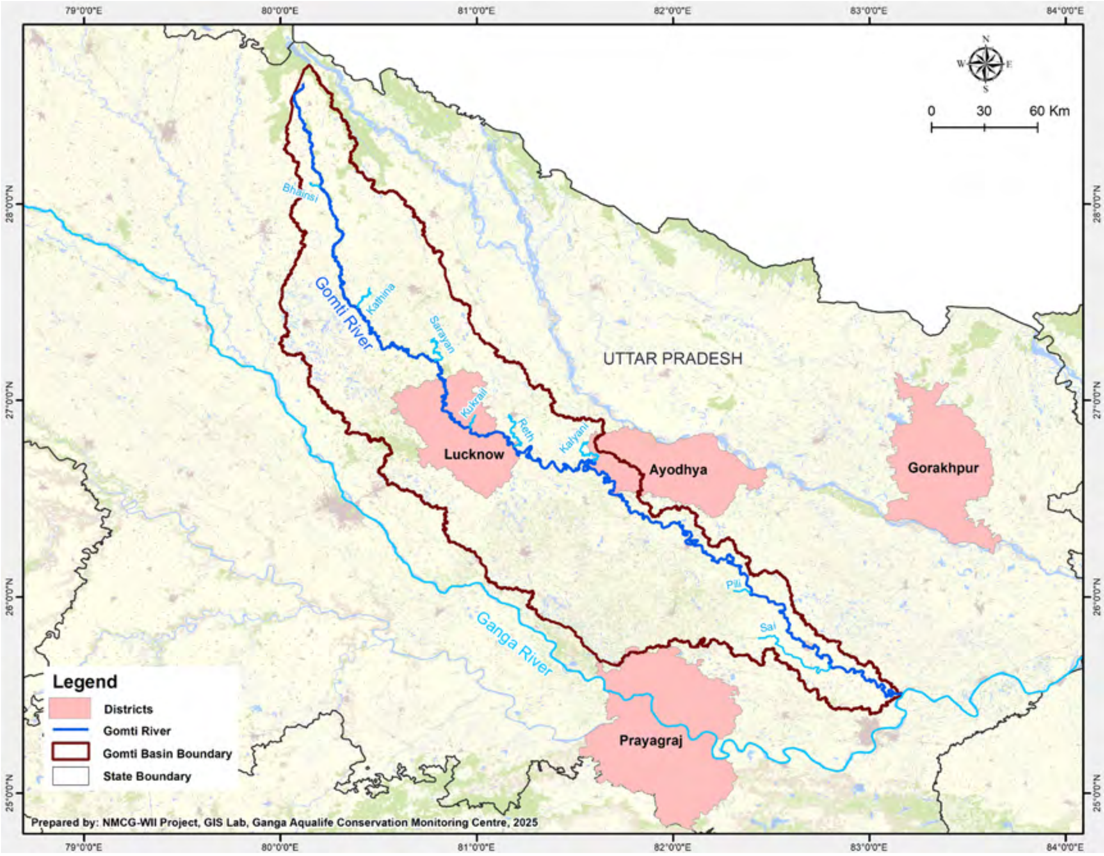
Note: Includes participants from both the Gomti and Ghaghra River basins.

Figure 11.13. District-wise coverage of the multiple stakeholders trained in the onsite and offsite training programmes.

11.4.5. Capacity Building of Forest Department, Animal Husbandry Department, veterinarians and volunteers in rescue and rehabilitation techniques

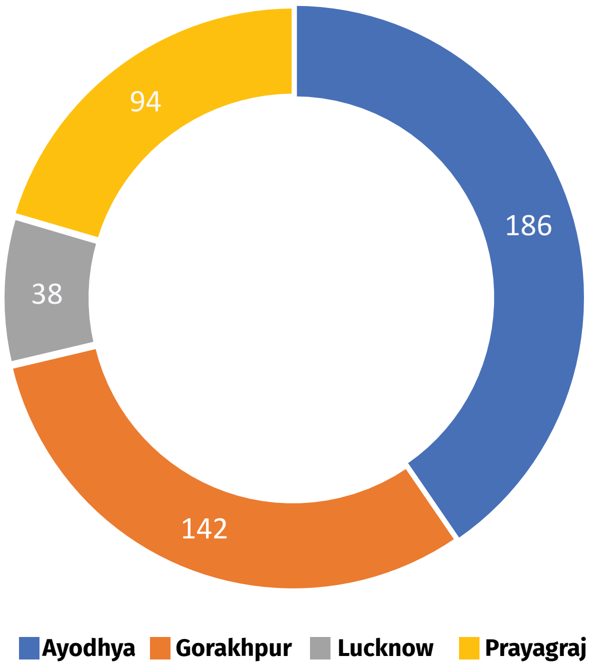
The 12 rescue-specific training sessions, including four specialised rescue and rehabilitation trainings (192 participants), were conducted to equip stakeholders with skills for wildlife rescue and rehabilitation in the Gomti River Basin. Focused on protecting species like the Gangetic dolphin, gharial, and freshwater turtles, these sessions engaged a total of 460 participants across four districts of Uttar Pradesh. The data presented below, organized by district and stakeholder category, highlights participation patterns and informs strategies for expanding future rescue training interventions. Figure 11.14 presents the district-wise distribution, reflecting active participation from regions that play an important role in the ecological and cultural landscape of the Gomti River.

Ayodhya recorded the highest participation with 186 individuals (40.4%), indicating strong engagement in conservation efforts within the midstream stretch of the river. Gorakhpur followed with 142 participants (30.9%), highlighting its proactive involvement in community-based aquatic biodiversity initiatives. Prayagraj contributed 94 participants (20.4%), emphasizing its relevance as a confluence zone where river-based training has substantial outreach potential. Lucknow, with 38 participants (8.3%), represented institutional and administrative engagement, supporting technical and academic capacity-building efforts (Figure 11.15).



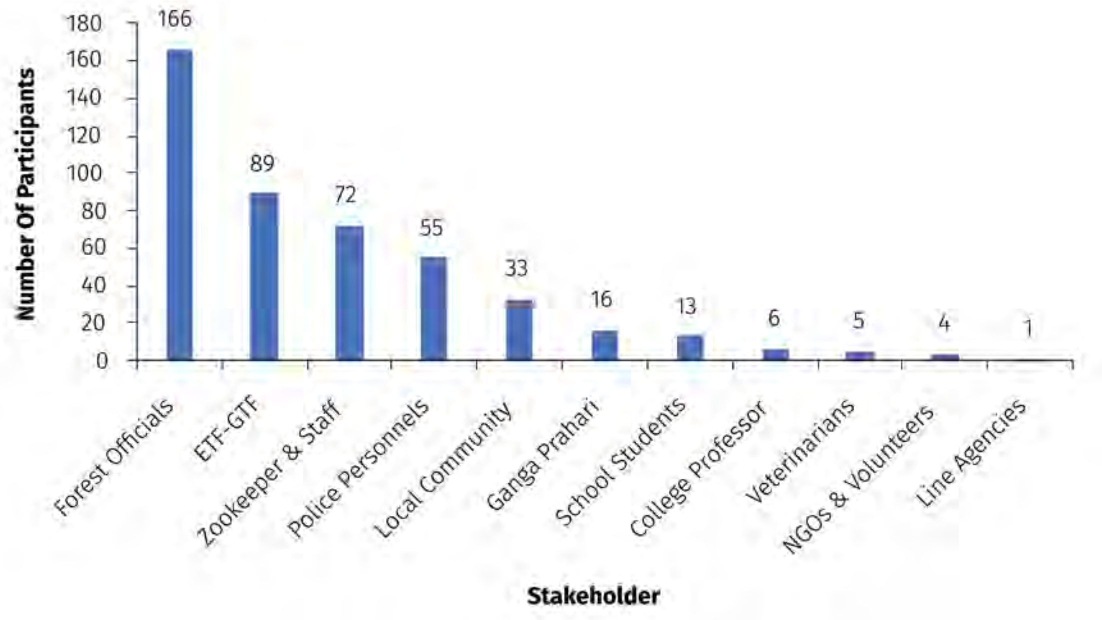
Note: Includes participants from both the Gomti and Ghaghra River basins.

Figure 11.14. District-wise coverage of the trained stakeholders in the rescue and rehabilitation training.



Note: Includes participants from both the Gomti and Ghaghra River basins.

Figure 11.15. District-wise distribution of rescue and rehabilitation training.



Note: Includes participants from both the Gomti and Ghaghra River basins.

Figure 11.16. Stakeholder-wise distribution of participants in the rescue and rehabilitation training.

A total of 460 stakeholders were trained under the Rescue and Rehabilitation module in the Gomti River Basin (Figure 11.16). The training aimed to enhance participants' technical and practical understanding of aquatic fauna rescue, rehabilitation, and management operations, focusing on species such as turtles, gharials, and freshwater dolphins. The highest participation was recorded among Forest Officials (166, 36.1%), representing their vital role in the on- ground implementation, coordination and execution of rescue operations. ETF-GTF members (89, 19.3%) and Zookeepers & Staff (72, 15.7%) also showed notable engagement, reflecting inter- departmental collaboration and technical contribution to the rehabilitation of rescued wildlife. Police personnel (55, 12.0%) played a key role in supporting enforcement and rapid- response activities, while Ganga Praharis (16, 3.5%) and local Community members (33, 7.2%) demonstrated the inclusion of community-based and citizen-led conservation initiatives. Participation from college professors (6, 1.3%), school students (13, 2.8%), veterinarians (5, 1.1%), NGOs and volunteers (4,0.9%), and line agencies (1, 0.2%) added to the diversity of stakeholders, strengthening interdisciplinary learning and awareness within the basin. Overall, the training under the Gomti River Basin showcased a balanced mix of institutional, enforcement, and community participation, thereby enhancing collective preparedness for wildlife rescue and contributing to the long-term conservation of riverine biodiversity (WWF, 2022).

11.4.6. Developing a network of riverside local communities capable of responding to emergent situations

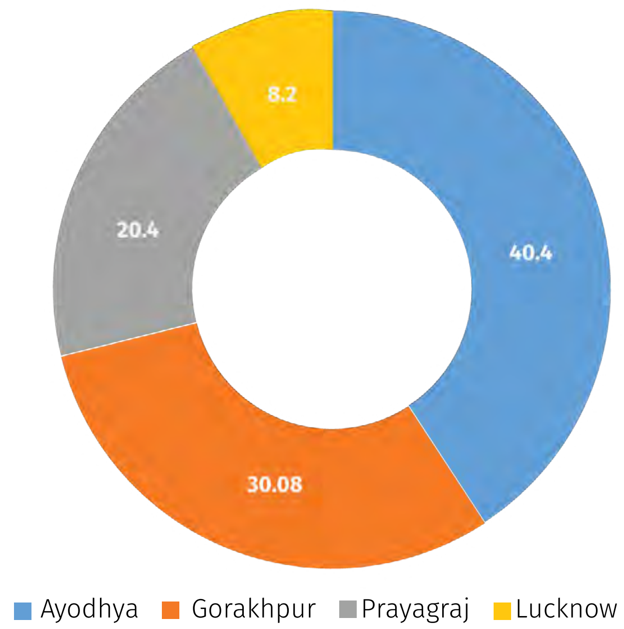
Local communities play a crucial role as first responders during emergent situations, particularly when rapid rescue and rehabilitation efforts are required. Strengthening the capacity of these groups ensures prompt and coordinated action in aquatic wildlife emergencies. Through 28 specialized training sessions conducted across the Gomti River Basin, emphasis was placed on building the preparedness of forest officials, Ganga Prahari, ETF-GTF, zookeepers, veterinarians, and local community members, alongside NGOs and volunteers (Figure 11.19). These capacity- building programs focused on fostering ecological stewardship, strengthening institutional coordination, and empowering riverside communities to respond efficiently to wildlife distress and environmental emergencies.

A responsive and interconnected network of riverside communities has been established across Uttar Pradesh, enhancing communication, collaboration, and resilience through joint efforts of local institutions and conservation stakeholders. The training sessions collectively engaged 460 participants from four major districts namely, Ayodhya, Gorakhpur, Lucknow, and Prayagraj, strengthening local capabilities in biodiversity conservation and wildlife response (Table 11.7). By integrating government agencies, technical experts, community representatives, and conservation volunteers, the programme strengthened local response mechanisms and promoted a collaborative framework for addressing wildlife emergencies and sustaining aquatic biodiversity conservation across the Gomti River Basin.

Table 11.7. District- and Stakeholder-wise distribution of first responders training participants.

States	Districts	ETF-GTF	Forest Officials	Ganga Prahari	Local Community	NGOs & Volunteers	Veterinarians	Zookeeper & Staff	Total
Uttar Pradesh	Ayodhya	-	125	2	-	-	2	-	186
	Gorakhpur	-	41	9	33	4	3	36	142
	Lucknow	-	-	-	-	-	-	36	38
	Prayagraj	89	-	5	-	-	-	-	94
	Total	89	166	16	33	4	5	72	460

Note: Includes participants from both the Gomti and Ghaghra River basins



Note: Includes participants from both the Gomti and Ghaghra River basins.

Figure 11.17. District-wise distribution (percentage) of the first responder training.

The 28 training sessions engaged 460 participants across four key districts in Uttar Pradesh (Figure 1119). Ayodhya recorded the highest participation represented in (Table 11.7, Figure 11.17), (186, 40.4%) dominated by forest officials (125), demonstrating strong institutional presence and field coordination. Gorakhpur followed with 142 participants (30.8%), with broad representation across seven stakeholder categories, including forest officials, local community members, Ganga Prahari, and zookeepers, reflecting a balanced network of responders at the district level. Prayagraj contributed 94 participants (20.4%), mainly ETF-GTF members (89), highlighting the district's growing technical engagement in riverine monitoring and emergency coordination. Lucknow accounted for 38 participants (8.2%), primarily zookeepers, indicating its importance as a support hub for captive care and wildlife rehabilitation.

The training sessions engaged seven stakeholder categories with diverse expertise critical to environmental and wildlife emergency response. Forest officials (166, 36.1%) formed the largest group, emphasizing their leading role in executing rescue protocols and managing riverine habitats. ETF-GTF members (89, 19.3%) contributed technical and operational skills essential for rapid and coordinated action during distress events.
Zookeepers and staff (72, 15.6%) demonstrated strong involvement in post-rescue care, while Ganga Prahari (16, 3.5%) and local community members (33, 7.2%) showcased active grassroots participation in early detection, reporting, rescue support, and public awareness activities.

Other contributors included veterinarians (5; 1.1%), providing specialised health interventions, and NGOs & volunteers (4; 0.9%), who played key roles in awareness and outreach. The diverse participation profile reflects a multi-stakeholder and integrated approach to emergency preparedness, combining institutional expertise, technical knowledge, and community-based stewardship for effective wildlife conservation. During wildlife rescue situations, trained responders act swiftly by notifying relevant authorities such as the Forest Department, veterinary units, NGOs, and local police, while ensuring public safety and crowd management. Depending on the species' condition, responders determine the need for intervention, administer first aid if required, and coordinate with rescue and rehabilitation centres for transport and recovery.

For non-critical cases, responders monitor the species from a distance to prevent unnecessary disturbance, adhering to a standardized joint response protocol. Follow-ups by the Wildlife Institute of India (WII), local authorities, and community teams ensure proper monitoring, documentation, evaluation, and reporting of rescue outcomes (Figure 11.18).

Successful rescue efforts are recognised and appreciated through acknowledgements, encouraging sustained participation and ownership among local first responders. Supported by NMCG–WII and aligned with WWF- India (2022) recommendations, this decentralized, community-led approach enhances the preparedness, resilience, and responsiveness of stakeholders across the Gomti River Basin. The initiative contributes significantly to strengthening aquatic biodiversity conservation, wildlife rescue networks, and the broader ecological restoration objectives of the Ganga River system.

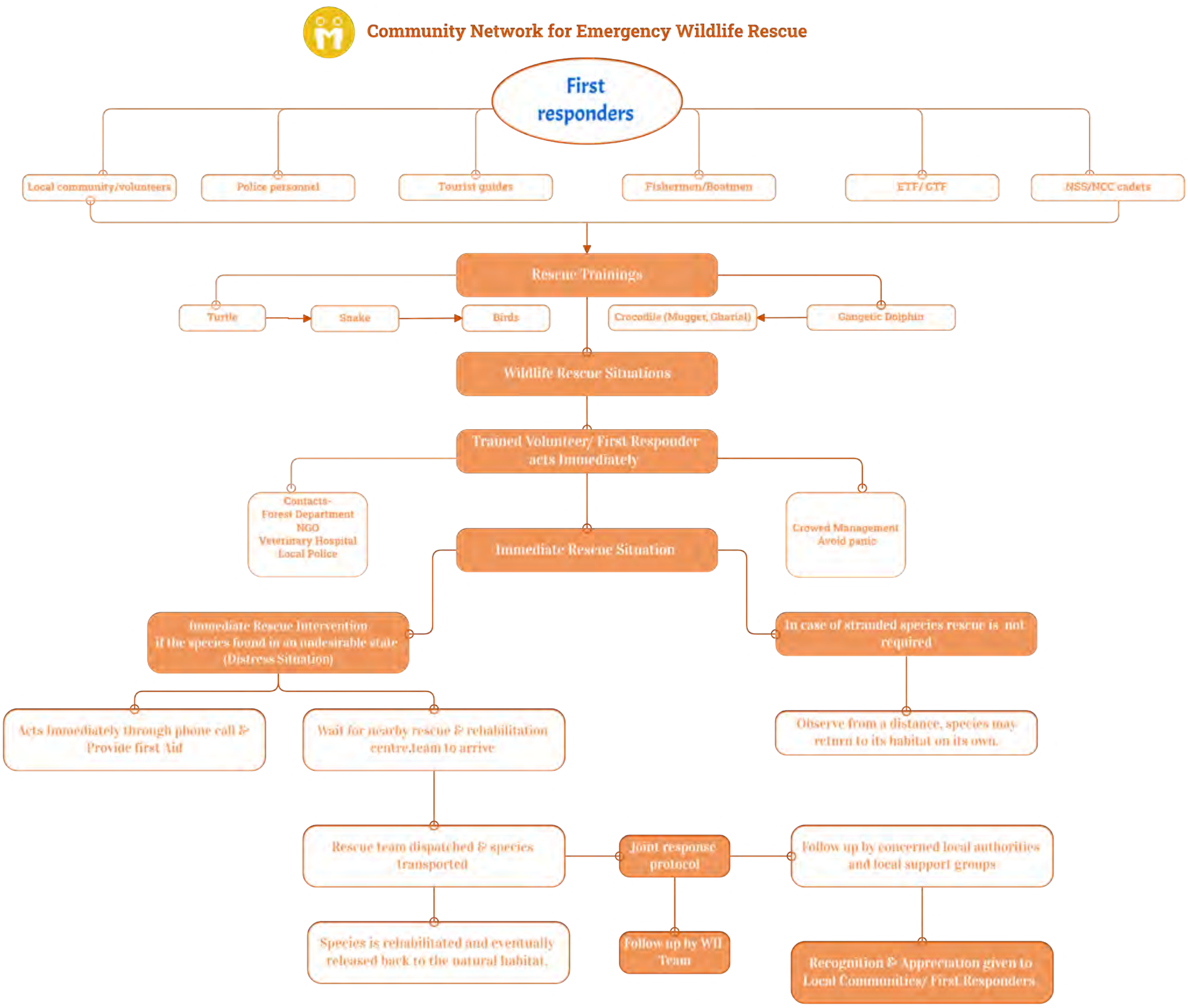


Figure 11.18. A Network of Riverside Communities Capable of Responding to Emergent Situations.

Note: Includes participants from both the Gomti and Ghaghra River basins.

Figure 11.19. District-wise coverage of the first responders trained in rescue protocols for responding to emergent situations.

11.4.7. Training Database Management

Management of a training database is essential for facilitating stakeholder networking and establishing standardized record-keeping protocols that ensure consistency, transparency, and accuracy in training-related information pertaining to trainers, trainees, implementing agencies, and local institutions.
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 downloaded by organizations, government departments, academic institutions, and other line agencies through https://wii.gov.in WII-NMCG Webpage at Training database 2019 to 2025 subtabs (Figure 11.20). This repository serves as a valuable resource for planning, implementing, monitoring, and replicating training programmes for diverse stakeholder groups across different thematic areas and geographical regions.

11.4.8. Training records in print and social media

To ensure wider dissemination and outreach of training outcomes and conservation messages, 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. These communication channels played an important role in increasing public awareness, promoting stakeholder engagement, documenting programme achievements, and amplifying the visibility of biodiversity conservation initiatives undertaken in the Gomti River Basin.

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

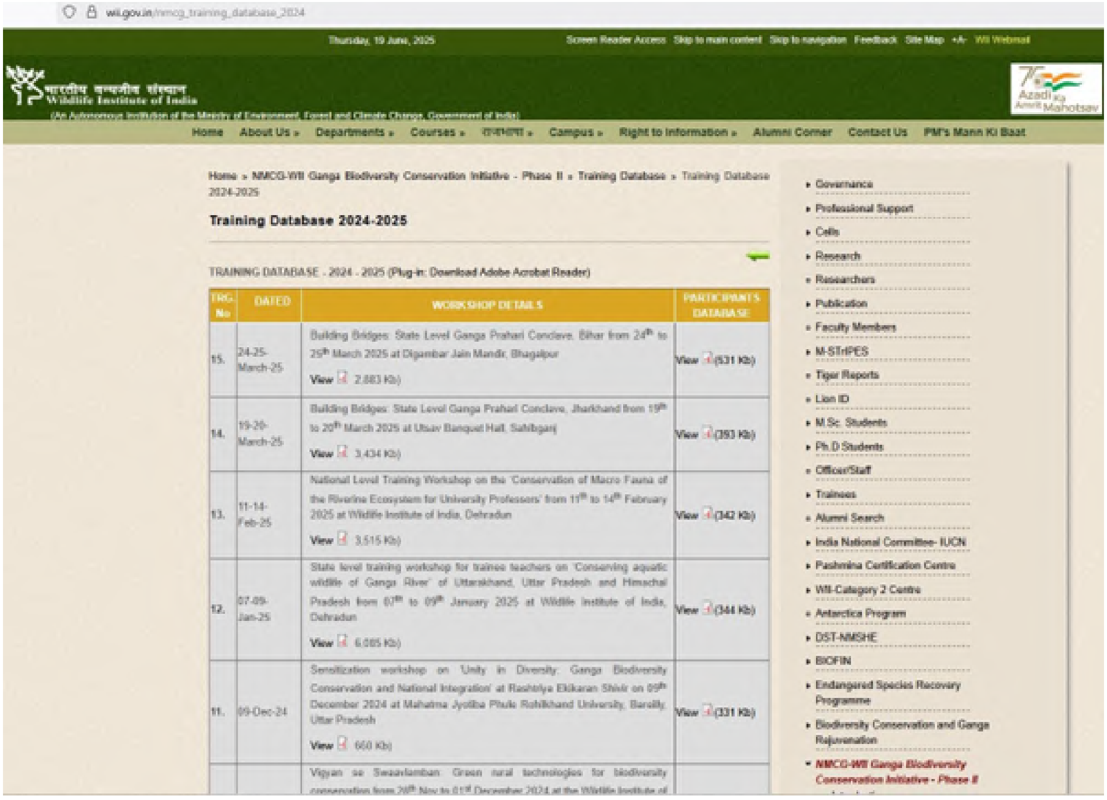


Figure 11.20. Training database at WII NMCG Webpage.

11.4.9. Carry Forward Activities in Gomti River Basin

The quality and effectiveness of the trainings imparted to diverse stakeholders were systematically assessed to evaluate the extent to which knowledge, skills, and awareness gained during the programmes translated into post-training actions and behavioural changes. This monitoring and evaluation process acts as critical indicators of past training while planning future activities to ensure efficacy and sustainability of the training imparted.

To assess the long-term impact of the training programme under the Gomti River biodiversity conservation initiative, a random sample of 150 participants from a total trained cohort of 360 individuals was evaluated regarding their involvement in carry forward activities undertaken independently or through their respective institutions following the training. The results, revealed that 54.62% of the respondents actively participated in post-training conservation and awareness initiatives (Figure 11.21). These included awareness campaigns, biodiversity education in schools, community sensitization, biodiversity monitoring, local clean-up drives, and support in rescue and rehabilitation efforts. The substantial proportion of participants engaged in such activities demonstrates the effectiveness of the training programmes in fostering environmental stewardship, strengthening community participation, and translating acquired knowledge into meaningful conservation actions.

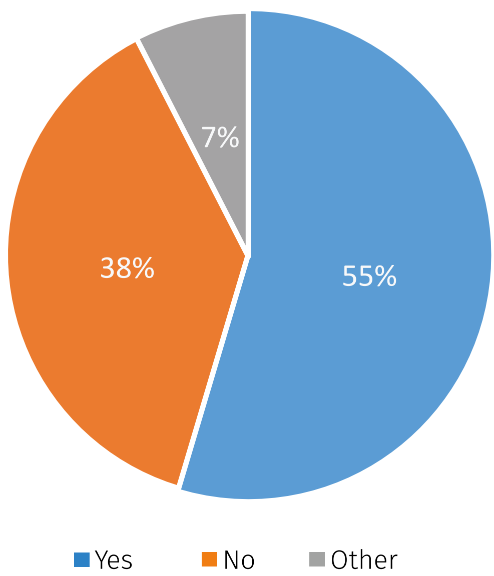


Figure 11.21. Evaluation of the carry-forward activities conducted by the trained participants.

Meanwhile, 37.86% of participants reported not having conducted any follow-up activities post-training. During follow-up interactions, common reasons cited were lack of institutional support, time constraints, or limited access to platforms for community engagement. Another 7.51% fell under the "Other" category, which included participants who were unsure how to proceed, had partially initiated activities, or were still in the planning stage. This segment represents a transitional group that could be mobilized further with targeted mentorship, peer support, or refresher training opportunities. Overall, the evaluation highlights that more than half of the trained participants are actively contributing to conservation goals along the Gomti River. At the same time, the presence of a sizable "Other" group suggests an opportunity to strengthen support mechanisms that can help channel their intent into concrete action.

Among the trained participants from the Gomti River Basin, a majority, 43.92% (n=166), reported self-implementation of conservation activities following their training. These actions included conducting biodiversity surveys, organizing local clean-up drives, supporting wetland or riverbank restoration efforts, and assisting in wildlife rescue operations.

Such activities demonstrate the successful application of acquired knowledge and skills to address local conservation challenges and strengthen environmental stewardship at the community level. Additionally, 41.27% (n=156) of participants focused on spreading awareness, engaging peers, schools, and local groups through campaigns, talks, and outreach activities (Figure 11.22). This demonstrates the ripple effect of the training programme in promoting environmental stewardship. Furthermore, 14.81% (n=56) participants took the initiative to train more individuals, thereby acting as multipliers who extended conservation knowledge to new groups. Collectively, these outcomes illustrate a strong culture of post- training engagement in the Gomti River Basin— where participants not only internalized conservation principles but also actively contributed to community-level biodiversity awareness and action.

In the Gomti River Basin, among participants who did not undertake post-training activities, the most frequently cited barrier was "Inadequate Response from Target Groups", reported by 39.69% (n=104) of respondents. These individuals expressed willingness to engage but encountered limited cooperation from schools, communities, or local institutions, hindering their efforts to mobilize conservation actions. Another 27.10% (n=71) participants stated they were "Not Interested", indicating a lack of motivation or shifting priorities after the training. This suggests the need for stronger engagement strategies to sustain participant interest over time. Additionally, 14.12% (n=37) mentioned "Lack of Resources", including financial limitations, material shortages, or logistical challenges that restricted their ability to implement conservation measures. A smaller share, 6.87% (n=18), pointed to "Insufficient Training", highlighting the need for refresher or advanced capacity-building sessions to boost confidence and skills. The remaining 12.21% (n=32) identified "Other" reasons such as personal commitments, role changes, or inadequate time since the training. Overall, these findings indicate that non-participation was shaped largely by external and structural constraints rather than disinterest alone, emphasizing the importance of continuous support, mentoring, and improved community coordination to enhance conservation engagement in the Gomti River Basin represented in Figure 11.23.

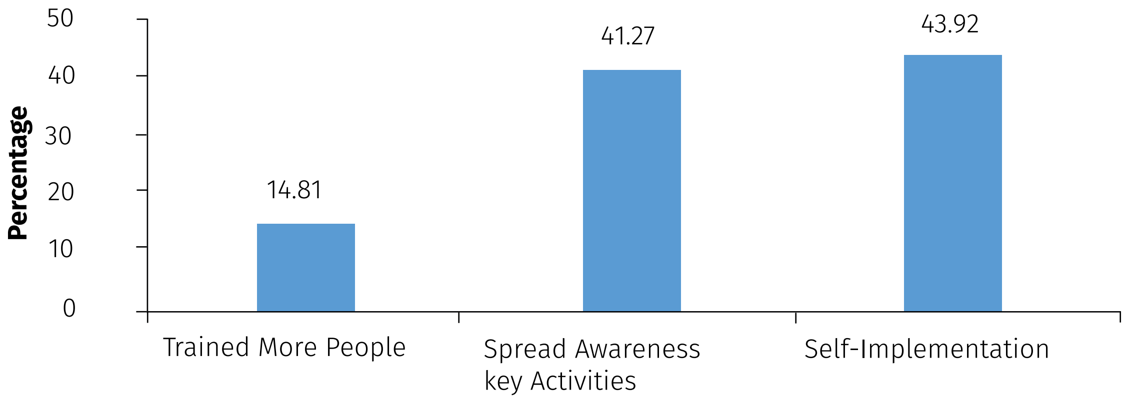


Figure 11.22. Evaluation of various activities conducted by the trained participants.

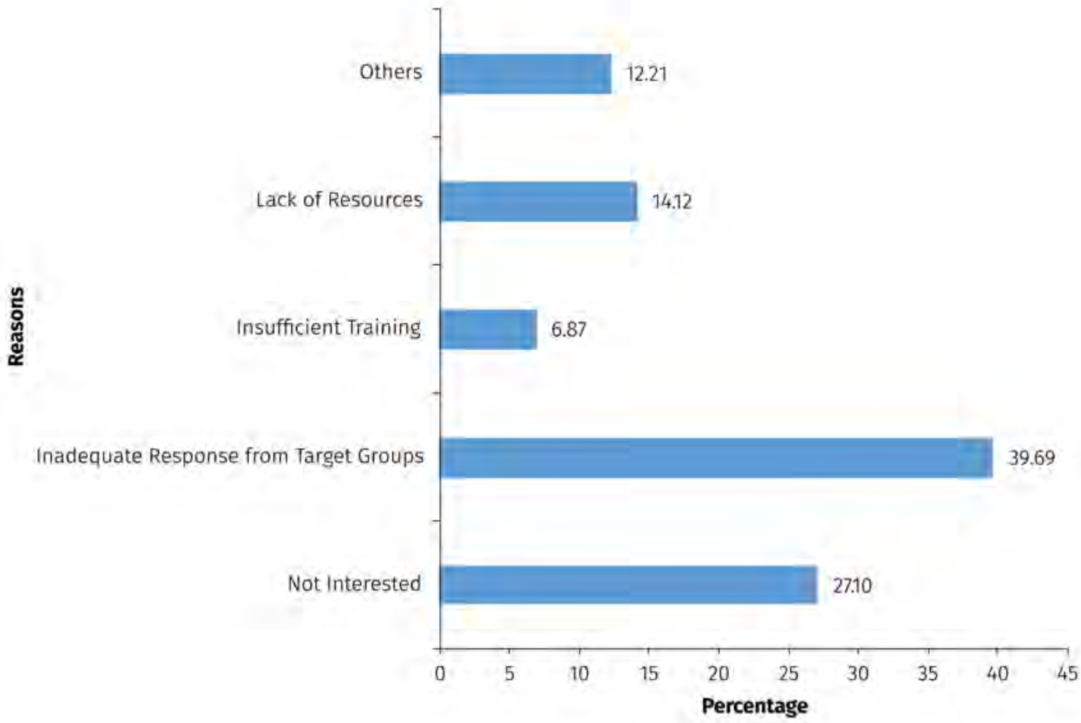


Figure 11.23. Evaluation of reasons for no carrying forward activities after obtaining training programme

11.5. DISCUSSION

The capacity-building initiatives undertaken across the Gomti River Basin have played a pivotal role in strengthening stakeholder knowledge, technical competency, and awareness regarding freshwater biodiversity conservation and river ecosystem management. Through 45 training programmes involving 1,610 participants from various districts of Uttar Pradesh, including Lucknow, Ayodhya, Gorakhpur, Sultanpur, Barabanki, Jaunpur, and Sitapur, the initiatives created a dynamic platform multi-stakeholder engagement, knowledge exchange, and cross-sectoral collaboration. These trainings engaged a diverse group of stakeholders such as forest officials, veterinarians, Ganga Praharis, zookeepers, college professors and students, NGOs, engineers, NSS and NCC volunteers, Gram Pradhans, and members of the local community, fostering collective ownership toward the ecological well-being of the Gomti River.

The 45 capacity-building programmes were classified into 13 spearhead trainings, 12 rescue-specific trainings, and 28 other thematic capacity-building sessions, collectively designed to address technical, ecological, and social dimensions of river conservation. The spearhead training focused on empowering master trainers and key personnel across departments to lead conservation activities, while the rescue trainings enhanced the practical skills required for the rescue, rehabilitation, and release of aquatic macro-fauna such as turtles, dolphins, crocodiles, and otters. The other thematic programmes covered topics including freshwater biodiversity conservation, sustainable fisheries management, ecological monitoring, livelihood linkages, documentation of traditional knowledge, and integration of river conservation into education systems.

Notable initiatives included national-level training workshops for zookeepers and veterinarians at Shaheed Ashfaq Ullah Khan Prani Udyan, Gorakhpur, capacity-building workshops for university teachers and school educators at WII Dehradun, and awareness programmes such as the Ganga Prahari Conclave and sensitization sessions for Gram Pradhans to mainstream biodiversity into village development planning.
Several online workshops with forest officials from Dudhwa and Pilibhit Tiger Reserves and naturalists from protected areas of the Ganga Basin further expanded the geographical reach of the programme, facilitating wider dissemination of conservation knowledge and ensuring continuity of learning beyond conventional classroom settings.

The 1,610 trained participants now represent a growing network of skilled conservation practitioners equipped with practical expertise in ecological assessment, habitat restoration, rescue and rehabilitation, sustainable resource use, and community engagement. Districts like Lucknow and Gorakhpur emerged as leading centres for training and outreach, while areas such as Ayodhya and Barabanki strengthened grassroots- level conservation engagement. The participation of women scientists, teachers, youth, and local volunteers highlighted an inclusive approach to river management, promoting gender balance and community-driven stewardship.

Overall, the 45 structured training programmes under the Gomti River Basin have successfully cultivated a foundation of informed, capable, and motivated stakeholders. By integrating scientific understanding with local wisdom and participatory learning, these efforts have enhanced the basin's socio-ecological resilience and reinforced long-term commitments to sustaining the biodiversity and ecological integrity of the Gomti River.

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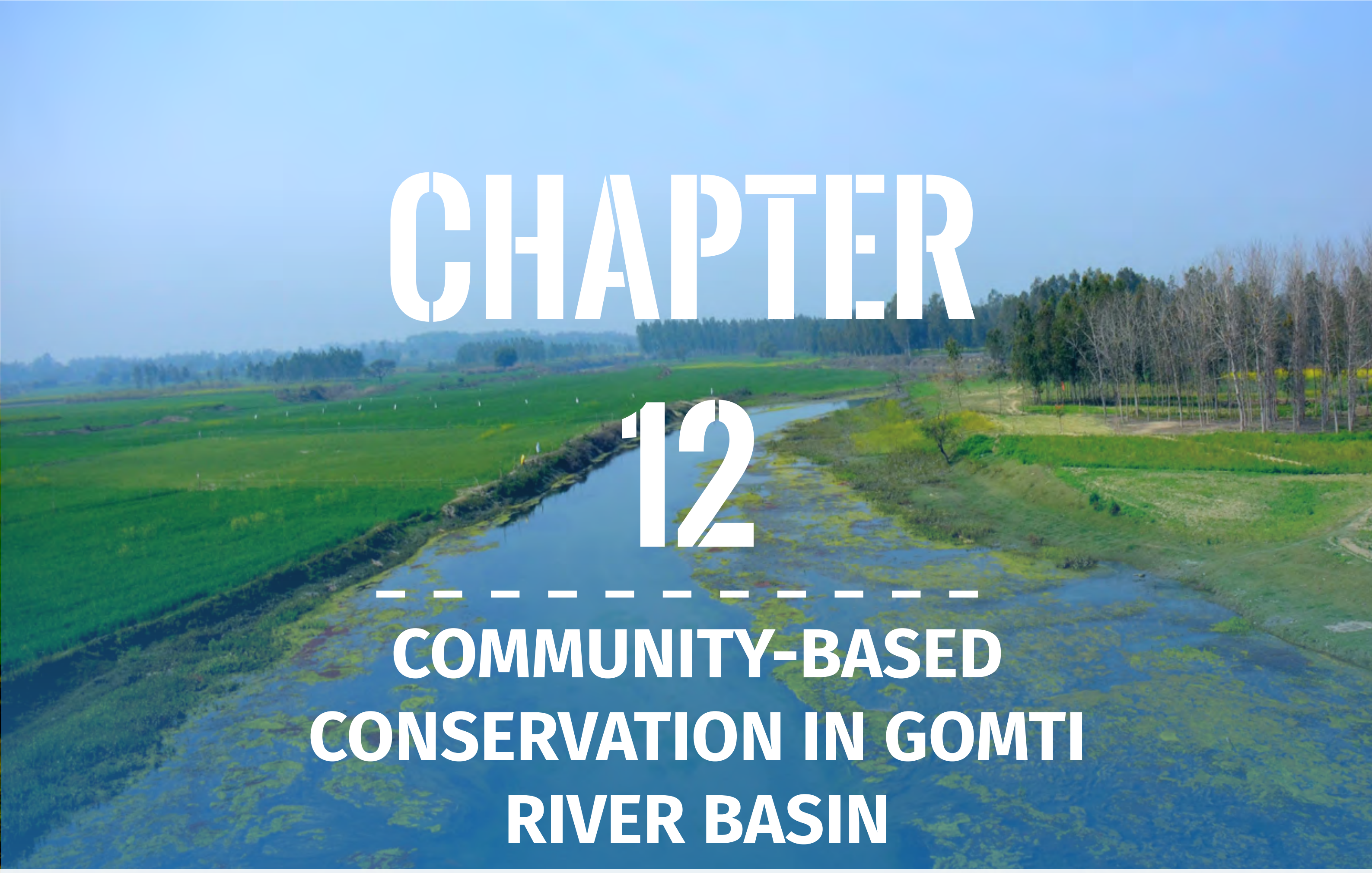
SECTION- V

COMMUNITY-BASED CONSERVATION AND CONSERVATION EDUCATION



CHAPTER 12

COMMUNITY-BASED CONSERVATION IN GOMTI RIVER BASIN

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SUMMARY

The Gomti River, a significant tributary of the Ganga that flows entirely within Uttar Pradesh, serves as a lifeline for agriculture, livelihoods, cultural traditions, and biodiversity across its 30,437 sq. km basin. Originating in Pilibhit and coursing 940 km before merging with the Ganga at Ghazipur, the river sustains nearly 28 million people across 18 districts. Despite its critical importance, the river's ecological integrity has been severely undermined by rapid urbanization, intensive agriculture, industrial effluents, and unregulated groundwater abstraction. These pressures have placed both human well-being and natural systems at considerable risk. Hydrologically, the Gomti is heavily exploited for irrigation during non-monsoon months, leading to reduced ecological flows in several stretches. Seasonal flooding, particularly in Jaunpur and Pratapgarh, further compounds riverine stress. Persistent discharge of untreated municipal wastewater, industrial effluents, and diffuse agricultural runoff has rendered multiple stretches unfit for bathing, fishing, or potable use without treatment. Simultaneously, groundwater reserves, especially in Lucknow, are depleting at 0.5–1 m annually due to excessive pumping for agricultural and urban supply. These hydrological alterations, coupled with declining base flows, are threatening aquatic biodiversity and diminishing the ecosystem services on which communities depend.

The Gomti remains central to regional socio-economic systems. Agriculture is the dominant water user, consuming more than 90% of resources, with high-demand crops such as paddy, sugarcane, and wheat reliant on canals and river-linked recharge zones. Small-scale industries, including textile dyeing, pottery, leather tanning, and brassware, depend on river water and floodplain resources. Fisheries, once sustained by native species, have declined drastically under the combined pressures of pollution, altered flows, and habitat fragmentation. While interventions such as the Gomti Hatchery under PMMSY and restocking efforts (e.g., Operation Chitala) are underway, their long-term viability is contingent upon broader ecological revival. Beyond its ecological and economic roles, the Gomti holds deep cultural and spiritual significance. Ghats in Lucknow, Sultanpur, and Jaunpur host daily rituals and annual fairs, while festivals such as Kartik Purnima, Ganga Dussehra, and Chhath Puja reinforce its sacred value. These traditions generate local economies for boatmen, vendors, and artisans, but they also contribute to pollution when unmanaged. Both natural and human-induced drivers are actively degrading the Gomti's ecological integrity. The basin is experiencing statistically significant warming with increasingly erratic rainfall, shorter heavy monsoon bursts separated by extended dry spells. Streamflow during lean seasons has declined, and groundwater recharge is less reliable. Projections indicate continued trends toward higher flood magnitude in upper and middle reaches and drying conditions in lower reaches. An earlier onset and withdrawal of monsoon is also projected, compressing the window of ecological flows. Population pressure, agricultural expansion, industrial effluents (particularly from sugar mills and distilleries), untreated municipal sewage, and floodplain encroachment are the dominant anthropogenic stressors.

Stakeholder analysis identifies 37 key actors across government, civil society, and academia. High-salience institutions, including the Uttar Pradesh Forest Department, State Program Management Group (SPMG), State Water Resources Authority (SWaRA), and Uttar Pradesh Pollution Control Board (UPPCB), hold regulatory and planning authority. District administrations, panchayats, and fisheries departments constitute medium-salience actors, while NGOs, academic institutions, and community groups provide social legitimacy and ecological expertise. National agencies such as NMCG, CPCB, and MoEFCC shape policy and funding frameworks. However, governance remains fragmented, marked by overlapping mandates, weak coordination, and limited enforcement. Past initiatives, including the Gomti Action Plans (2001, 2005) and the Gomti Riverfront Development (2015), achieved partial infrastructure outcomes but neglected ecological restoration and community engagement. Policy gap analyses underscore inadequate monitoring, poor enforcement, and the absence of basin-specific ecological flow regulations. The mismatch between ecological impact and institutional salience is a governance gap requiring targeted engagement strategies.

Participatory mapping was conducted in five villages across two districts (Pilibhit and Jaunpur), engaging 66 respondents (40 female, 26 male), representing low-flow (origin) and high-flow (confluence) stretches. Community dependence on the Gomti spans all three economic sectors:

- **Primary sector: Irrigation for rice, wheat, sugarcane; artisanal fisheries (historically supporting 35+ native fish species); livestock watering and grazing.**
- **Secondary sector: Cottage industries including handloom weaving, dyeing, pottery, and brick-making dependent on river water and riverine clay; groundwater-dependent micro-enterprises.**
- **Tertiary sector: Extensive cultural and religious services including ritual bathing, ghats, annual fairs, Ramleela, and syncretic Ganga-Jamuni Tehzeeb traditions generating cultural economy for artisans, boatmen, and vendors.**

Key provisioning services include groundwater (primary drinking source), canal-based irrigation (Sharda system), fisheries (rohu, catla, singhi, wallago, and others downstream of Gomti-Sai confluence), and fuelwood/NTFPs from riparian species. Regulating services include provision of habitat for 37 legally significant species, including the Endangered Gangetic dolphin (*Platanista gangetica*), Vulnerable smooth-coated otter, Critically Endangered pinna catfish (*Pinniwallago kanpurensis*), and five freshwater turtle species. No river segment is protected under the Wild Life (Protection) Act, 1972, a significant governance lacuna. Cultural services, though rich, are declining at the high-flow (Jaunpur) stretch due to pollution and degradation. Trend analysis reveals a sharp spatial contrast: upstream Pilibhit villages report relative stability or modest growth in ecosystem services, while downstream Jaunpur villages report near-universal decline, in water quality, fisheries, biodiversity, livestock services, and cultural values, with only waste disposal increasing. This spatial gradient of degradation carries important implications for prioritising conservation and restoration investments.

A cadre of 303 trained Ganga Praharis (GPs) was established across eight districts of the Gomti Basin. Notably, 82% (248) are women. Age distribution is overwhelmingly young: 44% are below 22 years and 40% between 22–31 years. Educationally, 30% hold undergraduate degrees, with 21.78% having secondary-level education. Professionally, students form the largest cohort (43.56%), followed by homemakers (21.45%) and labourers (8.58%), underscoring the programme's inclusive and community-rooted character. District-wise, Pilibhit hosts the largest share (178 GPs), followed by Varanasi (82) and Jaunpur (21).

Conservation activities undertaken by GPs totalled 59 events engaging 1,349 participants, dominated by awareness activities (24 events, 568 participants), special day celebrations (11 events, 185 participants), and cleanliness drives (7 events, 85 participants). The programme has achieved national recognition: one GP, Rama Tiwari from Kannauj, received the National Youth Icon Award in January 2021, while Pawan Katiyar was honoured by Deen Dayal Upadhyay Rajya Gram Vikas Sansthan in November 2020. Regarding activity preferences, awareness and cleanliness drives are the most universally popular across genders. A notable gender gap exists in ecological surveys and rescue-rehabilitation activities (preferred by males), while cultural activities attract proportionally greater female participation. These patterns have practical implications for designing gender-differentiated capacity-building strategies.

A total of 20 livelihood training sessions were conducted across Pilibhit (upper basin), Jaunpur (middle), and Varanasi (lower basin), training 523 individuals, of whom 95.4% were women. Training modalities included sewing and stitching (304 women; 11 sessions, the dominant programme), incense stick making (70 women; 3 sessions), health and wellness (28 women), millet value addition (35 participants including 4 men), bag making (25 participants), tie and dye/block printing (24 participants), and basket making from natural fibres (17 participants). The Jalaj initiative, operationalised as a circular-economy livelihood model, links skill development with conservation incentives and market integration. In Pilibhit, the Jalaj centre "Abhyaranya" supports four active Self-Help Groups (60 members), has engaged 150 Ganga Praharis, conducted 70 activities, and empowered 90 women. The model integrates sale points, training centres, nurseries, ecotourism boats, and local food processing units, demonstrating a promising template for conservation-linked livelihood security.

A biodiversity-sensitive microplan was developed for Rajepur village, Sirkoni Gram Panchayat, Jaunpur district, selected due to its riverbank location, presence of turtles (including documented nesting sites), dolphins, mugger crocodiles, and fishermen's dependence on river resources. Key conservation issues identified through PRA, FGD, household surveys, and SWOT analysis include: (i) riverbed farming by 25 fishermen families disrupting turtle nesting habitats; (ii) heavy chemical fertiliser use degrading aquatic micro-habitats; (iii) 66 families lacking toilet access, generating open defecation and river pollution; (iv) overexploitation of fish stocks using fine-mesh nets by approximately 20 fully river-dependent families; (v) unsustainable extraction of riparian vegetation; and (vi) limited community awareness of aquatic biodiversity. The microplan prescribes an integrated set of strategies spanning community awareness, organic farming promotion, sanitation improvement, alternative livelihood development, fisheries regulation, habitat restoration through plantation, and strengthening of the Ganga Prahari cadre. An MoU with the Gram Panchayat formalises community commitment, a significant institutional step toward local ownership of conservation.

The chapter provides a thorough multi-tier policy audit encompassing national-level instruments (from NWQMP 1978 through Environmental Flow Rules 2018 and Atal Bhujal Yojana 2019), state-level Uttar Pradesh frameworks, and Gomti-specific interventions including the Gomti River Rejuvenation Mission (2025) and NGT Orders (OA No. 116/2014 onwards). The chapter identifies the following critical governance gaps, inadequate STP operation and maintenance; failure to address non-point agricultural pollution; absence of Gomti-specific ecological flow standards (e-flows are currently notified only for the Ganga mainstem); weak enforcement of pollution norms; absence of legal protection for any river segment under wildlife law; inadequately mapped and legally unprotected wetlands; absence of real-time water quality monitoring in rural and peri-urban areas; top-down planning with minimal micro-level basin integration; limited and weak representation of stakeholders and their low participation and limited climate resilience mainstreaming. The 2025 Gomti River Rejuvenation Mission represents a positive recent development. These grassroots diagnostics provide practical roadmaps for linking ecological restoration with community development. The Gomti River thus embodies both ecological vulnerability and socio-cultural resilience. Its sustainable future requires integrated strategies that harmonize ecological restoration

with livelihood security, strengthen governance frameworks, and position local communities as central actors in stewardship. Scaling successful initiatives such as Ganga Praharis, Jalaj centers, and village-level microplanning offers a replicable framework for basin-wide rejuvenation. Ultimately, the restoration of the Gomti is not merely an environmental necessity but also a socio-economic imperative for the future of Uttar Pradesh.

12.1. BACKGROUND

12.1.1. Geographical Profile: Location, Extent, and Catchment Area of the Gomti River

The Gomti, an alluvial river of the Indo-Gangetic Plain, is one of the important tributaries of the Ganga River. It is one of the major groundwater-fed rivers of Ganga Plain. In Hindu mythology, it is believed that the Gomti River is the daughter of Sage Vashistha. During solar eclipse, devotees believe that taking a bath in the Gomti is equivalent to the bath taken in the river in Kurukshetra. It originates from Gomath Tal (formerly known as Fulhar Jheel) near Madho Tanda town of Pilibhit district. After traveling about 940 km, it drains into the Ganga River near Saidpur/ Kaithi in Ghazipur district of Uttar Pradesh (Tangri et al., 2018). The place of origin is located near the Piedmont zone of the Ganga Plain.

The Gomti Basin lies between East longitudes of 79°57’ and 83°11’ and North latitudes of 25°23’ and 28°42’, covering an area of 31,433.67 sq. km completely in Uttar Pradesh. It is bounded by Ramganga Basin in the North-West, Ghaghara Basin in the North and North-East, and Ganga Basin in the South-West, South and South-East. There are three Sub-basins defined in Gomti Basin namely Lower Gomti, Sai, and Upper Gomti, draining areas of 5,659.16 sq. km (18%), 12,188.39 sq. km (39%) and 13,586.12 sq. km (43%), respectively, within Uttar Pradesh (State Water Resource Agency, 2019).

12.1.2 River Course, Boundaries, and Hydrological Dynamics

The Gomti river flows entirely in the State of Uttar Pradesh. There are three sub-basins defined in Gomti Basin namely Lower Gomti, Sai and Upper Gomti. The basin covers 161 blocks (90 fully and 71 partial) in 18 districts (State Water Resource Agency, 2019). Most of the surface area of the Gomti Basin is generally flat-sloping towards South and South-East with altitudes varying from 200 m to 61 m amsl (CWC, 2020). For about 425 km from the origin, the difference in the elevation is about 90 m amsl. For the remaining stretch of 500 km, there is an elevation difference of 49 m. Two main irrigation systems of the Gomti basin, namely Sharda and Sharda Sahayak are essential run-of-river systems. In the non-monsoon period (October to May), Gomti’s water is used extensively for irrigation and drinking, leaving very little or no flow in the river. During Kharif, river flows at diversion points are generally much higher than canal capacities, whereas during Rabi and Zaid, the river flows are generally less than canal capacities (State Water Resource Agency, 2019).

12.1.3. Major Tributaries

Sukheta, Choha, and Andhra Choha River join Gomti in Lakhimpur Kheri district, Kathina at Mailani and Sarayan join in Sitapur district, and Sai River joins near Jaunpur district (Table 12.1). Other tributaries are the Peeli River and the Kalyani River.

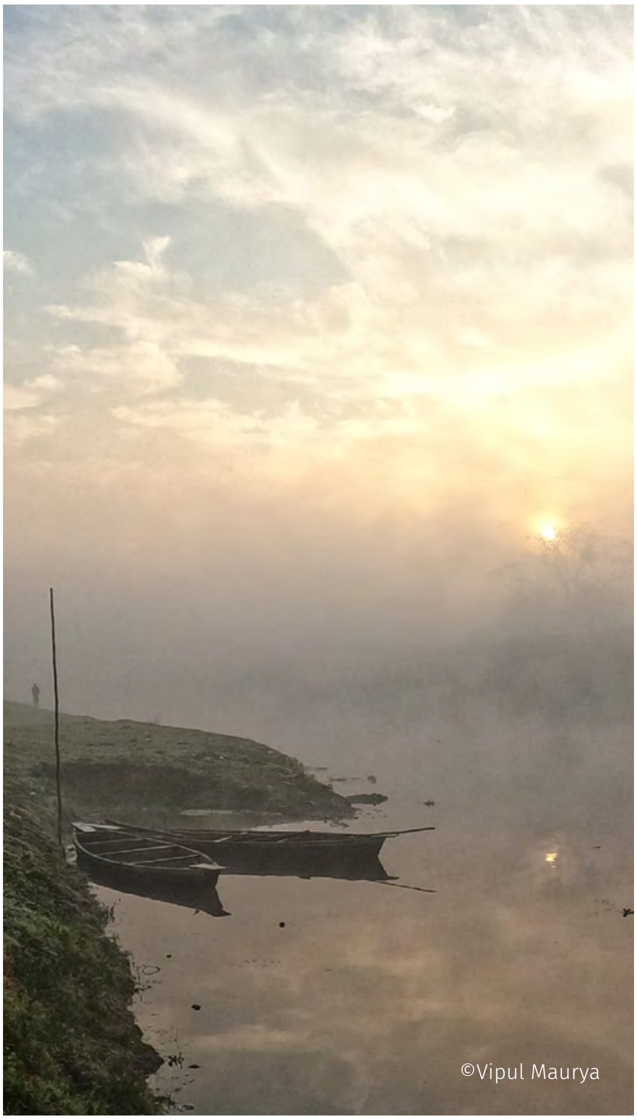

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Table 12.1. The major tributaries of Gomti River.

Sl. No.	Tributary	Point of confluence with Gomti	District
1	Sukheta	Lakhimpur Kheri	Lakhimpur Kheri
2	Choha	Lakhimpur Kheri	Lakhimpur Kheri
3	Andhra Choha	Lakhimpur Kheri	Lakhimpur Kheri
4	Kathina	Mailani	Lakhimpur Kheri
5	Sarayan	A village in Sitapur district	Sitapur
6	Sai River	Near Jaunpur district	Jaunpur

12.1.4. Seasonal Flow Variations and Flood Dynamics

The flow of the Gomti River increases from June to August, reaching its peak between July and August during the monsoon season, often leading to flooding. Monsoon rains also contribute to higher silt and debris levels, increasing turbidity and chemical oxygen demand, while surface runoff dilutes the river's ionic content. The flatter slope in the lower part creates some problems of flooding in Jaunpur and some parts of Pratapgarh district due to drainage congestion. Some low-lying areas in Jaunpur town are also flooded in the monsoon period for a shorter duration. In the 1980s, the river Gomti had caused floods in Lucknow city. To save the city from the fury of floods from Gomti, embankments were constructed (State Water Resource Agency, 2019).

12.1.5. Land Use Land Cover along Gomti River

A large part of the Gomti River basin is under agricultural field (74.80%); followed by fallow land (18.79%), forest cover (3.12%), built-up area (2.90%), and water (0.39%) (Das et al., 2021) (Figure 12.1). Decreasing forest cover and wetlands are cause of major concern in the entire Gomti basin. In Basin, majority of forests fall in open and less dense categories. Except Pilibhit and Kheri, all the districts in the basin are deficient in green cover (Dutta et al., 2011). Agricultural land and built-up area have increased from 1995 to 2020 (Asif et al., 2023; Table 12.2).

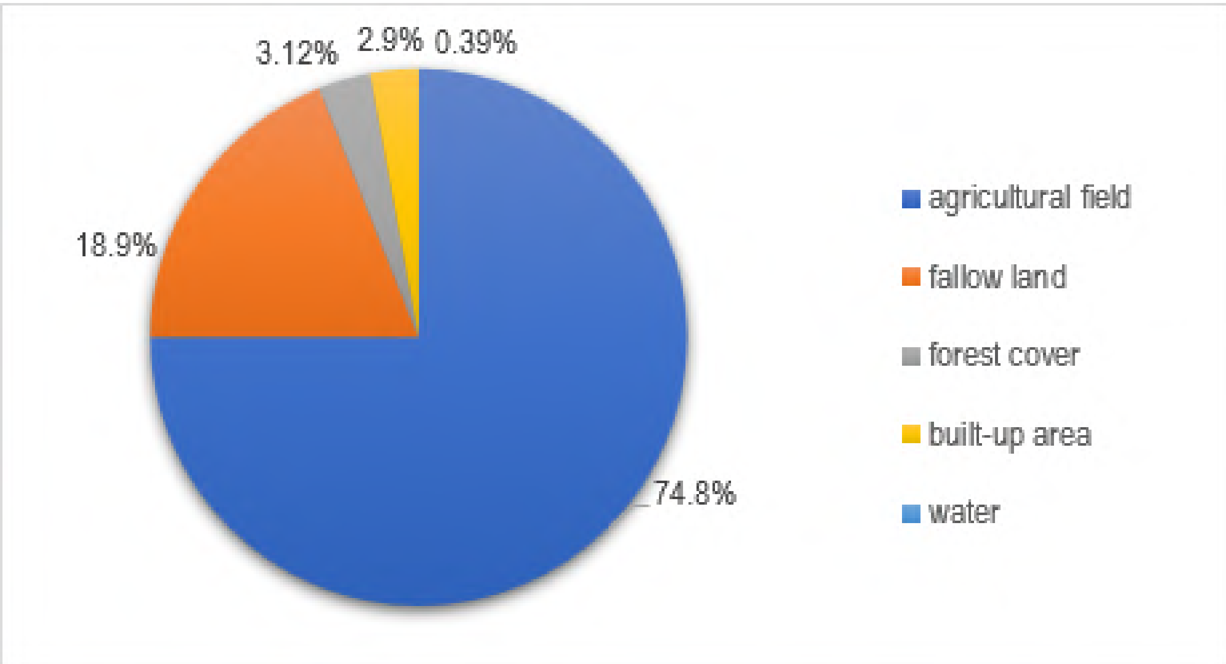

Figure 12.1. Percentage of Land use pattern in the Gomti River Basin in 2021 (Source: Das et al., 2021)

Table 12.2. Area and proportion of different LULC classes. Source: Asif et al. (2023)

Land Use Classes	1995 (ha)	2020 (ha)	Change (ha)
Water bodies	29045.36	20759.14	-8286.22
Vegetation	52350.6	42514.66	-9835.94
Agriculture	2939108.22	2949716	10607.78
Built-up area	40373.3	50491.87	10118.75
Barren land	25236.89	22593.35	-2643.54

12.1.6. Geology and Soil Characteristics

The entire Gomti basin is underlain by thick alluvial sediments of the Quaternary age. The alluvial sediments consist of boulders, pebbles, gravel, sand, silt, clay, and kankars. The unconsolidated unit may be further subdivided into younger alluvium and older alluvium. The younger alluvium occupies the present-day flood plains while the older group occupies elevated portions mainly the doab portions. The older alluvium is characterized by kankar nodules at depth otherwise it is similar to the younger alluvium (Dutta et al., 2015). The unique integration of low altitude, low gradient, heavy rainfall, highly fertile soil, and huge population density mark Gomti River Basin as a remarkable geographical characteristic of the Indian mainland (Thakur et al., 2009; Khan et al., 2021).

12.1.7. Climatic Conditions: Temperature and Rainfall Trends

The river basin experiences the three major seasons annually viz. winter, summer, and monsoon. The winter season starts from November to February. The temperature of the basin varies between 24.04°C to 39.40°C (data for 2000- 2014). The winter season experiences very low rainfall. Most of the rainfall during this season is a result of cyclonic disturbances or westerlies only. Winter season slows down the process of weathering (either chemical or mechanical) and erosion. Average annual pan evaporation is 1850 mm. The summer season starts at the beginning of March and continues up to the mid-June. The cyclonic rainfall occurs in the summer season (State Water Resource Agency, 2019). During this time, weathering and erosional processes are governed mainly by the wind action. The monsoon season starts in June and continues up to the mid-September. Average rainfall in the basin is 872.67 mm recorded in 1961 to 2015. During this time, the humidity is very high and most of the basin experiences heavy rain. Heavy rain advances the velocity and sediment supply of the river, which influences the process of weathering and erosion; these processes develop and modify most of the geomorphic features of the basin.

12.1.8. Human Population and Settlement Trends

According to the Gomti Basin Plan by State Water Resource Agency (2019), the basin accommodates a population of 27.7 million, with around 81.5% (22.6 million) living in rural areas and only 18.5% (5.1 million) residing in urban locales. This underscores the primarily agricultural character of the basin, where lives are intricately linked to agriculture, related sectors, and riverine resources. The Upper Gomti sub-basin is the most populated, with 12.7 million people living there, most of them are rural i.e., 69%. It has a low sex ratio of 900 females for every 1000 males, which shows that the population is under a lot of stress. However, it has a moderate literacy rate of 68.6%. The Sai sub-basin, on the other hand, has a slightly better sex ratio of 951 and 9.2 million people, but it has the lowest literacy rate (68.0%) of all the sub-basins. This shows that there are differences in educational attainment in rural areas (Table 12.3).

The Lower Gomti sub-basin has a lesser population (5.7 million) than the rest of the basin, but it has the greatest sex ratio (987) and literacy rate (69.9%), as well as a higher population density (1013 people/km²). This shows that the demographic structure is more balanced, but the strain on land resources is more in this area. The total sex ratio for the whole basin is 934, which stays below the national average. This suggests that there are gender inequalities in many parts of the basin. The average literacy rate of 68.7% shows that not many people have accessibility to the education facilities, especially in rural areas where poor infrastructure and reliance on farming is predominant. The number of people per square kilometre in the Sai sub-basin is 756, whereas in the Lower Gomti sub-basin it is over 1000 (Figure

12.2; Table 12.3). This shows that people are putting different amounts of pressure on land and water resources in different areas.

Overall, the demographics of the Gomti Basin show that most of the people live in rural areas and engage in agriculture, however social development indicators are not consistent. Rural areas are more common, but metropolitan centres, especially Lucknow in the Upper Gomti, are important socio-economic hubs that have a big impact on the rural areas around them. The differences in literacy, sex ratio, and population density between sub-basins show the need to achieve balanced regional development and long-term management of river basins.

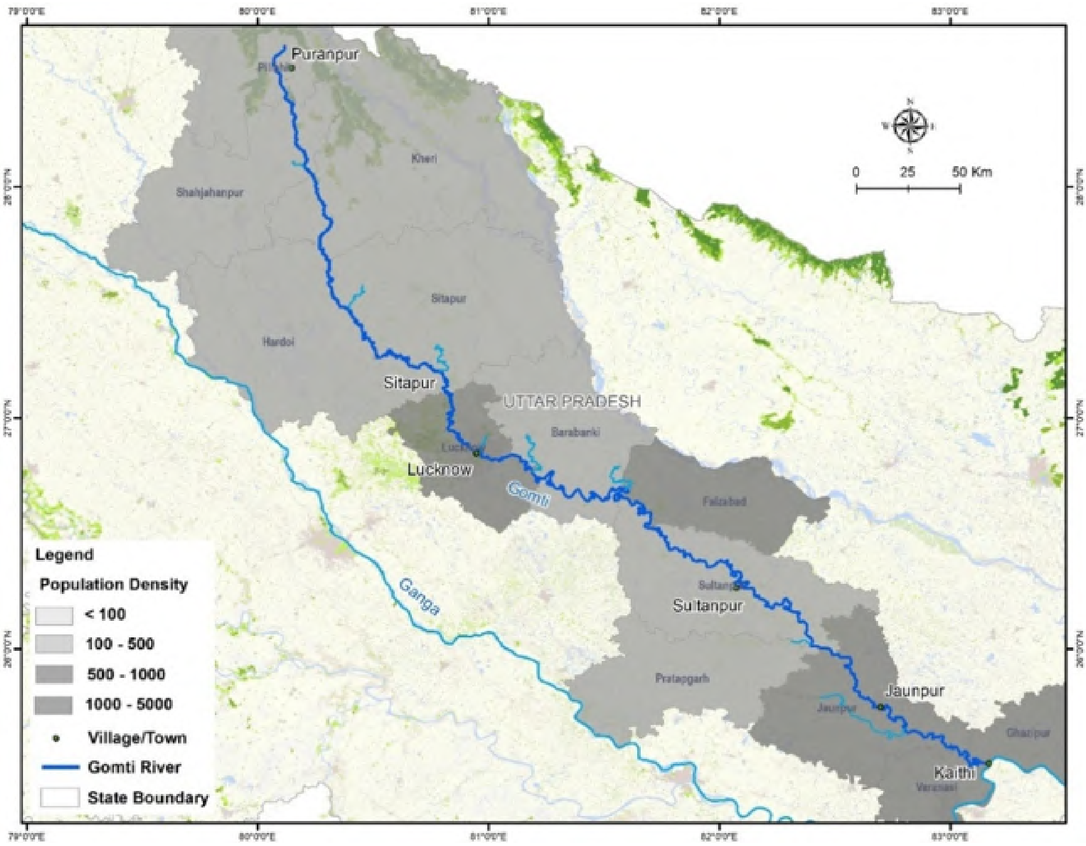

Figure 12.2. Spatial distribution of population density along Gomti River. Source: WII, NMCG

Table 12.3. Population distribution in Gomti Basin. Source: State Water Resource Agency (2019)

Sub Basin	Urban	Rural	Total	Male	Female	Sex Ratio	Population Density	Literacy Rate (%)
Lower Gomti	3,88,190	53,43,458	57,31,648	28,85,151	28,46,497	987	1013	69.9
Sai	8,08,867	84,02,076	92,10,943	47,22,314	44,88,629	951	756	68.0
Upper Gomti	39,29,869	88,43,504	1,27,73,373	67,22,018	60,51,355	900	940	68.6
Basin Total	51,26,926	2,25,89,038	2,77,15,964	1,43,29,483	1,33,86,481	934	882	68.7

In Gomti basin the population density varies greatly, from 524 people/km² in Lakhimpur Kheri to 2395 people/km² in Varanasi. This shows the difference between mostly rural agricultural areas and highly urbanised cultural and commercial centres. The growth rates are also different. For example, Kheri (25.4%) and Lucknow (25.8%) have fast-growing populations, whereas Jaunpur (14.9%) and Varanasi (17.1%) have slower-growing populations. This shows that the population is moving through different stages of demographic transition.

Sex ratios show inequities in society and culture. Some districts, like Jaunpur (1024) and Pratapgarh (998), have good ratios, while many others, like Hardoi (868) and Shahjahanpur (872), have ratios that are far lower than parity, which shows that there are indeed disparities between men and women. These differences are also seen in education: the overall literacy rate is 59.5%, and is lowest in Shahjahanpur (49.6%) and highest (77.3%) in Lucknow. The average literacy rate for women is 10–15 percentage points lower than that for men. The biggest differences are in rural areas like Hardoi and Sitapur (Table 12.4).

Socio-economic metrics highlight persistent imbalances. Lucknow has the highest per capita income (₹91,901/- per year), where urban services are most important. Varanasi has a reasonably high per capita income (₹50,153/-), which shows how good urban economies can be. On the other hand, agrarian areas like Pratapgarh (₹28,929/-) and Amethi (₹19,896/-) are much worse off because they don't have many industries and opportunities. The same is true for poverty rates: Lucknow has the lowest rate (8.48%), while agrarian districts like Sitapur (40.15%) and Lakhimpur Kheri (34.73%) have substantially higher rates of poverty (Table 12.4) (Census of India, 2011).

In general, the demographic profile of the Gomti riverine districts shows that there are two different types of economies. Urban areas like Lucknow and Varanasi are regional growth poles because they have greater literacy rates, a better balance between men and women, lower poverty rates, and higher earnings. On the other hand, rural and semi-rural areas still have low literacy rates, detrimental sex ratios, high poverty rates, and a lot of people who depend on farming. This uneven mix of people and businesses shows how important it is to have river-basin management plans that are adapted to each area and address not just ecological but also social inequalities between urban and rural areas.


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Table 12.4. Demographic Dynamics in the Districts along the Gomti River. Source: Census of India (2011)

District	Population	Male	Female	Population density (sq km)	Population growth rate %	Sex ratio	Literacy rate %	Literacy rate (male) %	Literacy rate (female) %	Poverty rate %	Per capita income (₹)
Pilibhit	2031007	1072002	959005	551	17.5	895	61.5	71.7	50	22.54	62038
Shahjahanpur	3006538	1606403	1400135	685	22	872	59.5	68.2	49.6	32.57	53272
Lakhimpur Kheri	4021243	2123187	1898056	524	25.4	894	60.6	69.6	50.4	34.73	48188
Sitapur	4483992	2375264	2108728	781	23.88	888	61.12	70.31	50.67	40.15	40924
Hardoi	4092845	2191442	1901403	684	20.4	868	64.6	74.4	53.2	34.14	37745
Lucknow	4589838	2394476	2195362	1816	25.8	917	77.3	82.6	71.5	8.48	91901
Barabanki	3260699	1707073	1553626	741	22	910	61.7	70.3	52.3	31.68	43640
Ayodhya	2470996	1259628	1211368	1056	18.3	962	68.7	78.1	59	17.79	43292
Sultanpur	3797117	1914586	1882531	856	18.1	983	69.3	80.2	58.3	22.32	42920
Pratapgarh	3209141	1606085	1603056	863	17.5	998	70.1	81.9	58.4	21.29	28929
Jaunpur	4494204	2220465	2273739	1113	14.9	1024	71.5	83.8	59.8	16.13	31682
Varanasi	3676841	1921857	1754984	2395	17.1	913	75.6	75.8	54.1	15.26	50153
Ghazipur	3620268	1855075	1765193	1072	19.2	952	71.8	82.8	60.3	18.22	31555
Amethi	1867678	945235	922443	802	17.64	983	69.72	80.19	58.28	-	-

12.1.9. Urban and Rural Interface along Gomti River

The demographic profile of the Gomti Basin exhibits a significant urban-rural disparity, with a predominant concentration of residents in rural regions. The Gomti River is a key point of transition between rural farming areas and urban centres that are rising swiftly, such Lucknow, Sultanpur, and Jaunpur (State Water Resource Agency, 2019). This interface shows how both traditional rural ways of life and the needs of cities are modifying river systems in the Indo-Gangetic plain at the same time. The Gomti is a source of water and a place to dump urban trash. Urban growth has turned lush floodplains and wetlands into hard surfaces, embankments, and infrastructure projects like the Gomti Riverfront Development. The changes make it harder for water to seep in, speed up stormwater runoff, and change how natural floodplains work. Untreated or partially treated municipal sewage significantly influences dry-season flows, with research indicating elevated levels of organic and microbial contamination, thereby categorising the river as one of India's officially recognised polluted stretches (Singh et al., 2025). Urban channelisation and hard engineering, intended for aesthetic enhancement and flood management, exacerbate the disruption of ecological processes and jeopardise the environmental flows essential for the maintenance of downstream ecosystems (CAG, 2017; WWF-India, 2024).

On the other hand, the rural parts of the Gomti still rely heavily on the river's natural flow. Rice, wheat, and sugarcane farming depends on seasonal flooding, irrigation withdrawals, and fertile alluvial soils. In this case, the interplay between groundwater and surface water is still very important since rural baseflows keep river levels up during the months when there is no monsoon (State Water Resource Agency, 2019). Rural drains and agricultural return flows provide nutrients to the river, but their effects are usually spread out and only last for a short time. Rural people also still do things like sand-bar farming and small-scale fishing, which depend on a floodplain system that is organically connected (cGanga -NMCG, 2022).

There is an evident distinction between urban and rural interfaces. Urban regions put a lot of pressure on the environment through sewage, infrastructure, and land-use changes. Rural areas, on the other hand, depend on the river for food and ecosystem services, which have more spread-out and seasonal effects. The overall state of the Gomti downstream is mostly due to the urban footprint of Lucknow, not the spread-out effects of agriculture. Integrated management is necessary to find a balance between treating urban wastewater, maintaining wetlands in the peri-urban area, and keeping the river's natural flow stable. This will protect rural livelihoods and make the river corridor more resilient to changes in the environment.

12.1.10. Drivers of Change

12.1.10.1. Natural Drivers (Climate Variability, Geomorphological Changes)

Studies show that the Gomti basin is getting warmer and, in many places, drier (Abeysingha et al., 2014; Kalyan et al., 2021; Das et al., 2021a). Streamflow and surface runoff have reduced in the lean season. Rainfall has become more erratic with short, heavy downpours separated by long dry spells (Kalyan et al., 2021; Das et al., 2021a). Higher temperatures increase evaporation, so even where seasonal rain rises, less water stays available. Groundwater recharge is less reliable, and periods of safe high flow are shorter while peak events are more damaging. Practically, this means heavier monsoon floods and very low baseflow from March to June (Abeysingha et al., 2014). These trends have been projected to likely to continue (Kalyan et al., 2021). In upper and middle reaches of Gomti River, frequent monsoon flooding happens due to drainage congestion. Projected increases in monsoon flow may raise flood magnitude and frequency, damaging crops, livestock, and property (Abeysingha et al., 2020). In the lower reaches, a drying tendency is observed with declining rainfall (annual, post-monsoon, winter), falling streamflow, and rising temperatures. An apparent shift in timing of monsoon is project which means earlier monsoon onset and earlier withdrawal in the river basin (Abeysingha et al., 2014). In the urban Lucknow stretch, warmer water and low dilution in lean months due to climate have deteriorated DO/BOD levels, even when treatment capacity expands (Kumar, 2018).

12.1.10.2. Human-Induced Drivers

Gomti River Basin is witnessing high water stress mainly due to the increase in human population along with an expansion of agricultural activity. Significant changes have taken place in the basin over the recent past and are continuing (Dutta et al., 2015).

Industries

Industrial waste from sugar factories and distilleries, domestic waste, and garbage dumps are the major causes of pollution in the Gomti River, which affects the aquatic ecosystem. One of the earliest studies of Kumar, (1989) depicted that the direct discharge of municipal wastes into the Gomti River around Lucknow via drains is highly answerable for raised levels of heavy metals and PO4. To study the nature of sediments deposited on streams, Singh et al., (2005) examined the six urban centres of the Ganga plain and its tributary, Gomti River in Lucknow. That paper reveals urban centers are responsible for metallic pollution that occurs from Cadmium, Copper, Chromium, Nickel, Lead, Zinc, etc. (Table 12.5).

Table 12.5. Key industries present in the Gomti River Basin.

	Districts													
Industries	**Pilibhit**	**Shahjahanpur**	**Kheri (Lakhimpur)**	**Sitapur**	**Hardoi**	**Lucknow**	**Barabanki**	**Faizabad / Ayodhya**	**Sultanpur**	**Pratapgarh**	**Jaunpur**	**Varanasi**	**Ghazipur**	**Amethi**
Agro-based	625	73	234	2213	3166	235	1680	3086	1244	864	1065	237	968	33
Ready-made Garments	898	35	200	1174	1121	3808	885	593	1417	43	605	720	163	
Wooden furniture	491	6	23	387	292	27	345	464	411	1239	1002	585	559	4
Leather	11	1	12	72	146	35	150	348	14	20	404	55	-	-
Rubber, Plastic & petro based	17	-	-	45	38	188	19	132	-	1	205	90	14	
Engineering unit	417	-	-	25	18	67	410	81	504	-	418	610	-	-
Electrical machinery & transport equipment	-	2	9	270	36	126	-	130	710	-	610	140	-	-
Repairing & Servicing	1016	37	156	139	3660	2892	3400	2265	1680	2218	1850	1098	3080	79
Soda water	-	2	-	14	-	8	5	29	-	-	-	-	-	-
Cotton textile	-	2	-	281	326	4	-	689	18	-	-	715	-	-
Woollen, silk, and artificial clothes	-	12	-	-	9	1	-	45	-	-	816	1163	13	-
Jute-based	-	2	-	3	1	3	2	80	-	-	-	75	165	-
Paper & Paper products	-	1	5	99	50	296	51	130	30	-	106	90	17	-
Chemical & chemi-cal-based	-	4	-	72	60	102	24	120	240		55	580	8	-
Mineral-based	-	3	4	63	30	159	250	47	-	-	50	360	-	-
Metal-based	-	3	-	25	298	41	240	454	527	660	212	515	29	-
Others	1734	145	32	2750	166	844	3740	-	2929	1427	3024	-	951	32

Pollution

The Gomti River faces significant pollution from agricultural runoff, sewage, fertilizers, and religious activities. This pollution impacts both the river's ecosystem and the communities that depend on it for drinking water and their livelihoods. Its water is most polluted and unfit for human consumption at down stretch of Gaughat pumping station. Sai River water is also polluted and unfit for human consumption near Rae Bareli and Jalalpur (State Water Resource Agency, 2019).

The pH of Gomti River ranges between 7.4 to 8.4. Free CO2 levels show fluctuations having higher concentrations during summer and lower concentrations during winter months (Singh et al., 2023). Water quality data from CPCB (2012–2023) reveal serious pollution in the Gomti River, especially at down stretch of Lucknow, where BOD rose to 12.5 mg/L, indicating heavy organic contamination. In contrast, upstream areas like Sitapur showed better conditions with improved dissolved oxygen. Downstream locations such as Varanasi saw modest improvements (Central Pollution Control Board, 2012 and 2023) (Table 12.6).

Table 12.6. Different parameters indicating water quality of Gomti River and their change from 2012 to 2023. Source: CPCB (2025)

Parameters	Sitapur Upper stretch		Lucknow Upper Stretch		Lucknow Down Stretch		Jaunpur Down Stretch		Varanasi	
	2012	2023	2012	2023	2012	2023	2012	2023	2012	2023
Temperature (°C)	26	-	28	-	27	-	25	26.75	25	26.5
Dissolved Oxygen (mg/L)	7.9	9.3	7.3	7.55	2.7	1.65	7.5	7.5	7.8	7.9
pH	7.9	8.15	7.9	7.9	7.5	7.4	8.4	8.15	8.2	8.15
BOD (mg/L)	2.6	3.2	3.2	3.45	9	12.15	3.5	3.75	3.9	3.5
Nitrate N (mg/L)	1.66	0.81	2.57	-	4.33	-	-	-	-	-
Conductivity (µmho/cm)	392	330	427	411	517	605	261	406	285	401

12.2. APPROACH USED TO ENSURE STAKEHOLDER PARTICIPATION IN GOMTI RIVER CONSERVATION

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 considered co-managers and stewards of the Gomti River and its biodiversity. Our approach consisted of the following five components which are sequential yet overlapping:

12.2.1. Stakeholder identification and mobilization

A comprehensive list of stakeholders of Gomti River in Uttar Pradesh was prepared. 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 Gomti River (Figure 12.3).

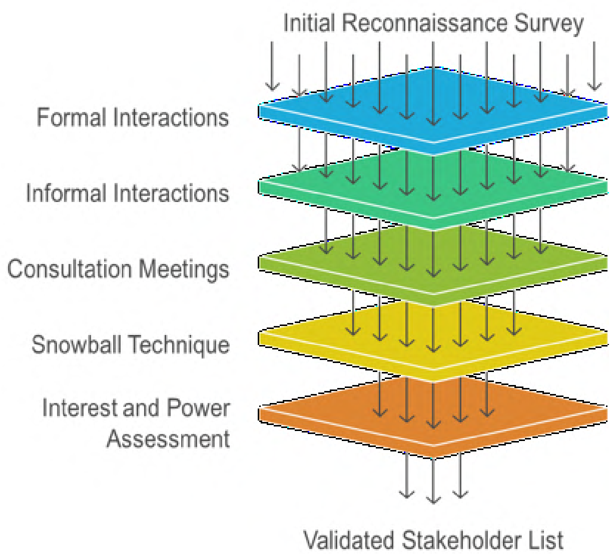

Figure 12.3. Approach to identify and classify stakeholders in Gomti River

Salience is the prioritization of stakeholders on the basis of their power, degree of moral legitimacy and interest towards claim on the resources of Gomti 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 following formula for each stakeholder group:

1) D= √(a2+b2+c2) .... Equation (1)

where D is salience, a is interest, b is power and c is legitimacy score (Figure 12.4)

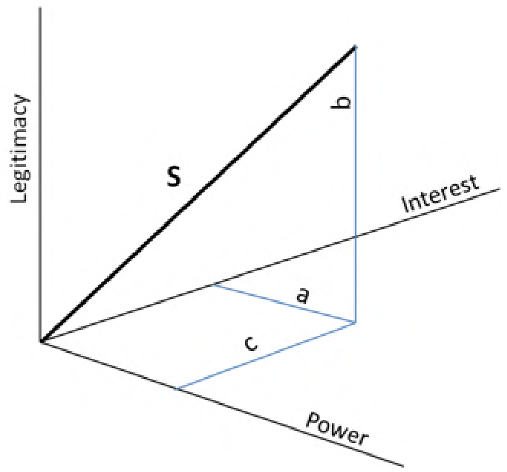

Figure 12.4. Approach to define salience of stakeholders (Nastran, 2014).

Following this, on the basis of 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 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.

12.2.2. Understanding the social-ecological linkages in Gomti 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 Gomti 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 (hills- 1 km; plains- 2 km), 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.

12.2.3. Institutionalization of community-based conservation through establishment of Ganga Prahari cadre.

Following the identification and mobilization of stakeholders and assessment of their dependence on Gomti 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, leadership skills, and geographical, demographic and knowledge representation. 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).

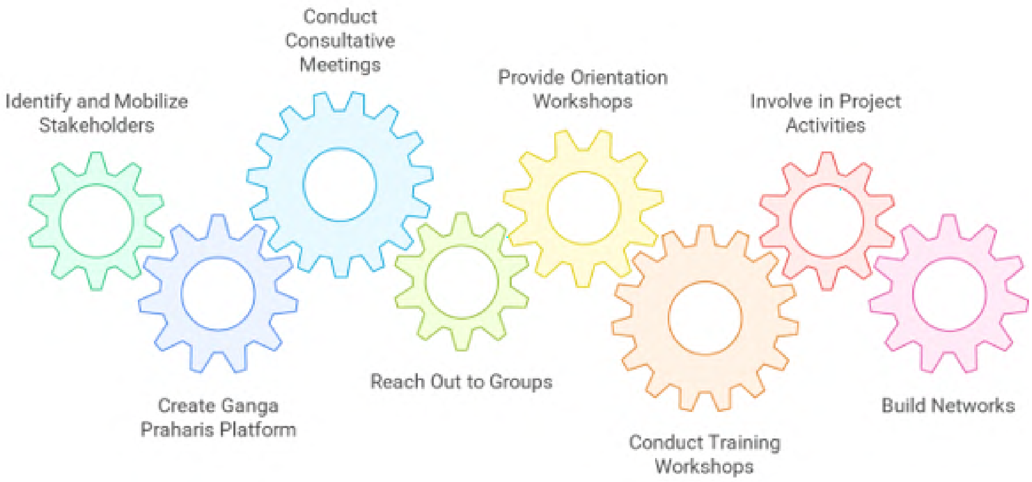

Figure 12.5. Process followed to identify Ganga Praharis and involve them in conservation actions in Gomti River Basin.

12.2.4. Livelihood Intervention to Link Livelihoods and Conservation

To ensure the long-term association of Ganga Praharis to Gomti 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 resource persons for training were identified in the area (Figure 12.6).

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 (Figure 12.6). 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.

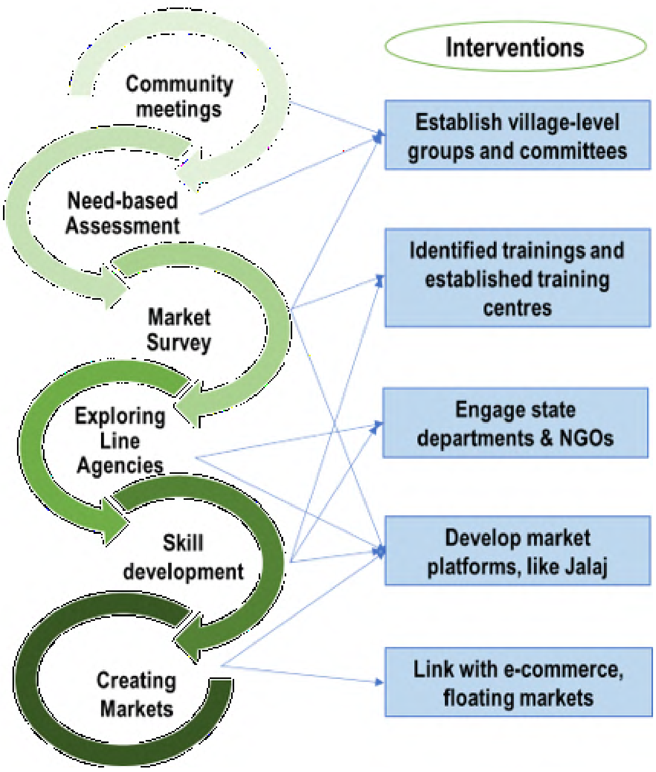

Figure 12.6. Approach of process and components of alternate livelihood development initiatives.

12.2.5. 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 Gomti 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. 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 12.7).

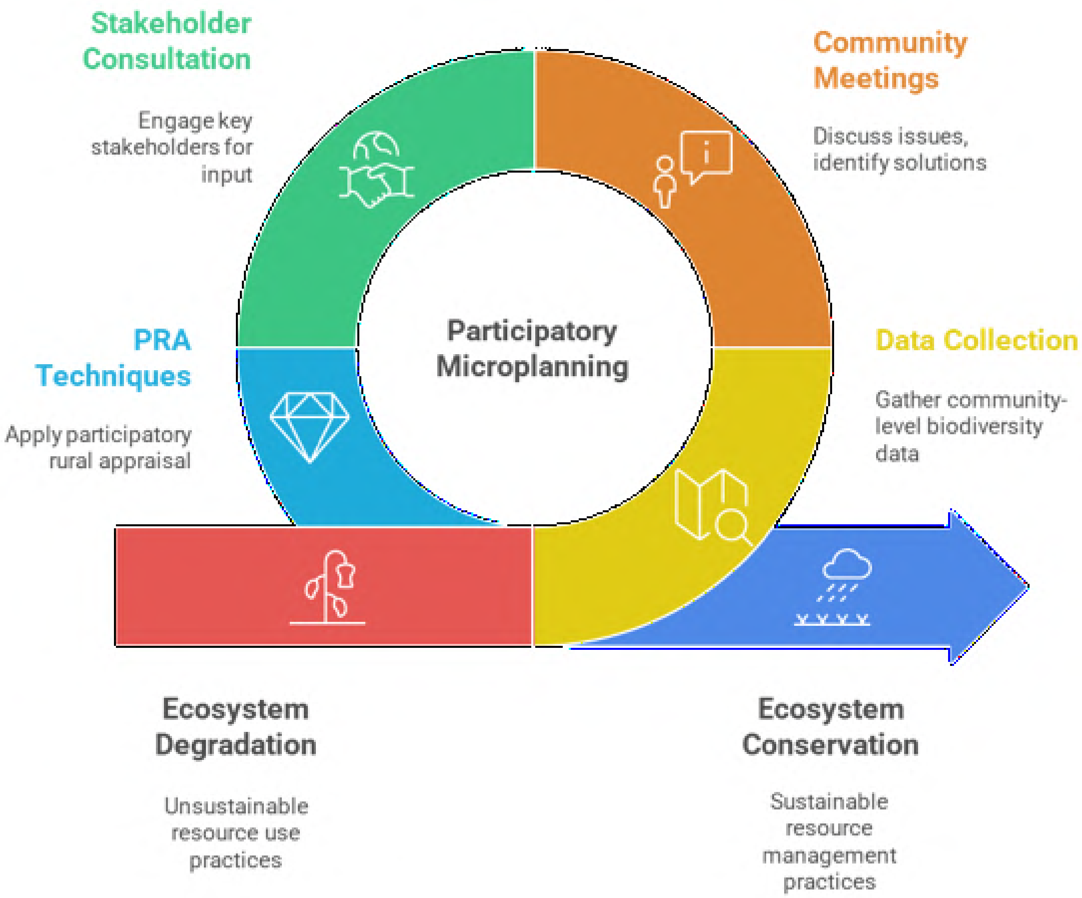

Figure 12.7. Approach for developing conservation sensitive village development planning.

12.2.5.1. Criteria for Village Selection

The villages for the study were selected based on the following criteria:

- Distance of the village from the river,
- Biodiversity value of the area,
- Dependence of local communities on the Gomti River for their livelihood security
- Lack of knowledge and awareness of the community about biodiversity
- Poaching in the river
- At the time of flood, aquatic animals from the river come to the Panchayat
- The problem of open defecation in the Panchayat
- Status of cleanliness in the Gram Panchayat
- The positive response of the community and Panchayat to the program
- A strong curiosity of the community (especially farmers and fishermen community) to get information about biodiversity
- Their willingness to participate in biodiversity conservation activities for the Gomti River.

12.2.5.2. Village selection process

After general observation of villages situated on the banks of the Gomti river, discussions with local

communities, meetings, and sensitization workshops, Rajepur village of Sirkoni Gram Panchayat was selected for the program. Dolphins, turtles, crocodiles, and fishes are found in the river. The turtle nesting site was also observed. The villagers do not know much about the aquatic species found there and their importance. The main reason for this is a lack of information and awareness. Meetings were held with the village community by contacting public representatives in the said Gram Panchayat and the Gram Panchayat members and villagers were informed about the objectives and program of the project. After everyone agreed, the MoU was signed with the Gram Panchayat.
After the selection of Gram Panchayat, Village Survey, Household Survey, PRA, SWOT, and FGD were conducted. In this survey, information was collected on the following aspects –

- Social and demographic details
- Economic status and occupation
- Drinking water and sanitation status in the village
- Agriculture and animal husbandry
- Details of rain and other water resources
- Availability of basic amenities and means of communication and access in the Gram Panchayat
- Details of forest resources and biodiversity in and around the Panchayat
- Details of river biodiversity
- Community dependence on the river

The development of the village microplan is based on an integrated participatory model framework, providing a platform for interaction between multiple stakeholders on social, ecological, conservation, and developmental issues and conflicts, as well as, institutional challenges (Figure 12.8).

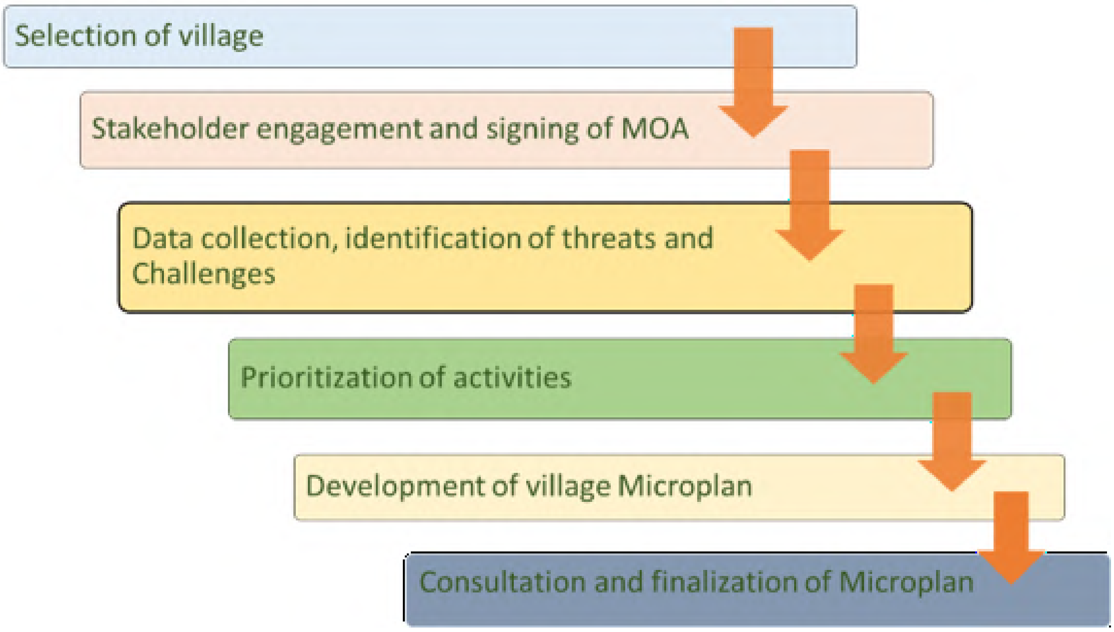

Figure 12.8. Steps followed in preparation of biodiversity sensitive village microplan.

12.2.6. Policy Gap Analysis

The current study tries to facilitate sustainable decision-making and policy implementation by adopting a simplified approach. A critical analysis, of the policies implemented under various programs in Gomti River Basin to understand their efficiency, effectiveness and possible reasons for their limited success, was undertaken. The analysis was aimed towards 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 12.9).

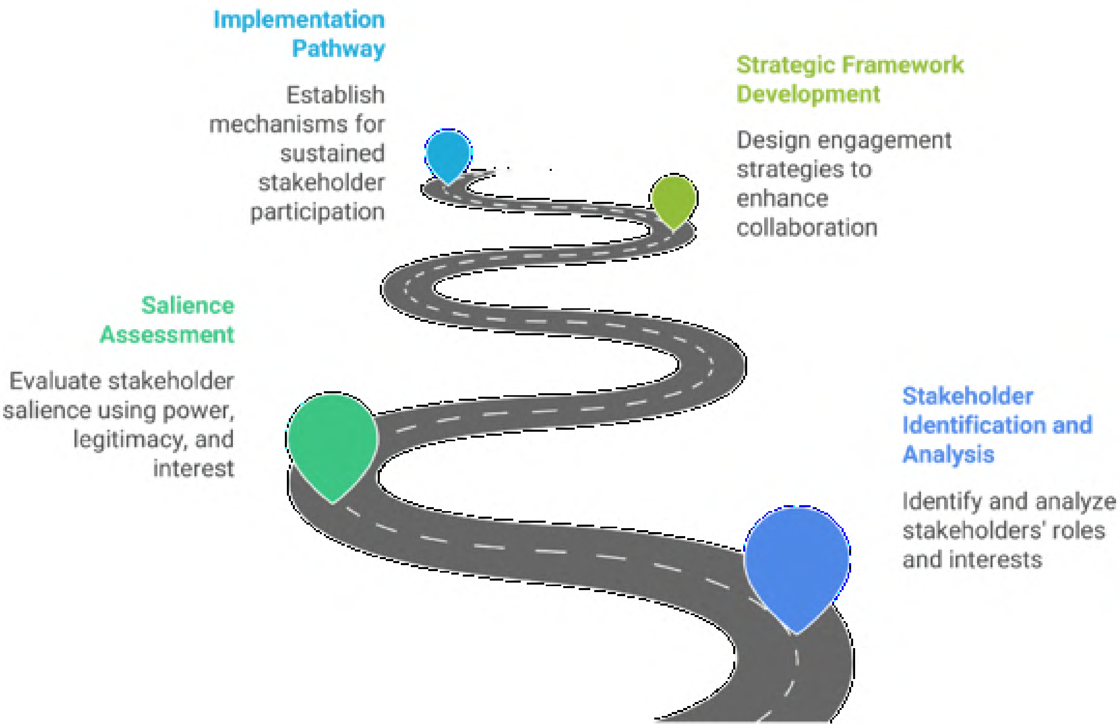

Figure 12.9. Approach adopted for analysis existing policies and schemes for their effectiveness in Gomti River Basin.

12.3. RESULTS

12.3.1. Stakeholders of Gomti River

The stakeholders involved in the conservation and management of the Gomti River are categorized into primary, secondary, and tertiary groups based on their level of involvement and institutional roles. Primary stakeholders, who are directly engaged in planning, implementation, and management activities, include the District Administration, Agriculture Department, Nagar Nigam/Municipality, Water and Sanitation Department, Village Panchayat, Nagar Panchayat, Forest Department, Religious Groups, Local Industry, Tourism Sector, SPMG, SWaRA, UPGWD, UPIWRD, UPPCB, Fisheries Department, Lucknow Development Authority (LDA), NGOs, and the local community. SWaRA (State Water Resources Agency) is a nodal agency for water resources planning, data management, and inter-agency coordination. Supports river basin management plans, water budgeting, and policy integration. UPGWD (Uttar Pradesh Ground Water Department) monitors and manages groundwater levels, quality, and recharge strategies in the Gomti basin. Plays a role in sustainable water extraction and aquifer protection. UPIWRD (Uttar Pradesh Irrigation and Water Resources Department) manages canals, embankments, river training works, drainage systems, and flood control infrastructure across Gomti. Implements irrigation projects connected to the river. UPPCB (Uttar Pradesh Pollution Control Board) is responsible for monitoring industrial pollution, enforcing effluent standards, and controlling the discharge of untreated sewage and pollutants into Gomti. Issues notice and penalties. Lucknow Development Authority (LDA) plays a role in urban riverfront development, sewage and drainage planning, and controlling encroachments on Gomti's floodplain in Lucknow. These stakeholders have significant interest and influence in the river's health, as they are either regulatory bodies, service providers, or communities dependent on the river for livelihood and ecosystem services.

The secondary stakeholders include Educational Institutions, NYKS (Nehru Yuva Kendra Sangathan), SRLM (State Rural Livelihoods Mission), and ETF (Ecological Task Force), who contribute through

education, awareness, community mobilization, and ecological restoration efforts. Academic and research institutions, including IITs, Babasaheb Bhimrao Ambedkar University (BBAU), Lucknow conduct studies on river ecology, pollution, and hydrology. NYKS (Nehru Yuva Kendra Sangathan) mobilizes youth volunteers for awareness rallies, clean-up drives, and river sensitization campaigns under Namami Gange (Gomti Basin Plan, 2019).
At the tertiary level, the National Mission for Clean Ganga (NMCG) plays a strategic role in policy formulation, funding, and monitoring of river rejuvenation programs. Together, these stakeholders form an interconnected framework essential for the sustainable management of the Gomti River.

12.3.1.1. Stakeholder Analysis

A total of 37 stakeholders were assessed, encompassing government departments, local governance bodies, civil society organizations, and community representatives. The analysis revealed that stakeholders such as the Uttar Pradesh Forest Department, State Program Management Group (SPMG), State Water Resources Agency (SWaRA), and Uttar Pradesh Pollution Control Board (UPPCB) exhibited the highest salience values (5.20), indicating strong institutional legitimacy, high decision-making authority, and active interest in river conservation. Other stakeholders, including the Water and Sanitation Department, Village Panchayat, Ecological Task Force (ETF), and Nehru Yuva Kendra Sangathan (NYKS), also demonstrated high salience scores (4.69), reflecting their significant operational role in implementing sanitation and conservation measures. In contrast, stakeholders such as local industries (1.73) and religious groups (2.45) showed lower salience due to limited regulatory authority or institutional legitimacy, despite potential localized influence (Table 12.7). This analysis highlights the critical need to prioritize high-salience stakeholders in policy design and execution while enhancing the participatory role and institutional capacity of lower-salience actors to promote integrated and inclusive river basin management.

Table 12.7. The stakeholder attributes' estimates and their salience in Uttar Pradesh state.

Sl. No.	Stakeholder	Type	Interest (a)	Power (b)
1	District Administration	Primary	2	3
2	Agriculture Department	Primary	2	3
3	Water and Sanitation Department	Primary	3	3
4	Village Panchayat	Primary	3	3
5	Nagar Panchayat	Primary	2	3
6	Uttar Pradesh Forest Department	Primary	3	3
7	Religious Groups	Primary	1	1
8	Local Industry	Primary	1	1
9	Tourism Sector	Primary	2	2
10	State Program Management Group (SPMG)	Primary	3	3
11	State Water Resources Authority (SWaRA)	Primary	3	3
12	Uttar Pradesh Ground Water Department (UPGWD)	Primary	3	2
13	Uttar Pradesh Irrigation and Water Resources Department	Primary	1	3
14	Uttar Pradesh Pollution Control Board (UPPCB)	Primary	3	3
15	Fisheries Department	Primary	3	3
16	Lucknow Development Authority	Primary	2	3
17	Non-Governmental Organizations (NGOs)	Primary	3	2
18	Local Communities	Primary	3	1
19	Educational & Research Institutions	Secondary	2	1
20	Nehru Yuva Kendra Sangathan (NYKS)	Secondary	3	2
21	State Rural Livelihoods Mission (SRLM)	Secondary	1	2
22	Ecological Task Force (ETF)	Secondary	3	2
23	Disaster Management Authorities	Secondary	2	2
24	Urban Planning and Development Authorities	Secondary	2	3
25	Waste Management Agencies	Secondary	2	1
26	Media and Communication Agencies	Tertiary	2	1
27	Policy Makers and Legislators	Tertiary	3	3
28	Corporate Social Responsibility Wings	Tertiary	2	2
29	Traditional Knowledge Holders and Indigenous Groups	Tertiary	2	1
30	Law Enforcement Agencies	Tertiary	3	3
31	Central Pollution Control Board (CPCB)	Tertiary	3	3
32	Ministry of Urban Development / Housing and Urban Affairs	Tertiary	2	3
33	National Mission for Clean Ganga (NMCG)	Tertiary	3	3
34	Ministry of Environment, Forest and Climate Change (MoEFCC)	Tertiary	3	3
35	Ministry of Jal Shakti	Tertiary	3	3
36	Ministry of Agriculture & Farmers Welfare	Tertiary	2	3
37	Ministry of Rural Development	Tertiary	2	2

Legitimacy Score (c)	Impact	Position	Salience (D=√(a²+b²+c²))
2	2	+/-	4.12
2	3	+/-	4.12
2	2	+/-	4.69
2	3	+/-	4.69
2	2	+/-	4.12
3	3	+	5.2
2	3	+/-	2.45
1	1	-	1.73
2	3	+/-	3.46
3	3	+	5.2
3	3	+	5.2
3	3	+	4.69
1	3	-	3.32
3	3	+	5.2
2	3	+/-	4.12
2	3	+/-	4.12
2	3	+/-	3.74
2	3	+/-	3.74
3	3	+	3.74
3	2	+	4.69
3	2	+	3.74
3	3	+	4.69
2	3	+/-	3.74
2	2	+/-	3.87
2	2	+/-	3
1	2	+/-	2.69
3	3	+	5.2
2	2	+/-	3.46
2	1	+/-	2.45
3	3	+	5.2
3	3	+	5.2
3	2	+	4.12
2	2	+/-	5.2
3	3	+	5.2
3	3	+	5.2
3	3	+	4.69
2	3	+	3.87

The stakeholder structure for Gomti River conservation is structured across varying levels of salience, reflecting their relative influence, authority, and functional roles. High-salience government departments such as the Uttar Pradesh Forest Department, State Program Management Group (SPMG), State Water Resources Authority (SWaRA), and Uttar Pradesh Pollution Control Board (UPPCB) constitute the institutional core of river basin governance, given their mandates in regulatory enforcement, watershed management, biodiversity conservation, and pollution control. Medium-high salience departments, including District Administration, Agriculture, Water and Sanitation, Village Panchayats, Fisheries, Lucknow Development Authority, and the Ground Water Department, bridge policy and field-level implementation through community mobilization, livelihood management, and resource regulation. Community and civil society stakeholders, notably NGOs and local communities, though less powerful, provide essential social capital, ecological knowledge, and cultural legitimacy. In contrast, local industries, categorized as low-salience actors, pose ecological challenges due to pollution but require strict regulation and sustainable practices for meaningful integration into conservation. Secondary stakeholders such as the Ecological Task Force, Nehru Yuva Kendra Sangathan, higher education institutions (e.g., IIT Roorkee, University of Lucknow), and the State Rural Livelihoods Mission play supportive roles through research, youth mobilization, livelihood diversification, and awareness generation, complemented by administrative bodies ensuring coordination and delivery. At the strategic level, tertiary stakeholders, including national ministries (MoEFCC, Ministry of Jal Shakti), regulatory authorities (CPCB), and the National Mission for Clean Ganga (NMCG), provide overarching policy, legal frameworks, and funding, aligning Gomti-specific initiatives with broader Ganga basin conservation priorities. This multi-tiered network of stakeholders collectively underpins integrated governance, scientific management, and community-driven action for sustaining the Gomti River ecosystem (Table 12.8).


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Table 12.8. Role of various stakeholders in Gomti River conservation.

Stakeholder Level / Strategy Area	Key Actions/Initiatives
High Salience Stakeholders	
Institutional Strengthening & Coordination	- River Basin Management Authority - Real-time integrated data sharing platforms - Performance-based funding linking outcomes to resource allocation - Inter-departmental committees (district/basin level)
Policy Alignment & Regulatory Harmonization	- Harmonize conflicting regulations between departments - Unified environmental clearance processes - Joint monitoring/enforcement for pollution & habitat control
Medium Salience Stakeholders	
Capacity Building & Technical Support	- Training village panchayats for water quality and biodiversity monitoring - Micro-finance for community conservation enterprises - Technology/equipment transfer - Governance training for participatory decision-making
Community-Government Interface	- River Conservation Committees linking villages with government - Community-based monitoring networks - Benefit-sharing for community conservation efforts
Cultural and Social Stakeholders	
Religious & Cultural Integration	- Work with religious leaders for sustainable festivals/ river reverence - Use traditional knowledge in conservation planning - Culture-based programs - Media campaigns about heritage/conservation
Community Behavioural Change	- Strengthening the Ganga Prahari Cadre -Pollution/sustainability awareness campaigns - Youth education in schools/colleges - Mobilize women's groups for local level conservation
Academic & Research Partners	
Decision Support & Research	- Partner with academic for scientific decision tools - Ecological monitoring networks - Research into ecosystem service values and economics - Develop affordable pollution/habitat technology
International & Financial Partners	
Innovative Financing	- Payment for ecosystem services - Public-private partnerships for infrastructure - Carbon credits for forest/climate linkages

12.3.2. Activities conducted with stakeholders to ensure their participation in conservation

A wide range of conservation, awareness, capacity-building, and community engagement activities were conducted with various stakeholders, including District administration, Ganga Praharis, media, State Government, visitors and tourists, local businesses, Bal Ganga Praharis, local communities, educational institutions, Uttar Pradesh Forest Department, Pravasi Ganga Prahari, Panchayati Raj institutions, civil society organizations, line agencies and other relevant groups. A total of 548 activities were conducted, engaging 25,613 participants across different thematic areas. The distribution of activities and participation reflects the project's strong focus on awareness generation, stakeholder engagement, and livelihood enhancement as key components of river conservation.

Awareness and sensitization activities constituted the largest category, accounting for 165 activities (30.11% of the total) and engaging 14,512 participants (56.66% of all participants). These activities were conducted with diverse stakeholder groups to promote awareness on river conservation, biodiversity protection, sustainable practices, and the importance of community participation in safeguarding the Ganga and its tributaries. Consultative meetings formed the second largest category, with 129 activities (23.54%) involving 1,207 participants (4.71%). These meetings served as important platforms for interaction and dialogue among stakeholders, facilitating collaborative planning, information sharing, and strengthening participation in conservation initiatives. Sensitization workshops accounted for 93 activities (16.97%) and engaged 2,549 participants (9.95%). Conducted with various stakeholder groups, these workshops contributed to capacity building by enhancing knowledge and understanding of ecological conservation, sustainable resource management, and community-led environmental action.

Livelihood development activities represented 61 activities (11.13%) and involved 1,907 participants (7.45%). These interventions aimed to promote sustainable livelihood opportunities among local communities while supporting conservation objectives and strengthening socio-economic resilience. Celebration of special days and events accounted for 29 activities (5.29%) and attracted 1,704 participants (6.65%). Events such as World Environment Day and other conservation-related observances provided opportunities for public outreach, awareness generation, and stakeholder mobilization. Cleanliness drives comprised 23 activities (4.20%) with 922 participants (3.60%), encouraging collective action among stakeholders for maintaining riverine ecosystems and promoting environmental stewardship. Similarly, life activities, which included various community-focused interventions, accounted for 14 activities (2.55%) involving 791 participants (3.09%). Socio-economic surveys were conducted through 12 activities (2.19%), engaging 151 participants (0.59%). These surveys generated valuable information on local livelihoods, community needs, and socio-economic conditions relevant to conservation planning. Plantation drives were undertaken through 7 activities (1.28%) involving 361 participants (1.41%), contributing to habitat restoration and ecological improvement in riverine areas. Field visits and river walks, although limited in number (5 activities; 0.91%), engaged 36 participants (0.14%) and provided practical learning opportunities related to river ecology, biodiversity, and conservation challenges. Participatory mapping activities were conducted through 2 activities (0.36%) involving 34 participants (0.13%), helping document local knowledge and identify conservation priorities.

The category classified as "Others" included 8 activities (1.46%) that engaged 1,439 participants (5.62%). These activities addressed specific local needs and included diverse interventions that complemented the project's broader conservation and outreach objectives. Overall, the activity profile demonstrates the project's extensive engagement with a wide range of stakeholders through awareness generation, consultations, capacity-building programmes, livelihood development initiatives, and direct conservation actions. The high level of participation, particularly in awareness and sensitization activities, highlights the project's effectiveness in fostering stakeholder involvement and strengthening collective efforts towards river conservation and sustainable resource management (Table 12.9).


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Table 12.9. Conservation activities conducted with stakeholders to ensure their long-term participation.

Sl. No.	Type of Activities	No. of Activities	Percentage	No. of Participants	Percentage
1	Awareness and sensitization activities	165	30.11	14512	56.66
2	Cleanliness drives	23	4.20	922	3.60
3	Consultative meetings	129	23.54	1207	4.71
4	Field visits / river walks	5	0.91	36	0.14
5	Life activities	14	2.55	791	3.09
6	Livelihood development activities	61	11.13	1907	7.45
7	Participatory mapping activities	2	0.36	34	0.13
8	Plantation drive	7	1.28	361	1.41
9	Sensitization workshops	93	16.97	2549	9.95
10	Socio-economic survey	12	2.19	151	0.59
11	Celebration of special days and events	29	5.29	1704	6.65
12	Others	8	1.46	1439	5.62
	Total	548	-	25613	-

12.3.3. Community Dependence on Gomti River

The Gomti River plays a vital role in sustaining diverse livelihood activities across the primary, secondary, and tertiary sectors, forming an integral part of the socio-economic framework of communities along its banks. In the primary sector, the river supports agriculture through irrigation, enables fisheries that provide nutritional and financial security specially to marginalized groups and serves as a critical water source for livestock rearing (Khan et al., 2022). In the secondary sector, small-scale and cottage industries depend on the river for textile washing, dyeing, and food processing, while households in rural and peri-urban areas use its water for daily needs such as cooking, bathing, and cleaning due to limited piped supply. The river also contributes to groundwater recharge, supporting borewell irrigation and drinking water access (Dutta et al., 2011; Kumar et al., 2014).

In the tertiary sector, the Gomti is central to cultural and religious activities such as ritual bathing and idol immersion, particularly in cities like Lucknow. These traditions foster a cultural economy involving vendors, boatmen, and tour operators (Singh et al, 2023; Jain, 2024). Despite its ecological degradation, the river remains a spiritual and practical lifeline. A growing population in Lucknow continues to rely on fish from the Gomti (Yadav and Mishra, 2022), though the river has suffered from biomass accumulation, declining flow, and encroachment of floodplains (Shukla et al., 2025). Covering a drainage area of 30,437 sq. km with the Sai River contributing 43% of the catchment (Dutta et al., 2011), the Gomti's water quality has rapidly declined. Bhargava and Tirath (1982) observed that while upstream water near Gaughat remained suitable for most uses, the downstream stretch past Lucknow was heavily polluted and unfit for bathing, fishing, or drinking without treatment.

12.3.3.1. Dependency on Gomti river for Fishing

The Gomti River has historically served as a crucial source of livelihood and nutrition for small-scale fishing communities residing along its banks, particularly in riverine villages across districts such as Lucknow, Sitapur, and Sultanpur. Traditionally, these communities engaged in artisanal fishing, drawing their nets in the river and supplying fresh fish to local markets, with fish also serving as a key component of their daily diet (Pandey, 2025).

While specific demographic data on the number of active fishers along the Gomti is limited, it is understood that most belong to low-income, multi-generational families, echoing trends seen across the broader Ganga basin, where tens of thousands are engaged in inland fisheries. Historically, the Gomti supported over 35 native fish species, which in turn sustained numerous fishing households, particularly in and around Lucknow (Earth5R, 2025).

However, the situation has deteriorated significantly in recent decades. It is estimated that approximately 60% of the native fish species have vanished from the urban stretches of the Gomti due to severe pollution and ecological degradation (Earth5R, 2025). This has led to a dramatic decline in fish catches, pushing many fisher families into economic distress. The decrease in fish population has had a cascading effect, not only eroded traditional livelihoods but also increased household food insecurity, as many fishers are now forced to purchase what they once freely harvested.

The primary threats to riverine fisheries in the Gomti are pollution from untreated sewage and industrial discharge, combined with low water flow and hydrological alterations caused by dams and barrages. These factors have contributed to habitat fragmentation, loss of breeding grounds, and disruption of migratory pathways (Earth5R, 2025). As fish populations decline, fisher families face not only economic hardship but also health risks from exposure to contaminated water and toxic fish, exacerbating their vulnerability. In response, the government has initiated several support schemes to bolster the riverine fishing sector (Table 12.10). Under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), Uttar Pradesh has begun upgrading the state hatchery in Lucknow into a modern facility, now known as the Gomti Hatchery, aimed at enhancing native fish seed production. Additionally, programs like Operation Chitala promote restocking efforts for endangered riverine species. Welfare initiatives, including subsidies for boats, fisheries credit cards, and accident insurance, have also been introduced to improve fisher security. National-level efforts such as the National Fishermen Welfare Scheme offer broader health and social protection measures.

Table 12.10. Initiatives by the Government of Uttar Pradesh to support riverine fishing.

Initiative / Program	Description / Objective	Implementing Body	Scale
Pradhan Mantri Matsya Sampada Yojana (PMMSY)	Upgrading the state hatchery in Lucknow to the modern Gomti Hatchery for native fish seed production	Fisheries Department	State-level (Uttar Pradesh), Central scheme
Operation Chitala	Restocking of endangered riverine species like Chitala chital	State Fisheries Department	State level
Subsidies for Boats	Financial assistance to support acquisition and maintenance of fishing boats	State Fisheries Department	State and Central Governments
Fisheries Credit Cards	Easy access to institutional credit for fisheries-related activities	NABARD & Banks under PMMSY	National level
Accident Insurance	Personal accident coverage for registered fishers	Central Government	National level
National Fishermen Welfare Scheme	Health and social protection programs for fishermen and their families	Ministry of Fisheries, GoI	National level

Despite these efforts, the restoration of livelihoods remains closely tied to the ecological revival of the river itself. Without significant improvements in water quality, flow regulation, and habitat conservation, such policy interventions are unlikely to yield sustainable results. Addressing the challenges of the Gomti's fishing communities thus demands an integrated approach, linking socio-economic support with ecological rehabilitation.

12.3.3.2. Dependence on Gomti river for agricultural production

Agriculture represents the single largest sectoral demand on water resources in the Gomti River basin. Farmers residing along the river, particularly in the districts of Pilibhit, Lakhimpur Kheri, Sitapur, Hardoi, Lucknow, Sultanpur, and Jaunpur, depend heavily on the Gomti for irrigation and crop productivity. The river supports cultivation of high-water-demand crops such as rice, wheat, and sugarcane, primarily through canal diversions and groundwater pumping via wells located in the floodplain areas (Pandey, 2025). This spatial distribution highlights a strong geographic concentration of agricultural reliance in both upper and middle basin districts.

Water use statistics for Uttar Pradesh underscore the centrality of agriculture in regional water management: approximately 92.2% of the state's total water consumption is allocated to irrigation, compared to just 5.2% for domestic use and 2.6% for industrial purposes (Government of Uttar Pradesh, 2009). Although basin-specific data are not published, extrapolations suggest that tens of thousands of hectares in the Gomti basin are irrigated using river water or alluvial groundwater sources recharged by the river. In addition to water, farmers have traditionally benefited from natural silt deposition during periodic monsoon flooding, which enriched soil fertility. However, the construction of embankments and extensive river engineering works has curtailed these processes (Pandey, 2025).

The irrigated and water demand profile of districts within the Gomti River basin reflects significant spatial variability in agricultural water use. Pilibhit, Shahjahanpur, Sitapur, Hardoi, and Jaunpur emerge as major irrigated districts, with gross irrigated areas exceeding 3.5 lakh hectares each. Shahjahanpur records the highest gross irrigated area (6.04 lakh ha) and Lucknow has the highest gross water demand (0.25 BCM), highlighting its intensive irrigation dependence. In contrast, districts like Lakhimpur Khiri, Varanasi and Ghazipur report relatively lower irrigated areas, although their gross water demand (0.194, 0.193, 0.180 BCM, respectively) remains substantial, indicating high water requirements despite limited irrigated extent. The net irrigated area follows a similar trend, with Hardoi, Sitapur, and Ghazipur accounting for more than 3.5 lakh hectares each, while districts like Lakhimpur Kheri and Varanasi have smaller net irrigated areas. Notably, Barabanki records a high unirrigated or rainfed extent (2.9 lakh ha), suggesting a strong reliance on rainfall for cultivation, whereas Pilibhit shows minimal rainfed agriculture (7,575 ha), given its widespread irrigation coverage as mentioned earlier (Table 12.11).

Gross water demand across districts varies between 0.10 BCM (Pilibhit, Amethi) and 0.25 BCM (Lucknow), closely linked to irrigation intensity and cropping practices. The dataset highlights that the districts Hardoi, Lucknow, and Lakhimpur Khiri are particularly water-intensive, underscoring the importance of efficient irrigation practices, water budgeting, and demand management strategies in the basin (Table 12.11). The demand of water for irrigation is projected to increase in the future for all these districts.


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Table 12.11. District-wise irrigation profile and gross water demand in the Gomti River Basin. Source: State Irrigation Plan Uttar Pradesh (2018)

District	Gross Irrigated Area (ha)	Net Irrigated Area (ha)	Un-Irrigated or Totally Rainfed (ha)	Gross Water Demand (BCM)
Pilibhit	387109	231439	7575	0.100077870
Shahjahanpur	603972	322962	27276	0.161184110
Lakhimpur Khiri	28219	18532	133098	0.194315963
Sitapur	559368	375266.9787	61116	0.103708680
Hardoi	560820	397900	96067	0.218131610
Lucknow	152188	106425	14332	0.249504000
Barabanki	217109	168748	290975	0.118992379
Ayodhya	244979	151938	16934	0.132814000
Sultanpur	230992	152962.192	43192	0.123488920
Pratapgarh	261634	158665	37835	0.167141342
Jaunpur	401875	256753	73813	0.156475349
Varanasi	131624	84159	21276	0.193728240
Ghazipur	-	352757	46373	0.180907648
Amethi	203978	129922.29	19728	0.101324786

The agricultural community now faces multiple emerging challenges. Climate variability, particularly declining monsoon rainfall, has made water supply increasingly unreliable. Most of the agriculture and crops are dependent on irrigation (Table 12.12). Groundwater levels are falling across key agricultural areas; for instance, in Lucknow, water tables have been observed to decline at a rate of 0.5–1.0 meters per year since 2005, largely due to intensive groundwater pumping (Pandey, 2025). Moreover, pollution from untreated sewage and industrial effluents has degraded river water quality, raising concerns about the suitability of Gomti water for irrigation and its potential impacts on crop yields. The disruption of natural flooding cycles also means that farmers must supplement declining soil fertility with increased fertilizer use, raising production costs and ecological risks (Government of Uttar Pradesh, 2009).

In response to these pressures, both state and central governments have introduced a suite of policy interventions aimed at promoting water-efficient agriculture. The Uttar Pradesh Water Policy encourages the adoption of micro-irrigation technologies such as drip and sprinkler systems, which have been made mandatory for certain high-water-use crops (Ground Water Department, 2013). National-level programs like the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) and the Micro Irrigation Fund offer financial subsidies to support the implementation of water-saving technologies at the farm level (https://www.pmksy.gov.in/). While there are no Gomti-specific agricultural schemes currently active, broader watershed and farm productivity initiatives are being leveraged by state agencies to engage farmers in sustainable water use practices. These programs mark important steps toward reducing agricultural pressure on the Gomti River. However, their effectiveness remains limited unless coupled with larger river basin restoration efforts and active community participation in water governance.

Table 12.12. Gross cropped area along Gomti River Basin. Source: Mali et al. (2017)

Sl. No.	Crops	Irrigated area (ha)	Rainfed area (ha)
1	Wheat	11,27,555	5561
2	Paddy	7,21,896	18117
3	Sugarcane	1,58,390	19812
4	Mustard	46,826	9623
5	Black Gram	0	54227
6	Maize	2718	49063
7	Potato	40,628	4142
8	Lentil	0	35469
9	Pigeon Pea	26	30532
10	Sorghum	40	21683
11	Pearl Millet	79	18819
12	Chickpea	1,143	14667
13	Sesame	35	15717
14	Peas	15,109	0
15	Groundnut	124	9954
	Total	21,14,569	307386

12.3.3.3. Dependence on Gomti river for cultural and spiritual services

The Gomti River serves as more than a physical watercourse; it functions as a deeply embedded cultural and spiritual lifeline for numerous communities across Uttar Pradesh, particularly in the urban and peri-urban areas of Lucknow, Sultanpur, Jaunpur, and Pilibhit. Its historical and cultural importance is reflected in centuries-old traditions that continue to shape religious rituals, communal gatherings, and everyday practices of river-dependent populations.

In Lucknow, Gomti Ghat stands as one of the most significant ritual locations, hosting daily aartis, ritual bathing, and post-cremation rites. Similarly, towns like Sultanpur and Jaunpur organize annual fairs along the ghats, attracting thousands of devotees during key festivals such as Kartik Purnima, Ganga Dussehra, Chhath Puja, and Makar Sankranti. Specific sites like Kudiya Ghat host mass aartis and evening rituals, while Machchli Ghat and Laxman Ghat are essential for ancestral rites. The Gomti Sangam in Jaunpur, where the Gomti and Sai rivers converge, holds spiritual importance as a site of collective purification through ritual bathing. These gatherings play a pivotal role in intergenerational cultural transmission, communal bonding, and spiritual enrichment. However, they also pose significant ecological challenges. The large-scale deposition of biodegradable and non-biodegradable waste—often in the form of ritual offerings—places immense pressure on the river's biomass and overall ecological health. The consequences of these practices underscore the complex intersection of tradition and environmental sustainability.

Beyond religious functions, the river also acts as a space for cultural expression. During festivals, local theatre troupes and folk artists gather along the riverbanks to perform traditional dramas such as Ramleela and devotional bhajans, reinforcing regional folklore and oral traditions. These events provide a platform for the practice and preservation of Ganga-Jamuni Tehzeeb—a syncretic tradition reflecting Hindu-Muslim cultural harmony in the region. These gatherings not only sustain cultural identity but also generate economic opportunities for local artisans, craftsmen, and vendors, who rely on festival markets for their livelihood. Furthermore, the washer folks (dhobi) community represents a unique segment of cultural and occupational dependency on the river. For these communities, the Gomti is not only a natural resource but also a space of daily ritual and spiritual purification. Washing clothes along the riverbank is seen as both a livelihood practice and a symbolic act of cleansing, passed down through generations.

In sum, the Gomti River is intricately woven into the cultural fabric of the region. Its ghats and waters continue to serve as sites of spiritual, communal, artistic, and economic activity. However, this cultural reliance also brings with it environmental vulnerabilities that must be addressed through culturally sensitive ecological management and active community engagement.

12.3.3.4. Dependence on Gomti River for cottage or small-scale industries

Small cottage industries along the Gomti River Basin form an essential part of the rural economy, reflecting a deep-rooted dependence on the river's resources, both directly and indirectly. These include traditional crafts such as handloom weaving, pottery, brassware, leather tanning, and small-scale food processing units, many of which rely on water either as a raw material or for production processes (Pandey, 2013). For instance, dyeing units in districts like Sultanpur and Jaunpur depend on the Gomti for water used in textile colouring, while pottery and brick-making industries use riverine clay extracted from the banks (Gupta et al., 2014; Kumar et al., 2023). Leather tanning, particularly in peri-urban areas near Lucknow, also historically depended on Gomti water, though increased pollution and regulatory interventions have pushed many units to adopt alternative sources or close operations altogether (Verma et al., 2021). Furthermore, the river's flow supports agriculture-based microenterprises, such as jaggery production and oil pressing, by sustaining crop cycles and irrigation (Mali et al., 2018). Thus, fluctuations in river health, caused by pollution, over-extraction, or climate variability, directly impact the sustainability of these livelihoods, underscoring the need for integrated river basin management that includes small-scale industry stakeholders in conservation planning.

12.3.4. Gomti River: Ecosystem Services

Participatory mapping of ecosystem services was carried out in five villages along the Gomti River, spanning two districts, viz. Pilibhit and Jaunpur, in Uttar Pradesh. A total of 66 individuals participated in the mapping, of which 26 were males and 40 were females. Three of the villages surveyed, namely Madhotanda, Navdia Dhanesh and Udaikaranpur (Pilibhit district, Uttar Pradesh), were situated in the low flow zone of the river, i.e., upstream of Mohammadi Kheri block, near Gomat Taal, and two of the villages surveyed, namely Chandwak and Balua (Jaunpur district, Uttar Pradesh), were situated in the high flow zone of the river, i.e., downstream of the Gomti-Sai confluence and Jaunpur city, and upstream of the Ganga-Gomti confluence. An overview of the perceived extent and trend of ecosystem services availed by the sampled villages is presented in Table 12.13.

12.3.4.1. Provisioning Services

Water for drinking and domestic use: Groundwater is the primary source of drinking and domestic water for communities along the Gomti River. The three major urban centres, Lucknow, Sultanpur, and Jaunpur, rely heavily on groundwater, supplemented by surface water extraction from the Gomti in Lucknow and Jaunpur. Outside the monsoon season, the Gomti flows as a narrow stream with sluggish discharge; the Sharda and Sharda Sahayak Canal systems therefore supplement supply in Lucknow.

Water *for* irrigation
Irrigation depends largely on groundwater through borewells and tubewells. The Gomti flows as a narrow, fragmented stream for approximately 100 km until it is joined by the Sukheta, Chuha, and Andhra Chuha tributaries near Mohammadi Kheri block, Lakhimpur Kheri district; upstream of this confluence, the Sharda system supplements irrigation. Downstream of the Gomti–Sai confluence, agricultural fields near the riverbank are irrigated from river water. Lift irrigation schemes on the Gomti remain under-utilised due to irregular water availability and energy shortages, functioning at nearly half their installed capacity. Extensive groundwater extraction to meet growing population demands has reduced the river's flows, given its groundwater-fed character.

Agriculture
Agriculture dominates livelihoods in the basin. Cropping patterns include wheat and pea (Rabi), rice, sugarcane, and peanuts (Kharif), and cucurbits (Zaid). Perennial and horticultural crops such as banana, mango, and guava are also cultivated, and water chestnut (*Trapa bispinosa*) grows in marshy areas. Opportunistic agricultural expansion has led to encroachment on the riverbed—particularly in upper stretches—intensifying pressure on both groundwater and surface water resources.

Livestock
Cows, buffaloes, and goats are widely reared, with grazing grounds along canals, ponds, and riverbanks. Fodder comes from cultivated crops (barseem, bajra, oats) and wild grasses *(Saccharum spontaneum, Imperata cylindrica*). The river provides water for livestock drinking and bathing. Encroachment and reduced flow threaten the availability of grazing and bathing areas.

Biotic Resources – Fish
Fishing is a key livelihood downstream of the Gomti–Sai confluence, where flow conditions support diverse species including rohu (*Labeo rohita*), catla *(Catla catla)*, phul dhok *(Channa punctatus)*, bachwa (*Eutropiichthys vacha*), ghaura (*Clupisoma garua*), singhi (*Heteropneustes fossilis*), and boyari (*Wallago attu*), among others. Upstream, fishing occurs mainly in canals and ponds, often supplemented by aquaculture; gill nets and drag nets are commonly used. Fish catches have declined due to pollution, reduced flow, unsustainable practices, and habitat loss from channelisation and riverfront development—only two of the eight fish habitat types documented in undisturbed stretches persist in channelised segments (Dutta et al., 2018).

Biotic Resources – fuelwood and fodder
Communities near Gomat Taal collect dry wood from mango orchards and eucalyptus plantations for fuelwood. Species collected for personal use include semal (*Bombax ceiba*), arjun (*Terminalia arjuna*), neem (*Azadirachta indica*), peepal (*Ficus religiosa*), banyan (*Ficus bengalensis*), bamboo, and giloy (*Tinospora cordifolia*). For fodder, cultivated crops (barseem, bajra, oats) are supplemented by riverine grasses: kans/wild sugarcane (*Saccharum spontaneum*), munj (*Saccharum bengalense*), darbh/cogon grass *(Imperata cylindrica),* and loonder (*Themeda anathera*). Agricultural expansion and

urbanisation threaten grazing grounds and riverine grasses.

Abiotic Resources
Due to its groundwater-fed origin and limited sediment supply, the Gomti has minimal sand deposits. Localised sand mining is reported only in the lower reaches, though it remains small in scale.

12.3.4.2. Regulation and Maintenance Services

Provision of habitat for biodiversity
The Gomti supports species of conservation significance, including the Endangered Gangetic dolphin (*Platanista gangetica*), Vulnerable smooth-coated otter (*Lutrogale perspicillata*), Vulnerable mugger (*Crocodylus palustris*), five freshwater turtle species, water-associated birds such as the Endangered Indian skimmer (*Rynchops albicollis*) and Vulnerable river tern (*Sterna aurantia*) and sarus crane (*Grus antigone*), and the Critically Endangered pinna catfish (*Pinniwallago kanpurensis*) and Endangered wagur (*Clarias magur*). Four protected areas lie within the Gomti Basin: Pilibhit Wildlife Sanctuary, Kishanpur Wildlife Sanctuary, Shaheed Chandra Shekhar Azad Bird Sanctuary, and Samaspur Bird Sanctuary. No segment of the river itself is protected under the Wild Life (Protection) Act, 1972. River channelisation, encroachment, and pollution have led to the loss of fish habitats; only two of eight habitat types persist in modified segments. The Critically Endangered three-striped roofed turtle (*Batagur* dhongoka) was last reported in 1992. Declining forests and wetlands further reduce tributary flows, impacting biodiversity.

Soil fertility
The Gomti is a groundwater- and rain-fed perennial river flowing through the alluvial plain. It carries no freshly weathered Himalayan material but redistributes alluvial sediments (Kumar & Singh, 1978). Soils along the river are fertile and support intensive agriculture. However, fertility is increasingly threatened by siltation from runoff, excessive agrochemical use, and sewage contamination. While farmers perceive soil fertility as stable, long-term risks of degradation are evident.

Waste water management
The Gomti receives untreated or partially treated sewage from villages, towns, and industries, including distilleries, sugar mills, and paper mills. Sewage from surveyed villages is discharged directly into the river, village ponds, and agricultural fields, impacting water and soil quality. Nutrient enrichment has resulted in widespread proliferation of water hyacinth (*Eichhornia crassipes*), observed at both the river's origin and mouth.

12.3.4.3. Cultural Services

The Gomti River embodies a layered cultural landscape, linking sacred mythology, pilgrimage, funerary rituals, historical architecture, and syncretic traditions. It is one of the Purāṇic rivers mentioned in the Bhāgavata Purāṇa and Kūrma Purāṇa, and is revered in Hindu tradition as the daughter of Sage Vasiṣṭha (one of the Saptarishis). Though not deified as a Goddess like the Ganga or Yamuna, its waters are considered purifying, with ritual bathing observed during festivals. This belief is reinforced by the association that Lord Rāma bathed in the Gomti to atone for the killing of Rāvaṇa, linking the river directly to the Rāmāyaṇa.

Both the river's origin (Gomat Taal, Pilibhit district) and mouth (Ganga–Gomti confluence at Kaithi village, Varanasi district) hold immense religious value. Gomat Taal, maintained as a temple reservoir, draws pilgrims for ritual bathing. The Markandey Mahadev Temple at Kaithi attracts large congregations during the month-long Sawan fair. Siddh Baba Temple, a 500-year-old shrine within the Pilibhit Tiger Reserve, hosts an annual pilgrimage in May–June. Riverbanks also serve as cremation sites for riverside communities. Numerous sacred sites line the Gomti: Naimisharanya (comprising Naimisharanya Temple, Lalita Devi Temple, Chakra Tirth, and others) and Rudravart Mahadev Temple in Sitapur district; Gomeshwar Mahadev Temple (an island temple) and Chandrika Devi Temple in Lucknow district; and Sitakund and Dhopap Temple in Sultanpur district. The religio-cultural landscape is further enriched by the Sharqi dynasty mosques of Jaunpur and the Nawabi-era mosques and Imambadas of Lucknow.

Historically, the Gomti was integral to the cultural identity of the Kingdom of Awadh. Cities such as Lucknow, Sultanpur, and Jaunpur evolved as centres of political authority, artistic innovation, and syncretic culture. In Lucknow, the Nawabs of Awadh patronised the Ganga-Jamuni Tehzeeb—a composite cultural ethos blending Hindu and Muslim traditions—reflected in literature, cuisine, architecture, and performing arts. Monumental architecture on the Lucknow riverbanks includes Asafi Imambada, Rumi Darwaza, Farhat Baksh (Chhatar Manzil complex), Constantia (La Martinière), and Qaiserbagh.

Nature-based tourism centred on the river remains minimal, constrained by degraded conditions, low flow, and the absence of protected areas along its length. A ghat developed at the Ganga–Gomti confluence in Kaithi, Varanasi, is served only by Ganga boats. Kukrail Reserve Forest in Lucknow, an urban forest with a picnic spot and the Gharial

Rehabilitation Centre (a breeding centre for gharials and freshwater turtles), is a popular tourist destination, with the Kukrail River (now a drain) flowing through it. Popular recreational sites cited by surveyed villages include the Sharda Canal bifurcation point and Chuka Beach within Pilibhit Tiger Reserve. The Gomti Riverfront in Lucknow has been developed for river-centric recreation, with boats available for hire.

Despite its cultural richness, the Gomti's ritual and heritage values are under stress. Agricultural encroachment, untreated sewage, heavy pollution, and the lack of well-maintained ghats have eroded its ritualistic significance. Gomat Taal, despite being a sacred origin point, suffers from untreated sewage inflows and agricultural runoff, diminishing its sanctity.

Table 12.13. An overview of the perceived extent and trend of ecosystem services availed by the sampled villages

	Villages near the origin (low flow stretch) ***(Madhotanda, Navdia Dhanesh, and Udaikaranpur villages, Pilibhit district)***	**Villages near the confluence (high flow stretch)** ***(Chandwak and Balua villages, Jaunpur district)***
Extent	·Groundwater is the primary source of water for drinking, domestic use, and irrigation. ·Surface water use is limited and sourced from the Sharda Canal system, reflecting the Gomti's sluggish flow near its origin. ·Agriculture dominates livelihoods, supported by high groundwater irrigation and fertile soils. ·Livestock services—water, grazing, and fodder—are of moderate extent, with animals using the Sharda Canal system, ponds, and riverbanks. ·Fuelwood and NTFPs are important, particularly in Madhotanda, which is rated high owing to its proximity to Pilibhit Tiger Reserve. ·Fishing is low, confined to ponds and canals. ·Sand mining is absent. ·Cultural services are prominent: religious value is rated medium to high, anchored by Gomat Taal and Siddha Baba Temple, while tourism is perceived as high, reflecting the importance of pilgrimage and ecotourism linked to Pilibhit Tiger Reserve.	·Groundwater remains the main water source ·Surface water use is low to medium. ·Agriculture remains central, supported by groundwater irrigation and moderate soil fertility. ·Livestock services are more significant here than upstream, consistently rated high. ·Fishing is moderately important, aligning with higher flow and species diversity, though catches are under pressure. ·Fuelwood and NTFPs are of low extent, reflecting reduced tree cover. ·Sand mining is present but limited. ·Sewage disposal into the river is consistently high, indicating heavy dependence on the Gomti as a waste sink. ·Provision of habitat for biodiversity is rated medium, though community perceptions already suggest degradation. ·Cultural services are weaker than upstream, with religious value and tourism both rated low.
Trend	·Perceptions in the Pilibhit district stretch suggest relative stability with pockets of increase. ·Groundwater for drinking and irrigation is generally stable, though Navdia Dhanesh reports a decline in drinking water availability. ·Surface water irrigation is stable or increasing in Madhotanda and Udaikaranpur, reflecting use of the Sharda Canal system. ·Agricultural services and soil fertility are consistently rated stable. ·Livestock-related services are also stable. ·Fishing shows variability—increasing in Madhotanda, stable in Udaikaranpur, and declining in Navdia Dhanesh. ·Fuelwood and NTFPs are mostly stable, with increases reported in some cases. ·Waste disposal into the river is uniformly increasing, pointing to growing pressures on water quality. ·Provision of habitat for biodiversity is generally perceived as stable, though ecological conditions suggest underlying stress. ·Religious value is stable or increasing, reflecting sustained pilgrimage activity ·Tourism is perceived as increasing, supported by ecotourism at Pilibhit Tiger Reserve and nearby religious sites.	·In the Jaunpur district stretch, nearly all services are reported to be declining. ·Both groundwater and surface water for drinking and irrigation are decreasing, highlighting pressures from overextraction and pollution. ·Agriculture is in decline, though soil fertility is still perceived as stable. ·Livestock services (water, grazing, fodder) are all reported as decreasing, reflecting reduced riverine resource availability. ·Fishing is also declining, driven by pollution, habitat degradation, and unsustainable exploitation. ·Sand mining is reported as decreasing, potentially reflecting resource depletion or regulatory restrictions. ·Fuelwood and NTFPs are declining, consistent with low extent and increasing urbanisation. ·Sewage disposal, by contrast, is increasing, pointing to intensifying waste discharge. Biodiversity provision is perceived as declining, in line with loss of aquatic and riparian habitats. ·Cultural services—religious value and tourism—are both declining, with pollution and riverfront degradation eroding traditional practices and riverine aesthetics.

12.3.5. Ganga Prahari program for fostering stewardship

A functional cadre of motivated and trained Ganga Praharis (n= 303) has been established across the eight districts of Uttar Pradesh, to aid in and carry forward conservation activities across the Gomti River Basin (Figure 12.10; Table 12.14). Approximately 82% of the Ganga Praharis are women in the Gomti River Basin. The age class distribution of respondents in the Gomti River Basin reveals a predominantly young population.

About 44% of the Ganga Prahari cadre in Gomti River Basin is comprised of young population of age below 22 years while about 40% of Ganga Praharis aged between 22 to 31 years, and about 2% of the Ganga Praharis are older than 52 years (Figure 12.10). This age structure indicates a demographic skewed toward the younger generation, which has important implications for awareness programs, livelihood planning, and community engagement activities within the Gomti River Basin, and sustainability of conservation efforts.

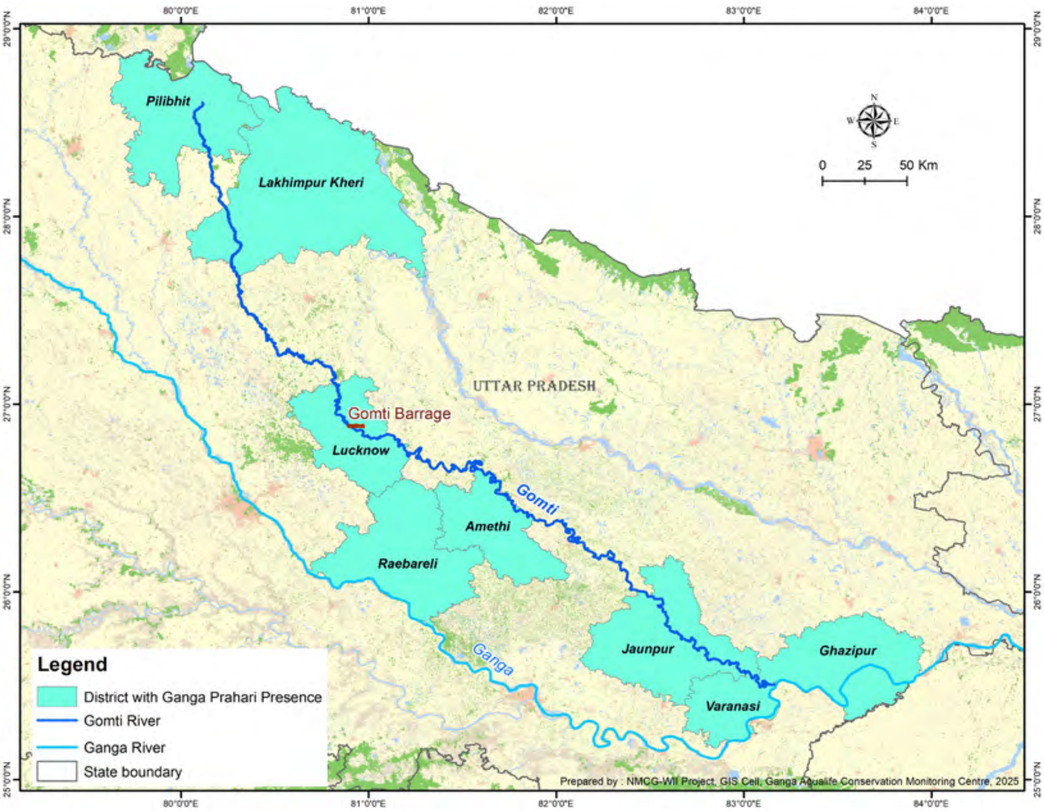

Figure 12.10. Spatial distribution of Ganga Praharis in Gomti River Basin.

Table 12.14. District wise distribution of Ganga Praharis in the Gomti River Basin.

Sl. No.	District	Ganga Praharis		
		Female	Male	Total
1	Amethi	-	1	1
2	Ghazipur	-	5	5
3	Jaunpur	12	9	21
4	Lakhimpur Kheri	-	1	1
5	Lucknow	5	9	14
6	Pilibhit	165	13	178
7	Raebareli	-	1	1
8	Varanasi	66	16	82
	Total	248	55	303
	Percentage	81.85	18.15	-

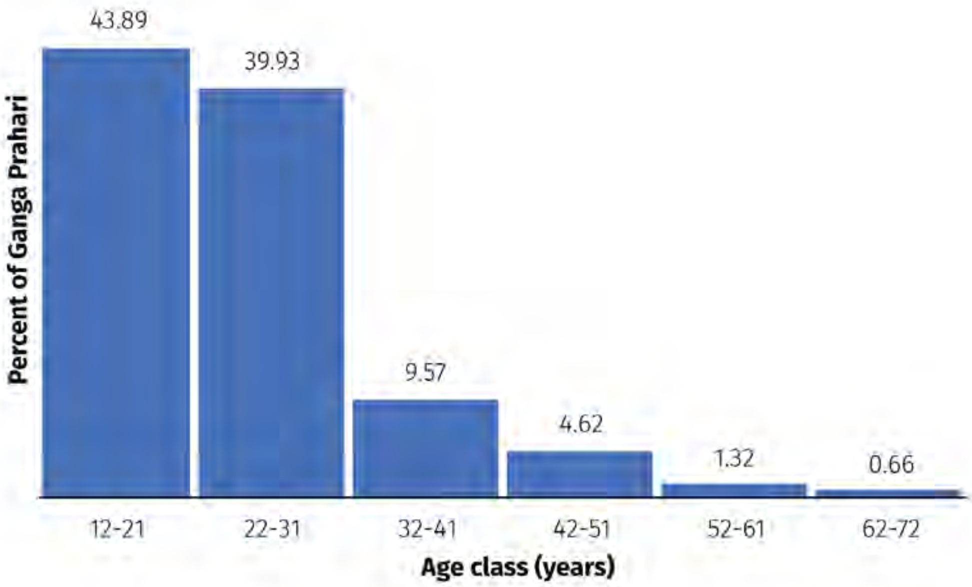

Figure 12.11. Age class distribution of Ganga Praharis in Gomti River Basin

About 30% of the Ganga Praharis have received their education till graduation level, followed by 21.78% and 18.81% of Ganga Praharis who have received secondary and higher secondary education, respectively. Few of Ganga Praharis in Gomti Basin have received doctoral degree while 4.29% have undergone some professional trainings (Figure 12.12).

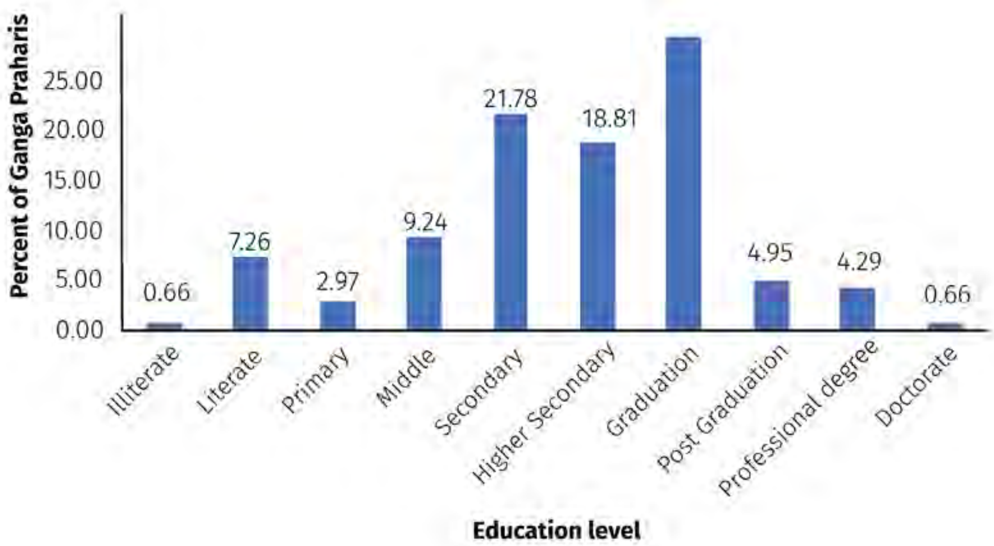

Figure 12.12. Educational qualification of Ganga Praharis in Gomti River Basin

The professional profile of Ganga Praharis in the Gomti River Basin reflects the participation of individuals from diverse socio-economic and professional backgrounds. Students constitute the largest group, accounting for 43.56% of the total Ganga Praharis, indicating strong engagement of youth in river conservation and environmental stewardship activities. Homemakers represent the second-largest category at 21.45%, demonstrating significant involvement of women in community-based conservation efforts. Labourers account for 8.58% of the Ganga Praharis, highlighting the inclusion of economically vulnerable sections of society in the programme. Self-employed individuals (5.61%) and those working with civil societies and self-help groups (4.95%) also form an important segment, reflecting active participation from community-oriented and entrepreneurial backgrounds. Smaller proportions of Ganga Praharis are unemployed (3.63%), engaged in agriculture (2.97%), business (2.64%), government agencies (1.98%), village panchayats (1.65%), and teaching professions (1.32%). Representation from the private sector (0.99%) and research scholars (0.66%) was comparatively limited (Figure XX). The broad occupational diversity of Ganga Praharis demonstrates the inclusive nature of the programme, bringing together students, homemakers, workers, community organizations, and professionals to collectively contribute towards the conservation and sustainable management of the Gomti River ecosystem (Figure 12.13).

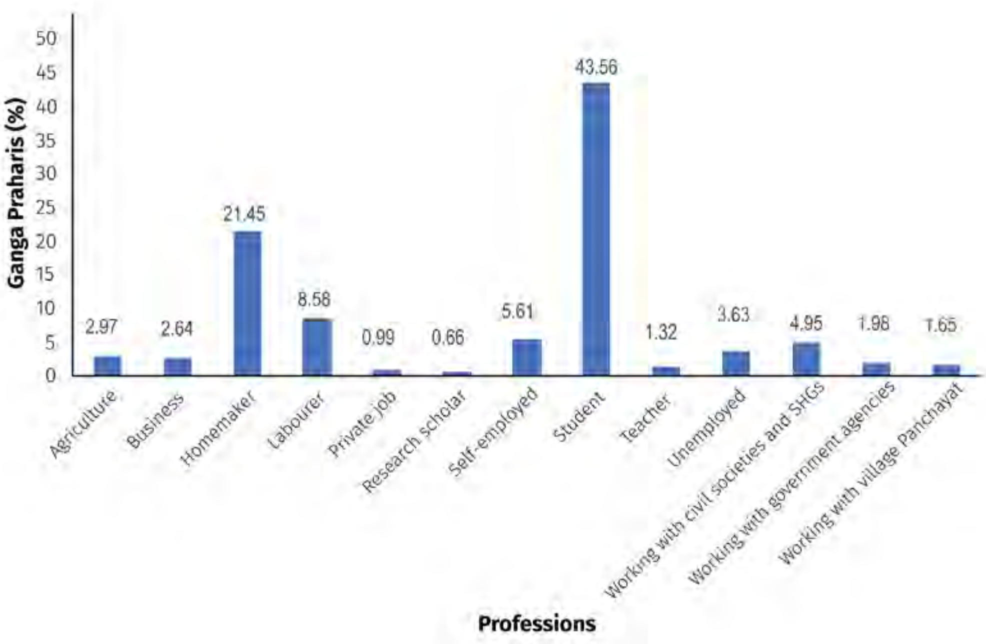

Figure 12.13. Professional profile of Ganga Praharis in the Gomti River Basin

12.3.5.1. Interest and preference of Ganga Praharis in conservation related activities

To understand the preferred areas of engagement among Ganga Praharis, their interests in various environmental and community-based activities were assessed. The findings reveal notable gender-based differences in the choice of activities, while also highlighting a strong overall commitment towards river conservation and community welfare (Figure 12.14). Awareness activities emerged as the most preferred area among both male and female Ganga Praharis, with 70.91% of males and 70.56% of females expressing interest. This indicates a widespread willingness among Praharis to engage in environmental education, community outreach, and dissemination of conservation messages. Cleanliness drives were another highly preferred activity, attracting interest from 63.64% of male and 54.44% of female Praharis. These initiatives play a crucial role in maintaining river health by reducing waste accumulation and encouraging community participation in sanitation efforts. Livelihood-related activities also received considerable interest, with 63.64% of males and 53.23% of females expressing willingness to participate. This suggests that many Ganga Praharis recognize the importance of linking conservation objectives with sustainable livelihood opportunities for local communities. Plantation activities were similarly popular, particularly among males (61.82%) compared to females (48.39%), reflecting strong support for habitat restoration, enhancement of green cover, and ecosystem improvement along the river basin. Interest in survey-based activities showed substantial gender differences. Ecological surveys attracted 38.18% of male Praharis but only 10.08% of female Praharis, while socio-economic surveys interested 43.64% of males and 10.89% of females. These findings suggest greater male participation in data collection and monitoring activities, although both activities remain important components of evidence-based river conservation planning. Likewise, rescue and rehabilitation activities were preferred by 47.27% of male Praharis compared to 12.50% of female Praharis, indicating a higher inclination among males towards wildlife rescue and emergency response efforts. A contrasting pattern was observed in cultural activities, where 10.48% of female Praharis expressed interest, while no male respondents reported participation interest. Cultural programmes can serve as effective tools for promoting conservation awareness by integrating traditional values, local heritage, and river stewardship messages. Interest in other miscellaneous activities was minimal, with only 1.82% of males reporting participation and no interest recorded among females. Overall, the results demonstrate that awareness generation, cleanliness drives, livelihood promotion, and plantation activities constitute the primary areas of interest among Ganga Praharis.

The strong participation in these activities reflects the potential of the programme to combine environmental conservation with community engagement, while the observed gender differences highlight opportunities for designing more inclusive capacity-building and participation strategies across different conservation activities (Figure 12.14).

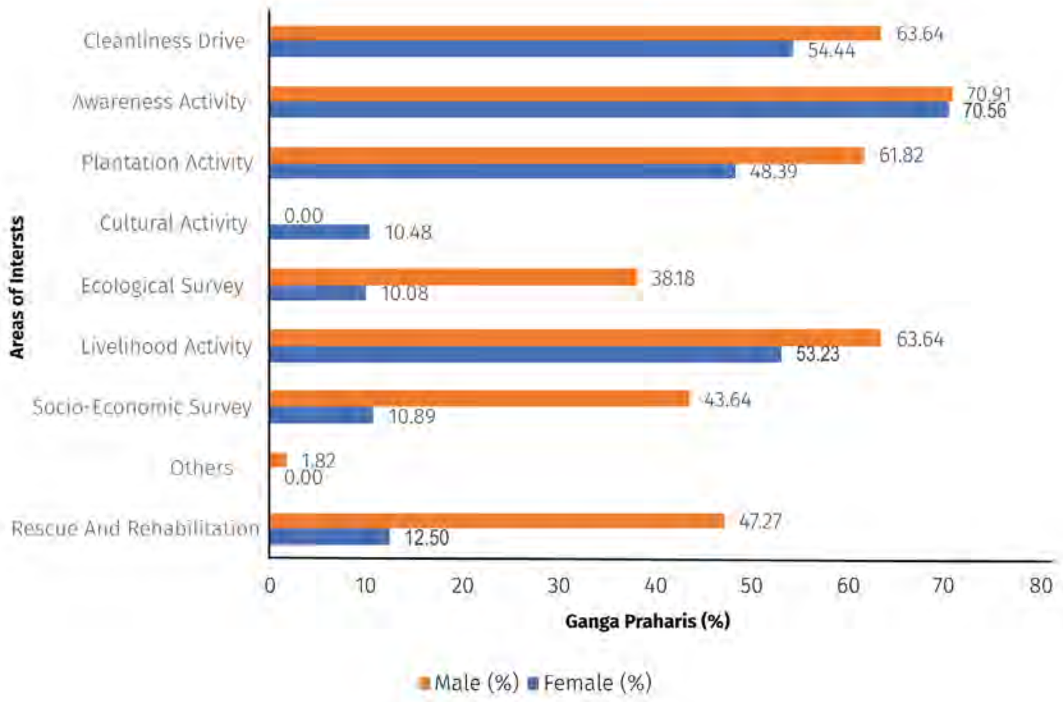

Figure 12.14. Interest and preference of Ganga Praharis in conservation related activities in the Gomti River Basin.

12.3.5.2. Ganga Praharis in action: conservation activities conducted by Ganga Praharis in Gomti River Basin

The conservation activities undertaken by Ganga Praharis in the Gomti River Basin demonstrate their active involvement in a wide range of environmental awareness, community engagement, and conservation initiatives. A total of 59 activities were organized, engaging 1,349 participants across different thematic areas. Awareness activities constituted the largest component of the programme, with 24 events involving 568 participants, highlighting the emphasis placed on educating communities about river conservation and sustainable environmental practices. Special occasions and environmental day celebrations were another major area of engagement, with 11 events attracting 185 participants. Participation in activities organized by other organizations also contributed substantially, with a single event involving 204 participants, reflecting strong collaboration and networking among stakeholders. Cleanliness drives formed an important component of the programme, with seven activities engaging 85 participants in efforts to improve river and community sanitation. Consultative meetings were organized through four events, bringing together 121 participants for discussions on conservation and community issues. Plantation activities included two events involving 65 participants, while livelihood-related activities engaged 57 participants through two programmes aimed at linking conservation with sustainable economic opportunities. Rescue and rehabilitation initiatives comprised three activities with 23 participants, contributing to biodiversity conservation and wildlife protection. Other miscellaneous activities accounted for two events involving 37 participants. Awards and achievements-related events and ecological monitoring represented specialized areas of engagement. Overall, the wide range of activities and substantial participation demonstrate the effectiveness of the Ganga Prahari programme in mobilizing communities and promoting conservation-oriented action in the Gomti River Basin (Figure 12.15).

Table 12.15. Conservation activities conducted by Ganga Praharis in Gomti River Basin.

Sl. No.	Conservation activities	No. of activities	No. of participants
1	Awards & Achievements	2	3
2	Awareness Activities	24	568
3	Cleanliness Drives	7	85
4	Consultative Meetings	4	121
5	Ecological Monitoring	1	1
6	Livelihood Activities	2	57
7	Others	2	37
8	Participation in activities organized by other organizations	1	204
9	Plantation	2	65
10	Rescue & Rehabilitation	3	23
11	Special Occasions and Days Celebration	11	185
	Total	59	1349

12.3.5.3. Achievements and recognition of Ganga Prahari programme

The Ganga Praharis from the Gomti River Basin are steadily emerging as leaders of change, demonstrating exceptional dedication not only to river conservation but also to broader domains of community development. Their consistent efforts and growing commitment are now being recognized and celebrated on various prestigious platforms. On 26th November 2020, one of our Ganga Praharis Shri Pawan Katiyar was honored in Lucknow with a certificate for the successful completion of training by the Deen Dayal Upadhyay Rajya Gram Vikas Sansthan, an acknowledgment of their preparedness to lead grassroots environmental action.

Further elevating the pride of the Gomti Basin, Rama Tiwari, a dynamic Ganga Prahari from Kannauj, was conferred with the *National Youth Icon Award* on 20th January 2021 for her outstanding contributions in the fields of art, culture, sports, and leadership. The award, presented in the presence of former Chief Minister Shri Akhilesh Yadav, stands as a testament to her inspiring journey and community impact. These milestones reflect the growing influence and potential of our Ganga Praharis, who are continuously achieving new heights and serving as role models in the mission to protect our rivers and uplift society.

12.3.6. Livelihood development activities for ensuring community participation in conservation of Gomti River Basin

12.3.6.1. Livelihood skill development trainings in the Gomti River Basin

To strengthen community participation in conservation and promote sustainable livelihood opportunities, a series of skill development and livelihood training programmes were organized across the Gomti River Basin. These trainings aimed to enhance local capacities, create alternative income-generating opportunities, and improve the socio-economic well-being of community members, particularly women. A total of 20 livelihood training programmes were conducted, benefiting 523 participants, of whom 499 (95.4%) were women and 24 (4.6%) were men (Table 12.16), across three Gomti-basin districts: Pilibhit in upper basin (n= 152), Jaunpur in middle (n= 223) and Varanasi in lower basin (n= 148). The strong participation of women reflects the programme's emphasis on women's empowerment and household-level economic strengthening.

Among all livelihood interventions, sewing and stitching emerged as the most prominent training activity. A total of 11 training programmes were organized, engaging 304 participants, accounting for approximately 58.1% of all trainees. The overwhelming participation in this activity indicates a high demand for tailoring and garment-related skills among local women, as these skills can be readily converted into home-based enterprises and supplementary household income. The second most widely attended activity was incense stick (agarbatti) making, for which three training programmes were conducted involving 70 participants. This activity is particularly suitable for rural households because it requires relatively low investment, can be undertaken from home, and offers opportunities for small-scale entrepreneurship. The significant participation demonstrates the potential of such cottage industries for livelihood enhancement in the basin. Several specialized livelihood trainings were also organized. Millet Value Addition Training engaged 35 participants, including 31 women and 4 men, making it one of the few trainings with participation from both genders. The training focused on enhancing the value of locally available agricultural products and promoting nutrition-sensitive livelihoods. Such interventions contribute to both income generation and local food security. Similarly, Health and Wellness Training benefited 28 women participants, while Bag Making Training and Tie and Dye, Block Printing and Patch Work Training trained 25 and 24 women, respectively. These activities provide opportunities for self-employment and support the development of micro-enterprises based on traditional and marketable skills. Basket Making Training attracted 17 women participants, helping preserve traditional craftsmanship while creating avenues for additional income. In contrast, the Electrician Training programme involved 20 male participants, representing the only exclusively male-oriented skill development activity in the dataset. This training focused on technical skills that can enhance employability and support local service needs.

Overall, the livelihood training initiatives demonstrate a strong focus on women-centric skill development, reflecting the programme's commitment to inclusive community development and economic empowerment. The diversity of training themes, from tailoring and handicrafts to food processing and technical trades, indicates a deliberate effort to provide participants with multiple livelihood options suited to local socio-economic conditions. By equipping community members with practical skills and income-generating opportunities, these interventions contribute not only to improved household livelihoods but also to stronger community engagement in river conservation and sustainable development efforts across the Gomti River Basin.

Table 12.16. Details of livelihood trainings conducted in Gomti River Basin.

Sl. No.	Livelihood training	No. of trainings	No. of people trained
1	Bag Making	1	25
2	Basket Making Training	1	17
3	Electrician	1	20
4	Health and wellness	1	28
5	Incense stick making	3	70
6	Millet Value addition	1	35
7	Sewing & Stitching	11	304
8	Tie and dye, block printing and patch work	1	24
	Total	20	523

12.3.7. Jalaj initiative to link local livelihoods with conservation goals

Jalaj is based on the circular economy model where the local people are trained in sustainable livelihood practices and mobilized to contribute to biodiversity conservation and clean river ecosystem. The objective of Jalaj, an innovative mobile livelihood facility, is to synchronize skill development initiatives with the preservation of the Ganga. Jalaj serves as an exemplar for diversifying livelihoods by promoting locally produced goods and encouraging stakeholder engagement in ecological and economic domains to conserve rivers. The site-specific models of Jalaj, enhances local skill sets. Market, and demands are also shaped, such as providing knowledge corners, livelihood training and sale points, ecotourism-based safari boats, nurseries, health and wellness centres, sewing and stitching centres, local produce-based food processing units and sale points, etc.

In Pilibhit district, a Jalaj named Abhayaranya, an awareness & sale point, has been established in the Gomti River Basin, promoting both ecological awareness and sustainable livelihoods. This center facilitates the sale of eco-friendly products sourced from various Jalaj centers across the Ganga River Basin. Aligning with the Sustainable Development Goals, the centre has empowered 90 women through its initiatives. It supports 4 active Self-Help Groups

(SHGs), i.e., Triveni, Ekkottar Nath Prerna, Mahalaxmi, and Balaji, comprising 60 members in total. Moreover, the center has engaged 150 Ganga Praharis and conducted 70 diverse activities, including community consultations and special campaigns from Gomti River Basin. To enhance local livelihoods, the center has provided skill development training in areas like incense stick making and sewing and stitching, and supporting their integration into the green economy.

12.3.8. Village-level micro-plan development to mainstream biodiversity conservation in local development planning in Gomti River Basin

The microplan for village Rajepur, district Jaunpur, Uttar Pradesh, located along the Gomti River, has been developed. Key issues impacting aquatic biodiversity conservation include riverbed farming causing habitat loss for species, particularly turtles; the use of chemical fertilizers in agriculture; inadequate sanitation and waste management facilities; overexploitation of river resources; the use of inappropriate fishing nets; lack of alternative livelihood skills and a lack of awareness about conserving aquatic species (Figure 12.15; Table 12.17).

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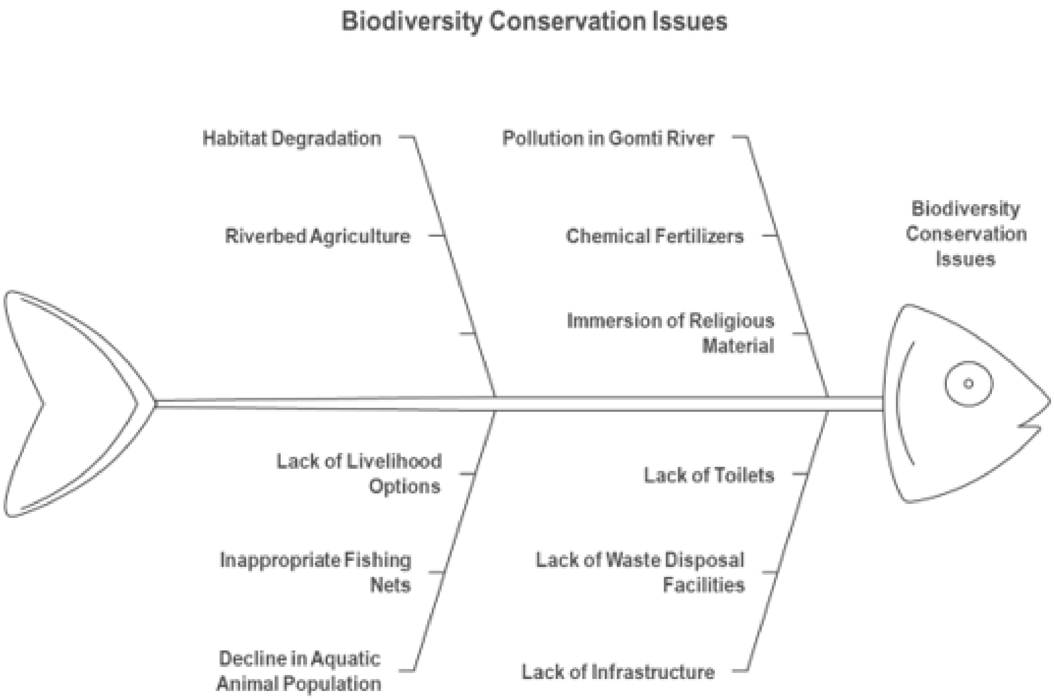

Figure 12.15. Key conservation issues identified in village Rajepur, district Jaunpur, Uttar Pradesh, Gomti River Basin.

12.3.8.1. Details of key conservation issues identified in Gomti River Basin

a) Riverbed farming.
In Rajepur block village 25 fishermen families are engaged in seasonal cultivation of watermelon and cucumber along the banks of the Gomti and Sai rivers, for nearly six months in a year. This regular and prolonged cultivation on the riverbed disturbed the habitat and breeding ground of species, especially Turtles. Prolonged cultivation is further disrupting aquatic ecosystems and adversely affecting nearby human settlements, thereby posing long-term risks to both environmental sustainability and community well-being.

b) Use of chemical fertilizers in agriculture.
To maximize yield, farmers extensively use chemical fertilizers and pesticides. These practices are exerting significant ecological pressure, leading to the degradation of riverine biodiversity, soil health deterioration, and micro-habitat loss.

c) Inadequate sanitation and waste management facilities.
In the village, 66 families lack access to toilets, which forces them to practice open defecation—a significant contributor to river pollution. Additionally, the absence of a waste management facility has led to indiscriminate dumping of solid waste in open areas. Riverside shops further aggravate the problem by disposing of their waste near the river, thereby intensifying pollution and degrading the local environment.

d)Overexploitation of river resources.
Around 20 fishermen families in the village are entirely dependent on the river for their livelihood. However, with the steady decline in fish populations over the years, they have resorted to using fine-meshed nets to maximize their catch, which further threatens juvenile fish and accelerates the depletion of aquatic resources. In addition, local communities rely on riverside vegetation for fodder, as well as for making mats and baskets. This unsustainable extraction is degrading riverbank habitats and adversely affecting the survival of aquatic and riparian species.

e) Use of inappropriate fishing nets.
The use of inappropriate fine-meshed fishing nets results in the indiscriminate capture of even juvenile and undersized fish that hold little or no market value. While these small fish are often discarded as waste, their removal from the ecosystem disrupts the natural replenishment cycle of fish populations.

f) Lack of alternative livelihood skills .
The community in Rajepur village, particularly the fishermen families, lacks alternative livelihood skills. To reduce their dependence on river resources and ensure sustainable income opportunities, there is a strong need for targeted skill development and vocational training programs.

g) Lack of awareness.
The community has limited awareness and understanding of the ecological importance of aquatic species. This lack of knowledge and skills is resulting in unintentional damage to aquatic habitats and breeding grounds along the Gomti River, thereby threatening the survival of species and the overall health of the river ecosystem.

12.3.8.2. Strategies and mechanisms suggested to address the conservation issues in Gomti River Basin

To address the above issues a comprehensive set of strategies and activities was designed to promote aquatic biodiversity conservation. The strategies focus on fostering community participation, raising awareness, and building capacity for biodiversity conservation and sustainable development. Key interventions include promoting organic farming, improving sanitation and waste management facilities, organising skill development trainings for developing alternative livelihoods, adopting alternative energy sources, and protecting aquatic ecosystems through targeted training i.e., training the community in monitoring & rescue of aquatic species and other community-led initiatives like plantation, cleanliness and awareness drives. Collaboration with government departments, local institutions, and establishment and strengthening of a cadre of Ganga Praharis is emphasized to ensure long-term success and sustainability (Figure 12.15; Table 12.17).

The proposed interventions collectively aim to address the interlinked challenges of biodiversity loss, river pollution, unsustainable livelihoods, and inadequate community awareness in Rajepur village. By combining awareness generation, skill development, sustainable agriculture, improved sanitation, and habitat restoration, these activities provide an integrated roadmap for conserving the Gomti River and its aquatic life, while simultaneously strengthening community resilience and livelihood security. Successful implementation will require active participation of the local community, coordination with government departments, and continued support from conservation organizations to ensure long-term sustainability (Figure 12.16; Table 12.17).

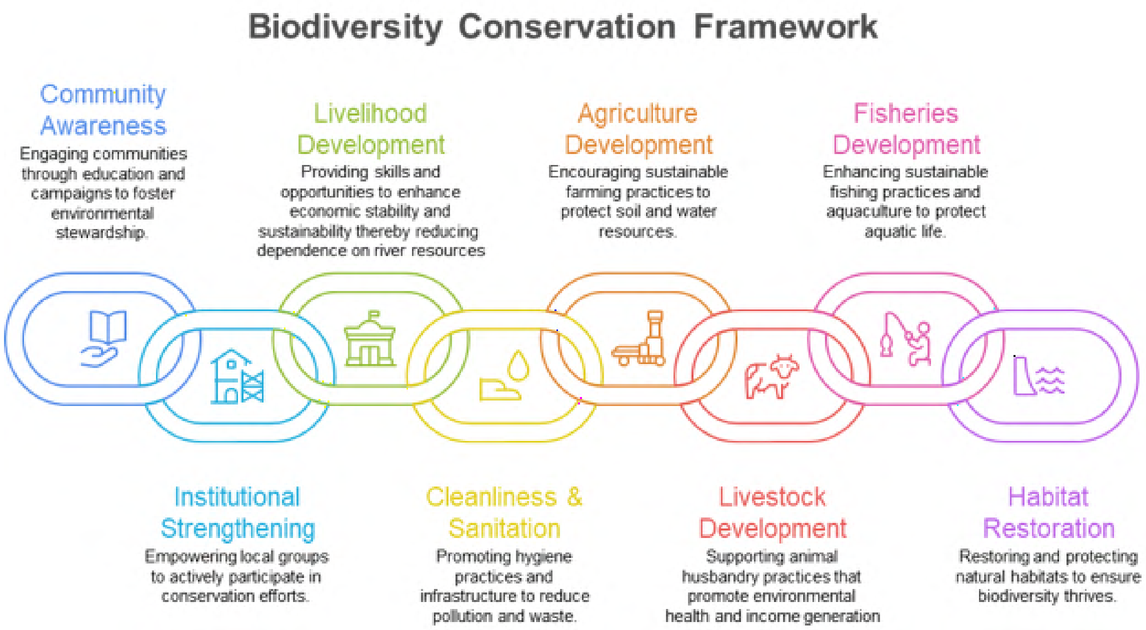

Figure 12.16. Strategies suggested to address conservation issues in village Rajepur, district Jaunpur, Uttar Pradesh, Gomti River Basin.

Table 12.17. Strategies and activities suggested to address the identified conservation issues in Gomti River Basin.

Sl. No.	Issues	Strategy	Proposed activities	Purpose/ Benefit
1	Lack of awareness about aquatic biodiversity, Riverbed farming disrupting turtle habitat & aquatic ecosystems, and unsustainable fishing practices	Community Awareness	Awareness meetings and campaigns on biodiversity, especially turtles	Habitat restoration, Increased community awareness and participation, Sustainable fishing practices
			Discussions on turtle habitat loss due to riverbed farming	
			Training farmers on aquatic habitat conservation and organic farming	
			Workshops with school children for awareness	
			Celebration of special days such as world Turtle Day and Biodiversity Day	
			Campaign, rallies, street plays, wall writings for awareness	
			Awareness on sustainable fishing practices	

Sl. No.	Issues	Strategy	Proposed activities	Purpose/ Benefit
2	Lack of awareness about aquatic biodiversity	Strengthening Community-Based Institutions	Sensitizing community-based groups on Biodiversity conservation	Strengthening & sensitisation of Community based institutions on biodiversity conservation
			Involving groups in Ghat and Riverbank cleanliness	
			Linking the groups livelihood training institutions	
3	Overexploitation of river resources, Lack of alternative livelihood skills	Livelihood & Skill Development	Skill development training for women and youths	Diverse and sustainable livelihood, Reduced dependency on the river and reduces vulnerability
			Livelihood trainings for farmers and fishermen	
			Market Linkages for local products	
			Support in accessing government schemes	
4	Inadequate sanitation and waste management facilities	Cleanliness & Sanitation	Awareness on cleanliness, toilet construction and Plastic reduction	Reduced plastic pollution, better sanitation & waste management structure & improved ecological health
			Awareness on waste segregation and management	
			Coordination for sanitation facilities creation	
			Conducting cleanliness drives	
5	Use of chemical fertilizers in agriculture	Agriculture Development	Awareness and Training on Organic/Natural farming	Sustainable farming practices, reduced pollution and better soil and river health
			Linkages with Agriculture and Horticulture department	
			Promoting Organic fertilisers, Plantation of fruit trees and Nurseries	
			Encouraging traditional crops like Millets etc.	
6	Overexploitation of river resources, lack of alternative livelihood skills	Livestock Development	Awareness on government schemes for animal husbandry	Enhanced livelihood security and better soil health by using green manure
			Promotion of fodder grass and trees	
			Training on organic manure/ composting	
			Organising Animal vaccination camps	

Sl. No.	Issues	Strategy	Proposed activities	Purpose/ Benefit
7	Use of inappropriate fishing nets	Fisheries Development	Awareness on Fish farming	Sustainable fishing practices with inclusion in government schemes
			Awareness on using proper fish nets	
			Linking fishermen to Government schemes like Matsya Sampada Yojna	
8	Lack of awareness about aquatic biodiversity, loss of habitat & aquatic ecosystems, and unsustainable agriculture and fishing practices	Biodiversity & Habitat Restoration	Community awareness on ecology, biodiversity and threats	Habitat revival, sensitised community, regular grassroots actions and monitoring, sustainable practices and strengthened community institutions
			Sensitisation on conservation of Aquatic life esp. Turtles	
			Regular awareness with boatmen and fishermen	
			Training of Ganga Praharis on Rescue and Rehabilitation	
			Co-ordination with forest department	
			Awareness on harmful effects of chemical fertilisers	
			Promotion and training on organic farming	
			Plantation drives on riverbanks	
			Alternative livelihood trainings and market support	
			Discouraging use of mosquito nets	
			Forming /strengthening community organisation like Ganga Praharis	

12.3.9. Institutional Policy, and Governance Contexts and Frameworks

Water governance refers to the multi-level decision-making process involving various stakeholders (Dirwai, et al., 2019). It encompasses a framework of rules, principles, and incentives designed to promote sustainable development by guiding and coordinating human actions toward shared goals (Muñoz-Torres et al., 2014). A significant number of water-related issues stem from weak governance systems. Therefore, addressing present and future challenges requires the implementation of robust public policies that are aligned with clearly defined, measurable objectives (Oñate-Valdivieso et al., 2021). These policies should operate within appropriate spatial and administrative scales, follow structured timelines, assign clear responsibilities to competent authorities, and include mechanisms for regular monitoring and evaluation. Finally, the obtained results will help to understand and target the policy gaps necessary to be filled on an urgent basis for the sustainable development of water resources.

The Ganga Action Plan (GAP-II) was launched in 1993 and the scheme was extended to Yamuna and Gomti, the major tributaries of the Ganga. This was further expanded to include the other major rivers of the country in 1995 under the aegis of NRCP and the existing schemes were also merged into it (Sinha and Sedai, 2025). The policy framework for Gomti River conservation is embedded within broader national and state-level water and environmental governance mechanisms, yet it remains fragmented and weak in implementation. The river is nominally protected through provisions of the Water (Prevention and Control of Pollution) Act, 1974, the Environment (Protection) Act, 1986, National River Conservation Plan (NRCP) and guidelines of the National Mission for Clean Ganga (NMCG). Additionally, state pollution control boards, irrigation departments, and forest/wildlife authorities hold overlapping responsibilities for managing pollution, biodiversity, and riverfront development. Despite this multi-layered framework, many gaps persist at various levels limiting the effectiveness of policies on the ground. A strengthened, basin-specific policy framework that prioritizes ecological flows, biodiversity monitoring, pollution abatement, and participatory river governance is crucial for the long-term conservation of the Gomti.

12.3.9.1. National level acts, policies, plans and programs related to river conservation

The policy and institutional framework governing river conservation, water resource management, pollution control, biodiversity conservation, sanitation, and groundwater governance in India has evolved significantly over the past five decades. The interventions collectively demonstrate a gradual shift from sector-specific pollution control measures towards integrated river basin management, ecosystem restoration, environmental flow maintenance, biodiversity conservation, and community-based resource governance (Table 12.18). These policies and programmes provide the broader governance framework within which river systems such as the Gomti are managed and restored.

The foundation of water quality management was established through the National Water Quality Monitoring Programme (NWQMP) initiated in 1978 and subsequently expanded through the MINARS programme. This initiative created a nationwide monitoring network that generated long-term datasets on surface and groundwater quality, enabling identification of polluted water bodies and informing major river conservation programmes. Complementing this monitoring framework, the Water (Prevention and Control of Pollution) Act, 1974 and the Environment (Protection) Act, 1986 established the principal legal and regulatory mechanisms for pollution control. These legislations empowered regulatory agencies, prescribed environmental standards, and provided legal provisions for monitoring and enforcement. However, recurring challenges identified across these interventions include weak enforcement, limited monitoring of non-point pollution sources, inadequate compliance mechanisms, and insufficient public participation. At the policy level, the National Water Policy (1987, revised in 2002 and 2012) introduced principles of Integrated Water Resources Management, emphasizing water-use efficiency, equitable distribution, rainwater harvesting, river basin planning, and institutional strengthening. Similar objectives are reflected in the River Basin Management Scheme (2021 onwards), which promotes basin-scale planning, flood management, erosion control, and integrated development of surface and groundwater resources. Despite these advances, fragmented governance structures, weak local-level implementation, and limited integration of climate change considerations continue to constrain effective river basin management. River restoration and pollution abatement have been addressed through dedicated programmes such as the National River Conservation Plan (1995), Namami Gange Programme (2014), and the National Mission for Clean Ganga (NMCG). These initiatives have facilitated substantial investments in sewerage infrastructure, sewage treatment plants, riverfront development, afforestation, biodiversity conservation, and river surface cleaning. Community participation has also been strengthened through initiatives such as Ganga Praharis. Nevertheless, challenges remain in terms of infrastructure implementation, inter-agency coordination, monitoring of treatment facilities, and addressing pollution hotspots, tributaries, and sub-tributaries.

Groundwater conservation and hydrological sustainability have received increasing policy attention through the CGWA Guidelines (1997), Jal Jeevan Mission (2019), and Atal Bhujal Yojana (2019). These initiatives promote groundwater regulation, rainwater harvesting, aquifer recharge, water budgeting, and participatory groundwater management. While they have strengthened awareness and community involvement, concerns persist regarding groundwater over-extraction, inadequate enforcement, limited assessment of river–groundwater interactions, and insufficient climate adaptation measures. The policy framework also recognizes the importance of ecological integrity through interventions such as the Wetlands (Conservation and Management) Rules, 2017, Environmental Flow Monitoring, and the Biological Diversity Act, 2002. These measures have established mechanisms for wetland conservation, biodiversity governance, ecological flow maintenance, and local biodiversity documentation. The table highlights the need to strengthen monitoring of aquatic biodiversity, improve protection of riverine habitats, expand environmental flow assessments to tributaries such as the Gomti, and enhance coordination between biodiversity institutions and river restoration programmes.

Urban sanitation and pollution management are addressed through the National Urban Sanitation Policy (2008), Swachh Bharat Abhiyan (2014), and AMRUT (2015), which have improved sanitation infrastructure, wastewater treatment, and public awareness regarding river cleanliness. Similarly, the National Water Conservation Campaign (2019) has promoted rainwater harvesting, groundwater recharge, and community-led conservation efforts. However, common policy gaps include inadequate monitoring, limited climate resilience, insufficient wastewater management frameworks, weak behavioural change mechanisms, and inadequate control of non-point pollution sources. Overall, the analysis reveals that while India possesses an extensive and comprehensive policy architecture for river conservation and water management, effective implementation, stronger institutional coordination, enhanced stakeholder participation, and improved monitoring remain critical requirements for achieving long-term river basin sustainability. Additionally, state pollution control boards, irrigation departments, and forest/wildlife authorities hold overlapping responsibilities for managing pollution, biodiversity, and riverfront development. Despite this multi-layered framework, many gaps persist at various levels limiting the effectiveness of policies on the ground (Table 12.18). A strengthened, basin-specific policy framework that prioritizes ecological flows, biodiversity monitoring, pollution abatement, and participatory river governance is crucial for the long-term conservation of the Gomti.

12.3.9.2. State-level acts, policies, plans and programs related to river conservation

The policy framework for wetland conservation and integrated water resource management in Uttar Pradesh has evolved through a combination of state-specific initiatives and implementation of national environmental regulations. The interventions in state reflect increasing recognition of the role of wetlands, groundwater systems, drainage networks, and integrated water governance in maintaining river health and ecological sustainability, including within the Gomti River Basin (Table 12.19).

A significant state-level initiative is the Wetland and Drainage Basin Mapping Initiative, launched in 2017 and continuing thereafter. Linked to the Wetlands (Conservation and Management) Rules, 2017, the initiative aims to systematically map wetlands, ponds, and drainage systems that contribute to the hydrological functioning of the Gomti basin. Initial surveys have been undertaken and data on encroachments in some areas have been recorded, providing an important baseline for future conservation planning. However, the initiative remains at an early stage and requires accelerated mapping efforts, legal protection of wetlands within the Gomti basin, and stronger measures to restrict encroachments that threaten wetland integrity and hydrological connectivity. The programme is implemented through the Ministry of Environment, Forest and Climate Change (MoEFCC) in coordination with the Uttar Pradesh State Wetlands Authority.

The Uttar Pradesh State Water Policy, 2018, represents the state's primary framework for sustainable water governance and is aligned with the National Water Policy (2012). The policy promotes Integrated Water Resources Management (IWRM) and emphasizes water conservation, groundwater regulation, equitable distribution of water resources, and sustainable water use. It further encourages stakeholder participation, decentralized water governance, and the application of modern technologies in water management. Several institutional and management achievements have emerged from the policy. These include the formation of the Uttar Pradesh Ground Water Department Authority to strengthen groundwater regulation, promotion of rainwater harvesting and aquifer recharge in both urban and rural areas, initiation of irrigation modernization projects in major river basins, digitization of water resources data, mapping of critical aquifers, and the establishment of Water User Associations to enhance community participation in irrigation management. Despite these advancements, several challenges remain. The policy requires stronger enforcement mechanisms for water allocation and pollution control, greater integration of micro-level river basin planning for smaller rivers such as the Gomti, enhanced focus on wetland conservation associated with river systems, expanded real-time water quality monitoring in smaller towns and rural areas, improved coordination between state and central agencies, greater transparency in fund allocation, and incorporation of climate resilience measures such as floodplain zoning and seasonal water budgeting.

Further strengthening wetland governance, Uttar Pradesh has implemented the Wetlands (Conservation and Management) Rules, 2017 through the Uttar Pradesh State Wetland Authority (UPSWA) since 2017. The initiative focuses on the identification, notification, conservation, restoration, and sustainable management of wetlands, including those associated with the Gomti basin. Major achievements include the establishment and operationalization of UPSWA, preparation of wetland inventories across the state, strengthening of the institutional framework for wetland conservation, support for biodiversity conservation, groundwater recharge and flood moderation, and promotion of restoration and protection initiatives in ecologically significant areas. Nevertheless, important gaps persist, including the need for faster wetland identification and legal notification, improved protection against encroachment, urbanization and agricultural expansion, riverfront development challenges, deforestation for developmental works, pollution control, and community engagement. Stronger ecological monitoring, enhanced community participation, and better integration of wetland management with river basin planning, are highly recommended (Table 12.19). To strengthen conservation outcomes, the state is increasingly recognizing the need for a more integrated and collaborative approach between various departments and stakeholders. To achieve a more substantial and lasting impact, a unified and collaborative approach across the state is essential.

12.3.9.3. Acts, policies, plans and programs related to Gomti river conservation

The Gomti River has been the focus of multiple conservation, restoration, pollution control, and river management interventions implemented through national and state-level programmes. These initiatives collectively address catchment conservation, pollution abatement, ecological restoration, riverfront development, judicial enforcement, and flow augmentation, reflecting an evolving approach towards river rejuvenation and sustainable management (Table 12.20). One of the foundational interventions has been the Catchment Area Treatment and Afforestation Projects, implemented under various programmes linked to CAMPA and State Forest Plans. These projects focus on reforestation and erosion control in the upper catchment of the Gomti River to improve water quality and maintain river flows. The initiatives have supported local plantation drives and achieved limited erosion control in some areas. However, the scale of intervention remains relatively limited. The identified gaps indicate the need for large-scale scientific afforestation programmes and stronger community-based watershed management approaches to improve catchment stability, reduce soil erosion, and enhance long-term ecological sustainability.

A major recent initiative is the Gomti River Rejuvenation Mission (2025) launched by the Government of Uttar Pradesh. The mission adopts a basin-wide restoration approach focusing on wetland restoration, encroachment removal, pollution control, ghat beautification, green corridor development, and public participation. Key achievements include preparation of district-specific action plans, restoration efforts in wetlands such as Ekana Wetland and Saijan Lake, establishment of inter-departmental coordination through the Gomti Task Force under NMCG, and increased emphasis on ecological restoration and public awareness. Despite these efforts, significant challenges remain. Thirteen major drains continue to discharge untreated wastewater into the river, highlighting the need for expansion and efficient operation of sewage treatment infrastructure. The mission also requires long-term ecological monitoring, stronger enforcement against encroachments and solid waste dumping, and better integration of floodplain, wetland, and groundwater conservation within river management strategies.

Earlier conservation efforts originated under the Gomti Conservation Programme implemented through Ganga Action Plan (Phase I) in 1993, later incorporated under the National River Conservation Plan. These interventions focused on sewage treatment plants, low-cost sanitation facilities, and afforestation measures to reduce river pollution. The programme contributed to the establishment of sewage treatment infrastructure in Lucknow and reduction of visible waste in selected urban stretches. However, the table identifies important gaps related to operation and maintenance of sewage treatment plants, management of non-point pollution sources, and limited participation of local communities. Addressing these issues remains critical for sustaining long-term conservation outcomes. The Gomti Riverfront Development Project (2015) improved the aesthetics and usability of riverbanks, particularly in Lucknow, through the construction of walkways, lighting systems, and embankments. While the project enhanced the visual appeal of the riverfront, concerns have been raised regarding loss of natural habitats and alteration of the river's ecological characteristics. These modifications may reduce the resilience of the river ecosystem to floods and climate change. Consequently, future planning should involve local institutions, communities, environmental experts, and ecologists to ensure that development objectives remain compatible with ecological requirements. Judicial intervention through National Green Tribunal (NGT) orders on Gomti River pollution from 2014 onwards has played a significant role in strengthening accountability for pollution control. The directions mandated sewage treatment, interception and diversion of drains, water quality monitoring, and action against polluters. These measures accelerated sewage infrastructure development, enhanced monitoring and reporting, and brought river pollution issues under greater public scrutiny. Nevertheless, persistent discharge of untreated sewage from several drains demonstrates the need for stricter enforcement, stronger compliance monitoring, greater emphasis on ecological restoration, environmental flow maintenance, floodplain protection, and increased transparency and community participation in implementation and monitoring processes.

The proposed Sharda–Gomti Link Project (2021) represents a future intervention aimed at augmenting flows in the Gomti River through transfer of water from the Sharda basin. Following completion of the Pre-Feasibility Report by the National Water Development Agency, options for enhancing river flows, improving water availability, and supporting ecological restoration have been identified. However, the project requires detailed environmental and social impact assessments before implementation. Additional recommendations include ensuring ecological flow requirements in both donor and recipient rivers, strengthening stakeholder consultations with affected communities, integrating groundwater recharge and watershed management measures, and establishing robust monitoring mechanisms for biodiversity and water quality impacts. Collectively, these interventions demonstrate substantial progress in Gomti River management while also highlighting the need for stronger implementation, ecological safeguards, community engagement, and long-term monitoring to achieve sustainable river rejuvenation.

Table 12.18. National level acts, policies, plans and programs related to river conservation

Policy/Guidelines/ Interventions	Year	Description
National Water Quality Monitoring Program (NWQMP)	1978 (under GEMS) / later expanded as National Water Quality Monitoring Programme (NWMP). By 1984, a parallel national initiative called Monitoring of Indian National Aquatic Resources (MINARS) was launched.	Initiated by the Central Pollution Control Board (CPCB) in 1978 under the Global Environmental Monitoring System (GEMS) Water Programme, the NWMP provides a nationwide framework for monitoring the quality of rivers, lakes, groundwater, and other aquatic resources Regular monitoring of the water quality of major rivers in India to assess pollution levels and water quality
The Water (Prevention and Control of Pollution) Act	1974	Provides a legal framework for the prevention and control of water pollution by regulating the discharge of pollutants into water bodies and maintaining water quality standards.

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	1. Established a comprehensive network of monitoring stations across India to assess the quality of surface and groundwater. It laid the foundation for consistent, long-term water quality data collection, helping to identify pollution trends and areas requiring attention. 2. Through systematic monitoring, the program identified critically polluted rivers, lakes, and other water bodies, leading to targeted interventions and policy measures to reduce pollution. This helped in addressing major water pollution issues, such as untreated industrial effluent discharge and sewage contamination. 3. The data generated by the NWQMP served as a critical resource for formulating and enforcing water quality standards and policies. It contributed to the development of national and state-level water management strategies, environmental protection laws, and initiatives like the Ganga Action Plan and the National River Conservation Plan.	1. The program primarily monitors major rivers and urban water sources, focusing little on smaller rivers, rural water bodies, and localised pollution hotspots. 2. Limited participation of local community, industries, and other stakeholders in monitoring, pollution control, and public awareness initiatives undermined the program's	Central Pollution Control Board (CPCB) under the Ministry of Environment, Forest and Climate Change
	1. Established the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs). 2. Set water quality standards and effluent discharge norms for industries and municipalities. 3. Enabled monitoring and regulation of water pollution across river basins. 4. Provided legal provisions for penalties and prosecution of polluters.	1. Limited enforcement, particularly in rural areas and against non-point pollution sources such as agricultural runoff. 2. Strengthen monitoring and compliance mechanisms. 3. Improve public participation and awareness regarding water pollution. 4. Ensure stricter action against untreated sewage and industrial effluent discharge into rivers.	CPCB, SPCBs, Ministry of Environment, Forest and Climate Change (MoEFCC)

Policy/Guidelines/ Interventions	Year	Description
Environment (Protection) Act	1986	Umbrella legislation empowering the Central Government to protect and improve environmental quality and coordinate actions for pollution control.
National Water Policy (NWP)	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.
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.

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	1. Established a comprehensive framework for environmental protection covering air, water, and land. 2. Empowered the government to issue environmental standards and regulations. 3. Served as the basis for Environmental Impact Assessment (EIA) notifications and other environmental rules. 4. Enabled stronger legal action against environmental violations.	1. Weak enforcement and compliance monitoring in many regions. 2. Need for stronger implementation of environmental safeguards in river basins. 3. Enhance community participation and transparency in environmental decision-making. 4. Strengthen penalties and monitoring of industries located along riverbanks.	Ministry of Environment, Forest and Climate Change (MoEFCC)
	1. The policy emphasized the adoption of Integrated Water Resources Management (IWRM) principles, advocating for a holistic approach to water management that integrates economic, social, and environmental considerations. It promoted the coordination of water use across various sectors like agriculture, industry, and domestic consumption. 2. The policy highlighted the need to improve water-use efficiency, particularly in agriculture, which is the largest consumer of water in India. It encouraged the use of water-saving technologies, such as drip irrigation, and promoted rainwater harvesting to ensure long-term water availability. 3. The National Water Policy aimed for the equitable distribution of water resources, ensuring that water reaches all sectors and communities, including marginalized groups. 4. The policy called for the strengthening of institutions at both the state and national levels, including the creation of a National Water Regulatory Authority. It also recommended the establishment of water rights and pricing mechanisms to ensure proper allocation and sustainable use of water resources.	1. Weak implementation and monitoring mechanisms for river basin management at the local levels and remote areas. 2. Limited mention of climate change adaptation. 3. Fragmented water governance due to management, regulation, and decision-making related to water resources are divided among multiple agencies, sectors, and jurisdictions, often leading to inefficiencies, conflicts, and a lack of coordination.	Ministry of Jal Shakti
	1. It focused on reducing the discharge of untreated sewage and industrial effluents into these rivers, improving water quality in targeted stretches. 2. Establishment of Sewage Treatment Plants (STPs) in cities along the rivers, significantly reducing water pollution. 3. Emphasized community involvement and public awareness programs to sensitize people about the importance of river conservation.	1.Inadequate monitoring of rural pollution due to long gaps in monitoring and maintenance. 2. Limited community involvement due to a lack of sensitization and awareness.	Ministry of Jal Shakti, CPCB, SPCBs

Policy/Guidelines/ Interventions	Year	Description
Central Ground Water Authority (CGWA) Guide-lines	1997	Guidelines to regulate groundwater extraction and prevent over-extraction, impacting river health through hydrological connectivity.
National River Linking Project (NRLP) – 2002	2002	Aims to interlink India's major rivers for equitable water distribution, flood and drought mitigation through dams, reservoirs, and canals.

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	1. Guidelines provided a regulatory framework to control excessive groundwater extraction, particularly in water-stressed regions. 2. Emphasized sustainable groundwater management by introducing measures like rainwater harvesting, artificial recharge, and the promotion of efficient irrigation methods, especially in areas facing over-exploitation. 3. Established a framework for groundwater monitoring and assessment by setting up a system to regularly track water levels and quality across different regions. This helped authorities make informed decisions regarding groundwater regulation and resource management.	1. Lack of strong enforcement and penalties for violations results in ineffective implementation of groundwater conservation measures. 2. Focusing mainly on urban and industrial sectors, neglecting rural areas and agriculture, where excessive groundwater extraction is a major issue. 3. The guidelines do not fully promote integrated water resource management, ignoring the interconnectedness between surface water and groundwater systems. 4. Limited community involvement and lack of public awareness programs hinder the effective implementation of groundwater conservation initiatives.	Ministry of Jal Shakti, CGWA
	1. Expected to improve water availability, irrigation coverage and flood management in water-deficit regions. 2. Helped in improving water availability for irrigation, drinking, and industrial use in drought-prone and arid regions, also mitigating floods in flood-prone areas. 3. Provide stable irrigation to areas facing inconsistent rainfall, thereby improving agricultural productivity. The project aimed to reduce dependency on monsoon rains and ensure reliable water supply for crops. 4. Construction of reservoirs and dams, which not only supported irrigation but also contributed to hydroelectric power generation. This enhanced the energy security of the country and provided additional sources of renewable energy.	1. Environmental concerns (ecosystem disruption, biodiversity loss, loss of environmental flow and natural habitat loss and alterations 2. Not equipped to address futuristic climate challenges 3. Financial and technical challenges. 4. Opposition from states due to water-sharing disputes.	Ministry of Jal Shakti

Policy/Guidelines/ Interventions	Year	Description
National Environment Policy (2006)	2006	A comprehensive policy focusing on environmental protection, including river conservation and managing water quality.
Flood Management and Control (FMC) Program subsequently continued as a component of "Flood Management and Border Areas Programme" (FMBAP) for the period from 2017-18 to 2020-21 and was further extended up to 2026 with limited outlay	2008	A program to address flood risks in river basins and improve floodplain management, particularly for flood-prone rivers.
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.
River Basin Management (RBM) Scheme	2021–22 onwards (continued for 2026–31)	Central sector scheme promoting integrated planning, investigation, and development of water resources at river basin scale, covering both surface water and groundwater systems.

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	1. Emphasized the need for sustainable development by balancing economic growth with environmental conservation. It encouraged the integration of environmental concerns into developmental planning at all levels to ensure long-term ecological sustainability. 2. The policy focused on improving environmental governance by enhancing the effectiveness of regulatory bodies like the Ministry of Environment, Forests, and Climate Change (MoEFCC) and other state-level agencies. It called for better enforcement of environmental laws and the creation of a more transparent, participatory process for decision-making. 3. NEP highlighted the conservation of India's natural resources, such as water, biodiversity, and forests. It promoted initiatives like biodiversity preservation, water management, and reducing the degradation of critical ecosystems	1.The policy does not adequately address the urgent need for climate change mitigation and adaptation strategies. 2. The policy lacks robust enforcement and monitoring frameworks, leading to inconsistent implementation across states and sectors. 3. Limited Public Participation	Ministry of Environment, Forest and Climate Change (MoEFCC
	1. Supported the construction and strengthening of flood protection infrastructure such as embankments, dams, and flood control channels in vulnerable regions. 2. Strengthened flood forecasting and early warning systems, improving the ability to predict floods and issue timely alerts. This helped in minimizing loss of life and property by allowing communities and authorities to take preventive measures before floods hit.	1. Inadequate addressing of upstream watershed management or river basin-wide solutions. 2. Weak disaster preparedness and response, leaving communities vulnerable.	Ministry of Jal Shakti, CWC
	1.mandated the treatment of sewage and industrial effluents before they are discharged into rivers, thereby increased the accountability for municipalities and industries, leading to the establishment of sewage treatment plants and better waste management practices along riverbanks. 2. Issued rulings to preserve and restore river ecosystems by preventing encroachments, illegal sand mining, and other activities that damage riverbeds and floodplains.	1. Despite the NGT's orders, there is a lack of effective enforcement mechanisms, leading to delayed or incomplete implementation of river protection measures. 2. Limited focus on holistic river ecosystem management like ecological flow maintenance, biodiversity conservation, and integrated river basin management.	National Green Tribunal (NGT)
	Supports basin master plans, DPR preparation, flood and erosion management, drainage development, and inter-basin water planning.sss	Expand basin-level planning to rivers such as Ghaghra; strengthen stakeholder participation, ecological flow assessment, and basin-wide monitoring.	Ministry of Jal Shakti, CWC, NWDA

Policy/Guidelines/ Interventions	Year	Description
National Urban Sanitation Policy	2008	Promote urban sanitation, sewage management, wastewater treatment infrastructure to reduce wastewater discharge into the river and water bodies.
Atal Mission for Rejuvenation and Urban Transformation (2015)	2015	Strengthens sewerage, septage management and wastewater treatment infrastructure, reducing urban pollution loads entering the river and other water bodies
Swachh Bharat Abhiyan (Clean India Mission)	2014	A nationwide cleanliness campaign aimed at reducing open defecation and solid waste dumping along the river corridor and water bodies.
Namami Gange Programme - 2014	2014	Flagship program for the rejuvenation and conservation of the Ganga River, focusing on pollution abatement, riverfront development, afforestation, and sustainable livelihoods.

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	1. Enhanced River health by pollution control, wastewater treatment, and safe water access, ensuring sustainable use of river resources. 2. Promotes city-wide sanitation planning and sewage management in urban centres such as Lucknow, Sitapur, Sultanpur and Jaunpur, thereby reducing the discharge of untreated sewage into the river and its tributaries	Lacks a comprehensive focus on climate resilience, equitable access.	Ministry of Housing and Urban Affairs
	1. Enhanced River health by pollution control, wastewater treatment, and safe water access, ensuring sustainable use of river resources. 2. Supports the construction and upgrading of sewerage infrastructure and sewage treatment facilities in urban areas, thereby reducing untreated wastewater inflows into the river and improving its ecological health.	Lacks a comprehensive focus on climate resilience, equitable access and non-point pollution	Ministry of Housing and Urban Affairs
	1. Improved sanitation infrastructure and waste management have significantly reduced open defecation and waste dumping into rivers, leading to cleaner water bodies. 2. Increased public awareness and involvement in river cleanliness drives, promoting long-term behavioural changes for sustainable river conservation.	1. Lacks a robust framework for wastewater treatment and management. 2.Insufficient emphasis on long-term behavioural change regarding waste segregation, disposal, and hygiene practices.	Ministry of Jal Shakti, MoEFCC
	1. The program has sanctioned 200 sewerage infrastructure projects with a total cost of ₹31,810 crore, completing 116 projects that are now operational. This effort has significantly increased sewage treatment capacity, reducing pollution levels in the river. 2. Initiatives have been undertaken for the construction, modernization, and renovation of 267 ghats and crematoria, enhancing the riverfront's aesthetic and cultural value while promoting ecotourism. 3. To address floating solid waste, river surface cleaning projects have been implemented at 11 locations, improving the visual and environmental quality of the river. 4. The program has developed and trained volunteers known as 'Ganga Praharis' to support conservation actions. These volunteers, along with 'Ganga Doots,' engage in activities such as tree planting, ghat cleaning, and organizing cultural events like Ganga Aarti to raise public awareness about the river's health.	1. Slow infrastructure and sewage treatment plant implementation due to lack of data at the initial phase. 2. Coordination issues between central and state governments. 3. Need of more detail addressing of pollution hotspots. 4. Need of stringent policy regarding waste management and discard of hazardous material without affecting the biodiversity	Ministry of Jal Shakti, NMCG

Policy/Guidelines/ Interventions	Year	Description
National Mission for Clean Ganga (NMCG) - 2011	2011	Implement the Namami Gange program with a focus on wastewater treatment, pollution control, and biodiversity conservation in the Ganga Basin.
Wetlands (Conservation and Management) Rules - 2017	2017	Aims to conserve and manage wetlands that regulate river flows, recharge groundwater, and support biodiversity.
National Water Conser-vation Campaign	2019	Promotes water conservation through rainwater harvesting, efficient use of water, and pollution reduction measures.

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	1. Out of 492 initiated projects valued at ₹40,121.48 crore, 307 have been completed and made operational, marking substantial progress in river restoration efforts. 2. The NMCG has significantly increased sewage treatment capacity, creating 3,446 million liters per day (MLD), surpassing the pre-2014 capacity by over 30 times. This includes the completion of 127 sewage infrastructure projects, contributing to pollution abatement and improved water quality in the Ganga River. 3. In 2024, the NMCG achieved notable milestones in biodiversity conservation, including the ranching of 4.925 million Indian Major Carps (IMC), 7,370 Mahseer, and 42,117 Hilsa fish. Additionally, afforestation efforts have been undertaken to restore and preserve the ecological balance of riverine environments.	1. Need consistent monitoring of water quality and treatment plants. 2. More focus required on tributaries and sub-tributaries. 3. Stronger community-based governance.	Ministry of Jal Shakti, NMCG
	1. Shifted the responsibility of wetland management from a central authority to state-level bodies, enhancing localized conservation efforts and allowing for more region-specific strategies. 2. India has significantly increased its network of Ramsar sites, with 89 wetlands designated as of January 2025, covering approximately 1.36 million hectares. This expansion underscores the country's commitment to international wetland conservation standards. 3. Provided a structured legal framework for the identification, notification, and protection of wetlands, facilitating better management practices and conservation outcomes across various states.	1. Strong guidelines to enforce conservation strategies and stringent actions on illegal encroachments. 2. Threats from urbanization and agricultural expansion.	Ministry of Environment, Forest and Climate Change (MoEFCC)
	1. Completion of over 1.05 crore (10.5 million) water conservation projects, including approximately 34 lakh (3.4 million) related to water conservation and rainwater harvesting, and nearly 18.5 lakh (1.85 million) focused on reuse and recharge structures, directly benefiting river ecosystems. 2. National Water Awards have honoured exemplary efforts in water conservation and management. By 2024, 38 winners across nine categories were recognized for their contributions, including initiatives that have positively impacted river rejuvenation and sustainable water resource management.	1. Need for more comprehensive and sustained public awareness programs 2. Adequate monitoring of water conservation efforts and sufficient enforcement of water-saving measures across sectors.	Ministry of Jal Shakti

Policy/Guidelines/ Interventions	Year	Description
Jal Jeevan Mission (JJM) - 2019	2019	Aims to provide potable water to every rural household, promoting sustainable water management and protection of river systems.
Environmental Flow (E-Flow) Monitoring	Commenced in 2014, with the first mandated minimum e-flow rules and institu-tional setups notified in 2018	1. Government of India notified minimum environmental flows for the Ganga through Gazette Notification dated 9 October 2018. 2. Aims to maintain ecological flows required for river health, aquatic biodiversity, and ecosystem functioning. 3.E-flow compliance is monitored by the Central Water Commission (CWC).
Biological Diversity Act	2002	1. Provides a legal framework for conservation, sustainable use, and equitable benefit-sharing of biological resources. 2. Establishes the National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs), and Biodiversity Management Committees (BMCs).• Supports documentation of biodiversity through People's Biodiversity Registers (PBRs).

	Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
	Initiatives in 2025: 1. Catch the Rain – 2025': Initiated by the Ministry of Jal Shakti on World Water Day 2025, this campaign emphasizes community-led water conservation across 148 districts, focusing on rainwater harvesting and groundwater recharge to rejuvenate river ecosystems. 2. Inauguration of 'Water Conservation Campaign 2025' in Dehradun: Launched by Chief Minister Pushkar Singh Dhami, this initiative encourages residents to identify and rejuvenate critical or drying water sources, directly contributing to the health and sustainability of local rivers.		
	1. promoted rainwater harvesting and groundwater recharge, leading to improved water availability and reduced dependency on river water sources. 2. The mission has trained over 2.4 million women to manage and monitor water supplies, fostering community-led conservation efforts that benefit river ecosystems.	1. Water scarcity and quality challenges in several areas need to be addressed 2. Over-extraction of groundwater should be checked and penalised. 3. Lack of climate change adaptation strategies to mitigate the loss of drinking water.	Ministry of Jal Shakti
	1. Established legally notified environmental flow requirements for the Ganga basin. 2. Strengthened integration of ecological considerations into river management and restoration programmes.	1. Extend e-flow assessments to major tributaries such as the Gomti. 2. Incorporate biodiversity and habitat-based indicators into flow monitoring. 3. Strengthen compliance and enforcement mechanisms during lean-flow periods.	Ministry of Jal Shakti; National Mission for Clean Ganga (NMCG); Central Water Commission (CWC)
	1.Established a three-tier biodiversity governance framework across India. 2.Strengthened local participation in biodiversity conservation and documentation. 3.Facilitated conservation planning at national, state, and local levels.	1. Improve integration of freshwater biodiversity into PBRs. 2. Strengthen monitoring of aquatic species and riverine habitats. 3. Enhance coordination between BMCs and river restoration programmes.	Ministry of Environment, Forest and Climate Change (MoEF&CC); National Biodiversity Authority (NBA); State Biodiversity Boards

Policy/Guidelines/ Interventions	Year	Description
Atal Bhujal Yojana (Atal Jal)	2019	1. Community-led groundwater management programme focused on water-stressed areas. 2. Promotes water budgeting, demand-side management, aquifer recharge, and participatory planning. 3.Designed to improve long-term groundwater sustainability.

Table 12.19. State-level acts, policies, plans and programs related to river conservation

State	Year	Policy Name	Description
Uttar Pradesh	2017 (Ongoing)	State-Level Wetland and Drainage Basin Mapping Initiative	Linked to national Wetland Rules 2017, aiming to map wetlands, ponds, and drainage systems feeding the Gomti.
Uttar Pradesh	2018	Uttar Pradesh State Water Policy	Aligns with the National Water Policy (2012). Promotes integrated water resources management (IWRM). Focus on water conservation, groundwater regulation, equitable distribution, and sustainable water use. Encourages stakeholder participation, decentralized water governance, and use of modern technologies.
Uttar Pradesh	2017 onwards	Implementation of Wetlands (Conservation and Management) Rules, 2017 through Uttar Pradesh State Wetland Authority (UPSWA)	Implementation of the Wetlands (Conservation and Management) Rules, 2017 for identification, notification, conservation, restoration, and sustainable management of wetlands in Uttar Pradesh, including wetlands associated with the Gomti basin. The initiative aims to protect biodiversity, improve groundwater recharge , regulate hydrological flows, and enhance ecosystem services.

Achievement	Policy Gaps/Suggestions	Implementing Agency/ Ministry
1. Strengthened community participation in groundwater governance. 2. Improved awareness of groundwater conservation and water-use efficiency. 3. Developed scalable models for participatory groundwater management.	1. Expand implementation in groundwater-dependent parts of the Gomti Basin. 2. Strengthen assessment of river–groundwater interactions. 3. Integrate groundwater management with river restoration and environmental flow objectives.	Ministry of Jal Shakti; Department of Water Resources, River Development & Ganga Rejuvenation; Central Ground Water Board (CGWB)

Achievements	Policy Gaps/suggestions	Implementing Ministry
Initial surveys conducted; some encroachment data recorded.	Accelerate mapping, declare Gomti basin wetlands under legal protection, and restrict encroachments.	MoEFCC & Uttar Pradesh State Wetlands Authority
Formation of UP Ground Water Department Authority for better regulation. Promoted rainwater harvesting and aquifer recharge in urban and rural areas. Irrigation modernization projects initiated in major river basins. Steps taken to digitize water resources data and map critical aquifers. Introduction of Water User Associations (WUAs) to involve communities in irrigation management.	Strict binding of enforcement mechanisms for water allocation and pollution control. Limited integration of river basin planning at the micro-level, especially for smaller rivers like Gomti. Increasing the focus on wetland conservation under river-linked water bodies. More real-time data is needed for water quality monitoring, especially in smaller towns and rural areas. Need for stronger coordination between state and central water bodies and better fund allocation transparency. Encourage climate resilience measures (e.g., floodplain zoning, seasonal water budgeting) in planning.	Uttar Pradesh Government
1. Constitution and operationalization of the Uttar Pradesh State Wetland Authority (UPSWA). 2. Identification and inventory preparation of wetlands across the state. 3.Improved institutional framework for wetland conservation and management.	1. Need for faster wetland identification, notification, and legal protection. 2. Continued threats from encroachment, urbanization, and agricultural expansion. 3. Limited wetland-specific monitoring and ecological assessment.	Uttar Pradesh State Wetland Authority (UPSWA), Department of Environment, Forest and Climate Change, Government of Uttar Pradesh, Ministry of Environment, Forest and Climate Change (MoEFCC)

State	Year	Policy Name	Description

Table 12.20. Acts, policies, plans and programs related to Gomti river conservation

Policy/Guidelines/Interventions	Year	Description
Catchment Area Treatment and Afforestation Projects	Various (linked with CAMPA and State Forest Plans)	Targets reforestation and erosion control in Gomti's upper catchment, contributing to improved water quality and flow.
Gomti River Rejuvenation Mission	2025	A river restoration mission launched by the Government of Uttar Pradesh to revive the Gomti River through wetland restoration, encroachment removal, pollution control, ghat beautification, green corridor development, and public participation. The mission aims to restore the river's natural flow and ecological health.
Gomti Conservation under Ganga Action Plan (Phase I)	1993 (Later under NRCP 1995)	Gomti conservation interventions originated under GAP-II (1993) and later under NRCP. Launched under the National River Conservation Plan (NRCP) to reduce pollution in the Gomti River. Included construction of sewage treatment plants (STPs), low-cost sanitation, and afforestation.
Gomti Riverfront Development (State-Led, National Oversight)	2015	Aimed to improve aesthetics and usability of the riverbanks, especially in Lucknow. Initially envisioned with conservation elements.

Achievements	Policy Gaps/suggestions	Implementing Ministry
4. Support for biodiversity conservation, groundwater recharge, and flood moderation. 5. Promotion of wetland restoration and protection initiatives in ecologically significant areas.	4. Strengthen community participation and local stewardship in wetland conservation. 5. Improve integration of wetland management with river basin planning, particularly in the Gomti basin.	

Achievements	Improvements/Suggestions in Policy Gap	Implementing Ministry/Agency
Local plantation drives and minor erosion control achieved.	Large-scale scientific afforestation; community-based watershed management.	Ministry of Environment, Forest and Climate Change with State Forest Department
1. Adopted a basin-wide rejuvenation approach through district-specific action plans. 2. Promoted wetland restoration, including initiatives such as Ekana Wetland and Saijan Lake. 3. Strengthened inter-departmental coordination through the Gomti Task Force under NMCG. 4. Enhanced focus on pollution control, encroachment removal, ghat beautification, and ecological restoration. 5. Increased public awareness through community participation and educational outreach programmes.	1. Thirteen major drains continue to discharge untreated wastewater into the river. 2. Need for expansion and efficient operation of sewage treatment infrastructure. 3. Long-term monitoring of ecological restoration outcomes remains limited. 4. Stronger enforcement against encroachments and solid waste dumping is required. 5. Greater integration of floodplain, wetland, and groundwater conservation into river management is needed.	Government of Uttar Pradesh, Gomti Task Force, National Mission for Clean Ganga (NMCG), State Clean Ganga Mission, Irrigation Department, Uttar Pradesh Pollution Control Board (UPPCB), Uttar Pradesh Jal Nigam, Lucknow Municipal Corporation, Lucknow Development Authority
Initiated STP construction in Lucknow, reduced visible waste in certain urban stretches.	Ensure proper operation & maintenance of STPs, address non-point pollution sources, involve local communities.	Ministry of Environment, Forest and Climate Change (MoEFCC)
Riverfront beautified; walkways, lighting, and embankments constructed.	loss of natural habitat and characteristic of the river ecosystem; reduced resilience of river ecosystem towards floods and climate change;involve local institutions, local communities, environmental experts and ecologists in development planning.	Uttar Pradesh Government (with coordination from central urban development agencies)

Policy/Guidelines/Interventions	Year	Description
NGT Orders on Pollution in River Gomti (OA No. 116/2014 and subsequent directions)	2014 onwards	National Green Tribunal (NGT) issued directions regarding pollution in the Gomti River, particularly untreated sewage and effluent discharge through drains entering the river in Lucknow and other urban stretches. The orders mandated sewage treatment, interception and diversion of drains, monitoring of water quality, and action against polluters.
Sharda–Gomti Link Project (National River Linking Programme)	2021 (Pre-Feasibility Report submitted)	Proposed intra-state river-linking project in Uttar Pradesh to transfer water from the Sharda River basin to the Gomti River for river rejuvenation, augmentation of flows, and drinking water supply. It is part of the broader National River Linking Programme.

	Achievements	Improvements/Suggestions in Policy Gap	Implementing Ministry/Agency
	1. Increased accountability of municipal bodies and state agencies for sewage management. 2. Accelerated construction and upgrading of sewage treatment infrastructure. 3. Regular monitoring and reporting on Gomti water quality and pollution sources. 4. Brought river pollution issues under judicial scrutiny and public attention.	1. Persistent discharge of untreated sewage from several drains despite NGT directions. 2. Need for stricter enforcement and compliance monitoring by local authorities. 3. Greater focus required on ecological restoration, environmental flows, and floodplain protection. 4.Strengthen community participation and transparency in implementation and monitoring.	National Green Tribunal (NGT), Uttar Pradesh Pollution Control Board (UPPCB), Lucknow Municipal Corporation, Uttar Pradesh Jal Nigam, Ministry of Environment, Forest and Climate Change (MoEFCC)
	1. Pre-Feasibility Report (PFR) completed by the National Water Development Agency (NWDA). 2. Identified options for augmenting Gomti River flows. 3. Aimed at improving water availability and supporting ecological restoration of the Gomti River.	1. Conduct detailed environmental and social impact assessments before implementation. 2. Ensure ecological flow (e-flow) requirements in both donor and recipient rivers. 3. Strengthen stakeholder consultation with affected communities. 4. Integrate groundwater recharge and watershed management measures. 5. Establish robust monitoring mechanisms for biodiversity and water quality impacts.	National Water Development Agency (NWDA) under the Ministry of Jal Shakti, Government of India, in coordination with the Government of Uttar Pradesh.

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12.3.7.4. Key Policy Gaps in Gomti River Management

The Gomti River continues to face significant environmental and governance challenges despite a range of conservation and restoration initiatives implemented over the past three decades. While substantial investments have been made in pollution control, sewage infrastructure, riverfront development, wetland conservation, and river rejuvenation programmes, several policy and implementation gaps continue to constrain long-term ecological recovery. A major challenge remains the inadequate operation and maintenance of sewage treatment infrastructure and the continued discharge of untreated wastewater through drains entering the river. In addition, non-point pollution sources, including agricultural runoff and diffuse urban waste, remain insufficiently addressed within existing management frameworks. Although river-specific interventions such as the Gomti River Rejuvenation Mission and various conservation programmes have been initiated, these efforts often remain fragmented and are not fully integrated within a basin-scale ecological planning framework. Current management approaches continue to rely heavily on engineering and infrastructure-based solutions, while ecological restoration measures such as wetland conservation, floodplain protection, biodiversity recovery, and environmental flow management receive comparatively less attention. The ecological functions of wetlands associated with the Gomti basin are not yet fully integrated into river management despite their importance for groundwater recharge, flood moderation, water purification, and biodiversity conservation. Although wetland inventories and mapping exercises have been initiated, many wetlands still require notification, legal protection, ecological assessment, and effective protection from encroachment, urbanization, and land-use change.

Institutional and governance challenges also remain significant. Existing regulatory provisions for pollution control and water allocation require stronger enforcement, monitoring, and accountability mechanisms. River governance continues to be characterized by fragmented institutional arrangements involving multiple agencies with overlapping responsibilities, often resulting in coordination challenges and inefficient implementation. Greater transparency in fund allocation, improved inter-agency coordination, and stronger stakeholder participation are needed to enhance policy effectiveness. Another critical gap is the limited availability of real-time, publicly accessible water quality information, particularly in rural and peri-urban areas. While monitoring systems exist under CPCB, UPPCB, NMCG, and related programmes, spatial coverage and timely dissemination of information remain inadequate for adaptive river management. Similarly, river–groundwater interactions are insufficiently incorporated into planning despite the importance of groundwater in sustaining Gomti flows.

Another important limitation in the current policy framework is the relatively weak integration of community participation and stakeholder engagement in river governance. Although several programmes, including Namami Gange, NMCG initiatives, the Uttar Pradesh State Water Policy, Wetland Management programmes, and the Gomti River Rejuvenation Mission, recognize the importance of public involvement, participation often remains consultative rather than institutionalized. Local communities, farmers, fisher groups, wetland-dependent populations, academic institutions, civil society organizations, and local self-government bodies have limited roles in decision-making, monitoring, and adaptive management processes. Existing mechanisms such as Water User Associations and community-based conservation initiatives have demonstrated potential; however, their integration into basin-level planning and river restoration remains limited. Furthermore, awareness programmes are often project-driven and lack long-term engagement strategies that can foster stewardship and behavioural change. Strengthening participatory governance through community-led monitoring, citizen science initiatives, wetland stewardship programmes, local biodiversity management committees, and formal representation of stakeholders in river basin planning processes would improve accountability, enhance local ownership of conservation efforts, and support more effective and socially inclusive river management outcomes.

Finally, climate resilience remains inadequately mainstreamed within river basin planning. Future conservation strategies should incorporate floodplain zoning, seasonal water budgeting, catchment-scale afforestation, environmental flow assessment, wetland restoration, and climate adaptation measures. A more integrated river basin approach that combines hydrological, ecological, social, and institutional dimensions, while strengthening community participation and biodiversity conservation, will be essential for ensuring the long-term sustainability and ecological integrity of the Gomti River.

12.4. CONCLUSION

The Gomti River Basin presents a complex socio-ecological system where ecological degradation, demographic pressures, urbanization, and climate variability converge to impact river health and community well-being. Analysis of the document shows that while the Gomti sustains agriculture, fisheries, cottage industries, and cultural practices, its ecosystem is increasingly threatened by untreated sewage, industrial effluents, altered hydrology, and declining base flows. Urban footprints, especially in Lucknow, have amplified ecological disruption through channelization and encroachment of floodplains, while rural areas continue to depend on the river for agriculture, fisheries, and domestic use. This dual urban-rural dependency underscores the urgent need for integrated and adaptive basin management.

The analysis reveals that the ecological integrity of the Gomti River has progressively deteriorated due to cumulative anthropogenic pressures superimposed on increasing climatic variability. Extensive irrigation withdrawals during non-monsoon periods have significantly reduced ecological flows, particularly in upper and middle stretches, while erratic rainfall patterns, declining groundwater recharge, rising temperatures, and altered monsoon dynamics are intensifying hydrological instability. Flooding in districts such as Jaunpur and Pratapgarh, alongside declining lean-season flows, illustrates the growing climate vulnerability of the basin. Simultaneously, widespread conversion of wetlands and vegetation into agricultural and built-up landscapes has reduced the basin's natural ecological buffering capacity. The reduction in water bodies and vegetation cover between 1995 and 2020 reflects a concerning trajectory of ecological degradation and landscape fragmentation.

Stakeholder analysis reveals that high-salience government institutions such as the Uttar Pradesh Forest Department, State Program Management Group (SPMG), State Water Resources Authority (SWaRA), and Uttar Pradesh Pollution Control Board (UPPCB) form the core of river governance, but their mandates require harmonization and stronger enforcement. Medium-salience actors, including Panchayati Raj institutions, fisheries and agriculture departments, NGOs, and community organizations, provide the essential grassroots interface for conservation, awareness, and livelihood initiatives. Civil society efforts, particularly the Ganga Prahari program, have successfully mobilized women, youth, and marginalized groups, demonstrating that community stewardship can be scaled up to strengthen ecological resilience and ensure social legitimacy in conservation.

The Gomti basin simultaneously reflects deep socio-economic dependence on riverine resources. Agriculture remains the dominant water-consuming sector, accounting for more than 90% of water demand, with extensive dependence on irrigation-intensive crops such as rice, wheat, and sugarcane. Groundwater extraction linked to agricultural intensification is causing alarming declines in water tables, particularly around urban-agricultural interfaces such as Lucknow. Fisheries, although historically important for livelihood security among marginalized communities, have experienced substantial decline due to pollution, habitat fragmentation, and altered river hydrology. The deterioration of fisheries not only threatens livelihoods but also weakens local food security and traditional occupational systems.

Importantly, the chapter establishes that the challenges confronting the Gomti are not purely ecological but fundamentally socio-economic and governance-related. Demographic pressures, uneven development patterns, rural poverty, gender disparities, and inadequate access to education and sanitation continue to shape human dependence on the river. Urban centres such as Lucknow exert disproportionate ecological pressure through sewage discharge, floodplain encroachment, and infrastructure expansion, while rural communities remain highly dependent on the river for agriculture, livestock, and domestic needs. This urban-rural interface has created a complex socio-ecological system where ecological degradation directly undermines livelihood resilience and community well-being.

The results highlight that the Gomti River cannot be rejuvenated through infrastructure-centric or single-sectoral approaches alone. Effective conservation demands strengthening ecological flows, curbing point and non-point pollution sources, protecting wetlands and floodplains, and promoting sustainable agriculture. The Gomti's degradation is not solely a technical challenge but a socio-ecological governance issue. Sustainable revival requires effective ecological restoration. Equally critical is integrating livelihood security into conservation through capacity building, alternative income opportunities, and cultural alignment of ecological practices. Policy gap analysis underscores that existing schemes are fragmented; basin-level planning, backed by real-time data integration and cross-sectoral coordination, is essential to translate policies into measurable ecological improvements. Achieving this necessitates coordinated action by high-salience institutions such as the Forest Department, UPPCB, SWaRA, and SPMG, alongside community and civil society partners. On the basis of our results, we recommend following activities for effective conservation of Gomti River Basin:

• Awareness generation should be a continuous process and regular awareness and sensitization programme should be conducted with local stakeholders. Stakeholder-specific awareness programme should be designed.

• Regular monitoring and control of pollution in the river system should be in place. Local people and institutions should be mobilized and equipped to do the same through community monitoring mechanisms.

• Organic and natural farming practices should be promoted through farmer training and incentives, and buffer and filter zones such as vegetation zones along riverbanks should be introduced to filter the agricultural runoff.

• Rationalize irrigation withdrawals during lean seasons through water budgeting and demand-side management. Promote micro-irrigation systems, crop diversification, and climate-resilient agricultural practices to reduce excessive water extraction.

Implement groundwater recharge and aquifer restoration programmes in over-exploited districts such as Lucknow, Sitapur, and Hardoi.

• Stricter controls should be placed on effluents from small-scale industries such as tanneries and dyeing units.

• Formalise the Ganga Prahari cadre through institutionalization under governance structures such as UP Panchayati Raj system, giving GPs defined roles in local governance with performance-linked honoraria tied to ecological monitoring deliverable.

• Expansion of community-based institutions and groups such as Ganga Prahari cadre should be promoted with balanced gender and age representation, providing them with sustained training and recognition.

• Institutionalize the Ganga Prahari cadre within district-level river conservation planning frameworks.

• Increase participation of women, youth, fisher communities, and marginalized groups in river governance and conservation planning.

• Local livelihoods should be linked with conservation goals and livelihood programmes should with stronger market linkages, and conservation-linked microenterprises under schemes such as NRLM and Jalaj initiatives should be integrated.

• Create community incentive mechanisms and benefit-sharing frameworks linked to conservation performance. Institutionalization of community-based river committees linking Panchayats with district-level governance should be introduced.

• Eco-labelling and certification for river-friendly agricultural and artisanal products should be established and promoted.

• Expand the Jalaj circular-economy model to one centre per sub-basin (Upper Gomti, Sai, Lower Gomti), with formal convergence of PMKVY, NRLM, and PMMSY schemes, and a Gomti eco-label for GP-linked SHG products on state e-marketplaces.

• Support biodiversity-sensitive village microplans across additional riverine gram panchayats. Scaling up of village microplanning based on the Rajepur model to at least 50 high-priority riverine Gram Panchayats, selected by biodiversity value, fisher dependence, sanitation deficit, and drain proximity, each formalised through an MoU with the Gram Panchayat.

• State policies (water, wetlands, agriculture) should be aligned with basin-level ecological objectives.

• Water table restoration should be promoted through recharge structures and rainwater harvesting activities in catchment areas under schemes such as Catch the Rain 2025, and climate adaptation strategies (e.g., resilient crop varieties, afforestation) in basin management should be mainstreamed.

• A three-tier Gomti River Health Monitoring System should be operationalized including community-level Ganga Prahari biodiversity reporting via a mobile platform, real-time water quality monitoring and public data release, and biennial scientific assessments, all feeding into informed decision-making.

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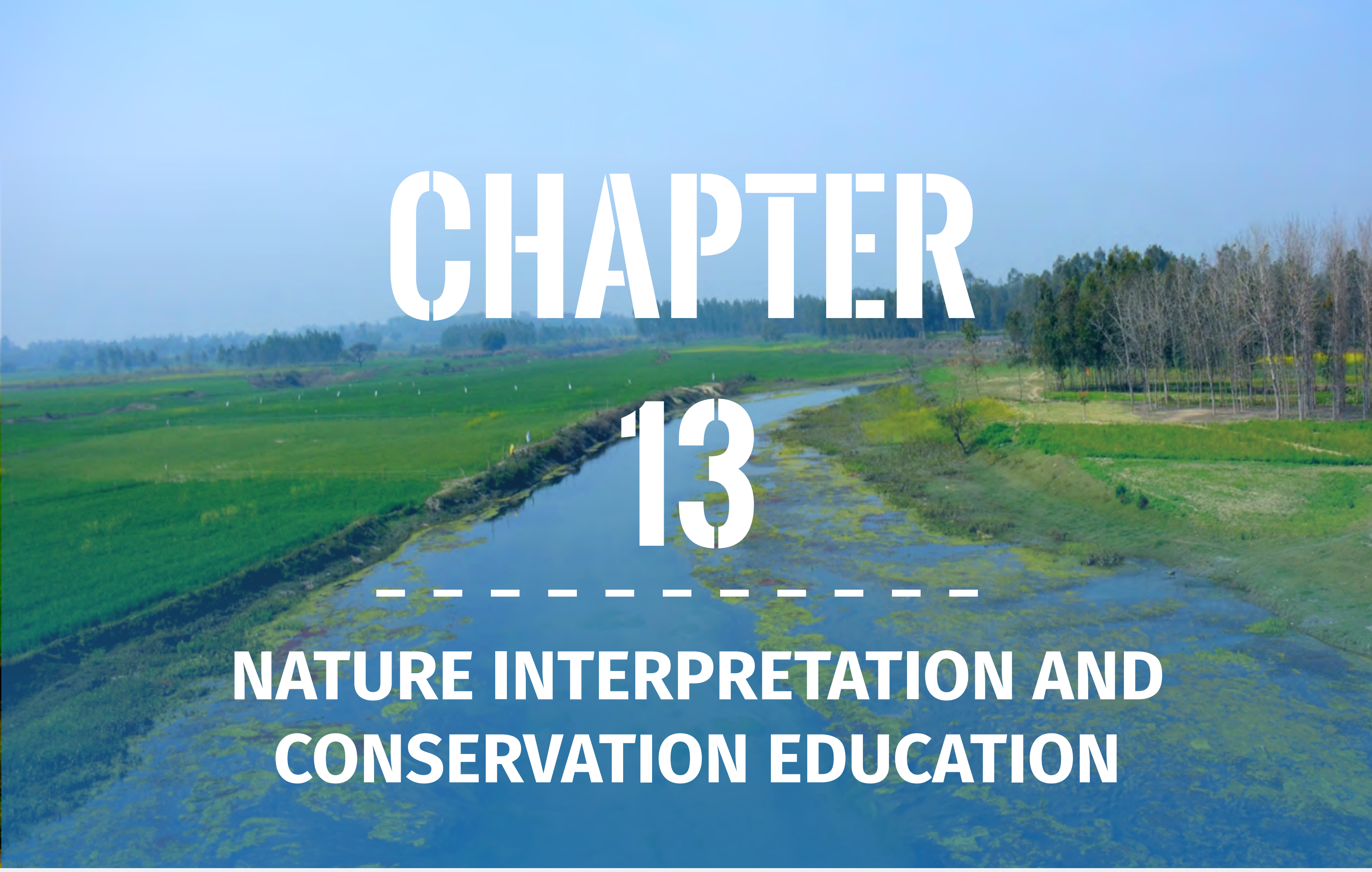

CHAPTER 13

NATURE INTERPRETATION AND CONSERVATION EDUCATION

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SUMMARY

Awareness and sensitization programme were conducted along the Gomti River aimed to strengthen environmental education and instill conservation values among school students and teachers in Uttar Pradesh. Framed within the broader goals of conservation education, the initiative emphasized enhancing ecological knowledge, promoting positive environmental attitudes, and motivating responsible actions toward biodiversity protection. Conservation education, as highlighted in the report, plays a crucial role in enabling individuals—particularly young learners—to understand environmental challenges, appreciate natural resources, and actively contribute to sustainable practices. Schools present an effective platform for such interventions, and the programme strategically integrated interactive pedagogy, interpretation tools, and teacher capacity-building to foster long-term engagement with riverine ecosystems. The programme comprised three major components: student awareness workshops, low-cost interpretation corners (Jalmala Samvaad), and teacher training sessions. A total of 25 student workshops were organized across government schools along the Gomti River, reaching 1,321 students. These workshops employed visual presentations, games, and discussions to simplify complex concepts about river ecology, biodiversity, pollution, and conservation. A structured pre- and post-questionnaire survey (n = 187) revealed significant knowledge gains, with a 62.27% increase in understanding of riverine

biodiversity and notable improvements in conservation values. Statistical analysis using the Wilcoxon Signed-Rank Test confirmed that the changes were significant ($p < 0.05$). To ensure sustained learning, 19 low-cost interpretation corners—Jalmala Samvaad—were established across six districts. These permanent, visually rich learning spaces sensitized 24,330 students and 324 teachers, serving as ongoing hubs for environmental activities, exhibitions, and inter-school engagement. Recognizing teachers as key influencers of student learning, the programme also conducted interactive teacher training workshops, training 213 in-service teachers. Sessions included experiential learning through games, discussions, and biodiversity-focused activities. Each participating school received a "Gyan Kosh" toolkit, containing manuals, activity books, biodiversity factsheets, educational games, videos, and a water testing kit, enabling teachers to integrate river conservation themes into daily classroom practice. Overall, the programme established an effective, replicable model for river-based environmental education. By combining student engagement, permanent interpretation infrastructure, and teacher empowerment, the initiative significantly enhanced awareness and fostered a culture of environmental stewardship across the Gomti River basin.

13.1. INTRODUCTION

Conservation education aligns closely with the objectives of environmental education, focusing on nurturing environmental awareness, imparting knowledge, fostering positive attitudes, enhancing problem-solving abilities, and encouraging active involvement. It motivates individuals to comprehend environmental challenges, cultivate concern for nature, and participate meaningfully in addressing these issues (Jacobson et al., 2015). Environmental Education (EE) serves as a developmental process that builds skills, shapes decision-making, and instills attitudes necessary to identify environmental problems and understand the intricate connections between humans and the natural world (IUCN, 1970). In the Indian educational context, EE has long been recognized, with ecological and environmental values deeply embedded in the curriculum (Ravindranath, 2007). Given the prevailing environmental challenges, promoting EE as a lifelong learning tool from early childhood has become increasingly important (Sonowal, 2009). Incorporating biodiversity education into school curricula further empowers young people to tackle environmental challenges through informed and responsible actions (Burton et al., 2024). While many school curricula include environmental topics, few provide comprehensive programs or directly aim to achieve conservation goals (Jacobson et al., 2015). Several studies show that inclusion of environmental and ecological topics in academics increases students' awareness and affects their attitude, behavior and conservation values positively (Leeming et al., 1993; Zelezny, 1999; Rickinson, 2001; Humston & OrtizBarney, 2007). School-based environmental awareness programs are necessary for developing positive attitudes and behaviors toward biodiversity conservation in students. Integrating such awareness programs into school curricula and activities can enhance students' understanding of biodiversity issues; while countering negative perceptions and promoting sustainable practices, addressing drivers of biodiversity loss like poaching and deforestation (Montana & Mlambo, 2018). Students can also benefit from an interpretation programme, for instance, it increases their understanding of how they can contribute to the protection of an area's natural resources upon which they depend for sustenance. Interpretation is the process of conveying the significance of a place or thing to people in a way that deepens their appreciation, fosters understanding, and encourages a positive outlook toward conservation. It aims to enrich visitors' experiences, communicate deeper symbolic meanings, and inspire changes in attitudes or behavior towards the natural or cultural environment (Prentice, 1996). People use interpretation to help them understand the place they are visiting (Stewart et al., 1998). Teacher education and teachers themselves are critical components of educational transformation and growth (Darling-Hammond, 2020). Studies emphasize that teacher quality significantly impacts student learning outcomes (Gaertner & Brunner, 2018), highlighting the importance of continuous professional development to improve teaching skills (Wang & Zhang, 2023). Teacher development programs have also increasingly been integrated into school improvement strategies (Garcés & Granada, 2016; Powell et al., 2003), aiming to foster ongoing professional growth for teachers, which ultimately enhances student learning outcomes and overall school effectiveness (Darling-Hammond et al., 2017; Holloway, 2006). When discussing a vast river like the Ganges, and its tributaries, it is necessary not to narrow our focus to a single aspect. An interdisciplinary approach becomes essential for the conservation of both the water and its biodiversity. 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

3. Training school teachers to integrate river conservation into classrooms.

13.2. METHODOLOGY

To promote environmental awareness and biodiversity conservation along Gomti River, Awareness and Sensitization programs were conducted. This program was designed to target students and teachers to create sustained impact through education and engagement. Figure 13.1 that outlines a comprehensive framework for "Awareness and Sensitization Programs," divided into three main categories:

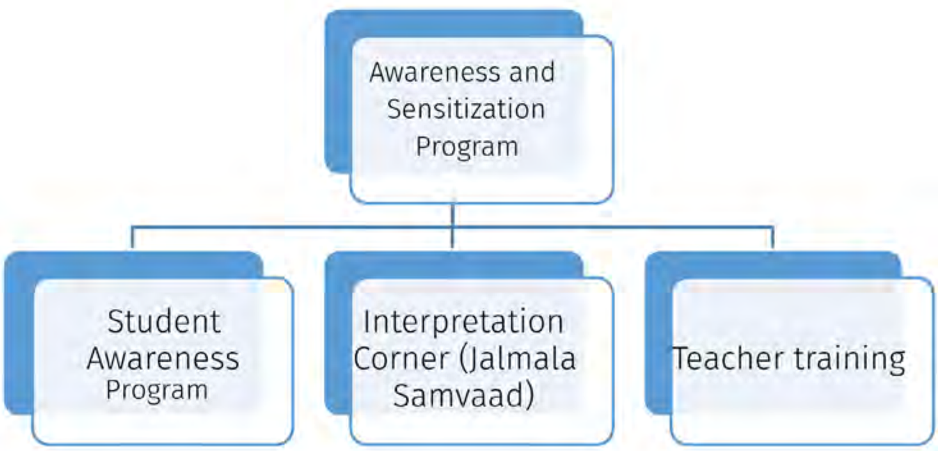

Figure 13.1. Flow chart representing approach taken for conducting awareness and sensitization programs along Gomti River.

13.2.1. Student Awareness Program

Interactive awareness workshops were conducted in government schools located near the Gomti 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. To assess the effectiveness of the intervention, a structured pre- and post-questionnaire (Annexure 1) survey was administered, measuring knowledge gains and attitude shifts. Wilcoxon Signed-rank test was conducted to check if the pre to post changes are statistically significant and it gave a p value < 0.05, indicating the significance.

13.2.2. Interpretation Corners (Jalmala Samvaad)

To provide students with continuous access to learning materials, low-cost interpretation corners—Jalmala Samvaad—were established within the school premises. These permanent learning spaces displayed educational panels and artwork related to riverine biodiversity and conservation issues.

13.2.3. Teacher Training

Recognizing the vital role of educators in shaping student perspectives, teacher training workshops were organized for both pre-service and in-service teachers. These sessions were activity-based and included distribution of resource toolkits like "Gyan Kosh" to enable teachers to integrate river conservation topics into their curriculum. The training empowered educators to become facilitators of change in their respective schools and communities.

This integrated approach ensured not only knowledge dissemination but also the development of environmental stewardship among the youth and teaching community, thereby contributing to the larger Ganga Basin conservation goals through tributary-focused action along the Gomti River.

13.3. RESULTS

13.3.1. School Awareness Programs

Awareness and sensitization workshops were organized in government schools situated along the Gomti 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 Gomti River basin and were implemented across the state of Uttar Pradesh. A total of 25 awareness and sensitization workshops were conducted, through which 1321 school students were sensitized.

Game-based activities and Questionnaire survey being conducted at Govt. Schools, Uttar Pradesh along Gomti River

13.3.2. Pre and Post Questionnaire Survey

In order to find out the retention power amongst school students, a pre and post workshop questionnaire survey (Annexure 1) was conducted along Gomti River. From the analysis of the questionnaire of (n = 187) along the Gomti River we found out that there was a knowledge gain amongst students across three categories. Comparing the responses, we found a 62.27% increase in their knowledge about riverine biodiversity (Figure 13.2), and 6.82% in conservation values (Figure 13.3). Comparatively, a significant improvement in the knowledge of participants was recorded in post-workshop assessments than pre- assessments ($v = 13852$, $p < 0.05$).

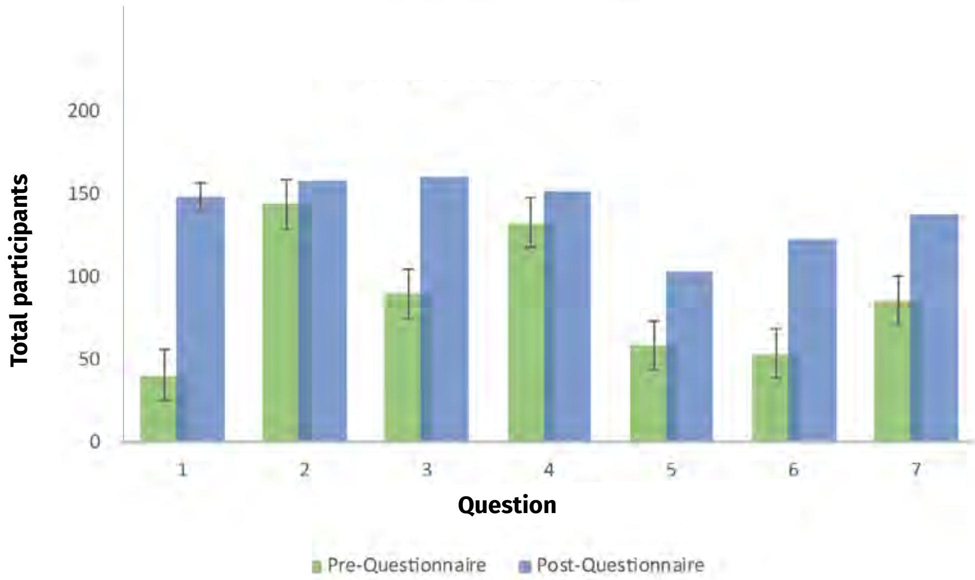

Figure 13.2. Graph representing comparison of pre and post score and average percentage Increase in knowledge level along Gomti River in the category "Riverine Biodiversity".

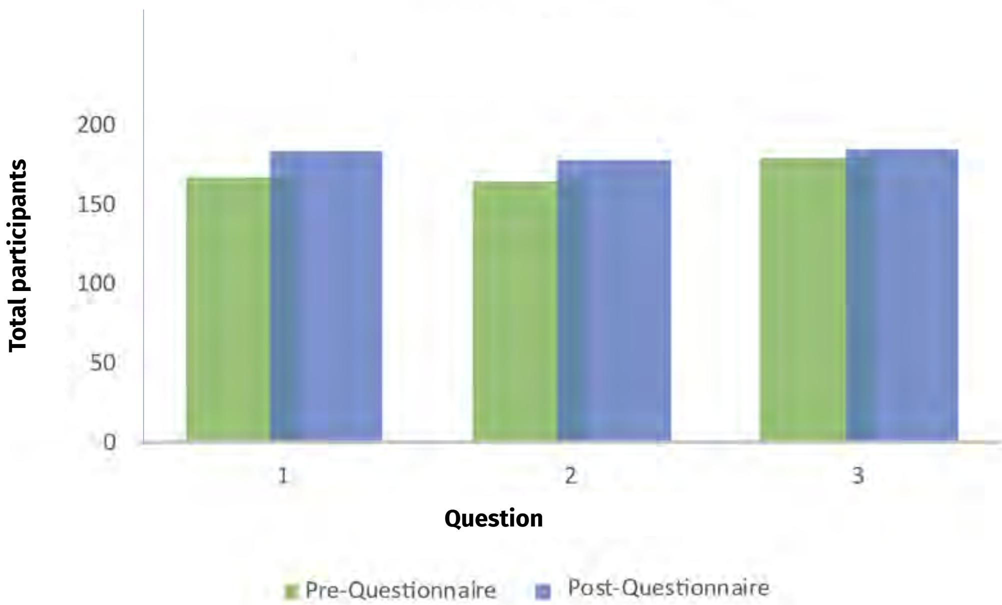

Figure 13.3. Graph representing comparison of pre and post score and average percentage Increase in knowledge level along Gomti River in the category "Conservation Values".

13.3.3. Low-cost Interpretation Center “Jalmala Samvaad”

A total of 19 low-cost interpretation corners have been established along Gomti River making significant impact in education outreach (Table 13.1, Figure 13.4). These smaller-scale interpretation corners act as specialized galleries, equipped with panels, and artwork focused on Ganga and Gomti biodiversity. 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 19 low-cost interpretation corners along the Gomti River we have reached out to 24330 students and 324 in-service school teachers.

Table 13.1. Low-cost interpretation corners “Jalmala Samvaad” established along Gomti River.

S.No.	District	Number of Jalmala Samvaads Established	Number of Students Sensitized	Number of Teachers Sensitized
1.	Jaunpur	3	4285	45
2.	Lucknow	2	4000	45
3.	Sitapur	3	4600	85
4.	Pilibhit	4	3352	45
5.	Sultanpur	3	5600	56
6.	Varanasi	4	2493	48
	Total	19	24330	324

Jalmala Samvaad established at Govt Schools along Gomti River

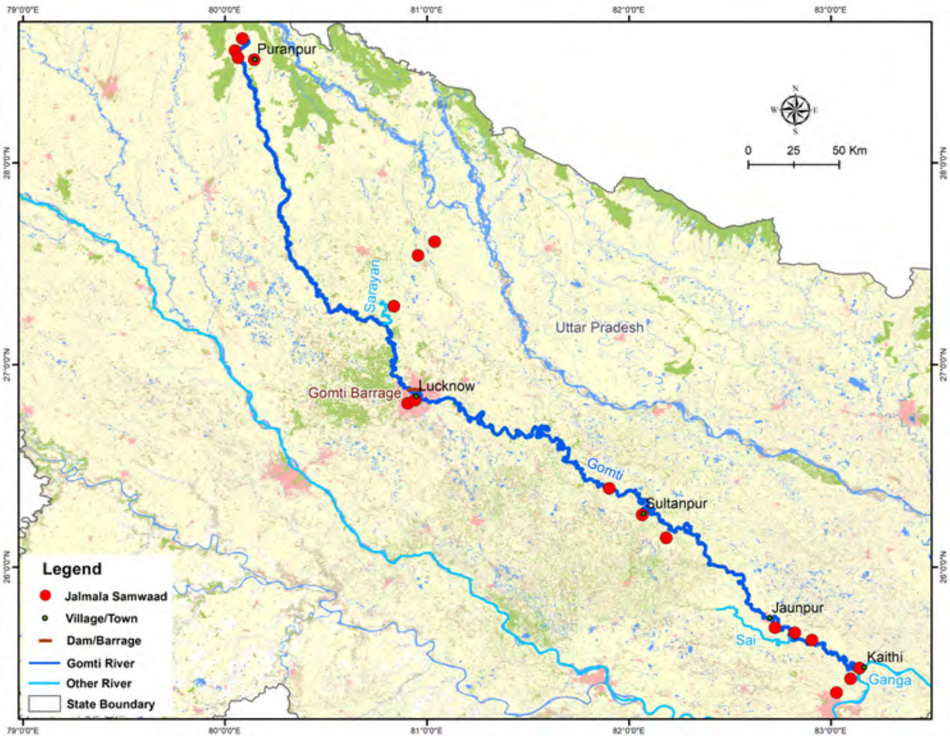

Figure 13.4. Map representing the Jalmala Samvaad established along the Gomti River.

13.3.4. Teacher Training

A total of 213 in-services teachers have been trained through these training workshops. The teacher training program was successfully implemented using an interactive, activity-based approach to enhance educators' understanding of riverine ecosystems and conservation. Each session began with a presentation on the biodiversity of the Ganga River and its tributaries, highlighting the ecological significance of the river system and the impacts of human activities on its health. This was followed by a series of hands-on, experiential learning activities designed to actively engage participants. Educators participated in group discussions using the instructional manual "Discovering Ganga" and took part in educational games such as Snake and Ladder, Web of Life, Biodiversity Dart, and Species Puzzle. These activities fostered critical thinking, collaboration, and innovative teaching strategies for integrating river conservation themes into classroom practice.

Gyan Kosh

Following the training, each school received a resource kit called "Gyan Kosh." This kit includes a teacher training manual, activity books, a factsheet on river biodiversity, a booklet addressing plastic pollution, educational games, puppets, origami materials, a pen drive containing relevant videos, and a water testing kit. These resources aim to empower teachers with the necessary knowledge and tools to integrate engaging and informative environmental education into their classrooms.

'Gyan kosh' a resource kit provided to the teachers after the awareness workshops

13.4. CONCLUSION

The integrated awareness and sensitization program along the Gomti River has proven to be an effective model for promoting environmental education and fostering a culture of river conservation among students and educators. Through interactive student workshops, the establishment of low-cost interpretation corners (Jalmala Samvaad), and comprehensive teacher training sessions, the initiative successfully addressed knowledge gaps and promoted long-term engagement with riverine ecosystems. The pre- and post-questionnaire analysis revealed a statistically significant improvement in students' understanding of riverine biodiversity and conservation values, indicating the success of the awareness workshops in enhancing knowledge and altering perceptions. The creation of 19 Jalmala Samvaads across schools provided a permanent, low-cost infrastructure for sustained learning, reaching over 24,000 students and more than 300 teachers—thereby amplifying the program's outreach and long-term impact. Meanwhile, the teacher training component, complemented by the distribution of the "Gyan Kosh" toolkit, equipped educators with innovative pedagogical resources to integrate river conservation themes into the school curriculum effectively. This multi-pronged approach demonstrates a replicable and scalable strategy for environmental education in riverine regions.

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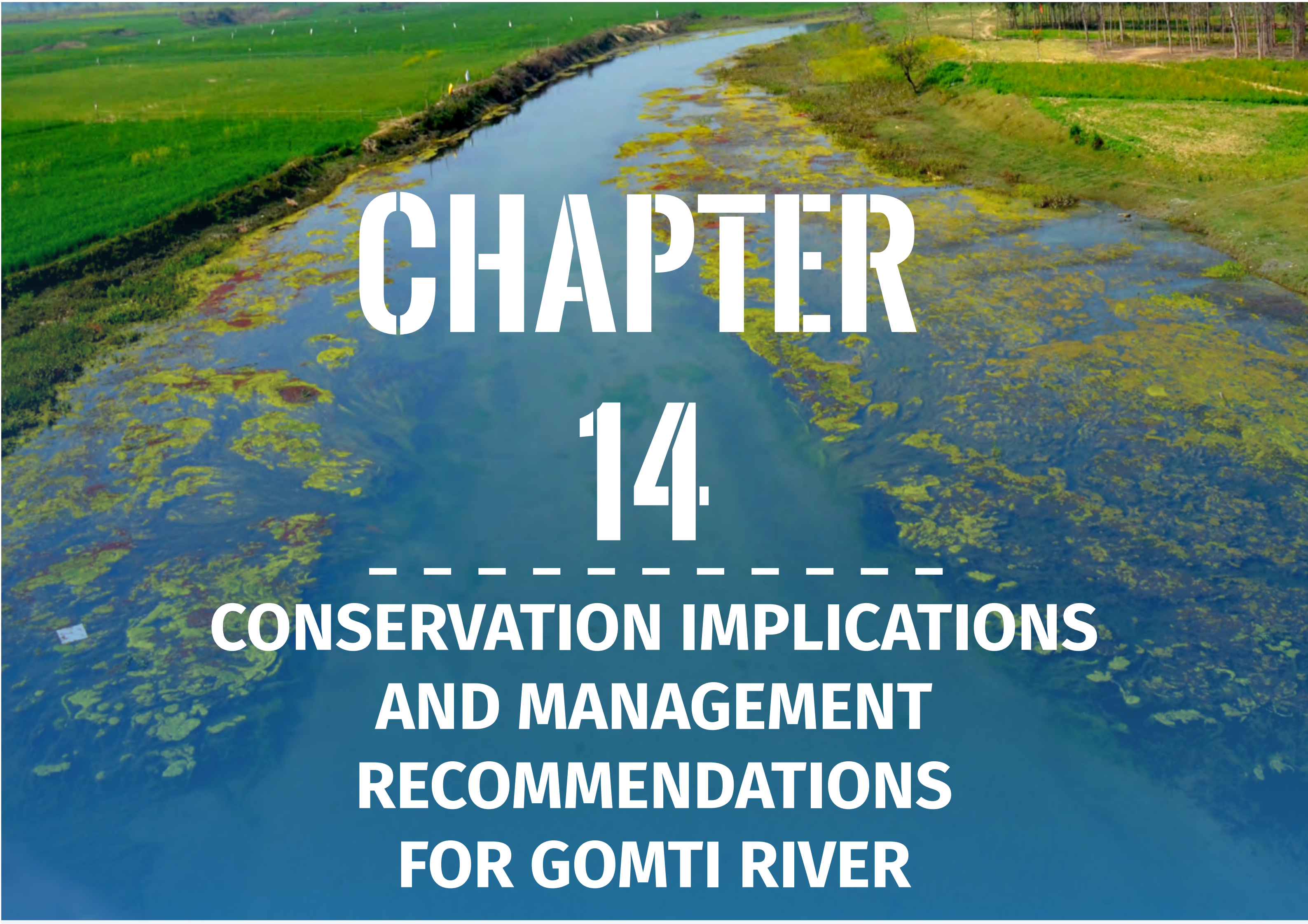
SECTION- VI

CONSERVATION ACTION PLAN



CHAPTER 14

CONSERVATION IMPLICATIONS AND MANAGEMENT RECOMMENDATIONS FOR GOMTI RIVER

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SUMMARY

The Gomti River, a 930 km long tributary of the Ganga River, flowing through Uttar Pradesh, supports a significant assemblage of freshwater biodiversity. The biodiversity of the Gomti River is represented by 408 plant species, 41 fish species, 10 amphibian species, 5 turtle species, the mugger, 51 bird species including 44 water and water-associated bird species, and the smooth-coated otter. Many species of global conservation concern have been recorded from the Gomti River, viz., the Endangered Indian skimmer and Egyptian vulture, the Vulnerable smooth-coated otter, sarus crane and river tern, and Near Threatened fish and reptile species. The Gangetic dolphin, once historically present in the river, has been locally extirpated. Absence of apex predators in the riverine ecosystem highlights that the river's ecological integrity is severely compromised by a complex, spatially heterogeneous regime of anthropogenic stressors.
This chapter synthesises the findings of the preceding biodiversity and threat assessment chapters to evaluate management options, and propose a coherent framework for the ecological recovery of the

Gomti River. The study identifies, six overarching conservation priorities, viz. (i) restore and maintain environmental flows; (ii) control point-source and diffuse pollution; (iii) protect and restore floodplain and riparian habitats; (iv) implement species-specific conservation actions for globally threatened taxa; (v) regulate fishing, sand mining, and water abstraction; and (vi) establish a long-term, standardised biodiversity monitoring programme. These priorities are grounded in the systematic baseline data generated by this study and need to be implemented through an integrated, basin-scale management approach that spans sectoral boundaries and engages communities, local governance institutions, and state and national policy frameworks.

14.1. INTRODUCTION

Rivers are among the most biodiverse and ecologically productive ecosystems, yet they are among the most threatened (Dudgeon et al., 2006; Vörösmarty et al., 2010). This paradox is starkly illustrated in the rivers of the Ganga basin, where freshwater biodiversity persists despite decades of ecological degradation driven by population growth, agricultural intensification, urbanisation and inadequate environmental governance (Sinha et al., 2012; Rai et al., 2024). The Gomti River exemplifies this condition, as it maintains ecological significance through the presence of globally threatened species and serves as both a breeding habitat and a migratory corridor for a diverse aquatic and avian fauna, yet has been profoundly altered throughout its length.

The preceding chapters of this volume have, collectively, produced the first comprehensive, multi-taxon, multi-year baseline assessment of biodiversity and anthropogenic pressures across the Gomti River's full course from Gomat Tal in Pilibhit to its confluence with the Ganga at Kaithi, Ghazipur. This baseline is the essential foundation for evidence-based conservation planning. Without knowing what the river supports, where it supports it, and what threatens it, management interventions are necessarily speculative. This study documents the principal stressor types and their longitudinal distribution with a spatial resolution — 5 km Biodiversity Evaluation Units — sufficient for targeted management.

This chapter draws on the findings of preceding chapters to derive conservation implications, identify management priorities, and propose a framework for the long-term ecological stewardship of the Gomti River. It is intended as both a scientific synthesis and a practical resource for river managers, conservation practitioners, and policy-makers engaged with the Gomti and, by extension, with the broader challenge of freshwater conservation in the Indo-Gangetic Plain.

14.2. STATE OF THE GOMTI: A BIODIVERSITY SYNTHESIS

14.2.1. Floral diversity

A total of 408 angiosperm taxa representing 31 orders, 86 families, and 299 genera were documented along the Gomti River during this study. Three species—*Alternanthera philoxeroides*, *Synedrella vialis*, and *Ceratophyllum submersum*—were recorded as new reports for Uttar Pradesh and the Gangetic plains, highlighting the scientific significance of the Gomti River. Highest diversity was found along the meanders and the confluences. Species diversity declined with increasing distance from the river, greatly impacted by agricultural activity, monocultures, and habitat fragmentation. This study highlights the need for native species restoration, minimising exotic monocultures, protecting ecosystem mosaics, and conserving buffer zones along the Gomti River.

14.2.2. Ichthyofauna

The 41 fish species recorded across 11 sampling sites represent a substantially reduced fauna relative to historical surveys, which documented between 56 and 64 species (Kumar & Rao, 2009; Sarkar et al., 2010). This decline of approximately 35–40% in recorded species richness over two to three decades is consistent with global trends in freshwater fish diversity. It reflects the compounding effects of habitat degradation, flow alteration, water quality deterioration, and overfishing documented in the chapter on anthropogenic stressors. The highest species richness and catch-per-unit-effort recorded at sites in the lower and middle reaches — particularly at Jalalpur and Kaithi — suggests that the larger channel dimensions, greater water depth, and higher hydrological connectivity with the Ganga mainstem in these reaches provide refugial conditions that partially buffer against the pressures prevalent upstream. The presence of threatened species including the Near Threatened *Ompok bimaculatus* underscores that the river retains conservation value for fish, but only where ecological conditions remain sufficiently intact to support sensitive taxa.

14.2.3. Herpetofauna

The herpetofaunal assemblage of the Gomti is notable both for its diversity and for the conservation significance of its component species. Ten amphibian species were recorded, with the highest species richness at Phulhar and the highest Shannon–Wiener diversity at Makaria Kalan, both in the upper and upper-middle reaches where habitat quality is comparatively higher. Among reptiles, the documentation of five turtle species — including the ecologically sensitive crowned river turtle — and the continued presence of the mugger crocodile along sandy riverbanks and clay islands through the middle and lower reaches are ecologically significant findings. These species are sensitive indicators of riverine habitat quality: turtles require clean water, productive benthic communities, and undisturbed nesting beaches, while mugger crocodiles depend on shallow, low-disturbance bank habitats for basking and nesting. Their persistence in the Gomti, despite pervasive anthropogenic pressure, indicates that pockets of suitable habitat remain, but the distribution of both groups is increasingly restricted and fragmented.

14.2.4. Avifauna

The 51 bird species, including 44 water and water-associated bird species recorded during systematic surveys between 2019 and 2023 demonstrate the Gomti River's importance as avian habitat across the Central Asian Flyway, supporting both resident breeding populations and winter migratory assemblages. The detection of 57 Indian skimmers resting on a sandy island near Palauli in February 2022, with evidence of possible nesting attempts, is among the most conservation-significant findings of the entire study. The Indian skimmer is Endangered, with a declining global population increasingly restricted to a few large river systems, and the Gomti River may represent a previously undocumented breeding location whose protection is both urgent and achievable. Equally significant are the records of the Endangered Egyptian vulture, Vulnerable sarus crane and river tern, and Near Threatened Asian woolly-necked stork and river lapwing — a suite of globally threatened species whose presence in an unprotected riverine habitat outside recognised sanctuaries challenges the assumption that biodiversity of conservation priority is confined to formally protected areas.

14.2.5. Aquatic and Semi-Aquatic Mammals

The mammal survey produced the starkest finding of the entire study: the confirmed local extinction of the Gangetic dolphin from the Gomti River, a species documented in the river since Anderson (1878), juxtaposed with the first confirmed record of the Vulnerable smooth-coated otter near Gayabar village in Sitapur. The dolphin's extirpation, attributable to the compounding effects of the Gomti Barrage, chronic pollution, reduced flows, and bycatch mortality, serves as a sentinel indicator of the river's overall ecological condition. The otter's presence, restricted to a single individual in the relatively less disturbed upper-middle reach, suggests residual ecological integrity in localised stretches but cannot be interpreted as evidence of a viable, self-sustaining population without further targeted survey effort.

14.2.6. Global Threat Assessment of Gomti River's Biodiversity

The multiple ecological assessments recorded a total of 517 species, of which 408 were angiosperm plant taxa, 41 were freshwater fish species, 10 were amphibian species, five were freshwater turtle species, one crocodile, 51 were bird species, including 44 water and water-associated species, and the first confirmed record of smooth-coated otter. Flagship threatened species documented include the Indian skimmer, sarus crane, river tern, painted stork, *Clarias magur* (an Endangered fish), and the crowned river turtle; the critically endangered three-striped roofed turtle appears to have declined to functional local extinction from its last known sites in the river. Of the 517 species recorded, the majority of fall under Least Concern (LC), totalling 255 (49.2%). About 241 species (46.5%) remain Not Evaluated (NE), largely comprising flora, which limits any comprehensive threat assessment for this taxon. Of the evaluated 109 faunal species, 11 species are threatened: five Endangered (EN) — distributed across fish, herpetofauna, and avifauna — and six Vulnerable (VU), spanning herpetofauna, avifauna, and mammals. Four species are Near Threatened (NT) and five are Data Deficient (DD), the latter flagging significant gaps in available population data (Figure 14.1). Collectively, these figures underscore the urgent need for targeted monitoring of threatened fauna, particularly freshwater fish and reptiles, and systematic Red List evaluation of the basin's extensive floral diversity, which remains largely unassessed.

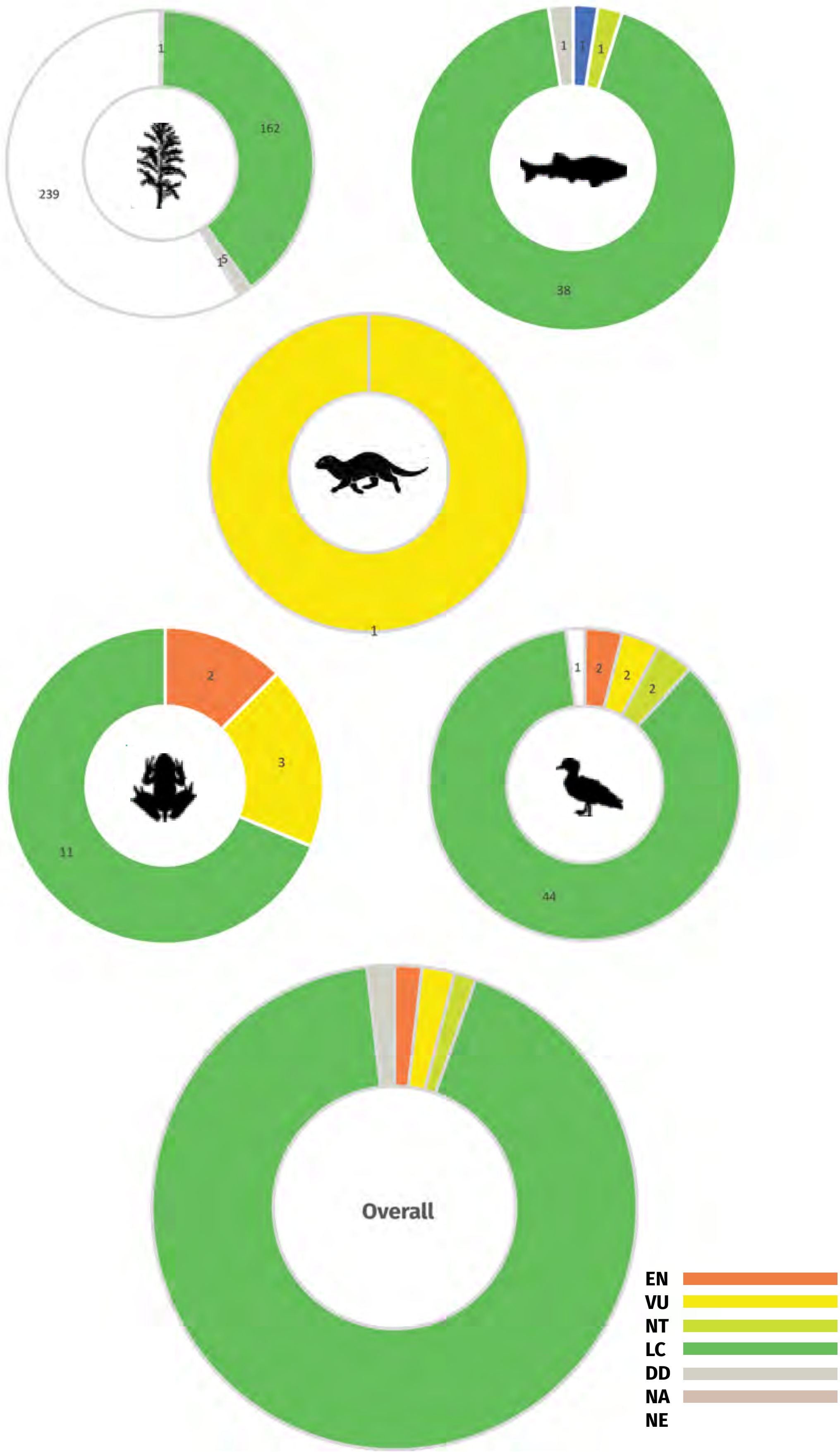

Figure 14.1. IUCN Red List status of different taxa recorded in the Gomti River.

14.3. THREAT SYNTHESIS: INTERACTING PRESSURES ALONG THE LONGITUDINAL GRADIENT

A central insight of this study, and one with direct implications for conservation planning, is that the threats facing the Gomti River's biodiversity are not uniformly distributed along the river's length, nor do they operate independently. The information on anthropogenic stressors, when seen in conjunction with the findings of ecological assessment, reveals a longitudinal gradient of stressor regimes in which different threat types dominate at different points along the river.

In the upper zone of the Gomti River, hydrological failure, in the form of seasonal intermittency driven by groundwater extraction, floodplain encroachment, and the loss of riparian recharge, is the master stressor. This hydrological failure establishes the fundamental ecological template on which all other pressures act. A river that loses surface flow for extended periods cannot support obligate aquatic species regardless of water quality or fishing regulation. This hydrological impairment in the source reach cascades downstream as altered hydrological and thermal regimes, modified sediment dynamics, and reduced organic carbon inputs that restructure biological communities throughout the river (Poff et al., 1997; Vannote et al., 1980).

In the middle zone, the dominant stressor shifts to chemical, with the untreated sewage and industrial effluent loads entering the Gomti River at Lucknow constituting an acute and chronic pollution pressure that depletes dissolved oxygen, introduces persistent toxicants, and fundamentally alters aquatic community structure. The coincidence of this chemical stress with the highest intensities of fishing, sand mining, water extraction, and human and livestock disturbance creates a multiple-stressor environment in which synergistic interactions between pressures amplify ecological impacts (Ormerod et al., 2010).

In the lower zone, the biological communities are shaped by the upstream stressor and local conditions. Pollutant loads, altered flow regimes, and depleted fish recruitment from degraded upstream spawning habitats are delivered to the lower river through hydrological transport, constraining its ecological potential even where direct local disturbance is relatively low.

This longitudinal stressor has a critical management implication when it comes to rejuvenation of the river. Interventions that address only the most visibly degraded reach (the middle zone), without simultaneously addressing the source-reach hydrology and the lower zone's downstream connectivity, will achieve partial ecological recovery in a limited spatial scale. A sustainable and coherent conservation strategy must span the entire length of the Gomti River and treat the three zones as components of an integrated system, which would require different strategies.

14.4. CONSERVATION PRIORITIES AND MANAGEMENT RECOMMENDATIONS

14.4.1. Priority 1: Restoring and Maintaining Environmental Flows

The single most fundamental conservation intervention for the Gomti River is the restoration of a natural flow regime that sustains perennial flow throughout the river's length, including the currently intermittent upper zone. Environmental flows — the quantity, timing, and quality of water flows required to sustain freshwater ecosystems and the human livelihoods that depend upon them (Brisbane Declaration, 2007) — have been severely curtailed in the Gomti River by groundwater extraction for irrigation, agricultural encroachment on the floodplain, and the regulatory effects of the Gomti Barrage. Restoring ecological flows requires a coordinated response across multiple sectors, including the regulation of groundwater extraction in the upper catchment, the implementation of minimum ecological flow standards at the Gomti Barrage, the restitution of encroached floodplain land to the river system, and the enforcement of riparian buffer zones that protect the river's natural recharge processes.

The Uttar Pradesh State Water Policy and the National Water Policy (2012) both recognise the principle of environmental flows, and Namami Gange Programme guidelines include provisions for ecological flow management. However, the translation of these policy commitments into enforceable standards on individual tributaries such as the Gomti requires specific flow assessments, stakeholder negotiation, and institutional capacity that are currently lacking. Conducting a formal environmental flow assessment for the Gomti should be treated as an urgent research and policy priority.

14.4.2. Priority 2: Pollution Abatement and Water Quality Management

Reducing the pollutant load entering the Gomti — particularly at Lucknow — is essential for the recovery of water quality throughout the middle and lower zones. Untreated domestic sewage discharged daily into the river at Lucknow constitutes the most quantitatively important single pollution source on the river and the one with the most direct and documented impact on aquatic biodiversity. Investment in sewage treatment infrastructure — increasing the capacity, operational efficiency, and effluent quality standards of Sewage Treatment Plants in Lucknow and other urban centres along the river — is a non-negotiable prerequisite for ecological recovery in the middle zone. Industrial point sources, including distilleries, sugar mills, and chemical plants, require rigorous real-time effluent monitoring and strictly enforced discharge standards, with meaningful penalties for non-compliance. The broader diffuse pollution from agricultural runoff — carrying fertilisers, pesticides, and sediment from the intensively cultivated floodplain — requires landscape-level management interventions, including the promotion of integrated pest management, precision fertiliser application, and the restoration of riparian buffer strips capable of intercepting and processing agricultural runoff before it reaches the channel.

14.4.3. Priority 3: Species-Specific Conservation Actions

Indian skimmer: The observation of 57 Indian skimmers at a single sandy island near Palauli, with evidence of possible nesting activity, makes the protection of this site and comparable sandy island habitats along the Gomti River an immediate conservation priority. Urgent actions include: (i) formal identification and mapping of all sandy island habitats along the middle and lower stretches of the Gomti River through satellite imagery and field survey; (ii) the establishment of seasonal no-disturbance zones around confirmed and potential skimmer nesting sites during the breeding season (February–June); (iii) strict regulation of sand mining, cattle grazing, and fishing activity in the vicinity of skimmer colonies; and (iv) a dedicated breeding survey in subsequent seasons to confirm nesting status and quantify productivity. The Gomti River is among one of the few rivers in India supporting this Endangered species during the post-monsoon season. Systematic annual monitoring of the sandbar islands along the Gomti River will reaffirm the ecological and conservation profile of the River and will create new opportunities for site-level protection.

Gangetic dolphin: Although the Gangetic dolphin is locally extinct in the Gomti River, the anecdotal evidence of seasonal upstream migration from the Ganga mainstem during high-flow periods suggests that the Gomti–Ganga confluence may retain some value as seasonal habitat. Systematic visual monitoring along with acoustic monitoring at the confluence during and after the monsoon season would determine the frequency of the species' presence.

Smooth-coated otter: The single otter record near Gayabar village in Sitapur district represents the species' first documented occurrence in the Gomti River. This points to the need for an immediate, targeted population assessment. Camera trap surveys at likely otter habitat — shallow, fish-productive reaches with intact riparian vegetation and low human disturbance — across the upper-middle zone should be initiated to determine the extent of occupancy and, if possible, the number of individuals.

Freshwater Turtles: The documentation of five turtle species across the Gomti River requires dedicated sand bars and island surveys to identify and protect critical nesting sites. The islands and sandbars are acutely vulnerable to sand mining and human disturbance during the pre-monsoon nesting season. They must be subject to seasonal protection measures analogous to those recommended for the Indian skimmer. Community-based nest protection programmes, a practical and cost-effective intervention that engages local communities as active conservation partners, must be implemented for the Gomti River.

Fish: The recovery of fish biodiversity in the Gomti requires a multi-pronged approach addressing the full spectrum of pressures. Specific measures include the identification and protection of spawning aggregation sites — particularly in the upper-middle reaches where water quality is relatively higher — as seasonal fisheries exclusion zones; the enforcement of minimum legal mesh sizes for gill nets to reduce juvenile bycatch; the phasing out of destructive fishing methods including fine-mesh drag nets; and the promotion of community-managed fisheries cooperative models that align the economic interests of fishing communities with the long-term productivity of fish populations.

14.4.4. Priority 4: Floodplain and Riparian Habitat Protection and Restoration

The lateral connectivity between the Gomti and its floodplain — which drives the exchange of nutrients, organic matter, fish recruits, and terrestrial-aquatic subsidies that underpin river productivity — has been severely diminished by agricultural encroachment, embankment construction, and floodplain drainage. Restoring this connectivity is essential for the long-term ecological productivity of the river and for the recovery of species such as the sarus crane and painted stork that depend on seasonal floodplain wetlands for foraging and breeding. Priority floodplain restoration actions include: (i) the legal demarcation and physical restoration of river corridor land in the upper zone, where encroachment has been most severe; (ii) the establishment of vegetated riparian buffer strips of at least 50–100 m width along the entire river course, with priority on the most degraded agricultural reaches; (iii) the restoration of oxbow lakes and seasonal wetlands along the middle zone floodplain, which provide critical habitat for waterbirds, amphibians, and floodplain-dependent fish species; and (iv) the prohibition of further embankment construction along unengineered reaches of the river, which would sever remaining lateral connectivity.

14.4.5. Priority 5: Regulating Extractive Activities

Sand mining, water extraction, and fishing represent the three extractive pressures with the most direct and immediate impacts on the Gomti River's biodiversity and physical habitat. Their regulation — through a combination of legal enforcement, economic instruments, and community engagement — is essential for maintaining the ecological baseline established by this study.

Sand mining should be prohibited from identified ecologically sensitive reaches, including confirmed nesting sites for Indian skimmers, turtles, and muggers, and should be subject to seasonal restrictions. Water extraction for irrigation must be rationalised against environmental flow requirements, with groundwater extraction in the upper catchment regulated through metered permits tied to seasonal flow conditions. The introduction of more water-efficient irrigation technologies — micro-irrigation, drip systems, precision scheduling — in the Gomti River's catchment, supported by state agricultural extension services, would reduce extraction pressure while maintaining agricultural productivity. Seasonal fishing closures during key spawning and breeding periods, enforced with community participation, would provide the most cost-effective mechanism for rebuilding fish populations.

14.4.6. Priority 6: Long-term Biodiversity Monitoring

The biodiversity baseline established by this study is its most enduring contribution to Gomti River conservation. However, a baseline has value only when maintained through repeated, standardised surveys that enable the detection of temporal trends and the evaluation of management interventions. A formal, multi-taxon monitoring programme for the Gomti River should be established, incorporating annual or biennial surveys for various taxa using the sampling protocols and BEU framework developed in this study, supplemented by continuous water quality monitoring at strategic locations and regular assessment of anthropogenic pressure indices. Monitoring data should feed into an adaptive management framework in which conservation strategies are systematically evaluated against measurable ecological targets — such as the maintenance of fish species richness above a defined threshold, the recovery of Indian skimmer breeding success, or the expansion of smooth-coated otter range.

14.5. GOVERNANCE, POLICY, AND INSTITUTIONAL FRAMEWORK

The conservation of the Gomti River cannot be achieved through biological interventions alone; it requires a governance framework that integrates ecological objectives into the management of water resources, land use, fisheries, and urban infrastructure across the entire basin. Existing policy instruments provide a foundation for this integration. The Namami Gange Programme — India's flagship Ganga river rejuvenation initiative — extends in principle to tributaries, including the Gomti. The Wildlife Protection Act (1972) provide legal protection for several species recorded in this study, including the Gangetic dolphin, smooth-coated otter, Indian skimmer, sarus crane, and all turtle species. Enforcement of these protections — particularly with respect to bycatch mortality in fishing nets, disturbance of nesting sites, and illegal harvest — requires dedicated law enforcement capacity and community awareness programmes in riverine villages along the Gomti River. The National Biodiversity Action Plan and India's commitments under the Kunming-Montreal Global Biodiversity Framework — including the 30×30 target to protect 30% of the world's lands and waters by 2030 — provide the overarching policy context for Gomti River conservation. The findings of this study suggest that the Gomti and its riparian corridor represent a significant, currently unprotected freshwater biodiversity resource whose inclusion in India's protected area network — through mechanisms such as Community Reserves, Conservation Reserves, or riverine Ramsar site designations — would substantially contribute to national and global biodiversity targets.

14.6. COMMUNITY ENGAGEMENT AND SOCIAL DIMENSIONS

Conservation strategies for the Gomti River cannot succeed without the active engagement and support of the local communities, whose livelihoods, cultural practices, and daily lives are intimately connected to the River. The communities that live alongside the Gomti River are not merely sources of anthropogenic pressure; they are also its most knowledgeable observers, its most committed potential stewards, and the group with the most to gain from its ecological recovery. Community-based conservation programmes — including participatory nest protection for turtles and skimmers, co-managed fisheries cooperatives, village-level riparian restoration initiatives, and school-based river awareness programmes — have demonstrated effectiveness in comparable riverine contexts across South and Southeast Asia (Baral et al., 2014). State wildlife and fisheries departments, non-governmental organisations, and academic institutions should support their implementation along the Gomti River. The river also holds profound cultural and spiritual significance for the communities of Uttar Pradesh. This value can be harnessed in support of conservation rather than seen as a source of conflict. Initiatives that frame river conservation as consistent with and supportive of the river's cultural importance — as has been done effectively in the context of the Ganga itself — are likely to generate broader social support for the ecological management measures recommended here.

14.7. CONSERVATION ROADMAP FOR THE GOMTI RIVER

Table 14.1 summarises the conservation priorities identified in this chapter, with indicative timeframes, responsible institutions, and measurable targets.

Table 14.1. Conservation priorities for the Gomti River: actions, timeframes, and targets.

Priority	Key action	Timeframe	Lead institution	Measurable target
Environmental flows	Minimum flow standards at Gomti Barrage	Immediate (0–2 years)	UPJAL, CWC, MoJS	Perennial flow restored in upper zone by 2030
Pollution control	STPs upgraded; industrial effluent standards enforced	Short–medium term (2–5 years)	UPPCB, Namami Gange	BOD < 3 mg/L in middle zone by 2030
Indian Skimmer	Nesting site mapping; seasonal disturbance exclusion zones	Immediate (0- 2 years)	UPFD, WII	Confirmed nesting and productivity data by 2028
Smooth-coated otter	Camera trap and eDNA survey; habitat protection	Immediate (0–2 years)	UPFD, WII	Distribution map and occupancy estimate by 2028
Freshwater turtles	Nesting beach surveys; community nest protection	Short term (1–3 years)	UPFD, local communities	Nest protection programme operational by 2029
Fish	Spawning site protection; mesh size enforcement	Short term (1–3 years)	UPFD, Fisheries Dept.	Species richness maintained above 41 species.
Floodplain restoration	Riparian buffer demarcation; oxbow lake restoration	Medium term (3–7 years)	Revenue Dept., UPFD	100 km riparian buffer restored by 2030
Sand mining regulation	Ecological sensitivity mapping; extraction limits	Short term (1–3 years)	Mining Dept., UPPCB	Zero extraction at identified sensitive reaches
Ecological assessment	Annual multi-taxon BEU surveys	Periodic every two years	WII, UPFD, Academia	Status and trend reports from 2027 onwards
Protected area	Community Reserve or Conservation Reserve designation	Medium term (3–7 years)	MOEF&CC, UPFD	At least one riverine protected area notified

14.8. CONCLUSION

The evidence provided in this report demonstrates both the ecological significance of what remains and the severity of what has already been lost. A river that once supported Gangetic dolphins and greater fish diversity now yields a single otter in four years of surveying and fish communities reduced by a third from their historical richness. However, it also supports a flock of Endangered Indian skimmers on a sandy island, mugger crocodiles basking on clay banks, and over 5,600 individual waterbirds across 44 species. It is a river diminished but not yet ecologically broken — a river in which the window for effective conservation intervention remains open but not for long.

The findings of this study make clear that the Gomti will not recover through partial or sectoral interventions. Treating Lucknow's sewage without restoring the flows that give the River the capacity to process pollutants, or regulating fishing without protecting spawning habitats, or protecting individual nesting sites without addressing the sand mining and human disturbance, alone will not be sufficient. What is required is a basin-scale, integrated management approach, grounded in the biodiversity evidence now available, embedded in appropriate governance structures, and sustained over the timescale — decades — on which river ecological recovery operates.

The Gomti is one of the most significant rivers in Uttar Pradesh that flows through the capital city of Lucknow. Its ecological recovery would deliver not only biodiversity benefits but improvements in water security, flood resilience, fisheries productivity, and ultimately human well-being. This report provides evidence for action and also a way forward to bridge the science-policy-practice interface for sustained action and rebuilding resilience of the Gomti River.

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ANNEXURES

Annexure I. Riparian plants recorded along the Gomti River during present study

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
Nymphaeales	Nymphaeaceae	*Nymphaea nouchali* Burm.f.	Blue water lily	H	A	Native	LC
		Nymphaea pubescens Willd.	Hairy water lily	H	A	Native	LC
Piperales	Piperaceae	*Peperomia pellucida* Kunth	Slate pencil plant	H	SA	Introduced	-
Alismatales	Hydrocharitaceae	*Hydrilla verticillata* (L.f.) Royle	Wterhymes	H	A	Native	LC
		Ottelia alismoides (L.) Pers.	Duck lettuce	H	A	Native	LC
		Vallisneria natans (Lour.) H. Hara	Jallil	H	A	Native	LC
		Najas minor All.	Jhangi	H	A	Native	LC
	Alismataceae	*Sagittaria sagittifolia* L.	Broad leafed arrowhead	H	A	Native	LC
	Potamogetonaceae	*Potamogeton crispus* L.	Crisp leaved pondweed	H	A	Native	LC
		Potamogeton natans L.	Broad leaved pond weed	H	A	Native	LC
		Stuckenia pectinata (L.) Boerner	Sago pondweed	H	A	Native	LC
	Araceae	*Colocassia esculenta* (L.) Schott.	Indian taro	H	A	Native	LC
		Pistia stratiotes L.	Water lettuce	H	A	Native	LC
		Lemna minor L.	Common Duckweed	H	A	Native	LC
		Lemna perpusilla Torr.	Duckweed	H	A	Native	LC
		Spirodela polyrhiza (L.) Schleid.	Gaint Duckweed	H	A	Native	LC
Dioscoreales	Dioscoreaceae	*Dioscorea bulbifera* L.	Air yam	H	T	Native	
Arecales	Arecaceae	*Calamus tenuis* Roxb.	Slender rattan cane	S	SA	Native	LC
		Borassus flabellifer L.	Asian palmyra palm	T	T	Native	-
		Phoenix sylvestris (L.) Roxb.	Indian date palm	T	SA	Native	-
Poales	Cyperaceae	*Bolboschoenus maritimus* (L.) Palla	Bayonet grass	G	SA	Native	LC
		Bulbostylis barbata (Rottb.) C.B.Clarke	Bearded Watergrass	G	SA	Native	-
		Cyperus alulatus J.Kern	Winged Sedge	G	SA	Native	LC
		Cyperus compressus L.	Poorland Flat Sedge	G	SA	Native	LC
		Cyperus michelianus subsp. pygmaeus (Rottb.) Asch. & Graebn.	Pygmy Sedge	G	SA	Native	LC
		Cyperus rotundus L.	Nut grass	G	SA	Native	LC
		Cyperus difformis L.	Variable flatsedge	G	SA	Native	LC
		Cyperus iria L.	rice flat sedge	G	SA	Native	LC

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Cyperus michelianus subsp. pygmaeus (Rottb.) Asch. & Graebn.	Pygmy Sedge	G	SA	Native	LC
		Cyperus mindorensis (Steud.) Huygh, syn. Kyllinga nemoralis (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel	White Water Sedge	G	SA	Native	LC
		Fimbristylis ovata (Burm.f.) J.Kern	One-Spike Fimbry	G	SA	Native	LC
		Fimbristylis dichotoma (L.) Vahl	Eight day grass	G	SA	Native	LC
		Eleocharis dulcis (Burm.f.) Trin. ex Hensch.	water chestnut	G	SA	Native	LC
		Schoenoplectiella articulata (L.) Lye	Jointed Sedge	G	A	Native	LC
		Schoenoplectiella mucronata (L.) J.Jung & H.K.Choi	Bog Bulrush	G	A	Native	LC
	Juncaceae	*Juncus bufonius* L.	toad rush	G	SA	Native	LC
		Juncus prismatocarpus R.Br.	Branching rush	G	SA	Native	LC
	Poaceae	*Alopecurus aequalis* Sobol.	orange foxtail	G	SA	Native	LC
		Eragrostis unioloides (Retz.) Nees ex Steud.	Chinese Lovegrass	G	SA	Native	LC
		Eragrostis tenella (L.) P.Beauv. ex Roem. & Schult.	Japanese lovegrass	G	SA	Native	-
		Apluda mutica L.	Mauritian grass	G	SA	Native	-
		Arundo donax L.	Narkat	G	SA	Native	LC
		Bambusa bambos (L.) Voss	giant thorny bamboo	G	SA	Native	-
		Cenchrus ciliaris L.	Buffel grass	G	SA	Native	LC
		Centrus biflorus Roxb.	Indian sand bur	G	SA	Native	-
		Cenchrus pedicellatus (Trin.) Morrone	Deenanath Grass	G	SA	Native	LC
		Cenchrus ciliaris L.	Buffel grass	G	SA	Native	LC
		Chloris barbata Sw.	Swollen fingergrass	G	SA	Native	-
		Coix lacryma-jobi L.	Job's Tears	G	SA	Native	-
		Cynodon dactylon (L.) Pers.	Scutch grass	G	SA	Native	-
		Cyrtococcum patens (L.) A. Camus	bowgrass	G	SA	Native	-
		Dctylotenium eaegypitum (L.) Willd.	Aegyptium crowfoot	G	SA	Native	-
		Dendrocalamus strictus (Roxb.) Nees	Calcutta bamboo	G	SA	Native	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Desmostachya bipinnata (L.) Stapf	Dharbha, Kush	G	SA	Native	LC
		Dichanthium annulatum (Forssk.) Stapf	Sheda Grass	G	SA	Native	-
		Chrysopogon fulvus (Spreng.) Chiov.	reddish-yellow beardgrass	G	UK	Native	-
		Chrysopogon aciculatus (Retz.) Trin.	Golden Beardgrass	G	UK	Native	-
		Chrysopgon zizaniodides (L.) Roberty	vetiver grass	G	SA	Native	-
		Echinochola colona (L.) Link	Jungle rice	G	SA	Native	-
		Echinochloa crus-galli (L.) P.Beauv.	Barnyard Grass	G	SA	Native	-
		Eleusine indica (L.) Gaertn.	Indian goosegrass	G	SA	Native	LC
		Eriochloa procera (Retz.) C.E.Hubb.	Tropical Cupgrass	G	SA	Native	LC
		Ischaemum rugosum L.	Saramolla grass	G	SA	Native	-
		Hygroryza aristata (Retz.) Nees ex Wight & Arn.	Bengal wild rice	G	SA	Native	-
		Imperata cylindrica (L.) Raeusch.	cogon grass	G	SA	Native	LC
		Leptochloa panicea (Retz.) Ohwi	Thread Sprangletop	G	SA	Native	LC
		Leersia hexandra Sw.	swamp rice grass	G	SA	Native	LC
		Oplismenus compositus (L.) P.Beauv.	Running mountain grass	G	SA	Native	LC
		Panicum paludosum Roxb		G	SA	Native	-
		Panicum repens L.	creeping panic	G	SA	Native	LC
		Paspalum dilatatum Poir.	Dallas grass	G	SA	Introduced	-
		Paspalium distichum L.	Water finger-grass	G	SA	Introduced	-
		Paspalidium flavidum (Retz.) A.Camus	Yellow Watercrown Grass	G	SA	Native	LC
		Perotis indica (L.) Kuntze	Indian comet grass	G	SA	Native	-
		Phalaris minor Retz.	Small-seeded canary grass	G	SA	Native	-
		Phragmites karka (Retz.) Trin. ex Steud.	Tall Reed	G	SA	Native	LC
		Polypogon monspeliensis (L.) Desf.	Annual beard-grass	G	SA	Native	LC
		Saccharum narenga (Nees ex Steud.) Hack.		G	SA	Native	-
		Saccharum spontaneum L.	Wild sugarcane	G	SA	Native	LC

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Saccharum bengalense Retz.	Munj Sweetcane, Sarkanda	G	SA	Native	-
		Saccharum ravennae (L.) L.	Ekra	G	SA	Native	LC
		Setaria pumila (poir.) Roem. & Schult.	yellow foxtail	G	SA	Native	-
		Setaria verticillata (L.) P.Beauv.	Bristly foxtail	G	SA	Native	-
		Urochloa distachyos (L.) T.Q.Nguyen	signal grass	G	SA	Native	LC
		Urochloa mutica (Forssk.) T.Q.Nguyen	Buffalo grass	G	SA	Introduced	
	Typhaceae	*Typha angustifolia* L.	Narrow leaf cattail	G	SA	Native	LC
Commelinales	Pontederiaceae	*Potederia crassipes Mart.*	Common water hyacinth	H	A	Introduced	LC
		Pontederia hastata L.	Heart shaped false pickerelweed	H	SA	Native	LC
	Commelinaceae	*commelinia benghalensis* L.	Bengal dayflower	H	SA	Native	-
		Cyanotis axillaris (L.) D.Don ex Sweet	Kana	H	SA	Native	LC
		Murdannia nudiflora (L.) Brenan	Dove weed	H	SA	Native	-
Ceratophyllales	Ceratophyllaceae	*Ceratophyllum demersum* L.	Coontail	H	A	Native	LC
Ranunculales	Ranunculaceae	*Ranunculus sceleratus* L.	Celery-leaved buttercup	H	SA	Native	LC
	Papaveraceae	*Argemone mexicana* L.	Mexican prickly poppy	H	T	Introduced	-
	Menispermaceae	*Cissampelos pareria* L.	Velvet leaf pareira	C	T	Native	-
		Tiliacora acuminata (Lam.) Hook.f. & Thomson	Tapering leaf tiliacora	C	T	Native	-
		Tinospora cordifolia (Thunb.) Miers	Amrita	C	T	Native	-
Proteales	Nelumbonaceae	*Nelumbo nucifera* Gaertn.	Lotus Sweetjuice	H	A	Native	DD
Vitales	Vitaceae	*Cayrtia trifolia* (L.) Domin	Bush grape	C	T	Native	-
Zygophyllales	Zyogophyllaceae	*Tribulus terrestris* L.	Gokharu	H	SA	Native	LC
Celastrales	Celastraceae	*Celastrus paniculatus* Willd.	Black oil plant, Jyotishmati	S	T	Native	_
Oxalidales	Oxalidaceae	*Oxalis corniculata* L.	Creeping woosorrel	H	SA	Native	-
Malpighiales	Euphorbiaceae	*Acalypha indica* L.	India copperleaf	H	SA	Native	-
	Euphorbiaceae	*Croton boplandianus* Baill.	Ban tulsi	H	SA	Introduced	-
	Euphorbiaceae	*Chrozophora rottleri* (Geiseler) Spreng.	Rottler's Chrozophora	H	SA	Native	-
	Euphorbiaceae	*Euphiorbia hirta* L.	Asthma plant	H	SA	Introduced	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
	Euphorbiaceae	*Euphorbia dracunculoides* Lam.	Dragon Spurge	H	SA	Native	-
	Euphorbiaceae	*Mallotus nudiflorus* (L.) Kulju & Welzen	False white teak	T	SA	Native	LC
	Euphorbiaceae	*Riccinus communis* L.	Caster bean plant	S	T	Introduced	-
	Euphorbiaceae	*Jatropha gossipyfolia* L.	Bellyache bush	S	T	Introduced	-
	Phyllantaceae	*Phyllanthus emblica* L.	Amla	T	T	Native	LC
		Phyllanthus niruri L.	Gale of wind	H	SA	Native	-
		Phyllanthus reticulata Poir.	Black honey shrub	S	SA	Native	-
		Phyllanthus urinaria L.	Stome breaker phyllanthus	H	SA	Native	-
		phyllanthus virgatus G.Forst.	Seed under leaf phyllanthus	H	SA	Native	-
	Putranjivaceae	*Putranjiva roxburghii* Wall.	Putranjiva	T	SA	Native	LC
	Salicaceae	*Salix tetrasperma* Roxb.	Indian Willow	T	A	Native	LC
	Violaceae	*Hybanthus enneaspermus* (L.) F.Muell.	Spade flower	H	SA	Native	-
	Elatinaceae	*Bergia ammannioides* Heyne ex. Roth.	Ammannia waterwort	H	SA	Native	LC
Fabales	Fabaceae	*Acacia auriculiformis* A.Cunn. ex Benth.	Earleaf Acacia	T	T	Introduced	LC
		Acacia catechu (L.) Willd.,Oliv.	Kher	T	T	Native	LC
		Acacia Farnesiana (L.) Wight et Arn.	Sweet Acscia	T	T	Introduced	LC
		Acacia nilotica (L.) P.J.H.Hurter & Mabb.	Gum arabic tree	T	T	Native	LC
		Acacia pennata (L.) Willd.	Large-Gland Acacia	C	SA	Native	-
		Alysicarpus vaginalis (L.) DC.	Alyce Clover	H	SA	Native	-
		Albizzia lebback (L.) Benth.	Siris	T	T	Native	-
		Alhagi maurorum Medik.	camelthorn-bush	H	SA	Native	-
		Cassia fistula L.	Amaltash	T	T	Native	LC
		Cajanus scarabeoides (L.) Thouars	Showy pigeonpea	C	SA	Native	-
		Caesalpinia bonduc (L.) Roxb.	knicker nut	S	SA	Native	LC
		Crotalaria juncea L.	Indian Hemp	H	T	Native	-
		Dalbergia sissoo Roxb.	Indin rosewood	T	T	Native	LC
		Desmodium gangaticum (L.) DC.	Salparni	H	SA	Native	-
		Desmodium triflorum (L.) DC.	Three-flower beggarweed	H	SA	Native	-
		Indigofera linifolia (L.f.) Retz.	Birdsville indigo	H	SA	Native	LC

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Indigofera linnaei Ali	nine-leaved indigo	H	SA	Native	-
		Lathyrus sativus L.	Grass pea	H	SA	Introduced	-
		Lathyrus aphaca L.	yellow pea	H	SA	Native	LC
		Lens culinaris Medik.	Lentil.	H	SA	Introduced	-
		Leucaena leucocephala (Lam.) de Wit	Hotse tamarind	T	T	Introduced	-
		Medicago polymorpha L.	Toothed bur clover	H	SA	Introduced	LC
		Medicago lupulina L.	Black medick	H	SA	Native	LC
		Melilotus albus Medik.	White Sweet Clover	H	SA	Introduced	LC
		Melilotus indicus (A.) All.	Indian Sweet Clover	H	SA	Native	-
		Mimosa himalayana Gamble	Himalayan mimosa	S	T	Native	-
		Pithecellobium dulce (Roxb.) Benth.	Monkeypod tree	T	T	Introduced	LC
		Pongamia pinnata (L.) Pierre	Karanj	T	SA	Native	LC
		Senna absus (L.) Roxb.	Tropical Sensitive Pea	H	SA	Native	-
		Senna occidentalis (L.) Link	Coffee senna	S	SA	Introduced	LC
		Senna tora (L.) Roxb.	Chinese senna	H	SA	Introduced	-
		Teramnus labailus (L.f.)Spreng.	Mashaparni	C	SA	Native	-
		Trifolium resupinatum L.	Persian clover	H	SA	Introduced	LC
		Trifolium alexandrinum L.	Berseem clover	H	SA	Introduced	NA
		Vicia faba L.	Broad bean	H	SA	Introduced	-
		Vicia sativa L.	Common Vetch	H	SA	Native	LC
	canabaceae	*Cannabis sativa* L.	Hemp	H	T	Introduced	-
		Trema orientalis (L.) Blume	Indian Charcoal tree	T	SA	Native	LC
	Moraceae	*Artocarpus heterophyllus* Lam.	Jackfruit	T	T	Native	-
		Artocarpus lacucha Buch.-Ham.	Monkey jack.	T	T	Native	-
		Streblus asper Lour.	Siamese rough bush	T	SA	Native	LC
		Ficus assamica Miq.		S	SA	Native	-
		Ficus amplissima Rees.	Bat fig	T	T	Native	-
		Ficus benghalensis L.	Banayan tree	T	T	Native	-
		Ficus racemosa L.	Gular	T	SA	Native	LC
		Ficus heterophylla L. f.	Creeping fig	S	SA	Native	-
		Ficus hispida L.f.	opposite leaf fig	T	SA	Native	LC
		Ficus palmata ssp. virgata (Roxb.) Browicz	Punjab Fig	S	SA	Native	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Ficus religiosa L.	Pipal	T	T	Native	LC
		Ficus semicordata Buch.Ham. ex Sm.	Drooping fig	T	SA	Native	LC
		Ficus virens Aiton	White fig	T	SA	Native	LC
		Morus alba L.	White mulberry	T	T	Introduced	-
	Ulmaceae	*Holoptelea integrefolia* (Roxb.) Planch.	Indian elm	T	T	Native	-
	Rosaceae	*Potentilla indica* (Andrews) Th.Wolf	Indian-strawberry	H	SA	Native	-
		Potentilla supina l.	Spreading Cinquefoil	H	SA	Native	LC
	Rhamnaceae	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Jhar Beri	S	T	Native	LC
		Ziziphus mauritiana Lam.	Indian jujube	T	T	Native	LC
		Ziziphus oenophlia (L.) Mill.	Jackel jujube	S	T	Native	-
	Urticaceae	*Pilea microphylla* (L.) Liebm.	Angeloweed	H	SA	Introduced	-
		Pouzolzia pentandra (Roxb.) Benn.	Narrow-lef pouzolzs bush	H	SA	Native	-
		Pouzolzia zeylanica (L.) Benn.	Graceful pouzolzs bush	H	SA	Native	-
Cucurbitales	Cucurbitaceae	*Actinostemma tenerum* Griff.	Tender Ray -flower gourd	C	SA	Native	-
		Benincasa hispida (Thunb.) Cogn.	Wax gourd	C	T	Introduced	-
		Coccinea grandis (L.) Voigt	Ivy gourd	C	T	Native	-
		Cucumis maderaspatanus L.	Madras pea pumpkin	C	SA	Native	-
		Ctenolepis garcinii (Burm.f.) C.B.Clarke	Garcins bur cucumber	C	T	Native	-
		Diplocyclos palmatus (L.) C.Jeffrey	Shivlingi	C	T	Native	-
		Momordica charantia L.	Bitter momordica	C	T	Native	-
		Trichosanthes tricuspidata Lour.	Indrayan	C	T	Native	-
Myrtales	Combretaceae	*Terminalia arjuna* (Roxb.) Wight & Arn.	Arjun	T	SA	Native	-
	Myrtaceae	*Sizium cumnini* (L.) Skeeles.	Jamun	T	SA	Native	-
	Lythraceae	*Ammania baccifera* L.	Blistering ammannia	H	SA	Native	-
		Ammannia multiflora Roxb.	Many Flowered Ammannia	H	SA	Native	-
		Trapa natans L.	Singhara	H	A	Native	LC
		Woodfordia fruticosa (L.) Kurz	Fire Flame bush	S	SA	Native	LC
	Onagraceae	*Ludwiga adscendens* (L.) H.Hara	Water primerose	H	SA	Native	LC
		Ludwigia octovalvis (Jacq.) P.H.Raven	Willow Primrose	H	SA	Native	LC

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Ludwiga perennis L.	Perennial water primerose	H	SA	Native	-
Sapindales	Anacardiaceae	*Mangifera indica* L.	Mango	T	T	Native	DD
	Sapindaceae	*Cardiospermum halicacabum* L.	Ballon vine	C	T	Native	LC
		Schleichera oleosa (Lour.) Oken	Ceylon oak	T	T	Native	LC
	Meliaceae	*Azadirachta indica* A.Juss.	Neem tree	T	T	Introduced	LC
		Melia azedarach L.	Chinaberry tree	T	T	Native	LC
		Toona ciliata M. Roem.	Indian mahogany	T	T	Native	LC
	Rutaceae	*Aegle marmelos* (L.) Correa	Bel	T	T	Native	NT
		Glycosmis pentaphylla (Retz.) DC.	Gin berry	S	T	Native	LC
		Murraya koenigii (L.) Sprenge	Kadipatta,curry leaf tree	S	T	Native	LC
	Simaroubaceae	*Ailanthus excelsa* Roxb.	Maharuk	T	T	Native	-
Malvales	Bixaceae	*Bixa orellana* L.	Lipstick tree	T	T	Introduced	LC
	Malvaceae	*Abitulon indicum* (L.) Sweet	Bala	S	T	Native	-
		Bombax cebia L.	Shalmali	T	T	Native	-
		Corchorus aestuans L.	East indian mallow	H	T	Native	-
		Malvestrum coromandelianum (L.) Garcke	Three lobed false mallow	H	T	Native	-
		Melochia corchorifolia L.	Chocolate weed	H	T	Native	LC
		Sida acuta Burm.f.	Common wireweed	H	T	Native	-
		sida cordifolia L.	Flannel weed	H	T	Native	-
		Sida cordata (Burm.f.)	Long stock sida	H	T	Native	-
		sida rhombifolia L.	Arrowleaf sida	H	T	Native	-
		Triumfetta rotundifolia Lam.	Roundleaf Burr-Bush	H	SA	Native	-
		Triumfetta rhomboidea Jacq.	Burr Bush	H	SA	Native	-
		Urena lobata L.	Caesarweed	S	T	Native	LC
Brassicales	Moringaceae	*Moringa oleifera* Lam.	Drumstick tree	T	T	Native	LC
	Cleomaceae	*Cleome viscosa* L.	Asian spider flower	H	T	Native	-
	Capparaceae	*Capparis zeylanica* L.	Ceylon caper	S	T	Native	-
	Brassicaceae	*Lepidium didymum* L	Bitter Cress	H	SA	Introduced	-
		Capsella bursa-pastoris (L.) Medik.	shepherd's purse	H	T	Native	-
		Cardamine hirsuta L.	Hairy Bitter Cress	H	T	Native	-
		Lepidium didymum L.	Lesser swine-cress	H	SA	Introduced	-
		Rorippa indica (L.) Hiern	Indian Field-Cress	H	SA	Native	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Nasturtium officinale W.T.Aiton *syn. Rorippa officinalis* (W.T.Aiton) P.Royen	Yellowcress	H	A	Introduced	LC
Caryophyllales	Aizoaceae Marinov	*Trianthema portulacastrum* L.	Desert horse purslane	H	T	Native	-
	Molluginaceae	*Glinus lotoides* L.	Lotus Sweetjuice	H	SA	Native	LC
		Glinus oppositifolius (L.) Aug.DC.	Jima	H	SA	Native	LC
	Polygonaceae	*Polygonum barbatum* L.	Bearded knotweed	H	SA	Native	LC
		Polygonum glabrum (Willd.) M.Gomez	Common marsh buckwheat	H	SA	Native	LC
		Persicaria hydropiper (L.)	water pepper	H	SA	Native	LC
		Polygonum plebeium R.Br.	common knotweed	H	SA	Native	LC
		Rumex dentatus L.	Toothed dock	H	SA	Native	LC
		Portulaca oleracea L.	common purslane	H	T	Introduced	LC
		Portulaca Pilosa L.	Hairy pigweed	H	T	Introduced	-
	Amaranthaceae	*Achyranthes aspera* L.	Devils horsewhip	H	T	Native	-
		Aerva lanata (L.) Juss. ex Schult.	Mountain Knotgarss	H	T	Native	-
		Alternanthera paronychioides A.t. Hil.	Smooth chaff flower	H	SA	Introduced	-
		Alternantera pungens Kunth	Khaki weed	H	SA	Introduced	-
		Alternanthera sessils (L.) R.Br. ex DC.	Stalkless joyweed	H	SA	Native	-
		Alternanthera ficoidea (L.) Sm.	Josephs goat	H	SA	Introduced	-
		Alternanthera philoxeroides Mart.) Griseb.	Alligator weed	H	SA	Introduced	-
		Amaranthus graecizans L.	Mediterranean amaranth	H	T	Native	-
		Amaranthus spinosus L.	spiny amaranth	H	T	Introduced	-
		Amaranthes viridis L.	Green amaranth	H	T	Introduced	-
		Chenopodium album L.	Wild spinach	H	T	Native	-
		Chenopdiastrum murale (L.) S.Fuentes, Uotila & Borsch	Nettle-Leaved Goosefoot	H	T	Native	-
		Digrea muricata (L.) Mart	False Amaranth	H	SA	Native	-
		Gomphrena serrata L.	Prostrate Gomphrena	H	SA	Introduced	-
		Pupalia lappacea (L.) Juss.	Forest Burr	H	T	Native	LC
	Caryophyllaceae	*Polycarpon prostratum (Forssk.) Asch. & Schweinf. Syn. Spergula prostrata* (Forssk.) D.Dietr.	Prostrate Manyseed	H	SA	Native	LC

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
	Nyctaginaceae	*Boerhavia diffusa* L.	Punarnava	H	T	Native	-
	Tamaricaceae	*Tamarix indica* Willd.	Indian Tamarisk	S	SA	Native	-
		Tamarix dioica Roxb. ex Roth	Red Tamarisk	S	SA	Native	-
	Basellaceae	*Basella alba* L.	Malabar spinach	H	T	Native	-
Ericales	Primulaceae Batsch ex Borkh.	*Ardisia solanacea* Roxb.	Shoebutton ardisia	S	T	Native	-
		Anagallis arvensis L.	The Scarlet Pimpernel	H	SA	Introduced	-
		Androsace umbellata (Lour.) Merr.	Umbelled Rock Jasmine	H	SA	Native	-
	Sapotaceae	*Mimuscops elengi* L.	Bakul	T	T	Native	-
		Madhuca longifolia (J.Konig) J.F.Macbr.	Mahu	T	T	Native	-
	Lecythidaceae	*Barringtonia acutangula* (L.) Gaertn.	Freshwater Mangrove	T	SA	Native	LC
Lamiales	Acanthaceae	*Blepharis maderaspatensis L.)* B.Heyne ex Roth	Creeping Blepharis	H	T	Native	-
		Dicliptera paniculata (Forssk.)	Panicled foldwing	H	T	Native	-
		Hygrophila auriculata (Schumach.) Heine	Marsh Barbel	H	SA	Native	LC
		Hygrophila polysperma Anderson	Dwarf hygrophila	H	SA	Native	LC
		Justicia adhatoda l.	Adulsa	S	SA	Native	LC
		Justicia concinna J.R.I.Wood	Elegant Rungia	H	SA	Native	-
		Justicia simplex Lindau	Simple Justicia	H	SA	Native	-
		Ruellia prostrata Poir.	Bell Weed	H	T	Native	-
		Strobilanthes hirta (Vahl) Blume	Hairy Coneflower	H	T	Native	-
	Lamiaceae	*Anisomeles indica* (L.) Kuntze	Indian catmint	S	T	Native	-
		Callicarpa macrophylla Vahl	Large leaf beauty berry	S	T	Native	LC
		Clerodendrum viscosum Vent.	Hill glory bower	S	T	Native	-
		Clerodendrum phlomidis L.f.	Arani, Agnimantha	S	SA	Native	LC
		Colebrookia oppositifolia Sm.	Indian Squirrel til	S	T	Native	-
		Hyptis suvaeolens (L.) Point.	American mint	S	T	Introduced	-
		Leonotis nepetifolia (L.) R. Br.	Lions Ear leonotis	S	T	Native	-
		Leucas aspera (Willd.) Link	Common Leucas	H	SA	Native	-
		Leucas biflora (Vahl) Sm.	Two-Flowered Leucas	H	SA	Native	-
		Leucas cephalotes (Roth) Spreng.	Head leucas	H	SA	Native	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Leonurus sibiricus L.	Honeyweed	H	SA	Native	-
		Nepeta hindostana (B. Heyne ex Roth) Hanines	North Indian catmint	H	SA	Native	-
		Ocimum americanum L.	American basil	H	SA	Native	-
		Salvia plebeia R.Br.	Sage Weed	H	SA	Native	-
		Tectona grandis L.f.	Sag	T	T	Native	LC
		Vitex negundo L.	Five-leaved chaste tree	S	SA	Native	LC
	Pedaliaceae	*Pedalium murex* L.	Gokhru	H	SA	Native	-
	Linderniaceae	*Lindernia antipoda* (L.) Alston | Species	Sparrow Lindernia	H	SA	Native	-
		Lindernia ciliata (Colsm.) Pennell	Fringed False Pimpernel	H	SA	Native	LC
		Lindernia crustacea (L.) F.Muell.	Malaysian false pimpernel.	H	SA	Native	LC
		Lindernia dubia (L.) Pennell	Yellowseed Lindernia	H	SA	Native	-
		Lindernia viscosa (Hornem.) Merr.	Sticky Lindernia	H	SA	Native	-
		Mazus pumilus (Burm. f.) Steenis	Japanese mazus	H	SA	Native	-
	Bignoniaceae	*Oroxylum indicum* (L.) Benth. Ex Kurz	Indian trumpet tree	T	T	Native	-
	Plantaginaceae	*Limnophila indica* (L.) Druce	Indian Marshweed	H	SA	Native	-
		Plantago major L.	Broadleaf plantain	H	SA	Native	LC
		Scoparia dulcis L.	Sweet broom weed	H	SA	Introduced	-
		Veronica anagallis-aquatica L.	Water speedwell	H	SA	Native	LC
		Baccopa monnieri (L.) Wettst.	Brahmi	H	SA	Native	LC
		Mecardonia procumbens (Mill.) Small	Yellow flowered waterhyssop	H	SA	Introduced	-
	Orobanchaceae	*Lindenbergia indica* (L.) Vatke	Indian Lindenbergia	H	SA	Native	LC
		Lindenbergia macrostachya (Benth.) Benth.	West-Himalayan Lindenbergia	H	SA	Native	-
	Scrophulariaceae	*Verbascum chinense* (L.) Santapau	Chinese Mullein	H	SA	Native	-
	Verbinaceae	*Lantana camera* L.	Common lantana	S	T	Introduced	-
		Lippia alba (Mill.) N.E. Br. Britton & P.Wilson	Bushy lippia	S	T	Introduced	-
		Phyla nodiflora (L.)	Turkey tangle frogfruit	H	SA	Native	LC
		Verbena officinalis L.	Herb of Grace	H	SA	Native	LC
	Martyniaceae	*Martynia annua* L.	Devils claws	S	T	Introduced	-
	Lentibulariaceae	*Utricularia aurea* Lour.	Golden Bladderwort	H	A	Native	LC

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
Solanales	Convolvulaceae	*Convolvulus arvensis* l.	Field bindweed	H	T	Native	-
		Cuscuta campestris Yunck.	Golden Dodder	H	T	Introduced	-
		Cuscuta reflexa Roxb.	Gaint dodder	H	T	Native	LC
		Evolvulus nummularius (L.) L.	Roundleaf bindweed	H	T	Introduced	-
		Evolvulus alsinoides (L,) L.	Dwarf Morning Glory	H	SA	Native	-
		Merremia hederacea (Burm.f.)Hallier f.	Ivy rosewood	H	T	Native	-
		Merremia emarginata (Burm.f.) Hallier f. Syn. Merremia gangetica.	Kidney Leaf Morning Glory	H	SA	Native	-
		Operculina turpethum (L.) Silva Manso	Transparent wood Rose	H	T	Native	-
		Ipomoea aquatica Forssk	Water morning glory	H	SA	Native	LC
		Ipomoea eriocarpa R.Br.	Tiny morning glory	H	T	Native	-
		Ipomoea carnea Jacq.	Bush morning glory	S	T	Introduced	-
		Ipomoea nil (L.) Roth	Japanese morning glory	H	T	Introduced	-
		Ipomoea obscura (L.) Ker Gawl.	Obscure morning glory	H	T	Native	-
		Ipomoea triloba L.	Little bell morning glory	H	T	Introduced	LC
	Solanaceae	*Datura metel* L.	Purple Thorn-Apple	H	T	Introduced	-
		Datura innoxia Mill.	Datura	H	SA	Introduced	-
		Nicotiana plumbaginifolia Viv.	Tex-Mex tobacco	H	SA	Introduced	-
		Physalis minima L.	wild cape gooseberry	H	T	Introduced	-
		Solanum nigrum L.	European black nightshade	H	T	Native	-
		Solanum sisymbriifolium Lam.	sticky nightshade	H	T	Introduced	-
		Solanum torvum Sw.	Turkey Berry	S	T	Introduced	-
		Solanum violaceum Ortega	Asian nightshade	H	T	Native	-
		Solanum virginianum L.	Indian nightshade	H	T	Native	-
		Solanum erianthum D. Don	Big Eggplant	T	SA	Introduced	LC
		Withania somnifera (L.) Dunal	Ashwagandha	S	T	Native	DD
Gentianales	Apocynaceae	*Alstonia scholaris* (L.) R.Br.	Blackboard tree	T	T	Native	LC
		Calatropis procera (Aiton) W.T. Aiton	Giant milkweed	S	T	Native	-
		Calotropis gigantea (L.) Dryand.	crown flower	S	T	Native	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Cryptolepis buchanani Roem. & Schult.	Indian Sarsaparilla	C	T	Native	-
		Dregea volubilis (L.f.) Benth. Ex Hook.f.	Green milkweed climber	C	T	Native	-
		Pergularia daemia (Forssk.) Chiov.	Trellis-vine	C	T	Native	LC
		Hemidesmus indicus (L.) R. Br.	Anantamul	C	T	Native	-
		Ichnocarpus frutescens (L.) W.T. Aiton	Black creeper	C	T	Native	-
		oxystelma esculentum (L.f.) Sm.	Rosy Milkweed Vine.	C	T	Native	LC
		Vallaris solanacea (Roth) Kuntze	Bread flower	C	T	Native	-
	Gentianaceae	*Centaurium pulchellum* L.	Lesser Centaury	H	SA	Native	LC
	Rubiaceae	*Haldina cordifolia (Roxb.)* Ridsdale	Haldu	T	T	Native	-
		Mitragyna parviflora (Roxb.) Korth.	Kalamb	T	T	Native	-
		Neolamarkia cadamba (Roxb.) Bosser	Kadamb	T	T	Native	-
		Oldenlandia biflora L.	Two flower mille graines	H	SA	Native	-
		Oldenlandia corymbosa L.	Corymb diamond flower.	H	SA	Native	LC
		Spermacoce articularis L.f.	Jointed Buttonweed	H	SA	Native	-
		Wendlandia heynei (Schult.) Santapau & Merchant	Heyne's Wendlandia	T	T	Native	LC
		Dentella repens (L.) J.R.Forst. & G.Forst.	Creeping Dentella	H	SA	Native	LC
Boraginales	Boraginaceae	*Cordia dicotoma G.* Forst.	Fragrant manjack	T	T	Native	-
		Heliotropium indicum L.	Indian heliotrope	H	SA	Introduced	-
		Heliotropium strigosum Willd.	Bristly Heliotrope	H	SA	Native	-
		Trichodesma indicum (L.) R. Br.	Indian Borage	H	SA	Native	-
		Ehretia laevis Roxb.	Chamror	T	T	Native	DD
Asterales	Asteraceae	*Artemisia vulgaris* L.	Common mugwort	S	T	Native	LC
		Ageratum conyzoides L.	Goatweed	H	SA	Introduced	LC
		Ageratum houstonianum Mill.	Blueweed	H	SA	Introduced	-
		Acmella ciliata (Kunth) Cass.	Toothache Plant	H	SA	Introduced	-
		Bidens pilosa L.	Beggar's Tick	H	SA	Introduced	-
		Blumea axillaris (Lam.) DC.	Soft Blumea	H	SA	Native	-
		Blumea lacera (Burm.f.) DC.	Lettuce-Leaf Blumea	H	SA	Native	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Caesulia axillaris Roxb.	Pink node flower	H	SA	Native	LC
		Calyptocarpus vialis Less.	creeping Cinderella-weed	H	SA	Introduced	-
		Chromolaena odorata (L.) R.M.	Devil weed	H	SA	Introduced	-
		Cirsium arvense (L.) Scop.	Field Thistle	H	T	Native	-
		Cichorium intybus L.	Chicory	H	T	Introduced	LC
		Cyanthillium cinereum (L.) H.	Little ironweed	H	SA	Native	-
		Cyathocline purpurea (Buch.-Ham. ex D.Don) Kuntze	Gangotra	H	SA	Native	LC
		Eclipta prostrata (L.) L.	False daisy	H	SA	Introduced	LC
		Erigeron bonariensis L.	Flaxleaf Fleabane	H	T	Introduced	-
		Enydra fluctuans Lour.	Buffalo Spinach	H	A	Native	LC
		Pseudognaphalium luteoalbum (L.) Hilliard & B.L.Burtt	Weedy Cudweed	H	SA	Native	LC
		Gnaphalium pensylvanicum Willd.	Pennsylvania Cudweed	H	SA	Introduced	-
		Gnaphalium polycaulon Pers.	Many-Stemmed Cudweed	H	SA	Native	LC
		Gnaphalium pulvinatum Delile	Prostrate gnaphalium	H	SA	Native	DD
		Grangea maderaspatana (L.) Poir.	Madras carpet	H	SA	Native	LC
		Grangea minima (L.) Dum.Cours.	Spreading Sneeze Weed	H	SA	Native	-
		Galinsoga parviflora Cav.	Quick Weed	H	SA	Introduced	-
		Parthenium hysterophorus L.	Carrot weed	H	T	Introduced	-
		Pulicaria undulata (L.) C.A.Mey.	Desert Golden Daisy	H	SA	Native	-
		Tridax procumbens L.	Tridax daisy	H	T	Introduced	-
		Launaea procumbens (Roxb.) Ramayya & Rajagopal	Creeping Launaea	H	SA	Native	-
		Mikania micrantha Kunth	Bitter vine	C	T	Introduced	-
		Oligochaeta ramosa (Roxb.) Wagenitz	Branched Sweet-Sultan	H	SA	Native	-
		Sigesbeckia orientalis L.	Indian-weed	H	SA	Native	-
		Soliva anthemifolia (Juss.) Sweet	Button Burrweed	H	SA	Introduced	LC
		Sonchus asper (L.) Hill	prickly sow-thistle	H	T	Introduced	-
		Sonchus oleraceus L.	common sowthistle	H	T	Introduced	-

Order	Family	Botanical name	Common name	Habit	Habitat	Nativity	IUCN status
		Sphagneticola calendulacea (L.) Pruski	Chinese Wedelia	H	SA	Native	LC
		Sphaeranthus indicus L.	East Indian Globe Thistle	H	SA	Native	LC
		Xanthium strumarium L.	Common cocklebur	H	T	Native	-
		Youngia japonica (L.) DC.	Oriental false hawksbeard	H	SA	Native	-
		Laggera crispata (Vahl) Hepper & J.R.I.Wood	Curly Blumea	H	SA	Native	-
	Menyanthaceae	*Nymphoides cristata* (Roxb.) Kuntze	Creasted floating heart	H	A	Native	LC
	Campanulaceae	*Campanula dimorphantha* Schweinf.	Two formed bell flower	H	SA	Native	-
		Wahlenbergia marginata (Thunb.) A.DC.	Asiatic Bellflower	H	SA	Native	-
		Lobelia alsinoides Lam. Hel.	Chickweed Lobelia	H	SA	Native	
Apiales	Apiaceae	*Centella asiatica* (L.) Urb.	Asiatic pennywort	H	SA	Native	LC
		Hydrocotyle sibthorpioides Lam.	Water Pennywort	H	SA	Native	LC
		Oenanthe javanica (Blume) DC.	Java waterdropwort	H	SA	Native	LC

Annexure II. Ichthyofauna recorded from the Gomti River system, Uttar Pradesh, India.

Family	Species name	Common name	IUCN status	Present Findings	Previous studies
Ailiidae	*Ailia coila* (Hamilton 1822)	Gangetic ailia	NT	-	3, 5, 6, 9,10, 14, 15, 17,19, 28, 29, 34
	Clupisoma garua (Hamilton 1822)	Garua bachcha	LC	-	3, 5, 6, 10, 11, 14, 15, 18, 19, 21, 22, 23, 24, 28, 29, 34, 36
	Eutropiichthys vacha (Hamilton 1822)	Batchwa vacha	LC	-	3, 5, 6, 14, 15, 18, 19, 29, 34
	Silonia silondia (Hamilton 1822)	Silond catfish	LC	-	10, 29, 34
Ambassidae	*Chanda nama* Hamilton 1822	Elongate glass-perchlet	LC	+	3, 5, 6, 9, 10, 15, 17, 19, 21, 23, 24, 28, 29, 34
	Chanda baculis Hamilton 1822	Himalayan glassy perchlet	LC	+	34
	Chanda ranga Hamilton 1822	Indian glassy fish	LC	+	6, 9, 10, 15, 23, 24, 29, 34
Anabantidae	*Anabas testudineus* (Bloch 1792)	Climbing perch	LC	+	3, 5, 6, 9, 10, 14, 15, 17, 19, 23, 24, 29, 34, 36
Badidae	*Badis badis* (Hamilton 1822)	Badis	LC	-	3, 6, 9, 28, 29, 34
Bagridae	*Hemibagrus menoda* (Hamilton 1822)	Menoda catfish	LC	-	10, 14, 15, 34
	Mystus bleekeri (Day 1877)	Day's mystus	LC	+	6, 28, 29, 34
	Mystus cavasius (Hamilton 1822)	Gangetic mystus	LC	+	1, 3, 5, 6, 10, 14, 15, 19, 22, 23, 24, 28, 29, 34
	Mystus tengara (Hamilton 1822)	Tengara catfish	LC	-	2, 3, 5, 6, 9, 10, 11, 14, 15, 17, 19, 22, 23, 24, 28, 29, 34, 35
	Mystus vittatus (Bloch 1794)	Striped dwarf catfish	LC	-	3, 5 ,6, 9, 10, 14, 15, 17, 19, 22, 23, 24, 25, 28, 29, 30, 36
	Sperata aor (Hamilton 1822)	Long-whiskered catfish	LC	+	3, 4, 5, 6, 10, 11, 14, 15, 18, 19, 23, 24, 27, 29, 30, 34, 36
	Sperata lamarrii (Valenciennes 1840)	—	NE	+	3, 5, 6, 9, 10, 13, 14, 15, 18, 19, 21, 23, 24, 28, 29, 30, 34, 36
Belonidae	*Xenentodon cancila* (Hamilton 1822)	Freshwater garfish	LC	+	3, 5, 6, 7, 9, 10, 14, 15, 19, 23, 24, 28, 29, 34
Botiidae	*Botia dario* (Hamilton 1822)	Bengal loach	LC	-	10, 28, 34
	Botia lohachata (Chaudhuri 1912)	Reticulate loach	LC	-	3, 5, 19
Chacidae	*Chaca chaca* (Hamilton 1822)	Squarehead catfish	LC	-	34
Channidae	*Channa gachua* (Hamilton 1822)	Red seam snake-head	LC	-	10, 14, 15, 22, 23, 24, 34
	Channa marulius (Hamilton 1822)	Great snakehead	LC	-	3, 5, 6, 9, 10, 14, 15, 19, 22, 23, 24, 28, 29, 34
	Channa punctata (Bloch 1793)	Spotted snakehead	LC	+	1, 2, 3, 5, 6, 9, 10, 11, 14, 15, 16, 17, 19, 22, 23, 24, 25, 29, 34
	Channa stewartii (Playfair 1867)	Assamese snake-head	LC	-	28, 34
	Channa striata (Bloch 1793)	Striped snakehead	LC	+	3, 5, 6, 9, 10, 14, 15, 17, 19, 22, 23, 29, 34
Cichlidae	*Oreochromis aureus* (Steindachner 1864)*	Blue tilapia	NE	-	4
	Oreochromis mossambicus (Peters 1852)*	Mozambique tilapia	VU	-	3

Family	Species name	Common name	IUCN status	Present Findings	Previous studies
	Oreochromis niloticus (Linnaeus 1758)*	Nile tilapia	LC	+	8, 26, 31, 33
Clariidae	*Clarias magur* (Hamilton 1822)	Magur	EN	+	1, 3, 5, 6, 9, 10, 13, 14, 15, 17, 19, 23, 24, 29, 34
	Clarias gariepinus (Burchell 1822)*	North African catfish	LC	-	5, 6, 8, 15, 19, 20, 26, 36
Cobitidae	*Canthophrys gongota* (Hamilton 1822)	Gongota loach	LC	-	34
	Lepidocephalichthys guntea (Hamilton 1822)	Guntea loach	LC	-	3, 5, 10, 19, 22, 23, 24, 28, 34
Cyprinidae	*Bangana dero* (Hamilton 1822)	Kalabans	LC	-	5, 9, 28, 34, 36
	Barbonymus gonionotus (Bleeker 1849)*	Silver barb	LC	-	14, 15
	Chagunius chagunio (Hamilton 1822)	Chaguni	LC	+	5, 19, 30, 34
	Cirrhinus mrigala (Hamilton 1822)	Mrigal carp	LC	+	3, 4, 5, 6, 9, 10, 14, 15, 17, 18, 19, 23, 24, 28, 29, 34, 36
	Cirrhinus reba (Hamilton 1822)	Reba carp	LC	+	3, 5, 6, 9, 10, 15, 17, 19, 29, 34, 36
Cyprinidae	*Cyprinus carpio* Linnaeus 1758*	Common carp	LC	+	3, 5, 6, 8, 10, 14, 15, 17, 19, 20, 26, 31, 32, 34, 36
	Labeo angra (Hamilton 1822)	Angra labeo	LC	-	6, 28, 29, 34
	Labeo bata (Hamilton 1822)	Bata	LC	+	3, 5, 6, 9, 10, 15, 17, 19, 23, 28, 29, 30, 34
	Labeo boga (Hamilton 1822)	Boga labeo	LC	-	28, 29
	Labeo boggut (Sykes 1839)	Boggut labeo	LC	-	5, 19, 29
	Labeo calbasu (Hamilton 1822)	Orangefin labeo	LC	+	3, 5, 6, 10, 12, 14, 15, 17, 19, 22, 23, 24, 28, 29, 34, 36
	Labeo catla (Hamilton 1822)	Catla	LC	-	2, 3, 4, 5, 6, 9, 10, 14, 15, 19, 23, 24, 29, 34, 36
	Labeo fimbriatus (Bloch 1795)	Fringed-lipped peninsula carp	LC	-	29
	Labeo gonius (Hamilton 1822)	Kuria labeo	LC	+	3, 5, 6, 10, 15, 19, 29, 34
	Labeo pangusia (Hamilton 1822)	Pangusia labeo	NT	-	6, 29
	Labeo rohita (Hamilton 1822)	Rohu	LC	-	1, 2, 3, 5, 6, 9, 10, 14, 15, 17, 19, 22, 23, 24, 27, 28, 29, 34, 35, 36
	Osteobrama cotio (Hamilton 1822)	Cotio	LC	+	3, 5, 6, 10, 14, 15, 19, 28, 29, 34
	Pethia conchonius (Hamilton 1822)	Rosy barb	LC	+	6, 15, 16, 22, 23, 28, 29
	Pethia guganio (Hamilton 1822)	Glass-barb	LC	-	29
	Pethia phutunio (Hamilton 1822)	Spottedsail barb	LC	-	29
	Pethia ticto (Hamilton 1822)	Ticto barb	LC	+	3, 5, 6, 9, 10, 14, 15, 16, 17, 19, 21, 22, 23, 24, 29, 34, 36
	Puntius chola (Hamilton 1822)	Swamp barb	LC	+	6, 10, 15, 22, 23, 28, 29, 34, 35
	Puntius sophore (Hamilton 1822)	Pool barb	LC	+	3, 5, 6, 9, 10, 14, 15, 16, 19, 21, 22, 23, 24, 28, 29, 34

Family	Species name	Common name	IUCN status	Present Findings	Previous studies
	Systomus sarana (Hamilton 1822)	Olive barb	LC	-	3, 5, 6, 9, 10, 14, 15, 19, 22, 23, 24, 28, 29, 34
	Tariqilabeo latius (Hamilton 1822)	Gangetic latia	LC	+	34
	Tor tor (Hamilton 1822)	Tor barb	DD	-	9
Danionidae	*Amblypharyngodon microlepis* (Bleeker 1853)	Indian carplet	LC	-	34
	Amblypharyngodon mola (Hamilton 1822)	Mola carplet	LC	+	5, 6, 9, 10, 14, 15, 21, 23, 24, 29, 34
	Cabdio jaya (Hamilton 1822)	Jaya	LC	-	29, 34
	Cabdio morar (Hamilton 1822)	Morari	LC	+	5, 6, 10, 19, 28, 29, 34, 36
	Chela cachius (Hamilton 1822)	Silver hatchet chela	LC	-	28, 34
	Devario devario (Hamilton 1822)	Sind danio	LC	+	5, 9, 10, 17, 28, 34
	Esomus danrica (Hamilton 1822)	Indian flying barb	LC	+	3, 5, 10, 15, 16, 28, 29, 34
	Laubuka laubuca (Hamilton 1822)	Indian glass barb	LC	+	5, 6, 10, 19, 22, 23, 24, 28, 29, 34
	Opsarius bendelisis (Hamilton 1807)	Hamilton's barila	LC	-	9
	Raiamas bola (Hamilton 1822)	Trout barb	LC	-	15, 34
	Rasbora daniconius (Hamilton 1822)	Slender rasbora	LC	+	3, 5, 9, 19, 21
	Salmostoma bacaila (Hamilton 1822)	Large razorbelly minnow	LC	+	3, 5, 6, 10, 14, 15, 19, 22, 23, 24, 28, 29, 36
	Salmostoma balookee (Sykes 1839)	Bloch razorbelly minnow	LC	-	14, 15, 22, 23, 24
	Securicula gora (Hamilton 1822)	Gora chela	LC	-	9, 34
Dorosomatidae	*Gonialosa manmina* (Hamilton 1822)	Ganges river gizzard shad	LC	-	14, 15, 23, 24, 29, 34
	Gudusia chapra (Hamilton 1822)	Indian river shed	LC	-	3, 5, 6, 9, 14, 15, 17, 19, 21, 23, 24, 29, 34
	Tenualosa ilisha (Hamilton 1822)	Hilsa shad	LC	-	10
Engraulidae	*Setipinna phasa* (Hamilton 1822)	Gangetic hairfin anchovy	LC	-	6, 10, 14, 15, 23, 24, 28, 29, 34
Gobiidae	*Glossogobius giuris* (Hamilton 1822)	Tank goby	LC	+	3, 5, 10, 14, 15, 19, 28
Hemiramphidae	*Hyporhamphus limbatus* (Valenciennes 1847)	Congaturi halfbeak	LC	-	10
Heteropneus-tidae	*Heteropneustes fossilis* (Bloch 1794)	Asian stinging catfish	LC	-	1, 2, 3, 5, 6, 9, 10, 11, 13, 14, 15, 17, 19, 23, 24, 25, 28, 29, 34
Horabagridae	*Pachypterus atherinoides* (Bloch 1794)	Indian potasi	LC	-	28
Loricariidae	*Pterygoplichthys disjunctivus* (Weber 1991)*	Vermiculated sailfin catfish	LC	-	5, 20, 26, 36
Mastacembel-idae	*Macrognathus aculeatus* (Bloch 1786)	Lesser spiny eel	LC	-	9, 10, 14, 15, 28
	Macrognathus pancalus (Hamilton 1822)	Barred spiny eel	LC	+	3, 5, 6, 14, 15, 19, 21, 25, 28, 34

Family	Species name	Common name	IUCN status	Present Findings	Previous studies
	Mastacembelus armatus (Lacepede 1800)	Zig-zag eel	LC	-	1, 3, 5, 6, 9, 10, 14, 15, 19, 21, 23, 24, 28, 29, 34, 35
Mugilidae	*Sicamugil cascasia* (Hamilton 1822)	Yellowtail mullet	LC	-	29, 34
	Rhinomugil corsula (Hamilton 1822)	Corsula	LC	+	3, 5, 10, 14, 15, 19, 34
Nandidae	*Nandus nandus* (Hamilton 1822)	Gangetic leaf fish	LC	-	3, 5, 6, 9, 10, 14, 15, 17, 19, 23, 24, 29, 34
Nemacheilidae	*Paracanthocobitis botia* (Hamilton 1822)	Mottled loach	LC	+	10, 14, 15
	Paracanthocobitis mooreh (Sykes 1839)	Murangi loach	LC	-	10
Notopteridae	*Chitala chitala* (Hamilton 1822)	Clown knifefish	NT	-	5, 6, 9, 10, 14, 15, 19, 23, 24, 28, 29, 30, 34
	Notopterus synurus (Bloch & Schneider 1801)	Bronze featherback	LC	+	1, 3, 5, 6, 9, 10, 11, 14, 15, 18, 19, 28, 29, 34, 36
Osphronemidae	*Trichogaster chuna* (Hamilton 1822)	Honey gourami	LC	-	3, 10, 14, 21
	Trichogaster fasciata Bloch & Schneider 1801	Banded gourami	LC	+	3, 5, 6, 9, 10, 14, 15, 16, 17, 19, 21, 23, 24, 28, 29, 34
Pangasiidae	*Pangasius pangasius* (Hamilton 1822)	Pangas catfish	LC	-	4, 6, 10, 14, 15, 29, 34
Pristigasteridae	*Ilisha megaloptera* (Swainson 1839)	Bigeye ilisha	LC	-	28
Psilorhynchidae	*Psilorhynchus balitora* (Hamilton 1822)	Balitora minnow	LC	-	29
Ritidae	*Rita rita* (Hamilton 1822)	Rita	LC	+	1, 3, 5, 6, 9, 10, 14, 15, 19, 21, 22, 23, 24, 27, 28, 29, 34, 36
Sciaenidae	*Johnius coitor* (Hamilton 1822)	Coitor croaker	LC	-	3, 10, 14, 34
Siluridae	*Ompok bimaculatus* (Bloch 1794)	Butter catfish	NT	+	3, 5, 6, 14, 18, 19, 23, 24, 28, 29, 36
	Ompok pabda (Hamilton 1822)	Pabdah catfish	NT	-	3, 5, 6, 7, 9, 17, 19, 29
	Ompok pabo (Hamilton 1822)	Pabo catfish	NT	-	6, 29
	Pinniwallago kanpurensis Gupta, Jayaram & Hajela 1981	Pinna catfish	CR	-	29
	Wallago attu (Bloch & Schneider 1801)	Wallago	VU	-	3, 5, 6, 9, 10, 11, 13, 14, 15, 17, 18, 19, 21, 22, 23, 24, 25, 27, 28, 29, 34
Sisoridae	*Bagarius bagarius* (Hamilton 1822)	Goonch	VU	-	3, 5, 6, 9, 10, 14, 15, 19, 22, 23, 24, 28, 29, 34
	Erethistes hara (Hamilton 1822)	Kosi hara	LC	-	28
	Erethistes pusillus Muller & Troschel 1849	Gangetic erethistes	LC	-	34
	Gagata cenia (Hamilton 1822)	Indian gagata	LC	-	3, 5, 10, 19, 28, 29, 34
	Glyptothorax telchitta (Hamilton 1822)	Telchitta catfish	LC	-	5, 36
	Nangra nangra (Hamilton 1822)	Kosi nangra	LC	-	3, 5, 19
	Sisor rabdophorus Hamilton 1822	Sisor catfish	LC	-	34

Family	Species name	Common name	IUCN status	Present Findings	Previous studies
Synbranchidae	*Ophichthys cuchia* (Hamilton 1822)	Swamp eels	LC	-	6, 9, 10, 22, 23, 24, 28, 29, 34
Tetraodontidae	*Leiodon cutcutia* (Hamilton 1822)	Ocellated pufferfish	LC	-	3, 5, 6, 10, 19, 23, 24, 28, 29, 34
Xenocyprididae	*Ctenopharyngodon idella* (Valenciennes 1844)*	Grass carp	LC	-	3, 5, 6, 8, 10, 14, 15, 19, 20, 23, 24, 34, 35, 36
	Hypophthalmichthys molitrix (Valenciennes 1844)*	Silver carp	NT	-	3, 5, 6, 8, 10, 14, 15, 19, 20, 23, 24, 26, 34, 36
	Hypophthalmichthys nobilis (Richardson 1845)*	Bighead carp	DD	-	8, 26, 34

IUCN Status: CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient, NE: Not Evaluated
'+' for species recorded and '-' for species not recorded in the present study.

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Annexure III. Herpetofauna recorded in and around Gomti River basin, Uttar Pradesh.

Order	Family	Common Name	Scientific Name	IUCN	WPA Schedule	Present Findings	Previous Studies
Schedule	Present Findings	Previous Studies	*Duttaphrynus melanostictus* (Schneider, 1799)	LC	NL	+	1, 3, 4
		Marbled Toad	*Firouzophrynus stomaticus* (Lütken,1864)	LC	NL	+	1, 3
	Dicroglossidae	Terai Cricket Frog	*Minervarya teraiensis* (Dubios, 1984)	LC	Sch-II	_	3
		Indian Bullfrog	*Hoplobatrachus tigerinus* (Daudin,1802)	LC	Sch-II	+	1, 3, 4
		Jerdon's Bullfrog	*Hoplobatrachus crassuss* (Jerdon,1854)	LC	NL	+	1, 3
		Indian Burrowing Frog	*Sphaerotheca breviceps* (Schneider, 1799)	LC	NL	+	_
		Indian Cricket Frog	*Minervarya agricola* (Rana agricola Jerdon,1853)	LC	NL	+	3
		Common Skittering Frog	*Euphlyctis cyanophlyctis* (Schneider, 1799)	LC	Sch-II	+	1, 3, 4
		Indian Pond Frog	*Euphlyctis hexadactyla* (Lesson, 1834)	LC	Sch-IV	_	1
		Boie's Wart Frog	*Fejervarya limnocharis* (Gravenhorst, 1829)	LC	NL	_	3
		Orissa Frog	*Fejervarya orissaensis* (Dutta, 1997)	LC	Sch-II	_	1
		Common Indian Cricket Frog	*Minervarya agricola* (Jerdon, 1853)	LC	NL	_	1
		Maskey's Burrowing Frog	*Sphaerotheca maskeyi* (Schleich & Anders, 1998)	LC	NL	_	1
	Rhacophoridae	Bengal Whipping Frog	*Polypedates taeniatus* (Boulenger, 1906)	LC	NL	+	3
		Dudhwa Tree Frog	*Chirixalus dudhwaensis* (Ray, 1992)	VU	NL	_	3
		Terai Tree Frog	*Polypedates teraiensis* (Dubios, 1987)	LC	Sch-II	_	3
		Common Indian Tree Frog	*Polypedates maculatus* (Gray, 1830)	LC	NL	_	3
		Whipping Frogs	*Polypedates* sp.	_	_	_	1
	Microhylidae	Ornate Narrow-Mouthed Frog	*Microhyla ornata* (Duméril and Bibron 1841),	LC	NL	+	3
		Nilphamarai Narrow-Mouthed Frog	*Microhyla nilphamariensis* Howlader, Nair, Goplan & Merilä, 2015	LC	NL	_	1
		Marbled Balloon Frog	*Uperodon systoma* (Schneider, 1799)	LC	NL	+	1, 3
		Sri Lankan Painted Frog	*Uperodon taprobanicus* (Parker, 1934)	LC	NL	_	1, 3
		Indian Balloon Frog	*Uperodon globulosus* (Gunther, 1864)	LC	NL	_	3
		Variegated Balloon Frog	*Uperodon variegatus* (Stoliczka, 1872)	LC	NL	_	1, 3
Testudines	Geoemydidae	Crowned River Turtle	*Hardella thurjii* (Gray, 1831)	EN	Sch-I	+	2
		Indian Roofed Turtle	*Pangshura tecta* (Gray, 1831)	VU	Sch-I	+	3

Order	Family	Common Name	Scientific Name	IUCN	WPA Schedule	Present Findings	Previous Studies
		Indian Tent Turtle	*Pangshura tentoria* (Gray,1834)	LC	Sch-I	+	2
		Three-Striped Roofed Turtle	*Batagur dhongoka* (Gray,1834)	CR	Sch-I	_	2
	Trionychidae	Indian Flapshell Turtle	*Lissemys punctata* (Bonnaterre, 1789)	VU	Sch-I	+	1
		Indiain Softshell Turtlei	*Nilssonia gangetica* (Cuvier, 1825)	EN	Sch-I	+	1
Squamata	Coloubridae	Common Indian Wolf Snake	*Lycodon aulicus* (Linnaeus,1758)	LC	Sch-II	_	1, 3, 4
		Barred Wolf Snake	*Lycodon striatus* (Shaw, 1802)	LC	Sch-II	_	1
		Indian Rat Snake	*Ptyas mucosa* (Linnaeus,1758)	LC	Sch-I	_	1, 3, 4
		Checkered Keel Back	*Fowlea piscator* (Schneider,1799)	LC	Sch-I	_	1, 3, 4
		Common Cat Snake	*Boiga trigonata* (Scheinder, 1802)	LC	Sch-II	_	1, 3
		Daudin's Bronzeback	*Dendrelaphis tristis* (Daudin,1803)	LC	Sch-II	_	3
		Long-Nosed Tree Snake	*Ahaetulla nasuta* (Lacepede, 1789)	LC	Sch-II	_	3
		Common Kukri Snake	*Oligodon arnensis* (Shaw, 1802)	LC	Sch-II	_	3
		Russell's Kukri Snake	*Oligodon russelius* (Daudin, 1803)	NL	Sch-II	_	1
		Common Trinket Snake	*Coelognathus helenae* (Daudin, 1803)	LC	Sch-II	_	3
		Ornate Flying Snake	*Chrysopelea ornata* (Shaw, 1802)	LC	Sch-II	_	3
		Indian Rat Snake	*Ptyas mucosa* (Linnaeus, 1758)	LC	Sch-I	_	3
	Natricidae	Buff Striped Keelback	*Amphiesma stolatum* (Linnaeus, 1758)	LC	NL	_	1, 3
	Elapidae	Spectacled Cobra	*Naja naja* (Linnaeus, 1758)	LC	Sch-I	_	1, 3, 4
		Monocled Cobra	*Naja kaouthia* (Lesson, 1831)	LC	Sch-I	_	3
		King Cobra	*Ophiophagus hannah* (Cantor, 1836)	VU	Sch-I	_	3
		Common Krait	*Bungarus caeruleus* (Scheinder, 1801)	LC	Sch-II	_	1, 3
		Banded Krait	*Bungarus fasciatus* (Scheinder, 1801)	LC	Sch-II	_	3
	Erycidae	Red Sand Boa	*Eryx johnii* (Russell, 1801)	NT	Sch-I	_	1, 3
	Pythonidae	Indian Rock Python	*Python molurus* (Linnaeus, 1758)	NT	Sch-I	_	1, 3
	Homalopsidae	Rainbow Mud Snake	*Enhydris enhydris* (Scheinder, 1799)	LC	NL	_	3
	Sibynophiidae	Cantor's Black Headed Snake	*Sibynophis Sagittarius* (Cantor, 1839)	LC	NL	_	3
	Typhlopidae	Brahminy Blind Snake	*Indotyphlops braminus* (Nussbaum, 1980)	LC	Sch-II	_	1, 3, 4

Order	Family	Common Name	Scientific Name	IUCN	WPA Schedule	Present Findings	Previous Studies
		Slender Worm Snake	*Pseudoindotyphlops porrectus* (Stoliczka, 1871)	NL	Sch-II	_	1
	Viperidae	Russell's Viper	*Daboia russelii* (Shaw & Nodder, 1797)	LC	Sch-I	_	1, 3
	Agamidae	Changeable Lizard	*Calotes versicolor* (Daudin,1802)	LC	NL	_	1, 3, 4
	Gekkonidae	Yellow-Bellied House Gecko	*Hemidactylus flaviviridis* (Ruppell,183)	LC	NL	_	3, 4
		Common House Gecko	*Hemidactylus frenatus* (Duméril & Bibron, 1836)	LC	NL	_	3
		Brooke's House Gecko	*Hemidactylus brookii* (Gray, 1845)	LC	NL	_	3
	Scincidae	Common Dotted Garden Skink	*Lygosoma punctata* (Das,1996)	LC	NL	_	1, 3, 4
		Bronze Mabuya	*Eutropis macularia* (Blyth, 1853)	LC	NL	_	1
		White-spotted Supple Skink	*Riopa albopunctata* Gray, 1846	LC	NL	_	1
		Keeled Indian Mabuya	*Eutropis carinata* (Scheinder, 1801)	LC	NL	_	3
	Varanidae	Bengal Monitor Lizard	*Varanus bengalensis* (Daudin, 1802)	NT	Sch-I	_	1, 3, 4
		Yellow Monitor Lizard	*Varanus flavescens* (Hardwicke & Gray, 1827)	EN	Sch-I	_	1, 3
	Gekkonidae	Northern House Gecko	*Hemidactylus flaviviridis* Rüppell, 1835	LC	NL	_	1
		Kushmore House Gecko	*Hemidactylus cf. kushmorensis* Murray, 1884	DD	NL	_	1
Crocodylia	Crocodylidae	Marsh Crocodile	*Crocodylus palustris* (Lesson, 1831)	VU	Sch-I	+	1, 3
		Gharial	*Gavialis gangeticus* (Gmelin in Linnaeus, 1789)	CR	Sch-I	_	3

IUCN Status: DD: Data Deficient, LC: Least Concern, VU: Vulnerable, NT: Near Threatened, EN: Endangered, CR: Critically Endangered, NL: Not Listed

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Annexure IV. Avifauna recorded in and around Gomti River basin, Uttar Pradesh.

Order	Family	Species	Scientific Name
Anseriformes	Anatidae	Bar-headed Goose	*Anser indicus (Latham, 1790)*
		Common Pochard	*Aythya farina* (Linnaeus, 1758)
		Common Teal	*Anas crecca* (Linnaeus, 1758)
		Cotton Pygmy-Goose	*Nettapus coromandelianus* (Gmelin, 1789)
		Eurasian Wigeon	*Mareca Penelope* (Linnaeus, 1758)
		Falcated Duck	*Mareca falcata* (Georgi, 1775)
		Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)
		Gadwall	*Mareca strepera* (Linnaeus, 1758)
		Garganey	*Spatula querquedula* (Linnaeus, 1758)
		Greylag Goose	*Anser anser* (Linnaeus, 1758)
		Indian Spot-billed Duck	*Anas poecilorhyncha* (Forster, 1781)
		Knob-billed Duck	*Sarkidiornis melanotos* (Pennant, 1769)
		Lesser Whistling-Duck	*Dendrocygna javanica* (Horsfield, 1821)
		Mallard	*Anas platyrhynchos* (Linnaeus, 1758)
		Northern Pintail	*Anas acuta* (Linnaeus, 1758)
		Northern Shoveler	*Spatula clypeata* (Linnaeus, 1758)
		Red-crested Pochard	*Netta rufina* (Pallas, 1773)
		Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)
		Tufted Duck	*Aythya fuligula* (Linnaeus, 1758)
Galliformes	Phasianidae	Black Francolin	*Francolinus francolinus* (Linnaeus, 1766)
		Grey Francolin	*Ortygornis pondicerianus* (Gmelin, 1789)
		Indian Peafowl	*Pavo cristatus* (Linnaeus, 1758)
		Jungle Bush-Quail	*Perdicula asiatica* (Latham, 1790)
		Painted Bush-Quail	*Perdicula erythrorhyncha* (Sykes, 1832)
		Rain Quail	*Coturnix coromandelica* (Gmelin, 1789)
		Red Junglefowl	*Gallus gallus* (Linnaeus, 1758)
		Red Spurfowl	*Galloperdix spadicea* (Gmelin, 1789)
		Swamp Francolin	*Ortygornis gularis* (Temminck, 1815)
Podicipediformes	Podicipedidae	Little Grebe	*Tachybaptus ruficollis* (Pallas, 1764)
		Great Crested Grebe	*Podiceps cristatus* (Linnaeus, 1758)
Columbiformes	Columbidae	Asian Emerald Dove	*Chalcophaps indica* (Linnaeus, 1758)
		Eurasian Collared-Dove	*Streptopelia decaocto* (Frivaldszky, 1838)
		Green Imperial-Pigeon	*Ducula aenea* (Linnaeus, 1766)
		Laughing Dove	*Spilopelia senegalensis* (Linnaeus, 1766)
		Orange-breasted Green Pigeon	*Treron bicinctus* (Jerdon, 1840)
		Oriental Turtle-Dove	*Streptopelia orientalis* (Latham, 1790)
		Red Collared-Dove	*Streptopelia tranquebarica* (Hermann, 1804)
		Rock Pigeon	*Columba livia* (Gmelin, 1789)
		Spotted Dove	*Spilopelia chinensis* (Scopoli, 1786)

IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	4, 12, 14
VU	Sch-I	-	3, 8, 10, 11
LC	Sch-II	-	8, 10, 11, 12
LC	Sch-I	-	3, 8, 10, 14
LC	Sch-II	-	3, 8, 11, 12, 14
LC	Sch-II	-	12
NT	Sch-II	-	11, 12, 14
LC	Sch-II	+	1, 10, 11, 12
LC	Sch-II	-	1, 8, 11, 12
LC	Sch-II	-	3, 8, 11, 12
LC	Sch-II	-	8, 10, 11, 14
LC	Sch-II	-	3, 8
LC	Sch-II	+	1, 8, 10, 11, 12, 14
LC	Sch-II	-	11, 12, 14
LC	Sch-II	-	1, 10, 11, 12,
LC	Sch-II	-	8, 11, 12, 14
LC	Sch-II	-	8, 11, 12, 14
LC	Sch-II	+	3, 8, 12, 14
LC	Sch-II	-	3, 8, 14
LC	Sch-II	-	8, 14, 15
LC	Sch-II	-	8, 14, 15
LC	Sch-I	-	3, 8, 14
LC	Sch-II	-	8
LC	Sch-II	-	8
LC	Sch-II	-	8
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
NT	Sch-I	-	12
LC	Sch-II	-	3, 4, 8, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 8, 14
NT	Sch-II	-	8
LC	Sch-II	-	8, 14
LC	Sch-II	-	14
LC	Sch-II	-	8
LC	Sch-II	-	8, 14
LC	NS	-	3, 8, 14, 15
LC	Sch-II	-	3, 8, 14, 15

Order	Family	Species	Scientific Name
		Yellow-footed Green-Pigeon	*Treron phoenicopterus* (Latham, 1790)
Cuculiformes	Cuculidae	Asian Koel	*Eudynamys scolopaceus* (Linnaeus, 1758)
		Common Cuckoo	*Cuculus canorus* (Linnaeus, 1758)
		Common Hawk Cuckoo	*Hierococcyx varius* (Vahl, 1797)
		Greater Coucal	*Centropus sinensis* (Stephens, 1815)
		Green-billed Malkoha	*Phaenicophaeus tristis* (Lesson, 1830)
		Indian Cuckoo	*Cuculus micropterus* (Gould, 1838)
		Lesser Coucal	*Centropus bengalensis* (Gmelin, 1788)
		Sirkeer Malkoha	*Taccocua leschenaultia* (Lesson, 1830)
Caprimulgiformes	Caprimulgidae	Indian Nightjar	*Caprimulgus asiaticus* (Latham, 1790)
Gruiformes	Gruidae	Sarus Crane	*Antigone antigone* (Linnaeus, 1758)
	Rallidae	Brown Crake	*Zapornia akool* (Sykes, 1832)
		Common Moorhen	*Gallinula chloropus* (Linnaeus, 1758)
		Eurasian Coot	*Fulica atra* (Linnaeus, 1758)
		Grey-headed Swamphen	*Porphyrio poliocephalus* (Latham, 1801)
		Watercock	*Gallicrex cinerea* (Gmelin, 1789)
		White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)
Charadriiformes	Burhinidae	Great Thick-knee	*Esacus recurvirostris* (Cuvier, 1829)
	Charadriidae	Grey-headed Lapwing	*Vanellus cinereus* (Blyth, 1842)
		Little Ringed Plover	*Thinornis dubius* (Scopoli, 1786)
		Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)
		River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)
		White-tailed Lapwing	*Vanellus leucurus* (Lichtenstein, 1823)
		Yellow-wattled Lapwing	*Vanellus malabaricus* (Boddaert, 1783)
	Jacanidae	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)
		Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)
	Laridae	Black-headed Gull	*Chroicocephalus ridibundus* (Linnaeus, 1766)
		Brown-headed Gull	*Chroicocephalus brunnicephalus* (Jerdon, 1840)
		Black-bellied Tern	*Sterna acuticauda* (Gray, 1831)
		Common Tern	*Sterna Hirundo* (Linnaeus, 1758)
		Indian Skimmer	*Rynchops albicollis* (Swainson, 1838)
		Lesser Golden- backed	*Larus fuscus* Linnaeus, 1758
		Pallas's Gull	*Larus ichthyaetus* Pallas, 1773
		River Tern	*Sterna aurantia* (Gray, 1831)
	Recurvirostridae	Black-winged Stilt	*Himantopus Himantopus* (Linnaeus, 1758)
	Scolopacidae	Black-tailed Godwit	*Limosa limosa*(Linnaeus, 1758)
		Common Greenshank	*Tringa nebularia* (Gunnerus, 1767)
		Common Redshank	*Tringa tetanus* (Linnaeus, 1758)
		Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)
		Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)
		Eurasian Curlew	*Numenius Arquata* (Linnaeus, 1758)
		Green Sandpiper	*Tringa ochropus* (Linnaeus, 1758)

IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	3, 8, 14
LC	Sch-II	-	8, 3, 14, 15
LC	Sch-II	-	14, 15
LC	Sch-II	-	14
LC	Sch-II	+	3, 8, 14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	3
LC	Sch-II	-	3, 14
VU	Sch-I	+	4, 6, 8, 12, 13, 14
LC	Sch-II	-	8, 14
LC	Sch-II	+	8, 3, 11, 14
LC	Sch-II	+	1, 8, 11, 14
NE	Sch-II	-	3, 4, 10, 11, 12, 14
LC	Sch-II	-	8
LC	Sch-II	+	3, 8, 10,14
NT	Sch-II	-	12
LC	Sch-II	-	14
LC	Sch-II	+	-
LC	Sch-II	+	3, 7, 10, 14, 15
NT	Sch-II	+	8, 14
LC	Sch-II	-	7
LC	Sch-II	-	3, 8
LC	Sch-II	-	4, 8, 10, 12, 14
LC	Sch-II	-	3, 8, 12
LC	Sch-II	+	-
LC	Sch-II	+	-
EN	Sch-I	-	12
LC	Sch-II	-	8
EN	Sch-I	+	-
LC	Sch-II	-	3
LC	Sch-II	-	14
VU	Sch-I	+	3, 12
LC	Sch-II	+	3, 8, 14
NT	Sch-II	-	12
LC	Sch-I	-	4
LC	Sch-II	-	3, 14
LC	Sch-II	+	3, 14
LC	Sch-II	-	14
NT	Sch-II	-	12
LC	Sch-II	+	4

Order	Family	Species	Scientific Name
		Little Stint	*Calidris minuta* (Leisler, 1812)
		Wood Sandpiper	*Tringa glareola* (Linnaeus, 1758)
Ciconiiformes	Ciconiidae	Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)
		Asian Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)
		Black Stork	*Ciconia nigra* (Linnaeus, 1758)
		Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)
		Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)
		Painted Stork	*Mycteria leucocephala* (Pennant, 1769)
		White Stork	*Ciconia ciconia* (Linnaeus, 1758)
Suliformes	Anhingidae	Oriental Darter	*Anhinga melanogaster* (Pennant, 1769)
	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)
		Indian Cormorant	*Phalacrocorax fuscicollis* (Stephens, 1826)
		Little Cormorant	*Microcarbo niger* (Vieillot, 1817)
Pelecaniformes	Ardeidae	Black Bittern	*Botaurus flavicollis* (Latham, 1790)
		Black-crowned Night Heron	*Nycticorax nycticorax* (Linnaeus, 1758)
		Cinnamon Bittern	*Botaurus cinnamomeus* (Gmelin, 1789)
		Common Little Bittern	*Ixobrychus minutus* (Linnaeus, 1766)
		Eastern Cattle-Egret	*Ardea coromanda* (Boddaert, 1783)
		Grey Heron	*Ardea cinerea* (Linnaeus, 1758)
		Great Egret	*Ardea alba* Linnaeus, 1758
		Indian Pond-Heron	*Ardeola grayii* (Sykes, 1832)
		Intermediate Egret	*Ardea intermedia* (Wagler, 1829)
		Little Egret	*Egretta garzetta* (Linnaeus, 1766)
		Purple Heron	*Ardea purpurea* (Linnaeus, 1766)
		Striated Heron	*Butorides striata* (Linnaeus, 1758)
		Yellow Bittern	*Botaurus sinensis* (Gmelin, 1789)
	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790)
		Red-naped Ibis	*Pseudibis papillosa* (Temminck, 1824)
		Eurasian Spoonbill	*Platalea leucorodia* (Linnaeus, 1758)
		Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)
Accipitriformes	Accipitridae	Black Eagle	*Ictinaetus malaiensis* (Temminck, 1822)
		Black Kite	*Milvus migrans* (Boddaert, 1783)
		Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)
		Bonelli's Eagle	*Aquila fasciata* (Vieillot, 1822)
		Brahminy Kite	*Haliastur indus* (Boddaert, 1783)
		Changeable Hawk Eagle	*Nisaetus cirrhatus* (Gmelin, 1788)
		Cinereous Vulture	*Aegypius monachus* (Linnaeus, 1766)
		Crested Serpent-Eagle	*Spilornis cheela* (Latham, 1790)
		Egyptian Vulture	*Neophron percnopterus* (Linnaeus, 1758)
		Eurasian Sparrowhawk	*Accipiter nisus* (Linnaeus, 1758)
		Greater Spotted Eagle	*Clanga clanga* (Pallas, 1811)
		Grey-headed Fish-eagle	*Icthyophaga ichthyaetus* (Horsfield, 1821)
		Himalayan Vulture	*Gyps himalayensis* (Hume, 1869)

IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	14
LC	Sch-II	+	3, 14
LC	Sch-II	+	1, 5, 8, 12, 14
NT	Sch-II	+	5, 10, 12, 14
LC	Sch-II	-	3
NT	Sch-II	-	3, 12, 14
NT	Sch-I	-	12, 14
LC	Sch-II	+	3, 4, 8, 10, 12, 14
LC	Sch-I	-	14
LC	Sch-II	+	3, 4, 8, 12, 14
LC	Sch-II	+	3, 4, 14
LC	Sch-II	+	3, 4, 14
LC	Sch-II	+	1, 4, 14
LC	Sch-II	+	3, 4
LC	Sch-II	+	3, 4, 12, 14
LC	Sch-I	+	8
LC	Sch-II	-	14
NE	Sch-II	+	5, 8, 14
LC	Sch-II	+	4, 8, 14
LC	Sch-II	+	14
LC	Sch-II	+	4, 7, 10, 14
LC	Sch-II	+	8, 14
LC	Sch-II	+	3, 4, 8, 14
LC	Sch-II	+	1, 8, 14
LC	Sch-II	-	3, 4, 14
LC	Sch-II	+	3, 4, 8
LC	Sch-II	+	3, 4, 11, 12, 14
LC	Sch-II	+	-
LC	Sch-I	-	4, 12
LC	Sch-II	-	3, 4, 8
LC	Sch-I	-	8
LC	Sch-II	+	3, 8, 14, 15
LC	Sch-II	-	8, 14
LC	Sch-I	-	14
LC	Sch-I	-	8, 14
LC	Sch-I	-	14
NT	Sch-I	-	12
LC	Sch-I	+	6, 14
EN	Sch-I	+	12, 14
LC	Sch-I	-	14
VU	Sch-I	-	12
NT	Sch-I	-	14
NT	Sch-I	-	12

Order	Family	Species	Scientific Name
		Indian Vulture	*Gyps indicus* (Scopoli, 1786)
		Oriental Honey-buzzard	*Pernis ptilorhynchus* (Temminck, 1821)
		Pallas's Fish-Eagle	*Haliaeetus leucoryphus* (Pallas, 1771)
		Pallid Harrier	*Circus macrourus* (Gmelin, 1770)
		Red-headed Vulture	*Sarcogyps calvus* (Scopoli, 1786)
		Shikra	*Tachyspiza badia* (Gmelin, 1788)
		Short-toed Snake-eagle	*Circaetus gallicus* (Gmelin, 1788)
		Slender-billed Vulture	*Gyps tenuirostris* (Gray, 1844)
		Tawny Eagle	*Aquila rapax* (Temminck, 1828)
		Western Marsh Harrier	*Circus aeruginosus* (Linnaeus, 1758)
		White-eyed Buzzard	*Butastur teesa* (Franklin, 1831)
		White-rumped Vulture	*Gyps bengalensis* (Gmelin, 1788)
	Pandionidae	Osprey	*Pandion haliaetus* (Linnaeus, 1758)
Strigiformes	Strigidae	Asian Barred Owlet	*Glaucidium cuculoides* (Vigors, 1831)
		Brown Boobook	*Ninox scutulata* (Raffles, 1822)
		Brown Fish-Owl	*Ketupa zeylonensis* (Gmelin, 1788)
		Collared Scops-owl	*Otus lettia* (Hodgson, 1836)
		Eurasian Eagle-Owl	*Bubo bubo* (Linnaeus, 1758)
		Indian Scops-Owl	*Otus bakkamoena* (Pennant, 1769)
		Jungle Owlet	*Glaucidium radiatum* (Tickell, 1833)
		Spotted Owlet	*Athene brama* Temminck, 1821)
	Tytonidae	Eastern Barn Owl	*Tyto javanica* (Gmelin, 1788)
		Eastern Grass-Owl	*Tyto longimembris* (Jerdon, 1839)
Bucerotiformes	Upupidae	Eurasian Hoopoe	*Upupa epops* (Linnaeus, 1758)
	Bucerotidae	Great Hornbill	*Buceros bicornis* (Linnaeus, 1758)
		Indian Grey Hornbill	*Ocyceros birostris* (Scopoli, 1786)
		Oriental Pied-Hornbill	*Anthracoceros albirostris* (Shaw, 1808)
Coraciiformes	Alcedinidae	Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)
		Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)
		Stork-billed Kingfisher	*Pelargopsis capensis* (Linnaeus, 1766)
		White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)
	Meropidae	Asian Green Bee-eater	*Merops orientalis* (Latham, 1801)
		Blue-bearded Bee-eater	*Nyctyornis athertoni* (Jardine & Selby, 1828)
		Blue-tailed Bee-eater	*Merops philippinus* (Linnaeus, 1767)
		Chestnut-headed Bee-eater	*Merops leschenaulti* Vieillot, 1817
	Coraciidae	Indian Roller	*Coracias benghalensis* (Linnaeus, 1758)
Piciformes	Megalaimidae	Brown-headed Barbet	*Psilopogon zeylanicus* (Gmelin, 1788)
		Coppersmith Barbet	*Psilopogon haemacephalus* (Müller, 1776)
		Lineated Barbet	*Psilopogon lineatus* (Vieillot, 1816)
	Picidae	Black-rumped Flameback	*Dinopium benghalense* (Linnaeus, 1758)
		Brown-capped Pygmy Woodpecker	*Yungipicus nanus* (Vigors, 1832)
		Grey-headed Woodpecker	*Picus canus* (Gmelin, 1788)
		Greater Flameback	*Chrysocolaptes guttacristatus* (Tickell, 1833)
		Great Slaty Woodpecker	*Mulleripicus pulverulentus* (Temminck, 1826)

IUCN	WPA Schedule	Present Findings	Previous studies
CR	Sch-I	-	14
LC	Sch-II	-	14
EN	Sch-I	-	12
NT	Sch-I	-	12
CR	Sch-I	-	12
LC	Sch-I	-	3, 8, 14
LC	Sch-I	-	14
CR	Sch-I	-	12
VU	Sch-I	-	14
LC	Sch-I	-	8, 12
LC	Sch-I	-	14
CR	Sch-I	-	12
LC	Sch-I	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-I	-	8
LC	Sch-II	-	14
LC	Sch-I	-	3
LC	Sch-II	-	8
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	3, 14
LC	NS	-	4, 14
LC	Sch-II	-	8
LC	Sch-II	-	3, 8, 14, 15
VU	Sch-I	-	12, 14
LC	Sch-II	-	3, 8, 14
LC	Sch-I	-	14
LC	Sch-II	+	3, 8, 10, 14
LC	Sch-II	+	3, 8, 10, 14
LC	Sch-II	-	14
LC	Sch-II	+	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	4, 14
LC	Sch-II	-	14
LC	Sch-II	+	3, 14, 15
LC	Sch-II	-	3, 14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14, 15
LC	Sch-II	-	14
VU	Sch-I	-	14

Order	Family	Species	Scientific Name
		Himalayan Flameback	*Dinopium shorii* (Vigors, 1831)
		Rufous Woodpecker	*Micropternus brachyurus* (Vieillot, 1818)
		Scaly-bellied Woodpecker	*Picus squamatus* Vigors, 1831
		Streak-throated Woodpecker	*Picus xanthopygaeus* (Gray & Gray, 1846)
		White-naped Woodpecker	*Chrysocolaptes festivus* (Boddaert, 1783)
		Yellow-crowned Woodpecker	*Leiopicus mahrattensis* (Latham, 1801)
Falconiformes	Falconidae	Laggar Falcon	*Falco jugger* (Gray, 1834)
		Peregrine Falcon	*Falco peregrinus* Tunstall, 1771
Psittaciformes	Psittacidae	Alexandrine Parakeet	*Psittacula eupatria* (Linnaeus, 1766)
		Plum-headed Parakeet	*Psittacula cyanocephala* (Linnaeus, 1766)
		Rose-ringed Parakeet	*Psittacula krameria* (Scopoli, 1769)
Apodiformes	Apodidae	Asian Palm Swift	*Cypsiurus balasiensis* (Gray, 1829)
		House Swift	*Apus nipalensis* (Hodgson, 1837)
Otidiformes	Otididae	Bengal Florican	*Houbaropsis bengalensis* (Gmelin, 1789)
		Lesser Florican	*Sypheotides indicus* (Miller, 1782)
Passeriformes	Pittidae	Indian Pitta	*Pitta brachyura* (Linnaeus, 1766)
	Campephagidae	Indian Cuckooshrike	*Coracina macei* (Lesson, 1831)
		Long-tailed Minivet	*Pericrocotus ethologus* Bangs & Phillips, 1914
		Scarlet Minivet	*Pericrocotus speciosus* (Latham, 1790)
		Small Minivet	*Pericrocotus cinnamomeus* (Linnaeus, 1766)
		Oriental Cuckooshrike	*Coracina javensis* (Horsfield, 1821)
	Oriolidae	Black-hooded Oriole	*Oriolus xanthornus* (Linnaeus, 1758)
		Eurasian Golden Oriole	*Oriolus oriolus* (Linnaeus, 1758)
		Indian Golden Oriole	*Oriolus kundoo* (Sykes, 1832)
	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus* Vieillot, 1817
		Black Drongo	*Dicrurus macrocercus* (Vieillot, 1817)
		Crow-billed Drongo	*Dicrurus annectens* (Hodgson, 1836)
		Greater Racket-tailed Drongo	*Dicrurus paradiseus* (Linnaeus, 1766)
		Hair-crested Drongo	*Dicrurus hottentottus* (Linnaeus, 1766)
		Lesser Racket-tailed Drongo	*Dicrurus remifer* (Temminck, 1823)
		White-bellied Drongo	*Dicrurus caerulescens* (Linnaeus, 1758)
	Laniidae	Bay-backed Shrike	*Lanius vittatus* Valenciennes, 1826
		Grey-backed Shrike	*Lanius tephronotus* (Vigors, 1831)
		Isabelline Shrike	*Lanius isabellinus* Hemprich & Ehrenberg, 1833
		Long-tailed Shrike	*Lanius schach* (Linnaeus, 1758)
	Corvidae	House Crow	*Corvus splendens* (Vieillot, 1817)
		Large-billed Crow	*Corvus macrorhynchos* Wagler, 1827
		Rufous Treepie	*Dendrocitta vagabunda* (Latham, 1790)
	Paridae	Cinereous Tit	*Parus cinereus* (Vieillot, 1818)
	Alaudidae	Bengal Bushlark	*Plocealauda assamica* (Horsfield, 1840)
		Crested Lark	*Galerida cristata* (Linnaeus, 1758)

IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-I	-	14
NT	Sch-I	-	12
LC	Sch-I	-	14
NT	Sch-II	-	3, 12, 14
LC	Sch-II	-	14, 15
LC	Sch-II	-	3, 8, 14, 15
LC	Sch-II	-	8, 14
LC	Sch-II	-	8
CR	Sch-I	-	2, 9, 12, 14
CR	Sch-I	-	12
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-I	-	14
LC	Sch-II	-	3
LC	Sch-II	-	3, 8, 14
LC	Sch-II	-	3, 8
LC	Sch-II	-	8, 14
LC	Sch-II	-	14
LC	Sch-II	+	3, 8, 14, 15
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	NS	-	3, 8, 14, 15
LC	Sch-II	-	8, 15
LC	Sch-II	-	3, 14
NE	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	14

Order	Family	Species	Scientific Name
		Indian Bushlark	*Plocealauda erythroptera* (Blyth, 1845)
	Cisticolidae	Ashy Prinia	*Prinia socialis* Sykes, 1832
		Common Tailorbird	*Orthotomus sutorius* (Pennant, 1769)
		Grey-breasted Prinia	*Prinia hodgsonii* Blyth, 1844
		Jungle Prinia	*Prinia sylvatica* Jerdon, 1840
		Plain Prinia	*Prinia inornata* (Sykes, 1832)
		Zitting Cisticola	*Cisticola juncidis* (Rafinesque, 1810)
	Acrocephalidae	Blyth's Reed Warbler	*Acrocephalus dumetorum* (Blyth, 1849)
		Paddyfield Warbler	*Acrocephalus agricola* (Jerdon, 1845)
	Locustellidae	Striated Grassbird	*Megalurus palustris* Horsfield, 1821
	Hirundinidae	Barn Swallow	*Hirundo rustica* (Linnaeus, 1758)
		Grey-throated Martin	*Riparia chinensis* (Gray, 1830)
		Eurasian Crag-Martin	*Ptyonoprogne rupestris* (Scopoli, 1769)
		Eastern Red-rumped Swallow	*Cecropis daurica* (Laxmann, 1769)
		Sand Martin	*Riparia riparia* (Linnaeus, 1758)
		Streak-throated Swallow	*Petrochelidon fluvicola* (Blyth, 1855)
		Wire-tailed Swallow	*Hirundo smithii* (Leach, 1818)
	Aegithinidae	Common Iora	*Aegithina tiphia* (Linnaeus, 1758)
	Rhipiduridae	White-browed Fantail	*Rhipidura aureola* Lesson, 1831
		White-throated Fantail	*Rhipidura albicollis* (Vieillot, 1818)
	Estrildidae	Indian Silverbill	*Euodice malabarica* (Linnaeus, 1758)
		Red Munia	*Amandava amandava* (Linnaeus, 1758)
		Scaly-breasted Munia	*Lonchura punctulata* (Linnaeus, 1758)
		Tricoloured Munia	*Lonchura malacca* (Linnaeus, 1766)
	Fringillidae	Common Rosefinch	*Carpodacus erythrinus* (Pallas, 1770)
	Emberizidae	Crested Bunting	*Emberiza lathami* Gray, 1831
	Leiothrichidae	Common Babbler	*Argya caudata* (Dumont, 1823)
		Jungle Babbler	*Argya striata* (Dumont, 1823)
		Large Grey Babbler	*Argya malcolmi* (Sykes, 1832)
		Striated Babbler	*Argya earlei* (Blyth, 1844)
	Sittidae	Chestnut-bellied Nuthatch	*Sitta cinnamoventris* Blyth, 1842
	Monarchidae	Indian Paradise-Flycatcher	*Terpsiphone paradisi* (Linnaeus, 1758)
	Motacillidae	Citrine Wagtail	*Motacilla citreola* Pallas, 1776
		Forest Wagtail	*Dendronanthus indicus* (Gmelin, 1789)
		Grey Wagtail	*Motacilla cinerea* Tunstall, 1771
		Paddyfield Pipit	*Anthus rufulus* (Vieillot, 1818)
		Tree Pipit	*Anthus trivialis* (Linnaeus, 1758)
		Western Yellow Wagtail	*Motacilla flava* (Linnaeus, 1758)
		White Wagtail	*Motacilla alba* (Linnaeus, 1758)
		White-browed Wagtail	*Motacilla maderaspatensis* (Gmelin, 1789)
	Muscicapidae	Black Redstart	*Phoenicurus ochruros* (Gmelin, 1774)
		Blue Rock-Thrush	*Monticola solitarius* (Linnaeus, 1758)
		Bluethroat	*Luscinia svecica* (Linnaeus, 1758)
		Blue Whistling-Thrush	*Myophonus caeruleus* (Scopoli, 1786)
		Brown Rock Chat	*Oenanthe fusca* (Blyth, 1851)

IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	14
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	6
LC	Sch-II	-	3
LC	Sch-II	-	14
LC	Sch-II	+	3, 14
LC	Sch-II	+	3
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 4, 14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	8, 14, 15
LC	Sch-II	-	14, 15
LC	Sch-II	-	3, 8, 14, 15
LC	Sch-II	-	14
LC	Sch-II	-	14, 15
LC	Sch-II	-	14
LC	Sch-II	-	3
LC	Sch-II	-	3, 8, 14, 15
LC	Sch-II	-	14
LC	Sch-II	-	12, 14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-I	-	3
LC	Sch-II	-	8, 4
LC	Sch-II	-	3, 14
LC	Sch-II	-	3, 14
LC	Sch-II	+	8, 14
LC	Sch-II	-	3, 4, 8, 14
LC	Sch-II	-	8, 14
LC	Sch-II	-	3, 4, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	8, 3

Order	Family	Species	Scientific Name
		Ferruginous Flycatcher	*Muscicapa ferruginea* (Hodgson, 1845)
		Grey Bushchat	*Saxicola ferreus* Gray & Gray, 1847
		Indian Robin	*Copsychus fulicatus* (Linnaeus, 1766)
		Jerdon's Bushchat	*Saxicola jerdoni* (Blyth, 1867)
		Oriental Magpie-Robin	*Copsychus saularis* (Linnaeus, 1758)
		Pied Bushchat	*Saxicola caprata* (Linnaeus, 1766)
		Red-breasted Flycatcher	*Ficedula parva* (Bechstein, 1792)
		Siberian Stonechat	*Saxicola maurus* (Pallas, 1773)
		Tickell's Blue Flycatcher	*Cyornis tickelliae* (Blyth, 1843)
		Verditer Flycatcher	*Eumyias thalassinus* (Swainson, 1838)
		White-capped Redstart	*Phoenicurus leucocephalus* Vigors, 1831
		White-rumped Shama	*Copsychus malabaricus* (Scopoli, 1786)
		White-tailed Stonechat	*Saxicola leucurus* (Blyth, 1847)
	Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos* (Latham, 1790)
	Stenostiridae	Grey-headed Canary-Flycatcher	*Culicicapa ceylonensis* (Swainson, 1820)
	Chloropseidae	Golden-fronted Leafbird	*Chloropsis aurifrons* (Temminck, 1829)
	Nectariniidae	Purple-rumped Sunbird	Leptocoma zeylonica (Linnaeus, 1766)
	Paradoxornithidae	Yellow-eyed Babbler	*Chrysomma sinense* (Gmelin, 1789)
	Passeridae	House Sparrow	*Passer domesticus* (Linnaeus, 1758)
		Yellow-throated Sparrow	*Gymnoris xanthocollis* (Burton, 1838)
	Pellorneidae	Indian Grassbird	*Graminicola bengalensis* (Jerdon, 1863)
	Phylloscopidae	Blyth's Leaf Warbler	*Phylloscopus reguloides* (Blyth, 1842)
		Common Chiffchaff	*Phylloscopus collybita* (Vieillot, 1817)
		Greenish Warbler	*Phylloscopus trochiloides* (Sundevall, 1837)
		Hume's Warbler	Phylloscopus humei (Brooks, 1878)
		Smoky Warbler	Phylloscopus fuligiventer (Hodgson, 1845)
	Timaliidae	Chestnut-capped Babbler	*Timalia pileate* (Horsfield, 1821)
		Pin-striped Tit-Babbler	*Mixornis gularis* (Horsfield, 1822)
	Ploceidae	Baya Weaver	*Ploceus philippinus* (Linnaeus, 1766)
		Black-breasted Weaver	*Ploceus benghalensis* (Linnaeus, 1758)
	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer* (Linnaeus, 1766)
		Red-whiskered Bulbul	*Pycnonotus jocosus* (Linnaeus, 1758)
	Sturnidae	Bank Myna	*Acridotheres ginginianus* (Latham, 1790)
		Brahminy Starling	*Sturnia pagodarum* (Gmelin, 1789)
		Chestnut-tailed Starling	*Sturnia malabarica* (Gmelin, 1789)
		Common Myna	*Acridotheres tristis* (Linnaeus, 1766)
		Common Starling	*Sturnus vulgaris* (Linnaeus, 1758)
		Indian Pied Starling	*Gracupica contra* (Linnaeus, 1758)
		Jungle Myna	*Acridotheres fuscus* (Wagler, 1827)
		Rosy Starling	*Pastor roseus* (Linnaeus, 1758)
	Turdidae	Black-throated Thrush	*Turdus atrogularis* Jarocki, 1819
		Orange-headed Thrush	*Geokichla citrina* (Latham, 1790)

IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	8, 3
LC	Sch-II	-	14
LC	Sch-II	-	3, 15
LC	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	6, 14
NA	Sch-II	-	14
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	3, 14
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	14
NT	Sch-II	-	12, 14
LC	Sch-II	-	14
LC	Sch-II	-	6, 14, 15
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	14
LC	Sch-II	-	3, 8, 14
LC	Sch-II	-	12
LC	Sch-II	+	7, 14, 15
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	8, 14
LC	Sch-II	-	3
LC	Sch-II	-	3, 14
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	14, 15
LC	Sch-II	-	3, 14, 8
LC	Sch-II	-	3, 14, 15
LC	Sch-II	-	3
LC	Sch-II	-	14
LC	Sch-II	-	14

Order	Family	Species	Scientific Name
	Vangidae	Common Woodshrike	*Tephrodornis pondicerianus* (Gmeli, 1789)
		Large Woodshrike	*Tephrodornis virgatus* (Temminck, 1824)
	Zosteropidae	Indian White-eye	*Zosterops palpebrosus* (Temminck, 1824)

IUCN status. CR - *Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Near Threatened*, LC - Least Concern, NE - Not Evaluated

WPA. NS - Not Scheduled, Sch-I - Schedule I, Sch-II - Schedule II

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IUCN	WPA Schedule	Present Findings	Previous studies
LC	Sch-II	-	3, 14
LC	Sch-II	-	14
LC	Sch-II	-	3, 14

Annexure V. Aquatic and Semi-Aquatic Mammals recorded along the Gomti River, Uttar Pradesh.

Order	Family	Species	Scientific Name	IUCN	WPA Schedule	Present Findings	Previous Studies
Artiodactyla	Platanistidae	Gangetic Dolphin	*Platanista gangetica* (Lebeck, 1801)	EN	Sch-I	-	a, b
Carnivora	Mustelidae	Smooth-coated Otter	*Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826)	VU	Sch-I	+	-

Note: The distribution map prepared for Gangetic dolphin by Sinha & Kannan (2014) shows, there was historical presence of the species in Gomti River according to Anderson (1879), but currently, the species no longer found in the Gomti River. However, as per anecdotal records, the species is known to migrate into the Gomti River from the Ganga mainstem during the monsoon season when the flow is high.

a Anderson, J. (1879). Anatomical and zoological researches: comprising an account of the zoological results of the two expeditions to western Yunnan in 1868 and 1875; and a monograph of the two cetacean genera, Platanista and Orcella. London, UK: Bernard Quaritich.

b Sinha, R. K., & Kannan, K. (2014). Ganges River dolphin: An overview of biology, ecology, and conservation status in India. *Ambio*, 43(8), 1029-1046.

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