नमामि गंगे

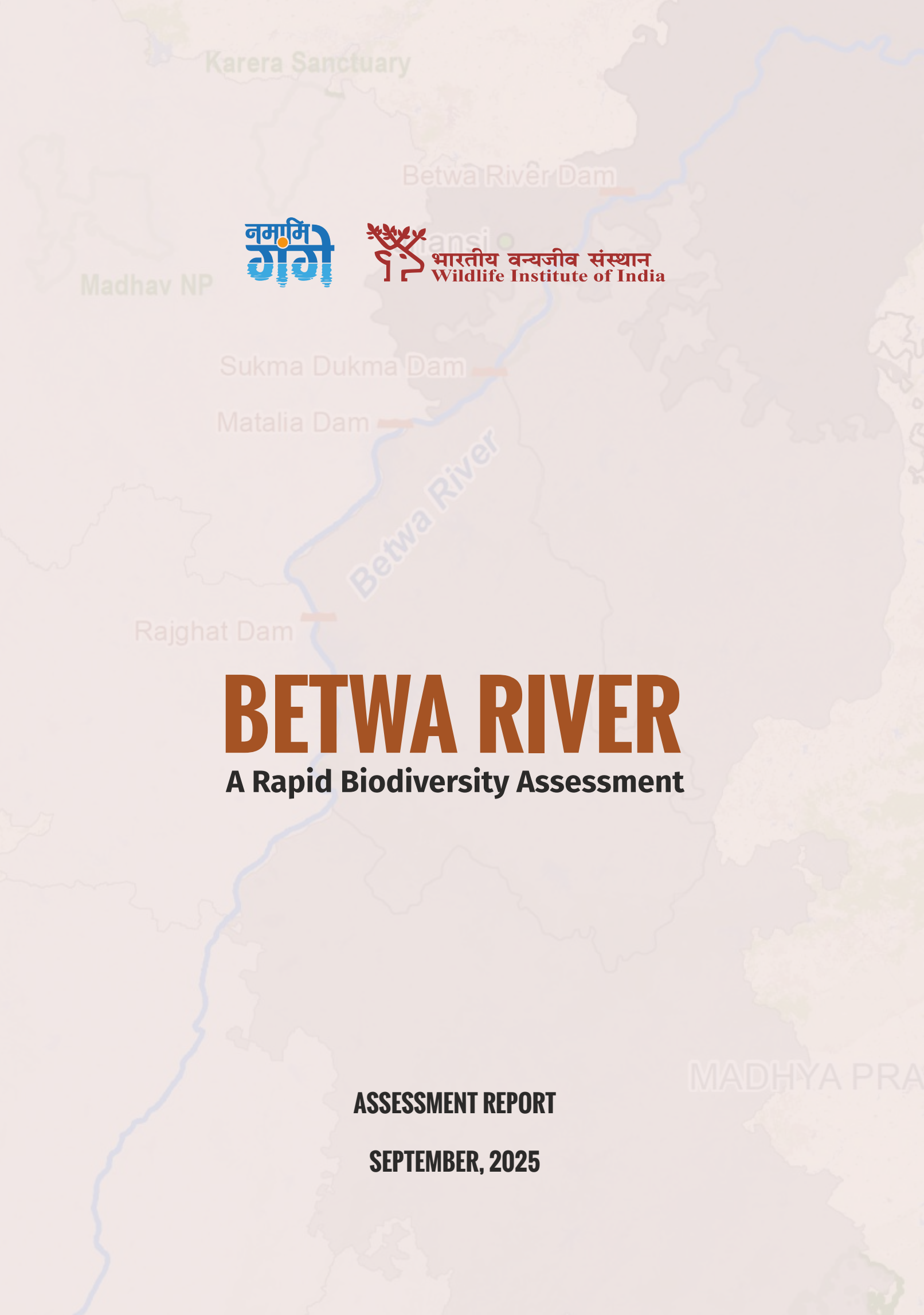
भारतीय वन्यजीव संस्थान
Wildlife Institute of India

BETWA RIVER

A Rapid Biodiversity Assessment

ASSESSMENT REPORT

SEPTEMBER, 2025



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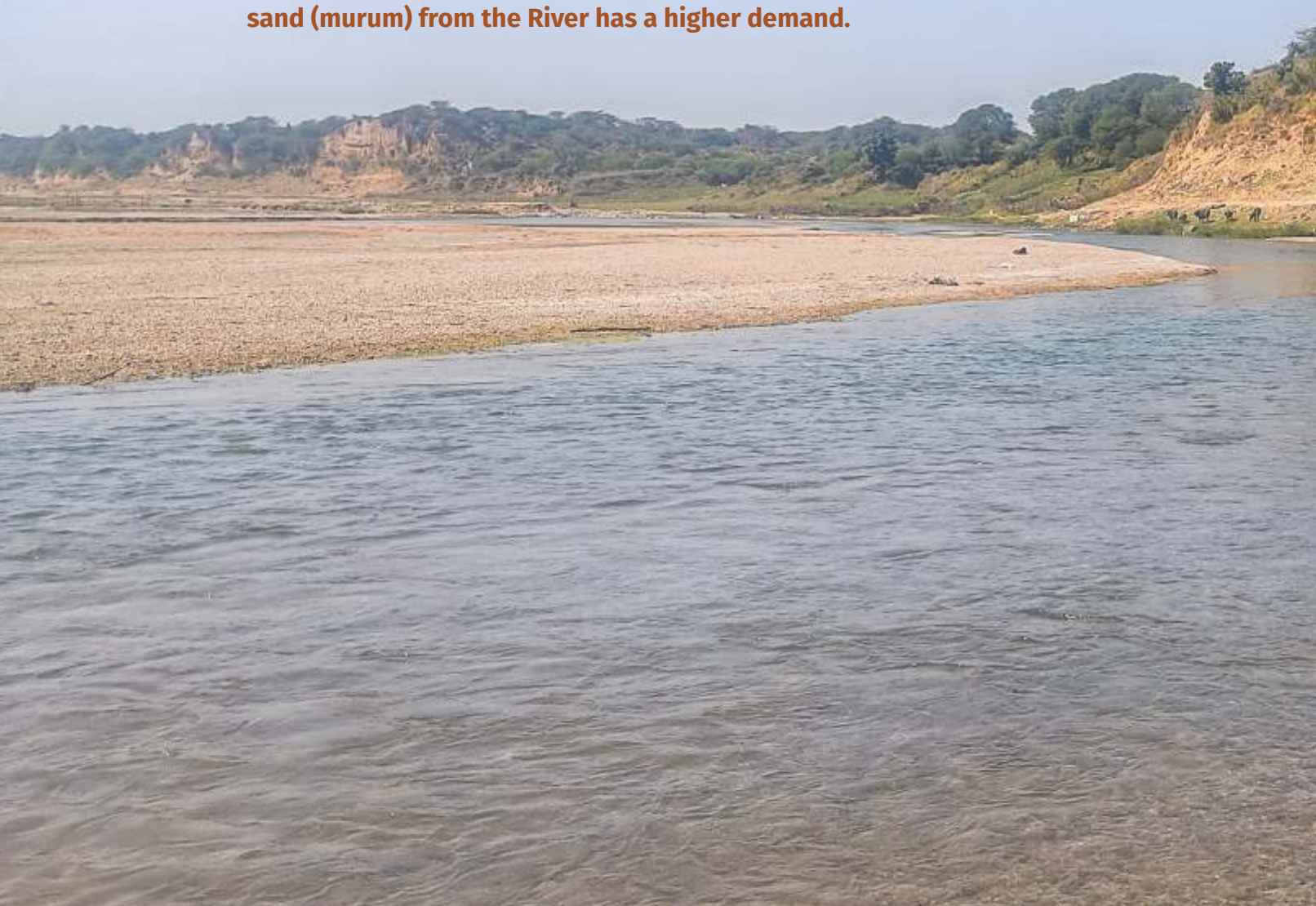
Contents

EXECUTIVE SUMMARY

The Betwa (Betrawati) is the second largest tributary of the Yamuna River that emerges from Vindhya ranges of the Madhya Pradesh. In mythological literature, it has been described as Shuktimati River during the era of Chedi kingdom. After traversing through several urban and semi-urban areas of Budelkhand region for 590 km, it meets the Yamuna River in Uttar Pradesh.

It is considered as one of the polluted rivers in the states of Madhya Pradesh and Uttar Pradesh. The Betwa River has also been exploited to fulfill irrigation and household demand of the region resulting in construction of multiple dams and barrages over the River. Water from the River will be diverted in large volume due to the planned Ken-Betwa River interlinking project. The River has undergone many anthropic changes especially due to sand mining, as the red sand (murum) from the River has a higher demand.



Literature suggests that the River was once a safe habitat of the gharials and Gangetic dolphins. Therefore, a rapid biodiversity assessment of the lower stretch of the Betwa River was carried out from Orai to Yaumna confluence (Hamirpur) during the post monsoon season. Through a considerable body of literature, a total of 95 plant species have been reported from its basin including 65 semi-aquatic and 12 aquatic species. Review also confirmed presence of 94 fish species from the Betwa River, including 4 vulnerable species.

A total 45 species of waterbirds were recorded during this survey of which 2 were near threatened. No evidence of the Gangetic dolphin or gharial was found during present survey; however local people claimed the presence of mugger in the surveyed stretch. Likely, pollution and hydro-morphological alterations due to sand mining and other activities have resulted in unsuitable habitats for the conservation priority aquatic species.

The Betwa River requires an urgent heed from the authorities and conservationists to save its ecological integrity. Ongoing mining activities have restricted the flow and volume of the River, which has resulted in shallow water pools and disjunctive unsuitable stretches for specialist species like Gangetic dolphin and gharial. First and foremost, regulation of mining activities is must to restore the ecological integrity of the Betwa River by involving higher authorities and other stakeholders. Natural habitats along the stretch also required to be conserved to improve their suitability for resident/breeding species especially for endangered species like gharial and Gangetic dolphin.

1. INTRODUCTION

The Betwa River originates from Vindhyan ranges in the Raisen district of Madhya Pradesh at an elevation of about 576 m asl and merges into the Yamuna River near Hamirpur in Uttar Pradesh at an elevation of about 106 m asl (Jeet et al., 2017). The River's total length is 590 km, of which 358 km flows in Uttar Pradesh and 232 km in Madhya Pradesh (Suryavanshi et al., 2017). In the active monsoon season, the Betwa River discharges exceptionally high levels, while in the summer; it discharges extremely low levels (Joshi et al., 2017). The Betwa River basin is located between 77°10′–80°20′ E, and 22°54′–26°05′ N in the central India (Suryavanshi et al., 2017). The Vindhyan hills and the Malwa plateau forms the south and south-west boundaries of the Betwa River basin, beyond which lies the Narmada River basin (Singh & Singh, 2022). The Lalitpur. Dhasan, Barwa, Parwaha, Jamini, and Paricha rivers are key tributaries of the Betwa River (Joshi et al., 2017).

1.1. Course of the River

Based on the geological properties and channel type, the Betwa River can be divided into three zones (Upper, Middle and Lower) (Figures 1.1; 1.2). Upper zone starts from its origin to Badera, which covers about 250 km of the total stretch of the River. Middle zone starts from Badera and ends at Chandwari Danda with total 205 kms of the stretch that has four dams on it. Lower zone is mostly sinuous with total 135 kms of the length between Chandwari Danda and Badagaon (Hamirpur).

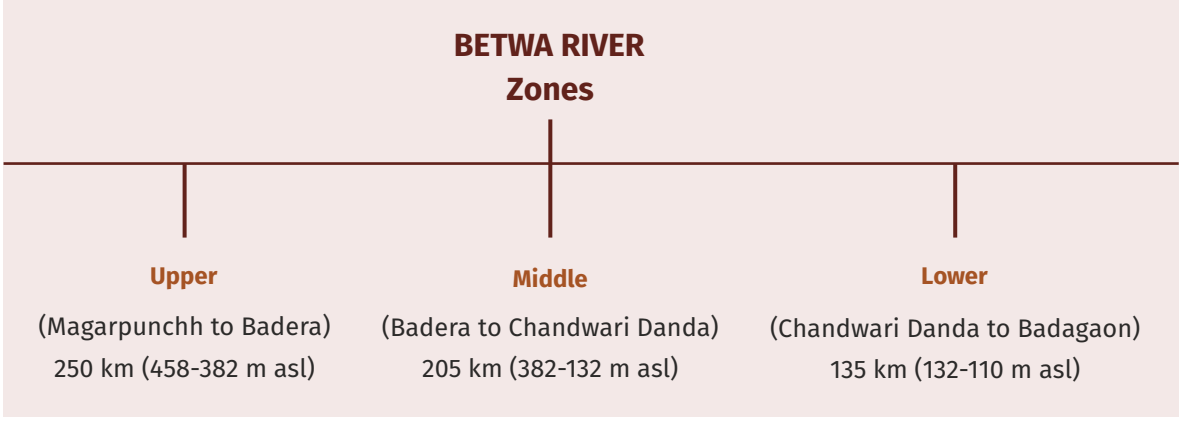


Figure 1.1. Details of the different zones of the Betwa River

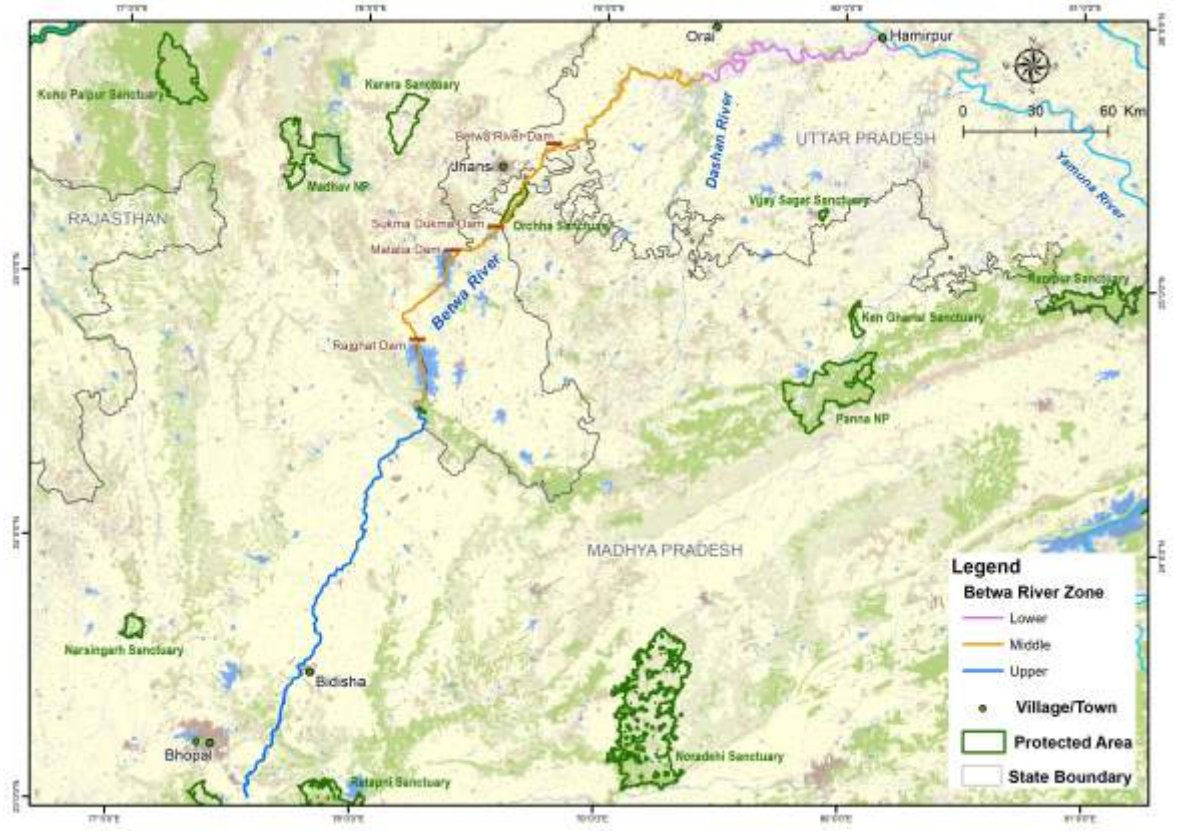


Figure 1.2. Zonation of the Betwa River

Table 1. Profile of the Betwa River

River	Betwa
Type	Rain fed
Passage through State/ Union Territory	Madhya Pradesh, Uttar Pradesh
No. of Districts	11
Biogeographic zone	Semi Arid (Central Highlands-6A) Deccan Plateau (Gujarat-Rajputana 4B)
Origin	Raisen district of Madhya Pradesh
Length (km)	590
Total surveyed length (km)	70
Average Discharge (m^3/s) *	658
Catchment area (sq. km)	43,895
No. of barrages/dams	4
Human population density (persons/sq. km)	306
Forest cover in basin (sq. km)	13111
Total irrigated area (sq. km)**	4040
No. of Protected Areas	2

*Chaube et al. (2011). Synthesis of flow series of tributaries in Upper Betwa basin. International journal of environmental sciences, 1(7), 1459-1475

** idup.gov.in

1.2. Geological features

The terrain of the Betwa basin comprises of granite, basalt, sandstone and alluvium rocks (Malviya et al., 2006). The major group of rocks within the basin have been identified as the Deccan trap (66 million years), the Vindhyna subgroup (1.4-0.9 billion years), the Bijawar group (2.6–2.4 billion years) and Bundelkhand complex (> 2.6 billion years) (Venkatesh & Anshumali, 2019). The Bundelkhand uplands, the Vindhyan scrap and the Malwa plateau are located in the districts of Tikamgarh, Sagar, Vidisha, Raisen, Bhopal, Guna, Ashoknagar, and Shivpuri in Madhya Pradesh, as well as in the Uttar Pradesh districts of Hamirpur, Jalaun, Jhansi, Mahoba.

1.1. Land Use Land Cover (LULC)

Agriculture occupies 61.60% of total land use type of the Betwa River Basin (Figure 1.3), while forests is spread over 20% and wasteland occupy 8.60% of the basin (Table 2). Large waterbodies visible in maps denote dams and barrages on the River that occupy 2.66% of total area (Figure 3). Human settlements contribute to 1.92% in LULC and Vidisha, Hamirpur and Jhansi urban spaces are located in close proximity to the River. Light green colour denotes open deciduous forest in the basin (Figures. 1.3 & 1.4).

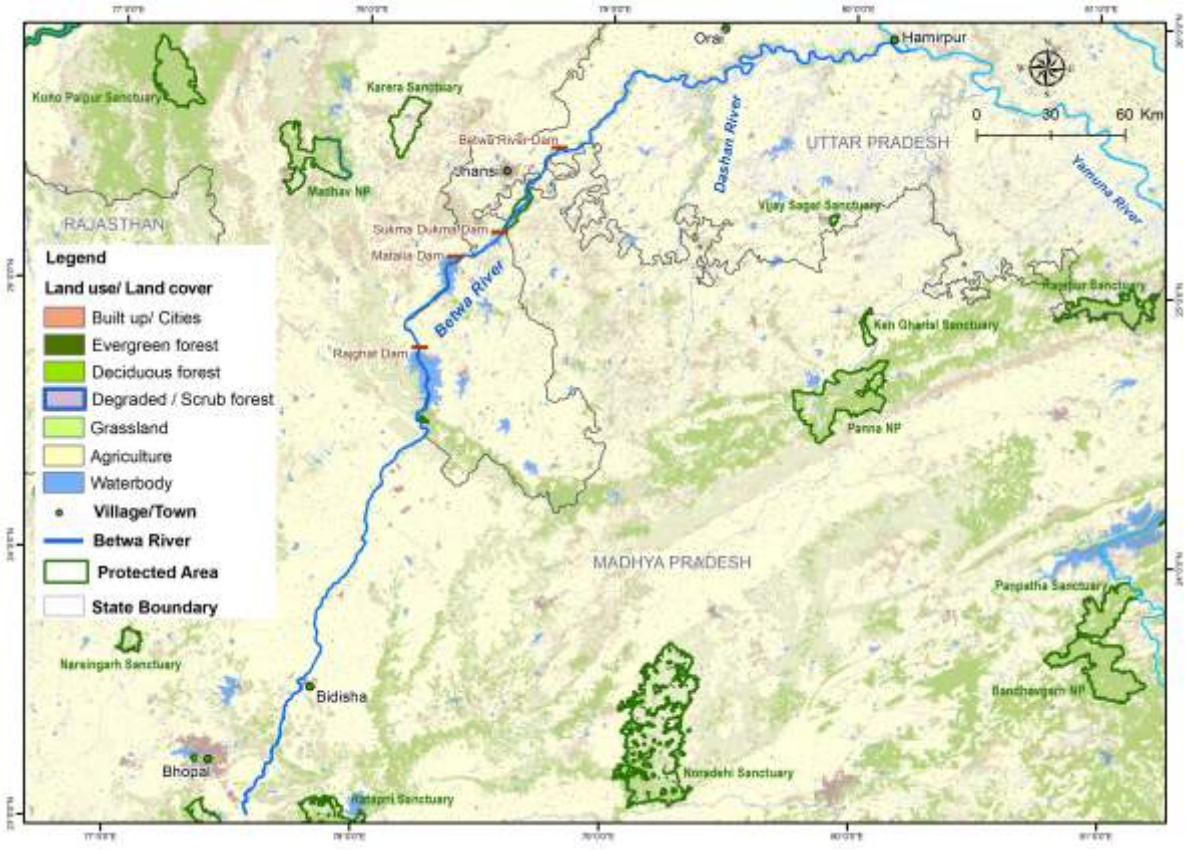


Figure 1.3. Land Use Land Cover map of the Betwa River and adjacent landscape (Satellite image source: NRSC)

Table 2. Land Use Land Cover of the Betwa River (Source: NRSC)

State	District	Built up	Agriculture	Current fallow	Plantation	Deciduous forest
Madhya Pradesh	Bhopal	212.94	1666.94	164.40	0.05	228.61
	Shivpuri	84.66	4214.23	420.56	0.11	1139.92
	Vidisha	109.36	5843.65	203.17	0.24	426.70
	Ashoknagar	36.27	3084.03	264.85	0.26	153.81
	Raisen	109.01	4556.45	281.34	0.71	1713.52
	Sagar	155.21	5928.69	300.19	1.08	1281.00
	Tikamgarh	76.46	3150.41	297.38	0.50	196.66
Uttar Pradesh	Jhansi	183.97	3619.74	409.87	6.48	158.94
	Lalitpur	76.74	3564.12	163.86	3.60	490.94
	Jalaun	148.28	3374.13	426.50	2.17	172.01
	Hamirpur	98.06	2450.80	931.59	4.21	140.88
Total area		1290.95	41453.19	3863.71	19.39	6103
Percentage		1.92%	61.60%	5.74%	0.03%	9.07%

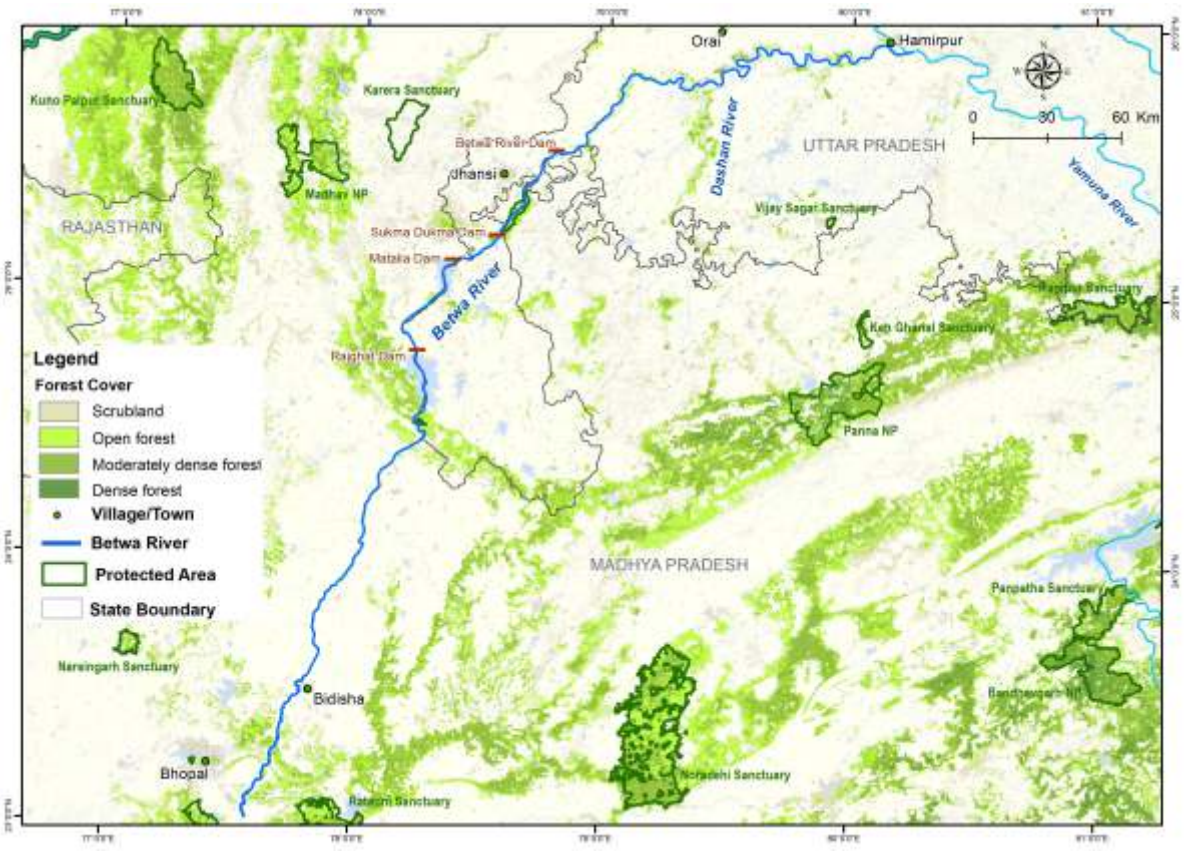


Figure 1.4. Forest Cover map of the Betwa River and adjacent landscape (Satellite image source: NRSC)

Degraded/ Scrub forest	Grassland	Wasteland	Water-body
207.34	--	185.68	106.06
1775.66	0.78	2150.28	279.80
506.54	--	182.05	99.29
664.24	--	316.07	154.47
1304.62	--	334.70	165.65
1869.79	--	634.14	81.90
284.90	--	891.90	149.80
90.53	--	376.69	177.72
148.13	--	267.47	324.13
86.90	--	248.91	106.10
50.66	--	199.48	145.33
6989.31	0.78	5787.39	1790.23
10.39%	0.001%	8.60%	2.66%

1.3. Soil Texture

Silt, sandy and clay loam are the major soil texture of the upper stretch, which has murram sand in the riverbeds of Betwa (Suryavanshi et al., 2017; Ahirwar et al., 2020).

1.4. Climatic conditions

The Betwa River basin has moderate climatic conditions, with mostly dry conditions except during the southwest monsoon (Chaube, 1988). There is an average rainfall of 700 to 1,200 mm per year, of which nearly 80% falls during the South-west monsoon (Suryavanshi et al., 2017). Winters are mild with a minimum temperature of 8.1 °C and summers are hot with maximum temperatures of 42 °C in the basin. The highest mean monthly relative humidity in the basin is 90% in August, while the least is around 18% in the months of April and May (Joshi et al., 2017).

1.5. Biogeography, flora and fauna

The Betwa basin includes various ecosystems such as deciduous forests, grasslands, riparian zones, and aquatic environments (Appendix 1), all essential for preserving ecological balance. The deciduous forests along the river foster biodiversity by offering habitat for mammals, birds, and other wildlife, while grasslands serve as grazing areas and help maintain soil integrity. Riparian zones-the vegetated stretches

along the riverbanks-function as natural buffers that filter pollutants and minimize erosion, which is vital for maintaining water quality. The basin hosts several forest types based on Champion & Seth (1968): Tropical Dry Deciduous Forests (teak (*Tectona grandis*), sal (*Shorea robusta*), and bamboo (*Dendrocalamus strictus*)), Tropical Moist Deciduous Forests (sal, teak, jamun (*Syzygium cumini*), amla (*Emblica officinalis*) and mahua (*Madhuca indica*)), and Tropical Throne Forests (babul *(Acacia nilotica*) and euphorbia (*Euphorbia* spp.)).

The riparian zones along the Betwa River are resplendent with diverse plant species adapted to seasonal flooding and moisture-rich soil. Common riparian vegetation includes willows (*Salix* spp.), figs (*Ficus* spp.), bamboo (Bambusoideae), and jamun, which form dense vegetation along the banks, providing habitat and nesting sites for birds and small mammals. Shrubs and grasses, such as *Saccharum* and *Phragmites*, often form an understory layer, which helps stabilize the soil and prevent erosion. These plants also act as natural filters, trapping sediments and pollutants from runoff, which helps maintain water quality. The aquatic vegetation within the Betwa River and its tributaries includes a range of submerged, floating, and emergent plants that are essential for maintaining a balanced aquatic ecosystem. Common species include hydrilla (*Hydrilla verticillata*), water hyacinth (*Pontederia crassipes*), water lilies (*Nymphaea* spp.), and lotus (*Nelumbo nucifera*), which provide shade and oxygenation, benefiting fish and other aquatic organisms. These plants also offer shelter for fish and breeding grounds for amphibians, while their root systems improve water clarity by stabilizing sediments. The Betwa River basin is home to several unique plant species that are crucial for the region's biodiversity. Among these is *Asparagus racemosus* (Satawar), prized for its medicinal qualities but at risk due to excessive harvesting; *Butea monosperma* (Flame of the Forest), recognized for its striking blossoms; *Boswellia serrata* (Indian Frankincense), which is becoming increasingly rare because of resin collection; *Hardwickia binata* (Anjan), a drought-tolerant tree facing decline from habitat destruction; *Saraca asoca* (Ashoka), a species of significant cultural importance; and *Diospyros melanoxylon* (Tendu), valued for its leaves. These plants play a vital role in enhancing the ecological and cultural diversity of the basin.

A considerable amount of research on ichthyofauna has been carried out in the Betwa River (Lakra et al., 2010; Sani et al., 2010; Vyas et al., 2012; Dubey et al., 2013; Joshi et al., 2017; Mishra et al., 2020).

Previously, mugger (*Crocodylus palustris*) has been recorded in the lower stretch of the Betwa River (Nair and Katdare, 2013). Historically, a small population of gharial (*Gavialis gangeticus*) was also found in the Betwa River (Singh, 1978; Rao et al., 1995), however their existence was not recorded in recent past (Nair and Katdare, 2013). More than a decade ago, six individuals of the Gangetic dolphin (*Platanista gangetica*) were recorded between the stretch of Orai and Hamirpur (Sinha et al., 2000).

Orccha Wildlife Sanctuary (OWLS) is a protected river island formed by the Betwa and the Jamni rivers. Tropical dry deciduous and kardhai are the dominant forest types (Champion & Seth, 1968) with abundance of teak (*Tectona grandis*) and kardhai (*Anogeissus pendul*) tree species (Shrivastava et al., 2017). The OWLS is home to three critically endangered vulture species namely *Gyps indicus*, *Gyps bengalensis,* and *Sacrogyps calvus*. Among turtles, *Nilssonia gangetica, Lissemys punctata, Pangshura tentoria* and *Batagur kachuga* are key species in this riverscape. In addition, nineteen mammal species are found in OWLS such as spotted deer (*Axis axis*), barking deer (*Munticaus vaginalis*), wild boar (*Sus scrofa*) (Shrivastava et al., 2020). UNESCO World Heritage Site, Bhimbetka Rock shelters are situated near origin of the Betwa River, and are famous for their prehistoric (Paleolithic and Mesolithic) era rock paintings of elephant, peafowl, snake, barasingha (swamp deer), gaur and deer (ASI, 2003).

The Betwa River, flowing through central India, faces a significant ecological challenge from invasive species, particularly aquatic weeds. These weeds,

Lush green riverine grass patch along the Betwa River

categorized into submerged, floating, and emergent types, disrupt native biodiversity and hinder ecosystem functions. Dominant invasive species observed during the survey include *Alternanthera ficoidea, Alternanthera philoxeroides, Croton bonplandianus, Ipomoea carnea, Lantana camara, Pontederia crassipes, Ricinus communis, Tridax procumbens,* and *Erigeron bonariensis*. Invasive or introduced species are particularly problematic due to their rapid growth and ability to outcompete native flora in riparian zones.

1.6. Demography

Average human density of the Betwa River and adjacent landscape is more (306 people/sq. km) than the state of Madhya Pradesh (236 people/sq. km), while remained less than average density of India (382 people/sq. km) and Uttar Pradesh (829 people/sq. km) (Census of India, 2011). The Betwa River flows through 11 districts of which seven are in Madhya Pradesh and four are in Uttar Pradesh (Table 3). Bhopal has the highest human density, while Sagar has maximum population among all the districts (Table 3). Vidisha, Jhansi and Hamirpur are three major townships located near banks of the Betwa River (Figure 1.5). Interstate River Betwa (Madhya Pradesh and Uttar Pradesh) traverses within the medium Human Development Index category states, which is comparable to some of the African countries (NSC, 2017-18; UNDP, 2021).

Table 3. Demographic details of districts along the Betwa River (Census of India, 2011)

State	District	Area (Sq. km)	Total Population	Density (Sq. km)
Madhya Pradesh	Bhopal	2772	2371061	855
	Shivpuri	10066	1726050	171
	Vidisha	7371	1458875	198
	Ashoknagar	4674	845071	181
	Raisen	8466	1331597	157
	Sagar	10252	2378458	232
	Tikamgarh	5048	1445166	286
Uttar Pradesh	Jhansi	5024	1998603	398
	Lalitpur	5039	1221592	242
	Jalaun	4565	1689974	370
	Hamirpur	4021	1104285	275

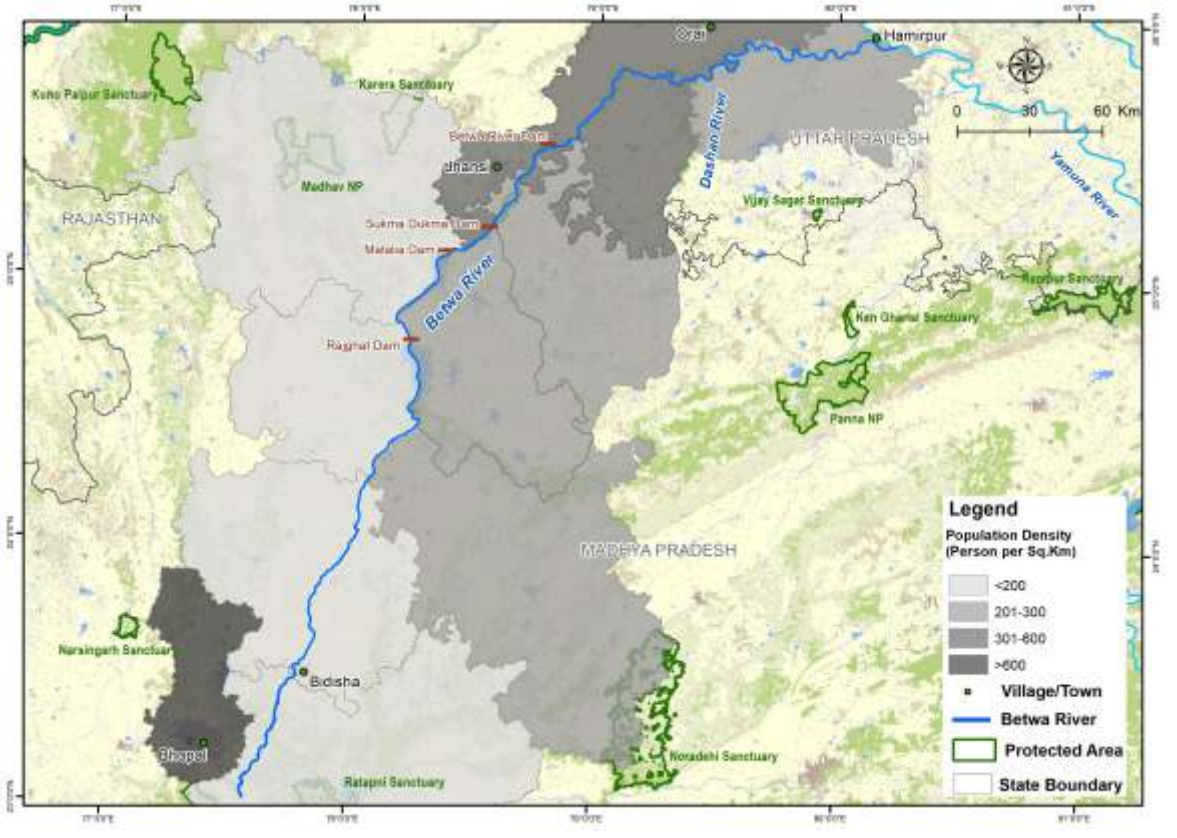


Figure 1.5. Human population density (in sq. km) in districts within the Betwa River

2. METHODOLOGICAL FRAMEWORK

2.1. Review of Literature

Published and unpublished literature was compiled from different online sources and WII database using different combination of keywords like "Betwa River", "Flora", "Vegetation", "plant", "invasive species". Subsequently, A comprehensive checklist of plant was compiled based on the review. Similarly, literature for fishes was searched and checklist was prepared.

2.2. Field Survey

A rapid ecological assessment was carried out between the stretch of Betwa-Yamuna confluence and Kurena (Orai), covering a distance of 70 km. The survey was carried out in the month of February, 2023 during daylight hours between 8:00 and 17:00 hrs using an inflatable rubber assembled with 25 hp engine (Oliveira et al., 2017; Das et al., 2022). The speed of the boat was kept in constant pace of 6-8 km/hr. A team comprised of two observers counted birds on both river banks and another two observers were stationed for counting of other taxa (aquatic mammals and reptiles) and to record habitat parameters.

Bird identification and counts were conducted using a 15x40 spotting scope and 8x42 binoculars. Direct observation was followed for the avifaunal counts and focal animal sampling method was adopted for recording of foraging behaviour of groups and individual (Altman, 1974). The total count method (Nagarajan & Thiyagesan, 1996) was followed to count the birds, and occasional photograph-based counts were also used when flocks were large (>10) or continuously changing (Boyd, 2000; Javed & Kaul, 2000). For the photograph-based method, a series of images of flocks was taken for counting and identification using image viewing software (Picasa photo viewer). The birds were identified using bird field guide (Kumar et al., 2003; Grimmett et al., 2011). For nomenclature of the birds, that included order, family, common name and scientific name Praveen et al. (2025) was followed. The residential status of birds was classified based on standard literature references (Ali & Ripley, 1983; Kumar et al., 2003; Gopi et al., 2014) and based on IUCN status (BirdLife International 2022). Feeding guilds were categorized as per direct observations and available literatures (Motup & Sahi, 2012; Ghosh et al., 2022). The feeding guilds were determined according to the primary and predominant food type. The observed bird species were categorized into 23 guilds (Motup & Sahi, 2012).

2.3 River Characteristics

Basic physiochemical parameters were recorded at every one kilometer point of the surveyed length. For measurement of channel width and river depth, laser range finder and depth finder were used, respectively. Flow meter was used at each point for measuring river flow. For collection of basic water parameters such as conductivity, total dissolve solids (TDS), salinity and pH, a water kit device (YSI EcoSense pH/ EC1030A) was used at each sampling point. River bank characteristics (soil type, vegetation), presence of the different anthropogenic factors such as presence of human, livestock, free-ranging dogs, distance to human settlement were recorded. Disturbance activities such as fishing, irrigation mode, sewage/drainage, mining were also recorded to assess the anthropogenic pressure on the River.

A pair of Great Cormorant loafing on a snag

3. RESULTS

3.1. Floristic diversity of the Betwa River

Based on the available literature, a comprehensive list of 95 angiosperm taxa was compiled (Appendix 1), representing 74 genera and 43 families (Figure 3.1). Among these, the Poaceae family was found to be the most dominant, with (11 species), followed by Fabaceae (6 species) and Euphorbiaceae (6 species each) (Figure 3.2). In terms of life form dominance, herbaceous plants were the most abundant, with (49 species), followed by trees (23 species), grasses (16 species), shrubs (6 species), and climbers (1 species) (Figure 3.3). The habitat preferences of these species were categorized as follows: terrestrial (18 species), semi-aquatic (65 species) and aquatic (12 species) (Figure 3.4). Of the total species documented, 85 are of native origin, while the remaining 10 are exotic species found within the Betwa River Basin (Figure 3.5).

Dominant trees based on the secondary literature were *Acacia catechu, Cassia fistula, Dalbergia sissoo, Pongamia pinnata, Ficus benghalensis, Ficus racemosa, Ficus hispida* etc.

Dominant shrubs were *Ricinus communis, Phyllanthus reticulata, Woodfordia fruticosa, Urena lobata* etc.

Dominant herbs included *Oxalis corniculata, Euphorbia hirta, Euphorbia heterophylla, Acalypha indica, Croton boplandianus, Phyllanthus urinaria* etc.

Dominant grasses recorded were *Fimbristylis dichotoma, Apluda mutica, Arundo donax, Chloris barbata* etc.

Asparagus racemosus was the only climber species recorded. In exotic plants species like *Euphorbia heterophylla, Croton boplandianus, Ricinus communis, Alternanthera ficoidea, Alternanthera philoxeroides, Hyptis suvaeolens* and *Pontederia crassipes* were mentioned throughout the literature.

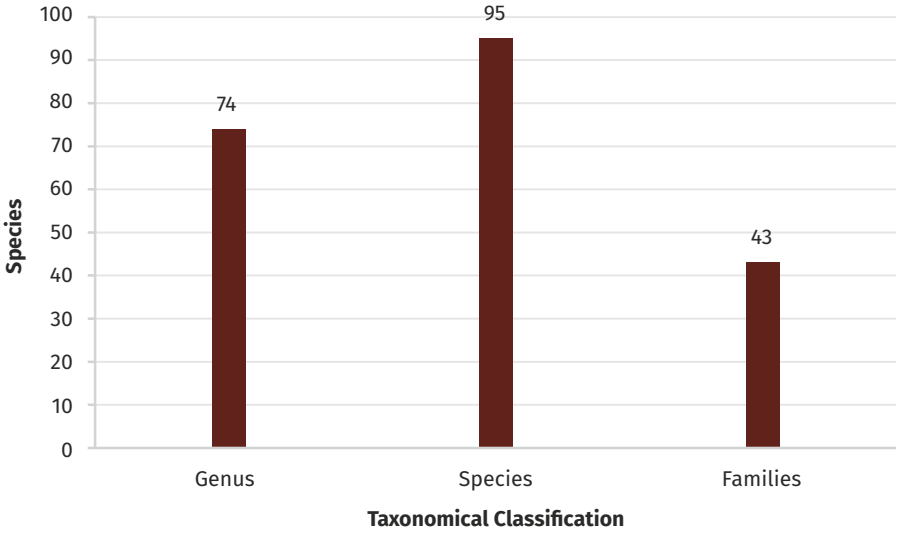


Figure 3.1. Taxonomical Classification of plants from Betwa River

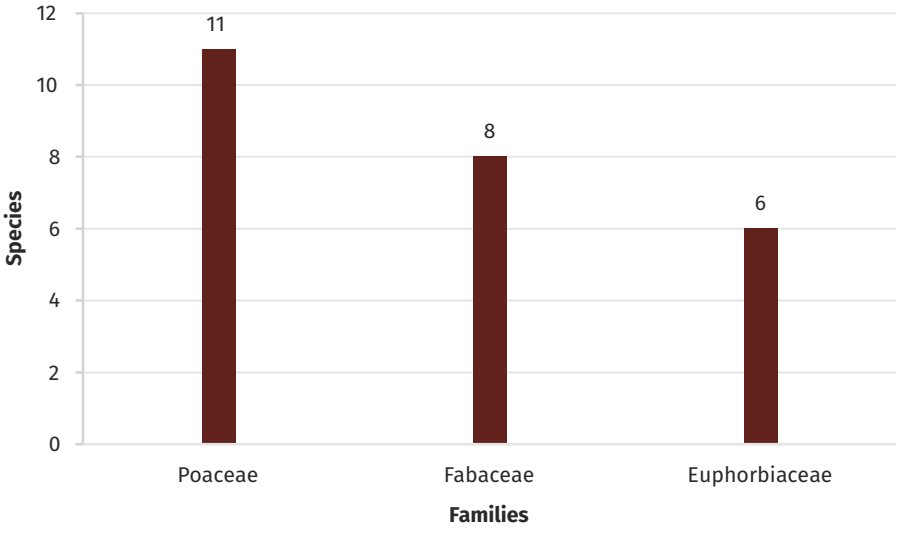


Figure 3.2. Dominant Plant Families recorded from Betwa River

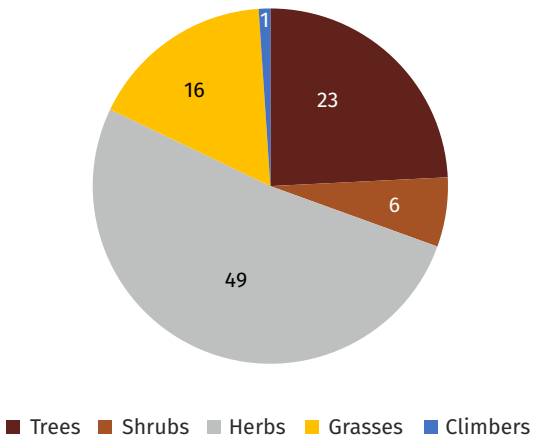


Figure 3.3. Habit wise classification of plants from Betwa River

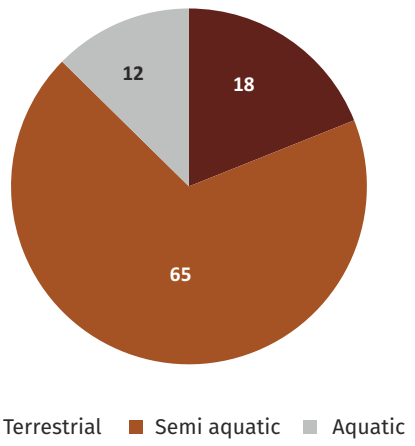


Figure 3.4. Habitat wise classification of plants from Betwa River

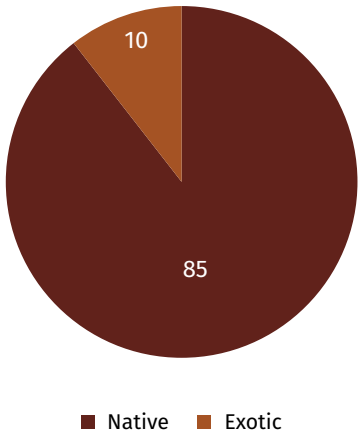


Figure 3.5. Nativity of Plant species from Betwa River

3.2. Faunal diversity of the Betwa River

3.2.1. Fish

Based on literature survey on the fish fauna of the Betwa River, 94 species belonging to 13 orders, 28 families and 62 genera have been reported (Appendix 2). Order cypriniformes was the most dominant with 45 species and order Anguilliformes, Mugiliformes, Gobiiformes, Beloniformes and Tetraodontiformes was the least dominant with one species (Figure 3.6). Family Cyprinidae was the most dominant group with 28 species among the other families (Figure 3.7). According to IUCN conservation status, 80 species are least concerned

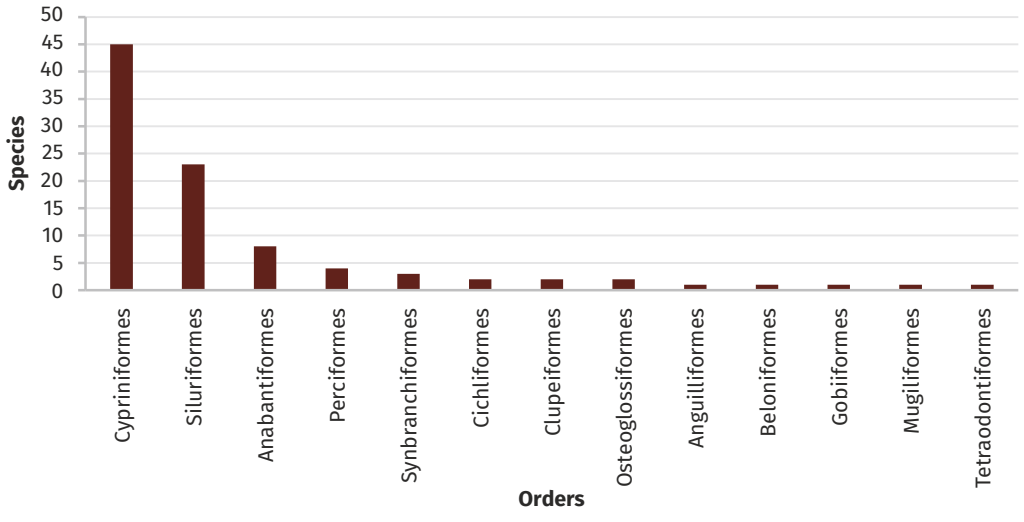


Figure 3.6. Order-wise composition of Fish assemblages across the Betwa River

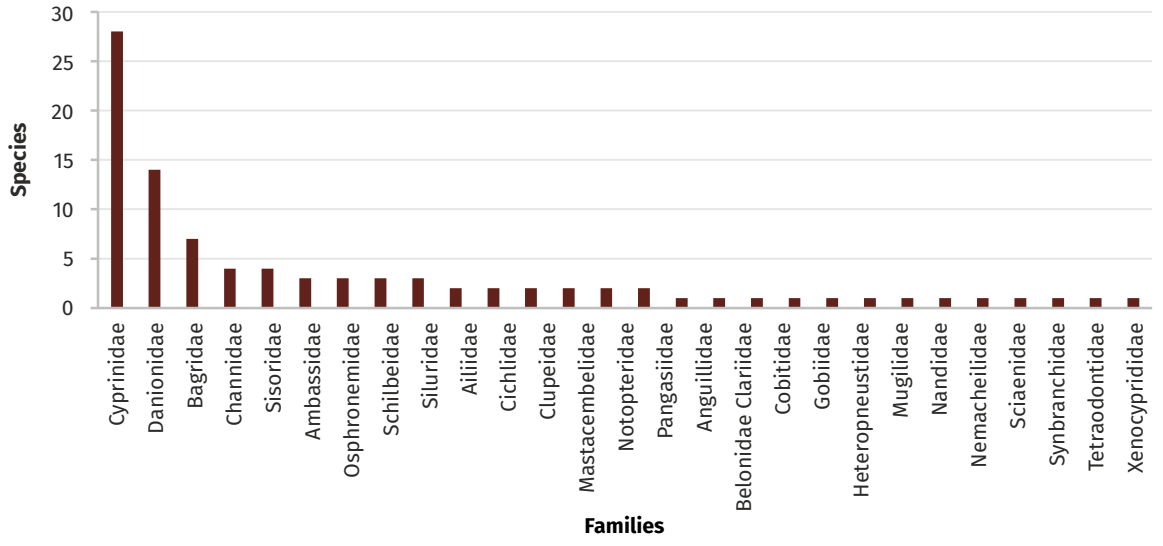


Figure 3.7. Family-wise composition of Fish assemblages across the Betwa River

(LC), 7 species are near threatened (NT), 4 species are vulnerable (VU) and 3 species are data deficient (DD) category.

3.2.2. Turtle

Only one individual of *Nilssonia gangtica* was recorded from the entire surveyed stretch of Betwa River.

3.3.3. Mugger (*Crocodylus palustris*)

During the survey no direct sighting of the mugger was made; however, during the informal discussions with local people, they claimed presence of mugger in a few sites.

3.2.4. Gharial (*Gavialis gangeticus*)

Earlier records confirmed release of 55 gharials in the lower Betwa River (Rao et al., 1995), however, no evidence of gharial was recorded during the present survey.

3.2.5. Gangetic dolphin (*Platanista gangetica*)

While revisiting same stretch sampled by Sinha et al. (2000), no confirmation of dolphin presence was found. However, local people claimed sporadic sightings during the monsoonal floods when water level rises significantly.

3.2.6. Avifauna of the Betwa River

Overall, 1556 individuals of 7 orders, 12 families, 30 genera and 45 species (Appendix 3), were recorded along the surveyed stretch of the Betwa River. Scolopacidae (9 species) was the most abundant family followed by Ardeidae (7 species) (Figure 3.8). The family Anatidae had the maximum number of observed individuals (335) followed by Charadriidae (259) and Scolopacidae (221). Flock size varied between 1 and 80 individuals with mean flock size of 3.06 ± 0.26 SE. Two Near Threatened species (river lapwing and Asian woolly-necked stork) were recorded from the Betwa River.

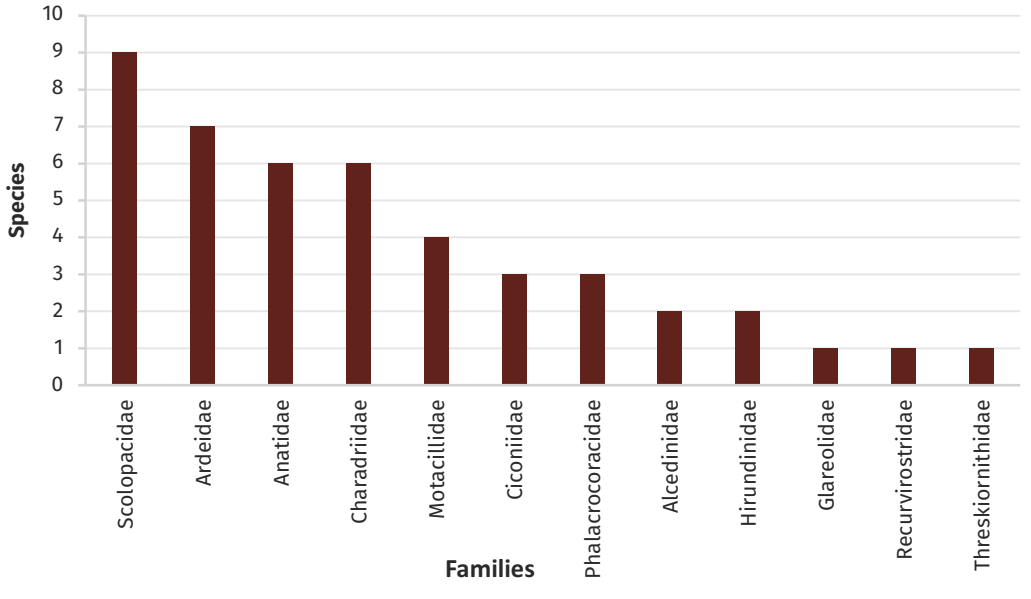


Figure 3.8. Family-wise composition of waterbird assemblages across the Betwa River

Out of the 45 species, 5 were resident, 17 were resident with local movement (R/LM), 8 were resident with winter influx (R/WM), 2 were resident with winter influx as well as passage movements (R/WM/PM), 1 species each were resident with altitudinal movements (R/AM), resident with altitudinal movements as well as winter influx (R/AM/WM), resident with altitudinal, winter and passage movements (R/AM/WM/PM), and largely winter migrant (WM/R) and partly resident, and 9 species were winter migrant (WM) as categorized in the "Waterbirds of India" (Gopi et al., 2014) and Checklist of Indian Waterbirds (Kumar & Tak, 2003) (Figure 3.9).

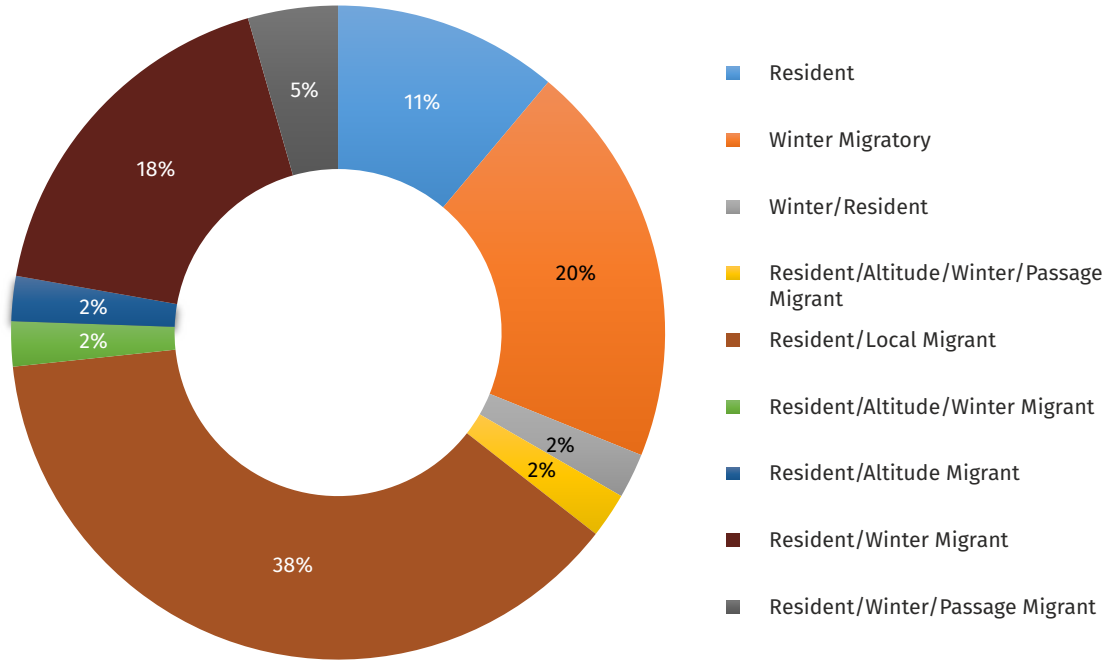


Figure 3.9. Residential status of waterbird assemblages across the Betwa River

Of the 45 waterbird species, 38% species were carnivores, 22% species were piscivores/carnivore, 18% species were insectivores, 7% species were omnivores, 5% species were herbivore/carnivore, 4% species were piscivores, 2% species were herbivores/ insectivores, 2% species were herbivores and 2% species were carnivores/ insectivores (Figure 3.10).

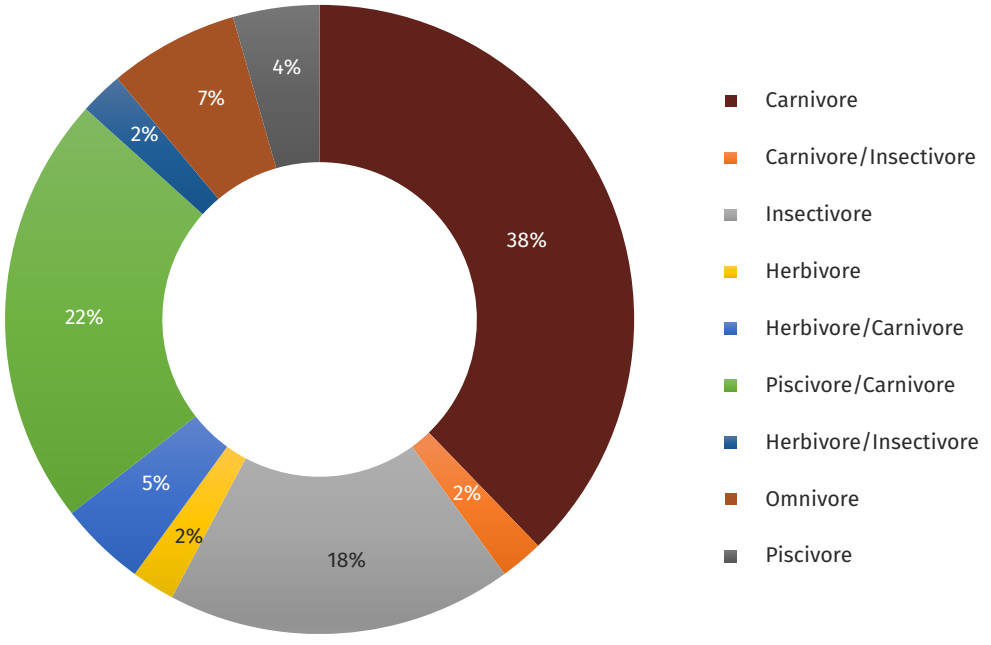


Figure 3.10. Feeding guilds composition of waterbird assemblages across the Betwa River

Further feeding behaviour of the 45 waterbird species was divided into 14 different groups (Figure 3.11), 11 species were WI/SIP (Wading Insectivore with Shore Insect Prober), followed by 9 species of WC (Wading carnivore), 5 species of SIP (Shore Insect Prober), 4 species of AqI/AqH (Aquatic Insectivore with Aquatic Herbivore) and SIP/TI (Shore Insect Prober with Terrestrial Insectivore), and 3 species of DC (Diving Carnivore). While, 2 species were AqC (Aquatic Carnivore) and AI (Aerial Insectivore), and only 1 species each of AqH/Pl (Aquatic Herbivore with Plankton feeder), AqI (Aquatic Insectivore), AqI/Pl (Aquatic Insectivore with Plankton feeder), TC (Terrestrial Carnivore), TI/TC (Terrestrial Insectivore with Terrestrial Carnivore) and WC/TI (Wading Carnivore with Terrestrial Insectivore) (Figure 3.11).

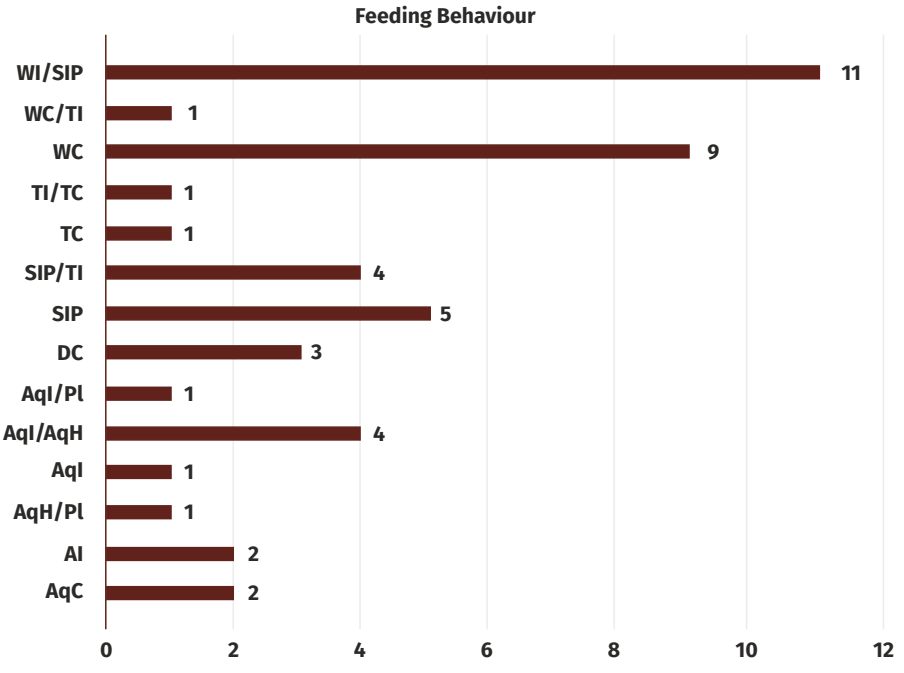


Figure 3.11. Feeding behaviour composition of waterbird assemblages across the Betwa River

3.3. Habitat characteristics of the Betwa River

3.3.1. Bank features

Substrates of the left banks were mostly formed by sand (57.74%), followed by mud (51.70%) and rocks (18%). Similarly, most of the right banks were formed by sand (64.78%), followed by mud (45%) and rocks (9%). In terms of vegetation cover, left side river banks were mostly devoid of vegetation (45%) or partially covered with natural vegetation and agriculture (42.25%), while a small proportion of the left bank was fully covered (12.67%). Akin to left

bank, right banks of the Betwa River were also mostly exposed (47.88%), followed by partially covered (39.43%) and fully covered by agriculture (11.26%) like cucurbits or yellow mustard. Left banks were mostly flat (84.50%), and the remaining 13% had moderate slope. The right banks were also mostly flat (77.46%), followed by moderate (11.26%) and steep slopes (9%).

3.3.2. River depth and width

Among the three studied tributaries (Betwa, Sind, Ken) of the Yamuna River, Betwa was the widest with an average width of (237.31 m ±9.54). The Betwa River's narrowest and widest stretches were 91 and 415 m, respectively. Depth of the river ranged from 0.30 to 7.10 m with average value of 1.97 m±0.15 (Figure 3.12; Table 4. About 61% of the sampled stretches had depth between 1 and 3 m followed by ~20% with < 1 m, 17% with >3-5 m and only 2.81% had depth of >5 m.

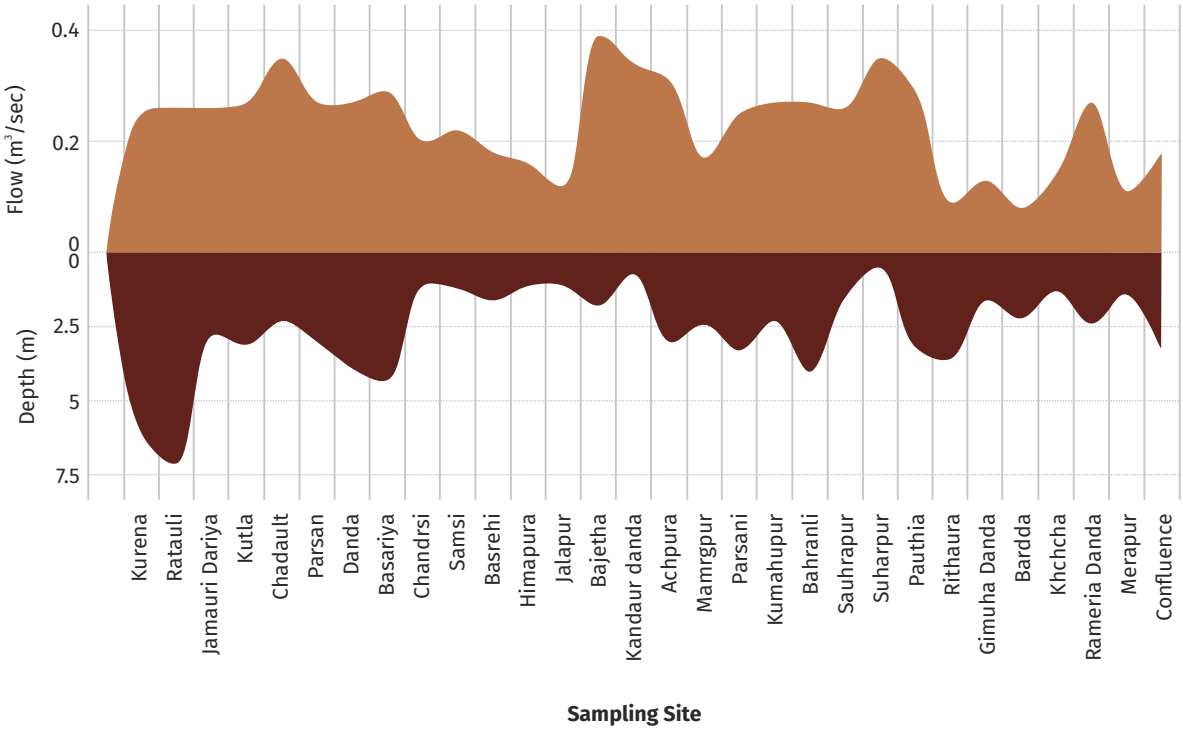
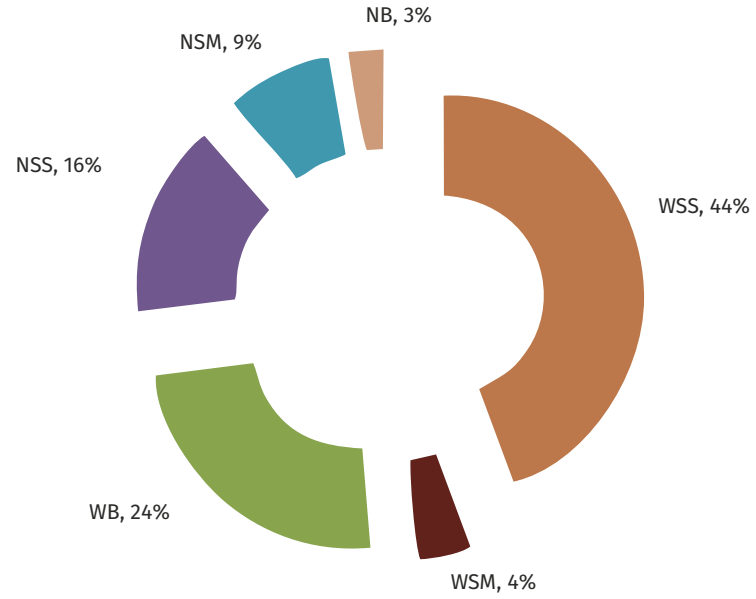


Figure 3.12. Depth profile and flow regime of the Betwa River between Orai and Yamuna-Betwa Confluence



Lagrest proportion of the River channel was wide single straight (WSS, 44%), followed by 24% of wide braided (WB) and 16% of narrow single straight (NSS) channel (Figure 3.13). While, in 9% of the sampled locations River flowed in narrow single meadering (NSM), 4% in wide single meadering (WSM) and 3% in narrow braided (NB) channels.

Figure 3.13. Channel property of the Betwa River between Orai and Betwa-Yamuna Confluence) (**WSS:** Wide Single Straight, **WSM:** Wide Single Meadering, **WB:** Wide Braided, **NSS:** Narrow Single Straight, **NSM:** Narrow Single Meadering, **NB:** Narrow Braided)

3.3.3. Flow regime

Flow of the Betwa River varied between 0 - 0.39 m^3/sec with average flow of 0.19 m^3/sec ± 0.01. Water was stagnant (0 m^3/sec) at sampling point near Merapur stretch (Figure 3.14; Table 4). Elevational gradient of the River varied between 77 and 105 m asl between Kurena and Betwa-Yamuna Confluence respectively.

Table 4. Habitat features along the surveyed stretch of the Betwa River (70 km)

Channel width ± SE in meters	Depth ± SE in meters	Flow ± SE (m^3/sec)
237.31 ±9.54	1.97 ±0.15	0.19± 0.01

3.3.4. Physiochemical properties of the Betwa River

Average conductivity within the surveyed stretch of the Betwa River was 420.65 µs/cm ±2.20 (349- 497) (Table 4), which was low (100 µs/cm) in a previous study by Tripathi & Tripathi (2017). TDS value along the sample locations varied between 208 and 296 mg/l with an average value of 250.94 mg/l ±1.35 likewise previous studies by Tripathi & Tripathi (2017). Salinity of the Betwa River was constant (0.2 ppt) throughout the surveyed stretch. pH value varied between 8.04 and 8.60 (Table 4). However, pH value was recorded lower in the previous studies (Patel & Datar, 2014; Tripathi & Tripathi, 2017). The pH value in few sites was found more than permissible drinking water limits (>8.5) (BIS, 2012). A couple of previous studies also measured dissolve oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) parameters, of which, DO (2-12.3 mg/l) was found mostly low in the multiple sites. In contrast, mostly high BOD (1.3-8.16 mg/l) and COD (8.4-165 mg/l) was recorded indicating domestic and industrial pollution in the Betwa River (Vishwakarma et al, 2014; Patel & Datar, 2014; Tripathi & Tripathi, 2017; CPCB, 2022).

Table 4. Physio-chemical properties of the surveyed stretch of the Betwa River (70 km)

Conductivity ± SE (µs/cm)	TDS± SE (mg/l)	Salinity Range (ppt)	pH Range
420.65 ±2.20	250.94±1.35	0.2	8.04 - 8.60

3.4. Anthropogenic pressures on the Betwa River

Betwa River is heavily mined in many stretches, in few sites entire river course has almost disappeared due to mining activities, and the River is flowing in the form of small channels/streams at these sites. Incessant mining has resulted in hydrological alterations and barriers, especially in the volume and flow of the River. Additionally, riverbank agriculture and fishing pose threats to aquatic ecosystem. Fishing intensity was found to be higher in the lower stretches (Figure 3.14). While, grazing was either low or medium in the most of stretches. Drastic fluctuation in the water depth could be one of the possible reasons for the absence of Gangetic dolphins in the lower stretch of the Betwa River. Human induced disturbances could have also restricted gharials from thriving in the lower stretch of the Betwa River. In terms of pollution, it has been listed as Priority class-IV polluted river of Madhya Pradesh and Uttar Pradesh (CPCB, 2022). Linking Ken-Betwa could have detrimental effects on the aquatic ecology of the both rivers since it is the first such experiment of the linking rivers in India.

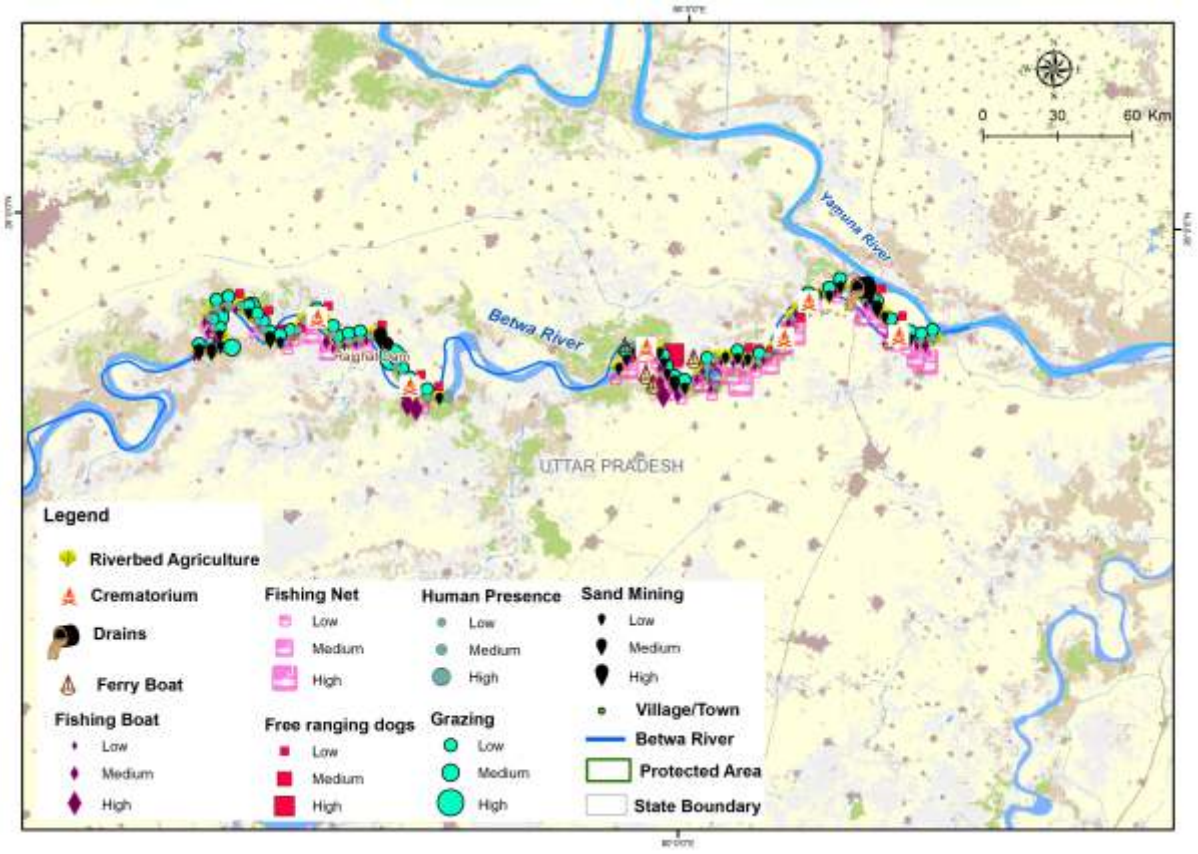


Figure 3.14. Different anthropogenic pressures on the Betwa River (Orai to Betwa-Yamuna Confluence)

4. THREATS TO RIVER CONSERVATION

The Betwa River basin has witnessed rapid increase of industries, mining sites, industrial discharge, domestic sewage, dumping of solid waste, deforestation and unplanned urbanization. Pollution in groundwater and surface water has resulted in health problems among the residents of the basin. During a recent water quality assessment, the River was found to be one of the most polluted rivers of the Madhya Pradesh and Uttar Pradesh (CPCB, 2022). The quality of surface water is generally contaminated, especially by agriculture pesticides, dumping of biomedical waste, mining and industrial waste (Tripathi & Tripathi, 2017). Sand mining activities are rampantly going on along the stretch of the Betwa River affecting river flow at multiple sites (SANDRP, 2023). Sand mining poses negative impact on the island nesting birds, aquatic mammals and reptiles (Hussain, 2009; Arjun et al., 2023). Proposed 230 km long Ken-Betwa River linking project with budget of Rs. 44,605 crore in Bundelkhand region of Madhya Pradesh and Uttar Pradesh will probably affect the socio-ecological integrity of the River basin and alter downstream ecology of the River (Gopal & Marothia, 2016).

5. CONSERVATION IMPLICATIONS

Among the three studied tributaries of the Yamuna River, Betwa has the highest mining activity. Rampant mining along the lower stretch of the Betwa River needs to be monitored and regularized by the administration. Any alteration or prevention of river flow shall be dealt strictly by the authorities, especially in the case of mining. Influx of industrial and sewage discharge attributes to depleting water quality of the river, should be a serious concern. The installation of sewage treatment plant (STP) units in and around major townships and industrial areas should be formularized that would improve the river water quality. Monitoring fishing activities and the distribution of exotic fish species should be a routine exercise. A minimum ecological flow should be ensured by the authorities to sustain aquatic life in the Betwa River. Integrated long-term monitoring of pollution from the source to sink could help in formation of foolproof policy, hence, such studies should be encouraged by the concerned departments. In the purview of climate change, such a semi-arid landscape would require high resilience, thus strategies and basin/river management plans should be formed immediately in line with stochastic climatic events like drought and flood. There is also a need to control invasive species (plants and animals). At the level of public participation, fostering water and river conservation

through programs like *Namami Gange* could assist in the restoration of the Betwa River.

Control measures for the invasive species damand a combination of mechanical, chemical, and ecological strategies. Techniques such as cutting, raking, and dredging can remove submerged and emergent weeds, though repeated efforts are needed to prevent regrowth. Mechanical harvesters effectively clear floating plants but risk spreading invasive species if not carefully managed. The use of EPA-registered herbicides targets specific invasive plants without harming native wildlife. For species like *Ipomoea carnea*, mowing during the early dry season reduces resprouting potential, while erecting barriers in shallow waters can limit the spread of *Alternanthera philoxeroides*. Habitat manipulation, including water drawdown and shading, is another effective method.

Raising public awareness and promoting responsible practices for sustainable agriculture could abate load of harmful chemicals through argricultural runoff. Conservation efforts in the Betwa River basin must integrate invasive species management with broader initiatives addressing threats like deforestation, sand mining, and agricultural expansion, ensuring the protection of this vital ecosystem.

Township sewage discharge in the Betwa River near Hamirpur

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APPENDIX 1: List of plants along the Betwa River (based on available literature)

S.no	Plant Name (Botanical name)	Family	Nativity	Habit	Habitat
1	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitaceae	Native	H	A
2	*Ottelia alismoides* (L.) Pers.	Hydrocharitaceae	Native	H	A
3	*Vallisneria natans* (Lour.) H. Hara	Hydrocharitaceae	Native	H	A
4	*Potederia crassipes* Mart.	Pontederiaceae	Introduced	H	A
5	*Pontederia hastata* L.	Pontederiaceae	Native	H	SA
6	*Pontederia vaginalis* Burm.f.	Pontederiaceae	Native	H	SA
7	*Commelinia benghalensis* L.	Commelinaceae	Native	H	SA
8	*Cyanotis cristata* (L.) D.Don	Commelinaceae	Native	H	SA
9	*Cyanotis axillaris* (L.) D.Don ex Sweet	Commelinaceae	Native	H	SA
10	*Murdannia nudiflora* (L.) Brenan	Commelinaceae	Native	H	SA
11	*Commelina forsskalii* Vahl	Commelinaceae	Native	H	SA
12	*Limnophyton obtusifolium* (L.) Miq.	Alismataceae	Native	H	A
13	*Colocassia esculenta* (L.) Schott.	Araceae	Native	H	SA
14	*Lemna minor* L.	Araceae	Native	H	A
15	*Lemna perpusilla* Torr.	Araceae	Native	H	A
16	*Spirodela polyrhiza* (L.) Schleid.	Araceae	Native	H	A
17	*Dioscorea bulbifera* L.	Dioscoreaceae	Native	H	T
18	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Native	T	SA
19	*Cyperus rotundus* L.	Cyperaceae	Native	G	SA
20	*Cyperus iria* L.	Cyperaceae	Native	G	SA
21	*Cyperus michelianus* subsp. pygmaeus (Rottb.) Asch. & Graebn.	Cyperaceae	Native	G	SA
22	*Fimbristylis dichotoma* (L.) Vahl	Cyperaceae	Native	G	SA
23	*Apluda mutica* L.	Poaceae	Native	G	SA
24	*Arundo donax* L.	Poaceae	Native	G	SA
25	*Chloris barbata* Sw.	Poaceae	Native	G	SA
26	*Coix lacryma*-jobi L.	Poaceae	Native	G	SA
27	*Chrysopogon aciculatus* (Retz.) Trin.	Poaceae	Native	G	SA

S.no	Plant Name (Botanical name)	Family	Nativity	Habit	Habitat
28	*Chrysopogon fulvus* (Spreng.) Chiov.	Poaceae	Native	G	SA
29	*Chrysopogon zizaniodides* (L.) Roberty	Poaceae	Native	G	SA
30	*Cynodon dactylon* (L.) Pers.	Poaceae	Native	G	SA
31	*Echinochloa colona* (L.) Link	Poaceae	Native	G	SA
32	*Echinochloa crus* -galli (L.) P.Beauv.	Poaceae	Native	G	SA
33	*Hygroryza aristata* (Retz.) Nees ex Wight & Arn.	Poaceae	Native	G	A
34	*Oxalis corniculata* L.	Oxalidaceae	Native	H	SA
35	*Euphorbia hirta* L.	Euphorbiaceae	Introduced	H	SA
36	*Euphorbia heterophylla* L.	Euphorbiaceae	Introduced	H	SA
37	*Acalypha indica* L.	Euphorbiaceae	Native	H	SA
38	*Croton boplandianus* Baill.	Euphorbiaceae	Introduced	H	SA
39	*Riccinus communis* L.	Euphorbiaceae	Introduced	S	T
40	*Phyllanthus reticulata* Poir.	Phyllantaceae	Native	S	SA
41	*Phyllanthus urinaria* L.	Phyllantaceae	Native	H	SA
42	*Phyllanthus virgatus* G.Forst.	Phyllantaceae	Native	H	SA
43	*Hybanthus enneaspermus* (L.) F.Muell.	Violaceae	Native	H	SA
44	*Bergia ammannioides* Heyne ex. Roth.	Elatinaceae	Native	H	SA
45	*Aeschynomene indica* L.	Fabaceae	Native	H	SA
46	*Acacia catechu* (L.) Willd., Oliv.	Fabaceae	Native	T	SA
47	*Cassia fistula* L.	Fabaceae	Native	T	T
48	*Dalbergia sissoo* Roxb.	Fabaceae	Native	T	SA
49	*Desmodium gangaticum* (L.)DC.	Fabaceae	Native	H	SA
50	*Pongamia pinnata* (L.) Pierre	Fabaceae	Native	T	SA
51	*Ficus benghalensis* L.	Moraceae	Native	T	SA
52	*Ficus racemosa* L.	Moraceae	Native	T	SA
53	*Ficus hispida* L.f.	Moraceae	Native	T	SA
54	*Ziziphus mauritiana* Lam.	Rhamnaceae	Native	H	SA

S.no	Plant Name (Botanical name)	Family	Nativity	Habit	Habitat
55	*Ziziphus oenophlia* (L.) Mill.	Rhamnaceae	Native	H	SA
56	Terminalia arjuna (Roxb.) Wight & Arn.	Combretaceae	Native	T	SA
57	*Syzygium cumini* (L.) Skeels	Myrtaceae	Native	T	SA
58	*Ammania baccifera* L.	Lythraceae	Native	H	SA
59	*Woodfordia fruticosa* (L.) Kurz	Lythraceae	Native	S	SA
60	*Aegle marmelos* (L.) Correa	Rutaceae	Native	T	T
61	*Urena lobata* L.	Malvaceae	Native	S	SA
62	*Alternanthera sessils* (L.) R.Br. ex DC.	Amaranthaceae	Native	H	SA
63	*Alternanthera ficoidea* (L.) Sm.	Amaranthaceae	Introduced	H	SA
64	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Introduced	H	SA
65	*Dicliptera paniculata* (Forssk.)	Acanthaceae	Native	H	SA
66	*Hygrophila auriculata* (Schumach.) Heine	Acanthaceae	Native	H	SA
67	*Hyptis suvaeolens* (L.) Point.	Lamiaceae	Introduced	S	SA
68	*Vitex negundo* L.	Lamiaceae	Native	S	SA
69	*Limnophila gratioloides* R. Br. Schrophulariaceae	Plantaginaceae	Native	H	A
70	*Veronica anagallis -aquatica* L.	Plantaginaceae	Native	H	SA
71	*Verbascum chinense* (L.) Santapau	Scrophulariaceae	Native	H	SA
72	*Phyla nodiflora* (L.)	Verbinaceae	Native	H	SA
73	*Utricularia vulgaris* L.	Lentibulariaceae	Native	H	A
74	*Sphaeranthus indicus* L.	Asteraceae	Native	H	SA
75	*Xanthium strumarium* L.	Asteraceae	Native	H	SA
76	*Launaea procumbens* (Roxb.) Ramayya & Rajagopal	Asteraceae	Native	H	SA
77	*Tridax procumbens* L.	Asteraceae	Introduced	H	SA
78	*Erigeron bonariensis* L.	Asteraceae	Introduced	H	SA
79	*Centella asiatica* (L.) Urb.	Apiaceae	Native	H	SA
80	*Nymphoides cristata* (Roxb.) Kuntze	Menyanthaceae	Native	H	A
81	*Lobelia alsinoides* Lam. Hel.	Campanulaceae	Native	H	SA

S.no	Plant Name (Botanical name)	Family	Nativity	Habit	Habitat
82	*Buchanania lanzan* Spreng.	Anacardiaceae	Native	T	T
83	*Terminalia pendula* (Edgew.) Gere & Boatwr.	Combrataceae	Native	T	T
84	*Haldina cordifolia* (Roxb.) Ridsdale	Rubiaceae	Native	T	T
85	*Shorea robusta* C.F.Gaertn.	Dipterocarpaceae	Native	T	T
86	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	Native	T	T
87	*Madhuca longifolia* (L.) J.F.Macbr.	Sapotaceae	Native	T	T
88	*Cymbopogon martini* (Roxb.) Will.Watson	Gramineae	Native	G	T
89	*Diospyros melanoxylon* Roxb.	Ebenaceae	Native	T	T
90	*Asparagus racemosus* Willd.	Asparagaceae	Native	C	T
91	*Butea monosperma* (Lam.) Kuntze	Leguminosae	Native	T	T
92	*Boswellia serrata* Roxb.	Burseraceae	Native	T	T
93	*Hardwickia binata* Roxb.	Fabaceae	Native	T	T
94	*Saraca asoca* (Roxb.) W.J.de Wilde	Fabaceae	Native	T	T
95	*Phyllanthus emblica* L.	Euphorbiaceae	Native	T	T

***H**- herbs, **S**- shrubs, **T** (habit)- trees, **C**-climber, **A**-aquatic, **SA** semi-aquatic, **T**(habitat)-terrestrial

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APPENDIX 2: List of fish species reported from the Betwa River

S. No.	Order	Family	Species name
1	Anguilliformes	Anguillidae	*Anguilla bengalensis* (Gray, 1831)
2	Osteoglossiformes	Notopteridae	*Notopterus notopterus* (Pallas, 1769)
3			*Chitala chitala* (Hamilton, 1822)
4	Cypriniformes	Cyprinidae	*Gymnostomus ariza* (Hamilton, 1807)
5			*Cirrhinus mrigala* (Hamilton, 1822)
6			*Cirrhinus reba* (Hamilton, 1822)
7			*Chagunius chagunio* (Hamilton, 1822)
8			*Cyprinus carpio* Linnaeus, 1758
9			*Garra gotyla* (Gray, 1830)
10			*Garra mullya* (Sykes, 1839)
11			*Tariqilabeo latius* (Hamilton, 1822)
12			*Labeo catla* (Hamilton, 1822)
13			*Labeo angra* (Hamilton, 1822)
14			*Labeo bata* (Hamilton, 1822)
15			*Labeo boggut* (Sykes, 1839)
16			*Labeo boga* (Hamilton, 1822)
17			*Labeo gonius* (Hamilton, 1822)
18			*Labeo dyocheilus* (McClelland, 1839)
19			*Labeo fimbriatus* (Bloch, 1795)
20			*Labeo calbasu* (Hamilton, 1822)
21			*Labeo pangusia* (Hamilton, 1822)
22			*Labeo rohita* (Hamilton, 1822)
23			*Osteobrama cotio* (Hamilton, 1822)
24			*Puntius amphibius* (Valenciennes, 1842)
25			*Pethia conchonius* (Hamilton, 1822)
26			*Systomus sarana* (Hamilton, 1822)
27			*Puntius sophore* (Hamilton, 1822)
28			*Puntius chola* (Hamilton, 1822)
29			*Pethia ticto* (Hamilton, 1822)
30			*Puntius dorsalis* (Jerdon, 1849)
31			*Tor tor* (Hamilton, 1822)
32		Danionidae	*Opsarius bendelisis* (Hamilton, 1807)
33			*Opsarius barna* (Hamilton, 1822)
34			*Barilius barila* (Hamilton, 1822)
35			*Cabdio morar* (Hamilton,1822)
36			*Rasbora daniconius* (Hamilton, 1822)
37			*Megarasbora elanga* (Hamilton, 1822)
38			*Esomus danrica* (Hamilton, 1822)
39			*Devario devario* (Hamilton, 1822)

Common name	IUCN status	Source
Indian mottled eel	NT	e
Bronze featherback	LC	a, b, c, d, e, f
Clown knifefish	NT	a, d, e
Ariza labeo	LC	f
Mrigal carp	LC	a, c, d, e
Reba carp	LC	a, d, e, f
Chaguni	LC	a, d, e
Common carp	VU	a, c, d, e, f
Sucker head	LC	a, c, d
Sucker fish	LC	e
Gangetic latia or stone roller	LC	e
Catla	LC	a, c, d, e, f
Angra labeo	LC	c, e
Bata	LC	a, c, d, e
Boggut labeo	LC	a, d, e
Boga labeo	LC	c
Kuria labeo	LC	a, c, d, e
Boalla or Kali	LC	a, d, e
Fringed-lipped peninsula carp	LC	c, e
Orangefin labeo	LC	a, b, c, d, e
Pangusia labeo	NT	a, d, e
Rohu labeo	LC	a, c, d, e, f
Cotio	LC	a, c, d, e
Scarlet-banded barb	DD	a, d, e
Rosy barb	LC	c, e
Olive barb	LC	a, b, c, d, e
Pool barb	LC	a, c, d, e, f
Swamp barb	LC	a, c, d, e
Ticto barb	LC	a, c, d, e
Long snouted barb	LC	c
Tor barb	DD	a, c, d, e
Indian hill trout	LC	a, c, d, e
Barna baril	LC	e
Barred baril	LC	c
Morari	LC	a, d, e
Slender rasbora	LC	a, c, d, e
Bengala barb	LC	c
Indian flying barb	LC	e
Sind danio	LC	c, e

S. No.	Order	Family	Species name
40			*Amblypharyngodon mola* (Hamilton, 1822)
41			*Laubuka laubuca* (Hamilton, 1822)
42			*Raimas bola* (Hamilton, 1822)
43			*Securicula gora* (Hamilton, 1822)
44			*Salmostoma balookee* (Sykes, 1839)
45			*Salmostoma bacaila* (Hamilton, 1822)
46		Xenocyprididae	*Ctenopharyngodon idella* (Valenciennes, 1844)
47		Nemacheilidae	*Acanthocobitis botia* (Hamilton, 1822)
48		Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)
49	Siluriformes	Bagridae	*Mystus cavasius* (Hamilton, 1822)
50			*Mystus tengara* (Hamilton, 1822)
51			*Mystus vittatus* (Bloch, 1794)
52			*Mystus bleekeri* (Day, 1877)
53			*Sperata aor* (Hamilton, 1822)
54			*Sperata seenghala* (Sykes, 1839)
55			*Rita rita* (Hamilton, 1822)
56		Siluridae	*Ompok bimaculatus* (Bloch, 1794)
57			*Ompok pabda* (Hamilton, 1822)
58			*Wallago attu* (Bloch and Schneider, 1801)
59		Schilbeidae	*Eutropiichthys vacha* (Hamilton, 1822)
60			*Eutropiichthys murius* (Hamilton, 1822)
61			*Silonia silondia* (Hamilton, 1822)
62		Ailiidae	*Ailia coila* (Hamilton, 1822)
63			*Clupisoma garua* (Hamilton, 1822)
64		Sisoridae	*Glyptothorax brevipinnis* Hora, 1923
65			*Bagarius bagarius* (Hamilton, 1822)
66			*Gogangra viridescens* (Hamilton, 1822)
67			*Gagata cenia* (Hamilton, 1822)
68		Clariidae	*Clarias batrachus* (Linnaeus, 1758)
69		Heteropneustidae	*Heteropneustes fossilis* (Bloch, 1794)
70		Pangasiidae	*Pangasius pangasius* (Hamilton, 1822)
71			*Pangasius bocourti* Sauvage, 1880
72	Mugiliformes	Mugilidae	*Rhinomugil corsula* (Hamilton, 1822)
73	Clupeiformes	Clupeidae	*Gudusia chapra* (Hamilton, 1822)
74			*Gonialosa manmina* (Hamilton, 1822)
75	Gobiiformes	Gobiidae	*Glossogobius giuris* (Hamilton, 1822)
76	Perciformes	Ambassidae	*Parambassis ranga* (Hamilton, 1822)
77			*Parambassis lala* (Hamilton, 1822)
78			*Chanda nama* Hamilton, 1822
79		Sciaenidae	*Johnius coitor* (Hamilton, 1822)

Common name	IUCN status	Source
Mola carplet	LC	c, e
Indian glass barb	LC	c, e
Trout barb	LC	a, d, e
Gora chela	LC	a, c, d, e
Bloch razorbelly minnow	LC	c
Large razorbelly minnow	LC	a, c, d, e
Grass carp	LC	f
Mottled loach	LC	a, c, d, e
Guntea loach	LC	a, c, d, e
Gangetic mystus	LC	a, b, c, d, e
Tengara catfish	LC	a, c, d, e
Striped dwarf catfish	LC	a, d, e
Day's mystus	LC	c, e
Long-whiskered catfish	LC	a, b, c, d, e, f
Giant-river catfish	LC	a, c, d, e
Rita	LC	a, c, d, e, f
Butter catfish	NT	a, b, c, d, e
Pabdah catfish	NT	a, d, e, f
Wallago catfish or Helicopter catfish	VU	a, c, d, e, f
Batchwa vacha	LC	a, c, d, e
Murius vacha	LC	e
Silond catfish	LC	a, c, d, e
Gangetic ailia	NT	a, d, e
Garua bachcha	LC	a, c, d, e
Mountain catfish	DD	a, d
Goonch	VU	a, c, d, e
Huddah nangra	LC	e
Indian gagata	LC	a, d, e
Philippine catfish	LC	c, e, f
Asian stinging catfish	LC	a, c, d, e, f
Pangas catfish	LC	a, d
Basa catfish	LC	f
Corsula	LC	a, b, c, d, e
Indian river shad	LC	a, b, d, e
Ganges river gizzard shad	LC	c, e
Tank goby	LC	a, c, d, e
Indian glassy fish	LC	a, c, d, e
Highfin glassy perchlet	NT	e
Elongate glassy perchlet	LC	a, c, d, e, f
Coitor croaker	LC	a, d, e

S. No.	Order	Family	Species name
80	Anabantiformes	Nandidae	*Nandus nandus* (Hamilton, 1822)
81		Osphronemidae	*Trichogaster fasciata* Bloch and Schneider, 1801
82			*Trichogaster lalius* (Hamilton, 1822)
83			*Trichogaster chuna* (Hamilton, 1822)
84		Channidae	*Channa gachua* (Hamilton, 1822)
85			*Channa marulius* (Hamilton, 1822)
86			*Channa punctata* (Bloch, 1793)
87			*Channa striata* (Bloch, 1793)
88	Cichliformes	Cichlidae	*Oreochromis mossambicus* (Peters, 1852)
89			*Oreochromis niloticus* (Linnaeus, 1758)
90	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus* (Lacepede, 1800)
91			*Macrognathus pancalus* Hamilton, 1822
92		Synbranchidae	*Monopterus cuchia* (Hamilton, 1822)
93	Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton, 1822)
94	Tetraodontiformes	Tetraodontidae	*Leiodon cutcutia* (Hamilton, 1822)

Source: [a]Lakra et al. (2010), [b]Sani et al. (2010), [c]Vyas et al. (2012), [d]Dubey et al. (2013), [e]Joshi et al. (2017), [f]Mishra et al. (2020)

Common name	IUCN status	Source
Gangetic leaffish	LC	a, c, d, e, f
Banded gourami	LC	e
Dwarf gourami	LC	e
Honey gourami	LC	e
Red seam snakehead	LC	c
Great snakehead	LC	a, c, d, e
Spotted snakehead	LC	a, c, d, e
Striped snakehead	LC	a, c, d, e, f
Mozambique tilapia	VU	a, c, d
Nile tilapia	LC	e
Zig-zag eel	LC	a, b, c, d, e, f
Barred spiny eel	LC	a, c, d, e
Cuchia	LC	e
Freshwater garfish	LC	a, c, d, e, f
Ocellated pufferfish	LC	a, d, e

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APPENDIX 3: List of recorded avi-faunal species in the Betwa River

Sl No	English Name	Scientific Name	Residential Status	IUCN Category	Feeding Guild*
	Order: Anseriformes				
	Family: Anatidae				
1	Knob-billed Duck	*Sarkidiornis melanotos* (Pennant, 1769)	R/LM	LC	AqI/AqH
2	Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	R/WM/PM	LC	AqI/AqH
3	Northern Shoveler	*Spatula clypeata* (Linnaeus, 1758)	WM	LC	AqI/P1
4	Gadwall	*Mareca strepera* (Linnaeus, 1758)	WM	LC	AqH/Pl
5	Indian Spot-billed Duck	*Anas poecilorhyncha* Forster, JR, 1781	R/LM	LC	AqI/AqH
6	Red-crested Pochard	*Nettarufina* (Pallas, 1773)	WM	LC	AqI/AqH
	Order: Charadriiformes				
	Family: Recurvirostridae				
7	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	R/LM	LC	WI/SIP
	Family: Charadriidae				
8	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	R/LM	NT	SIP
9	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	R/LM	LC	WC/TI
10	Lesser Sand Plover	*Charadrius mongolus* Pallas, 1776	R/WM	LC	SIP
11	Greater Sand Plover	*Charadrius leschenaultia* Lesson, 1826	WM	LC	SIP
12	Kentish Plover	*Anarhynchus alexandrinus* (Linnaeus, 1758)	R/WM	LC	SIP
13	Little Ringed Plover	*Thinornis dubius* (Scopoli, 1786)	R/WM	LC	SIP
	Family: Scolopacidae				
14	Temminck's Stint	*Calidris temminckii* (Leisler, 1812)	WM	LC	WI/SIP
15	Little Stint	*Calidris minuta* (Leisler, 1812)	WM	LC	WI/SIP
16	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	R/WM	LC	WI/SIP
17	Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	R/WM	LC	WI/SIP
18	Green Sandpiper	*Tringa ochropus* Linnaeus, 1758	WM/R	LC	WI/SIP
19	Spotted Redshank	*Tringa erythropus* (Pallas, 1764)	WM	LC	WI/SIP

Sl No	English Name	Scientific Name	Residential Status	IUCN Category	Feeding Guild*
20	Common Greenshank	*Tringa nebularia* (Gunnerus, 1767)	WM	LC	WI/SIP
21	Wood Sandpiper	*Tringa glareola* Linnaeus, 1758	WM	LC	WI/SIP
22	Common Redshank	*Tringa totanus* (Linnaeus, 1758)	R/WM	LC	WI/SIP
	Family: Glareolidae				
23	Small Pratincole	*Glareolalactea* Temminck, 1820	R/LM	LC	WI/SIP
	Order: Ciconiiformes				
	Family: Ciconiidae				
24	Asian Openbill	*Anastomusoscitans* (Boddaert, 1783)	R/LM	LC	WC
25	Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	R	NT	WC
26	Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	R/LM	NT	WC
	Order: Suliformes				
	Family: Phalacrocoracidae				
27	Little Cormorant	*Micro carboniger* (Vieillot, 1817)	R/LM	LC	DC
28	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	R/WM	LC	DC
29	Indian Cormorant	*Phalacrocorax fuscicollis* Stephens, 1826	R/LM	LC	DC
	Order: Pelecaniformes				
	Family: Ardeidae				
30	Grey Heron	*Ardea cinerea* Linnaeus, 1758	R/WM	LC	WC
31	Purple Heron	*Ardea purpurea* Linnaeus, 1766	R/LM	LC	WC
32	Great Egret	*Ardea alba* Linnaeus, 1758	R/LM	LC	WC
33	Intermediate Egret	*Ardea intermedia* Wagler, 1829	R/LM	LC	WC
34	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	R/LM	LC	WC
35	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	R/AM	LC	TI/TC
36	Indian Pond Heron	*Ardeola grayii* (Sykes, 1832)	R/LM	LC	WC

Sl No	English Name	Scientific Name	Residential Status	IUCN Category	Feeding Guild*
	Family: Threskiornithidae				
37	Red-naped Ibis	*Pseudibis papillosa* (Temminck, 1824)	R	LC	AqI
	Order: Coraciiformes Family: Alcedinidae				
38	White-throated Kingfisher	Halcyon smyrnensis (Linnaeus, 1758)	R/LM	LC	AAqC
39	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	R	LC	AAqC
	Order: Passeriformes Family: Hirundinidae				
40	Grey-throated Martin	*Riparia chinensis* (Gray, JE, 1830)	R/LM	LC	AI
41	Striated Swallow	*Cecropis striolata* (Schlegel, 1844)	R	NR	AI
	Family: Motacillidae				
42	Western Yellow Wagtail	*Motacilla flava* Linnaeus, 1758	R/AM/WM/PM	LC	SIP/TI
43	Citrine Wagtail	*Motacilla citreola* Pallas, 1776	R/AM/WM	LC	SIP/TI
44	White-browed Wagtail	*Motacilla maderaspatensis* Gmelin, JF, 1789	R	LC	SIP/TI
45	White Wagtail	*Motacilla alba* Linnaeus, 1758	R/WM/PM	LC	SIP/TI

***WI/SIP**- Wading Insectivore with Shore Insect Prober; **WC**-Wading Carnivore; **SIP**-Shore Insect Prober; **AqI/AqH**- Aquatic Insectivore with Aquatic Herbivores; **SIP/TI**- Shore Insect Prober with Terrestrial Insectivore; **DC**-Diving Carnivore; **AO**-Aquatic Omnivore; **AqC**- Aquatic Carnivore; **AI**-Aerial Insectivore; **AqH/Pl**- Aquatic Herbivore with Plankton feeder; **AqI**- Aquatic Insectivore; **AqI/P1**- Aquatic Insectivore with Plankton feeder; **TC**- Terrestrial Carnivore; **TI/TC**- Terrestrial Insectivore with Terrestrial Carnivore; **WC/TI**- Wading Carnivore with Terrestrial Insectivore.

NOTE

NOTE

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

NMCG

National Mission for Clean Ganga,
Department of Water Resources,
River Development & Ganga Rejuvenation,
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