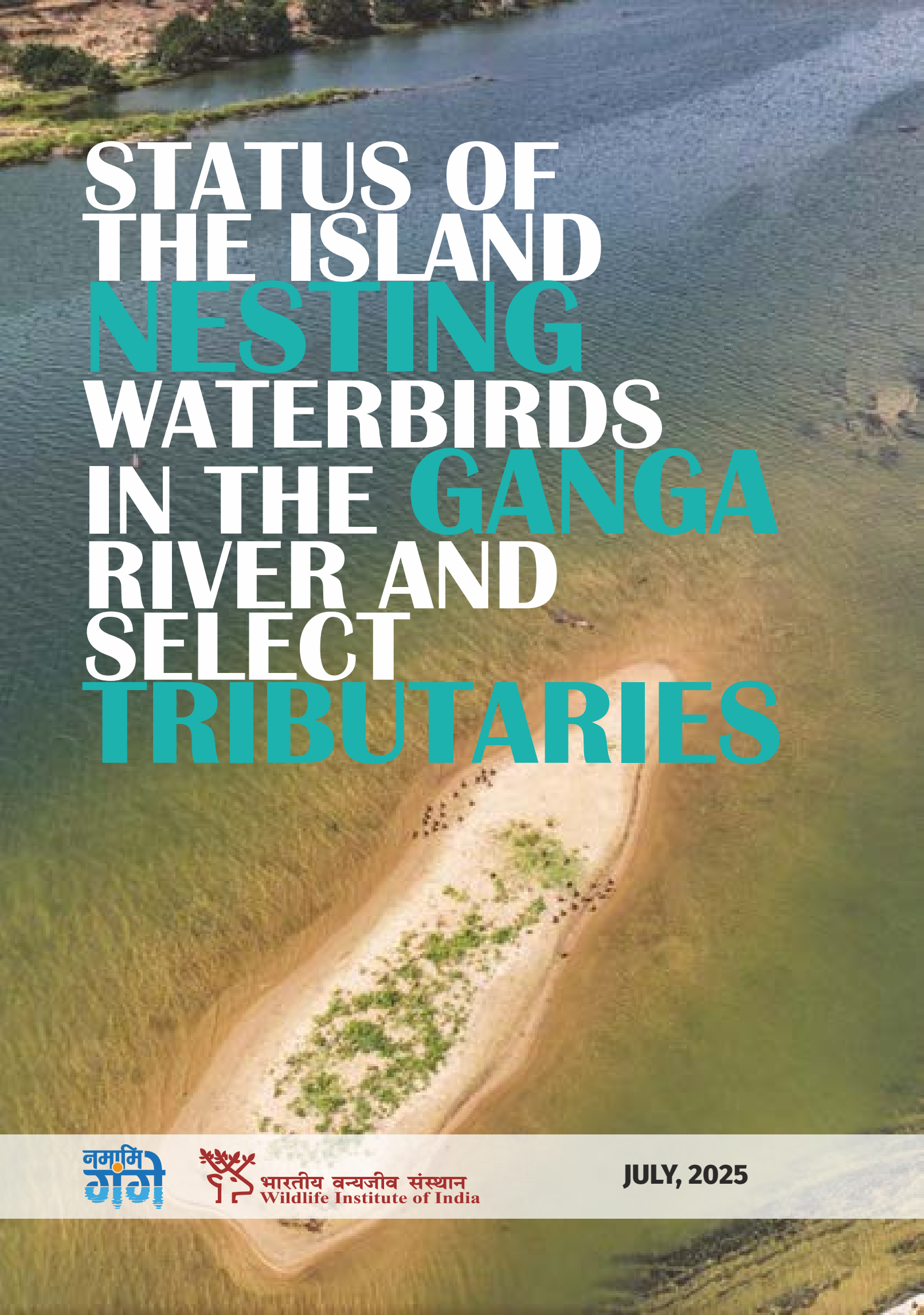




# STATUS OF THE ISLAND NESTING WATERBIRDS IN THE GANGA RIVER AND SELECT TRIBUTARIES



भारतीय वन्यजीव संस्थान  
Wildlife Institute of India

JULY, 2025





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select tributaries**  
July, 2025

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# EXECUTIVE SUMMARY



The riverine habitats provide ideal nesting sites to island or sandbar waterbirds such as colonial waterfowls, terns, lapwings, plovers and skimmers. Species like black-bellied tern, Indian skimmer, river tern, and river lapwing breed during the spring and summer seasons in the Ganga River Basin. A substantial body of literature in the different rivers of India highlights concerns related to the impact of anthropogenic activities on nesting birds. The river islands of the mainstem Ganga River and select tributaries were surveyed to document nesting activities of the waterbirds. The assessment of the river islands was conducted for two years; the first survey was undertaken during May-June, 2023, and the second during the months of April and May, 2024.

A total of 13 species of waterbirds were found to be nesting in the islands of the Ganga River and five select tributaries. The highest number of species was recorded from the Ghaghra River (11 species), while the least was reported for the Gandak River (1 species). During the first pre-monsoon survey, a total of 232 nesting events, 429 unhatched eggs, 61 hatchlings, and 1249 fledglings were recorded for 11 nesting waterbird species, like little tern, small pratincole, Indian skimmer, river lapwing, black-winged stilt, great thick-knee, and little ringed plover. A total of 1832 nesting events, 4022 unhatched eggs, 214 hatchlings, and 356 fledglings of 12 nesting waterbird species were recorded from five rivers during the second pre-monsoon survey, which included the black-bellied tern. The survey highlighted the importance of rivers like the Chambal and the Son for nesting waterbirds, especially for endangered species like the Indian skimmer and the black-bellied tern. Besides continuous monitoring of the five rivers, specific sites in the Ramganga and the Son rivers were also

monitored opportunistically during 2022 and 2024, respectively. A total of 35 nesting events of the river tern were recorded from the Kalagarh dam on the Ramaganga River in Uttarakhand.

In state-wise assessment, the highest number of nesting events was recorded from the islands along the three rivers in Uttar Pradesh. River stretches of the Yamuna and Ghaghra harboured the highest number of unhatched eggs in the state of Uttar Pradesh. The highest number of hatchlings was also recorded in the state of Uttar Pradesh, specifically in the islands of the Ganga, Yamuna and Ghaghra rivers. Fledglings' numbers were found to be highest in the islands along the Ghaghra and Yamuna rivers, traversing through Uttar Pradesh. The endangered black-bellied tern was recorded from the islands along the Chambal and Son rivers in Madhya Pradesh. Another important species, the Indian skimmer, was found to be nesting in islands along the Ghaghra, Chambal, Son and Ganga rivers, mostly within the boundaries of Uttar Pradesh, Madhya Pradesh and Rajasthan states.

Interestingly, a few incidences of brood parasitism were also recorded from the Yamuna River, where little terns laid eggs in the nests of black-winged stilt. Indian skimmer specifically used sandy substrate for nesting, while other species used a variety of substrates. The average distance of the nest from the river bank varied between 40 m (in Gandak) and 229 m (in Yamuna) during both surveys. Area of the nesting islands varied from 0.001 to 4 sq. km in the Ganga, Gandak and Yamuna rivers. Nest collection, trampling, free-ranging dogs, sand mining, cucurbit cultivation and flooding appeared as major threats to eggs and fledglings in the islands along the Ganga River and select tributaries.

**The river islands in the Ganga basin hold immense ecological values, and yet these are the most ignored in terms of conservation measures. These river islands are amongst the most fertile landscapes and are heavily exploited, particularly for sand mining, farming and settlements. This study is the first comprehensive account of the nesting events of the island nesting birds from the islands along the rivers in the Ganga River basin. The present assessment provides baseline information on the nesting island waterbirds of the five rivers through intensive monitoring, and a snapshot of two rivers (Son and Ramganga). This baseline information suggests that there is a need to study the breeding biology of the threatened species, nesting/hatching/fledging success (breeding success), nest survival, and other aspects that will unveil the requirements of the nesting species and related threats to cope with. At the same time, it is equally important to protect these habitats through policy measures, collaborations, awareness and public support.**

# INTRODUCTION

Islands and shorelines are important components of aquatic ecosystems, as they provide crucial nesting habitats for waterbirds (Nagarajan and Thiyagesan 1996; Rehman et al. 2021; Mansfield et al. 2024). The riverine habitats provide ideal nesting sites for island (sandbar) waterbirds such as colonial waterfowls, terns, lapwings, plovers, pratincoles and skimmers. Many species like black-bellied tern, Indian skimmer, river tern, river lapwing breed during the spring and summer seasons along the river islands in the Ganga River Basin (Mishra et al. 2018; Ankit et al. 2024). The riverine habitats in the Ganga River Basin provide refuge to 177 water and water-associated species of birds, of which 20-30% species breed in river islands and

A photograph of a man in a river, wearing a cap and a jacket, holding a clipboard and pen, looking out over a wide river with a sandy bank. The word 'INTROD' is overlaid in large, white, outlined letters at the bottom of the image.

INTROD

# 1.

banks, where their breeding activities collide with anthropogenic factors. A recent review-based synthesis reported the presence of 236 water and water-associated bird species in the Ganga River Basin (Mahar et al. 2025). The river islands and the shoreline are heavily modified by humans for various activities, which range from agriculture and fishing to sand mining. A substantial body of literature in the different rivers of India highlights concerns regarding the impact of anthropogenic activities on nesting birds (Kar et al. 2012; Shaikh et al. 2018; Kar and Debata 2019; Debata and Kar 2021; Arjun et al. 2023; Ankit et al. 2024). A recent study confirmed that human activities at breeding sites significantly reduced the breeding success of Indian skimmers (Debata et al. 2019).

# UCTION

Among nesting waterbirds of the Ganga River Basin, Indian skimmer (*Rynchops albicollis*) is listed as an Endangered species on the IUCN Red List and falls within Schedule-I of the Indian Wild Life Protection (Act), 1972. A recent assessment identified the Indian skimmer as one of the highest conservation value species in the states of Uttar Pradesh and Madhya Pradesh (SolB 2023). According to an estimate, approximately less than 3000 individuals are left in the Indian sub-continent (BirdLife International 2021). Usually, skimmers start breeding in March, it lay eggs in April with a clutch size of one to five (Debata et al. 2019; Rajguru 2017; Ankit et al. 2024). The chicks are hatched after an incubation period of ~22 days. Breeding records of the species in India are mostly from the Chambal, Ganga and Mahanadi rivers (Debata et al. 2017). Debata et al. (2019) reported the first description of brood parasitism (interspecific nest parasitism) by the Indian skimmer in a river tern's (*Sterna aurantia*) nest, where two eggs of the skimmer were found in the nest of the tern. Another noteworthy island nesting bird is also an Endangered species, the black-bellied tern (*Sterna acuticauda*), its presence has been confirmed from the different river basins of the Indian states (Nair 2010; Palei 2015; Kar et al. 2018, Bayani 2020). The contemporary confirmed records of the black-bellied tern are also from the lower Garhwal valley of Uttarakhand (Singh 2002), and the Ganga River in Uttar Pradesh (Vasudeva et al. 2020). Recent studies have confirmed their nesting along the sandy islands of the Mahanadi River, where the nest survival rate was 46% (Kar et al. 2018; Kar and Debata 2019). Generally, the clutch size of black-bellied tern varies between 1-3 eggs.

Some other important nesting species found in the Ganga River Basin are small pratincole (*Glareola lactea*), little tern (*Sternula albifrons*), and river lapwing (*Vanellus duvaucelii*). Previously, small pratincoles. These species have been reported from the Chambal, Nazafragh, and Mullaperiyar dams (Tyabji 1961; Sundar 2004; Zockler et al. 2005; David et al. 2020). Little tern is one of the widely distributed island nesting birds in the Ganga River Basin, however, studies related to breeding biology are sparse. Studies on the breeding behaviour and population of the river lapwing have been carried out in the Ganga River Basin (Mishra et al. 2018; 2020). Another species, the black-winged stilt (*Himantopus himantopus*) is considered one of the widely distributed generalist species in a variety of aquatic habitats, ranging from the murky polluted water to pristine river stretches. Its incubation period varies between 20-30 days, and clutch size ranges from one to five eggs (Emmanuel et al. 2022).

Various factors affect the nesting success of island nesting waterbirds, such as predation, flooding, cyclones and nest desertion. Debata and Kar (2021) studied nesting activities and factors influencing the nesting success of threatened riverine birds in Odisha,

eastern India. Some other factors responsible for nest failure have been identified as trampling and egg collection. A recent study provides information on the breeding ecology of the endangered black-bellied tern along the Mahanadi River in Odisha (eastern India), assessing factors affecting survival of nests owing to anthropogenic changes in water level, predation, and trampling (Kar and Debata 2019). Mishra et al. (2020) reported that across the years, river lapwing nests on open substratum and barren river banks achieved significantly greater nesting success than those in crop fields. Nest failure was mainly due to predation and farming activities, and trampling by domestic cattle and human disturbance.

Despite the sporadic studies on the nesting ecology of the riverine birds, conservation challenges remain, which can be categorized as 1) incomplete information on the breeding and nesting ecology of the nesting island birds and 2) ways to minimize human disturbance at breeding sites. Intensive information on the island nesting waterbirds of the Ganga River Basin mostly remains undocumented to date. To address this gap, the status of island nesting birds in the Ganga mainstem and its six tributaries was assessed during 2023 and 2024. The Ganga, Gandak, Ghaghra, and



Yamuna rivers were monitored during the pre-monsoon season (April-June), which is the peak breeding season for the island nesting waterbirds, for two consecutive years, while Chambal and Son rivers were surveyed only during 2024. The key objectives of this study were to identify nesting islands, nesting waterbird species and associated anthropogenic threats in the Ganga mainstem and select tributaries.

## 1.1. STUDY SITES

### 1.1.1. Ganga Mainstem

The Ganga River, designated as the National River of India, is a glacial-fed river originating from the Gangotri glacier in Uttarakhand. With a total length of 2,525 km, the Ganga River crosses five Indian states and submerges into the Bay of Bengal. The geographical extent of its basin spans over 8,61,452 sq. km in the 11 Indian states. During its journey from the Himalayan mountains to the Sundarbans deltas, it passes through different Biogeographic zones- the Himalaya (2a), the Gangetic plain (7a and 7b), and the Coast (12 a). Based on its passage, the River is generally divided into three segments, the upper Ganga, the middle Ganga and the

lower Ganga. Through its course in the Himalaya, the River flows through a steep gradient and is fast flowing and narrow. On entering the Gangetic Plains, the River slows down and deposits the sediments brought along with it. This results in the formation of river islands and sandy banks, which are found along the middle and lower stretches of the Ganga River. To study the nesting islands, the middle Ganga River was monitored from Bijnor to Buxar (Uttar Pradesh), covering a total distance of 1131 km during the second pre-monsoon survey (2024). A total of 435 km stretch of the lower Ganga River was monitored across two consecutive pre-monsoon surveys (2023 & 2024) between Sitabdiara (Bihar) and Farakka (West Bengal).

### 1.1.2. Chambal

The Chambal River, also known as Charmanvati River, is the major tributary of the Yamuna River. Originating from the Vindhyan ranges of Madhya Pradesh, it flows through three Indian states for 960 km before joining the Yamuna River at Bareilly. With a 1,43,219 sq. km basin area, it harbours some of the key breeding sites of crocodilians and Indian skimmers in the National Chambal sanctuary. The Chambal River traverses through Madhya Pradesh, Rajasthan and Uttar Pradesh



states of India, covering Semi-Arid, Gangetic plain and Desert Biogeographic zones. The monitoring of island nesting waterbirds was conducted in 25 prominent river islands between Pali and Bareilly, covering a 250 km stretch of the River.

### 1.1.3. Gandak

The Gandak River, also known as Narayani or Kali Gandak, is a trans-boundary river between Nepal and India. The Gandak is the left bank tributary of the Ganga River, which originates from the glaciers in Nepal. It is globally famous for its Shaligram fossils, especially among the Hindu devotees. In India, Gandak traverses the states of Uttar Pradesh and Bihar. Out of 700 km of total length, ~43% of the river flows within the Indian boundary before joining the mainstem of the Ganga River in Patna. The Gandak River flows in the Upper and Lower Gangetic plain Biogeographic provinces (7a and 7b) (Rodgers et al., 2000) and has a basin area of 9,540 sq. km (India-WRIS 2014). The River was monitored for 238 km during May 2023 and 2024, covering 18 potential nesting islands between Paniyawaha (Uttar Pradesh) and the Gandak-Ganga confluence in Patna (Bihar).

### 1.1.4. Ghaghra

The Ghaghra is the largest tributary of the Ganga River by volume, which is a glacial-fed river originating from the Matsang glacier in the Tibetan Plateau, where it is known as the Karnali River. This trans-boundary river flows for 1080 km through Uttar Pradesh and Bihar in India and merges into the Ganga River in Chapra (Bihar). The River basin covers almost 57,577 sq. km area (India-WRIS 2014) in the Upper and Lower Gangetic plain Biogeographic provinces (7a and 7b) of India (Rodgers et al. 2000). During first and second surveys, nearly 612 km stretch of the River was covered, where 51 to 57 potential nesting islands were monitored from downstream of Kailashpuri dam (Uttar Pradesh) to Realganj near Chapra (Bihar).

### 1.1.5. Yamuna

The Yamuna River, one of the major tributaries of the Ganga River, traverses through the Himalaya, Semi-Arid and Gangetic plain Biogeographic zones, covering a total length of 1326 km. The lower zone of the Yamuna River was surveyed for island nesting waterbirds. Lower zone of the River starts after the Chambal confluence and ends at the confluence with the Ganga at Prayagraj. The depth remains low, and the water is murky in the lower middle zone. The Chambal, Sindh, Betwa, and Ken rivers contribute a large amount of water volume in the lower zone of the Yamuna River. Sand deposition in the lower zone increases after the confluence of Chambal, and the water depth throughout remains suitable for boats and island nesting waterbird species. During the first and second surveys, nearly a 440 km stretch of the

River was covered, where 40 to 44 potential nesting islands were monitored from Pachnada to Prayagraj.

### 1.1.6. Ramganga

The Ramganga originates from the lesser Kumaon Himalayan ranges of Uttarakhand. With an area of 32,493 sq. km the basin encompasses two Biogeographic zones - the Himalaya and the Gangetic plains. The Ramganga River passes through Uttarakhand and Uttar Pradesh for 596 km before joining the Ganga mainstem in Kannauj. The Kalagarh dam is situated on the river in the foothills of the Himalaya in the Corbett National Park. The Kalagarh reservoir spread over 78.31 sq. km, has a catchment area of 3134 sq. km. To get a snapshot of nesting waterbirds in the reservoir, the monitoring of nesting waterbirds was conducted on foot using shoreline walks and through point counts from vantage points.

### 1.1.7. Son

The Son River originates from the Deccan peninsula Biogeographic zone in Central India, and it travels for 881 km before joining the Ganga River near Doriganj (Bihar) in the Gangetic plain biogeographic zone. This perennial River originates from the Amarkantak hills in Madhya Pradesh. The Son River Basin spans over 70,055 sq. km, with key protected areas like Son Gharial Sanctuary, primarily established for the conservation of crocodilians. The island nesting waterbirds were monitored during the second pre-monsoon season of 2024 in a few potential nesting sites identified by the Madhya Pradesh Forest Department near the Bichi area at the confluence of the Son and Gopad rivers.

## 1.2. METHODOLOGICAL FRAMEWORK

The continuous monitoring of the river islands was carried out during the first (May-June, 2023) and second (May-June, 2024) pre-monsoon surveys by two observers using an inflatable boat from 07:00 to 18:00 hrs in the five rivers of the Ganga River Basin, following standard protocol (WII-NMCG 2019; WII-GACMC 2024). On locating a river island, the observers dismounted the boat and visually examined the presence of nests, and noted the clutch size, hatchlings or fledglings. Their numbers were counted carefully along with other habitat parameters like the distance to the nearest nest, distance to the river current, and distance to the river bank. Substantial distance was maintained from nests/hatchlings, ensuring minimum disturbance to them. In addition, anthropogenic parameters like the presence of humans, livestock, potential predators and other site variables were also recorded at each nesting island.

Apart from the continuous monitoring of the five rivers, Kalagarh (Ramnagar) Reservoir on the Ramganga River,

and Son-Gopad confluence (Son River) were surveyed using point count methods and shoreline walks during March 2022 and May 2024, respectively, in a few selected potential nesting sites rather than monitoring entire river stretches. The monitoring was conducted on foot using shoreline walks since a boat survey was not feasible in these sites.

Generalized linear model (GLM) was used to determine the factors affecting island nesting birds in the Yamuna and Ghaghra rivers. Different explanatory variables were used for the analysis, and nesting activity was considered as the dependent (response) variable for the GLM. Prior to GLM, multicollinearity was tested

among the nine explanatory variables (continuous variables-island area, distance to human settlement, distance to nearest nest, distance to shoreline, distance to river current, and categorical variables-presence of vegetation, livestock, predator, and agriculture) and variables with  $R^2 > 0.70$  were omitted from the analysis based on ecological understanding. To overcome over dispersion in data, the negative binomial family with log function was selected. The analysis was performed in R Core Team software using glmmTMB and other packages (R Core Team 2025).

**Table 1.1.** Details of sampling during monitoring of Island Nesting River Waterbirds in the Ganga River Basin

| River        | River distance covered (km) | Basin states covered                     |
|--------------|-----------------------------|------------------------------------------|
| Middle Ganga | 1131                        | Uttar Pradesh                            |
| Lower Ganga  | 435                         | Bihar, Jharkhand, West Bengal            |
| Chambal      | 250                         | Madhya Pradesh, Rajasthan, Uttar Pradesh |
| Gandak       | 238                         | Bihar                                    |
| Ghaghra      | 612                         | Uttar Pradesh                            |
| Yamuna       | 577                         | Uttar Pradesh                            |
| Son*         | 20                          | Madhya Pradesh                           |
| Ramganga*    | NA                          | Uttarakhand                              |

\*Only opportunistic monitoring of potential nesting sites restricted to small sampled areas, Son River: Bicchi area (on Son and Gopad River confluence); Ramganga River: Kalagarh Dam



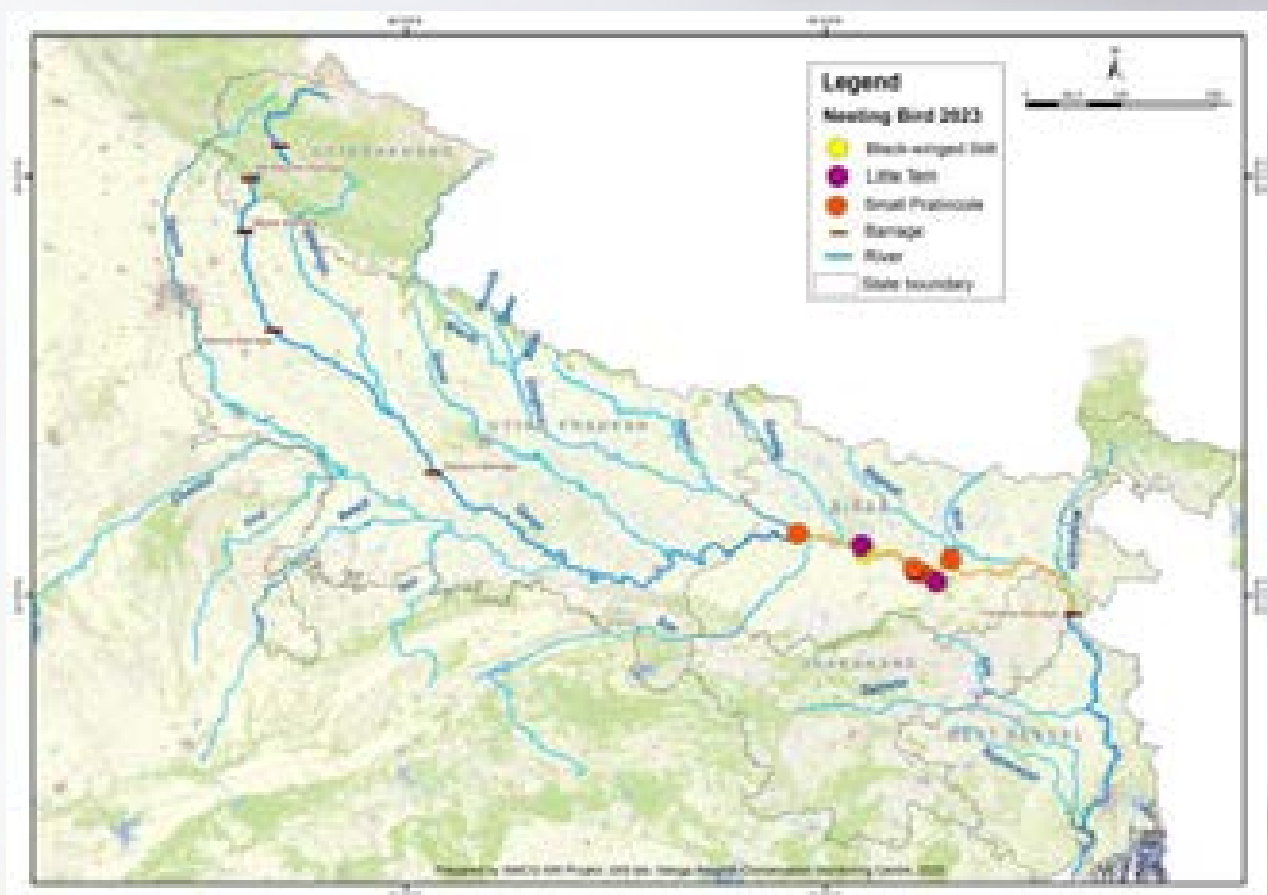
# STATUS OF NESTING WATERBIRDS IN GANGA AND SELECT TRIBUTARIES

## 2.1. GANGA RIVER

### 2.1.1. Island nesting waterbirds in the Ganga River during First Survey (2023)

With a survey effort of 43.5 km/day, a total of 38 islands were monitored to determine status of island nesting waterbirds during the first pre-monsoon

survey (early June, 2023). This survey was restricted to the lower stretch of the Ganga River, from Sitabdiara to Manihari (435 km). A total 18 nesting events were recorded for three species namely black-winged stilt, little tern, and small pratincole (Figure 2.1). Six islands were actively utilized by the nesting birds. A total of 35 unhatched eggs, nine hatchlings and 56 fledglings of three species were recorded during this survey (Table 2.1). Little tern had the highest number of nests (15), with 27 unhatched eggs, 7 hatchlings and 2 fledglings.



**Figure 2.1** Nesting sites of different island nesting birds in the Ganga River during First Pre-Monsoon Survey (2023)

## 2.

The clutch size of little tern ranged between 1 and 3. A total of 2 nests with 4 unhatched eggs, 2 hatchlings, and 54 fledglings of small pratincole were recorded while only a single nest consisting of 4 unhatched eggs of black-winged stilt was found. The mean clutch size of small pratincole was  $2.50 \pm 0.50$  (SE), and  $2.20 \pm 0.17$  for little tern (Figure 2.3).



### 2.1.2. Island nesting waterbirds in the Ganga River during Second Survey (2024)

A total of 1131 km of the Ganga River, from Bijnor to Barrackpore, was surveyed in 2024, which included the middle and the lower Ganga stretches. The middle stretch of the Ganga River was monitored with a survey effort of 102.82 km/day covering all potential nesting islands between Bijnor and Narayanpur (Buxar) during May to June, 2024. The lower Ganga was monitored with a survey effort of 33.46 km/day. A total of 252 nests were observed for six river island nesting waterbird species (black-winged stilt, Indian skimmer, little tern, red-wattled lapwing *Vanellus indicus*, river lapwing *Vanellus duvaucelii* and small pratincole) (Table 2.1; Figure 2.2). Indian skimmer was recorded nesting in the middle stretch during the second pre-monsoon survey. Out of 300 surveyed river islands between the stretch of Bijnor and Manihari, only 14 were used by nesting waterbirds. In toto, 484 unhatched eggs, 57 hatchlings and 12 fledglings were recorded from the river islands. Among six nesting bird species, small pratincole had the highest number of nesting events (n=143) with 264 unhatched eggs, 28 hatchlings and six fledglings, followed by little tern with 80 nesting events, 166



unhatched eggs, 25 hatchlings and one fledgling. A total of 21 nest events, 30 unhatched eggs, four hatchlings and five fledglings were recorded for Indian skimmer and river lapwing, with 4 nests with 11 unhatched eggs. In terms of clutch size, the black-winged stilt had a consistent clutch size of 4 eggs per nest. The little tern and river lapwing both exhibited a clutch size range from 1 to 4 eggs per nest. The red-wattled lapwing had a slightly smaller clutch size with 1 egg. Meanwhile, the small pratincole showed most variation in clutch size, ranging from 1 to 5 eggs per nest. The average clutch size of the Indian skimmer was  $2.36 \pm 0.23$ , small pratincole was  $2.11 \pm 0.06$ , and little tern was  $2.45 \pm 0.08$  (Figure 2.3).

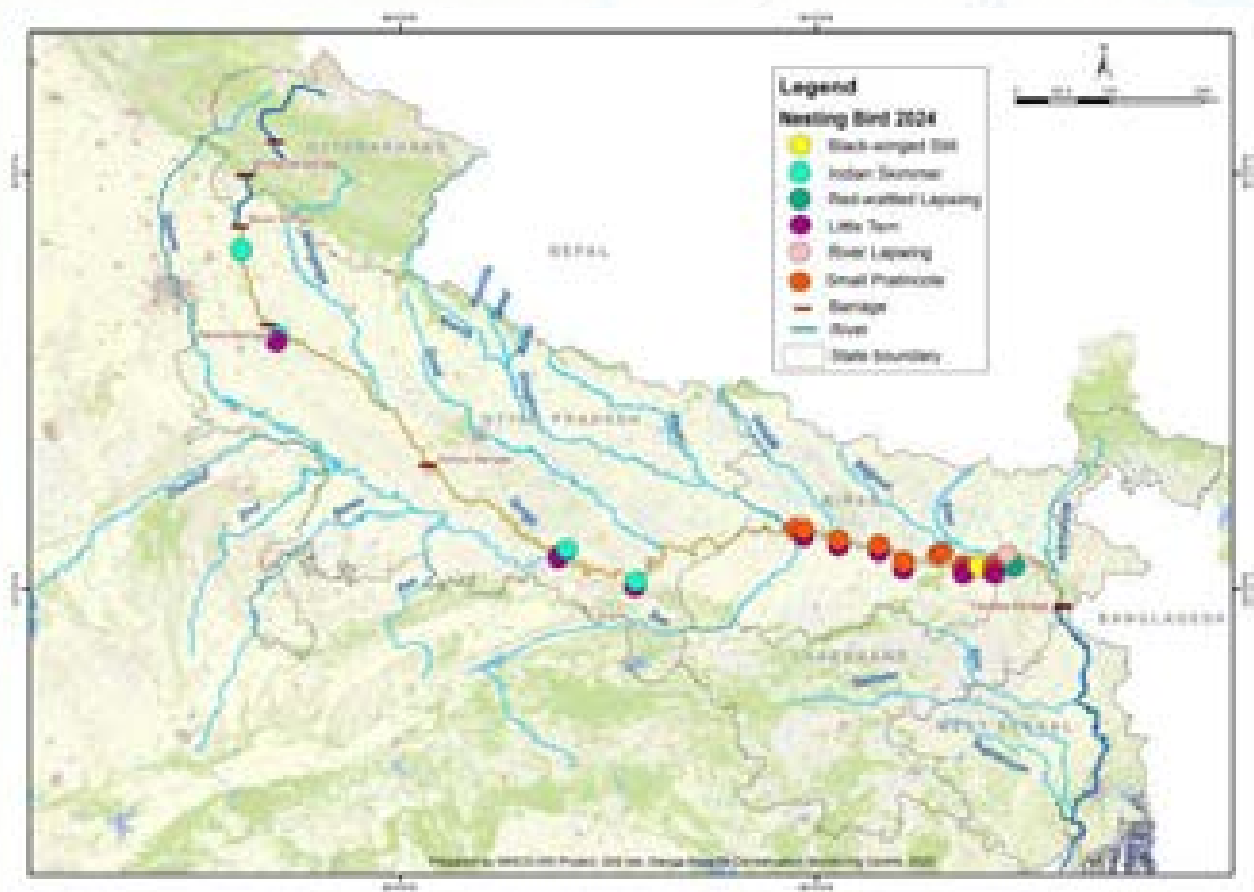


Figure 2.2 Nesting sites of different island nesting birds in the Ganga River during Second Pre-Monsoon Survey (2024)

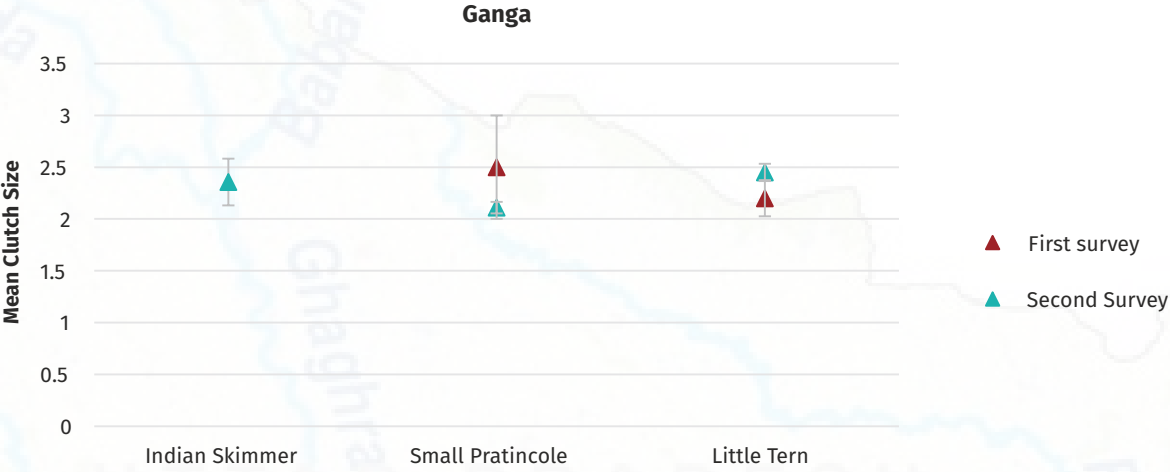


Figure 2.3. Mean clutch size (±SE) of three key island nesting waterbirds

Table 2.1. Summary of island nesting bird species and nests observed in the Ganga River

| Year | Species name        | Nesting event (number) | Clutch size (number) | Unhatched eggs (number) | Hatchling (number) | Fledgling (number) |
|------|---------------------|------------------------|----------------------|-------------------------|--------------------|--------------------|
| 2023 | Black-winged stilt  | 1                      | 4                    | 4                       | -                  | -                  |
|      | Little tern         | 15                     | 1-3                  | 27                      | 7                  | 2                  |
|      | Small pratincole    | 2                      | 2-3                  | 4                       | 2                  | 54                 |
|      | Total               | 18                     |                      | 35                      | 9                  | 56                 |
|      | Black-winged stilt  | 3                      | 4                    | 12                      |                    |                    |
|      | Indian skimmer      | 21                     | 1-3                  | 30                      | 4                  | 5                  |
|      | Little tern         | 80                     | 1-4                  | 166                     | 25                 | 1                  |
|      | Red-wattled lapwing | 1                      | 1                    | 1                       |                    |                    |
| 2024 | River lapwing       | 4                      | 1-4                  | 11                      |                    |                    |
|      | Small pratincole    | 143                    | 1-5                  | 264                     | 28                 | 6                  |
|      | Total               | 252                    |                      | 484                     | 57                 | 12                 |

## 2.2. CHAMBAL RIVER

A total of 25 potential nesting islands were monitored on the Chambal River, covering 250 km, with a survey effort of 15.62 km/day during May 2024. A total of 139 nesting events of eight island nesting species, viz. black-bellied tern, black-winged stilt, great thick-knee, Indian skimmer, little tern, river lapwing, river tern and small pratincole were recorded from nine river islands of the Chambal River between Pali and Bareh (Chambal-Yamuna confluence) (Figure 2.4). For species like great thick-knee and river lapwing, only hatchlings were recorded, whereas for the rest of the species, unhatched eggs, hatchlings and fledglings were recorded (Table 2.2).

Out of 139 nesting events, 51 were recorded for little tern, followed by 40 events for river tern, 31 for Indian skimmer and nine for small pratincole. The little tern had the highest number of unhatched eggs (n=50), followed by the river tern (n=38) and the Indian skimmer (n=31). While, highest fledgling numbers belonged to the Indian skimmer (n=75), followed by the river tern and pratincole with five each, and the highest number of hatchlings belonged to the little tern and the river tern (Table 2.2). The average clutch size of the Indian skimmer was found to be 2.82±0.26 (Range 1-4), 2.50±0.22 (1-4) for river tern, 2.32±0.17 (1-4) for little tern and 1.80±0.37 (1-3) for small pratincole (Figure 2.5).

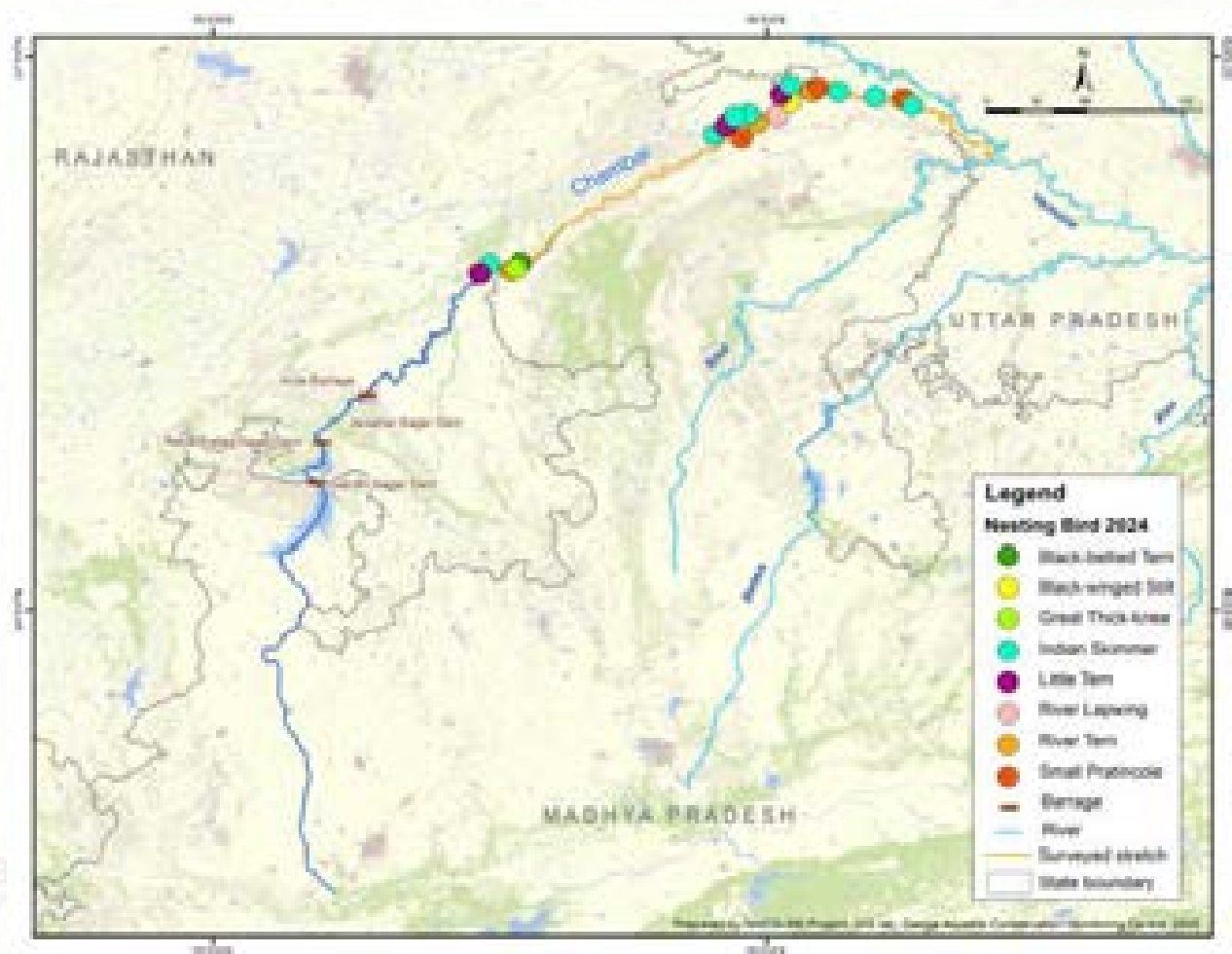


Figure 2.4. Nesting sites of different island nesting birds in the Chambal River during Second Pre-Monsoon Survey (2024)

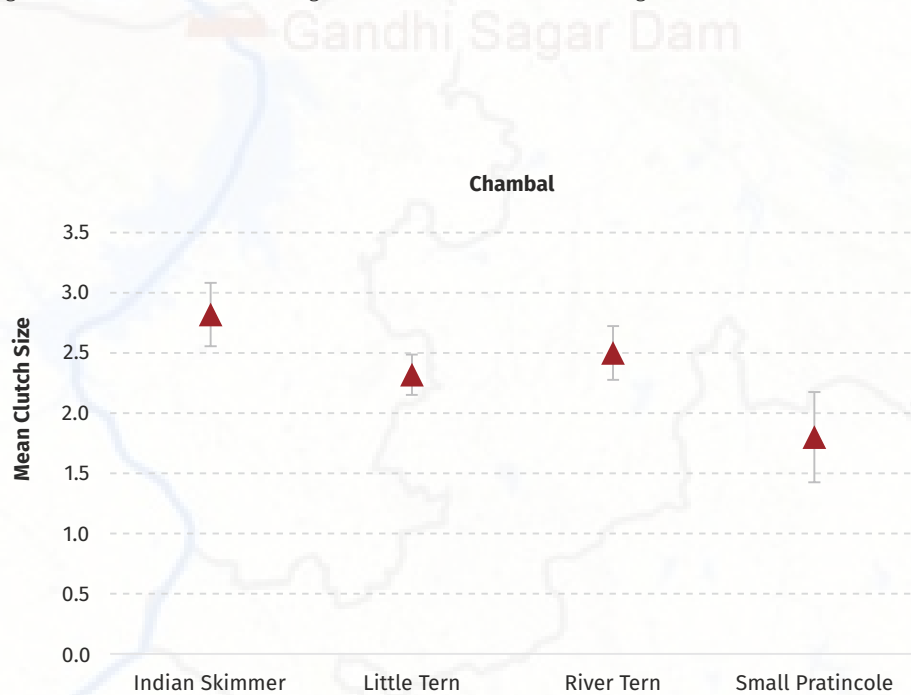


Figure 2.5. Mean clutch size of key nesting island birds from the Chambal River

**Table 2.2.** Summary of island nesting bird species and nests observed in the Chambal River

| Species            | Nesting events | Total unhatched eggs | Total hatchlings | Total fledglings |
|--------------------|----------------|----------------------|------------------|------------------|
| Black-bellied tern | 5              | 2                    | 3                | -                |
| Black-winged stilt | 3              | 3                    | -                | -                |
| Great thick-knee   | -              | -                    | 1                | -                |
| Indian skimmer     | 31             | 31                   | 2                | 75               |
| Little tern        | 51             | 50                   | 6                | 2                |
| River lapwing      | -              | -                    | 3                | -                |
| River tern         | 40             | 38                   | 6                | 5                |
| Small pratincole   | 9              | 9                    | 2                | 5                |
| Grand total        | 139            | 133                  | 23               | 87               |

## 2.3. GANDAK RIVER

### 2.3.1. Island nesting waterbirds of the Gandak River

About 238 km of the Gandak River was monitored with a survey effort of 39.66 km/day, for identifying the island nesting riverbirds in June 2023. Out of 18 monitored islands in the Gandak River, only one nesting island

was observed. During this survey, small pratincole, the only island nesting species, was recorded, with 21 fledglings within 40 m distance from the shoreline. Subsequently, during the second pre-monsoon survey (early June, 2024) with the same survey effort, again only one active nesting island was found among 17 river islands (Table 2.3; Figure 2.6). A total of three nesting events with four clutches and four unhatched eggs of small pratincoles were recorded in the river island with an average 1.33 (1-2) clutch size and one fledgling.



**Figure 2.6.** Nesting sites of Small Pratincole in the Gandak River

Table 2.3. Summary of island nesting bird species and nests observed in the Gandak River

| Year | Species name     | No of nests | Clutch size | Unhatched eggs | Hatchling | Fledgling |
|------|------------------|-------------|-------------|----------------|-----------|-----------|
| 2023 | Small pratincole | -           | -           | -              | -         | 21        |
| 2024 | Small pratincole | 3           | 1-2         | 4              | -         | 1         |
|      | Total            | 3           |             | 4              |           | 22        |

2.4. GHAGHRA RIVER

2.4.1. Island nesting waterbirds of the Ghaghra River during 2023

The first (May-June, 2023) nesting waterbird survey was conducted on the Ghaghra River with a survey effort of 61.2 km/day from Kailashpuri Dam to Revalganj, covering 612 km. The survey covered a total of 57 islands on the Ghaghra River. Nesting activity for 11 waterbird species was recorded, which included Indian skimmer,

river tern, river lapwing, little ringed plover, little tern, red-wattled lapwing, Indian thick-knee, pheasant-tailed jacana, small pratincole, greater painted snipe, and watercock (Figure 2.7). A total of 183 nests, 331 unclutched eggs, 52 hatchlings, and 633 fledglings were recorded. Of these, the Indian skimmer nests were found on 17 islands, with a total of 45 nests, 92 unhatched eggs, 18 hatchlings and 64 fledglings (Table 2.5). Mean clutch size of Indian skimmer was  $2.47 \pm 0.18$  (1-4),  $1.86 \pm 0.05$  (1-3) for small pratincole, and  $1.71 \pm 0.17$  (1-3) for little tern (Figure 2.9).

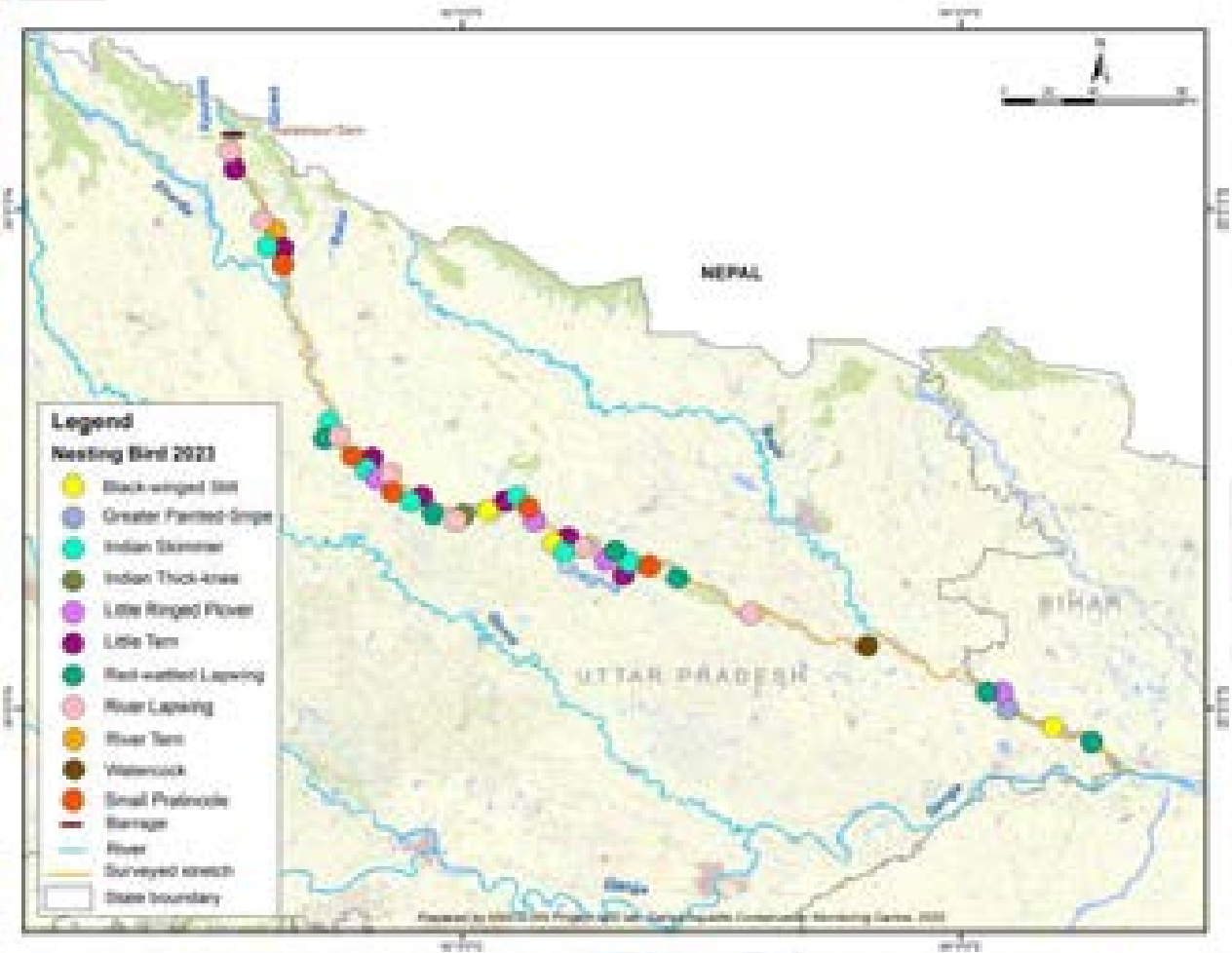
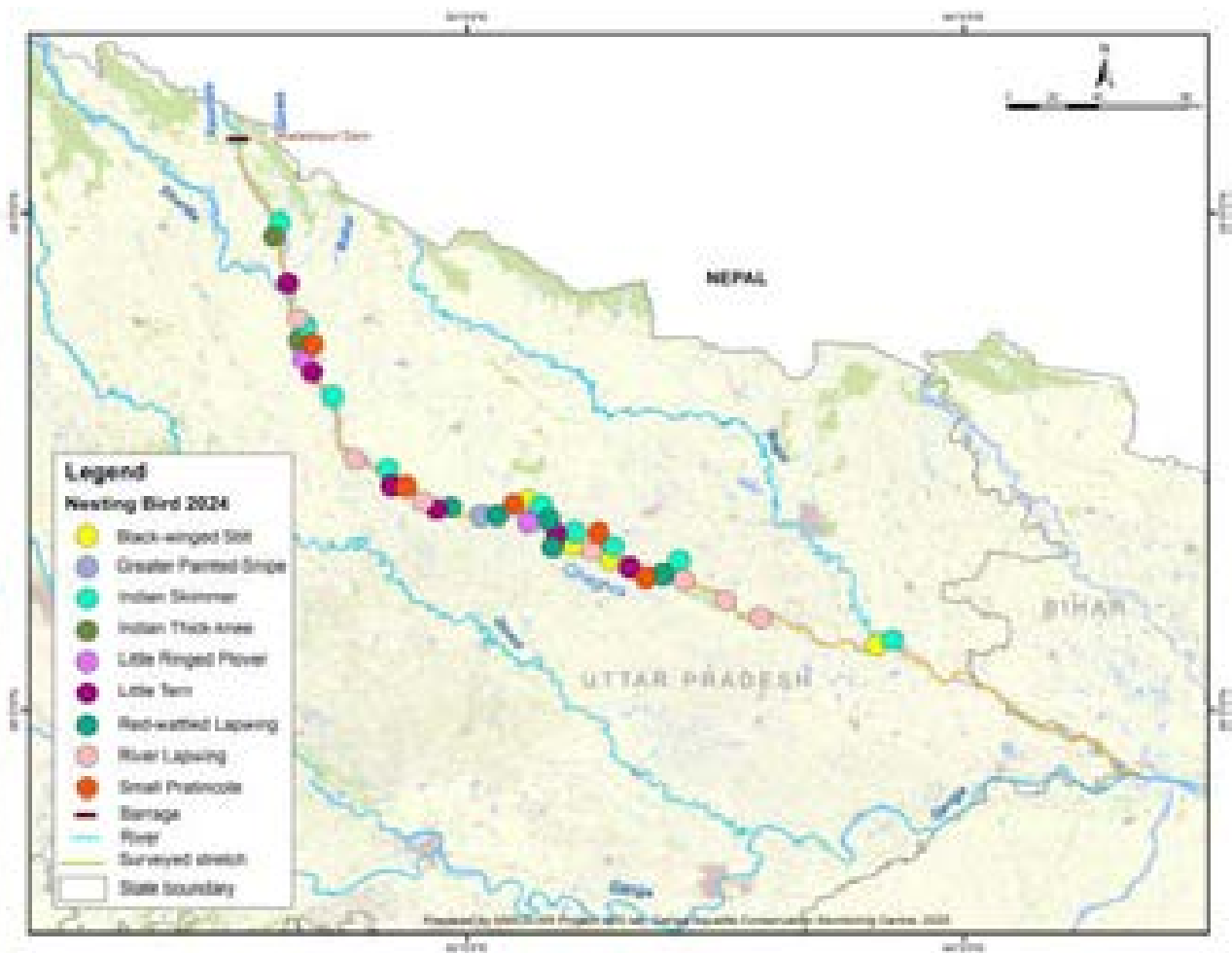


Figure 2.7. Nesting sites of different island nesting birds in the Ghaghra River during First Pre-Monsoon Survey (2023)



**Figure 2.8.** Nesting sites of different island nesting birds in the Ghaghra River during Second Pre-Monsoon Survey (2024)

### 2.4.2. Island nesting birds of the Ghaghra River during 2024

The nest monitoring was also conducted between Kailashpuri Dam and Revalganj, covering about 612 km, with a survey effort of 51 km/day during April-May, 2024. A total of 51 river islands were surveyed, and nesting occurrences were observed and recorded from 37 islands. The formation of islands varies due to the temporal fluctuation of water level in the river, perhaps attributed to the formation of relatively fewer islands during the second survey, particularly small islands. A total of 542 nests belonging to nine waterbird species, such as black-winged stilt, greater painted-snipe, Indian skimmer, Indian thick-knee, little ringed plover, little tern, red-wattled lapwing, river lapwing, and small pratincole, were recorded (Figure 2.8). Among these islands, the presence of Indian skimmers was confirmed from 15 islands with 36 nests and 123 unhatched eggs (Table 2.4). The average clutch size of Indian skimmer ( $3.42 \pm 0.13$ ; 2-5), small pratincole ( $2.01 \pm 0.02$ ; 1-3) and little tern ( $2.70 \pm 0.05$ ; 1-3) was found higher during the second survey (2024) than first (2023) (Figure 2.9).



Status of the Island Nesting Waterbirds in the Ganga and select tributaries

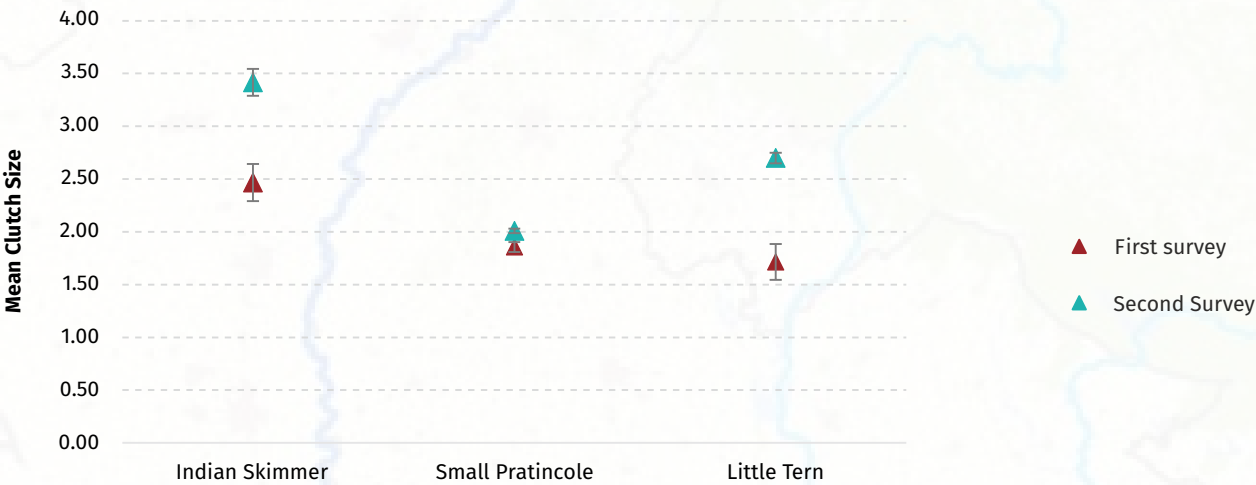


Figure 2.9. Average clutch size of Key species in the Ghaghra River

Table 2.4. Summary of island nesting bird species and nests observed in the Ghaghra River

| Year | Species name          | No of nests | Unhatched eggs | Hatchling | Fledgling |
|------|-----------------------|-------------|----------------|-----------|-----------|
| 2023 | Black-winged stilt    | 5           | 18             | -         | 13        |
|      | Greater painted-snipe | -           | -              | -         | 2         |
|      | Indian skimmer        | 45          | 92             | 18        | 64        |
|      | Indian thick-knee     | 1           | 4              | -         | 0         |
|      | Little tern           | 19          | 33             | 1         | 177       |
|      | Little ringed plover  | 2           | 5              | -         | 8         |
|      | River lapwing         | 1           | 2              | -         | 49        |
|      | Red-wattled lapwing   | 4           | 15             | 1         | 12        |
|      | River tern            | 3           | 9              | -         | -         |
|      | Small pratincole      | 102         | 151            | 32        | 308       |
|      | Watercock             | 1           | 2              | -         | -         |
|      | Total                 | 183         | 331            | 52        | 633       |
|      | Black-winged stilt    | 14          | 51             | -         | -         |
|      | Greater painted-snipe | 1           | 2              | -         | -         |
|      | Indian skimmer        | 36          | 123            | 0         | -         |
|      | Indian thick-knee     | 1           | 4              | -         | 2         |
|      | Little tern           | 113         | 284            | 18        | -         |
| 2024 | Little ringed plover  | 2           | 3              | -         | -         |
|      | River lapwing         | 17          | 54             | 1         | -         |
|      | Red-wattled lapwing   | 11          | 41             | -         | -         |
|      | Small pratincole      | 347         | 643            | 37        | -         |
|      | Total                 | 542         | 1205           | 56        | 2         |

## 2.5. YAMUNA RIVER

### 2.5.1. Island nesting birds of the Yamuna River during 2023

The lower stretch of the Yamuna River was monitored, with a survey effort of 72.66 km/day, between Pachnada and Prayagraj during May-June 2023, covering 436 km and 40 potential islands. A total of 31 nesting events for seven island waterbird species including little tern, small pratincole, Indian skimmer, river lapwing, black-

winged stilt, great thick-knee, and little ringed plover, were recorded across the 14 river islands in the lower Yamuna River (Table 2.5; Figure 2.10). The average clutch size of the Indian skimmer was  $2.25 \pm 0.48$  (1-3), 2 for the small pratincole, and  $2.24 \pm 0.15$  (1-4) for little tern (Figure 2.12). The maximum nesting events were recorded for little tern ( $n= 21$ ), followed by other waterbirds. A total of two nesting events were recorded for the river lapwing in the Yamuna River and four events for the Indian skimmer (Table 2.5). Three fledglings of great thick-knee were observed, while 4 for little ringed plover and 11 for black-winged stilt.

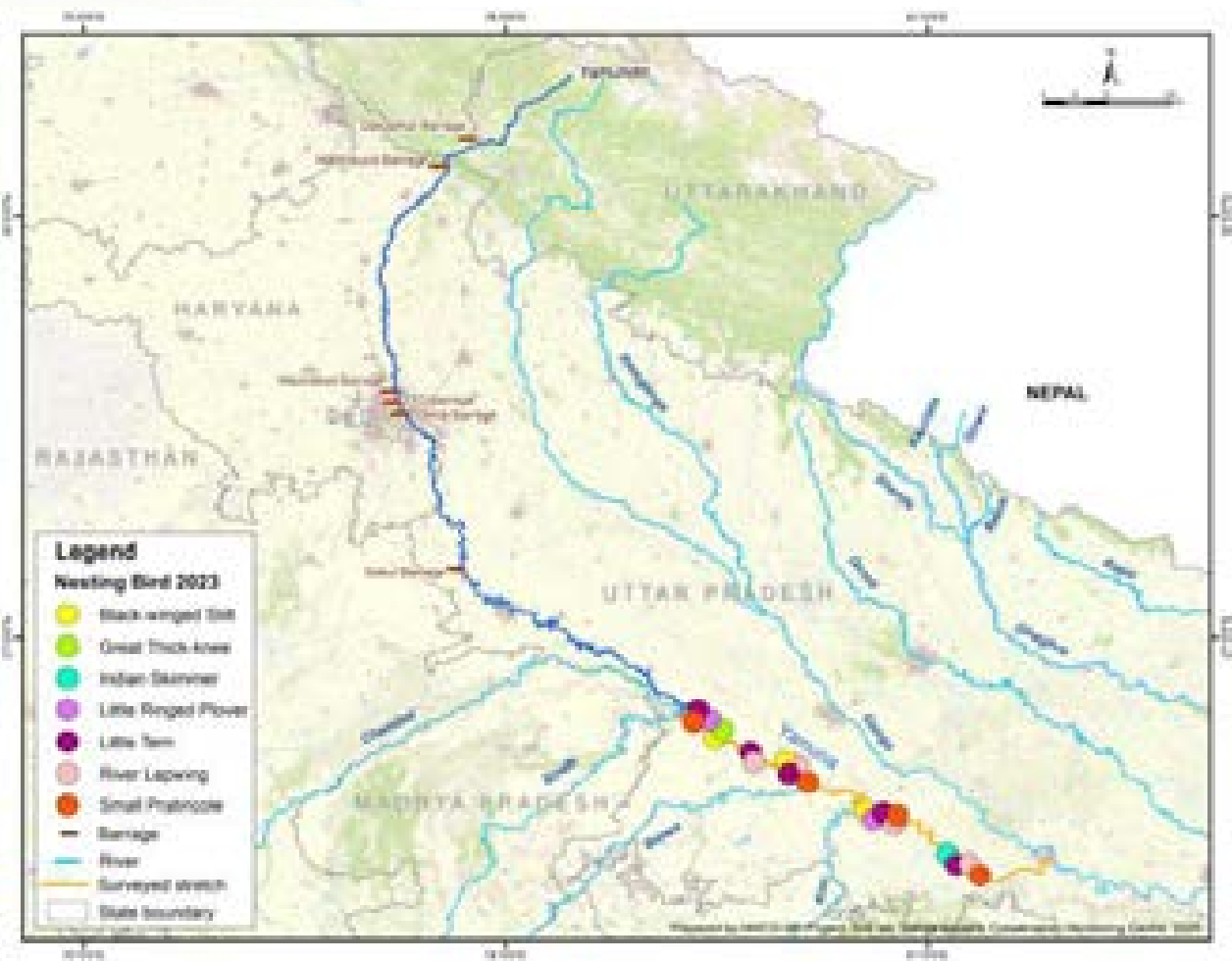
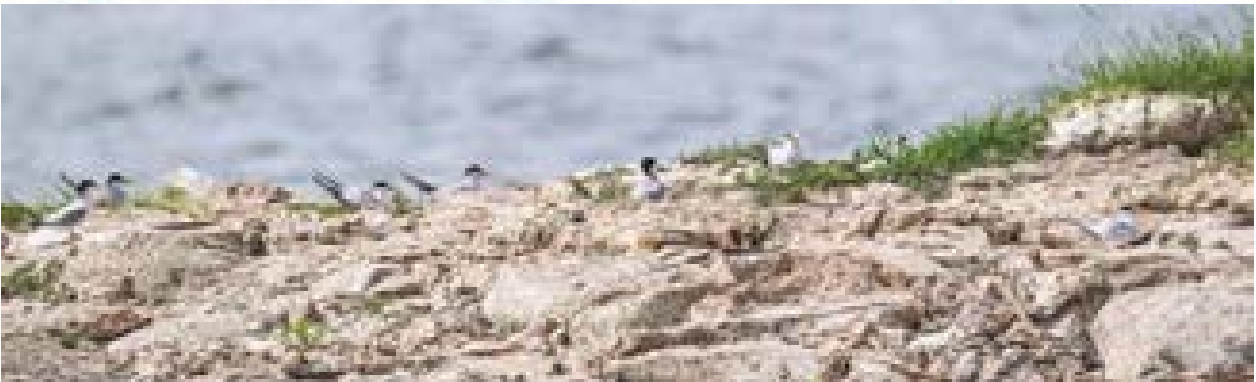


Figure 2.10. Nesting sites of different island nesting birds in the Yamuna River during First Pre-Monsoon Survey (2023)



2.5.2. Island nesting birds of the Yamuna River during 2024

During the second pre-monsoon survey (May 2024), the potential nesting islands were monitored with a survey effort of 62.28 km/day, covering about 436 km. A total of 852 events were recorded for eight breeding species between the lower Yamuna River stretch of Pachnada and Prayagraj. Out of 44 surveyed potential islands, active nesting was recorded from 41 islands. The nesting events of eight breeding species were recorded in the Yamuna River islands, namely black-winged stilt, greater painted-snipe, Indian skimmer, little tern, red-wattled lapwing, river lapwing, small pratincole, and white-browed wagtail (Table 2.5). The average clutch size of the Indian skimmer (4) was found to be higher during the second survey than the first, while the small pratincole clutch was calculated as  $1.8 \pm 0.09$  (1-4) and  $2.59 \pm 0.11$  (1-4) for the little tern (Figure 2.11). A total of 852 nesting events, 2093 unhatched eggs, 60 hatchlings and 252 fledglings of different species were recorded during this survey. Among these islands, maximum nesting events were recorded for the little tern (n=548), followed by the black-winged stilt (159) and the small

pratincole (99) (Table 2.5). The presence of the Indian skimmer was reconfirmed from the previously identified island at Mau, where two nests, eight unhatched eggs, and nine fledglings were recorded with a mean clutch size of 4, during the second pre-monsoon survey (2024) (Figure 2.12). In small pratincoles, the mean clutch size varied between 1 and 4 clutches (1.8) during the second survey, and it ranged from 1 to 4 (2.59) for little tern.

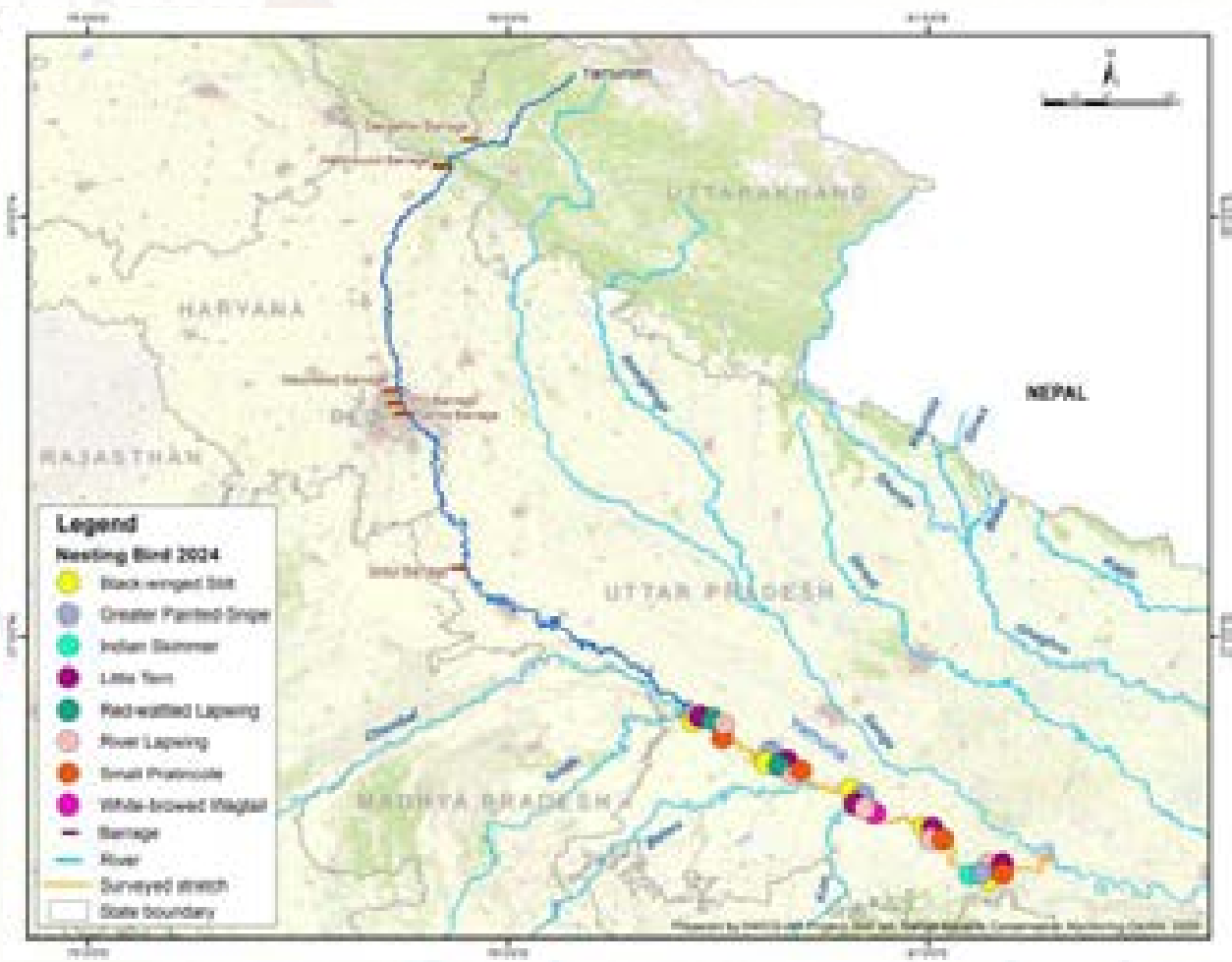


Figure 2.11. Nesting sites of different island nesting birds in the Yamuna River during Second Pre-Monsoon Survey (2024)

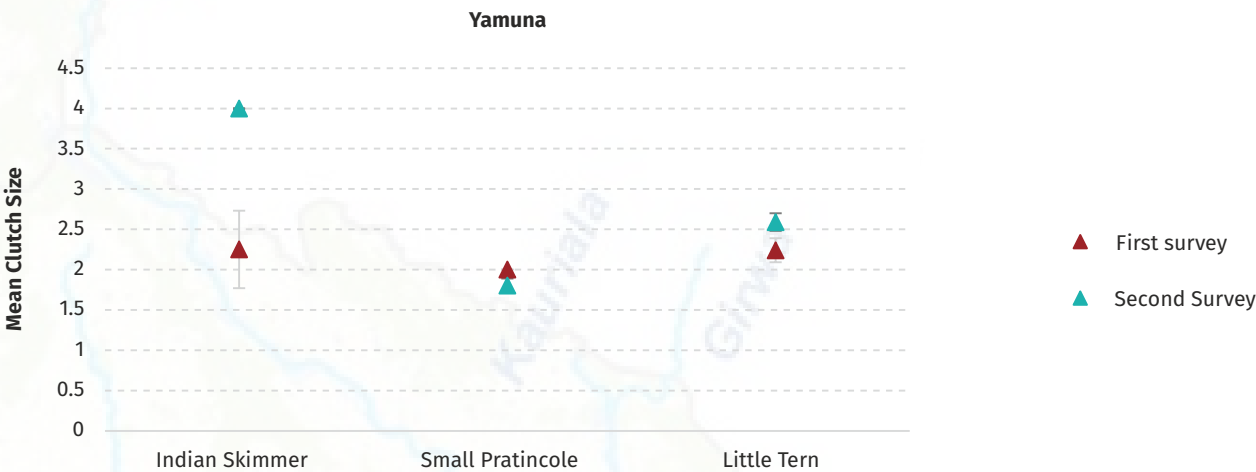


Figure 2.12. Mean clutch size of key nesting island birds during First (2023) and Second (2024) Pre-Monsoon Survey

2.5.3. Mixed Clutch and Brood Parasitism

During the second pre-monsoon survey, mixed clutches of two species were encountered on four occasions, likely indicating incidents of brood parasitism. These mixed clutches contained unhatched eggs and hatchlings of the little tern in the nests of black-winged stilt (Figure 2.13). Antagonistic inter-species interactions

between parent stilts and terns were observed, in which stilts chased away brood parasitic little terns whenever approaching their nests. In addition, black-winged stilt was observed incubating all the eggs in their clutches irrespective of their identity. On one occasion, a black-winged stilt was observed caring for one little tern hatchling along with its two own hatchlings. Although brood parasitism is found across many avian species, such events have not been observed for the little tern and the black-winged stilt.

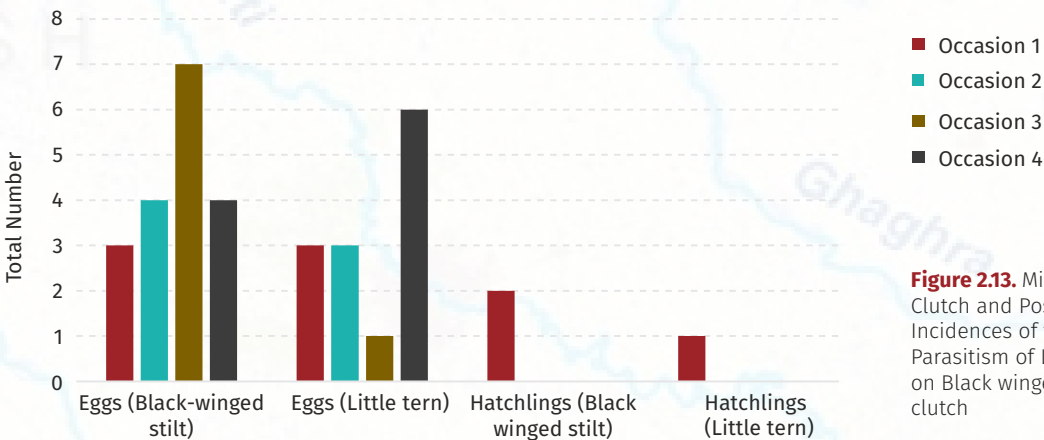


Figure 2.13. Mixed Clutch and Possible Incidences of the Brood Parasitism of Little tern on Black winged stilt clutch



Nesting sites of black-winged stilt and little tern in the Yamuna River

Table 2.5. Summary of island nesting bird species and nests observed in the Yamuna River

| Year  | Species name          | Total nesting events | Unhatched eggs | Hatchling | Fledgling |
|-------|-----------------------|----------------------|----------------|-----------|-----------|
| 2023  | Black-winged stilt    | -                    | -              | -         | 11        |
|       | Greater thick-knee    | -                    | -              | -         | 3         |
|       | Indian skimmer        | 4                    | 9              | -         | 9         |
|       | Little ringed plover  | -                    | -              | -         | 4         |
|       | Little tern           | 21                   | 46             | -         | 210       |
|       | River lapwing         | 2                    | 1              | -         | 31        |
|       | Small pratincole      | 4                    | 7              | -         | 271       |
|       | Total                 | 31                   | 63             | -         | 539       |
|       | Black-winged stilt    | 159                  | 554            | -         | -         |
|       | Greater painted snipe | 3                    | 3              | -         | 12        |
| 2024  | Indian skimmer        | 2                    | 8              | -         | 9         |
|       | Little tern           | 548                  | 1371           | 50        | 107       |
|       | River lapwing         | 31                   | 95             | 5         | 19        |
|       | Red-wattled lapwing   | 8                    | 8              | -         | 3         |
|       | Small pratincole      | 99                   | 54             | 3         | 102       |
|       | White-browed wagtail  | 2                    | -              | 2         | -         |
| Total |                       | 852                  | 2093           | 60        | 252       |

2.6. RAMGANGA RIVER

Kalagarh (Ramnagar) reservoir, located on the Ramganga River, was surveyed during March 2022. A total of 35 nests of river tern were observed during this survey (Figure 2.14). Of which three eggs were damaged, and the average clutch size was calculated as 2.63±0.12 with a range of 1-3. The fluctuation in water level of the reservoir determines the availability of islands in the reservoir, especially when the water level recedes significantly. These nesting sites were located in the eastern direction of the reservoir. Apart from the river terns, 10 individuals of small pratincole were recorded with no evidence of breeding activity.



Figure 2.14. Nesting site in Kalagarh Dam (Ramaganga River)

2.7. SON RIVER

Monitoring of island nesting waterbirds in a 20 km stretch of the Son River was conducted during May 2024. A total of 44 nesting events, including 103 unhatched

eggs, 18 hatchlings and 2 fledglings of five island nesting waterbird species were recorded (Table 2.7; Figure 2.15). The average clutch size of the Indian skimmer was  $3.03 \pm 0.16$ , the little tern was  $2.81 \pm 0.23$ , and the river lapwing was  $2 \pm 1$ . Only one clutch each was recorded for the black-bellied tern with a clutch size of 4 and the river tern with a clutch of 2 (Figure 2.16).



Figure 2.15. Nesting sites of the Island Nesting Waterbirds in the Son River, Madhya Pradesh

Table 2.7. Summary of island nesting bird species and nests observed in the Son River

| Species            | Total nesting events | Total unhatched eggs | Total hatchling | Total fledglings |
|--------------------|----------------------|----------------------|-----------------|------------------|
| Black-bellied tern | 1                    | 4                    | -               | -                |
| Indian skimmer     | 29                   | 65                   | 15              | 2                |
| Little tern        | 11                   | 29                   | 2               | -                |
| River lapwing      | 2                    | 3                    | 1               | -                |
| River tern         | 1                    | 2                    | -               | -                |
| Grand total        | 44                   | 103                  | 18              | 2                |

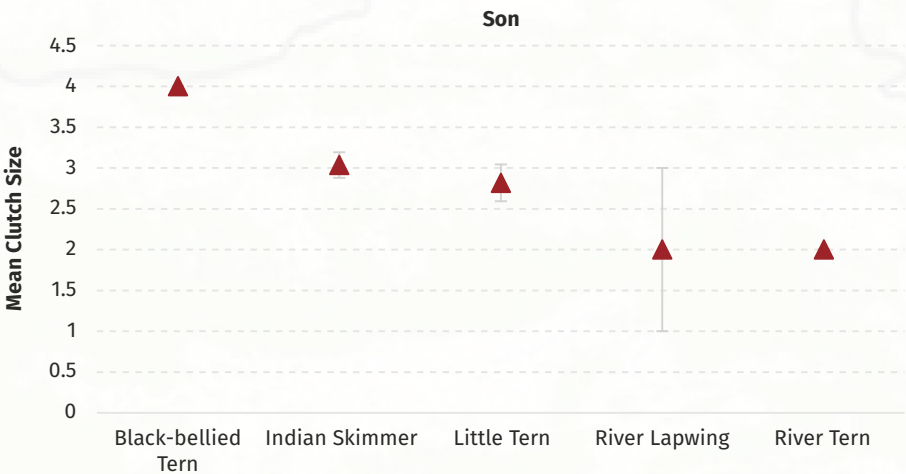


Figure 2.16. Average clutch size of nesting birds in the Son River during second survey, 2024

# NEST SITE CHARACTERISTICS AND ANTHROPOGENIC PRESSURES ACROSS THE RIVERS

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# 3.

## 3.1. GANGA

All the nesting waterbirds were found to be using sandy substrate for egg laying during both surveys, and the area of nesting islands varied from 0.5 to 4 sq. km. The average distance to the shoreline from the nest was recorded as  $44.59 \text{ m} \pm 10.90$  (SE) during the first survey, while it this distance was almost three times greater ( $124.47 \text{ m} \pm 5.46$ ) during the second survey. In most of the stretch, river width was  $>1000 \text{ m}$ , while  $400 \text{ m}$  was the shortest width recorded near nesting islands in the lower Ganga River. The presence of free-ranging dogs was confirmed on eight river islands during the first survey. This survey also recorded the presence of dead fledglings and abandoned eggs. During the second survey, the pack size of 3 - 5 dogs in the lower Ganga stretch was noted. Human presence was confirmed from only one island. Livestock was not recorded from any of the nesting islands in the lower Ganga. Although in the second survey, human presence was confirmed from 26% of the nesting islands, animal presence (potentially predator) was recorded from 20% of the islands. Additionally, livestock and riverbed agriculture practices were present in only one island out of 10 active nesting islands of the lower Ganga River.

## 3.2. CHAMBAL

Sand was the uniformly used as nest substrate by all nesting waterbird species between Pali and Dholpur stretch of the Chambal River, except on a rare occasion where the Indian skimmer used sand with pebbles to construct a nest cavity. The average distance of nests from the river shoreline was  $153.89 \text{ m} \pm 3.22$ . Despite the Chambal River being a protected area, there are several threats visible to wildlife, including nesting waterbirds. Among anthropogenic pressures, out of 11 nesting islands, five were facing the issues of sand mining

during the breeding season of waterbirds, while 27% of nesting islands were facing the problem of livestock grazing, which often leads to trampling of eggs and chicks. The presence of natural predators like jackals was confirmed from one of the nesting islands.

## 3.3. GANDAK

In the river islands with nesting activities, along the Gandak River, the nest substrate for all events was sand. The average distance between two nests was sparse ( $250 \pm 50 \text{ m}$ ), and the average distance to the shoreline was  $116.66 \text{ m} \pm 16.67$ . The island area was upto 5.6 sq. km. Among anthropogenic pressures, human presence on river bed agriculture was recorded on the islands, however, we did not record any human settlement or livestock evidence.

## 3.4. SON

Interestingly, all island nesting species utilized sand as substrate for all the nesting events in the Son River. The average distance of nest or clutch from the river shoreline was recorded as  $143.46 \text{ m} \pm 11.79$ . In anthropogenic pressures, all active nesting islands had the presence of humans, livestock and predators, while island agriculture was not practised in these islands.

## 3.5. GHAGHRA

Most of the species used sand substrate for nesting, except the Indian thick-knee and greater painted snipe. Species like the Indian skimmer and the little ringed plover preferred sand with a rare nesting event on clay substratum. During the second survey, the Indian thick-knee was found to prefer a clay substratum for nesting, and the greater painted snipe used a clay/loam substrate. Black-winged stilt used sand (60%) and clay (40%). The pratincole preferred sand substrate ( $> 90\%$ )

and occasionally clay for nesting on islands of the Ghaghra River. River tern and watercock completely preferred sand substratum (Figure 3.1). Comparatively fewer nesting bird species were recorded during the second pre-monsoon survey. Nesting island species such as great painted-snipe only used clay/loam substrate for nesting, while species like Indian thick-knee and little ringed plover only used sand substratum for nesting. In a couple of events, Indian skimmer used mixed soil, otherwise preferred sand (>90%) and similarly, little tern was occasionally found

using mixed and clay/loam substrates for nesting in the Ghaghra River (Figure 3.2).

The average distance of nests from river current was 35.33 m  $\pm$  23.48, with variation up to 500 m, and average distance to river bank (shoreline) was 56.33 m  $\pm$  23.48, which varied between 22-521 m, during the first pre-monsoon survey. Whereas, the average distance of the nest from the river current was 15.22 m  $\pm$  1.64, and the average distance from the river shoreline was 80.14 m  $\pm$  8.96, during the second survey.

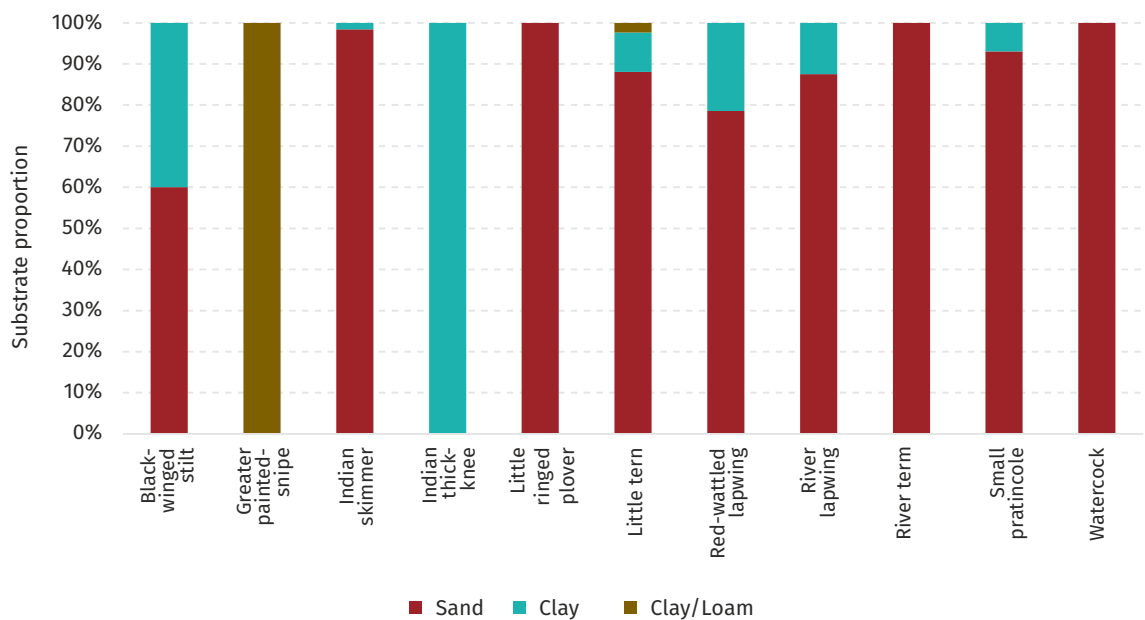


Figure 3.1. Nest Substrate proportion of island nesting waterbirds during first survey

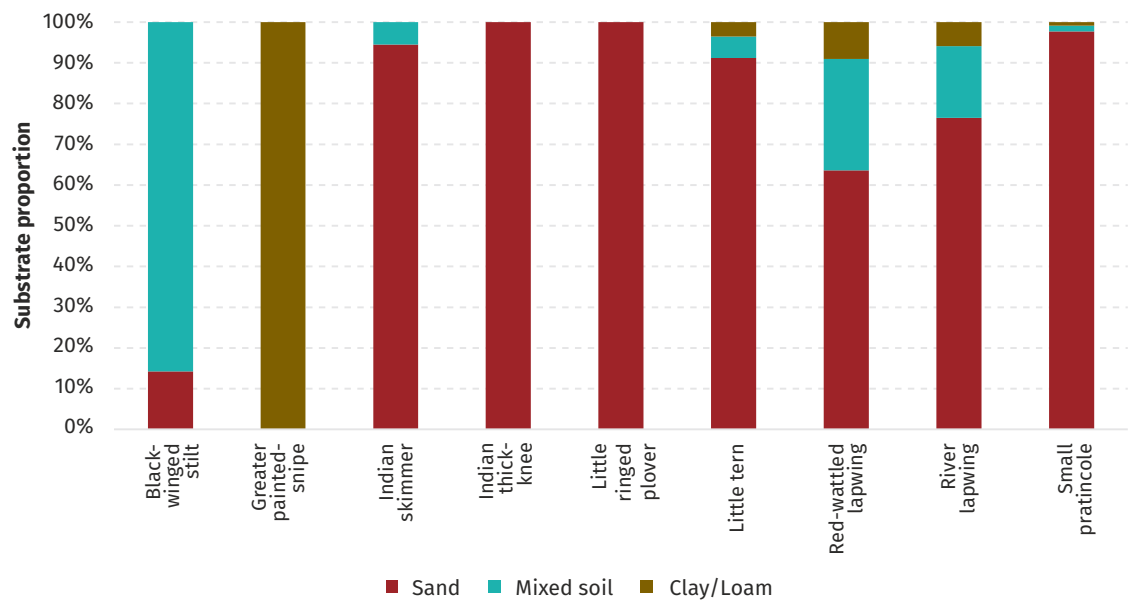


Figure 3.2. Nest Substrate proportion of island nesting waterbirds during the second survey

On a broader scale, major threats to the nesting birds in the Ghaghra River were attributed to sand mining, cattle grazing, and free-ranging dogs. Animal predators include the Indian monitor lizard, jackals, jungle cats, and raptors. Disturbance factors such as the presence of free-ranging dogs, raptors, crows, cattle, riverbed agriculture, mining, and other human-induced activities were also recorded. During the first pre-monsoon survey, 19% of the nesting islands had human presence, while 14% had livestock presence. Animal presence, including potential predators, was reported from 19% of the nesting islands. During the second pre-monsoon survey, 33% of the nesting islands had human presence, while livestock presence was confirmed from 30% of the nesting islands in the Ghaghra River. Animal presence was reported from 47% of the surveyed islands, higher than in the previous survey. No agricultural activity was recorded during the first survey, while during the second survey, about 11% of the nesting islands (11%) had cucurbits sown.

### 3.6. YAMUNA

During the first survey, an average distance of  $4.57 \text{ m} \pm 0.67$  was recorded between the nearest nest, which was  $3.53 \text{ m} \pm 0.17$  during the second survey. Waterbirds prefer colonial nesting mainly for protection from predators, efficient use of suitable habitats, and easy mate selection. However, they maintain a substantial distance from the nearby nest to avoid any probable resource competition or disturbance. Being a specialist, the Indian skimmer specifically used sandy substrate for nesting during both years, whereas other species utilized different types of substrates for nesting purposes. The little ringed plover and river lapwing used sand and clay substrates. Black-winged stilt, little

tern and small pratincole used a combination of sand, clay and pebble substrates during the first pre-monsoon survey in 2023 (Figure 3.3). Species like river lapwing and small pratincole mostly utilized sandy substrate along with rocky, loam and pebble, while greater painted-snipe, little tern and red-wattled lapwing used sandy as well as loamy and pebble substrates for nesting during the second pre-monsoon survey (Figure 3.4). Only a single nesting event was recorded for species like the great thick-knee during the first survey, and the white-browed wagtail during the second survey. In terms of offspring, little tern and small pratincole were the most abundant breeding species in the Yamuna River during both surveys. Comparatively, a high proportion of sandy substrate was preferred for nesting by small pratincole (70%) and little tern (90%) during the second survey than first.



Dead chick of little tern found at nesting site, likely due to predation

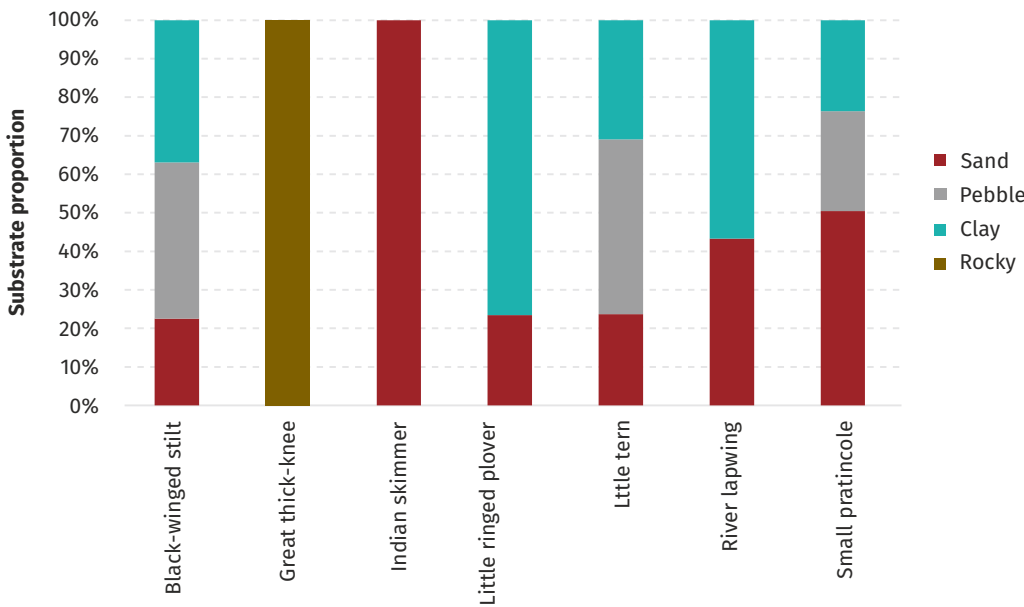
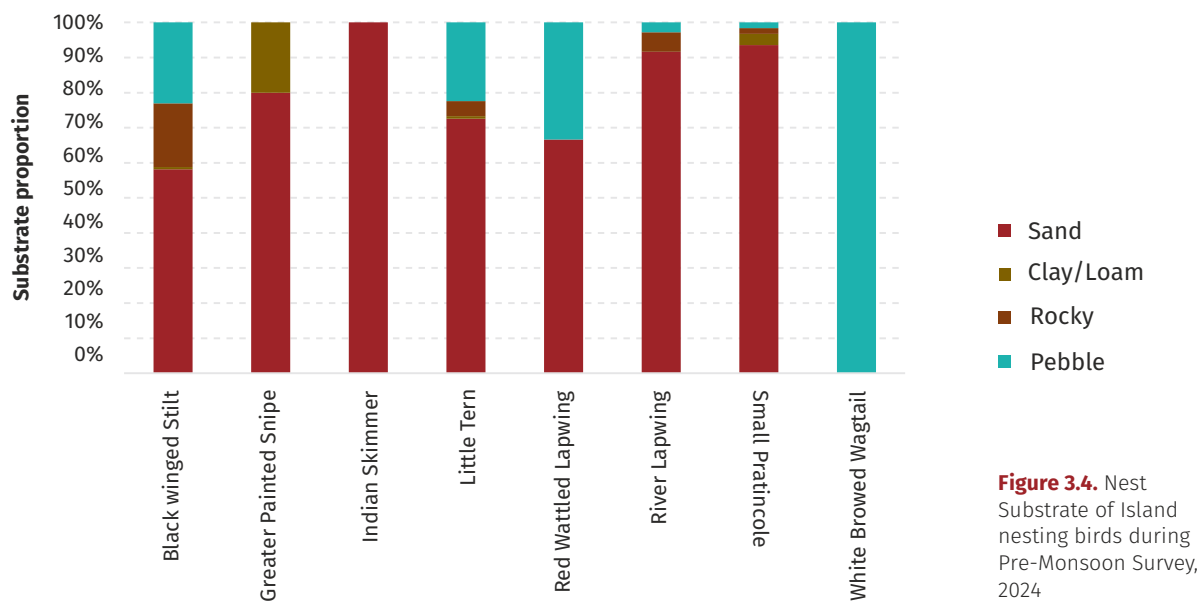


Figure 3.3. Nest Substrate of Island nesting birds during Pre-Monsoon Survey, 2023



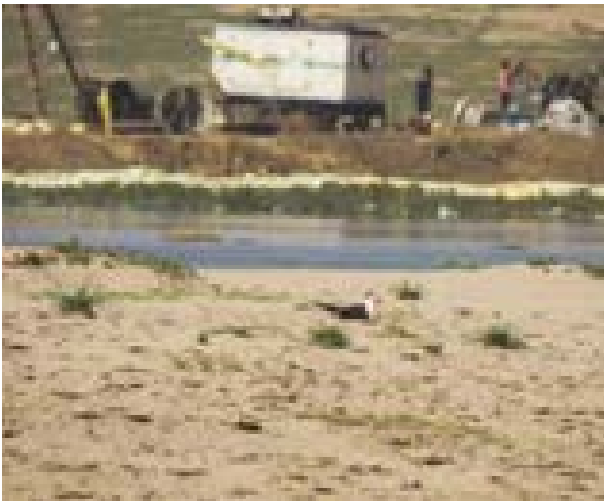
**Figure 3.4.** Nest Substrate of Island nesting birds during Pre-Monsoon Survey, 2024

During the first pre-monsoon survey (2023), the average distance from the river shoreline was about 229.38 m  $\pm$  13.29, and the average distance of nest fledgling/hatchling from the river current was 7.50 m  $\pm$  1.57. In contrast, the average distance of the nest/fledgling/hatchling was 156.09 m  $\pm$  4.77 from the shoreline and 7.10 m  $\pm$  0.30 away from the river current during the second pre-monsoon survey (2024). The area of the nesting island varied between 0.001 and 1.24 sq. km during the first survey, while it ranged between 0.001 and 1.1 sq. km during the second survey.

A few instances of unhatched eggs, comprising about 60 eggs of little tern and black-winged stilt, were observed near Udayan Fort in Kaushambi district, during the second survey. These eggs might have been collected by local people and later left behind.

More than 100 adults and fledglings of small pratincoles and a dead adult green sandpiper (*Tringa*

*ochropus*) were found dead, near a river island. The mortality could be due to poisoning or exposure to high concentrations of toxic chemicals in the river near Yamuna-Ken Confluence. Free-ranging dogs were also found to have contributed to the predation of fledglings and eggs. During the first pre-monsoon survey, the researcher witnessed four dogs chasing the fledglings, which resulted in death of 20 fledglings. During the second survey, predation by dogs was also observed on multiple occasions. The presence of humans and livestock was frequent along the lower stretch of the Yamuna River. During the second survey, apparent trampling of three fledglings each of little tern and black-winged stilt by cattle was recorded ~5 km downstream of Kalpi township. Sand mining through boats was quite prevalent after the Mau motor bridge till the Prayagraj railway bridge.



Flooding and developmental activities in and around nesting habitats

### 3.7. FACTORS INFLUENCING NESTING IN THE GHAGHRA AND YAMUNA RIVERS: A CASE STUDY

The factors affecting the nesting ecology of a few select species in the Ghaghra and Yamuna rivers were studied. In the Ghaghra River, eight variables were selected. To overcome overdispersion in data, the negative binomial family with log function was selected. Among multiple model outputs, the top five models ( $\Delta AICc \leq 2$ ) are given in Table 3.1. Factors like area of nesting island, distance to nearest nest and presence of livestock are some of the major factors that influenced the nesting

of little tern and small pratincole. Little terns are known to prefer small islands ( $< 3$  hectares) for nesting, perhaps as a strategy to avoid predation risk from terrestrial predators along with other factors like availability of food resources (Eason et al. 2012). The negative relation with inter-nest distance and island's area indicates that species are largely colonial nesting birds, which actually provides them with flock safety and less chances of predation (de leon et al. 2006; Beauchamp 2013). Generally, large islands are prone to more anthropogenic disturbances. Small pratincole was largely influenced by the presence of livestock and the island area, both of which negatively affected nesting.

**Table 3.1.** Generalized Linear Model of Little tern and Small pratincole in the Ghaghra River

| Model                                   | $\Theta$ Value | DF | LL       | AICc  | $\Delta AICc$ | AICc weight |
|-----------------------------------------|----------------|----|----------|-------|---------------|-------------|
| <b>Little tern</b>                      |                |    |          |       |               |             |
| ~ Area+ Distance to nearest nest        | 1.59           | 4  | -129.123 | 267.6 | 0             | 0.158       |
| ~ Area+ Livestock                       | 1.57           | 4  | -129.439 | 268.3 | 0.63          | 0.115       |
| ~Area                                   | 1.46           | 3  | -130.791 | 268.4 | 0.76          | 0.108       |
| ~ null                                  | 1.36           | 2  | -132.142 | 268.7 | 1.05          | 0.093       |
| ~Distance to Shoreline                  | 1.45           | 3  | -130.949 | 268.7 | 1.07          | 0.092       |
| <b>Small pratincole</b>                 |                |    |          |       |               |             |
| ~Area+ Livestock                        | 0.85           | 4  | -292.525 | 593.6 | 0             | 0.217       |
| ~Area+ Predator                         | 0.851          | 4  | -292.557 | 593.7 | 0.07          | 0.210       |
| ~Area                                   | 0.821          | 3  | -294.265 | 594.9 | 1.25          | 0.116       |
| ~Area+ Distance to shoreline + Predator | 0.859          | 5  | -292.096 | 595   | 1.43          | 0.106       |
| ~Area+ Distance to shoreline            | 0.835          | 4  | -293.576 | 595   | 1.90          | 0.084       |

In the top-ranked model of little tern (Table 3.2), area of nesting island, and distance to shoreline ( $\beta_{Area} = -0.40$ ,  $SE = 0.15$  and  $\beta_{Dist\_nest} = -0.34$ ,  $SE = 0.15$ ) showed a significant relation with the response variable. In the top model of small pratincole (Table 3.2), area of nesting island, and livestock presence ( $\beta_{Area} = -0.40$ ,  $SE = 0.11$  and  $\beta_{Livestock} = -0.58$ ,  $SE = 0.29$ ) influenced nesting events.

**Table 3.2.** Summary of top-ranked model variables in the Ghaghra River

| Variable                 | $\beta$ Estimate | SE     | z value | Pr(> z )  | Sig (p value) |
|--------------------------|------------------|--------|---------|-----------|---------------|
| <b>Little tern</b>       |                  |        |         |           |               |
| (Intercept)              | 2.8162           | 0.1431 | 19.681  | $< 2e-16$ | ***           |
| Area                     | -0.4006          | 0.1517 | -2.641  | 0.00827   | **            |
| Distance to nearest nest | -0.3444          | 0.1565 | -2.201  | 0.02775   | *             |
| <b>Small pratincole</b>  |                  |        |         |           |               |
| (Intercept)              | 3.1177           | 0.1566 | 19.908  | $< 2e-16$ | ***           |
| Area                     | -0.4021          | 0.1142 | -3.520  | 0.000431  | **            |
| Livestock                | -0.5818          | 0.2929 | -1.986  | 0.047032  | *             |

Signif. codes:  $p=^{****} 0.001$ ;  $^{***} 0.01$ ;  $^{**} 0.05$

All nine variables were used for analysis in the Yamuna River, of which a combination of variables like area of nesting island, vegetation and predator played a significant role in influencing nesting of black-winged stilt and little tern. Among multiple model outputs, the top four models ( $\Delta AICc \leq 4$ ) for little tern are given in Table 3.3. Of which, nesting island area, presence of vegetation and presence of predator explained the nesting of little tern in the top model, followed by a combination of variables like nesting area, vegetation, distance to nearest nest, and predator explained the nesting of little tern. The positive relation with predator presence could be taken as a surrogate of the presence

of nesting of little tern in the island, which actually indicates that predator presence is attributed to the pursuit of hunting in the island rather than having a positive effect on nesting. The sparse vegetation in terms of grass or shrubs, perhaps provided shelter or cover to juveniles, which could be attributed to an essential factor for nesting of little tern against harsh weather conditions and predators (Gochfeld, 1983; Lopes et al., 2015). Black-winged stilt was mostly influenced by the area of the island, which indicates the need for large islands for nesting.

**Table 3.3.** Generalized linear model of little tern and black-winged stilt in the Yamuna River

| Model                                                     | $\Theta$ Value | DF | LL       | AICc   | $\Delta AICc$ | AICc weight |
|-----------------------------------------------------------|----------------|----|----------|--------|---------------|-------------|
| <b>Little tern</b>                                        |                |    |          |        |               |             |
| ~ Area + Vegetation + Predator                            | 5.2            | 4  | -1085.32 | 2180.8 | 0             | 0.526       |
| ~ Area + Vegetation + Distance to nearest nest + Predator | 5.23           | 6  | -1085.31 | 2182.8 | 2             | 0.193       |
| ~Area + Vegetation                                        | 5.17           | 4  | -1087.43 | 2182.9 | 2.17          | 0.178       |
| ~ Area + Vegetation + Distance to nearest nest            | 5.17           | 5  | -1087.14 | 2184.4 | 3.62          | 0.086       |
| <b>Black-winged stilt</b>                                 |                |    |          |        |               |             |
| ~ Area                                                    | 9.82           | 3  | -347.319 | 700.8  | 0             | 0.299       |
| ~ Area + Predator                                         | 9.95           | 4  | -346.713 | 701.7  | 0.89          | 0.191       |
| ~ Area + Vegetation                                       | 9.96           | 4  | -346.935 | 702.1  | 1.33          | 0.153       |
| ~ Predator                                                | 9.49           | 3  | -348.284 | 702.7  | 1.93          | 0.114       |
| ~ Area + Predator + Livestock                             | 10.1           | 5  | -346.358 | 703.1  | 2.31          | 0.094       |

In the top-ranked model for little tern (Table 3.4), area of nesting island, presence of vegetation and presence of predator ( $\beta_{Area} = 0.13$ , SE = 0.02;  $\beta_{Vegetation} = 0.33$ , SE = 0.10 and  $\beta_{Predator} = 0.15$ , SE = 0.07) showed significant positive relations with the response variable. In the top model for black-winged stilt, ( $\beta_{Area} = 0.12$ , SE = 0.04) showed a significant positive relationship (Table 3.4).

**Table 3.4.** Summary of top ranked model variables in the Yamuna River

| Variable                  | $\beta$ Estimate | SE      | z value | Pr(> z ) | Sig (p value) |
|---------------------------|------------------|---------|---------|----------|---------------|
| <b>Little tern</b>        |                  |         |         |          |               |
| (Intercept)               | 0.99634          | 0.03646 | 27.324  | < 2e-16  | ***           |
| Area                      | 0.13307          | 0.02743 | 4.852   | 1.22E-06 | ***           |
| Vegetation                | 0.33933          | 0.10455 | 3.246   | 0.00117  | **            |
| Predator                  | 0.15546          | 0.075   | 2.073   | 0.03819  | *             |
| <b>Black winged stilt</b> |                  |         |         |          |               |
| (Intercept)               | 1.37101          | 0.04669 | 29.363  | < 2e-16  | ***           |
| Area                      | 0.12830          | 0.04303 | 2.982   | 0.00287  | **            |

Signif. codes: p='\*\*\*' 0.001; '\*\*' 0.01; '\*' 0.05



Overall, the Ganga and select rivers are facing different anthropogenic pressures, especially due to seasonal agriculture on islands that coincide with the nesting season of island breeding waterbirds. There are site-specific requirements of island nesting waterbirds, thus, each river variable has a different impact on the nesting of waterbirds. The presence of predators, especially free-ranging dogs, also impacted the nesting of waterbirds in select rivers by predating on eggs and chicks. Livestock presence was also found to be one of the threats to nesting sites, as it might result in nest/egg trampling. Sand mining was also identified as one of the major threats to nesting sites, for instance, the Chambal River is known for its high-value *murum* sand, which has a high demand in construction work due to its high durability and quality. Mining activities are attributed to the destruction of pristine nesting islands in the select rivers. Boats and dredgers were observed mining from deep water habitats in the lower Yamuna River.

# STATE-WISE STATUS OF ISLAND NESTING WATERBIRDS IN THE GANGA AND SELECT TRIBUTARIES

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The island nesting waterbirds were studied in the seven Ganga River Basin states (Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Uttar Pradesh, Uttarakhand and West Bengal), focusing on seven rivers. The state-wise details of the island nesting waterbirds are given in this chapter. A major proportion of the studied rivers flow through the states of Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan. Uttar Pradesh harboured the highest number of nesting species, nesting events, unhatched eggs, hatchlings and fledglings. Significant nesting colonies of Indian skimmer and black-bellied tern were recorded from Madhya Pradesh, Rajasthan and Uttar Pradesh. The Chambal River demarcates the boundary between Madhya Pradesh and Rajasthan; therefore, the information on nesting waterbirds is included in both states' status assessment. The state-wise details are as follows-



## 4.1. UTTAR PRADESH

Overall, 13 island nesting waterbird species were recorded from river islands in Uttar Pradesh (Figure 4.1). A total of 214 nesting events, 397 unhatched eggs, 52 hatchlings and 1107 fledglings were recorded from 52 islands for 12 nesting waterbirds species during the first pre-monsoon survey (2023) in three rivers (Ganga, Yamuna and Ghaghra) of Uttar Pradesh. While altogether, 1423 nesting events, 3320 unhatched eggs, 123 hatchlings and 267 fledglings were recorded from 83 islands for 10 species from the Yamuna, and Ghaghra rivers during the second pre-monsoon survey (2024) in Uttar Pradesh. A total of 71 nesting events

were recorded for the Indian skimmer in the three rivers of the state during the second survey, whereas 49 nesting events were observed during the first survey (Table 4.1). Different sand islands/bars of the Ghaghra River were utilized for nesting by 11 waterbird species, followed by the Yamuna River with five species, and Ganga River with two species (Figure 4.2, 4.3).



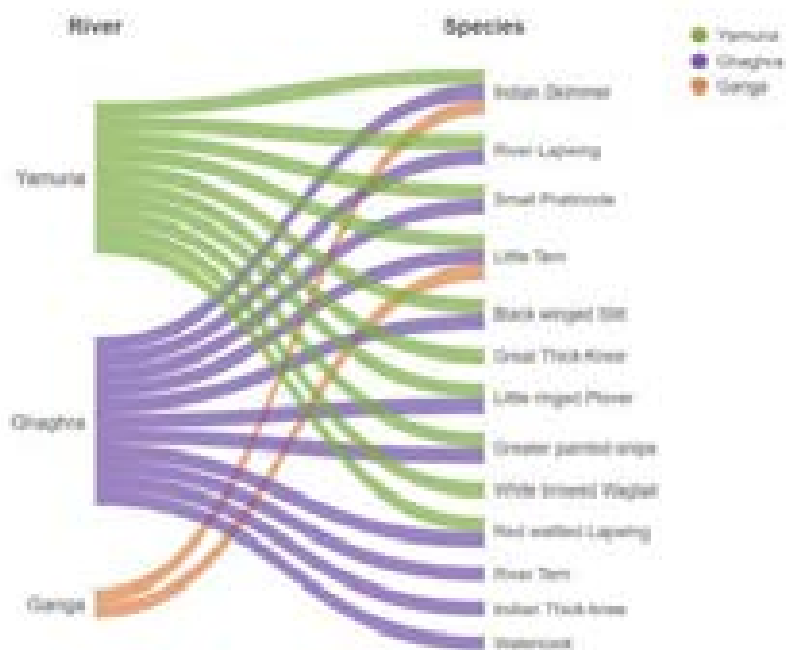


Figure 4.1. Nesting Waterbird species in different rivers of Uttar Pradesh

Various anthropogenic factors such as mining, cattle grazing and agriculture activities were recorded during monitoring of nesting waterbirds. Mining intensity was relatively higher in the lower Yamuna stretch, where some of the previously important islands changed due to mining activities.

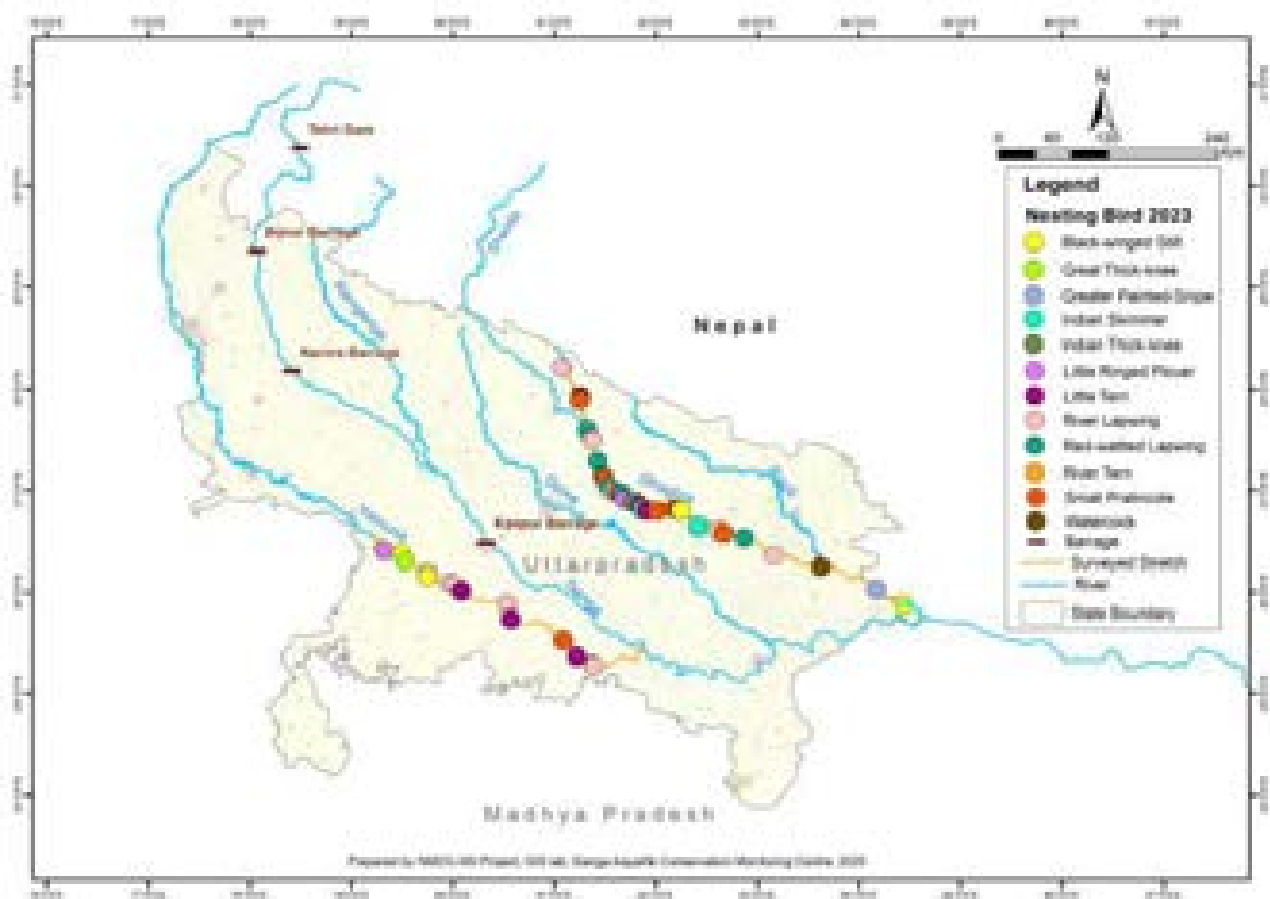


Figure 4.2. Island Nesting Waterbirds in the different rivers within the boundaries of Uttar Pradesh during 2023

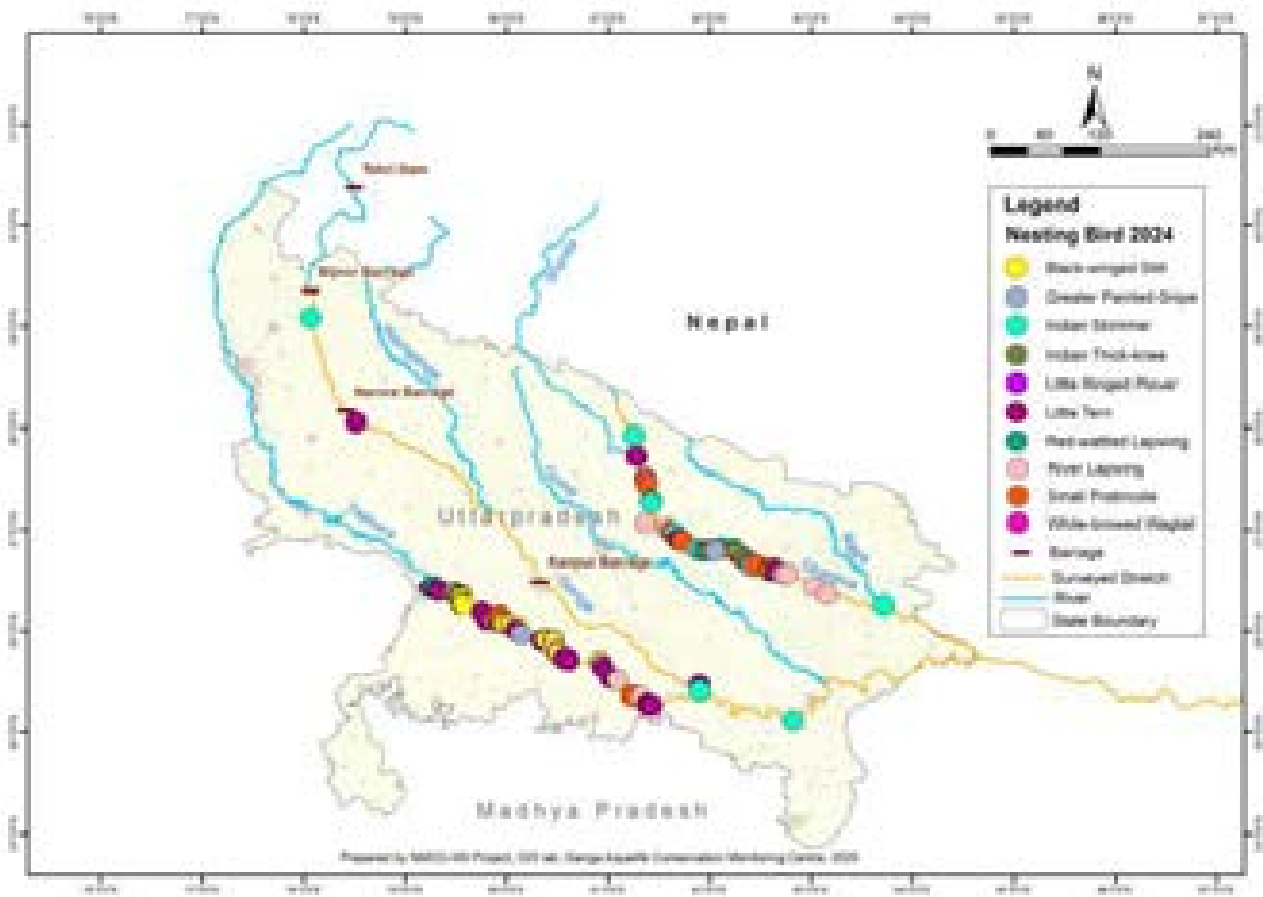


Figure 4.3. Island Nesting Waterbirds in the different rivers within the boundaries of Uttar Pradesh during 2024

Table 4.1. Summary of island nesting bird species and nests observed in the state of Uttar Pradesh (Ganga, Yamuna and Ghaghra)

| Species               | Nesting events |      | Unhatched eggs |      | Fledglings |      | Hatchlings |      |
|-----------------------|----------------|------|----------------|------|------------|------|------------|------|
|                       | 2023           | 2024 | 2023           | 2024 | 2023       | 2024 | 2023       | 2024 |
| Indian skimmer        | 49             | 71   | 101            | 161  | 18         | 4    | 9          | 36   |
| River lapwing         | 3              | 48   | 3              | 149  |            | 6    | 67         | 19   |
| Small pratincole      | 106            | 446  | 158            | 697  | 32         | 40   | 579        | 102  |
| Little tern           | 40             | 665  | 79             | 1658 | 1          | 71   | 387        | 108  |
| Black-winged stilt    | 5              | 173  | 18             | 605  |            |      | 24         |      |
| River tern            | 3              |      | 9              |      |            |      |            |      |
| Red wattled lapwing   | 4              | 11   | 15             | 41   | 1          |      | 12         |      |
| Greater painted snipe |                | 4    | 3              | 2    |            |      | 14         |      |
| Great thick-knee      |                |      |                |      |            |      | 3          |      |
| Indian thick-knee     | 1              | 1    | 4              | 4    |            |      |            | 2    |
| Little ringed plover  | 2              | 2    | 5              | 3    |            |      | 12         |      |
| Watercock             | 1              |      | 2              |      |            |      |            |      |
| White-browed wagtail  |                | 2    |                |      |            | 2    |            |      |
| Total                 | 214            | 1423 | 397            | 3320 | 52         | 123  | 1107       | 267  |

4.2. BIHAR

In Bihar, a total of five island nesting species were recorded. The Ganga and Gandak rivers were monitored to assess the status of island nesting waterbirds during the first and second surveys. Altogether, 18 nesting events, 35 unhatched eggs, 9 hatchlings and 77 fledglings of small pratincole, little tern, greater-painted snipe and black-winged stilt were recorded from the seven islands during the first survey of the Ganga and Gandak rivers in Bihar (Figure 4.4). Whereas

during the second survey, a total of 245 nesting events with 483 unhatched eggs, 50 hatchlings and 9 fledglings were recorded from 10 islands for five species of island nesting waterbirds (black-winged stilt, little tern, red-wattled lapwing, river lapwing and small pratincole) (Table 4.2; Figure 4.5). Nesting activities were more predominant in the Ganga than the Gandak River. In Gandak, only small pratincole was observed nesting in a river island, whereas the Ganga River in Bihar, was more frequently used for nesting by five species (Figure 4.4 & 4.5).

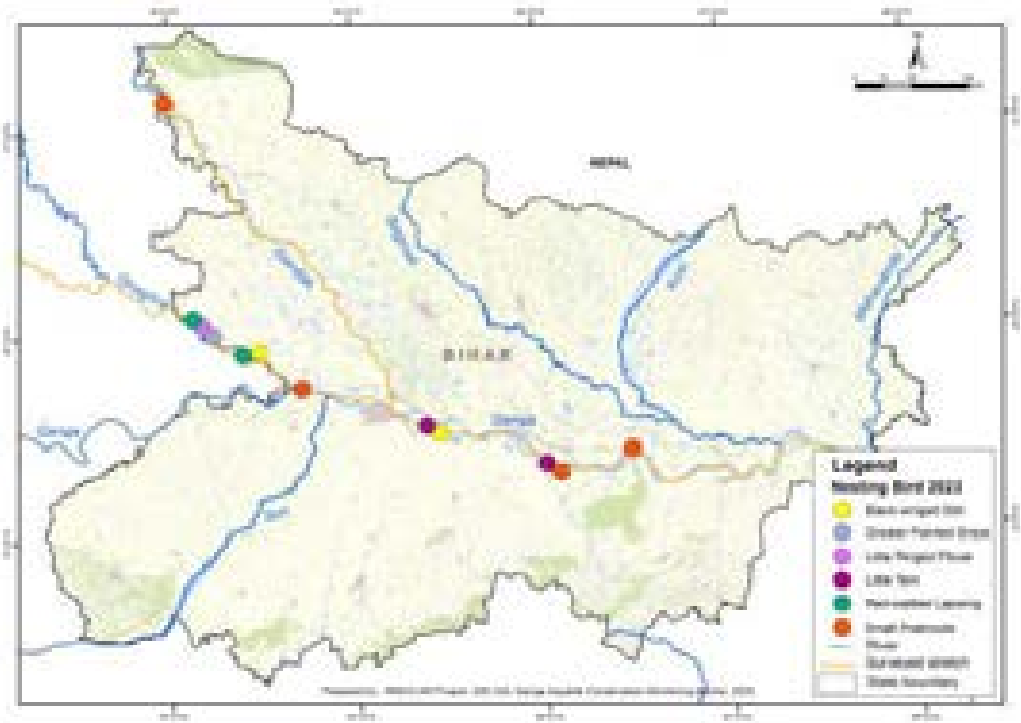


Figure 4.4. Island Nesting Waterbirds in the different rivers within the boundaries of Bihar during 2023

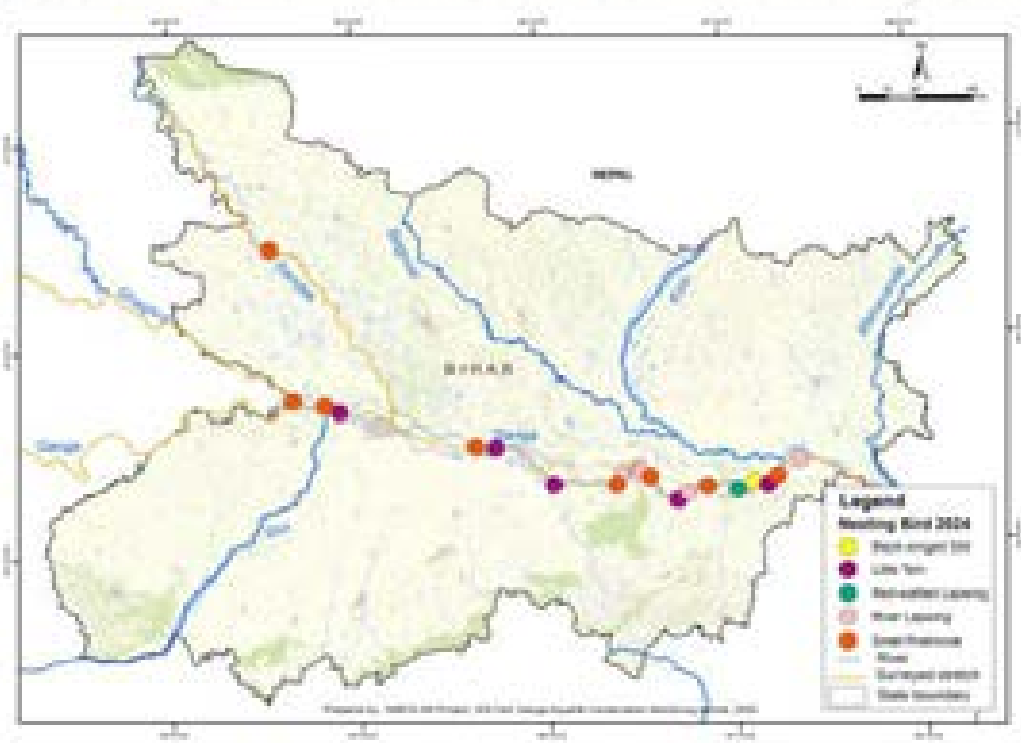


Figure 4.5. Island Nesting Waterbirds in the different rivers within the boundaries of Bihar during 2024

### 4.3. JHARKHAND

The Ganga River in Jharkhand was surveyed for nesting waterbirds during both sampling periods. There was no evidence of nesting found during the first pre-monsoon survey. However, during the second survey, one active nesting island was recorded near Sahibganj with 16

nesting events, where species like little tern, small pratincole and red-wattled lapwing were observed breeding. Unhatched eggs of little tern (n=7), red-wattled lapwing (n=3) and small pratincole (n=18) were recorded in Jharkhand. The island was free of all anthropogenic disturbances with a 150 m shoreline distance (Figure 4.6).



Figure 4.6. Nesting locations of the different Island Nesting Birds in Jharkhand

### 4.4. MADHYA PRADESH

The Chambal River bifurcates the states of Rajasthan and Madhya Pradesh, thus information on nesting waterbirds is included in both states. Two tributaries of the Ganga River (Chambal and Son) were surveyed in the state of Madhya Pradesh only during the second pre-monsoon survey (2024) (Figure 4.7). A total of 183 nesting events with 236 unhatched eggs, 41 hatchlings and 89 fledglings were recorded from nine islands for eight species of island nesting waterbirds in the state of Madhya Pradesh (Table 4.3). Of these, a total of 44 nesting events, including 103 unhatched eggs, 18

hatchlings and 2 fledglings of five island nesting bird species, were recorded in a small stretch of the Son River (Table 2.7). There were 65 unhatched eggs, 15 hatchlings and 2 fledglings of Indian skimmer in the Son River, while 31 unhatched eggs, 2 hatchlings and 75 fledglings were recorded from the Chambal River (Table 2.2). Two unhatched eggs and three hatchlings of black-bellied tern were recorded in the Chambal, whereas in Son River, 4 unhatched eggs were recorded. Both rivers are facing a major challenge from intense sand mining.

Table 4.3. Summary of island nesting bird species and nests observed in the state of Madhya Pradesh

| Species            | Nesting events | Unhatched eggs | Hatchlings | Fledglings |
|--------------------|----------------|----------------|------------|------------|
| Black-bellied tern | 6              | 6              | 3          | -          |
| Black-winged stilt | 3              | 3              | -          | -          |
| Great thick-knee   | -              | -              | 1          | -          |
| Indian skimmer     | 60             | 96             | 17         | 77         |
| Little tern        | 62             | 79             | 8          | 2          |
| River lapwing      | 2              | 3              | 4          | -          |
| River tern         | 41             | 40             | 6          | 5          |
| Small pratincole   | 9              | 9              | 2          | 5          |
| Total              | 183            | 236            | 41         | 89         |

4.5. RAJASTHAN

The Chambal River was monitored only during the second pre-monsoon season between the stretch of Pali and Bareilly, monitoring all potential nesting islands. A total of 95 nesting events of eight island nesting species- black-bellied tern, black-winged stilt, great thick-knee, Indian skimmer, little tern, river lapwing (Figure 4.7), river tern and small pratincole were recorded from nine river islands of the Chambal River between the stretch of Pali and Dholpur (see Table 2.2).

For species like great thick-knee and river lapwing, only hatchlings were recorded, whereas for the rest of the species, unhatched eggs, hatchlings and fledglings were recorded. Out of 139 nesting events, 51 belonged to little tern and 31 to Indian skimmer. Little tern had the highest number of unhatched eggs (n=50), followed by river tern (n=38) and Indian skimmer (n=31). While, highest fledgling numbers belonged to the Indian skimmer (n=75), followed by river tern and pratincole with 5 each, and the highest number of hatchlings (6 each) belonged to little tern and river tern.

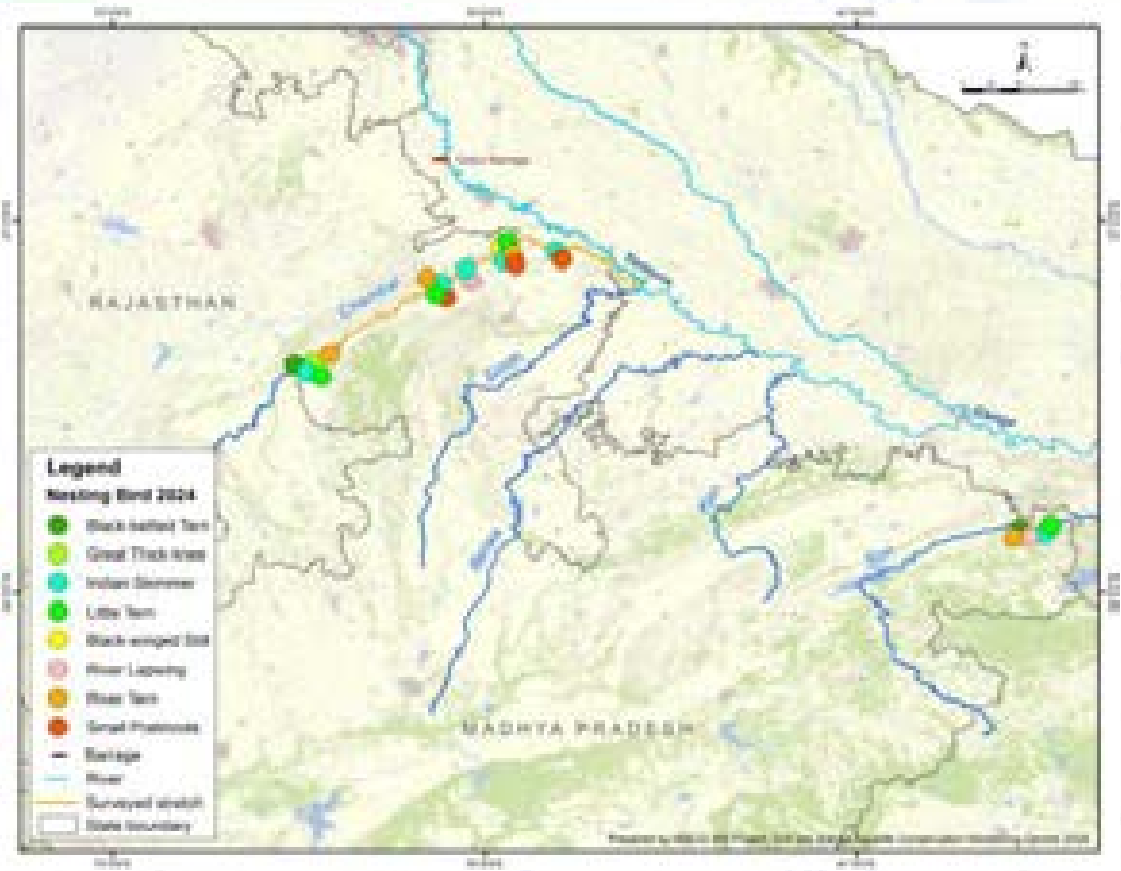


Figure 4.7. Common Nesting sites in the states of Madhya Pradesh and Rajasthan

#### 4.6. UTTARAKHAND

Only Kalagarh reservoir on the Ramganga River was surveyed for assessing the status of the island nesting waterbirds, and a total of 35 nests of river tern were observed during the rapid survey of 2022 (Figure 2.14). A small stretch (75 km) of the Ganga River was covered in Haridwar during the first survey in 2023, however, no nesting species were encountered.

#### 4.7. WEST BENGAL

A small (~70 km) stretch of the Ganga River was surveyed in the state of West Bengal between Kesarpur and Farraka. No evidence of nesting was found in this stretch during both survey years.

Black-winged stilt nest recorded in the Yamuna River



# CONSERVATION IMPLICATIONS & WAY FORWARD

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The present monitoring provides baseline data for the island nesting waterbirds of the Ganga and select tributaries, which also paved out way for future research and monitoring. The study has provided evidence that rivers like the Ganga, Ghaghra and Yamuna have the potential to accommodate multiple island nesting waterbirds. The study also highlights that there is a need to study the breeding biology of the threatened species, including breeding success, nest survival, and other important aspects that will unveil the requirements of the nesting species and solutions to related threats. Issues of free-ranging dogs, cattle and other potential predators also need to be addressed, especially for endangered species, which are already facing the risk of local or global extinction. For instance, the breeding biology of the Indian skimmer needs to be studied intensively in the Ganga River Basin. Similarly, species like black-bellied tern require to be studied intensively. The state-wise status of nesting waterbirds is essential to guide management and conservation actions on activities related to riverine resources, such as sand mining, agriculture and fishing, since such activities come under the jurisdiction of the state governments. Moreover, State Forest Departments are custodians of wildlife in their respective states, thus river stretches under their jurisdiction need to be managed effectively by them with active patrolling and by regulating mining activities in the nesting islands and stretches that often have high-quality and quantity of sand, and nesting sites. Sand mining and agriculture create a trade-off between economic development and conservation. This trade-off can be mediated by carefully designing the mining plans, avoiding nesting seasons and sites as well as temporal and seasonal overlaps.

Another major disturbance factor impacting the nesting of the waterbirds is agricultural activities on the river islands. The negative impacts of this activity can be mitigated through integrated agricultural practices aligned with respective Forest Departments. The farmers should be discouraged from occupying nesting islands and should be made aware of the importance of nesting birds in their respective rivers. The cadre of the *Ganga Praharis* might play a vital role in such river stretches. An unmanaged population of free-ranging dogs is a prime threat to nests and juveniles; thus, animal husbandry departments require active participation in managing dog populations, particularly in and around nesting islands. Rare and

threatened species like black-bellied tern require special attention in the Chambal and Son rivers. The nesting islands of this species should be protected from all anthropogenic pressures, especially mining, agriculture, predators and livestock. A month-long continuous (24x7) monitoring to protect their nests and hatchlings should be encouraged by the Forest Department by involving NGOs and local people, especially youth. Temporary hideouts for the observers could be established at safe distances from the nest sites to protect them from any anthropogenic threats, especially predators like dogs.

Some of the surveyed rivers form state borders, for instance, the Chambal demarks state boundaries

between Rajasthan and Madhya Pradesh. The National Chambal Sanctuary falls within the jurisdiction of three states (Madhya Pradesh, Rajasthan and Uttar Pradesh). Therefore, the respective state forest departments and other line agencies need to work in collaboration with an active and transparent exchange of information. Further, intensive sampling in the river stretches of the states like Uttarakhand, West Bengal and Madhya Pradesh is required. Availability of food resources, intra- and inter-specific competition, daily

water fluctuation, and avian predators are some other essential factors that could influence nesting sites of island waterbirds and need further quantification. In addition, the impact of water pollutants could also be studied to ascertain their impact on the island nesting waterbirds. Figure 5.1 provides an overview of the management and conservation actions needed for island nesting waterbirds.



**Figure 5.1**  
Proposed management and conservation actions

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