Identification of wetlands of international importance in Porbandar, Gujarat, western India during 2015–2021

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Abstract

The Asian Waterbird Census (AWC), established in 1987, is one of the longest-running citizen science initiatives in India. Porbandar District has unique low-lying floodplain areas, locally known as "ghed", which become inundated with rain and flood waters during the monsoon, creating temporary wetlands used by waterbirds in the region. The ghed-facilitated inundation is also important for protecting several villagers from the devastating effects of flash floods during heavy rains. Twenty-three of Porandar's wetlands were monitored in January each year from 2015–2021 inclusive, as a part of the AWC (following recommended count schedules and procedures), to assess their importance for waterbirds. A total of 101 counts were made across the 23 sites during the study, repeatedly covering an area of 20,192 ha. Seven wetlands supported > 20,000 waterbirds and two wetlands supported > 100,000 waterbirds at least once. Over 100,000 waterbirds were counted at the Mokarsagar Wetland Complex on five occasions. The highest annual total recorded for all wetlands combined was of 496,620 birds in 2016, and the highest number of species observed was 134 in 2020. Thirty-six species exceeded 1% of the total population (a criterion for designating sites for protection under the Ramsar Convention) at one or multiple sites. Mokarsagar alone supported 32 of these species, with Javar and Mendha Creek each receiving internationally important numbers of 11 species. Five species listed as globally threatened by the International Union for the Conservation of Nature (four classed as Vulnerable; one as Endangered) and a further 11 Near Threatened species were recorded at the Porbandar wetlands. Seventeen wetlands qualified for recognition on the basis that they exceeded at least one of the criteria used to identify sites of regional or international importance. Of the 23 wetlands surveyed, 12 faced one or multiple threats.

Key words: biodiversity, census, Important Bird Area (IBA), Key Biodiversity Area (KBA), Mokarsagar, Ramsar, waterbirds.

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Between the Arctic and Indian Oceans, the Central Asian Flyway (CAF) occupies a vast continental region of Eurasia. Within the Central Asian Flyway, at least 182 species of waterbirds (including 29 classed as globally threatened and near-threatened by the International Union for the Conservation of Nature; IUCN 2021) breed, migrate or spend the non-breeding (winter) season in India (Mundkur 2013). Birds from flyways other than the CAF also migrate to India. At least 370 species of migratory birds from three flyways are known to visit the Indian subcontinent, of which 310 use wetlands as their primary habitat, the rest being land-based birds that live in dispersed terrestrial areas (MoEFCC 2018). There is *c.* 150,174 km^2 of wetland habitat in the country (6.9% of the total geographical area), with Gujarat's wetlands covering *c.* 34,350 km^2, which is 17.6% of the state's geographical area and *c.* 22.9% of the area of wetlands in India. Around a quarter of India's wetlands occur in Gujarat, the largest share of any individual state (Singh 2013).

Even though the role of wetlands is well recognised globally, there is increasing pressure on wetland habitats. These are of vital importance to humans and wildlife, in protecting and maintaining surface water flow during dry periods and ameliorating the effects of climate change, yet freshwater ecosystems are in rapid decline (WWF 2020). Waterbirds are dependent on water and water-related resources, and are vulnerable to changes in water levels, quality and flow rates, which affect the vegetation and substrate conditions of their environments (Nolet *et al.* 2016; SoIB 2020; Essian *et al.* 2022). Whilst predation (including hunting by man), disturbance and disease can have serious impacts on waterbird populations, habitat destruction, modification/encroachment and degradation are the major concerns for birds staging or overwintering at wetland sites (Urfi 2015).

Most avian species occurring in India, including its waterbirds (both resident and migratory), have seen long-term declines, and this is particularly evident in the migratory shorebirds, gulls and terns, although national counts indicate that trends for wildfowl (ducks and geese) and other resident waterbirds (*e.g.* swamphens, coots, and storks) have also decreased since the start of the 21st century (SoIB 2020). Resident waterbirds appear to have suffered especially, with significant decreases in numbers over the last five years, a disturbing pattern that necessitates immediate action to halt and reverse the decline (SoIB 2020).

The Ramsar Convention is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources, and waterbird counts are one of the main measures used to identify wetlands of international importance that qualify for protection as Ramsar Sites (Scott 1980; Matthews 1993; Ramsar 2014; Stroud *et al.* 2022a,b). India, which became party to the Ramsar Convention in 1982, so far has listed 75 wetlands under the treaty (Ministry of Environment, Forestry and Climate Change (MoEFCC) 2022). The number of waterbirds visiting a wetland not only provides a measure of its importance for particular species but gives a strong indication of the site's ecological significance, and identification of internationally important wetlands has benefited greatly from long-term

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waterbird count records (Li *et al.* 2009). The Asian Waterbird Census (AWC), established 1987 to monitor waterbirds in the Indian subcontinent (and through this to inform governments and the general public about waterbird numbers, distribution and trends) is a particularly valuable resource used to identify sites that meet the Ramsar Convention's criteria (Verma & Nawab 2021). It grew rapidly, and the AWC now extends from Afghanistan eastwards to Japan, southeast Asia and Australasia. The count network thus encompasses the entire East Asian-Australasian Flyway and also a large part of the Central Asian Flyway followed by migratory waterbirds.

The AWC data have been used not only to aid policymaking and conservation efforts internationally but to advise and shape several national programmes, including the National Action Plan for Aquatic Ecosystem Conservation, the National Biodiversity Action Plan, and the National Action Plan for Migratory Birds and their Habitats in the Central Asian Flyway (SoIB 2020). Waterbird and wetland monitoring on a large scale therefore is important for environmental planning and management decisions, yet many wetland studies are based on a single/flagship species and are undertaken in protected areas or wetlands that have already been identified. Waterbird monitoring conducted outside of protected areas can help to form strategic management regimes for wetlands at a landscape level (Kumar 2019). For instance, although the population dynamics of shorebirds using sites along the east coast of India (including at Point Calimere, Lake Pichavaram, Lake Chilika and Lake Pulicat) is well understood (*e.g.* Balachandran 2006), there is a lack of long-term studies on shorebird populations from the west coast of India, despite invertebrates (the shorebirds' main food source) being even more abundant in this area (Aarif 2015). India's 29 wetlands of ornithological significance have been listed as being important staging sites for migratory waterbirds, where the birds congregate during autumn and spring. In this list of 29 wetlands, only two sites – the Khijadiya Bird Sanctuary and the Nal Sarovar Bird Sanctuary – are from Gujarat, despite there being many more sites in the state ideal for staging and wintering waterbirds, such as the wetlands of Porbandar (MoEFCC 2018).

Although the Porbandar wetlands of western India are well-known for the diversity and density of waterbirds using these sites, there has been no long-term waterbird monitoring undertaken in the region prior to our study. Moreover, most of the wetland sites included in this paper are not protected through national or international legislation. We therefore counted waterbirds in the area as part of the AWC programme, and related the results to global criteria used to identify wetlands of international importance (*e.g.* by their supporting ≥ 1% of a waterbird population, or through ≥ 20,000 waterbirds occurring at the site), with the aim of describing Porbandar's key wetlands and highlighting their need for protection under national or international legislation.

Methods

Study area

Porbandar, one of the 33 districts of Gujarat State, is located on the Kathiawar Peninsula

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in western India (MWCC 2015). The district has unique low-lying floodplain areas, locally known as "ghed", which become inundated with rain and river water during the monsoon and provide temporary storage of the flood water, protecting villages downstream from the devastating effects of flash floods during heavy rainfall. To the north lies Barda ghed, which acts as a floodplain of the Rivers Sorthi, Vartu, Kalindri and Kamand. Further south, Sorthi ghed acts as a floodplain of the Rivers Minsar, Bhadar and Ozat in an east-west direction. Wetlands are scattered in both of these ghed areas (Vargiya 2017).

There are 226 wetlands in Porbandar (including 95 small wetlands < 2.25 ha in size), extending over 22,199 ha. Porbandar's inland wetlands include reservoirs/barrages, tanks/ponds, riverine wetlands and salt pans, whilst creeks, beaches, intertidal mudflats and mangroves are the main coastal wetland habitats in the region. Inland wetlands account for 27.3% and coastal wetlands 72.7% of the total wetland area (Space Applications Centre 2010). Twenty-three wetlands of various habitat types (namely: reservoirs, tidal mudflats, estuaries, freshwater lakes, brackish/saline lakes, village tanks/ponds, mangroves, lagoons and sandy beaches) were included in the present study (Fig. 1, Table 1). Sites were selected so that a range of habitat types, and wetland sizes (area in ha) were assessed.

Waterbird monitoring

The Asian Waterbird Census (AWC) takes place in January each year, and the numbers of waterbirds present at the 23 wetlands included in our study were recorded as a part of the AWC from 2015–2021 inclusive.

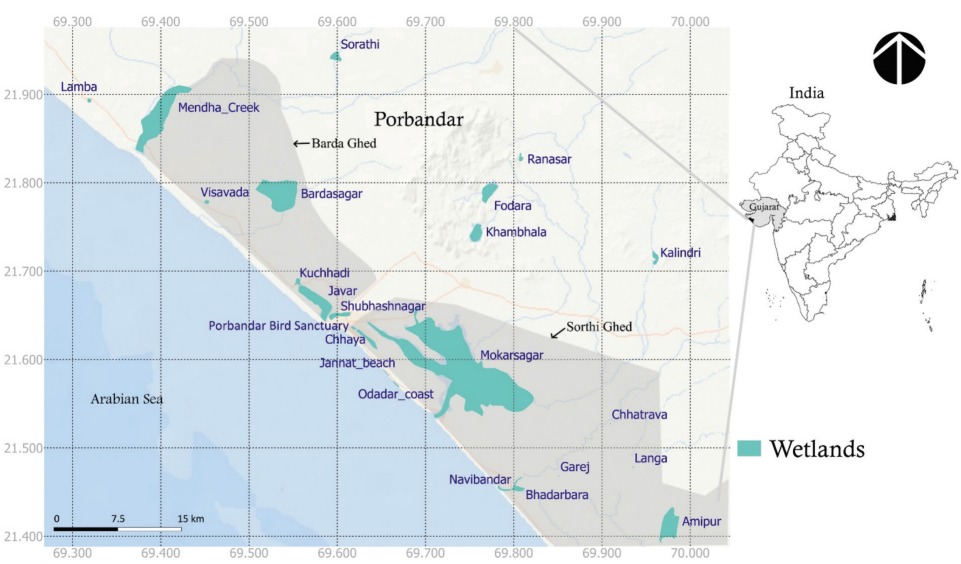

Figure 1. Map showing the location of the 23 wetlands in Porbandar, Gujarat, India, reviewed in this analysis.

Table 1. Wetlands at Porbandar, Gujarat, India included in the study, together with the type of wetland, extent of agriculture and grazing pressure, and the pollution and other threats faced at each site.

Site no.	Wetland	Area (ha)	Wetland type	Agriculture around wetland	Grazing pressure	Pollution and threats
1	Amipur 21.24°N, 69.58°E	1,250	Reservoirs/barrages	High	High	Pollution by pesticides & fertilisers. Agriculture along drying margins
2	Bardasagar 21.46°N, 69.32°E	2,000	Reservoirs/barrages	High	High	Pollution by pesticides & fertilisers
3	Bhadarbara 21.27°N, 69.48°E	365	Creek	High	High	Pollution by pesticides & fertilisers
4	Chhatrava 21.31°N, 69.54°E	2.5	Tanks/ponds	High	Nil	
5	Chhaya rann 21.37°N, 69.37°E	130	Tanks/ponds	Nil	High	Pollution by domestic sewage, solid waste & industrial waste
6	Fodara Dam 21.47°N, 69.46°E	200	Reservoirs/barrages	Nil	Nil	
7	Garej Talav 21.28°N, 69.51°E	11	Tanks/ponds	High	High	
8	Jannat beach 21.36°N, 69.38°E	40	Tanks/ponds	Nil	Low	Tourism & recreation (large number of tourists)
9	Javar 21.39°N, 69.34°E	560	Salt pans	Moderate	High	Pollution by industrial waste
10	Kalindri Dam 21.43°N, 69.57°E	80	Reservoirs/barrages	High	Low	
11	Khambhala Dam 21.44°N, 69.45°E	100	Reservoirs/barrages	High	Nil	
12	Kuchhadi 21.41°N, 69.33°E	350	Tanks/ponds	High	High	Partial reclamation of wetland

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Table 1 (*continued*).

Site no.	Wetland	Area (ha)	Wetland type	Agriculture around wetland	Grazing pressure	Pollution and threats
13	Lamba 21.53°N, 69.19°E	25	Tanks/ponds	High	Nil	
14	Langa 21.28°N, 69.55°E	3.5	Tanks/ponds	High	High	
15	Medha creek 21.52°N, 69.24°E	3,500	Reservoirs/barrages, creek, beach, intertidal mudflats & mangroves	High	High	Agriculture along drying margins
16	Mokarsagar Wetland Complex 21.34°N, 69.44°E	11,000	Reservoirs/barrages, creek & beach	High	High	Pollution by pesticides & fertilisers. Eutrophication/algal blooms on surface water. Cutting/clearance of aquatic vegetation
17	Navibandar 21.27°N, 69.46°E	150	Creek	Moderate	Low	Pollution by pesticides
18	Odadar Rangbai coastal area 21.34°N, 69.39°E	135	Beach	Moderate	High	Sand mining
19	Porbandar Bird Sanctuary 21.38°N, 69.37°E	15	Tanks/ponds	Nil	Nil	
20	Ranasar 21.50°N, 69.48°E	25	Tanks/ponds	High	Nil	
21	Sorthi Dam 21.56°N, 69.36°E	100	Reservoirs/barrages	High	Nil	
22	Subhashnagar 21.38°N, 69.35°E	100	Intertidal mudflat & Mangroves	Nil	Nil	Pollution by domestic sewage, solid waste, industrial waste. Partial reclamation of wetland
23	Visavada 21.46°N, 69.27°E	50	Tanks/ponds	High	Nil	

Larger wetlands such as Mokarsagar and Mendha Creek were divided into smaller blocks, which were counted simultaneously. Counts were made in accordance with Wetlands International's standard counting techniques (*i.e.* ground count, roost count, and block counts (Wetlands International 2018), during the count period scheduled for the AWC each year (mostly during the second and third weeks of January (Wetlands International South Asia 2020). Observers focussed on the waterbirds and other wetland-dependent bird species listed on Wetlands International South Asia's standard site count form, and the flock size for each species was recorded on the forms on-site during the surveys. Participants gave an assessment of each wetland, following Wetlands International South Asia guidelines. Potential threats to the wetlands observed during the surveys were also recorded for each site, in accordance with the guidelines. These included pollution (by domestic sewage, solid waste, industrial waste, oil pollution, pesticides or fertilisers), agriculture along the drying margins of the wetland, human crematoria adjacent to wetlands, dam/barrage construction, eutrophication/ algal blooms of surface water, cutting/ clearance of aquatic vegetation, excessive growth of aquatic vegetation, partial reclamation of the wetland, complete reclamation of the wetland, residential & commercial development encroaching on the wetland, mining (sand, soil), sedimentation, excessive tourism/recreation (large number of tourists, disturbing birds, leaving garbage, playing loud music, *etc.*), hunting, and the presence of domestic dogs. In addition to being passed to the AWC coordinators, the bird counts were uploaded to eBird India (eBird 2021).

Observations were made by teams of 4–5 volunteer counters with varying levels of experience in counting and identifying birds. In each team there was at least one experienced counter who would count and identify the waterbirds using 10× binoculars and/or a 20×–60× spotting scope, accompanied by participants who would record the counts on the AWC site count form. Participants were also accompanied by at least one of the authors as an experienced counter on each of the count surveys, and the teams undertook the AWCs at the same sites every year. Large flocks of waterbirds such as ducks, waders, cranes, gulls and flamingos were counted meticulously; if required, the count would be repeated, and an average of both counts was taken. All 101 census counts recorded during 2015–2021 inclusive were compiled and then analysed using Excel spreadsheets. Sites were sometimes omitted if their wetlands were dry, following a lack of rain. The *Waterbird Population Estimates* electronic database (5th Edition; Wetlands International 2012) was used to assess a 1% biogeographic population. IUCN's latest red list was used for globally threatened categories of all species recorded (IUCN 2021). Long-term status, current status, level of conservation concern, and migratory status were accessed from the *State of India's Birds* (SoIB 2020).

Results

The 23 wetlands surveyed annually from 2015–2021, covered an area of 20,192 ha, of which 12 (52%) were seen to have one or

multiple threats, and for a further seven (30%) there was agricultural activity around the wetland (Table 1). A total of 141 species were recorded from 214 species listed on Wetlands International South Asia's standard site count form (Supporting Materials Table S1). The total count of the waterbirds and other wetland-associated species recorded across the 23 sites ranged from 208,150 (in 2015) to 496,620 (in 2016), with a mean (± s.d.) count of 351,750 ± 130,370 over the study period (Table 2). At least 20,000 waterbirds and other wetland-associated species (*e.g.* kingfishers, swallows) were counted at Amipur, Shubhashnagar and Kuchhadi on a single occasion; twice at Bardasagar and Mokarsagar; and at Javar and Chhaya three times. The Mendha Creek wetland supported between 20,000 and 100,000 waterbirds in six of the 7 years of the study (mean ± s.d. count = 46,490 ± 17,361 for 2015–2020), plus one occasion (in 2021) when > 100,000 (206,478 birds) were counted. Highest numbers were recorded at the Mokarsagar wetland complex, which supported 52,680–319,675 waterbirds during the study, and ≥ 100,000 waterbirds were recorded on five occasions (mean ± s.d. = 231,980 ± 118,284 for these five years; Table 2). The number of different species identified at the 23 wetlands ranged from in 103 in 2015 to 134 in 2020 (Table 2).

Waterbirds

The 141 species identified during the study included 119 waterbirds: 17 species of ducks/geese, 2 flamingos, 2 grebes, 3 cranes, 41 waders, 10 rails & crakes, 16 gulls & terns (8 each), 2 pelicans, 1 skimmer, 5 storks, 4 cormorants/darter, and 16 species of bitterns, egrets, herons, ibises and spoonbill combined (Supporting Materials Table S1). Among these waterbirds, numbers of the Demoiselle Crane *Anthropoides virgo* at the Mokarsagar wetland exceeded the total global population estimate of 170,000–220,000 individuals (BirdLife International 2022) when 259,950 birds were counted there in 2019 (the mean count of Demoiselle Crane at Mokarsagar was 88,374 ± 88,205 during 2015–2021), whilst half of the total flyway population of Eurasian Wigeon *Mareca penelope* (1% = 2,500 birds) was recorded at Amipur (3,235 counted) and at Mendha Creek (120,100 counted) in 2021. Other notable counts revealed that 36% of the flyway population of Common Crane *Grus grus* was recorded at Mokarsagar wetland in 2020, where 17% of the flyway population of Lesser Flamingo *Phoeniconaias minor* and 11% of the flyway population of Greater Flamingo *Phoenicopterus roseus* were also recorded during 2017 and 2016, respectively. In addition to these, Eurasian Coot *Fulica atra*, Barn Swallow *Hirundo rustica*, Northern Pintail *Anas acuta*, Green-winged Teal *Anas crecca* and Gadwall *Mareca strepera* comprised the 10 most abundant species counted at the Porbandar wetlands, providing the highest numbers of birds counted across the sites (Supporting Materials Table S1).

Designation of wetlands of international importance under the Ramsar Convention, and as Key Biodiversity Areas (KBA; IUCN 2016), is based on 1% of the total population of a waterbird species occurring at a particular site. A total of 36 species exceeded the 1% criterion at one or multiple sites (Table 3). Five species classed as globally threatened by the International

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Table 2. Total numbers of waterbirds and wetland-associated species, listed on the Asian Waterbird Censuses (AWC) count form, recorded at each wetland in the study area from 2015–2021 inclusive. **Bold font** = wetlands supporting ≥ 20,000 waterbirds and wetland-associated species; **Bold and italics font** = wetlands supporting ≥ 100,000 waterbirds and wetland-associated species.

Wetland	2015		2016		2017		2018		2019		2020		2021	
	Count	Species	Count	Species	Count	Species	Count	Species	Count	Species	Count	Species	Count	Species
Amipur			1,137	5	12,348	22	8,412	25			15,519	58	**96,717**	56
Bardasagar	16,341	34	3,182	9	**32,308**	59	5,185	15	960	7	**28,642**	41	12,051	58
Bhadarbara			127	9	8,677	26	6,746	31			9,023	35		
Chhatrava					417	19								
Chhaya	19,529	40	**34,385**	32	19,036	39	**25,471**	45	6,139	41	6,924	20	**27,748**	58
Fodara			578	20										
Garej					769	19	540	15						
Jannat beach											1,287	8	1,089	50
Javar	7,798	28	18,433	49	10,716	30	**24,195**	35	**36,890**	50	**38,280**	24		
Subhashnagar	4,203	14	2,270	29	8,111	29	7,347	35					**37,266**	44
Kalindri			235	15										
Khambhala			454	21										
Kuchhadi	2,511	26	4,316	10	5,763	48	4,816	41	2,192	23	**21,728**	53	18,979	43
Lamba	4,398	14	60	5										
Langha					161	10								
Mendha Creek	**41,545**	25	**45,984**	55	**59,728**	58	**26,419**	47	**32,275**	66	**72,987**	71	***206,478***	59
Mokarsagar	***109,841***	84	***374,670***	96	**52,680**	97	***118,118***	91	***319,675***	120	***237,596***	100	**77,062**	90
Navibandar					838	25	1,247	20					3,947	27
Odadar Coast					557	25								
Porbandar Bird Sanctuary	1,535	36	1,362	40			1,472	31	1,887	33	594	28	1,469	43
Ranasar			219	11										
Sorathi			164	4										
Visavada	449	18	9,044	15										
TOTAL	**208,150**	**103**	**496,620**	**118**	**212,109**	**104**	**229,968**	**111**	**400,018**	**126**	**432,580**	**134**	**482,806**	**117**

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Union for Conservation of Nature (four classed as Vulnerable – Common Pochard *Aythya ferina*, Greater Spotted Eagle *Clanga clanga*, River Tern *Sterna aurantia* and Sarus Crane *Antigone antigone*, and one as Endangered – Indian Skimmer *Rynchops albicollis*; IUCN 2021) and a further 11 Near Threatened species were recorded during the surveys. Out of 20 species shortlisted for single species action plan (SSAP) at the all-India national level (MoEFCC 2018), 10 were recorded at the 23 sites included in the study (Table 3).

Of the 23 wetlands included in our study, 14 were found to receive ≥ 1% of the flyway population (Table 4). Moreover, 17 met the criteria required for designating sites of regional or international importance: 16 by fulfilling at least one of the criteria listed under the Ramsar Convention, and all 17 qualified as Key Biodiversity Areas (previously known as Important Bird and Biodiversity Areas) for the region (Table 5).

Trends in the number of birds recorded for the different taxonomic groups varied over the study period (Fig. 2). The relatively low numbers of gulls, pelicans and terns appear to be more or less stable over the years, whereas there was a marked rise in the number of ducks and coots in 2019–2021, particularly for Eurasian Wigeon which increased 13-fold from 9,300 in 2020 to 124,060 in 2021 (Table 3). Counts of migratory cranes doubled during 2019–2020, but in 2021 returned to earlier (2015–2018) levels (Fig. 2).

Discussion

The study provided crucial information for determining the number of waterbirds wintering in the Porbandar district, especially for species such as ducks, waders, pelicans, storks and cormorants for which count data were previously inadequate or did not exist. The huge congregations of cranes, flamingos and gulls recorded confirmed previous accounts. The Porbandar wetlands and surrounding agricultural areas provide the most crucial wintering sites for Demoiselle Crane in entire Asia. Numbers of Demoiselle Crane exceeded the 1% population threshold (1,000 birds) on 39 of the 101 occasions they were counted at the different sites. The mean number of Demoiselle Crane counted at Mokarsagar was 88,374 during 2015–2021 inclusive.

Following the 2021 census, counts from 477 wetlands covered by the AWC across India were uploaded by participants and AWC state coordinators, with some notable exceptions such as Lake Chilika (in Odisha) and Point Calimere (in Tamil Nadu). A total of 168 waterbird species were recorded at these 477 sites from across India's wetlands during AWC 2021 and, although data were missing for some sites, all those with ≥ 20,000 (n = 5) and ≥ 100,000 (n = 2) waterbirds on eBird India were from Gujarat. Moreover, out of five sites supporting ≥ 20,000 waterbirds, four were from Porbandar and the fifth was Mulvel Wetland Complex, near Dwarka, Gujarat. Likewise, of the two sites supporting ≥ 100,000 waterbirds, one was Mendha Creek (in our study area) whilst the other was at Nalsarovar, also in Gujarat (eBird 2021). Earlier observations have indicated that wetlands in other parts of Gujarat are also extremely important for waterbirds; a total of 414 Gujarat wetlands were covered

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Table 3. Total number of waterbirds counted across the Porbandar wetlands each year, for species that fell into one or more of the following categories: (a) listed as globally threatened or near threatened by IUCN (categories: LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered (IUCN 2021), (b) exceeded 1% of the biogeographic population estimate (from Wetlands International 2012), with the number of occasions (site counts) on which ≥ 1% of the population was recorded also provided (N/A = not applicable), or (c) shortlisted for a single species action plan (SSAP) under India's National Action Plan (NAP) for the species (10 species, from MoEFCC (2018)). Scientific names for the species are provided in Supporting Materials Table S1. Species classed as EN and VU by IUCN are given in bold font.

Species	IUCN[a]	1% threshold (flyway population)	No. of site counts with ≥ 1% of the population[b]	SSAP under NAP[c]	Total numbers counted across the 23 wetlands						
					2015	2016	2017	2018	2019	2020	2021
Black-headed Ibis	NT	250	4		369	1,499	149	293	379	797	219
Black-tailed Godwit	NT	1,500	4	Yes	6,199	11,524	1,250	2,330	6,008	2,473	1,145
Black-winged Stilt	LC	1,700	1		1,300	2,642	565	265	358	355	723
Brown-headed Gull	LC	1,400	8		4,868	9,497	1,020	2,050	10,850	4,650	573
Common Crane	LC	700	7		311	20,974	6,269	5,662	16,085	25,800	1,787
Common Pochard	**VU**	**3,200**	**2**	**Yes**	**75**	**6,280**	**236**	**785**	**3,107**	**5,365**	**5,515**
Common Redshank	LC	1,000	2		554	4,148	247	1,615	386	1,741	170
Curlew Sandpiper	NT	2,400	N/A	Yes	11	0	2	3	0	29	56
Dalmatian Pelican	NT	75	3		242	305	151	74	79	162	176
Demoiselle Crane	LC	1,000	39		53,833	96,206	85,148	72,985	263,475	189,407	103,160
Eurasian Coot	LC	15,000	2		28,397	19,993	16,183	13,690	6,348	18,908	45,651
Eurasian Curlew	NT	1,000	N/A	Yes	0	4	12	42	0	2	0
Eurasian Spoonbill	LC	230	6		240	3,435	321	540	724	404	1,294
Eurasian Wigeon	LC	2,500	5		675	9,182	2,690	3,231	1,729	9,300	124,060
Ferruginous Duck	NT	1,000	N/A	Yes	2	2	43	10	5	35	12
Gadwall	LC	3,000	5		339	6,778	626	2,114	564	16,220	8,570
Garganey	LC	3,500	1		262	5,420	16	76	200	1,980	1,382
Glossy Ibis	LC	250	3		300	902	73	3	53	176	703
Great Egret	LC	1,000	4		383	4,244	1,268	810	2,263	663	1,384

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Table 3 (*continued*).

Species	IUCN[a]	1% threshold (flyway population)	No. of site counts with ≥ 1% of the population[b]	SSAP under NAP[c]	Total numbers counted across the 23 wetlands						
					2015	2016	2017	2018	2019	2020	2021
Great Thick-knee	NT	250	N/A		13	10	2	4	14	2	9
Great White Pelican	LC	210	16		3,531	2,499	4,834	872	664	3,423	2,006
Greater Flamingo	LC	2,400	10	Yes	9,138	13,817	27,978	25,020	11,343	7,886	664
Greater Sand-Plover	LC	1,000	1		40	1,081	70	170	0	5	0
Greater Spotted Eagle	**VU**		**N/A**		**2**	**5**	**2**	**1**	**4**	**7**	**0**
Green-winged Teal	LC	4,000	4		1,556	15,161	1,808	7,138	1,332	4,883	19,070
Indian Cormorant	LC	300	3		1,188	447	79	104	21	852	282
Indian Skimmer	**EN**	**75**	**N/A**	**Yes**	**0**	**4**	**0**	**0**	**11**	**4**	**4**
Indian Spot-billed Duck	LC	1,000	1		176	5,407	244	236	197	234	531
Knob-billed Duck	LC	250	1		32	289	84	55	14	51	162
Lesser Flamingo	NT	3,900	17	Yes	34,633	69,831	24,300	31,515	29,720	20,110	45,566
Lesser Sand-Plover	LC	1,300	1	Yes	0	2,320	179	253	129	150	169
Little Cormorant	LC	2,500	1		1,526	5,264	568	468	231	780	765
Little Stint	LC	2,400	1	Yes	600	10,900	592	754	147	2,118	713
Northern Pintail	LC	20,000	1		1,663	20,772	7,041	13,130	2,235	20,582	14,976
Northern Shoveler	LC	7,100	2		10,855	19,904	2,740	11,201	7,532	7,701	14,190
Oriental Darter	NT	40	N/A		29	52	38	11	9	11	19
Painted Stork	NT	250	6		236	1,869	356	815	1,055	517	132
Red-naped Ibis	LC	100	3		154	696	28	21	16	6	24
River Tern	**VU**	**710**	**1**		**302**	**1,817**	**302**	**332**	**158**	**141**	**562**
Ruff	LC	1,000	2		378	10,779	230	2,100	235	853	359
Sarus Crane	**VU**	**90**	**N/A**		**0**	**3**	**0**	**0**	**1**	**0**	**0**
Slender-billed Gull	LC	1,500	1		298	104	701	60	3,256	1,536	21
Steppe Eagle	EN		N/A		0	0	0	0	1	3	0
Western Reef-Heron	LC	170	3		728	184	172	298	88	159	313
Woolly-necked Stork	NT	250	N/A		5	13	6	21	4	15	0
Yellow-wattled Lapwing	LC	70	1		7	75	0	0	13	88	1

Table 4. Sites in Porbandar where ≥ 1% of the flyway population was recorded, for at least one of 36 waterbird species where this criterion was met during the study. Scientific names for the species are given in Supporting Materials Table S1.

Survey sites	Waterbird species meeting the 1% criterion	Total no. of species
Mokarsagar	Knob-billed Duck, Garganey, Northern Shoveler, Gadwall, Eurasian Wigeon, Indian Spot-billed Duck, Northern Pintail, Green-winged Teal, Common Pochard, Greater Flamingo, Lesser Flamingo, Demoiselle Crane, Common Crane, Black-winged Stilt, Lesser Sand-Plover, Black-tailed Godwit, Ruff, Little Stint, Common Redshank, Brown-headed Gull, River Tern, Painted Stork, Little Cormorant, Indian Cormorant, Great White Pelican, Dalmatian Pelican, Great Egret, Western Reef-Heron, Glossy Ibis, Black-headed Ibis, Red-naped Ibis, Eurasian Spoonbill	32
Javar	Greater Flamingo, Lesser Flamingo, Demoiselle Crane, Yellow-wattled Lapwing, Greater Sand-Plover, Slender-billed Gull, Brown-headed Gull, Painted Stork, Great Egret, Western Reef-Heron, Black-headed Ibis	11
Mendha Creek	Gadwall, Eurasian Wigeon, Green-winged Teal, Common Pochard, Greater Flamingo, Lesser Flamingo, Eurasian Coot, Demoiselle Crane, Black-tailed Godwit, Brown-headed Gull, Great White Pelican	11
Bardasagar	Gadwall, Eurasian Wigeon, Demoiselle Crane, Common Crane, Great White Pelican, Dalmatian Pelican	6
Amipur	Eurasian Wigeon, Green-winged Teal, Demoiselle Crane, Great White Pelican, Eurasian Spoonbill	5
Subhashnagar	Lesser Flamingo, Demoiselle Crane, Brown-headed Gull, Painted Stork, Western Reef-Heron	5
Kuchhadi	Gadwall, Lesser Flamingo, Demoiselle Crane, Great White Pelican, Dalmatian Pelican	5
Bhadarbara	Demoiselle Crane	1
Chhaya	Lesser Flamingo	1
Fodara	Red-naped Ibis	1
Lamba	Demoiselle Crane	1
Navibandar	Demoiselle Crane	1
Ranasar	Red-naped Ibis	1
Visavada	Demoiselle Crane	1

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Table 5. Wetlands in Porbandar that meet criteria for identifying sites of international importance for conservation, on global and regional scales.

Wetland	Ramsar			KBA				
	Criterion 2	Criterion 5	Criterion 6	Global criteria		Regional IBA criteria		
				A1	A4	B1a	B3a	B3b
Amipur	Y	Y	Y	Y	Y	Y	Y	Y
Bardasagar	Y	Y	Y	Y	Y	Y	Y	Y
Bhadarbara	Y		Y	Y	Y	Y	Y	
Chhaya	Y	Y	Y	Y	Y	Y	Y	Y
Fodara	Y		Y	Y			Y	
Jannat beach							Y	
Javar	Y	Y	Y	Y	Y	Y	Y	Y
Subhashnagar	Y	Y	Y	Y	Y	Y	Y	Y
Khambhala	Y			Y		Y		
Kuchhadi	Y	Y	Y	Y	Y	Y	Y	Y
Lamba			Y		Y		Y	
Mendha Creek	Y	Y	Y	Y	Y	Y	Y	Y
Mokarsagar	Y	Y	Y	Y	Y	Y	Y	Y
Navibandar			Y			Y	Y	
Porbandar Bird Sanctuary	Y			Y		Y		
Ranasar			Y				Y	
Visavada	Y		Y	Y	Y		Y	

Y = site supports the criterion described below.

Ramsar (Ramsar 2014) criteria: Criterion 2 = site supports Vulnerable, Endangered, or Critically Endangered species; Criterion 5 = regularly supports ≥ 20,000 waterbirds; Criterion 6 = regularly supports ≥ 1% of the individuals in a population of one species.

Key Biodiversity Area (BirdLife International 2021a)

Global criteria: Criterion A1 = ≥ 15 individuals of Endangered species with a global population of > 1,500 individuals, or 30 individuals of a species classified as Vulnerable; Criterion A4 = the site is known to hold congregations of ≥ 1% of the global population of one or more species on a regular basis. (Based on a global population of 230,000–261,000 for the Demoiselle Crane and 2,220,000–3,240,000 for the Lesser Flamingo.)

Regional IBA criteria: B1a = the site regularly holds at least 30 individuals of non-passerine Near Threatened species; B3a = the site is known to hold, on a regular basis, ≥ 1% of a biogeographic population of a congregatory waterbird; B3b = the site is known to hold, on a regular basis, ≥ 20,000 waterbirds.

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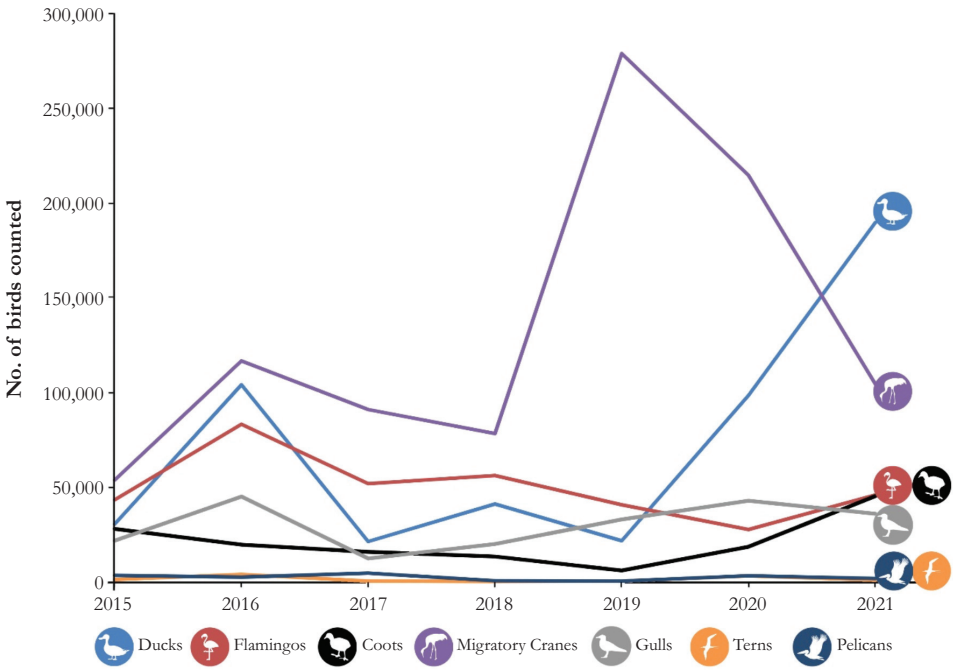

Figure 2. Numbers of birds counted for the most abundant families observed at the Porbandar wetlands, for each census during the study period.

by the AWC during 2006–2015, which is the highest number of sites covered by the census in an Indian state, followed by 286 in Maharashtra and 168 in Kerala. The wetlands of Gujarat also supported waterbird species of high conservation significance during AWC 2006–2015. Gujarat was the only state where near-threatened and threatened species such as the Dalmatian Pelican *Pelecanus crispus* and Sarus Crane were reported each year, with the Woolly-necked Stork *Ciconia episcopus* recorded annually from Gujarat and Kerala, and Common Pochard from Gujarat and Odisha each year (Wetlands International South Asia 2020).

The Mokarsagar Wetland Complex, which extends over an area of > 10,000 ha is the largest of the wetlands in Porbandar district, and perhaps the second largest in the state after Nalsarovar (Rahmani *et al.* 2016). The Mokarsagar wetland alone supported ≥ 1% of the biogeographic population of 32 species and also qualifies under other global criteria as a wetland of international importance. In 2014, 192,053 waterbirds were recorded at Mokarsagar, and the wetland is one of the most important roosting places for cranes on the Central Asian Flyway. An earlier study found > 70,000 Demoiselle Cranes and > 20,000 Common Cranes roosting at the site in 2016, meeting the criteria for the designation under Ramsar Convention (Jethva *et al.* 2017). A Memorandum of

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Understanding (MoU) was signed in 2015 between the Gujarat Forest Department and GIZ Germany, with the aim of developing a management plan, preparing documents (including an information sheet) for Ramsar Site designation and capacity building (Comptroller and Auditor General of India 2015). Although, Mokarsagar has not yet been listed for protection as a Ramsar Site by the government of India, it was declared an Important Bird and Biodiversity Area (now known as a Key Biodiversity Area) in March 2017 (BirdLife International 2021b).

Numbers of Slender-billed Gulls (1% of the W/SW/S Asia breeding population = 1,500 birds) have been declining nationally since 2008 (Mundkur *et al.* 2017), so the count of 3,000 recorded at the Javar wetland in Porbandar (in 2019) is very important for the region. The highest total reported for India during recent AWCs is of 13,883 birds counted in 2009 and only three wetlands (the Charakhla Salt Pans in Gujarat, Lakhota Lake in Gujarat and Point Calimere in Tamil Nadu, which supported > 1% of the population during the 2006–2015 AWCs; Wetlands International South Asia 2020) are protected for the species. The Charakhla Salt Pans at Dwarka and the Great Rann in Kutch, both in Gujarat, are the only known breeding sites for Slender-billed Gulls in the whole of Asia. Previously, 2,000 birds were recorded in Flamingo City, Kutch in 1992, and 5,000 birds were reported from the Jakhau Salt Pans, Kutch in 1992 (Li & Mundkur 2006; Parasharya *et al.* 2000), but these sites failed to meet the 1% population criterion during the 2006–2015 AWCs (Wetlands International South Asia 2020). The Lesser Flamingo, an itinerant near-threatened species which depends on a network of wetlands to respond to changes in local environmental conditions by moving between them (Childress *et al.* 2008), also nests in Gujarat and stays in Porbandar till the monsoon season starts. Along with Mokarsagar and Mendha Creek, Chhaya and Javar are important sites in Porbandar for the species, with the Chhaya wetland additionally being a crucial courtship site for Lesser Flamingos (Vargiya & Joshi 2016).

Out of 23 wetlands surveyed under the present study, only three wetlands – the Porbandar Bird Sanctuary, and the Fodara and Khambhala irrigation dams of the Barda Wildlife Sanctuary – have legal status as wildlife sanctuaries. Whilst protected areas can readily be managed for the benefit of wildlife, opportunities for conservation activities at wetlands outside of the protected area network are much more limited. At these sites, managers must find a balance between meeting the needs of local wetland-dependent communities and protecting waterbird habitats. Many of India's wetlands are eligible for protection as Ramsar Sites, and the number currently listed is insufficient for our wetland-rich country (Kumar 2019). Wetlands essential to waterbirds, which support ≥ 100,000 individuals, deserve special conservation consideration irrespective of whether they are protected or unprotected (Wetlands International South Asia 2020).

Conclusion

The wetlands covered under the present study support 141 species of waterbirds and

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wetland-associated species. Mendha Creek and Mokarsagar supported ≥ 100,000 while Amipur, Shubhashnagar, Kuchhadi, Bardasagar, Javar and Chhaya each supported > 20,000 waterbirds. A total of 36 species exceeded the 1% of the population estimate for the Central Asian Flyway at one or multiple sites, and 14 of the 23 sites included in the study received 1% of the population for one or several species. These wetlands have been proven equally important as a floodplains or flood regulators for humans (Vargiya 2017). The diverse wetland types and agricultural practices makes them a favourite wintering grounds for many migratory species. As the geographic area covered by most of the Porbandar wetlands are unprotected, there is a need to designate these sites for protection under India's latest wetland conservation legislation, so that they continue to provide important habitat for waterbirds and other species into the future. In particular, the Mokarsagar and Mendha Creek wetlands should be listed as Ramsar Sites, and as Community or Conservation Reserves.

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Photograph: Avian biodiversity at the Mokarsagar wetland, India, by Dhaval Vargiya.