Rapid decline of waterbirds in urban wetlands: A case study from Perur-Sundakamuthur Lake, Coimbatore, Tamil Nadu, India

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Abstract: We present the first six-year results of the ongoing long-term systematic monthly monitoring of birds, in Perur-Sundakamuthur Lake, an urban wetland in Coimbatore, Tamil Nadu, conducted between May 2014 and April 2020. We analysed the status and population trends of 125 species. Of the 49 waterbirds recorded, 29 of them are present in high numbers when water level is Medium. Also, about 80% of the shorebirds are present only during the aforesaid condition, feeding on the moist mudflats. We found that the abundance of 23 waterbird species, which is 47% of waterbird species recorded in Perur Lake, dropped significantly during this period. Of the 12 representative waterbirds that were analysed, eight species are categorized as 'Gravely Impacted' and four as 'Highly Impacted'. From our data analysis, we suspect that the decline may be due to sand mining, commercial fishing, and road expansion.

Introduction

Birds occupy a range of habitats and are responsive and sensitive to environmental changes. Several studies have shown that the health of bird populations in a habitat can indicate the health of that habitat and ecosystem (Frazier 1999; Gregory et al. 2003; Fraixedas et al. 2020). Wetlands constitute some of the most productive ecosystems in India, whose health is often correlated with the waterbird communities that play vital roles in their effective functioning (Raju 2015). In urban areas, wetlands remain some of the last natural ecosystems that not only provide refuge to a wide variety of flora and fauna, but also provide important space for humans to interact with nature (Raju 2015). Although many urban wetlands in India are extremely polluted, they still attract a large number of birds (Reginald et al. 2007). However, urban wetlands are also continuously disturbed by development activities, which affect their bird populations (Foote et al. 1996).

Here, we present results of the first six years of our ongoing long-term systematic monitoring in one such urban wetland, Perur-Sundakamuthur Lake (hereinafter, Perur Lake), that we carried out between 2014 and 2020, and discuss the same from a conservation perspective.

Study area

Perur Lake (10.97ºN, 76.93ºE) lies in the southwestern corner of metropolitan Coimbatore, Tamil Nadu. It is one of the 30 lakes that were constructed during the Kongu-Chola regimes in the 8th and 9thC CE in the vicinity of the Noyyal River (Pragatheesh & Jain 2013). Whenever it rained, the Noyyal used to flood downstream villages. To exploit the scanty rainfall, the Kongu-Chola kings channelized the monsoon rains by creating a system of lakes and anicuts to store and recharge groundwater. Over a period of time, these wetlands started to harbour birds, fishes, and other forms of life (Pragatheesh & Jain 2013). Thus, the wetlands in this dry region not only provide the much-needed water for agriculture but also perform functions such as flood control, groundwater recharge, water purification, nutrient retention, and biodiversity conservation (Pragatheesh & Jain 2013).

Perur Lake (Table 1) is fed by the Kuniyamuthur anicut channel from the Noyyal River as an overflow of excess water from Ganganarayanasamudhram Lake located further upstream. Until 2014, the crescent shaped road that adjoins Perur Lake on the eastern side (Fig. 1) was a mere bund filled with partial vegetation on one side, residential areas, and huts on the other side. The far side of the wetland in the southwestern direction has trees as well as other shoreline vegetation which the birds use for roosting and occasional nesting. This area can only be accessed through water during most times of the year, or by foot when the wetland is dry. Its western edge tapers into farmlands. The water level within this wetland varies depending on rains, a key determining factor in the species composition of waterbirds.

Given the lack of industrial activity around this lake and the non-discharge of sewage (Mohanraj et al. 2000; Chandra et al. 2009), it is relatively unpolluted and is deprived of of the invasive Water Hyacinth *Eichhornia crassipes*. Occasionally, floating plant species such as water lilies (Nymphaeaceae) are also observed to bloom here. We have seen that this ecosystem contains molluscs and fish that are food for waterbirds. Currently, the erstwhile walkable bund which contained a mixed vegetation of both native and invasive species is a busy two-lane roadway with a containment wall, which has partially encroached into the wetland.

Table 1. Description of Perur Lake (based on Pragatheesh & Jain 2013)

Catchment area	5.768 sq. km
Water spread area	1.072 sq. km
Capacity	1,470,777 cu. m
Full tank level	4.51 m
Maximum water level	5.12 m
Top bund level	6.49 m
Depth	4.511 m
Length of the bund	1,350 m
Length of shoreline	4.4 km
Anicut	3.5 sq. km
Number of inlets (channel)	1
Number of outlets	7 (one weir & six sluices)
Length of surplus escape	35.67 m

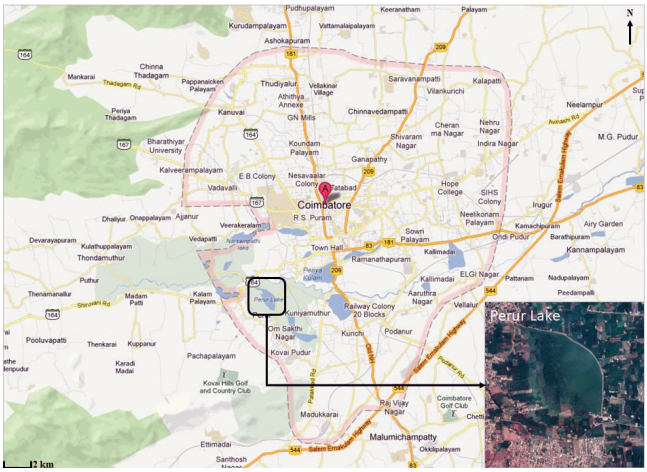


Fig. 1. Greater Coimbatore with Perur Lake inset. Source: https://www.worldmap1.com/

Materials and Methods

We monitored Perur Lake once a month from May 2014 to April 2020, usually on second Saturdays. We walked around the fixed 2 km road in the morning for approximately two hours and counted all birds that were seen or heard and recorded the information in a checklist. This count can be characterized as a "total count" because visibility is nearly 100%. Binoculars (Nikon 10x42.5, Zeiss 10x42 & Eagle optics 10x42), a spotting scope (Bausch & Lomb 20–80x magnification), and cameras were used for the monitoring.

The number of volunteers who participated in the count on any given day varied from three to eight. During the six years, there were 67 actual monthly counts conducted amounting to *c.*540 h of volunteer time. Of the five that were missed, four were due to sand mining operations between June and September 2017 because of noise, dust, poor sightline and unsafe conditions due to movement of heavy machinery and vehicles. The fifth was missed due to COVID-19 restrictions in April 2020.

We used the standard field guides (Ali & Ripley 1968a–d; Hayman et al. 1986; Kazmierczak 2000; Ali 2002; Paulson 2005; Grimmett et al. 2011; Rasmussen & Anderton 2012) to identify birds.

For the purpose of analysis, the 'Wetland Year' is calibrated from the May to the April of the succeeding year. Avian diversity of wetlands in southern India increases abruptly with the arrival of the Southwest monsoon in June and might vary based on autumnal and winter migration. This pattern extends to the next calendar year and hence recalibration of the study period offers continuity. We categorized birds as in Table 2 for our data analysis.

We have quantified the distribution status of all birds using a combination of 'Reporting Frequency' (RF) which measures their presence or absence during our survey period and 'Population Index' (hereinafter, PI), a relative measure that is computed by dividing the overall Mean Count (hereinafter, MC) of a species by its benchmark—a method we adapted for our purpose. Each

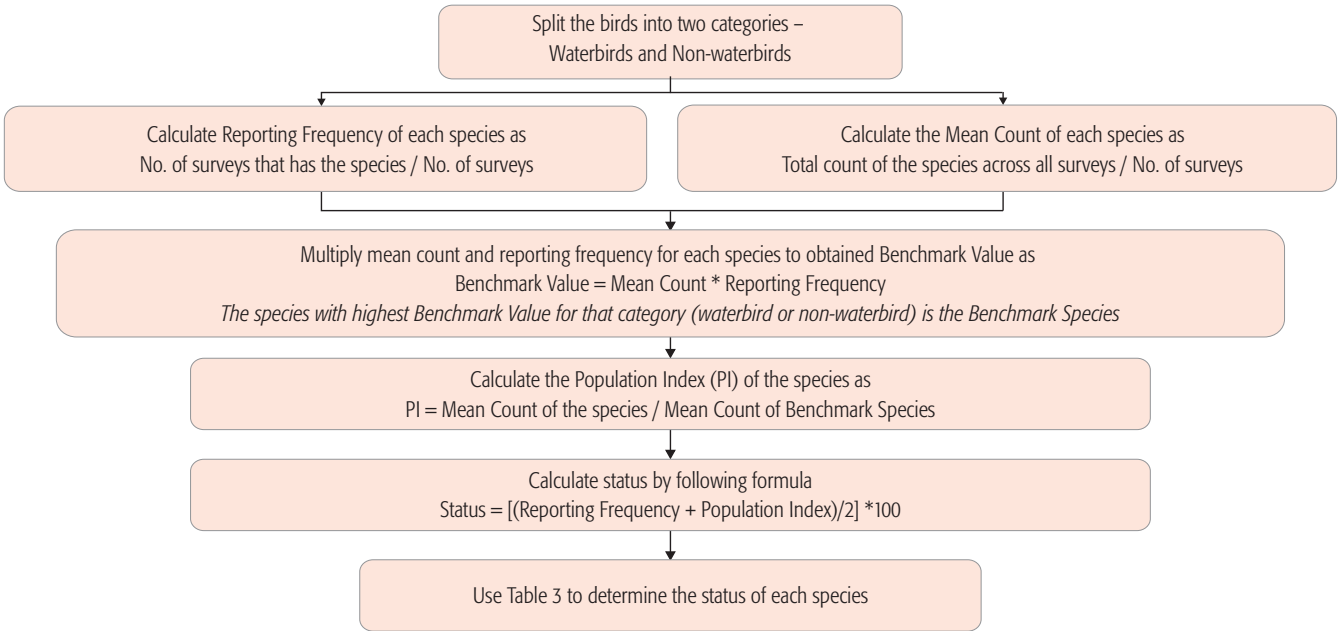


Fig 2. Flowchart explaining the methodology to derive abundance status.

Table 2. Status codes

Code	Status	Description
R	Resident	A species that stays year-round but also breeds in the area (e.g., Indian Spot-billed Duck *Anas poecilorhyncha*)
LM	Local Migrant	A species that stays in the area throughout (or most of) the year and whose adult population moves outside the area to breed. Occasionally, when resources are available these species may also breed in the area (e.g., Spot-billed Pelican *Pelecanus philippensis*).
WM	Winter Migrant	A species that spends its non-breeding winter months (mostly from September to April) in the area (e.g., Wood Sandpiper *Tringa glareola*).
PM	Passage Migrant	A species that is present between February–April and September–November in the area.
U	Uncertain	A species that occasionally visits an area and whose pattern cannot be discerned (e.g., Woolly-necked Stork *Ciconia episcopus*).

bird is designated with its distribution status as described in the Fig. 2 and Table 3.

Table 3. Abundance codes

Status	Percentage
Abundant	≥ 90%
Common	60–89%
Fairly Common	30–59%
Uncommon	10–29%
Rare	< 10%

The benchmark species for the waterbirds is the Little Cormorant *Microcarbo niger* while it is the House Crow *Corvus splendens* for non-waterbirds, as they have the highest benchmark values (see Fig. 2). For example, the waterbird Painted Stork *Mycteria leucocephala* was recorded 45 times in total of 67 counts making its RF as 0.67. To calculate PI, MC across 67 counts of the Painted Stork is taken, which is 11.86 and dividing it with the Little Cormorant's (benchmark species for waterbirds) MC of 37.71 gives 0.31. Half of the sum of RF and PI is 0.49 and multiplying it by 100 provides an abundance of 49%. As per our Table 3, this falls under 'Fairly Common' category. Similarly, for a non-waterbird like Common Myna *Acridotheres tristis* that was reported in all 67 counts has an RF of 1. However, its MC is 34.29 against the benchmark species (House Crow) MC of 50.82. This results in a PI being 0.67 and an abundance of 84% that makes this species 'Common' (*See supplementary file* https://zenodo.org/records/8353664 *for more details*).

Prior to the start of every count, the water level is estimated visually (Table 4). We obtained four different mean counts (MC) of every waterbird corresponding to each of the water level, calculated as below.

MC of a species per water level = Sum of all counts of a species in that water level / Number of surveys in that water level

Table 4. Description of Water Level

Water level	Description
Dry	The absence of water in the lake or the presence of a negligible wet ground.
Low	The presence of a small amount of water in a few isolated puddles.
Medium (Med.)	The presence of water in the whole lake with shoreline exposed in the periphery.
Full	The lake is completely filled with water without any exposed shoreline.

During surveys, we documented potential threats (threat events) to the habitats and associated the threats to the months. We compared both, waterbird species diversity, as well as population estimates before and after a threat event to assess the impact of the threat. In some cases, threat events occurred simultaneously, such as sand mining and commercial fishing, as depicted in Table 9, and hence their impacts were treated together.

We chose 12 representative water birds to compare their status in our study site with the national and international trends. We calculated the annual mean of their counts and plotted the trend for six years. We estimated the decline as the mean difference between the first and the sixth year to show the percentage of overall decline from the beginning to the end of the study period. We categorized the population decline of waterbirds as given in Table 5. We also calculated the annual decline which is an average of the mean difference (with SE) divided by the number of survey years. We compared our results with the global trends from IUCN (IUCN 2022), Wetlands International (2023) and national current annual trends during 2014–2020 available from the State of India's Birds 2020 (SoIB 2020) – their years of current trend almost identical to ours.

Table 5. Impacted Categories

Code	Impacted Category	Decline in Population
LC	Low Impacted	0–20%
MC	Medium Impacted	21–40%
HC	Highly Impacted	41–70%
GC	Gravely Impacted	71–100%

A detailed annotated checklist with bar charts that represents the presence/absence of the species across the year, line graphs depicting population trends, and notable differences from existing literature are provided in the supplementary file (https://zenodo.org/record/8353664).

Table 6. Summary of birds of Perur Lake

Status	Total Number of species	Number of species by Abundance (Table 3)				
		Abundant	Common	Fairly Common	Uncommon	Rare
Resident	49	3	5	18	15	8
Local Migrant	15	0	2	4	6	3
Winter Migrant	21	0	1	5	12	3
Passage Migrant	0	0	0	0	0	0
Uncertain	40	0	0	0	0	40
Total		3	8	27	33	54

Results

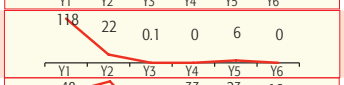
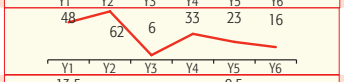
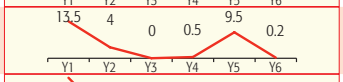
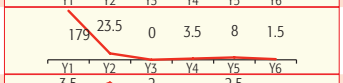
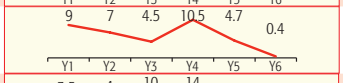
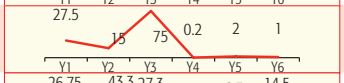
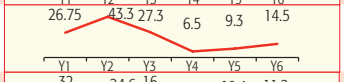
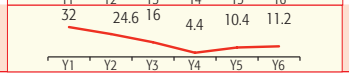
We recorded 125 species in Perur Lake; including 21 winter migrants and 15 local migrants (Table 6). Table 7 provides a summary of the monthly waterbird counts across six years, the corresponding water levels, number of waterbird species recorded, and their total count.

Table 7. Summary of waterbird counts in Perur lake (WB=Waterbird)

Period (No. of counts)	Details	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
		Summer		Southwest Monsoon			Northeast Monsoon			Winter		Summer	
2014–15	Water level	Low	Dry	Dry	Full	Full	Full	Full	Full	Full	Med	Med	Med
	No. of WB species	11	11	12	20	20	18	28	26	29	36	36	25
(12)	Total count of WBs	146	61	104	265	786	774	410	709	1598	2045	1278	605
2015–16	Water level	Med	Low	Full	Full	Med	Med	Full	Full	Full	Med	Med	Med
	No. of WB species	20	14	19	21	25	29	21	20	23	27	30	24
(12)	Total count of WBs	275	90	150	295	780	612	165	153	202	660	868	624
2016–17	Water level	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	No. of WB species	15	16	17	19	14	13	21	22	22	17	15	16
(12)	Total count of WBs	345	195	124	134	142	211	277	280	380	176	192	139
2017–18	Water level	Low	Survey not done				Med	Med	Low	Low	Low	Low	Low
	No. of WB species	8					21	31	15	17	14	12	17
(8)	Total count of WBs	58					165	218	246	122	110	36	33
2018–19	Water level	Low	Low	Full	Full	Full	Full	Full	Full	Full	Med	Med	Med
	No. of WB species	9	15	19	19	18	18	19	22	23	30	25	28
(12)	Total count of WBs	80	164	219	299	297	293	466	413	283	296	351	382
2019–20	Water level	Low	Low	Low	Full	Full	Full	Full	Full	Full	Full	Full	Survey not done
	No. of WB species	17	14	16	17	16	15	15	14	15	22	20	
(11)	Total count of WBs	178	237	382	90	149	131	94	80	121	218	332	

Table 8. Declining population trend of 12 representative water birds of Perur Lake (see Table 5) and their comparison with trend assessments from IUCN Red List, Wetlands International (WI), and State of India's Birds 2020 (SoIB).

Trends indicated by '↓' (Declining), '↑' (Increasing), '↔' (Stable), '?' (Unknown / Uncertain)

Sl. No.	Species Name	Perur Status	Trends in Perur Lake			Trends from other assessments		
			Decline	Annual Decline	Year-wise Mean	IUCN	WI	SoIB 2020 Mean & CI
1	Lesser Whistling-Duck	GI	- 95%	-15.8% ± 2.4%		↓	↓	+5% ± 2.73%
2	Garganey	GI	- 100%	-16.7% ± 6.0%		↓	?	-36% ± 5.2%
3	Indian Spot-billed Duck	HI	- 67%	-11.2% ± 3.1%		↓	?	+25% ± 2.7%
4	Little Grebe	GI	- 98%	-16.3% ± 1.5%		↓	?	-15% ± 2.2%
5	Eurasian Coot	GI	- 99%	-16.5% ± 3.8%		↑	↔	+13% ± 2.4%
6	Black-winged Stilt	GI	- 77%	-12.8% ± 1.3%		↑	↔	-14% ± 3.7%
7	Little Ringed Plover	GI	- 95%	-15.8% ± 1.7 %		↔	?	-57% ± 2.8%
8	Common Sandpiper	HI	- 43%	-7.2% ± 1.4%		↓	?	-40% ± 2.44%
9	Wood Sandpiper	GI	- 99%	-16.5% ± 1.8%		↔	?	-32% ± 3.04%
10	Asian Openbill	GI	- 96%	-16.0% ± 2.2%		?	↑	+33% ± 2.39%
11	Little Egret	HI	- 46%	-7.7% ± 2.6%		↑	?	-22% ± 1.56%
12	Indian Pond Heron	HI	- 65%	-10.8% ± 1.8%		?	?	-5% ± 1.58%

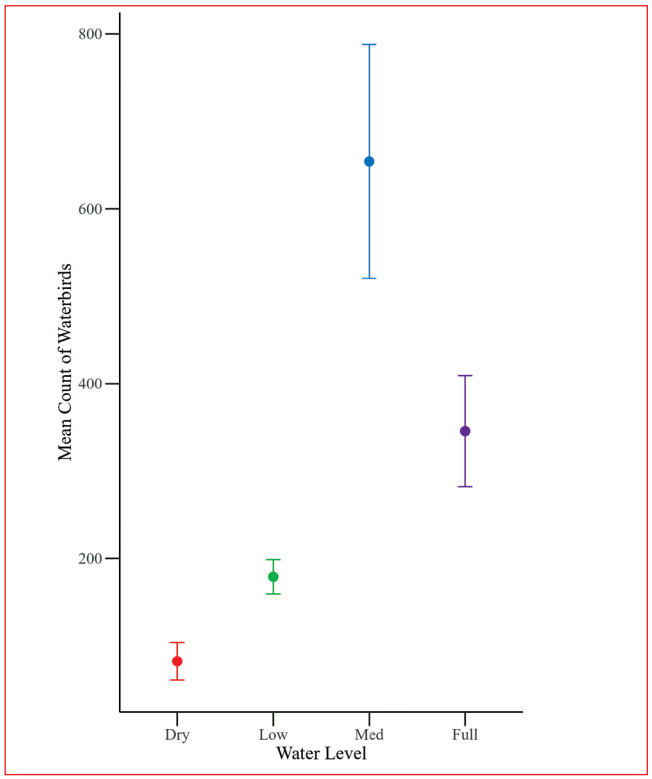


Fig. 3. The Mean Count of waterbirds based on water level across all years.

Fig. 4. Mean Counts of birds that utilize the deeper waters across all years.

Impact of Water levels

The highest counts of waterbirds were obtained when the water level of the lake was 'Medium' (Fig. 3) when large flocks of dabbling ducks, storks, and shorebirds occur when the lake is not brimming with water. This is true for birds found in the deeper water (Fig. 4) as well as those on the margins (Fig. 5)

Of the 49 waterbirds recorded, 29 of them are present in high numbers when water level is Medium. About 80% of the shorebirds are present only during the aforesaid condition, feeding on the moist mudflats.

Waterbird Declines

Several waterbird counts declined steeply in Perur Lake during the study period (Table 8), sometimes resulting in total disappearance. Eight species are categorized as 'Gravely Impacted' and four as 'Highly Impacted'.

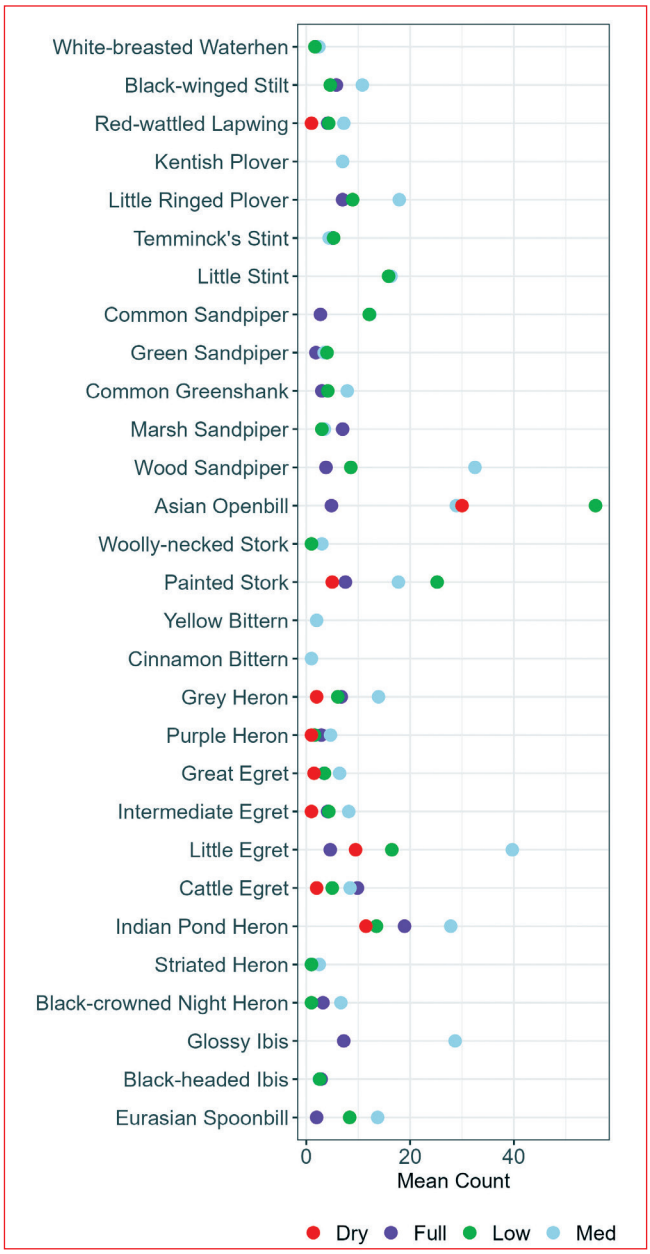


Fig. 5. Mean Counts of birds that utilize the lake margins across all years.

Impact of disturbances

Anthropogenic disturbances in Perur Lake can be broadly categorized as:

Sand-mining: From June 2017 to September 2017, Perur Lake was subjected to sand-mining, which altered the character of the wetland. Deep pits and ravines that resulted from sand-mining disfigured 69% of the water spread area **[115]**. The topography of the gentle-sloping bowl-shaped wetland that was once hospitable to various waterbird groups like ducks, shorebirds, and egrets, deteriorated significantly (see Table 9).

115. Sand mining in Perur Lake from June to September 2017.

Commercial fishing: The deepened wetland was subsequently utilised for commercial fishing from October 2018 onwards and during most of 2019 and 2020, when copious monsoons facilitated this conversion **[116]**. The commercial fishing was implemented without any safety features for the bird population. The partially damaged bill of the Oriental Darter *Anhinga melanogaster* (December 2018) and an Indian Cormorant *Phalacrocorax fuscicollis* (January 2020) trapped in a fishing net are some of the examples of the dangers that birds encountered due to the expansion of this activity **[117]**.

116. Commercial fishing using fixed nets and a coracle.

R. Sivashankar

117. An Oriental Darter's bill entangled in a fishing net.

Road expansion: From March 2019 onwards the wetland was subjected to an encroachment in the form of expansion of the existing road, which was finished in February 2021 **[118]**. This entailed the removal of vegetation and the appropriation of the wetland's area for a two-lane roadway **[119]**. An estimated 0.1 sq. km (*c.*9% of water coverage area) has been encroached for the construction of a containment wall of 1.5m in height along the perimeter of the wetland.

118. Encroachment of the wetland for road expansion.

All: G. Parameswaran

119. Building of the containment wall in the wetland during road expansion.

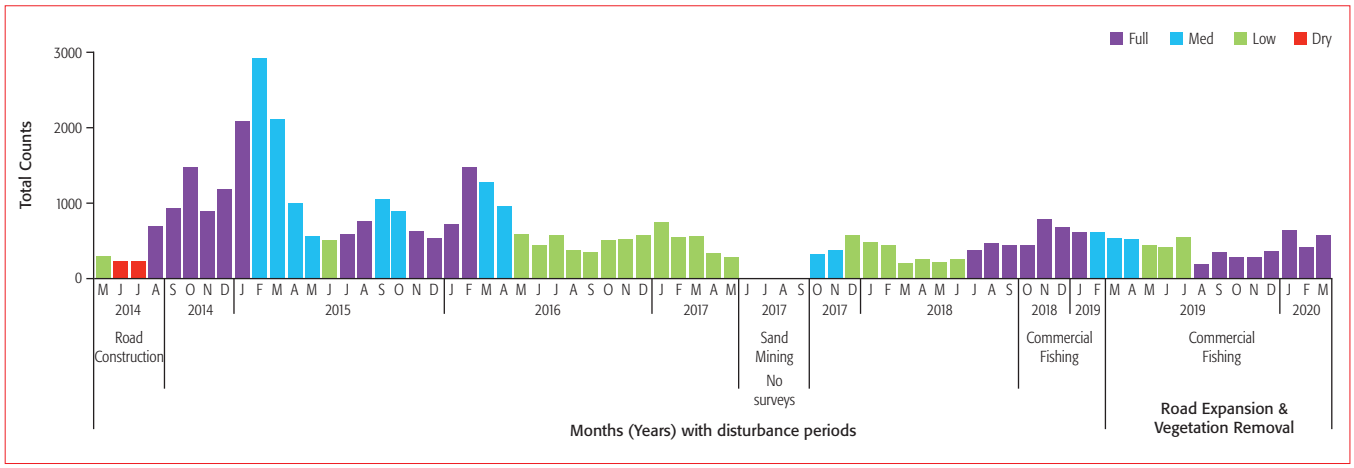


Fig. 6. The decreasing monthly trend from June to September 2017 of total number of birds due to various disturbances, colour-coded with water levels.

Due to all these disturbances, there is an overall decrease in waterbird population from 2014 till 2020 and the low counts are synchronous with threat events (Fig. 6). The road construction had a severe impact (98% decline) on bird population while sand-mining and subsequent commercial fishing resulted in 51% decline (Table 9–10).

Table 9. Cumulative negative impact of sand-mining and commercial fishing on waterbirds of the lake

Period	Average number of waterbird species	Average number of waterbirds
March 2014 to May 2017 (Before sand-mining)	19 ± 1	429 ± 72
October 2017 to March 2020 (After sand-mining and during commercial fishing)	17 ± 1	209 ± 21
Decrease	10.5%	51%

Table 10. Negative impact of road construction on birds of the lake

Period	Average number of species	Average number of birds
March 2014 to August 2014 (Road Construction period)	36 ± 4.21	460 ± 98
March 2015 to August 2015 (No road construction)	49 ± 4.82	910 ± 246
Increase on the cessation of road construction	36%	98%

Discussion & Conclusion

Results from our ongoing long-term study emphasizes the importance of monitoring common waterbirds. Their population levels and breeding status are good and reliable indicators of biodiversity and ecosystem health of wetlands (Gregory et al. 2003; Gregory & Van Strien 2010). Our data (see Fig. 6, Table 7–9) in conjunction with the studies mentioned above emphasizes the urgency of addressing this downward trend in the population of common birds.

Results from the first two years (Fig. 6 & Table 7), indicate that the peak species numbers and observation counts occur during the months of February, March, and April, possibly pointing towards their northward migration (Parameswaran & Sivashankar 2018). However, this conventional pattern has been seriously disrupted by a series of human activities from June 2017 to April 2020.

From the analysis of data provided in Table 8 we find that the overall population of twelve representative waterbirds in Perur Lake have all declined ranging from 43% to 100%, whereas the global and national data do not indicate any alignment with our local trends. According to Evans et al. (2008), local factors are more influential than regional ones and by logical extension national and international factors. Therefore, we can conclude, that the steep decline in 12 representative waterbird population in Perur Lake, are due to the cumulative effect of various aforementioned human activities executed locally.

The presence or absence of water and its corresponding level is the key determining factor of the waterbird species composition. It is probable that the water was artificially maintained at a higher than natural level to aid commercial fishing, technically called 'water impounding' (O'Connell 2000) that altered the functioning of the wetland by disrupting its flow and reducing bird counts (Table 9).

Sand-mining is technically a reclamation (O'Connell 2000), which along with the subsequent water impoundment may have negatively impacted both the individual species populations as well as their community composition. Globally, the modification of natural systems by activities such as sand-mining changes the character of the wetland and affects nearly 1,000 species (Lees et al. 2022). In addition, biological resource extraction like fishing alone exceeds 200 species, while human disturbances like road building are estimated to negatively impact on 40 species (Lees et al. 2022). The impact on bird population during an earlier road building spell, that removed existing vegetation during March-August 2014, is clear from the increase in waterbirds after the cessation of the activities (Table 10; Parameswaran & Sivashankar 2018).

We demonstrate that the anthropological disturbances in an urban wetland are detrimental to the waterbirds it supports. While the decline in waterbirds can be correlated with the disturbances, these threats may have acted in tandem together with decline events outside our study area. Hence, we cannot be certain

about the absolute individual contribution of each disturbance. Waterbirds usually avoid areas with extensive disturbance, choose roosting or foraging sites without them, and generally prefer wetlands with features that maximize the abundance and accessibility of their food (Khan et al. 2016).

Perur Lake was actively considered for the designation as a "Bird Sanctuary" due to the presence of a large number of migratory and resident birds (Mohanraj et al. 2000; Chandra et al. 2009). The establishment of buffer areas around the lakes could have reduced the anthropogenic pressures and augmented the natural purification processes in these systems and improved the environmental quality of the wetland (Chandra et al. 2009). The non-implementation of those protective measures in a timely manner has not only resulted in the reduction of bird population due to loss of habitat but also the overall deterioration in the functioning of the ecosystem.

Any study of a single wetland like ours even though limited in scope is like "a canary in a coalmine," that points towards the gradual erosion of the ecosystem especially in the wetlands of Coimbatore district. Hence, it is important that similar studies be conducted in some of the adjoining wetlands of the area in a synchronous manner.

The current geological epoch (*a.k.a.* Anthropocene), where human actions have an overwhelming influence on earth's ecosystems, bird populations have been found to be declining globally (BirdLife International 2018; SoIB 2020; Lees et al. 2022). We urge the administrative institutions whether they be national, state, or local, that they manage our wetlands as responsible stewards rather than enablers for unsustainable resource extraction that seriously disrupts its ecosystem.

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