CARAS
© 2023, Centre for Advanced Research in Agricultural Sciences
Research Journal of Agricultural Sciences
Volume 14; Issue 03 (May-Jun 2023); pp 676–682

Open Access
ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Full Length Research Article

Decreasing Waterbird Assemblages in Ulavaipu Mangroves due to Conservation Problems

Neena Narayanan*[1] and Latha C[2]

[1] Fatima Mata National College, Kollam - 691 001, Kerala, India
[2] Milad-E-Sherief Memorial College, Kayamkulam - 690 502, Kerala, India

Abstract

Water birds are one of the bio-indicators of wetland ecosystem. Inland mangroves help in monitoring the water bird diversity and their assemblages. This study has been conducted in Jan. 2021- Dec. 2022 as weekly surveys. Observations on water birds were carried out by using a 10X50 Nikon Coolpix Binocular and Nikon p1000 Camera. Bird Surveys were conducted using the following methods - Direct observation method, point count and Line transect method. A total of 18 species of water birds belonging to 7 orders and 10 families were observed in the study area. Of these, 7 species of water birds were observed only in the winter season whereas 11 species were observed in every month. According to the water bird assemblages, 61.11% are Common, 27.78% were Uncommon, and 11.11% are Rare water birds. The water bird count was low in 2022 compared to the starting time (2021). Analysis of reasons for the decreasing water bird count in Ulavaipu mangroves proves that Ulavaipu mangroves are undergoing the conservation problems. Anthropogenic activities are the major threat in this area which causes the decreasing count of water birds. The Shannon index (H) of water birds in 2021 is 2.08 and 1.95 in 2022. The highest water bird diversity was recorded in Nov and lowest was observed in July. Two globally threatened water birds of Black-headed ibis and Oriental darter were observed during the field time. Four species of mangroves were identified. They are *Rhizophora mangle, Kandelia candel, Bruguiera gymnorhiza and Rhizophora apiculata*.

***Key words*:** Water bird diversity, Assemblages of water bird species, Mangrove species, Physico- chemical parameters, Conservation problems

Water birds are one of the most important indicators in wetland ecosystems and gives a highly sensible habitat structure [30]. Birds as indicators are used for concentrating on ecological issues [3]. Also, they are excellent for long-distance dispersal and also important in terrestrial habitats, and provide connectivity across terrestrial – aquatic boundaries [11]. Wetlands support different activities of water birds like foraging, feeding, moving, resting, calling, preening, chasing etc. [1]. Wetlands are highly productive ecosystems [22] and it provides the home for many threatened water bird Species [19].

Mangroves occupies a major habitat of freshwater and marine water which protect the shorelines from the flood [25]. Mangrove ecosystems allow suitable habitats for survival of different species [28] including fish, crustaceans, birds and other organisms [7]. Marine ecosystem contains marine benthic infaunal species (Annelida, Arthropoda, Mollusca and Echinodermata) and it provides an ecological function in the ecosystem of mangroves [21]. Mangroves provide a healthy store of resident for migrant water bird diversity [21]. Mangrove vegetation has been found to be declined in the world [31] and 20-30% lost during the last decades because of conservation problems [16]. In India, 95% of mangrove species have been lost to the serious threat of climate change [32]. The present study aims to understand water bird species and their assemblages, different mangrove species and physico-chemical factors which causes the decreasing trend of water bird species.

MATERIALS AND METHODS

Study area

The study area belongs to the Central part of Kerala. Ulavaipu is an Inland Mangrove area and is a small village (9°48'10.6"N 76°19'49.2" E) situated on the Northern side of Thaikattussery Panchayat in Cherthala Taluk. This village is also known as the "Granary of Thaikattussery Panchayat". This is a famous tourist place in the Alappuzha district. The area is observed in freshwater mangroves near the Kaithapuzha river system. Inland mangroves that were found in the Ulavaipu area

Received: 09 Feb 2023; Revised accepted: 30 Apr 2023; Published online: 10 May 2023

Correspondence to: Neena Narayanan, Fatima Mata National College, Kollam - 691 001, Kerala, India, Tel: +91 1234567890; E-mail: neenanarayanan84@gmail.com

Citation: Narayanan N, Latha C. 2023. Decreasing waterbird assemblages in Ulavaipu mangroves due to conservation problems. *Res. Jr. Agril. Sci.* 14(3): 676-682.

are *Rhizophora mangle, Kandelia candel, Bruguiera gymnorrhiza,* and *Rhizophora apiculata.*

Water bird count

The study area has been observed once in a week from 6:00h–12:00 h [13]. The present study was conducted during the period of Jan. 2021 to Dec. 2022. Observations were made through binoculars (10 × 50 Nikon) and Nikon Coolpix p1000 Video Camera. Bird Surveys were conducted using the following methods - Direct observation method [13], Point count [30] and Line transect method [20]. Bird species were identified with the help of a field guide [2], [12] from the field itself. Different activities of birds were recorded as foraging and feeding, moving, resting, calling, preening, chasing, etc. [1]. All the visible water birds present in the study area were counted [30]. The purpose of the Direct observation method is to observe the wetland water birds directly and also to determine the various conservation problems affecting the wetlands and also water birds [33]. Using the Point count method, the observer reaches the centre of the point count plots and records all water birds seen or heard for a period of 10 or 15 minutes [24]. Point count is not performed on the days with heavy rain and strong wind [30], [34]. For Line transact method, the total no. of water birds were recorded by walking through transact from one scanning point to the adjoin one (approximately 500m) along a transect line [20]. When standing at each transacted sample point for ten minutes, birds seen or heard were recorded [8]. Counting of all water birds and logging them in a different datasheet were carried out.

Environmental parameters

In addition to the water bird diversity, water and soil samples were also collected once in a month during Jan. 2021-Dec. 2022. Soil quality parameters such as pH, Total Nitrogen, Total Phosphorus, Potassium, Organic carbon and water parameters such as pH, Phosphate, Nitrate, Potassium, Ca+ ions, Mg+ ions and Salinity were analysed during 2021-22. Estimation of Nitrogen was done using Kjeldahl method, estimation of phosphorus by molybdenum method, estimation of potassium by flame photometry, estimation of organic carbon by Walkey and Black's method, Soil pH was determined using pH meter and salinity by TDS meter [23], [30]. Water pH can be determined using a pH meter. Estimation of nitrate has been done using the cadmium reduction method, potassium by flame photometry, phosphate by spectrophotometry, calcium and magnesium by EDTA Titrimetric method. Salinity was checked by using a TDS Conductivity meter [23], [30].

RESULTS AND DISCUSSION

Water bird diversity in Ulavaipu mangroves

Analysis of water bird diversity in Ulavaipu mangroves carried out during Jan 2021-Dec 2022. A total of 18 species of water birds belonging to 7 Orders and 10 families were observed in the study area (Table 1). The observed water birds are the Little egret (*Egretta garzetta*), Median egret (*Ardea intermedia*), Large egret (*Ardea alba*), Indian pond heron (*Ardeola grayii*), Grey heron (*Ardea cinerea*), Purple heron (*Ardea purpurea*), Oriental ibis (*Threskiornis melanocephalus*), White-throated kingfisher (*Halcyon smyrnensis*), Stork-billed Kingfisher (*Pelargopsis capensis*), Common kingfisher (*Alcedo atthis*), White breasted waterhen (*Amaurornis phoenicurus*), Purple swamphen (*Porphyrio porphyrio*), Little Cormorant (*Microcarbo niger)*, Darter (*Anhinga melanogaster*), Little Grebe (*Tachybaptus ruficollis*), Wood Sandpiper (*Tringa glareola*), Whiskered Tern (*Chlidonias hybrid*) and Lesser whistling duck (*Anas arcuate*). The observed families and orders are: Family Ardeidae (6 species) and family Threskiornithidae (1 species) including egrets, herons, and ibis are under the Order Pelecaniformes, Family Alcedinidae (3 species) are under the Order Coraciiformes, Family Rallidae (2 species) are under the Order Gruiformes, Family Phalacrocoracidae (1 species) and Family Anhingidae (1 species) are under the Order Suliformes. Family Podicipedidae (1 species) are under the order Podicipediformes, Family Scolopacidae (1 species) and Family Laridae (1 species) are under the Order Charadriiformes, Family Anatidae (1 species) are under the Order Anseriformes.

Table 1 Checklist of water bird species in Ulavaipu mangroves

Order and family	Scientific name	Common name	Season	Assemblages of waterbirds	IUCN	Count (2021)	Count (2022)
Pelecaniformes					LC		
Ardeidae	*Egretta garzetta* (Linnaeus, 1766)	Little egret	S, M, W	COM	LC	103	59
	Ardea intermedia (Wagler, 1827)	Median egret	S, M, W	COM	LC	142	124
	Ardea alba (Linnaeus, 1766)	Large egret	W	UC	LC	13	7
	Ardeola grayii (Sykes, 1832)	Indian pond heron	S, M, W	COM	LC	661	539
	Ardea cinerea (Linnaeus, 1758)	Grey heron	S, M, W	COM	LC	51	29
	Ardea purpurea (Linnaeus, 1766)	Purple heron	S, M, W	COM	LC	108	60
Threskiornithidae	*Threskiornis melanocephalus* (Latham, 1790)	Oriental ibis	W	UC	NT	23	30
Coraciiformes					LC		
Alcedinidae	*Halcyon smyrnensis* (Linnaeus, 1758)	White-throated Kingfisher	S, M, W	COM	LC	52	34
	Pelargopsis capensis (Linnaeus, 1766)	Stork-billed Kingfisher	S, M, W	COM	LC	67	59
	Alcedo atthis (Linnaeus, 1758)	Common Kingfisher	W	UC	LC	21	17
Gruiformes					LC		
Rallidae	*Amaurornis phoenicurus* (Pennant, 1769)	White-breasted waterhen	W	UC	LC	9	4
	Porphyrio porphyrio (Linnaeus, 1758)	Purple swamphen	W	R	LC	78	21
Suliformes					LC		
Phalacrocoracidae	*Microcarbo niger* (Vieillot, 1817)	Little Cormorant	S, M, W	COM		761	603
Anhingidae	*Anhinga melanogaster* (Pennant, 1769)	Darter	S, M, W	COM	NT	68	39
Podicipediformes							
Podicipedidae	*Tachybaptus ruficollis* (Pallas, 1764)	Little Grebe	W	UC	LC	174	63
Charadriiformes							
Scolopacidae	*Tringa glareola* (Linnaeus, 1758)	Wood Sandpiper	S, M, W	COM	LC	43	29
Laridae	*Chlidonias hybrid* (Pallas, 1811)	Whiskered Tern	S, M, W	COM	LC	723	541
Anseriformes							
Anatidae	*Anas arcuate* (Horsfield, 1824)	Lesser whistling duck	W	R	LC	159	72

Season
S: Summer
M: Monsoon
W: Winter

Assemblages of waterbirds
Com: Common
Uc: Uncommon
R: Rare

IUCN
Lc: Least Concern
Nt: Near Threatened

The most abundant resident water bird species observed in the study area are Egrets, Herons, Little cormorants, Darter and Kingfishers. Other water birds such as ibis, terns, grebe, waterhen, swamphen, sandpiper and whistling duck were observed only in the winter season (Table 1). The highest water bird congregations were recorded in the winter season especially in Nov and the lowest in the Monsoon season in July. Globally threatened water birds such as Black-headed ibis and darter were observed during 2021-2022.

Among 18 species of water birds observed during 2021-2022, 11 species were observed in Summer and Monsoon season. In addition to this, 7 species of water birds were observed in the winter season (Fig 2). The winter visitors are large egret, oriental ibis, common kingfisher, white-breasted waterhen, purple swamphen, little grebe and lesser whistling duck. little egret, median egret, Indian pond heron, grey heron, purple heron, white-throated kingfisher, stork-billed kingfisher, little cormorant, darter, wood sandpiper, whiskered tern were observed in every month.

Table 2 Waterbird count in 2021- 2022

Order	Species	Total individuals in 2021	Total individuals in 2022
Pelecaniformes	7	1101	848
Coraciiformes	3	140	110
Gruiformes	2	87	25
Suliformes	2	829	652
Podicipediformes	1	174	63
Charadriiformes	2	766	570
Anseriformes	1	159	72
Total	18	3256	2330

The assemblages of water bird species

Water bird assemblages are classified into Common (COM): Seen on most of the visits, uncommon (UC): seen on a few visits, and rare (R): seen once or absent. Out of 18 species of water birds identified, 61.11% were common (COM), 27.78% were uncommon (UC) and 11.11% rare (R) water birds. Of these, the little egret, median egret, pond heron, grey heron, purple heron, white-throated kingfisher, stork-billed kingfisher, little cormorant, darter, wood sandpiper and tern were observed as common water birds. large egrets, oriental ibis, common kingfisher, white-breasted waterhen and little grebe are uncommon and purple swamphen and lesser whistling ducks are rare birds (Fig 1).

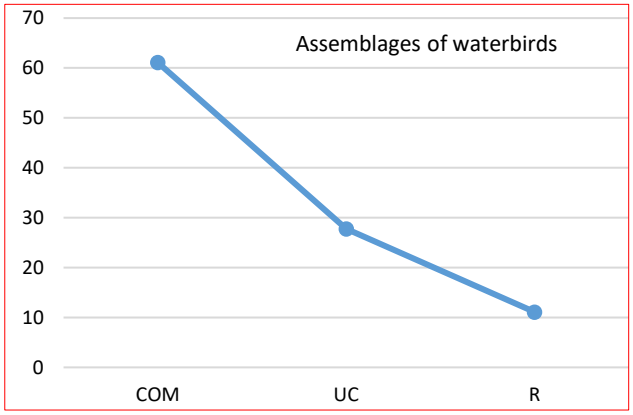


Fig 1 Water bird assemblages

The water bird diversity in 2021-2022

The study was conducted in 2021-2022 as weekly surveys. The water bird count in 2021 (Jan.-Dec.) was 3256 and in 2022 (Jan.-Dec.), it was 2330 (Fig 3). The water bird count in Ulavaipu was found decreasing from Jan 2021 to Dec.2022. During 2021, the total number of water bird species was 3256. Of these, for the Order Pelecaniformes, 1101 birds were observed which comes under 7 species. Under order Coraciiformes, 140 birds were observed which comes under 3 species. For order Gruiformes, 87 birds were observed under 2 species. For the order Suliformes, 829 birds were observed which comes under 2 species. Order Podicipediformes had 174 birds under 1 species. For the order Charadriiformes, 766 birds were observed which comes under 2 species. Order Anseriformes had 159 birds under 1 species.

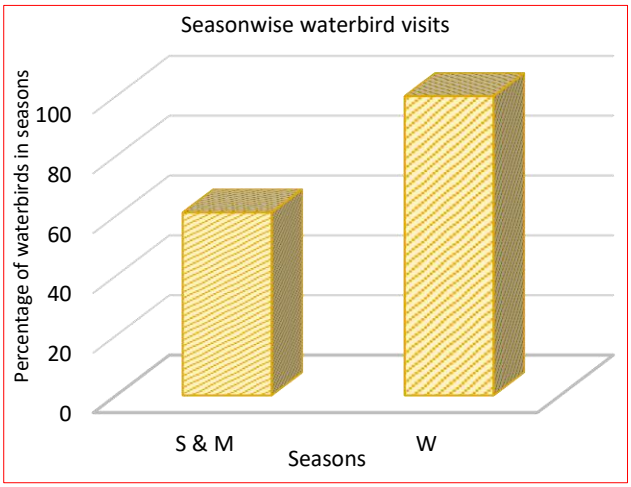


Fig 2 Water birds visits in season wise

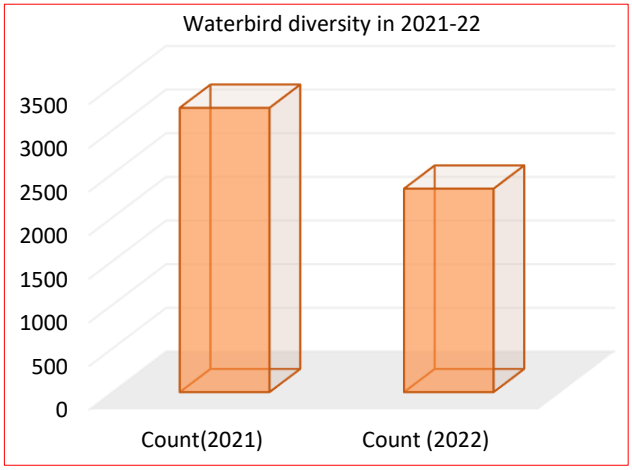
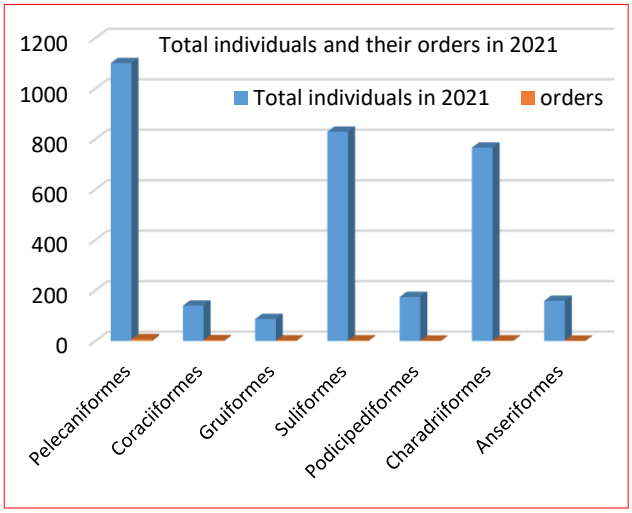


Fig 3 Compare the water bird count in 2021-22

In 2022, the total number of water bird species was 2330. Of these, for order Pelecaniformes, 848 birds were observed under 7 species. Under order Coraciiformes, 110 birds were observed under 3 species. Order Gruiformes had 25 birds under 2 species. For Suliformes. 652 birds were observed which comes under 2 species. Order Podicipediformes had 63 birds under 1 species. For the Order Charadriiformes, 570 birds were observed which comes under 2 species. 72 birds were observed under the order Anseriformes which comes under 1 species. (Table 2). (Fig 4) shows the individual water bird count and species congregation including orders in 2021 and 2022.

The reasons behind the decreasing level of water birds were analysed in Ulavaipu mangroves showed that anthropogenic activities were the main reason for the decreasing bird diversity. The wetland is very important habitat as it is the inland mangrove ecosystem that protects many freshwater species. So, the decreasing level of water bird count in Ulavaipu proves that this area is under conservation problems.



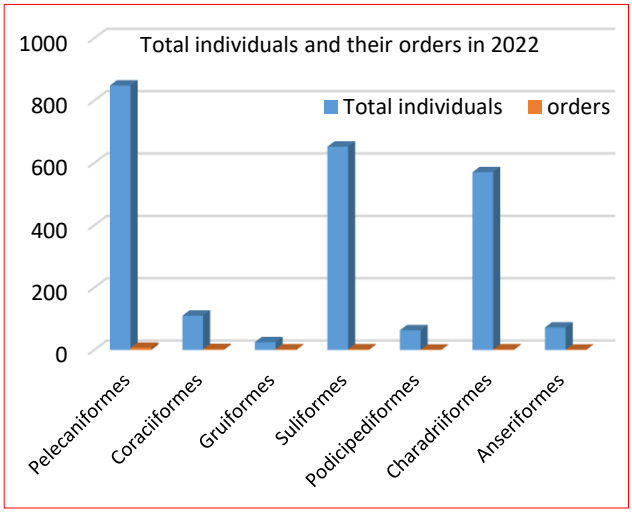


Fig 4 Total individuals and their orders in 2021-2022

Table 3 Species abundance and Shannon-Weiner Index in 2021

Species	No. of water bird count (2021)	Species abundance	Relative abundance (Pi)	Ln (Pi)	Pi (Ln(Pi))
Little egret	103	3.16	0.031	-3.47	-0.10
Median egret	142	4.36	0.043	-3.14	-0.13
Large egret	13	0.39	0.003	-5.80	-0.01
Indian pond heron	661	20.30	0.203	-1.59	-0.32
Grey heron	51	1.56	0.015	-4.19	-0.06
Purple heron	108	3.22	0.033	-3.41	-0.11
Oriental ibis	23	0.70	0.007	-4.96	-0.03
White-throated Kingfisher	52	1.59	0.015	-4.19	-0.06
Stork billed kingfisher	67	2.05	0.020	-3.91	-0.07
Common Kingfisher	21	0.64	0.006	-5.11	-0.03
White-breasted waterhen	9	0.27	0.002	-6.21	-0.01
Purple swamphen	78	2.39	0.023	-3.77	-0.08
Little cormorant	761	23.37	0.233	-1.45	-0.33
Darter	68	2.08	0.020	-3.91	-0.07
Little grebe	174	5.34	0.053	-2.93	-0.15
Wood sandpiper	43	1.32	0.013	-4.34	-0.05
Whiskered tern	723	22.20	0.222	-1.50	-0.33
Lesser whistling duck	159	4.88	0.048	-3.03	-0.14
Total	3256				
H	-2.08				

Table 4 Species abundance and Shannon-wiener Index in 2022

Species	No. of water bird count (2022)	Species abundance	Relative abundance (Pi)	Ln (Pi)	Pi (Ln(Pi))
Little egret	59	2.53	0.025	-3.68	-0.09
Median egret	124	5.32	0.053	-2.93	-0.15
Large egret	7	0.30	0.003	-5.80	-0.01
Indian pond heron	539	23.13	0.231	-1.46	-0.33
Grey heron	29	1.24	0.012	-4.42	-0.05
Purple heron	60	2.57	0.025	-3.68	-0.09
Oriental ibis	30	1.28	0.012	-4.42	-0.05
White-throated Kingfisher	34	1.45	0.014	-4.26	-0.05
Stork billed kingfisher	59	2.53	0.025	-3.68	-0.09
Common Kingfisher	17	0.72	0.007	-4.96	-0.03
White-breasted waterhen	4	0.17	0.001	-6.90	-0.00
Purple swamphen	21	0.90	0.009	-4.71	-0.04
Little cormorant	603	25.87	0.258	-1.35	-0.34
Darter	39	1.67	0.016	-4.13	-0.06
Little grebe	63	2.70	0.027	-3.61	-0.09
Wood sandpiper	29	1.24	0.012	-4.42	-0.05
Whiskered tern	541	23.21	0.232	-1.46	-0.33
Lesser whistling duck	72	3.09	0.030	-3.50	-0.10
Total	2330				
H	-1.95				

Data analysis

Data analysis have been done by using Species richness, Species abundance, Shannon-wiener index and Species evenness. Species richness of water birds in Ulavaipu mangroves are 18. In 2021, total number of water birds of all species was 3256 and 2022 is 2330. The Shannon index (H) of water birds in 2021 was 2.08 (Table 3). The Shannon index (H) of water birds in 2022 was 1.95 (Table 4). The higher value of H was in 2021 than 2022. So, the diversity of water birds in Ulavaipu is high in 2021 and low in 2022. EH in 2021 was 0.11, EH in 2022 was 0.10. Species evenness in 2021 was 0.71 and 2022 was 0.67. This value ranges from 0 to 1 where 1 indicates complete evenness.

Water and soil quality measurement in Ulavaipu mangroves

Analysis of soil and water quality parameters have been carried out in Jan 2021-Dec 2022. The soil parameters such as pH, total nitrogen and phosphorous, potassium and organic carbon were analysed (Table 5). In 2021; pH, total nitrogen, total phosphorous, potassium and organic carbon was 7.63, 2.96%, 1.15mg/kg, 3.3mg/kg, 34.3% respectively. In 2022, pH, total nitrogen, total phosphorous, potassium and organic carbon was 7.97, 2.96%, 1.15mg/kg, 3.28mg/kg, 30.12% respectively.

Water quality parameters such as pH, phosphate, nitrate, potassium, Ca^+ ions, Mg^+ ions and salinity were determined (Table 6). In 2021; pH, phosphate, nitrate, potassium, Ca^+ ions, Mg^+ ions and salinity was 7.36, 0.07mg/l, 0.76mg/l, 3.0mg/l, 80.67mg/l, 96 and 0.52ppt respectively. In 2022, pH, phosphate, nitrate, potassium, Ca+ ions, Mg+ ions and salinity was 7.95, 0.04 mg/l, 0.75 mg/l, 2.80 mg/l, 70 mg/l, 82 and 0.83ppt respectively.

Table 5 Soil quality parameters in 2021-2022

Soil	Parameters	2021	2022
Habitat type	Inland mangroves		
pH	6.5-8.0	7.63	7.97
Total nitrogen (N) (%)	0.5-1.0	2.96	2.96
Total phosphorous (P) (mg/kg)	10-25	1.15	1.15
Potassium (K) (mg/kg)	50-125	3.3	3.28
Organic carbon (OC) (%)	0.75-1.5	34.3	30.12

Table 6 Water quality parameters in 2021-2022

Water (Parameter)	Desirable limits as per IS: 10500-2012	2021	2022
Habitat type	Inland mangroves		
pH	6.5-8.5/l	7.36	7.95
Phosphate	0.1mg/l	0.07	0.04
Nitrate	45mg/l as NO3	0.76	0.75
Pottassium	300mg/l as CaCO3	3.0	2.80
Ca+ ions	75mg/l	80.67	70
Mg + ions	80mg/l	96	82
Salinity	3ppt	0.524	0.83

Mangrove species in Ulavaipu

Rhizophoraceae is the only mangrove family observed in Ulavaipu. Four species of Rhizophoraceae were identified during 2021-2022. They are *Rhizophora mangle, Kandelia candel, Bruguiera gymnorhiza* and *Rhizophora apiculata*. In addition to this, many flowering plants were also identified. Galactia (Genus of plants in the legume family), Indian tulip tree (species of flowering plant) and Schoepfia are a genus of small hemiparasitic trees whereas flowering plants belongs to the family of Schoepfiaceae.

Conservation problems in Ulavaipu area

Many factors that are listed below threatens the mangroves and it causes the decreasing level of the water bird population in these areas.

a. *Electric lines*: Water birds use their resting and preening time on electric lines. Sometimes the electric shock may affect and can cause death.
b. *High growth level of water hyacinth*: Water hyacinth were observed on the surface of the Kaithapuzha River and near the mangroves. It will decrease the count of water birds.
c. *Fishing nets*: Farmers use different types of fishing nets having different sizes. Small-sized nets dipped inside the water cause the death of open-water species of water birds like cormorants and darters.
d. *Solid wastes*: Solid wastes were found to be deposited from many factories and resorts.
e. *Water contamination*: Some chemicals are being used to remove the unwanted plants in the pathways. This causes the pollution of water.
f. *Tourism*: Ulavaipu is a tourist area, many peoples come to this place and this brings the disturbance for water birds.
g. *Sound materials*: During fishing, farmers use some sound-producing materials which makes disturbance for cormorants and darters.
h. *High level of fishing activities*: Fishermen used to disturb the foraging behaviour of water birds which leads to decreasing count of birds.
i. *Prawn farming*: Prawn farming is another reason of threatening to the water birds and also for Inland mangroves.
j. *High water intake*: Ulavaipu mangroves were observed near the river system. There is a connection between a pathway in the center of the Kaithapuzha River and Ulavaipu mangroves. Water-edged birds such as egrets and herons were feeding with the help of fish traps placed on the side of the pathway. Fish traps are partially covered by green nets and bamboo sticks. High water intake affects water-edged bird species like egrets and herons. But it will be helpful for Cormorants and Darters under the order Suliformes.

Species abundance and Shannon – Wiener Index in Water bird species (Jan-Dec 2021 to Jan-Dec 2022).

The present study documented the assemblages of water birds, different mangrove species, environmental parameters and reasons behind the decreasing water bird count in Ulavaipu mangroves. Different water birds were observed including egrets, herons, cormorants, darters, and shorebirds such as wood sandpipers. Mangrove ecosystems have a rich diversity of water birds [7]. Mangrove ecosystems are an important area for conserving different water birds. But since Ulavaipu is an Inland mangrove ecosystem, the water bird count had been low during 2022 because of conservation problems. We observed two globally threatened water birds in the Ulavaipu mangroves. Black-headed ibis and Oriental darter are the threatened water bird species. Globally threatened birds [10] were observed in worldwide. Of these, three globally threatened water birds are observed in the Pokali area, Alappuzha district [27]. The Shannon-wiener index is used to calculate the Relative abundance and diversity of water birds in the Ulavaipu mangroves (Table 3). Shannon index in 2021 was 2.08. The total number of water birds in 2021 (Jan-Dec) is 3256. Shannon index in 2022 was 1.95. The total number of water birds in 2022 (Jan-Dec) is 2330 (Table 4) [14].

Analysis of soil & water quality parameters in Ulavaipu Mangroves

Soil and water quality parameters that were collected monthly during 2021-2022 [30] were summarized. The soil parameters such as pH, total nitrogen and phosphorous, potassium and organic carbon were analysed (Table 5). In 2021; pH, total nitrogen, total phosphorous, potassium and organic carbon reported were 7.63, 2.96%, 1.15mg/kg, 3.3mg/kg, 34.3% respectively. In 2022, pH, total nitrogen, total phosphorous, potassium and organic carbon were found to be 7.97, 2.96%, 1.15mg/kg, 3.28mg/kg, 30.12% respectively. Similarly for water quality parameters, pH, phosphate, nitrate, potassium, Ca^{+} ions and salinity were measured. In 2021, the reported values are 7.36, 0.07, 0.76, 3, 80.67,96 and 0.524 respectively. The values for 2022 is 7.95, 0.04, 0.75, 2.8,70,82 and 0.83 respectively (Table 6).

Conservation aspects

Many bird species are close to extinction because of habitat conversion, and disturbance of other animals [5]. Human beings are the main threats to these areas that were observed during the study. Inland wetlands are now threatened by many factors. Protection of their habitat is one of the methods to conserve the water bird population [18]. One of the main threats is shrimp farming. Shrimp farming is one of the serious threats to mangrove ecosystems [6]. Micro plastic pollution in mangroves threatens the avifauna and other components of biodiversity [17]. Heavy metals are the major pollutant threats to the wetland environment [35]. Solid waste dumping affects mangroves and other organisms. Fishermen were disturbed mainly by cormorants and darters which prevented the ongoing prawn farming.

Aquaculture is one of the factors which cause the loss of mangroves worldwide. So, the growth of mangroves increased by 20.72% in India between 1988 and 2018 [15]. Environmental changes and climate change affects the mangrove ecosystem [7]. Urbanization is a threat that causes the extinction of many animals. In Kerala, wetland birds are adapted to fresh urban conditions [9]. Mangrove ecosystems have no clear boundaries. So, this causes the other animals to damage these ecosystems [4]. Exotic plants, agriculture [29] and fishnets, electric lines [26] exhibit lots of problems in the mangrove ecosystem.

CONCLUSION

Mangrove ecosystems are an important area for conserving different water bird population. Ulavaipu is an inland mangrove ecosystem and it provides shelter for water bird species such as egrets, herons, and cormorants. The water bird counts in 2021-2022 shows that the water bird species count has decreased. Conservation problems are the main reason that causes the decreasing level of water bird species.

LITERATURE CITED

1. Akhtar S, Kabir MM, Hasan MK, Begum S. 2009. Activity pattern of Bronze-winged Jacana (*Metopidius Indicus*) at Jahangirnagar University Campus, Bangladesh. *Jr. Life Sci.* 21(2): 111-120.
2. Ali S, Daniel. 2002. *The Book of Indian Birds*.13th Edition, Oxford University Press. pp 326.
3. Ali R, Shrivastava P, Gautham V. 2022. Study on the Avifaunal diversity and Species Richness in and around UPPER Lake, Bhopal, India. *Int. Jr. Appl. Research* 8(2): 121-126.
4. Aloysius N, Madhushanka S, Chandrika C. 2023. Avifaunal diversity and abundance in the proposed Sarasalai Mangrove Reserve, Jaffna, Sri Lanka. *Birds* 24(1): 103-116.
5. Arya AK, Bhatt D, Singh A, Saini V, Verma P, Rathi B, Bhatnagar P. 2019. Diversity and status of migratory and resident wetland birds in Haridwar, Uttarakhand, India. *Jr. of Applied and Nat. Sci.* 11(3).
6. Bijith P, Ramith M, Megha T. 2022. Shrimp farms as a threat to mangrove forests in Kannur district of Kerala, India. *Wetlands Ecol. Manage* 30: 1281-1289.
7. Bindiya ES, Sreekanth PM, Bhat SG. 2023. Conservation and management of mangrove ecosystem in diverse perspectives. *Springer*. https://doi.org/10.1007/978-981-19-5841-0_13.
8. Buckland ST, Anderson DR, Burnham KP, Lake JL. 1993. Distance sampling: Estimating abundance of biological populations. Chapman and Hall, London. pp 446.
9. Charutha K, Roshnath R, Sinu PA. 2021. Urban heronry birds tolerate human presence more than its conspecific rural birds. *Jr. of Nat. His.* 55(9-10): 561-570.
10. Deepa KM, Geoge J. 2017. Globally threatened species of birds recorded from Pokali wetland, Kerala, South India. *Jr. G. Bio. Sci*. 6(9): 5222-5226.
11. Green A, Lovas A, Reynolds C, Gonzalez E, Silva G, Leeuwen V, Wilkinson D. 2023. Dispersal of aquatic and terrestrial organisms by waterbirds: A review of current knowledge and future priorities. *Freshwater Biology* 68(2): 173-190. https://doi.org/10.1111/fwb.14038.
12. Grimmett R, Inskipp C, Inskipp T. 2000. *Birds of the Indian Subcontinent*. London: Oxford University Press. pp 384.
13. Hoves JG, Bakewell D. 1989. *Shorebird Studies Manual*. AWB Publication No 55, Kuala Lumpur. pp 362.
14. Issa MA 2019. Diversity and abundance of wild bird species in two different habitats at Sharkia Governorate, Egypt. *JoBAZ*. https://doi.org/10.1186/s41936-019-0103-5.
15. Jayanthi M, Samynathan M, Thirumurthy S, Duraismay MS, Kabiraj S, Vijayakumar A, Panigrahi M, Kumaran M, Muralidhar. 2022. Is aquaculture development responsible for mangrove conversion in India? - A geospatial study to assess the influence of natural and anthropogenic factors on mangroves in the last three decades. *Aquaculture* 561: https://doi.org/10.1016/j.aquaculture.2022.738696
16. Joshy S, Shukla J, Dhyani S. 2022. A participatory stakeholder-based approach to assess the drivers and challenges of mangrove loss in Kochi, Kerala, India. *Springer*. https://doi.org/10.1007/978-981-19-2738-6_5. pp 77–98.
17. Kannankai MP, Alex RK, Muralidharan VV. 2022. Urban mangrove ecosystems are under severe threat from microplastic pollution: a case study from Mangalavanam, Kerala, India. *Envt. Sci. Pollution Res*. 29: 80568-80580. https://doi.org/10.1007/s11356-022-21530-1.
18. Karikar S, Mali S, Prasad K. 2021. An assessment of bird communities across Ujjani and its five satellite wetlands in Solapur District of Maharashtra, India. *JoTT.* Partner Member Threatened Taxa Publisher & Host.

19. Kaur R, Brraich OS. 2021. Abundance and diversity of threatened birds in Nangal wetland, Punjab, India. *Journal of Threatened Taxa* 13(12): 19733-19742.
20. Luo K, Wu Z, Bai H, Wang Z. 2019. Bird diversity and waterbird habitat preferences in relation to wetland restoration at Dianchi Lake, Southwest India. *Avian Research* 10: 21. https://doi.org/10.1186/s40657-019-0162-9.
21. Kokkadan R, Cheruparambath P, Cabilao J, Albouchi S. 2023. A study of Infaunal abundance, diversity, and distribution in Chettuva mangrove, Kerala, India. *Envt. Sci*. 10(1): 82-92.
22. Kumari R, Shukla SK, Parmar K, Bordoloi N, Kumar A, Saikia P. 2020. Wetlands conservation and restoration for ecosystem services and halt biodiversity loss: An Indian perspective. *Springer.* https://doi.org/10.1007/978-981-13-7665-8_6.
23. Manju MN, Resmi P, Kumar G, Kumar R, Rahul R, Joseph MM, Chandramohanakumar N. 2012. Assessment of water quality parameters in Mangrove ecosystems along Kerala Coast: A statistical approach. *Int. Jr. Envt. Res.* 6(4): 893-902.
24. Mogaka, Muya, Ndwigah. 2019. Diversity, abundance, richness and birds of conservation interest in Nyando Sugar Belt, Muhoroni Sub- County, Lake Victoria Basin, Western Kenya. *Open. Jr. Animal Sci.* 9: 268-285.
25. Mukherji S, Imchen M, Mondal S, Bhattacharyya A, Siddhardha B, Kumavath R, Ghosh A. 2022. Anthropogenic impact accelerates antibiotic resistome diversity in the mangrove sediment of Indian Sundarban. *Chemosphere* 309(2): 136806.
26. Narayanan N. 2022. Diversity of waterbirds from coastal agroecosystem, central Kerala, India. *Uttar Pradesh Journal of Zoology* 43(11): 68-75.
27. Narayanan N. 2022. Three globally threatened waterbirds from Pokali wetland, Central Kerala. *International Journal of Science and Research* 11(6): 7-12.
28. Padmakumar V, Murugan S. 2022. Mangrove ecology and species distribution along the Gorai Creek of Mumbai coast, Maharashtra, India. *Ijfaf* 6(4): 22-26.
29. Patil S, Choudaj K. 2023. The importance of artificial wetlands in the conservation of wetland birds and the impact of land use attributes around the wetlands: A study from the Ajara Conservation Reserve, Western Ghats, India. *Zoodiversity* 57(1): 41-50.
30. Ramesh T, Hussain J, Satpathy KK, Das NPI, Rajendran P, Selvanayagam M. 2020. Abundance, assemblage, habitat characteristics and seasonal diversity of waterbirds at Kalpakkam, Southeast coast of India. *Asian Jr. of Cons. Biology* 9(1): 156-166.
31. Sievers M, Hale R, Parris KM, Swearer SI. 2018. Impacts of human-induced environmental change in wetlands on aquatic animals. *Biol. Rev.* 93: 529-545.
32. Sreelekshmi S, Harikrishnan M, Nandan SB. 2022. Ecosystem carbon stock and stable isotopic signatures of soil organic carbon sources across the mangrove ecosystems of Kerala, Southern India. *Wetlands* 42: 29. https://doi.org/10.1007/s13157-022-01540-y
33. Veeramani, Vinoth B, Ramakrishnan B, Mohanakrishnan H, Samson A. 2018. Diversity and habitat selection of wetland birds in Nilgiris, South India. *Int. Jr. of Zoology and Animal Biology* 1(3): 000114.
34. Volpato L, Mendonca, Bisheimer B, Anjos S. 2009. The use of the point count method for bird survey in the Atlantic Forest. *Zoologia* 26(1): 74-78.
35. Zhang Z, Zhang T, Yu W, Xu J, Li J, Wu T, Liu S, Wang H, Wang Y, Shang S, Lin A. 2022. Heavy metal contamination in sediments from wetlands invaded by *Spartina alterniflora* in the yellow river delta. *Toxics* 10(7): 374.