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IMPACT OF WETLAND MANAGEMENT ON THE DIVERSITY AND HABITAT UTILIZATION PATTERN OF WATERBIRDS IN A HUMAN-DOMINATED LANDSCAPE

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ABSTRACT: Wetlands are among the most productive ecosystems on earth and provide critical habitats for a wide range of avian species. A study on the impact of wetland management on the diversity and habitat utilization pattern of waterbirds was carried out from January 2024 to July 2024 at Jahangirnagar University campus. Bird species were recorded using point count method and fixed-route monitoring. A total of 25 species under 13 families were observed during the study period. Unmanaged lake had the highest diversity of birds (H'= 2.015, D= 0.833) compared to managed (H'= 1.616, D= 0.708) and partially managed wetlands (H'= 1.943, D=0.822). Wetland birds showed a clear preference for edge habitats (44%), followed by tree-adjoining wetlands (32%) and open water (24%). The current assessment of the status of wetland birds revealed 37% were common, 25% very common, 29% rare, and 8% as uncommon. Water parameters such as Dissolved Oxygen (DO) had a weak positive correlation with bird abundance (r= 0.42), while Total Dissolved Solid (TDS) and Temperature showed strong negative correlations (r= –0.81 and r= –0.87, respectively). The infrastructure development, uncontrolled growth of aquatic vegetation, pollution of waterbodies and anthropogenic disturbances such as noise from vehicles and loud human activity were identified as potential threats to wetland birds.

Key words*:* Waterbirds, Wetland management, Habitat preference, Diversity assessment, Water quality

INTRODUCTION

Wetlands are areas that form an interface between terrestrial and aquatic ecosystems, characterized by a water table that remains near the surface or by the presence of shallow surface water (Mitsch and Gosselink, 1986). Wetlands are among the most productive ecosystems globally and perform essential ecological functions, including flood mitigation, groundwater recharge, nutrient retention, and erosion prevention. Moreover, they support a wide range of biodiversity by providing habitat for numerous species of birds, mammals, fish, amphibians, insects, and plants (Buckton 2007, Jaman *et al.* 2023). A large

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proportion of the world's wetland bird species are currently facing threats, and they serve as crucial indicators of the overall health of the environment (Hayman *et al.* 1991, Shome *et al.* 2022). Jahangirnagar University campus is well known for its biological diversity. The high diversity of bird species on the campus is a result of both the presence of varied habitats and the low level of human disturbance (Mohsanin and Khan 2009). A total of 195 species of birds are recorded in the recent past here, with 76 species of them recorded as breeding residents and *accipitridae* was the most diverse family with 19 species (Jahan *et al.* 2018). Jahangirnagar University campus occupies an area of 280 hectares, it has 26 small and large wetlands spanning about 22 hectares comprising permanent water bodies and marshy areas those provide breeding and feeding habitats for both resident and migratory birds (Zaman 2018, Akhter *et al.* 2007, Feeroz *et al.* 1988). The wetlands here can be divided into three types, managed, unmanaged and partially managed wetlands. The managed wetlands are usually leased for fish culture and the growth of floating vegetations are strictly controlled. Partially managed wetlands included both leased area and naturally occurring area, and the unmanaged wetlands are the naturally occurring wetlands without any control by humans.

The physical and chemical attributes of water significantly control its quality, which ultimately governs its capacity to support fish populations and other aquatic life including aquatic birds (Swingle 1969). Study on physio-chemical parameters of the wetlands is very important from biological as well as environmental point of view (Rahman *et al.* 2015). Many resident and migratory birds inhabit in the selected three types of wetlands, therefore, water quality needs to be assessed to investigate the effect of these habitats on birds. This study was conducted focusing on the species diversity, habitat utilization pattern of wetland birds as well as analyzing water quality of the three categories of wetlands. These data may serve as a baseline data for waterbird conservation as no comprehensive study in this topic has been made so far in this study area.

MATERIAL AND METHODS

Study site and data collection: The study was conducted between January 2024 and July 2024 at Jahangirnagar University Campus, an area of about 280 hectares, is located at 23°52.764 N latitude and 90°16.068 E longitude. A total of six wetlands were selected as study sites (Table 1, Fig.1), comprising three unmanaged, two managed, and one partially managed wetland. The managed wetlands are usually leased for fish culture and the vegetations are strictly controlled. Partially managed wetlands included both leased area and naturally occurring area, and the unmanaged wetlands are the naturally occurring wetlands without any control by humans. Wetland bird species were recorded

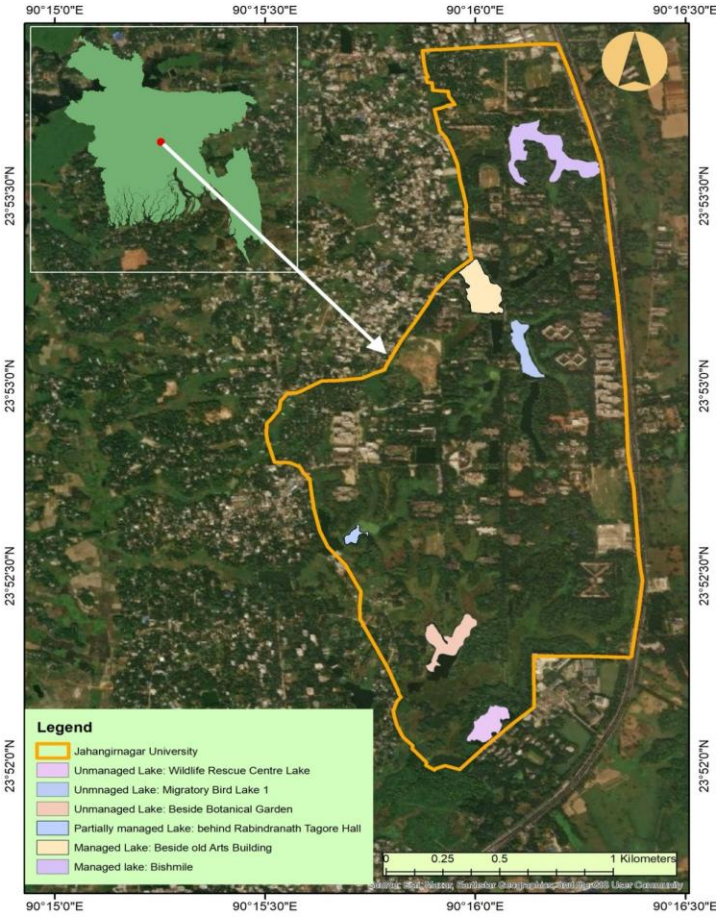

Fig. 1: Study area showing different study sites

using point count method and fixed route monitoring. In each point, 15 minutes were spent to enlist all available species. (Shahbaz *et al.* 2023). The data collection was performed at early morning and late afternoon when the bird activity was the highest. Birds were observed using Vortex Binocular (Diamondback HD 8 × 42). Grimmet *et al.* (2021) was followed for identification of birds. Photographs of the birds and wetlands were taken using Canon 80D DSLR camera with 70-300 mm zoom lens. In terms of habitat utilization pattern, three types of habitat were selected namely "edge", "tree adjoining wetland", and "open water". Where an edge habitat was considered as the area approximately 2 meters from the open water and where terrestrial and aquatic features interact. It often includes herbaceous vegetation and is used by birds for foraging or resting. Tree adjoining wetland is the zone with trees located around or at the periphery of the wetland. These trees provide nesting, perching, or shelter

Table 1: Characteristics and geographic location of the study sites

Lake/site	Size (Perimeter)	Wetland Category	GPS position
Bishmile lake	1826 meters	Managed	23°53'38" N 90°16'12" E
Lake beside old arts building	831 meters	Managed	23°53'14" N 90°15'58" E
Migratory bird lake-1	779 meters	Unmanaged	23°53'01" N 90°16'03" E
Lake of Wildlife rescue center	642 meters	Unmanaged	23°52'20" N 90°15'55" E
Lake behind Botanical garden	1094 meters	Unmanaged	23°52'26" N 90°16'04" E
Lake behind Rabindranath Thakur hall	366 meters	Partially managed	23°52'38" N 90°15'43" E

opportunities for birds. Open water is the unobstructed central part of the wetland. It is mainly used by swimming, diving, or surface-feeding bird species. Relative abundance and the status of birds were assessed as 'very common' (seen on 75–100% of visits), 'common' (seen on 50–74% of visits), 'uncommon' (seen on 25–49% of visits), or 'rare' (seen on <25% of visits) (Khan 2005). In case of water quality assessment, Dissolved oxygen (DO) was measured in General laboratory of the Department of Zoology, Jahangirnagar University following standard protocol. Likewise, data on TDS and Temperature were recorded using electric portable meters.

Data analysis: The bird species diversity was calculated using Shannon-wiener diversity index, $H' = -\Sigma piln(pi)$ (Shannon 1948), And Simpson's index, $D= 1-\{\sum n(n-1) / N(N-1)\}$ (Simpson 1949). In terms of habitat utilization pattern analysis, chi-square Goodness-of-fit was performed to evaluate whether the observed frequencies differed significantly from expected frequencies under the assumption of no preference. IBM SPSS (Version 23.0), and MS Excel were used for statistical analysis and graphical representation. Species accumulation curves for Unmanaged, Managed, and Partially Managed categories were plotted using species count data from January to July. The plot was generated with Python's matplotlib library (Version 3.10.3).

RESULTS AND DISCUSSION

During the study period, a total of 25 bird species belonging to 13 families were recorded (Table 2). The Ardeidae family was the most dominant, with most frequent members such as Little Egret (*Egretta garzetta*), Indian Pond Heron (*Ardeola grayii*) observed across all wetland types. Common year-round residents included the White-breasted Waterhen (*Amaurornis phoenicurus*), White-throated Kingfisher (*Halcyon smyrnensis)*, Bronze-winged Jacana

(*Metopdius indicus*), Little Cormorant (*Phalacrocorax niger*), and Indian Pond Heron (*Ardeola grayii*). The Lesser Whistling Duck (*Dendrocygna javanica*) showed peak abundance in winter (89%), with flocks reaching over a thousand individuals at the Wildlife Rescue Centre (WRC) lake where species like the Oriental Darter (*Anhinga melanogaster,* n=6), Black-crowned Night Heron (*Nycticorax nycticorax ,* n=53), and Grey-headed Fish Eagle (*Ichthyophaga ichthyaetus ,* n=5) were found only in this lake. Little Grebe (*Tachybaptus ruficollis*) was only found at the Botanical Garden Lake. While several species were consistently present throughout the year, others such as the Little Grebe (*Tachybaptus ruficollis*) and Oriental Darter (*Anhinga melanogaster*) were rare. There was a variation in the number of species found in each wetland category (Fig. 2). The species accumulation curves revealed distinct trends across the three wetland categories. The Unmanaged category exhibited the highest species count over time, peaking at 22 species by July (Fig. 3).

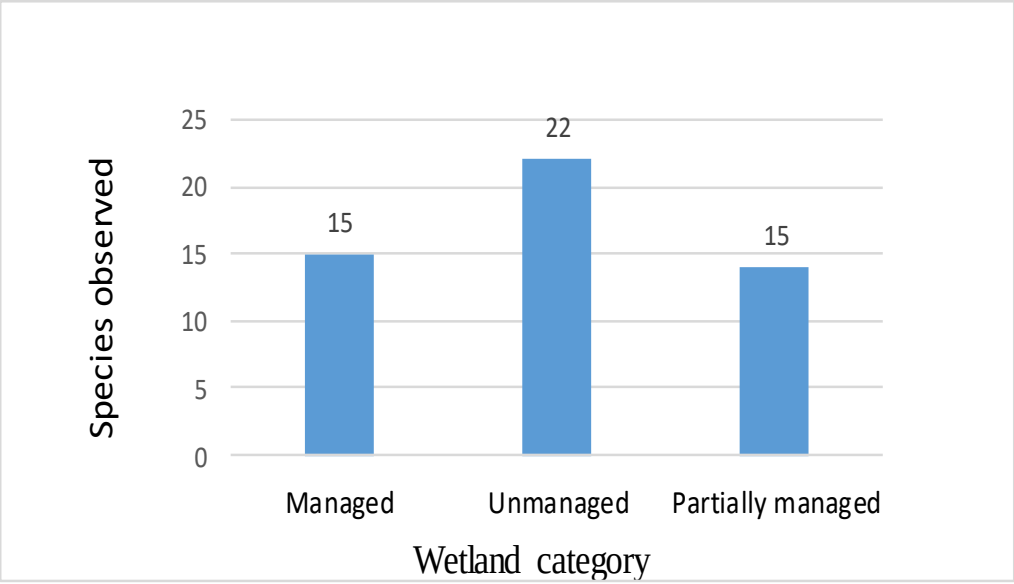

Fig. 2: Number of species in each wetland category.

In terms of Shannon-Weiner Diversity Index (H) and Simpson Diversity Index(D), Unmanaged Lake had the highest diversity of birds (H'= 2.015, D= 0.833) compared to managed (H'= 1.616, D= 0.708) and partially managed wetlands (H'=1.943, D=0.822) considering average value (Fig. 4). The current assessment of the status of wetland birds revealed 25% were very common, 37% common, 8% uncommon, and 29% as rare. Among the 25 species encountered during the study, a considerable number showed a preference for edge habitats (44%), followed by tree-adjoining wetlands (32%) and open water (24%). However, the differences in habitat preferences among edge, tree-adjoining wetlands, and

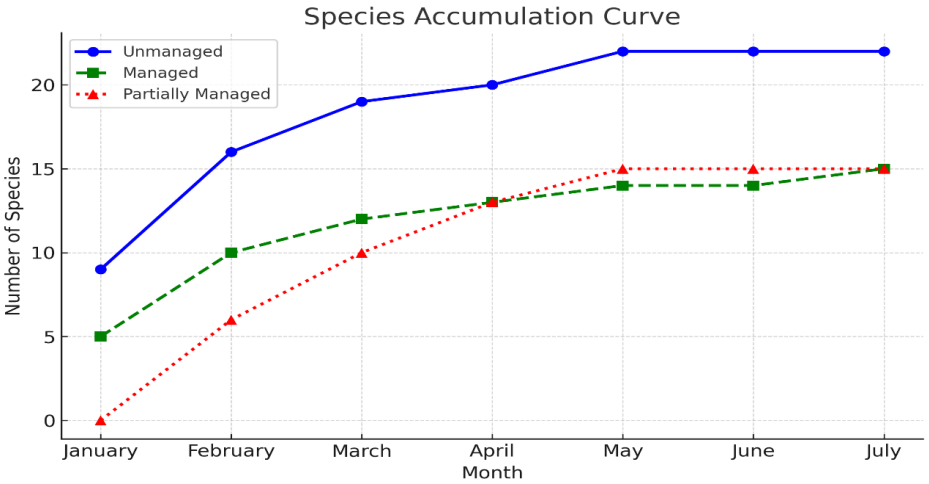

Fig. 3: Species accumulation curve for three categories of wetlands.

Table 2: Observed waterbird species during the study period

Family Name	Scientific name	English name	Wetland category
Rallidae	*Amaurornis phoenicurus*	White-breasted Waterhen	M,Un,P
	Gallnula chloropus	Common Moorhen	Un
Jacanidae	*Metopdius indicus*	Bronze winged Jacana	Un,P
Dendrocygnidae	*Dendrocygna javanica*	Lesser whistling Duck	M,Un,P
Podicipedidae	*Tachybaptus ruficollis*	Little Grebe	Un
Ciconidae	*Anastomus oscitans*	Asian Openbill	M,Un,P
Ardeidae	*Casmerodius albus*	Great Egret	M,Un
	Mesophoyx intermedia	Intermediate Egret	Un
	Egretta garzetta	Little Egret	M,Un,P
	Bubulcus ibis	Cattle Egret	P
	Ardeola grayii	Indian Pond Heron	M,Un,P
	Butorides striatus	Striated Heron	M,Un
	Nycticorax nycticorax	Black-crowned Night Heron	Un
	Ixobrychus sinensis	Yellow Bittern	Un
Charadriidae	*Vanellus indicus*	Red-wattled Lapwing	M,Un
Phalacrocoracidae	*Phalacrocorax niger*	Little Cormorant	M,Un,P
Anhingidae	*Anhinga melanogaster*	Oriental Darter	Un
Alcedinidae	*Alcedo atthis*	Common Kingfisher	M,Un,P
Dalcelonidae	*Halcyon smyrnensis*	White-throated Kingfisher	M,Un,P
	Halcyon capensis	Stork-billed Kingfisher	M,Un
Cerylidae	*Ceryle rudis*	Pied Kingfisher	P
Accipitridae	*Milvus migrans*	Black Kite	M
	Ichthyophaga ichthyaetus	Grey-headed Fish Eagle	Un
	Haliastur indus	Brahminy kite	M
Phalacrocoracidae	*Phalacrocorax fuscicollis*	Indian Cormorant	Un

open water habitats were not statistically significant ($x^2 = 1.52$, df = 2, $p > 0.05$), indicating that the observed variation could be due to chance**.** Regarding water quality assessment over the seven months period, Dissolved Oxygen (DO) ranged from 1.6 mg/l to 12.1 mg/l. The Total Dissolved Solids (TDS) levels showed a gradual increase each month. The TDS value was upto 139 ppm. The temperature steadily rose as the seasons transitioned from winter to summer. The temperature fluctuated between 21 to 33 °C. A detailed information (Mean ± Standard Error) on the physiochemical parameters of water of all the selected lakes is given in Table 3.

Table 3: Mean ± Standard Error value of the physiochemical parameters of water of all the selected wetlands:

Wetland types	Parameters		
	Temperature (°C)	TDS (PPM)	DO (mg/l)
Lake of Wildlife Rescue Center	30.50 ± 1.53	247.00 ± 11.14	8.53 ± 1.33
Lake beside Old Arts Building	29.57 ± 2.06	147.14 ± 12.64	6.13 ± 0.36
Migratory bird lake-1	29.93 ± 2.15	130.71 ± 11.18	5.66 ± 0.76
Bishmile lake	29.71 ± 1.81	127.71 ± 10.01	5.84 ± 0.30
Lake behind Botanical Garden	30.29 ± 2.17	78.29 ± 7.01	5.76 ± 0.31
Lake behind Rabindranath Thakur hall	31.07 ± 1.51	90.71 ± 5.96	4.86 ± 0.36

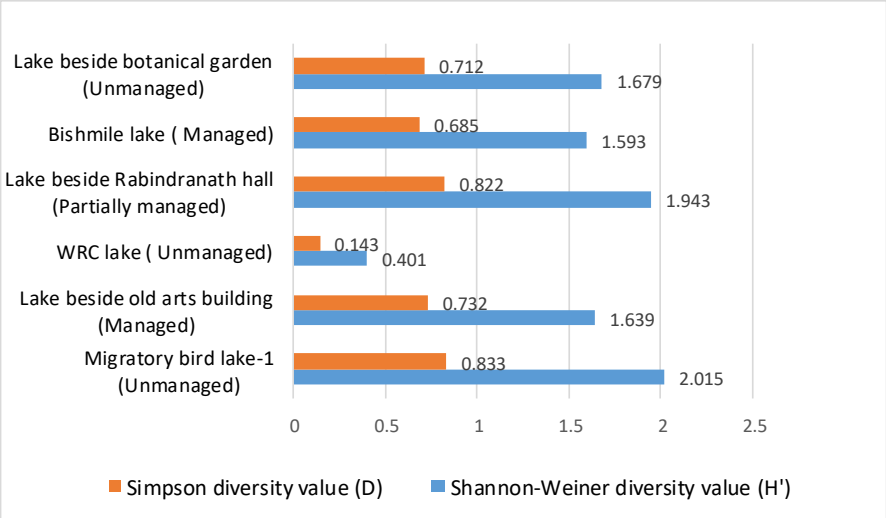

Fig. 4: Compare between Shannon-Weiner and Simpson diversity value among the wetlands.

Dissolved Oxygen (DO) exhibited a weak positive correlation with the abundance of waterbirds (r = 0.42), indicating that higher oxygen levels may slightly favor bird presence. In contrast, both Total Dissolved Solids (TDS) and Temperature showed strong negative correlations with bird abundance (r = –0.81 and r = –

0.87, respectively) at 0.05 significance level, suggesting that elevated levels of these parameters may adversely affect the suitability of wetland habitats for waterbirds (Fig. 5).

The findings revealed that unmanaged wetlands hosted the highest bird diversity, aligning with previous studies that highlight the ecological richness of less disturbed habitats (Shahbaz *et al.* 2023). The highest diversity in the unmanaged wetland can be attributed to the abundance of natural resources, such as aquatic organisms, vegetation, and fish, which serve as food and shelter for wetland birds (Ma *et al.* 2010). This ecological richness likely provides a more suitable environment for a variety of bird species, which explains the greater number of birds found in unmanaged areas compared to their managed and partially managed counterparts.

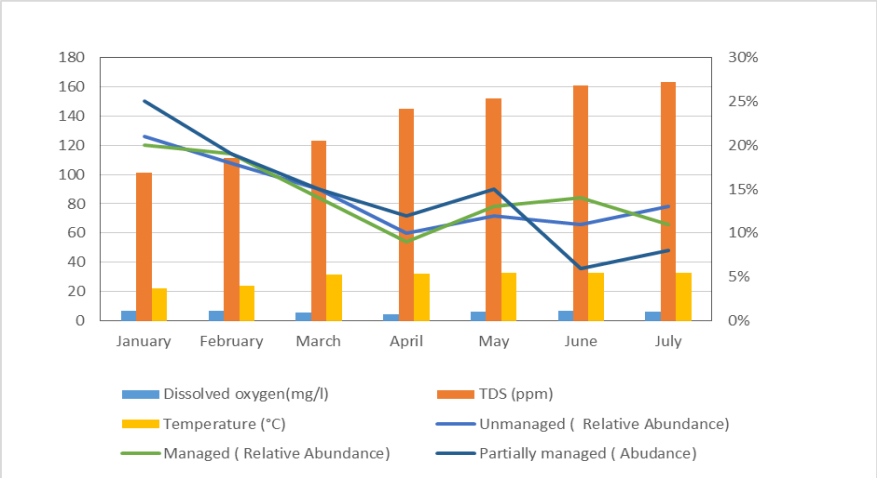

Fig. 5: Relationship between water quality parameters and bird abundance among the wetland categories.

In terms of habitat utilization, the birds predominantly favored edge habitats followed by tree-adjoining wetlands and open water. These preferences are consistent with similar studies where birds, particularly waterfowl, tend to select areas with dense vegetation along edges, as these locations provide food, shelter, and protection from predators (Masifwa *et al.* 2001, Jaman *et al.* 2023). Patton (2016) observed that edge microhabitats, characterized by the presence of emergent and submerged aquatic vegetation (SAV) and floating aquatic vegetation (FAV) in fresh edges, supported greater species and guild richness of waterbirds than open-water areas lacking emergent cover or emergent habitats devoid of SAV and FAV. However, the lack of significant statistical difference in habitat preferences suggest that while edge habitats were more frequented, the

variations in habitat choice among wetland types might also result from chance, or other ecological factors that were not directly addressed in this study.

Water quality was another key factor influencing bird abundance. Dissolved Oxygen (DO), Total Dissolved Solids (TDS), and Temperature all varied across the wetlands, with DO levels showing a weak positive correlation with bird abundance, and TDS and temperature displaying an inverse relationship. These findings support the observations of Rahman *et al.* (2015), who conducted study at Jahangirnagar University showed the dissolved oxygen (DO) level 2.7 mg/l to 7.6 mg/l. Mishra *et al.* (2023) reported a positive correlation between dissolved oxygen and waterbird species density, suggesting that higher oxygen levels promote a healthier and more productive aquatic ecosystem. Sufficient dissolved oxygen supports the survival of diverse aquatic organisms, which serve as important food resources for waterbirds. Conversely, higher TDS and temperature are often associated with poor water quality, which can negatively impact both aquatic life and the birds that depend on these resources (Swingle 1969). TDS levels above a certain threshold suggest the existence of toxic minerals, which can be harmful to aquatic organisms (Ajibade *et al.* 2020). The increasing TDS and rising temperatures in the studied wetlands throughout the study period may indicate potential water quality degradation, which could threaten the long-term viability of these bird populations. Furthermore, this study highlighted the vulnerability of wetland habitats to anthropogenic threats, such as infrastructure development, pollution, uncontrolled vegetation growth, noise from vehicles and loud human activity. These factors pose significant risks to the biodiversity of wetlands, as they disrupt the delicate balance required for sustaining bird populations (Hall and Beissinger 2017, Jaman *et al.* 2023).

CONCLUSION

This study emphasizes the critical need to preserve and restore unmanaged wetlands, which offer the most favorable conditions for supporting a diverse bird population. Moreover, regular monitoring of water quality parameters, such as DO, TDS, and temperature is essential for understanding the dynamic relationship between water quality and bird diversity in wetland ecosystems. Future conservation efforts should focus on minimizing anthropogenic disturbances and promoting natural wetland functions to enhance habitat suitability for wetland birds.

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