

Conservation of Biodiversity in the Riverine Wetland Ecosystem



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Abstract

Biodiversity is declining in the riverine wetland ecosystem. The sustainability of people in riverine wetlands is highly dependent on biodiversity for their livelihood. Environmental threats alter the biodiversity of plants, fish, and birds in a wetland ecosystem. Subsequently, community people have suffered to lead their sustainable livelihood. The present study evaluates the species distribution, causes of declining biodiversity, and conservation strategies in the riverine wetland ecosystem. Some species were recorded as critically endangered, such as *Chitala chitala*, *Channa marulius*, *Nymphaea nouchali*, *Gyps bengalensis*, *Alcedo atthis* and *Phalacrocorax fuscicollis*. The average percentage of critically endangered, endangered, vulnerable, and least concern species was 9.61, 16, 19.61, and 54.72 recorded in riverine wetland ecosystems, respectively. Agriculture and forest area decreased by 36% and 60%, respectively, in 2021 compared to 2013. Climate change, habitat modification, unplanned residential areas, invasive alien species, hunting, unplanned dams, and water management system change the land use land cover (LULC). The LULC enhances endangered, critically endangered, and species vulnerability. In this context, the guidelines are recommended to conserve riverine wetland biodiversity.

Keywords: Wetland biodiversity; Conservation; Least concern; Vulnerable; Endangered; Ecosystem

Introduction

The riverine area is a natural wetland ecosystem. Wetland ecosystems highlight periodically or continuously moving water or connecting two bodies of standing water. These wetlands provide ecosystem services for human benefits [1,2]. Humans are directly associated with the wetland ecosystem for food, medicine, and recreational and commercial purposes [3,4]. Riverine wetlands include rivers, streams, creeks, brooks, rivulets, canals, channels, watercourses, and tributaries [2]. Wetlands are mostly responsible for maintaining and supporting a healthy environment [5]. Species, ecosystems, and genetic diversity are visible in the wetland ecosystem for human benefit [6]. This biodiversity refers to the visibility of diverse life in the freshwater, tidal, and marine wetland ecosystems [7,8]. In addition, lakes, ponds, reservoirs, rivers, and streams work

as shelters for different species. They maintain the interaction between all species and habitats in an ecosystem. Besides, phytoplankton, zooplankton, aquatic plants, insects, fish, birds, mammals, and crops are visible in the wetland ecosystem [9]. Bangladesh ranks fourth in inland fish production among all countries [10]. Also, marine resources with a wide variety of indigenous and exotic fish are available in Bangladesh [11]. About 280 freshwater and 490 marine species are visible in different wetland ecosystems [12]. The freshwater bodies of Bangladesh are considered to have at least 265 fin fish species [13]. These wetland ecosystems are globally important because they comprise approximately 260 indigenous freshwater species with 143 small indigenous species [13]. The country is also enriched with endemic fish resources, including 475 marine,

260 freshwaters, 20 exotic, 24 freshwater prawns, 36 marine shrimp, 10 pearl-bearing bivalves, 16 turtles (11 freshwater and 5 marine water species), 15 crabs (4 freshwater and 11 marine water species), 6 lobster, 7 squid and 600 bird species (Department of Fisheries) [14].

Bangladesh is also a flat low-lying country with large inland water bodies, including some of the largest rivers in the world, which are extremely vulnerable due to their geographical characteristics [15]. Bangladesh's increasing urbanization and industrialization negatively affect water quality, where industrial effluents are directly absorbed into rivers without considering the environment [16]. There has been growing concern about possible contamination of soils, sediments, and water systems around many industrial areas of the country [17]. Large amounts of industrial waste, effluents, petroleum products from ships, launches, cargoes, boats, and untreated sewage are dumped into the river regularly. Furthermore, the municipal sewer system has become a dump for the disposal of solid, liquid, and chemical waste that pollutes the riverbank [18]. The intensity of water pollution is regulated to some extent by seasonal behavior; generally, in the wet season, intensive rainfall may help wash out pollutants that are not possible in the dry season due to limited rainwater [19]. The river basin has been a major source of water supply for many purposes such as improving soil fertility, which supports crop productivity in highly populated areas due to its favorable conditions [20].

Gomti is a major tributary hilly riverine wetland ecosystem in Bangladesh. Ground and surface water are highly polluted in wetland ecosystems through contamination by toxic substances and heavy metals. Also, the unplanned disposal of industrial effluents into water bodies and the massive use of fertilizers and pesticides have increased water pollution in the wetland ecosystem [21]. The wetland ecosystem has degraded due to rapid urbanization and industrialization for the last two decades [3]. Consequently, species vulnerability has increased due to the conversion of agricultural land, deforestation, climate change, pollution, loss of natural habitats, and the introduction of alien species [22]. Based on threats, the species' diversity becomes threatened, vulnerable, endangered, critically endangered, and extinct [3]. There are statistics on the species of fish that are almost extinct now. Despite this, according to the IUCN (International Union for Conservation of Nature), 64 fish species are listed as threatened in Bangladesh. The IUCN also revealed that 9 are critically endangered, 30 are endangered and 25 are vulnerable [23].

However, wetlands alleviated poverty and increased economic growth in many developing countries. Although modern technologies have been used in industries' growth, environmental considerations are not properly integrated with the design of industrial processes, mainly in developing countries. Although industries provide basic economic

growth for a developing country, in the long run, they create more difficulty in survival due to the pollution of their surrounding environment [24]. According to the perception of the community, the biodiversity of the Gomti River wetland has changed over the past two decades. As a result, different species are threatened, endangered, and extinct in these riverine wetlands due to the degradation of a sustainable environment for many years. In contrast, the wetland ecosystems in Sri Lanka are diverse, comprising 103 major rivers and associated marshes, and about 12,000 irrigation tanks. About 28 bird species were recorded with 14 orders and 22 families. Currently, these species are threatened by human activities, such as garbage dumping, noise pollution, lighting fires for garbage burning, and clearing of natural vegetation in and around wetlands [25].

The Convention on Biological Diversity (CBD), which came into force in 1993, is the global policy framework for action to maintain biodiversity for future generations. So, wetland biodiversity can be conserved through the restoration and protection of wetlands, preserve wetlands for future generations, reduces soil erosion, and physical, and chemical pollution, conservation of native plant species, and reduction of climate change impacts and motivation of community people through training programs to conserve wetland biodiversity [26].

Bangladesh has the Biodiversity Conservation Act. This Act regulates the biodiversity conservation and sustainable use of its resources, biota, and the fair and equitable share of the benefits derived from their use of and other matters. Many initiatives have been taken, especially in the recent decade to protect biodiversity. In this regard, biodiversity-rich areas have been protected through declared national parks, wildlife sanctuaries, ecologically critical areas, eco-parks, safari parks, and botanical gardens [27]. Therefore, the present study focuses on identifying species of least concern, vulnerable, endangered, and critically endangered with causes of declining biodiversity and conservation strategies of wetland species. It is hypothesized that this research will be helpful in the development of conservation strategies in the riverine wetland ecosystem to protect a sustainable environment.

Materials and Methods

Study Areas

The diversity of wetlands species was recorded at Adarsho Sadar and Burichang Upazila in Comilla, Bangladesh, in 2022. The wetland areas were Amratali, Panchthubi, Sholanal, Bharella, Pir-jatrapur, and Mainamati. The total area of Comilla Adarsho Sadar Upazila and Burichang Upazila is 187.71 and 163.76 square km, respectively. The geographical position of Comilla Adarsho Sadar Upazila is located between 23°24 and 23°31 north latitude and between 91°03 and 91°15 east longitude and Burichang Upazila is 23°37 north latitude and 91°13' east longitude (Figure 1 & 2).

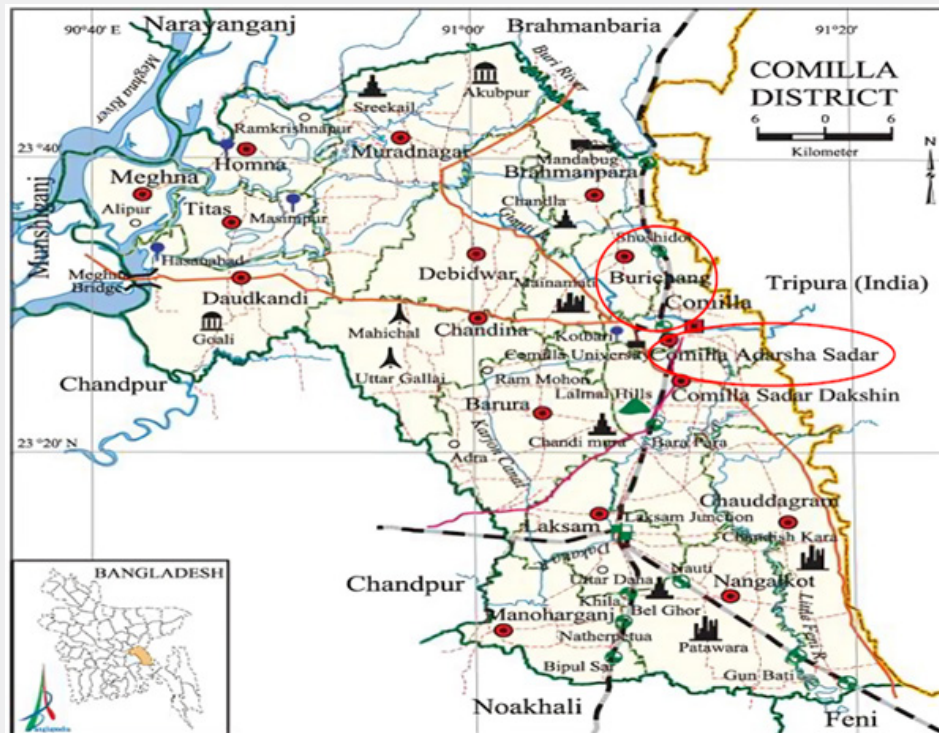


Figure 1: Study areas in Comilla District.

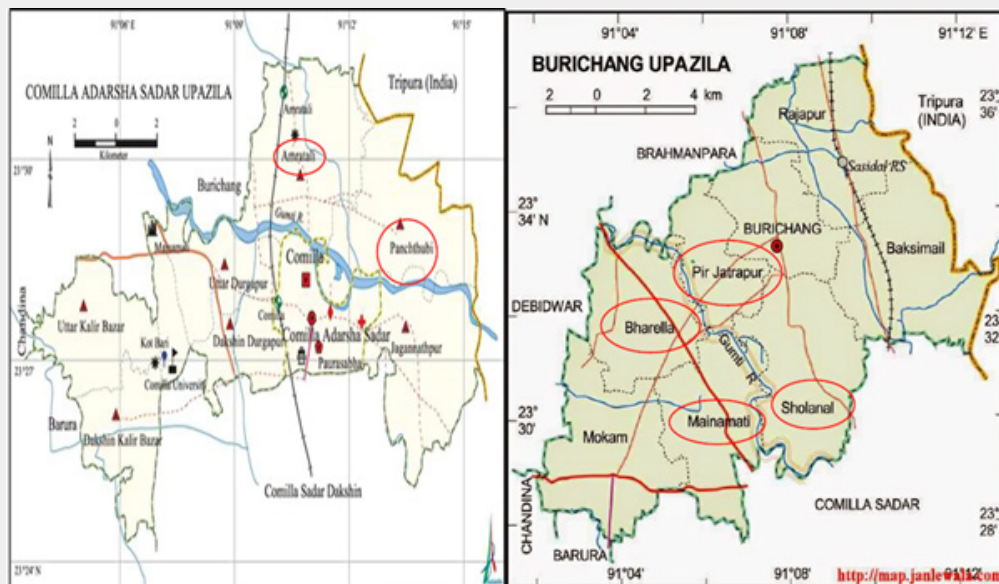


Figure 2: Indicated different study areas at the Gomti riverine wetland in Comilla District.

Inception meeting

An inception meeting was held at the Department of Agricultural Extension (DAE) in Comilla Adarsho Sadar and

Burichung Upazila. This meeting was held with government officials, fishermen, visitors, and farmers in the riverine wetland areas. This meeting was held to discuss the main causes of

the decline in wetland biodiversity. During this meeting, the participants provided their unique perspectives on environmental threats and possible impacts on species of wetlands, such as fish, plants, and animals. Based on this meeting, the main causes of the decline in wetland biodiversity in the Gomti River were also identified.

Questionnaire

To obtain a complete picture of biodiversity to fulfill the objectives, a draft interview schedule was prepared (interview schedule enclosed in the supplementary table) based on the scaling of the status of species availability. The draft interview schedule was used to collect data from respondents. In the pre-test, attention was paid to incorporating any new information designed to be asked or filled in the draft interview schedule. The interview schedule was then modified, changed, and rearranged according to the response from the pre-test. The final schedule was developed in a logical sequence so that the respondents could respond chronologically. The schedule included various questions concerning the status of fish, birds, and aquatic plants, and the causes of the decline of wetland biodiversity.

Data collection and sampling sites

The survey was carried out at six locations on the Gomti River such as Amratoli, Panchthubi, Sholanal, Bharella, Pirjatrapur, and Mainamati of Comilla Adarsha Sadar and Burichung Upazila (Figure 2). In the study, 70 respondents were randomly selected as professional and subsistence fishermen who live in the wetlands (more than 30 years of age). The level of their education ranged from primary to higher secondary certificates. The properties of the riverine ecosystem, such as wetland area, water life, topography, type of wetland, major crops, water use, and GPS location, were highlighted in Table 1 & 2. Information was recorded on the status of least concern (LC), vulnerable (VU), endangered (EN), and critically endangered species (CR). The main environmental threats and their impacts on wetland biodiversity, ecosystem services, and sustainability were also noted. The percent of the LC, VU, EN, and CR species was analyzed based on the total number of recorded fishes, aquatic plants, and bird species in different areas of the Gomti riverine wetland ecosystem.

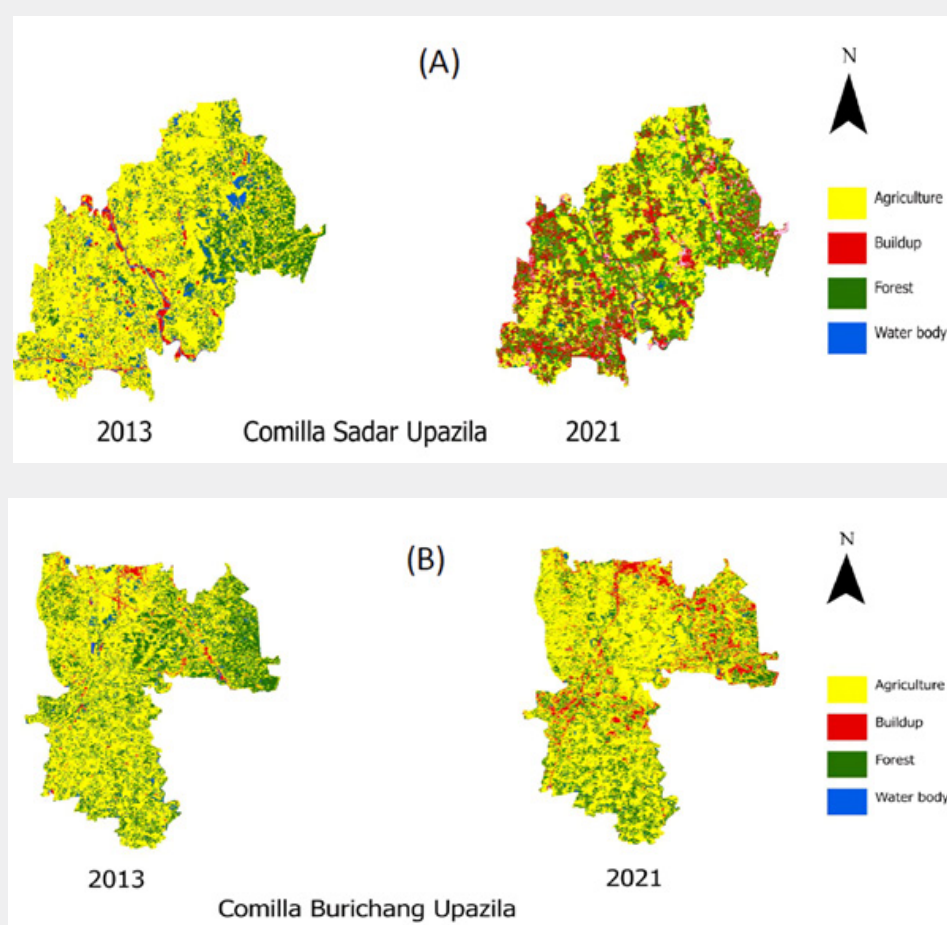


Figure 3: Changes in land use and land cover (LULC) from 2013 to 2021 at the Gomti riverine wetland ecosystem.

Table 1: Global Positioning System (GPS) of study locations.

Name of Locations	Latitude	Longitude
Amratali	23° 28' 59" N	91° 10' 59" E
Panchthubi	23° 29' 13" N	91° 13' 3" E
Sholanal	23° 30' 59" N	91° 8' 10" E
Pir Jatrapur	23° 33' 5" N	91° 6' 3" E
Mainamati	23° 29' 59" N	91° 6' 3" E
Bharella	23° 32' 6" N	91° 4' 18" E

Table 2: The properties of the different riverine wetland ecosystems.

Sl. Number	Name of the Riverine Area	Source of Water	Water Life	Topography of the Surrounding Area	Major Crops	Use of Water
1	Amratali	Natural	High	Low	Vegetables	Irrigation
2	Panchthubi	Natural	Medium	Medium-High	Vegetables	Irrigation
3	Sholanal	Natural	Medium	Low	Rice	Irrigation
4	Bharella	Natural	Low	High	Rice	Irrigation
5	Pirjatrapur	Natural	Medium	Medium-High	Vegetables	Irrigation
6	Mainamati	Natural	Medium	Medium-High	Rice	Irrigation

Data collection on species diversity

Based on the primary information from the initial meeting, we interviewed a group of people who have lived in the surrounding areas of water bodies to obtain data on the least concern (LC), vulnerable (VU), endangered (EN), and critically endangered (CR) species. The average age of the interviewed people was 40 to 60 years. Approximately 10-12 were women and the rest were men in each group. The interviewees were involved in various professions such as fishing, boating, agriculture, government officials, and research.

Major environmental causes, changes in land use land cover, threats, and conservation strategies

The main environmental causes and their effects on land use land cover (LULC) and biodiversity were noted in this wetland ecosystem. Land use and land cover (LULC) by agriculture, forests, built-up, and water bodies were analyzed using QGIS SAGA using cross-classification and tabulation tools in 2013 and 2021 (Figure 3A & 3B). Based on the threat, conservation strategies are also developed.

Statistical analysis

The percentages of least concern (LC), vulnerable (VU),

endangered (EN), and critically endangered (CR) species were analyzed for the validation of the data using R software, version 3.2.2 (R Foundation for Statistical Computing, (Vienna, Austria). Changes in land use land cover (LULC) were analyzed using the QGIS SAGA method.

Results

Least concern species

The fish species of least concern (LC) were Puti (*Puntius puntio*), Shing (*Heteropneustes fossilis*), Boal (*Wallago attu*), Rui (*Labeo rohita*), Koi (*Anabas testudineus*), Pabdah (*Ompok pabda*), Tengra (*Mystus vittatus*), Chingri (*Fenneropenaeus indicus*), Taki (*Channa punctate*), Katal (*Gibelion catla*), Chada (*Chanda nama*), Chela (*Salmostoma phulo*), Kachki (*Corica soborna*), Sol (*Channa striatus*), Mrigal (*Cirrhinus cirrhosis*), and Sharputi (*Puntius sarana*) recorded from different riverine wetland areas. Aquatic plants of Topa pana (*Pistia stratiotes*), Helencha (*Enhydra fluctuents*), Kolmi (*Ipomoea aquatic*), and Kachuripana (*Eichhornia crassipes*) were observed as LC species. The bird species of Balihash (*Anas platyrhynchos*) and Bog (*Ardeola grayii*) were found in the LC category (Supplementary table a-f).

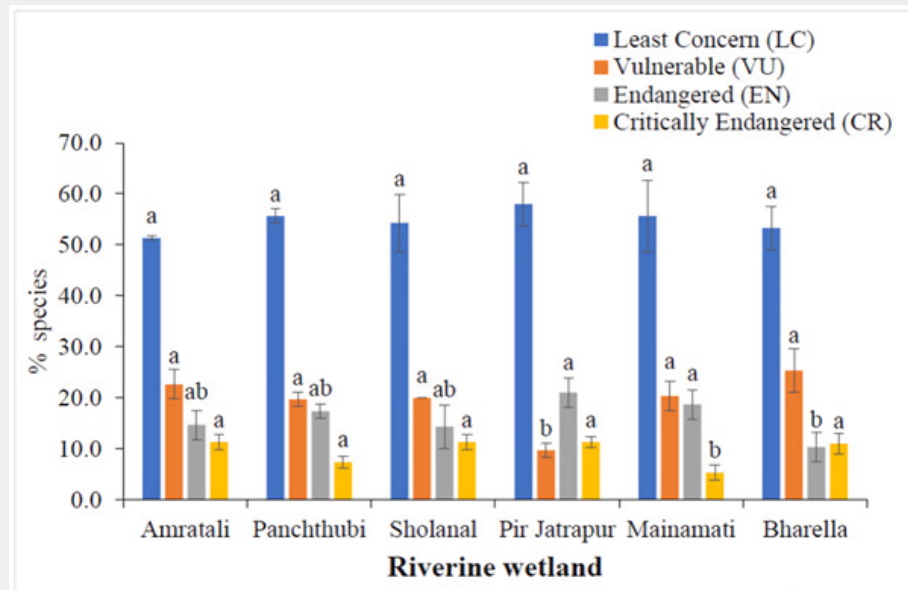


Figure 4: Status of wetland biodiversity at different riverine wetland ecosystems.

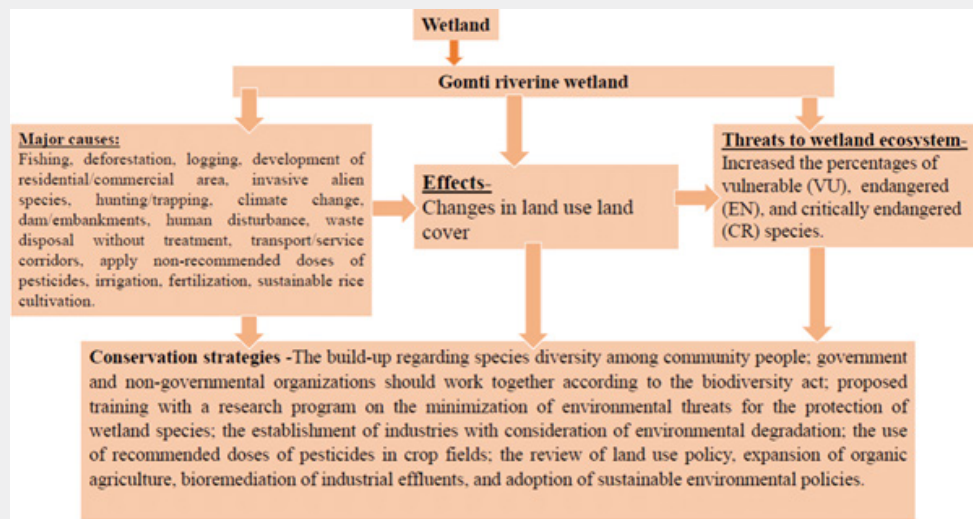


Figure 5: Environmental threats and conservation strategies of wetland species at Gomti riverine wetland.

Table 3: Present status of fish, aquatic plants, and bird biodiversity in different areas of the Gomti riverine wetland in Comilla.

Name of Species	Name of Riverine Wetland	Least Concern (LC) %	Vulnerable (VU) %	Endangered (EN)%	Critically Endangered (CR)%
Fish	Amratali	55	18	27	0
	Panchthubi	68	9	18	5
	Sholanal	64	27	9	0
	Pir Jatrapur	73	13	14	0
	Mainamati	51	27	22	0
	Bharella	59	27	14	0

Aquatic Plant	Amratali	66	17	0	17
	Panchthubi	66	17	17	0
	Sholanal	66	0	34	0
Aquatic Plant	Pir Jatrapur	84	0	16	0
	Mainamati	83	17	0	0
	Bharella	67	16	17	0
Bird's Biodiversity	Amratali	33	33	17	17
	Panchthubi	33	33	17	17
	Sholanal	33	33	0	34
	Pir Jatrapur	17	16	33	34
	Mainamati	33	17	34	16
	Bharella	34	33	0	33

The percentages of LC fish were 55, 68, 64, 73, 51, and 59 in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The percentages of aquatic plants were 66, 66, 66, 84, 83, and 67 in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The percentages of LC birds were 33, 33, 33, 17, 33, and 34 at Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The highest LC species (58%) were recorded in the Pir-Jatrapur area. The lowest was found in Amratali (51%) (Figure 4). The average percentage of LC species was 54.72 (Figure 4).

Vulnerable species

The vulnerable (VU) fish species were Pabdah (*Ompok pabda*), Bailla (*Glossogobius giuris*), Katal (*Gibelion catla*), Chela (*Salmostoma phulo*), Molla (*Amblypharyngodon mola*), Magur (*Clarias batrachus*), Koi (*Anabas testudineus*), Bailla (*Glossogobius giuris*), Chital (*Chitala chitala*), Gutum (*Lepidocephalichthys guntae*), Gajar (*Channa marulius*), Chada (*Chanda nama*), Tengra (*Mystus vittatus*) and Shing (*Heteropneustes fossilis*) found in different riverine areas. Aquatic plants of Shapla (*Nymphaea nouchali*), Shaluk (*Nymphaea nouchali*), Topa pana (*Pistia stratiotes*) were recorded as VU species. The bird species of Machranga (*Alcedo atthis*), Pankouri (*Phalacrocorax fuscicollis*), and Gangchil (*Larus ridibundus*) were recorded as VU categories (Supplementary tables a-f).

The percentages of VU fish were 18, 9, 27, 13, 27, and 27 in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The percentages of aquatic plants were 17, 17, 0, 0, 17, and 16 in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The percentages of VU birds were 33, 33, 33, 16, 17, and 33 at Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The highest VU species (25.3%) were recorded in the Bharella area. The lowest was found in Pir Jatrapur (9.7%). The average percentage of VU species was 19.61 (Figure 4).

Endangered species

The endangered species of fish (EN) were Shing (*Heteropneustes fossilis*), Gutum (*Lepidocephalichthys guntae*), Chital (*Chitala chitala*), Gajar (*Channa marulius*), Magur (*Clarias batrachus*), Katal (*Gibelion catla*), Boal (*Wallago attu*), Chela (*Salmostoma phulo*) and Molla (*Amblypharyngodon*) recorded from different riverine wetlands. Only Shaluk (*Nymphaea nouchali*) in aquatic plants were recorded as EN species. The bird species Gangchil (*Larus ridibundus*), and Pankouri (*Phalacrocorax fuscicollis*) were recorded as EN category (Supplementary tables a-f).

The percentages of EN fish were 27, 18, 9, 14, 22, and 14 recorded in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati and Bharella, respectively (Table 3). The percentages of EN aquatic plants were 0, 17, 34, 16, 0, and 17 observed in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The percentages of EN birds were 17, 17, 0, 33, 34, and 0 found in Amratali, Panchthubi, Sholanal, Pir Jatrapur, Mainamati, and Bharella, respectively (Table 3). The highest EN species (21%) were recorded in Pir Jatrapur. The lowest was found in Bharella (10%). The average percentage of EN species was 16 (Figure 4).

Critically endangered species

Some aquatic species were recorded as critically endangered (CR) from different study areas such as *Chitala chitala* (Chital), *Channa marulius* (Gajar), *Nymphaea nouchali* (Shaluk), *Gyps bengalensis* (Shukun), *Alcedo atthis* (Machranga) and *Phalacrocorax fuscicollis* (Pankouri) (supplemental tables a-f). The highest CR species (11.33%) were recorded in the Amratali, Sholanal, and Pir Jatrapur areas. The lowest was found in Mainamati (5%). The average percentage of CR species was 9.61 (Figure 4).

Major causes for the declining biodiversity

Severe climate change, soil and water pollution, industrial waste, pesticides / chemical fertilizers, lack of dissolved oxygen,

habitat modification, unplanned development of residential areas, invasive alien species, hunting / trapping, dams, and water management were recorded as the main causes of the decline of biodiversity in this wetland ecosystem (Table 4 & Figure 5).

Table 4: Resident perceptions of declining species distribution at different wetland ecosystems of the Gomti river in Comilla.

Sl. No	Causes According to Resident Perception	Impacts
1	Severe Climate change	Enhances vulnerable, endangered, and critically endangered species in the wetland ecosystem
2	Soil and Water pollution	
3	Industrial waste	
4	Use of pesticide	
5	Chemical fertilizer	
6	Shortage of dissolved oxygen	
7	Habitat modification	
8	Development of the residential area	
9	Invasive alien species	
10	Hunting/trapping	
11	Human disturbance	
12	Dams and water management	

Changes in land use land cover (LULC) and threats to biodiversity

The land is covered with agriculture, forest, built-up, and water in the wetland ecosystem. Agriculture and forest area decreased by 7% and 70% in 2021 compared to 2013 in Comilla Sadar. On the contrary, the built-up and water bodies increased by 41.36%, and 134 % respectively, in 2021 compared

to 2013 in Comilla Sadar (Table 5 & Figure 3A). In Burichang Upazila, agriculture and forest areas declined by 65% and 50% in 2021 compared to 2013. In contrast, the built-up and water bodies increased by 168% and 119 % respectively, in 2021 compared to 2013 in Burichang Upazila (Table 5 & Figure 3B). The number of vulnerable, endangered, and critically endangered species increases due to changes in land use and land cover in the wetland ecosystem of the Gomti River (Figure 5).

Table 5: Changes in land use and land cover (LULC) from 2013 to 2021 at the Gomti Riverine wetland ecosystems.

	Comilla Sadar		Burichang Upazila	
	% Changes in Land Use Land Cover in 2013	% Changes in Land Use Land Cover in 2021	% Changes in Land Use Land Cover in 2013	% Changes in Land Use Land Cover in 2021
Agriculture	67.22	62.46	64.35	22.25
Forest	8.9	2.64	7.65	3.83
Built-up	22.63	31.99	25.27	67.92
Water	1.24	2.91	2.73	5.99

Conservation strategies

Species conservation strategies such as awareness building; community people, government, and nongovernmental organizations should work together according to the Biodiversity Act; proposed training with a research program to minimize environmental threats in wetland ecosystems is highlighted in Figure 5. In this context, plantation, training & research programs, establishment of industries considering environmental degradation, use of recommended doses of pesticides in crop fields, increased public awareness, revision of land use policy, expansion of organic agriculture, bioremediation of industrial effluents, and adoption of sustainable environmental policies (Figure 5).

Discussion

Wetland biodiversity is the variety of earth's terrestrial, freshwater, and marine organisms. Biodiversity is crucial to the future of all life on the planet. It is the foundation for the ecosystem goods and services that enable human societies to thrive. Biodiversity provides food, water, and materials, and regulates climate, pollination, disaster, and nutrient cycling. Biodiversity, thus, is fundamental to sustainable development. However, biodiversity in the wetland ecosystem is degraded due to increasing environmental threats in Bangladesh [28,29]. The percentages of vulnerable, endangered, and critically endangered species increased in the wetland ecosystems [30]. For instance, Bird species, such as *Gyps bengalensis*, *Porphyrio porphyria*, *Larus*

ridibundus, *Anas platyrhynchos*, and *Phalacrocorax fuscicollis*, were recorded in the extinct category [31]. A similar result was found in this study, where many species are already vulnerable and are moving to a critically endangered category (Figure 4, Table 3 & Supplementary Table a-f).

Human activities involve the disappearance of wetland species. However, wetland biodiversity provides human benefits such as food, shelter, medicine, recreation, and basic needs. Losses of these benefits affect all ecosystem services for human beings. Many species in the wetland are declining; some are rare, endangered, vulnerable, and extinct. The natural environment is threatened by human activities, leading to habitat loss, loss of biodiversity, and the spread of invasive species. Consequently, healthy ecosystems are essential for producing ecosystem services for the survival of human beings [32].

Wetland protects natural ecosystems. This natural ecosystem enhances species richness in the wetland [33]. However, the sustainable agricultural system is the main global driver for wetlands with natural resources [34]. People in the wetland have been producing crops intensively. They have been applying pesticides to their crop fields against pests. This type of agricultural activity is important for crop cultivation, but it is the resilience of the key threat to the wetland ecosystem [35]. Vulnerable, endangered, and critically endangered species were recorded due to the intensive agricultural practices in this study (Table 4).

Furthermore, industrial pollution is the driving force behind the depletion of wetland biodiversity (Table 4). Besides, in the discharge of hazardous substances into the water by various industries, different pollutants can be toxic at low concentrations, carcinogenic, mutagenic, and bioaccumulate [36]. These unhealthy environments may be lethal to the wetland species. Further, these chemicals may be transported into aquatic organisms, which indicates a potential threat to the depletion of wetland species [3]. Also, water quality parameters have deteriorated due to domestic discharge, agricultural run-off, and industrial wastes leading to large amounts of nutrient inputs to the ecosystem in Anzali International wetland on the south coast of the Caspian Sea. Consequently, aquatic biodiversity was disordered substantially in this wetland ecosystem [37].

Unplanned industries have increased in Bangladesh due to economic growth and foreign investment. As a result, people are not interested in protecting the natural resources in the wetland ecosystem because they earn more money from industry than protecting the natural resources in the wetlands. Although wetland is one of the greatest biological resources for a sustainable environment, it is disrupted due to the inconsideration of natural resources. However, birds and fish are important bioindicators for maintaining aquatic vegetation in the wetland ecosystem, nevertheless, it is declining due to industrial pollution [32,38].

Environmental threats are harmful to land use and land cover (LULC). As a result, agriculture, forests, built-up, and water bodies change in this riverine wetland ecosystem. In this circumstance, the vulnerability of species and critically endangered species has already increased in these areas (Figure 3-5 & Table 3-5). Similarly, aquatic plants, fish, and bird species gradually declined due to changes in land use land cover, increasing population, indiscriminate use of pesticides, environmental pollution, and climate change [3].

In this circumstance, wetland biodiversity is threatened in Bangladesh [39]. Consequently, different plant and animal species have disappeared in the ecosystems [40]. As a result, wetland ecosystem services such as food, fuel, water, climate regulation, aesthetics, spiritual, recreational activities, and soil nutrient cycling are declined from the wetland ecosystem. As a result, some constraints are already established in wetland areas, such as a lack of personal security, basic materials, and good health, leading to a deteriorating sustainable environment for species conservation. However, protecting wetland biodiversity is necessary to mitigate climate change. It can also be protected by using recommended doses of pesticides and fertilizers in surrounding crop fields, planning urbanization, stopping deforestation, properly managing aquatic vegetation, avoiding hunting of migratory birds and other animals, avoiding continuous fishing, continuously monitoring species status, increasing public awareness, inspiring people who depend on wetland resources for alternative adoption, and implementing rules and regulations for the conservation of wetland resources by the government [3,41].

According to public perception, bioresource areas should be recognized as a protector of natural resources. Planting trees in the catchment area of the water body will prevent soil erosion and subsequently reduce the siltation in the water body. Preventing industrial and municipal discharge from the water body and increasing public awareness is significant for natural resources. If biodiversity is protected with the help of human activities and legal notice, the species will be restored in the targeted areas. As a result, people will earn money for natural resources after a certain time. Also, treatment costs will be reduced, leading to a healthy life in the wetland ecosystem for human beings.

Managing and protecting wetland biodiversity for current and future generations requires full engagement of governments at all levels, civil society organizations, the private sector, indigenous peoples, and local communities. In this regard, wetland biodiversity can be preserved through reduced habitat change, overexploitation, climate change, pollution, and invasive alien species [42]. The following approach is recommended to protect riverine wetland biodiversity according to the public perception in this study. First, vulnerable plant and animal species can be restored in wetland areas. As a result, habitats, ultimately biodiversity, will be rationally restored. Second,

maintain regular plantation of trees across the catchment area of the water body. The catchment area will prevent soil erosion and reduce siltation in the water body, significantly protecting aquatic organisms. Third, people should avoid the establishment of unplanned industries and thermal power plants near water resources. Fourth, use recommended doses of chemicals in crop fields. In this sense, a bioregional management system will be developed to protect the ecosystem. In addition, regulatory measures must be taken to discharge wastewater into the water body to conserve biological diversity. Finally, increase public awareness to conserve wetland biodiversity. For example, habitat type, water quality, and distance to water were the main factors in the decline of biodiversity of the Yangtze River in China. Species conservation and structural habitat restoration were recommended to conserve biodiversity [43].

Loss of habitat reduces species distribution in the wetland ecosystem. *Bruguiera gymnorhiza*, *Carex doniana*, *Glyptostrobilus pensilis*, *Leersia hexandra*, *Metasequoia glyptostroboides*, and *Pedicularis longiflora* were recorded as endangered species due to the habitat shifts from 1960 to 1990 in wetland ecosystem of China. Thus, habitat restoration is key to conserving wetland biodiversity [44]. In addition, wetland biodiversity in freshwater and marine environments is continuously declining because of overexploitation of species, introduction of exotic species, pollution, unplanned industries, continuous agricultural production, and loss and changes in ecological functions. These species can be conserved through bioregional management [45]. Still, lack of public awareness of species conservation is the leading cause of biodiversity loss for the UNESCO World Heritage sites. In this aspect, awareness should be emphasized to conserve biodiversity in the world [46].

Despite this lack of awareness, participants identified domestic and industrial wastewater pollution as the most significant threat to the wetland. Public awareness can be increased by education at the school level, the Internet, and virtual networks among the local population. This increases public participation and interaction among community people to enhance awareness of the wetland's value and environmental issues [47]. It also highlights the necessity for synchronized efforts among stakeholders in wetland management and policy-making, including government agencies and civil organizations. By examining the significance of public awareness, the study provides unique insights into wetland conservation efforts in a specific geographical and ecological setting. Furthermore, by considering the perceptions and opinions of these stakeholders, the study offers a holistic understanding of the diverse perspectives and interests related to wetland conservation, which adds depth and richness to the analysis [47]. Also, Wetland Conservation Act is the efficient management of wetlands to contribute to their species conservation and promote international cooperation [48]. Thus, monitoring species conservation strategies in the wetland ecosystem is essential to protect vulnerable species

[3]. Consequently, diversity could be highlighted through ecosystem services in the wetland ecosystem by providing food and shelter for the community people. In this regard, the conservation of species in the wetland ecosystem could be helpful for the development of a sustainable environment [30].

Conclusion

The riverine wetland ecosystem provides social benefits for human beings. It has massive connectivity with economic and aesthetic values. Humans depend on aquatic resources for their ecosystem services, such as food, medicine, recreational and commercial purposes, fishing, and tourism. The people around the wetland live an almost vulnerable life due to the decline of wetland resources. It indicates that social, economic, and ecological benefits have decreased substantially. Many species of wetlands are threatened and endangered; some species have already been extinct from the wetland ecosystem. As a consequence, the protection of the wetland ecosystem is significantly important for the conservation of biodiversity and the development of a sustainable environment in terms of human interest. Conservation strategies are highly recommended. For example, residents should be encouraged to increase vegetation in wetland areas to improve biodiversity. Additionally, the application of organic fertilizers should be increased in farmer's crop fields instead of chemical fertilizers. Therefore, community people around the wetland should be aware of environmental rules and regulations through the training program.

Data Availability

The data used to support the findings of this study are included in the article.

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Authors' Contribution

Mohammad Zahangeer Alam: Writing, original draft preparation, funding acquisition & review, and editing; **Jannatul Ferdous & Babu Hossain:** data collection & analysis; **Hasan Muhammad Abdullah:** GIS and remote sensing; **Moumita Choudhury, Emran Hossain, Md. Tamal Hasan, Md Shanewaz Khan & Farzana Alam:** Review and editing

Competing Interest Statement

The authors declare that the research was conducted without any commercial or financial relationship that could be construed as a potential conflict of interest.

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Supplementary Tables

References

- Larson JS, Adamus PR (1989) Functional assessment of freshwater wetlands: A manual and training outline (No. 89). University of Massachusetts at Amherst.
- Queensland Government (2024) Riverine wetland Information.
- Alam MZ, Bhuiyan MAB, Abdullah HM, Ghosh SR, Hassan MM, et al. (2021) Changes of Land Use and Land Cover with the Diversity of Fishes, Aquatic Plants, and Bird's Species at Wetland Ecosystem. *The Scientific World Journal* 7533119.
- Kumar GNP, Srinivas P, Chandra GNP, Sujatha P (2010) Delineation of groundwater potential zones using remote sensing and GIS techniques: A case study of Kurmapalli Vagu Basin in Andhra Pradesh, India. *International Journal of Water Resources and Environmental Engineering* 2(3): 70-78.
- Sagoff M (2007) On the compatibility of a conservation ethic with biological science. *Conservation Biology* 21(2): 337-345.
- Swingland IR (2001) Biodiversity, definition of. *Encyclopedia of biodiversity* 1: 377-391.
- Alam MZ, Halsey J, Haque M, Talukdar M, Moniruzzaman M, et al. (2018) Effect of Natural Disasters and Their Coping Strategies in the Kuakata Coastal Belt of Patuakhali Bangladesh. *Computational water, energy, and environmental engineering*, 7: 161-182.
- United Nations Environment Programme (UNEP) 2001. Bangladesh: State of the Environment (Biodiversity), pp. 77-92
- Grishma T, Akansha B (2016) Aquatic Biodiversity: Threats and Conservation, Department of Fishery Biology, College of Fisheries, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.
- Food and Agriculture Organization (FAO) (2016) Food and agriculture organization of the United Nations. FAO, Italy.
- Khan MH (2013) Community conserved areas in Bangladesh: sustainable management strategies (Doctoral dissertation, Curtin University).
- Hossain MS, Ehshan MA, Mazid MA (1999) Fish biodiversity study of three floodplains in Bangladesh. In *Sustainable Inland Fisheries Management in Bangladesh*. ICLARM Conference Proceedings 58: 229-233.
- Rahman AKA (2005) Fresh water fishes of Bangladesh. (2nd edn), Zoological Society of Bangladesh. Dhaka, Bangladesh, pp. 71-310.
- Department of Fisheries (DoF) (2010) Fish for night Compendium, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the people's Republic of Bangladesh, pp. 102-103.
- Matin MA, Kamal R (2010) Impact of climate change on river system. In *Proceedings of the International Symposium on Environmental Degradation and Sustainable Development (IS SD 2010)*. 12t.
- Sheikh AH, Molla AH, Haque MH, Alam MZ (2017) Evaluation of water quality and biodiversity of natural freshwater wetlands discharged by industrial effluent. *Academia Journal of Environmental Sciences* 5(3): 052-064.
- Chowdhury AMS, Rahman MA, Rahman MM, Mohiuddin ASM, et al. (2007) Nature and the extent of industrial pollution in river water around Dhaka city. *Bangladesh J Environ Sci* 13(1): 46-49.
- Rahman AL, Islam M, Hossain MZ, Ahsan MA (2012) Study of the seasonal variations in Turag river water quality parameters. *African Journal of Pure and Applied Chemistry* 6(10): 144-148.
- Rahman MO, Alam MZ (2021) Seasonal Variation of Water Quality Constituents in the Turag River. *International Journal of Research and Innovation in Applied Science* 6(9): 118-125.
- Mori AS (2011) Ecosystem management based on natural disturbances: hierarchical context and non-equilibrium paradigm. *Journal of Applied Ecology* 48(2): 280-292.
- Amann C, Fischer-Kowalski M (2002) Austria: An "Eco-Land"? In *Capacity Building in National Environmental Policy*. Springer, Berlin, Heidelberg, pp. 45-68.
- Cheffings CM, Farrell L (2005) The vascular plant red data list for Great Britain No. 7. JNCC, Peterborough, UK.
- International Union for Conservation of Nature (IUCN) (2015) Bangladesh Red Book of Threatened Fishes of Bangladesh. In: Islam MA, Ameen M, Nishat A (Eds.). *The World Conservation Union, Dhaka, Bangladesh*.
- Joly CA, Metzger JP, Tabarelli M (2014) Experiences from the Brazilian Atlantic Forest: ecological findings and conservation initiatives. *New Phytologist* 204(3): 459-473.
- Amarasekara EAKK, Jayasiri HB, Amarasekara C (2021) Avifaunal Diversity in Urban Coastal Wetland of Colombo Sri Lanka. *Open Access Library Journal* 8(3): 1-10.
- U.S. Fish & Wildlife Service (2023) Ten Ways You Can Help Conserve Wetlands.
- Ministry of Environment, Forest and Climate Change (2017) Biodiversity Act-2017.
- Alam MZ, Carpenter-Boggs L, Rahman A, Haque MM, Miah MRU, et al. (2017a) Water Quality and Resident Perceptions of Declining Ecosystem Services at Shitalakkh Wetland in Narayanganj City. *Sustainability of Water Quality and Ecology* 9-10: 53-66.
- Alam MZ, Carpenter-Boggs L, Mitra S, Haque M.M, Joan Halsey, et al. (2017b) Effect of salinity intrusion on food crops, livestock, and fish species at Kalapara coastal belt in Bangladesh. *Journal of Food Quality* 2045157: 23.
- Alam MZ (2014) Status of biodiversity at wetland ecosystem of Mohanganj Upazila in Netrakona District. *Advances in Ecology* 642450: 8.
- Alam MZ (2019) Effects of Environmental threats on biodiversity at wetland ecosystem in Netrakona area of Bangladesh. 2nd R & D Congress on East Asian- Australasian Flyway (EAAF) for Wetlands and Migratory Water birds in the Course of Climate Change. October 7-11, Bacolod City, Philippines.
- Adla K, Dejan K, Neira D, Dragana D (2022) Degradation of ecosystems and loss of ecosystem services, In: Joana C. Prata, Ana Isabel Ribeiro, Teresa Rocha-Santos (Eds.), *One Health*, Academic Press, pp. 281-327.
- Ishiyama N, Akasaka T, Nakamura F (2014) Mobility-dependent response of aquatic animal species richness to a wetland network in an agricultural landscape. *Aquatic Sciences* 76(3): 437-449.

34. Brussaard L, Caron P, Campbell B, Lipper L, Mainka S, et al. (2010) Reconciling biodiversity conservation and food security: scientific challenges for a new agriculture. *Current Opinion in Environmental Sustainability* 2(1-2): 34-42.
35. Benson MH, Garmestani AS (2011) Can we manage for resilience? The integration of resilience thinking into natural resource management in the United States. *Environmental Management* 48(3): 392-399.
36. Alam MZ, Ali MP, Abdullah AN, Choudhury TR (2011) Contamination status of arsenic, lead, and cadmium of different wetland waters. *Toxicological & Environmental Chemistry* 93(10): 1-12.
37. Golmarvi D, Kapourchali M, Moradi A, Fatemi M, Nadoshan R (2017) Influence of Physico-Chemical Factors, Zooplankton Species Biodiversity and Seasonal Abundance in Anzali International Wetland, Iran. *Open Journal of Marine Science* 7(1): 91-99.
38. Palacio-Núñez J, Verdú JR, Galante E, Jiménez-García D, Olmos-Oropeza G (2007) Birds and fish as bioindicators of tourist disturbance in springs in semi-arid regions in Mexico: a basis for management. *Animal Biodiversity and Conservation* 30(1): 29-41.
39. Butchart SH, Walpole M, Collen B, Van Strien A, Scharlemann JP, et al. (2010) Global biodiversity: indicators of recent declines. *Science* 328(5982): 1164-1168.
40. Cardinale BJ, Duffy JE, Gonzalez A, Hooper DU, Perrings C, et al. (2012) Biodiversity loss and its impact on humanity. *Nature* 486(7401): 59-67.
41. Peduzzi PR, Harding J, Richard S, Kluser LD, Boudol B (2011) UNEP Foresight Process: Phase I: Results of the UNEP Consultation, United Nations Environment Program, Nairobi.
42. Biodiversity (2024) Main issue: The Convention on Biological Diversity (CBD).
43. Zhang Z, Wang C, Gong G, Chen Y, Ma S, et al. (2024). Biodiversity conservation and management of lake wetlands based on the spatiotemporal evolution patterns of crane habitats. *Journal of Environmental Management* 353: 120257.
44. Cao B, Bai C, Xue Y, Yang J, Gao P, et al. (2020) Wetlands rise and fall: Six endangered wetland species showed different patterns of habitat shift under future climate change. *Science of The Total Environment* 731: 138518.
45. Irfan S, Alatawi AMM (2019) Aquatic Ecosystem and Biodiversity: A Review. *Open Journal of Ecology* 9(1): 1-13.
46. Ibrahim MSN, Assim MISA, Johari S, Mohammad SKW, Afandi SHM, et al. (2023) Public awareness on biodiversity conservation and well-being: case of Gunung Mulu National Park, Sarawak. *Geo Journal* 88(3): 3471-3496.
47. Allahyari MS, Marzban S, Gonzalez-Ollauri A, Nazari E, Ben Hassen T, et al. (2024) Unlocking the power of public awareness: paving the way for sustainable wetland management in Anzali, Iran. *Front Environ Sci* 11: 1277154.
48. Wetlands Conservation Act (2008) Enforcement Decree of the Wetlands Conservation Act.



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