Diversity of Aquatic Macrophytes with reference to Water Quality in Jakhor Lake, Dhangadi, Kailali

Kanchan Devi Upadhyay and Anand Prasad Joshi

Assistant professor, Aishwarya Multiple Campus, Dhangadhi, Kailali
Corresponding author email: kanchan.bjr@gmail.com

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Abstract

Water quality and other physical environmental factors determine the considerable variations in distribution and composition of aquatic species in freshwater ecosystems. Present study determined the physico-chemical parameters of water like temperature, pH, conductivity, nitrate, and ammonia which has brought variations in species community of macrophytes. Among all studied water parameter, **Water temperature, ammonia, and conductivity** are found to be most important influencing factor for macrophyte distribution while pH and nitrate have less influence. Altogether 37 Macrophyte species belonging to 21 families were recorded with the dominancy of emergent species, from the study area. Most of the macrophyte species showed strong but negative affinity with ammonia and water temperature. Jakhor Lake, which can be used for its management. This, study also provides useful information for decision makers aimed to the conservation and sustainable management of the lakes in Nepal.

Keywords: water quality, physico-chemical parameters, macrophyte distribution, Species composition, lake management

Introduction

Wetlands are interface between terrestrial and aquatic communities and the most productive ecosystem on the earth. They only occur in areas where shallow water covers the land or where the water table is at or close to the surface. Wetlands serve multiple vital functions that greatly enhance societal well-being, as noted by Costanza et al. (1997). They are essential for preserving biodiversity and protecting genetic resources. Oli et al. (2013) emphasize the importance of wetlands in providing wildlife habitats, offering refuge to migratory birds, regulating water quality, mitigating floods, generating organic matter, and safeguarding rare and endangered species. James (1995), as cited in Poddar et al. (2001), referred to wetlands as "nature's kidneys" due to their critical ecological roles. In the context of Nepal, wetlands are entirely freshwater ecosystems and cover approximately 5% of the nation's land area (Siwakoti, 2006).

Although aquatic biodiversity offers human societies a wide range of valuable products and services, some of which cannot be replaced (Dudgeon et al., 2006), these species are extremely susceptible to the deterioration of water quality brought on by physical or chemical changes (Water facts 2001; Alam et al., 2008).The efficiency of ecological communities to capture vital resources, produce biomass, decompose and recycle vital nutrients is diminished when aquatic biodiversity is lost (Cardinale et al., 2012).In this study, aquatic macrophytes and physico-chemical parameters of water is considered .

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Aquatic macrophytes are macroscopic forms of aquatic vegetation, including macroalgae, mosses, ferns, and angiosperms found in aquatic habitats (Dhanam and Elayaraj, 2015). They serve as a link between the sediment, water, and (sometimes) atmosphere in wetlands, lakes, and rivers (Gumbricht, 1993). These macrophytes can act as measurable indicators of the ecological conditions of surface water. Aquatic floating macrophytes take up inorganic nutrients, mainly nitrogen and phosphorus, by the roots; although uptake through the leaves may also be significant (Ferdoushi et al., 2008). Notably, the submerged species are strongly dependent on water quality have proved to be vulnerable to changes in the aquatic environment and can serve as eutrophication indicators (Lacoul and Freedman 2006; Sondergaard et al., 2010).

The water quality is important in macrophyte habitat assessment because a host of interacting physical and chemical factors can influence the level of primary productivity in aquatic systems and thus influence the trophic structure and total biomass throughout the aquatic food web.

However, the study mentioned in the above literature review shows such research gap in the Jakhor lake. Such research has not been perform from the conservation point of view as well as in adding taxonomic database in biodiversity. So, Recognizing the importance of macrophytes in the aquatic ecosystem, present study can be beneficial to fulfill the research gap as it provide the basic information about the pollution levels as well as the diversity and composition of aquatic biodiversity in the lake and to figure out their relationship with the water quality.

The general objective of this work is to explore patterns of diversity of aquatic macrophytes and examine their relationships to physico-chemical parameters of water of the study area.

Study Site

Jakhor Taal is a large perennial oxbow lake that lies in Dhangadhi-7, Kailali, Farwest, Nepal. It covers a total area of 13.49 ha and is situated at 165 m above sea level with a latitude of 28º 42' 23.08''N and longitude of 80º 37' 21''E. This lake is surrounded by a community forest (Chamraiya Forest) in the Northwestern part, farmland and settlements on the east and Dewariya Botanical Garden towards its south, which contains a total area of 149.50 ha and plays an important role in in-situ and ex-situ conservation.

The lake's beauty is enhanced by a diverse range of aquatic and amphibious plants and animals. The aquatic vegetation is represented by extensive coverage of floating leaf species mainly lotus (*Nelumbo nucifera*) followed by wild rice (*Hygrorhiza aristata*) and pondweed (*Potamogeton nodosus*). The free floating species include water velvet (*Azolla imbricata*) and duckweed (*Lemna* spp.)

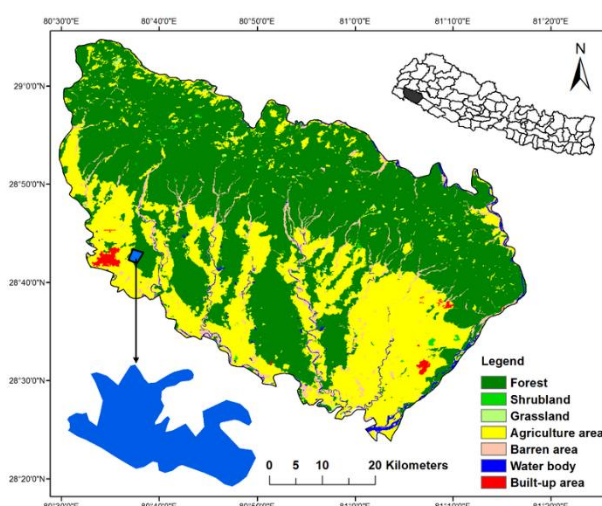

Figure 1: Map of the study area showing the Jakhor Taal and the land cover of associated areas (Singh and Bhattarai, 2021)

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Methods

To conduct the study and fulfill the objectives as mentioned as above, systematic and integrated methodology was followed. Field studies and collection of primary data were applied in the research. Primary data were collected through field survey and laboratory analysis.

Sampling, preservation and identification of Macrophyte

To determine the composition of Aquatic Macrophytes, random method was applied. It was applied on 15 different sampling unit with the help of quadrate method was applied (Ghos and Biswas, 2015). Macrophyte species Collected from 15 different plot of the study area were tagged, pressed and dried by standard herbarium specimen preparation technique. Appropriate field notes were also prepared in the field. Herbarium of collected Macrophyte specimen were identified and labeled in herbarium sheet.

Water sampling, preservation and laboratory analysis

All together 15 Water samples were collected from the depth of 0.5m of the lake for the lab analysis. The samples were collected in cleaned one-liter plastic containers, which were rinsed with and lake water before collection. Water samples were collected avoiding floating materials. The stoppers of the sample bottle were closed properly to prevent outside contamination. The bottle was labeled describing the name of the sampling site, sampling point, date and time under which it was sampled. The water temperature, was measured on the spot using a portable water analysis kit. PH, Conductivity, Nitrate as total nitrogen, and ammonia were determined in the khanepani sasthan, Dhangadhi.

Aquatic macrophyte sampling and water sampling were performed on January, 2025 at the same time.

Data Analysis

The relationship of Macrophyte with Physico-chemical variables was evaluated using ordination. Canonical Correspondence Analysis (CCA) was performed to access the species environment relationship. R version 4.4.3 (2025-02-28 ucrt) was used for DCA and CCA ordination.

Results and Discussions

Table 1:

Macrophyte composition in Jakhor lake.

S.N.	Name of Macrophytes	Family	Growth form	Abbrebrations
1.	*Aponogeton undulates* (Roxb.)	Aponogetonaceae	SM	Apo_undu
2.	*Azolla imbricate* (Roxb.)	Salviniaceae	FF	Azo_imb
3.	*Azolla pinnata* R.Br.	Salviniaceae	FF	Azo_pinn
4.	*Blyxa aubertii*	Hydrocharitaceae	SM	Bly_aub
5.	*Ceratophyllum demersum* L.	Ceratophyllaceae	SM	Cer_dem
6.	*Cryptocoryne windtii*	Araceae	SM	Cry_win
7.	*Cryptocoryne lucens*	Araceae	SM	Cry_luc

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S.N.	Name of Macrophytes	Family	Growth form	Abbrebrations
8.	*Eichhornia crassipes* (Mart.) Solms	Pontederiaceae	FF	Eic_cra
9.	*Hydrilla verticellate* (L.F.) Royle	Hydrocharitaceae	SM	Hyd_ver
10.	*Lemna minor*	Lemnaceae	FF	Lem_min
11.	*Ludwigia adscendens* (L.) H. Hara	Onagraceae	RFL	Lud_ads
12.	*Ludwigia hexapatala*	Onagraceae	RFL	Lud_hex
13.	*Maundia triglochinoides*	Acanthaceae	E	Mau_tri
14.	*Marsilea vestita*	Marsileceae	FF	Mar_ves
15.	*Miscanthus sinensis*	Poaceae	E	Mis_sin
16.	*Najas graminea*	Najadaceae	SM	Naj_gra
17.	*Nelumbo nucifera* Gaertn.	Nymphaeceae	FF	Nel_nuc
18.	*Nymphoides cristata* (Roxb.) Kuntze	Menyanthaceae	RFL	Nym_cri
19.	*Oryza rufipogon*	Poaceae	SM	Ory_ruf
20.	*Pistia stratoides* L.	Araceae	FF	Pis_str
21.	*Potamogeton crispus*	Potamogetonaceae	SM	Pot_cri
22.	*Potamogeton nodosus*	Potamogetonaceae	SM	Pot_ nod
23.	*Potamogeton pectinatus*	Potamogetonaceae	SM	Pot_pec
24.	*Vallisneria spiralis*	Hydrocharitaceae	SM	Val_spi
25.	*Alternenthera sessilis* (L.) DC.	Amaranthaceae	E	Alt_ses
26.	*Calocasiasculenta*(L.)Schott	Araceae	E	Cal_scu
27.	*Cyperus esculentus*	Cyperaceae	E	Cyp_esc
28.	*Ipomia carnea*ssp fistula (Mart.exChoisy) D.F.Austin	Convolvulaceae	E	Ipo_car
29.	*Leersia hexandra* Swartz.	Poaceae	E	Lee_hex
30.	*Panicum repens*	Poaceae	E	Pan_rep
31.	*Persicaria amphibian*	Polygonaceae	E	Per_amp
32.	*Persicaria barabata*	Polygonaceae	E	Per_bar
33.	*Persicaria hydropiper* (L.) Spach	Polygonaceae	E	Per_hyd
34.	*Phragmites karka* (Burm.f.)	Poaceae	E	Phr_kar
35.	*Ranunculus sceleratus*	Ranunculaceae	E	Ran_sce
36.	*Schenoplectus triqueter*	Cyperaceae	E	Sch_triq
37.	*Utricularia vulgaris*	Lentibulariaceae	Ff	Utr_vul

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Altogether 37 plant species belonging to 21 families were recorded from 15 different sampling sites of Jakhor lake. Poaceae was found to be dominant family and is followed by Areaceae and then Hydrocharitaceae, Potamogetonaceae and Polygonaceae family in the study period. The dominancy of these family might be due to the presence of different physical and physiological nature of the plant species belonging to these family. Such as ability of efficient long-distance dispersal, successful establishment bilology, ecological flexibility, resilience to disturbance and the capacity to modify environments by changing nature of fire and mammalian herbivory (Linder et al., 2018).

Among growth form, highest number of emergent macrophytes (Figure 3) were recorded which indicates the disturbance caused by the various anthropogenic activities of the tourists in the riparian zone of the wetland. The fact of getting highest species diversity of emergent and lowest free-floating species signifies the increasing richness in species with decreasing water level (Sharma and Singh, 2017). Similar result was supported by Upadhyay et el., (2022), Roka (2019), Dongol et al., (2014) and Burlakoti and Karmacharya (2004).

The distribution of macrophytes composition may also depends upon morphometric aspect like depth, slope, degree of connectivity and the distance of a site in a lake from the river channel, are particular to floodplain lakes. Depth affects the distribution of macrophytes and creates plant zonation along littoral zones (Sculthorpe, 1967; Santos and Thomaz, 2007). Similarly, the slope of the littoral zone may affect macrophyte establishment because in steeper habitats, few species are able to settle and anchor (Duarte and Kalff, 1986).

Figure 2:

Macrophyte species belonging to different families of Setikhola watershed.

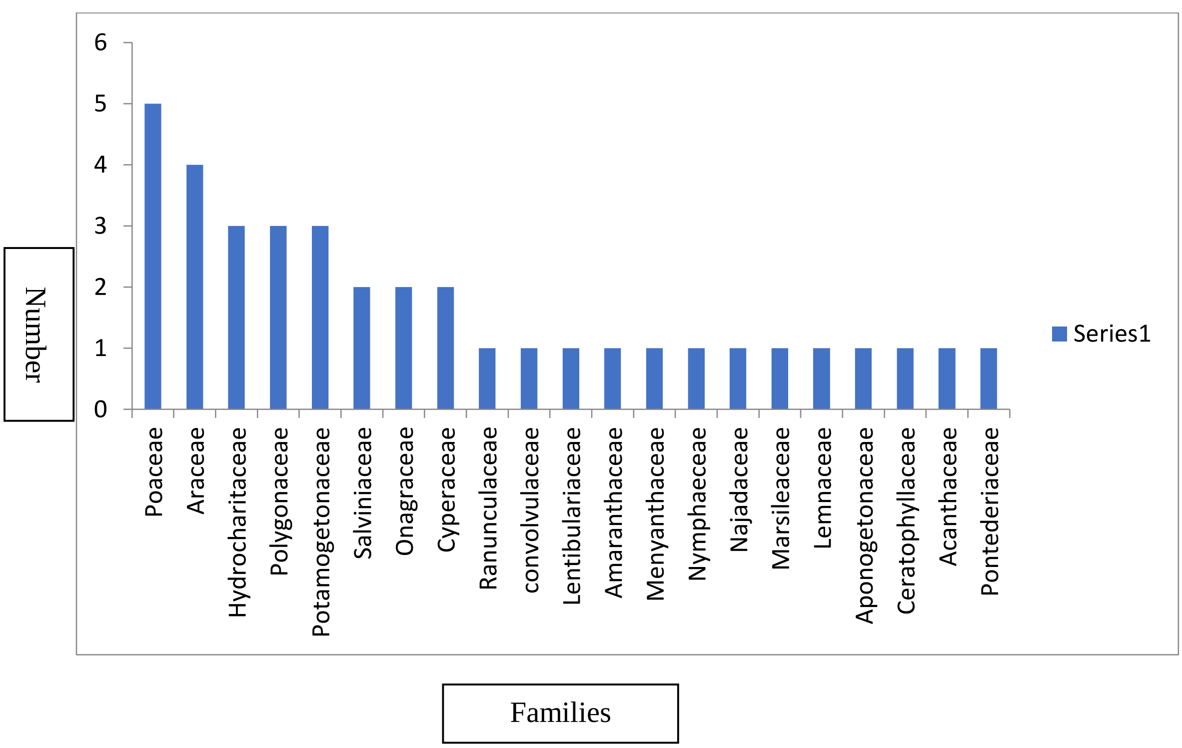
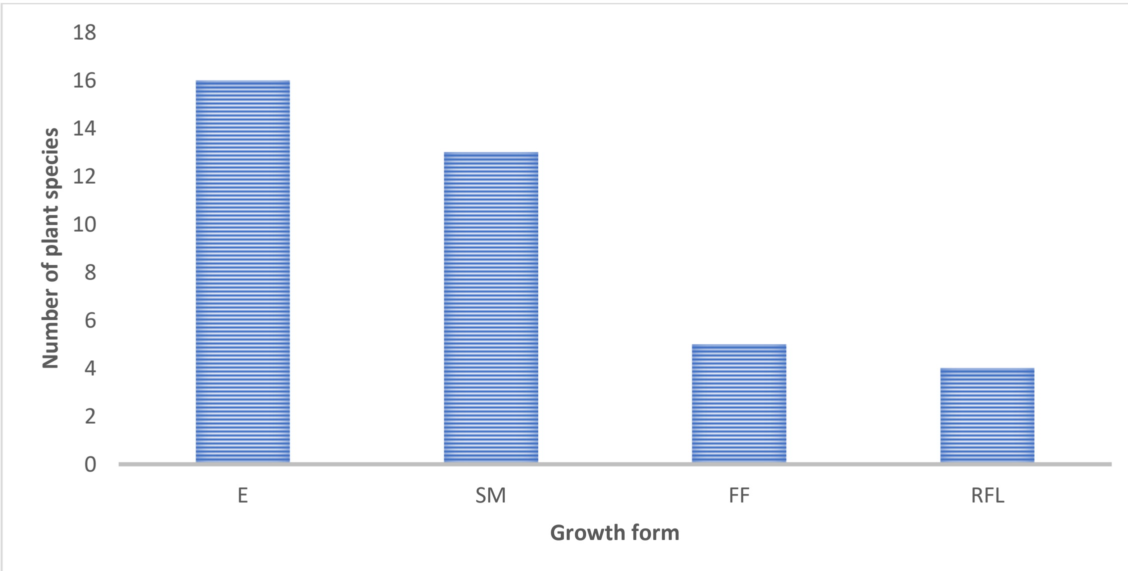


Figure 3:

Macrophyte species with Growth form.



(E= Emergent, SM= Submerged, FF= Free floating, RFL= Roots of free floating leaves)

Physico-chemical characteristics of water

Table 2.

Physico-chemical characteristics (mean±SD) of water of Lake

Water parameters	**Average**
Temperature(°C)	21.67±0.49
pH	6.75±0.47
Conductivity (µS/cm)	77.33±15.10
Nitrate (mg/L)	1.77±1.62
Ammonia (mg/L)	1.70±0.48

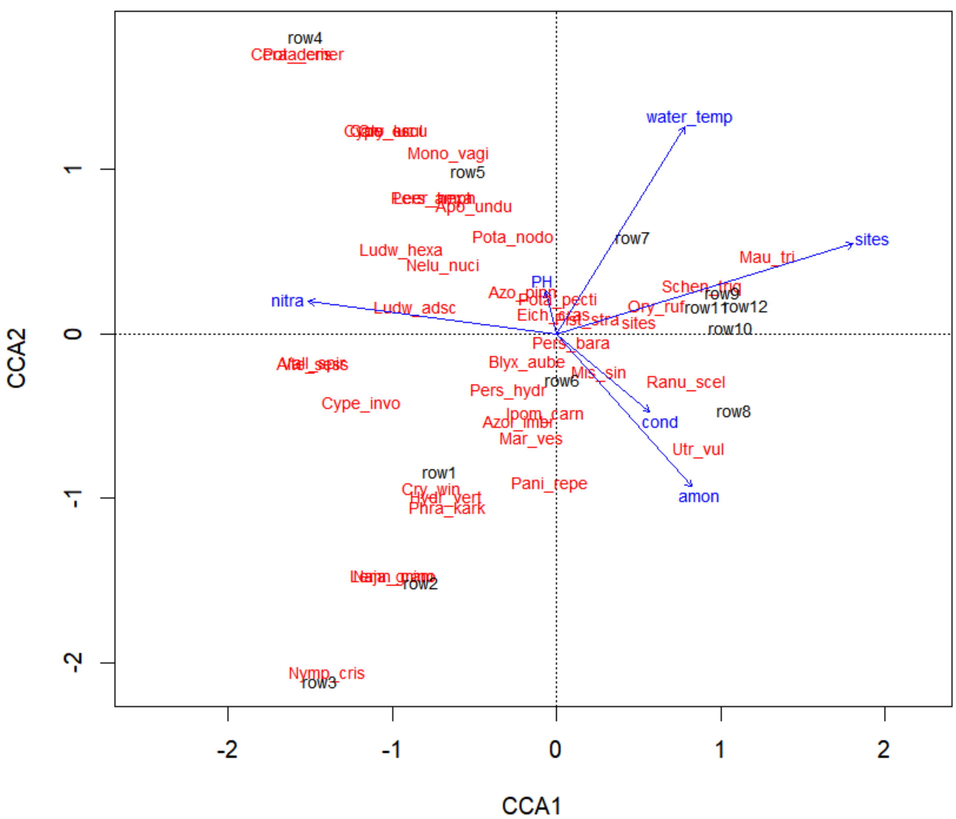
The provided water parameters indicate a moderately stable aquatic environment with some variability. The average temperature of **21.67 ± 0.49 °C** suggests a temperate setting, favorable for many freshwater species. A **pH of 6.75 ± 0.47** shows slightly acidic conditions, which could influence species composition and nutrient availability. The **conductivity of 77.33 ± 15.10 µS/cm** is relatively low, indicating limited dissolved ionic substances, typical of soft, low-mineral waters. **Nitrate levels averaging 1.77 ± 1.62 mg/L** suggest minimal nutrient enrichment, though the high standard deviation points to occasional spikes, possibly from runoff or organic matter decomposition. Meanwhile, the **ammonia concentration of 1.70 ± 0.48 mg/L** is relatively high and can be toxic to aquatic organisms, especially in warmer or low-oxygen conditions, raising concerns about potential pollution or inadequate waste breakdown. Overall, while most parameters appear within acceptable ranges, elevated ammonia and nitrate variability may indicate localized water quality issues needing closer monitoring.

Relationship between Physico-chemical Characteristics of water with aquatic macrophytes

The CCA ordination shows the relationship between macrophytes and different physico-chemical parameter of water (fig:4). Forward selection and Monte Carlo Permutation test revealed that Conductivity was the most important variable (p=0001) governing the macrophyte composition.

Figure 4.

CCA biplots for Macrophyte species along with environmental variables.



47% of total variation is explained by the first three CCA axes. The constrained structure in the data (i.e. the part related to explanatory variables) is well captured in the first few CCA axes, with CCA1–CCA2 explaining ~51% of it.

The length of each arrow reflects the strength of its correlation with the species distribution — longer arrows like water_temp indicate stronger environmental gradients. Species clustered near an arrow are positively associated with that variable, while those in opposite directions are negatively related.

Electrical conductivity is the measure of the ability of an aqueous solution to transmit an electric current in the aquatic environments (Lodh et al. 2014). Lowest conductivity denotes lowest organic water whereas highest conductivity denotes highly organic water (Singh et al., 2010).

Most of the species like *Eichhornia crassipes, Nelumbo nucifera, Ludwigia adscendens, Ludwigia hexapatala, Ceratophyllum demersum, Potamogeton nodosus, Potamogeton crispus, Azolla imbricate* showed negatively strong affinity with conductivity and ammonia i.e. the species composition highly decreases with increase in Conductivity and ammonia. But *Ranunculus sceleratus* and *Utricularia vulgaris* showed showed high abundances with Conductivity.

Similar result was reported by (Dhote, 2007) showed in Shahapura Lake in Bhupal.

Species like *Eichornia crassipes, Azolla pinnata*, and *Pistia stratoites* are moderately influenced by pH., Persic*ariabaratata, Ipomiacarnia, Cyperusesculentus, Phragmites karka, hydrilla verticellata, Blyxaaubertii*, *Persicaria hydropiper, Monochoria vaginalis and Cryptocoryne wendtii* showed negatively strong affinity water temperature. While, the Species like *Maundia triglochinoides*, *Maundia triglochinoides* and *Oryza rufipogon* are positively associated with higher water temperatures.

Conclusion

This study assessed the diversity and distribution of aquatic macrophytes in relation to water quality parameters in Jakhor Lake, Nepal, recording 37 species across 21 families, with emergent forms being most dominant. Canonical Correspondence Analysis revealed that water temperature, ammonia, and electrical conductivity were the most influential factors affecting species composition, while pH and nitrate had lesser impact. Most species showed a strong negative correlation with ammonia and temperature, indicating sensitivity to pollution and thermal changes, though some species like *Ranunculus sceleratus* and *Utricularia vulgaris* were positively associated with higher conductivity. These findings provide important baseline data for future ecological monitoring and offer valuable insight for the sustainable conservation and management of freshwater ecosystems like Jakhor Lake.

Recommendations

Further studies on macrophytes and additional water parameters across different seasons are strongly recommended, including key physico-chemical factors like DO, alkalinity, acidity, transparency, turbidity, BOD, and COD. Promoting research on ecosystem services and raising public awareness about the value of aquatic biodiversity are essential for effective conservation.

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