Nature Conservation & Health Care Council

Our Nature

Journal homepage: http://nepjol.info/index.php/ON

ISSN: 1991-2951 (Print)
ISSN: 2091-2781 (Online)

Macrophytes, ecosystem services and potentialities of ecotourism in some lakes of eastern Nepal

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Abstract

Lakes in the eastern Nepal enriched with a combination of mystical biodiversity and the essence of cultural ecosystem services are among the major ecotourism destinations. Wetland based ecotourism approach aims at conserving the environment and uplifting the socio-economic and cultural conditions through tourism development. The study aimed to list out the macrophytes of the lakes and to assess the ecotourism potentialities in some lakes (Taltalaiya, Raja-Rani, Chulachuli and Maipokhari) of eastern Nepal. Macrophytes were studied by quadrat method. Regarding the data for the components of ecotourism, primary data were collected by key informant survey and focus group discussion to know the visitor's perception on the current ecotourism status of these lakes. Secondary sources of data collection included published and unpublished literature. Collected data were analyzed both qualitatively and quantitatively. The rich macrophyte diversity of these lakes comprising 56 species of angiosperms and 4 species of aquatic pteridophytes reflects a natural and undisturbed habitat with great ecotourism potentials. However, Chulachuli lake is not familiar from ecotourism point of view till date. Based on numerous ecotourism activities, the study reveals that relaxation ranks top in Taltalaiya lake, picnic/outing in Raja-Rani lake, and religious activity in Maipokhari lake. Ecotourism activities integrated with public involvement could serve as a backbone for generating and improving the wetland revenue to sustain the conservation of wetland biodiversity.

Keywords: Biodiversity, Conservation, Sustainable tourism, Vascular macrophytes, Wetland

DOI: https://doi.org/10.3126/on.v23i2.82817
Manuscript details: Received: 03.05.2025 / Accepted: 25.07.2025
Citation: Siwakoti, E.A, Baniya, C.B., and Mandal, T.N. 2025. Macrophytes, ecosystem services and potentialities of ecotourism in some lakes of eastern Nepal. *Our Nature* 23(2): 1-18. DOI: https://doi.org/10.3126/on.v23i2.82817

Introduction

Macrophytes, water and sediments collectively regulate the function of aquatic ecosystem. Macrophytes occupy different ecological niche as: submerged, floating-leaved, free-floating and emergent. Macrophytes provide beneficial functions for the ecosystems and societies. *Euryale* (Makhana), *Nelumbo* (Lotus), *Nymphaea* (Water lily), *Trapa* (Singhada), *Typha* (Pater), *Vitiveria* (Khas-Khas) are some of the examples of macrophytes that provide benefit to the societies. Benefits provided by the

aquatic ecosystem and organism involved therein could be recognized as ecosystem (MEA, 2005). The Millennium Ecosystem Assessment of the United Nations emphasizes human well-being as a core ecosystem service which are categorized into provisioning, regulating, supporting and cultural services. Cultural ecosystem services are intangible non-material benefits that people obtain from nature are deeply connected to human culture and traditions including spiritual values and aesthetic experiences through recreations and tourism. Tourism connected with sustainable nature conservation and benefiting the local communities is referred to as ecotourism (Bricker, 2017). The International Ecotourism Society (TIES) of United States emphasizes exploring natural areas with a focus on environmental protection and providing local communities with more sustainable livelihoods.

Globally, ecotourism has emerged as one of the rapidly growing tourism markets in developing countries. Ecotourism serving as an economic development tool and conservation mechanism (Wood, 2002) would enhance the livelihood of the local communities in Asian context, especially in Nepal (Nepal and Spiteri, 2011). Ecotourism involves activities like nature walks, wildlife safari, nature photography, camping, canoeing, bird watching, scientific research, trekking and observing the beauty of wild plants and flowers (Dhakal and Dahal, 2000). However, species based (Dahal *et al.,* 2019; Adhikari *et al.,* 2023) and homestay based (Khatiwada, 2022) ecotourism is also common to Nepal. Ecotourism offers employment opportunities and minimize rural out-migration to urban areas (Joshi, 2010), infrastructure development and earnings from ecotourism based business (Pageni *et al.,* 2024).

Nepal is one of centers to scenic beauty, socio-cultural and ecological diversity holds several potential ideal destinations for nature based tourism. Nepal holds a great variety of fresh water wetlands harboring 11 globally threatened species, 11 floral and 42 faunal species and 26 endemic flowering plant species (IUCN, 2004). Till date, ten wetlands are listed as Ramsar Site of International Importance and Maipokhari represents the only Ramsar Site in the midhills of eastern Nepal. Owing to the recreational values, wetland based ecotourism is currently an emerging industry in Nepal (Pathak *et al.,* 2020; Khadka *et al.,* 2021; Adhikari *et al.,* 2023; Pageni *et al.,* 2024). Developing ecotourism requires a significant number of visitors (Sherpa and Suklabaidya, 2021). Khadka *et al.* (2021) reported more than 500 local visitors per day and 1500 foreign visitors visiting the Ghodaghodi Lake Complex for wetland related tourism activities in the Central lowland in Nepal.

Ecosystems are value-neutral in terms of structure and function, but some of their services have monetary values for which the users show their willingness to pay (WTP). WTP for ecosystem services is a key concept of Payment for Ecosystem Services (PES) (Carson and Mitchell, 1993). PES is characterized by voluntariness, clearness, ecosystem service buyer, ecosystem service seller and conditionality (Wunder, 2005). PES is a market based approach focusing on compensation by beneficiaries of specified ecosystem services such as clean water, biodiversity habitat or carbon sequestration capacities (Kangas and Ollikainen, 2022; Pissarra *et al.,* 2022) or ecotourism opportunities to those responsible for sustainable management of these services (Wegner, 2015). Although Nepal has explored PES mechanisms in watershed management (Sharma, 2011; Poudyal *et al.,* 2021) and forest conservation (Sharma *et al.,* 2021), its implementation in sustainable wetland conservation in eastern Nepal still remains limited.

Nepalese government has encouraged the development of protected areas and cultural heritage to boost tourism, still many wetlands including Ramsar Sites with rich biodiversity are devoid of government funded budget for

conservation. Most wetlands in Nepal are free to visit. However the targeted studied lakes (except Chulachuli) charges fees to enter could uplift the financial stability of these wetlands for their sustainable conservation.

In Nepal, some local people are providing homestay facilities to tourists receive direct payback from the ecosystem services. Well-managed homestay as an ecotourism product can be an alternative to mass tourism and can play a crucial role in involving the remote population and contribute to the conservation of wilderness and traditional cultures (Acharya and Halpenny, 2013). Thus, wetlands play an important role in promoting ecotourism in Nepal. While tourism is a component of green economy (Reddy and Wilkes, 2012), wetland based ecotourism signifies blue economy (Carlson *et al.,* 2024) that focuses on environmental conservation, socio-economic development and capitalistic development (KC *et al.,* 2015). The available tourism assets and facilities in a particular destination are the major motivating factors for tourism. Eastern Nepal is endowed with natural attractions of several lakes under varied topography with rich biodiversity and cultural ecotourism potentials. However, literature survey revealed very scanty information regarding ecotourism potentialities and ecotourism values of the lakes of eastern Nepal. Therefore, this study aims to assess the ecotourism potentialities and possibilities to implement various PES schemes for sustainable conservation of wetland resources and cultural heritage in and around the lakes of eastern Nepal.

Materials and Methods

Study area

The study was conducted across four lakes, namely Taltalaiya, Raja-Rani, Chulachuli and Maipokhari located in Sunsari, Morang, Dhankuta and Ilam districts of Koshi Province, eastern Nepal, respectively. These lakes were selected to account their geographical diversity and natural status with a great scenic beauty having great potentialities for nature based tourism prospects. Raja and Rani representing two separate lakes are addressed here as a single name under the name Raja-Rani due to their close proximity (Fig. 1).

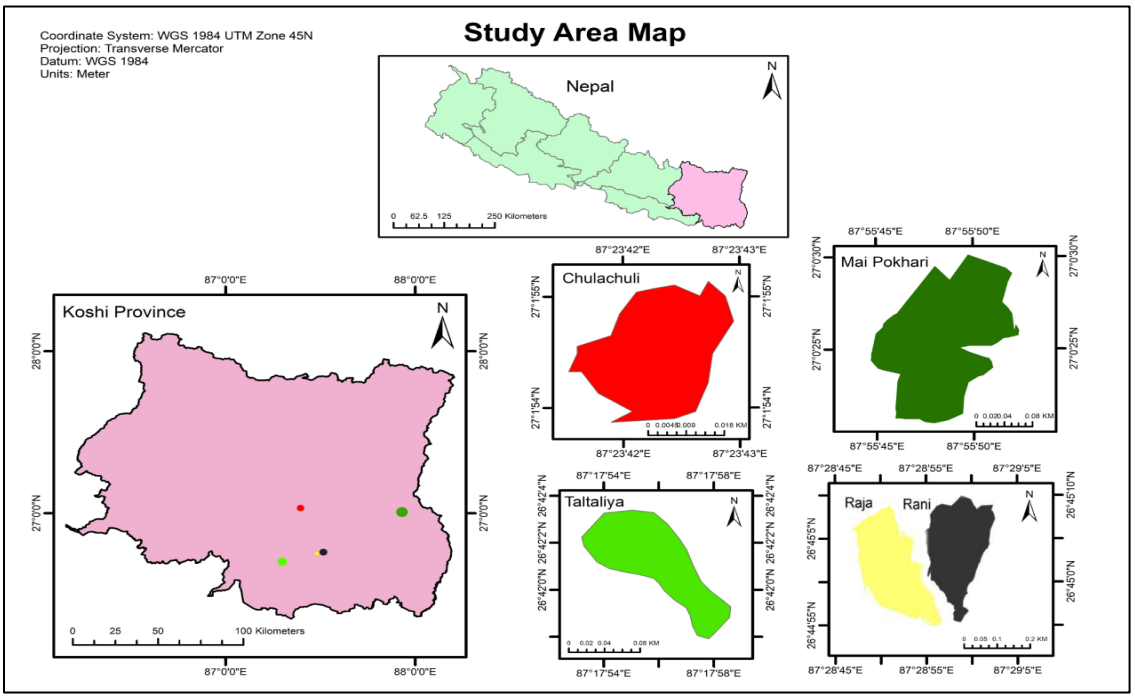

Figure 1. Map of study area located in Koshi province, eastern Nepal.

The study sites lie along an elevation range of 148 to 2132 m above mean sea level (m amsl), representing the Tarai planes to the Siwalik and the mid hills of the lower Himalayan range. The study area has hot tropical to cold and humid temperate climate. The geographical and climatic characteristics are shown in table 1.

Table 1. Characteristics of the studied lakes located in different districts of eastern Nepal

S.N.	Characteristics of lakes	Taltalaiya (Sunsari)	Raja-Rani (Morang)	Chulachuli (Dhankuta)	Maipokhari (Ilam)
1.	Elevation (m amsl)	148	483-487	1782	2132
2.	Latitude (N)	26°42'0.79"	26°45'2.73"-26°44'56.06"	27°1'54.43"	27°0'25.13"
3.	Longitude €	87°17'56.44"	87°28'56.27"-87°28'51.25"	87°23'42.26"	87°55'47.97"
4.	Area (m^2)	10306.67	100926	943	35083
5.	Average depth (m)	1.5	2.0	3.0	8.5
6.	Min. air temp. (ºC)	8.9-25.6	7.3-21.0	7.3-21.0	8.0-18.7
7.	Max. air temp. (ºC)	22.4-33.3	20.1-28.9	20.1-28.9	18.3-26.7
8.	Annual rainfall (mm)	1.2-528.9	1.2-614.7	1.2-614.7	2.4-359.0
9.	Relative humidity (%)	61.0-83.8	62.3-85.7	62.3-85.7	66.0-86.9

(Source: Office of Hydrology and Meteorology, Eastern Regional Climatic Office, Dharan, Nepal)

Four lakes, namely Taltalaiya, Raja-Rani, Chulachuli and Maipokhari are described for their ecological, religious and ecotourism perspectives.

Taltalaiya

Taltalaiya located on the East-West highway, is one of the major tourist destinations wetland of eastern Tarai. The major tourist attractions of the lake includes zoological parks with varieties of wild animals, the lush greenery forest, scenic beauty of the waterscape with wetland plants and mesmerizing, beautifully sculptured stone statues. Boating in certain sections of the lake area, children games, drinking water, and sanitation facilities has gained its popularity, particularly for picnic. The lake harbors several species of vascular macrophytes is a home for several resident waterfowls (Pandey, 2003), and serve as a touristic asset for research purpose.

Raja-Rani

Raja-Rani lake is located 16 Km north to the East-West highway in the Letang Municipality of Morang district. This wetland holds a great historical and religious significance for Dhimal tribes. Dhimal Community people and Dhimal Caste Development Center, Nepal believed that this sacred place is an origin land of the Dhimal Tribes. The rich biodiversity bestowed with the scenic beauty of wild orchids (Shakya and Bajracharya, 2005) anchored on the riparian vegetation *Cephalanthus tetrandrus* (Roxb.) Ridsdale & Bakh.f. of the wetland area along with the richness of vascular macrophytes has designated the lakes as a famous touristic destination of eastern Nepal. The peaceful environment with varieties of birds like hornbills, woodpeckers, peacock, etc. with water birds like white-breasted waterhen (*Amauromis phoenicurus*) and black-backed forktail (*Enicurus immaculatus*), etc. (Basnet *et al.,* 2005) including *Dendrocygna javanica* Horsfield frolicking in the lake has made the wetland as important bird watching area. Boating facilities in the Raja lake in harmony with the natural aquatic vegetation is also one of the prevailing ecotourism activities. It is worth mentioning that boating has become a source of income for local livelihood. The richness of vascular macrophytes diversity offering aesthetic visual appeal makes the wetland an attractive ecotourism destination.

Chulachuli

Chulachuli is a small beautiful lake located at approximately 40 km from Dhankuta district. Mythical belief as habitat for *naags* (serpent deities) and establishment of the *naag devata* idol where rituals are made during Naag Panchami highlights the spiritual and cultural values, promoting tourism among the local inhabitants. The surrounding landscape of the wetland characterized with mesmerizing beauty of its terrestrial and aquatic vegetation serve as a major attraction for ecotourism and eco-researchers.

Meanwhile, Chulachuli lake, though not included in "The inventory of lakes of Province 1, (Anonymous, 2019), possess significant spiritual and ecological value, offering untapped potential for ecotourism development. The absence of formal recognition is a missed opportunity, especially since visitor impressions suggest strong satisfaction where engagement occurs. Enhancing infrastructure, documentation, and promotion could significantly elevate its eco-tourism status.

Maipokhari

Maipokhari wetland is the only Ramsar site in the midhill region of eastern Nepal. The wetland has religious and cultural significance to the Hindus and the Buddhists. The surrounding religious and community forest in the wetland area has a rich biodiversity hosting several species of flora and fauna.

Framed within panoramic view of surrounding snow-capped mountains, the Maipokhari botanical garden presents a harmonious blend of lush greenery of rich plant diversity together with the enchanting beauty of epiphytic orchids, makes it a significant nature based tourism destination. The frolicking of *Carassius auratus* (golden fish), an invasive species in the lake water (Kafle & Savillo, 2009) further add to its ecotourism value. Additionally, the wetland is a home to protected species like White-rumped Vulture (*Gyps bengalensis*), Leopard cat (*Prionailurus bengalensis*), a semi aquatic mammal (*Lutra lutra*) and an endemic Variegated Mountain Lizard (*Japalura variegate*) (Shah *et al.,* 2023). Photographic view of the lakes is presented in plate 1.

Collection and identification of macrophytes

Macrophytes were collected using a quadrat method (1m x 1m) along a line transect positioned parallel to the shoreline. Macrophyte species recorded in the quadrats were identified at the Regional Herbarium of Botany Department of Degree Campus using relevant literature (Cook, 1996; Press *et al.,* 2000, Shrestha and Shrestha, 2021). The identified species were confirmed at the National Herbarium and Plant Laboratories, Godavari, Kathmandu, Nepal. Scientific names provided by the Plants of the World website (powo.science.kew.org) published by The Royal Botanic Gardens, Kew have been adopted for the nomenclature of the species

Data collection on different components of ecotourism

Primary data were collected in the early April, 2024 and late November 2024. Both primary and secondary data were used in the study. Primary sources of data included direct field observation, personal interviews with visitors, lake authorities and the use of Focus Group Discussion (FGD) while secondary sources of data included published literature and official records to know the existing opportunities and major issues in ecotourism promotion. A total of 105 respondents/visitors from each lake (Taltalaiya, Raja-Rani and Maipokhari) were selected randomly for data collection. The questionnaires for data collection are provided in Appendix 1.

Quantitative data such as relaxation, picnic/outing, photography, boating, bird watching, hiking and religious visit were collected by using ranking method. To assess preferences among visitors, a weighted ranking

scale from 1 to 5 was used for lake with 5 ecotourism activities: 5 = most preferred, 4 = second choice, 3 = third choice, 2 = fourth choice, 1 = least preferred (Pathak *et al.,* 2020). Likewise, the preference ranking scale also varied between 1 to 6 or 7, where 6 or 7 represented the most preferred activity, corresponding to the total number of ecotourism activities available at each lake. To evaluate the environmental quality of various lakes, a structured questionnaire (Sharma, 2019) with slight modification was administered to visitors at each site. Respondents were asked to rate the environmental condition based on their personal observations and experiences as they are the witness of their surrounding for many years. The evaluation was done by using four-point Likert scale with the following options: Excellent. Good, Neutral, Poor.

Annual incomes were also analyzed through annual report of the Wetland Management Committee and supplemented by interview with key stakeholders involved in ecotourism enterprises, such as home-stay operators and hotel managers.

Each of the lakes surrounding was hugely occupied by local as well as outside tourists. Thus, local residents have been initiating small business. To assess ecotourism preferences, respondents were asked the existing ecotourism activities such as relaxation, picnic/outing, photography, boating, religious, hiking, and bird watching based on their personal interest and perceived significance for local income generation. These activities were identified through a combination of literature reviews and initial field interactions.

Data analysis

Data were analyzed using both qualitative and quantitative techniques. Qualitative responses from interviews and FGDs were interpreted thematically to extract patterns related to environmental perception and ecotourism benefits. Quantitative data, especially the preference for ecotourism activities in and around the lakes were analyzed using a ranking method as in Pathak *et al.* (2020).

One hundred and five respondents from each lake (Taltalaiya, Raja-Rani and Maipokhari) were asked to rank each activity accordingly. The total weighted score for each activity was calculated by multiplying the number of respondents who selected each ranking by the corresponding weight and summing the results. This allowed for the computation of weighted mean values, which were then used to compare the relative preferences. This total score was then divided by the total number of respondents to compute a weighted mean value. The resulting values reflect both the frequency and priority of each activity and were used to compare and interpret the relative preference of ecotourism activities among visitors. The total score for each activity was calculated using the weighted mean formula (Pathak *et al.,* 2020):

Weighted mean = (x1*w1
+x2*w2+……xn*wn) / total respondents
Where,
w = weight of ranked position,
n= number of choices, x = response count for answer choice

This method allows for an aggregated score that incorporates both frequency and importance of respondents' preferences, thereby enabling meaningful comparison among activities.

Annual income trends were analyzed using reports from the Wetland Management Committees and cross-verified with stakeholder interviews to understand the economic impact of ecotourism enterprises.

Results

Species composition of vascular macrophytes in four lakes

Present study identified altogether 60 plant species under 23 families of angiospermic plants and 4 families of aquatic pteridophytes

from the studied lakes (Table 2). Maximum macrophyte species are available in Raja-Rani, with 39 species of angiosperms and 3 species of aquatic Pteridophytes. It is followed by Taltalaiya, hosting 18 species of angiospermic macrophytes and 3 species of aquatic pteridophytes. The least number of vascular macrophytes are present 8 in Maipokhari and 7 in Chulachuli. So far, the aquatic Pteridophytes, Taltalaiya and Raja-Rani each contain 3 species, while it was completely absent in Chulachuli and Maipokhari.

Among the families of angiospermic macrophytes, Poaceae and Polygonaceae contained the highest number of 8 species each, followed by Cyperaceae and Hydrocharitaceae, each comprising 4 species. Similarly, Asteraceae and Potamogetonaceae each have 3 plant species. Among the remaining families, 8 families contained 2 species each, while the other 8 families were represented by a single species each.

Table 2. Composition of vascular macrophytes in the lakes of eastern Nepal.

Families	Plant species	Lakes			
		T	R	C	M
Angiosperms					
Acanthaceae	*Hygrophila auriculata* (Schumach.) Heine		✓		
	Hygrophila polysperma (Roxb.) T.Anderson	✓	✓		
Alismataceae	*Sagittaria trifolia* L.		✓		
Amaranthaceae	*Alternanthera philoxeroide* (Mart.) Griseb.			✓	
	Alternanthera sessilis (L.) DC.		✓		
Apiaceae	*Oenanthe javanica* (Blume) DC.		✓		
	Oenanthe thomsonii C.B.Clarke				✓
Asteraceae	*Acmella calva* (DC.) R.K.Jansen			✓	
	Acmella uliginosa (Sw.) Cass		✓		
	Adenostemma lavenia (L.) Kuntze		✓		
Araceae	*Lasia spinosa* (L.) Thwaites		✓		
	Pistia stratiotes L.		✓		
	Spirodella polyrhiza (L.) Schleid.	✓			
Brassicaceae	*Nasturtium officinale* W.T.Aiton			✓	
Commelinaceae	*Floscopa scandens* Lour.	✓	✓		
Convolvulaceae	*Ipomoea aquatica* Forssk.	✓			
Cyperaceae	*Cyperus exaltatus* Retz.	✓	✓		
	Cyperus mindorensis (Steud.) Huygh		✓		
	Schoenoplectiella juncoides (Roxb.) Lye		✓		
	Schoenoplectiella mucronata (L.) J.Jung & H.K.Choi	✓			✓
Hydrocharitaceae	*Hydrilla verticillata* (L.f.) Royle	✓	✓		
	Najas graminea Delile		✓		
	Nechamandra alternifolia (Roxb. ex Wight) Thwaites		✓		
	Ottelia alismoides (L.) Pers	✓	✓		
Hydroleaceae	*Hydrolea zeylanica* L. Vahl	✓			
Lentibulariaceae	*Utricularia aurea* Lour.		✓		
Linderniaceae	*Torenia crustacea* (L.) Cham. & Schltdl.		✓		
Lythraceae	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne		✓		
Menyanthaceae	*Nymphoides hydrophyllum* (Lour.) Kuntze		✓		
	Nymphoides indica (L.) Kuntze		✓		
Nymphaeaceae	*Nymphaea nouchali* Burm.f.			✓	✓

	Nymphaea rubra Roxb. ex Andrews	✓	✓		
Onagraceae	*Ludwigia adscendens* (L.) H.Hara	✓			
	Ludwigia perennis L.		✓		
Plantaginaceae	*Limnophila aromatica* (Lam.) Merr.		✓		
Poaceae	*Arundinella nepalensis* Trin.		✓		
	Echinochloa colonum (L.) Link	✓	✓		
	Hemarthria compressa (L.f.) R.Br.		✓		
	Leersia hexandra Sw.		✓		
	Louisiella paludosa (Roxb.) Landge		✓		
	Panicum sumatrense Roth	✓			
	Paspalum distichum L.		✓		
	Sacciolepis indica (L.) Chase		✓		
Polygonaceae	*Persicaria barbata* (L.)H.Hara		✓		
	Persicaria glabra (Willd.) M.Gomez	✓	✓		
	Persicaria hastatosagittata (Makino) Nakai				✓
	Persicaria hydropiper (L.) Delarbre	✓	✓	✓	✓
	Persicaria lapathifolia (L.) Delarbre	✓			
	Persicaria nepalensis (Meisn.) H.Gross			✓	
	Persicaria runcinata (Buch.-Ham. ex D.Don) H.Gross			✓	✓
	Rumex nepalensis Spreng.				✓
Pontederiaceae	*Pontederia crassipes* Mart.	✓	✓		
	Pontederia hastata L.	✓	✓		
Potamogetonaceae	*Potamogeton lucens* L.				✓
	Potamogeton nodosus Poir.		✓		
	Potamogeton octandrus Poir.		✓		
Pteridophytes					
Marsileaceae	*Marsilea minuta* L.	✓			
Pteridaceae	*Ceratopteris thalictroides* (L.) Brongn.	✓	✓		
Salvinaceae	*Azolla pinnata* R.Br.	✓	✓		
Thelypteridaceae	*Thelypteris interrupta* (Willd.) K.Iwats.		✓		

(✓ = presence, T = Taltalaiya, R = Raja-Rani, C = Chulachuli, M = Maipokhari)

Integrated lake-vegetation systems for ecological sustainability

Dense surrounding vegetation around Raja-Rani and Maipokhari act as a natural buffer system in maintaining the watershed integrity of the lakes by regulating surface runoff, sediment stabilization, and enhanced groundwater recharge by retaining rainfall through canopy interception, leaf litter absorption and improved soil infiltration capacity. This helps in maintaining clear water state of the lakes. Comparatively, less vegetated surroundings of Taltalaiya and Chulachuli lakes with nearby populated areas and agricultural land use offer limited infiltration but increased runoff are more vulnerable to sedimentation and increased water turbidity, thereby exhibiting reduced capacity to sustain the hydrological balance.

Macrophytes maintain water quality and clarity by trapping the sediments within the lakes and reducing the turbidity in addition to their role in nutrient cycling (Song *et al.,* 2019). Macrophytes enrich aquatic biodiversity (Thomaz and Cunha, 2010) and enhance the ecological integrity of watersheds by their role in phytoremediation of lake water (Ansari *et al.,* 2020).

Lake water maintains hydrological connectivity with the surrounding terrestrial

ecosystem that helps sustain the terrestrial and riparian vegetation including macrophyte communities by creating stable microclimate (Liu *et al.,* 2025). Presence of *Cephalanthus tetrandrus,* the riparian vegetation in Raja-Rani lake signifies a valuable example of the contribution of lake to watershed sustainability. Thus, the synergy between the lakes, macrophytes and the surrounding vegetation ensures ecological resilience that forms the basis for sustainable ecotourism (Kafle and Savillo, 2009).

Ecosystem services as components of ecotourism

The ranking of ecotourism activities varied across the studied lakes, each offering a distinct set of existing ecotourism activities. Relaxation stood as the 1st rank followed by picnic/outing in Taltalaiya. In contrast, picnic/outing was ranked 1st followed by hiking in Raja-Rani while religious visit secured the 1st rank followed by relaxation in Maipokhari (Table 3). Notably, bird watching was consistently ranked the last in all the studied lakes.

Table 3. Visitor rankings for existing ecotourism activities in the lakes,
(A) Taltalaiya, (B) Raja-Rani (C) Maipokhari

(A) Taltalaiya lake

Ecotourism activities	**Response count**					**Weighted mean**	**Rank**
Relaxation	42	30	20	10	3	3.9	I
Picnic/Outing	25	27	15	12	26	3.1	II
Photography	12	15	22	48	8	2.7	III
Boating	11	15	31	20	28	2.6	IV
Bird watching	15	18	17	15	40	2.5	V

(B) Raja-Rani lake

Ecotourism activities	**Response count**							**Weighted mean**	**Rank**
Picnic/Outing	25	22	15	12	10	12	9	4.7	I
Hiking	20	20	20	12	10	13	10	4.5	II
Relaxation	13	15	20	23	18	12	4	4.3	III
Religious visit	15	18	18	15	12	15	12	4.2	IV
Photography	12	12	10	15	20	18	18	3.6	V
Boating	10	10	12	18	20	15	20	3.5	VI
Birdwatching	10	8	10	10	15	20	32	3.1	VII

(C) Maipokhari lake

Ecotourism activities	**Response count**						**Weighted mean**	**Rank**
Religious visit	30	30	10	10	10	10	4.1	I
Relaxation	25	25	10	10	15	10	3.8	II
Hiking	10	15	25	25	30	2	3.5	III
Photography	20	20	10	10	10	15	3.3	IV
Picnic/outing	10	5	25	25	35	13	3.2	V
Birdwatching	10	10	25	25	5	5	2.7	VI

Purpose of visitors' activities to attend the lakes for different services and their frequency patterns are mentioned in figure 2. Maximum frequency (67%) was seen in Maipokhari for the purpose of religious visit. Taltalaiya represented 36% frequency for relaxation purpose. Chulachuli lake is not even familiar in the eastern Nepal.

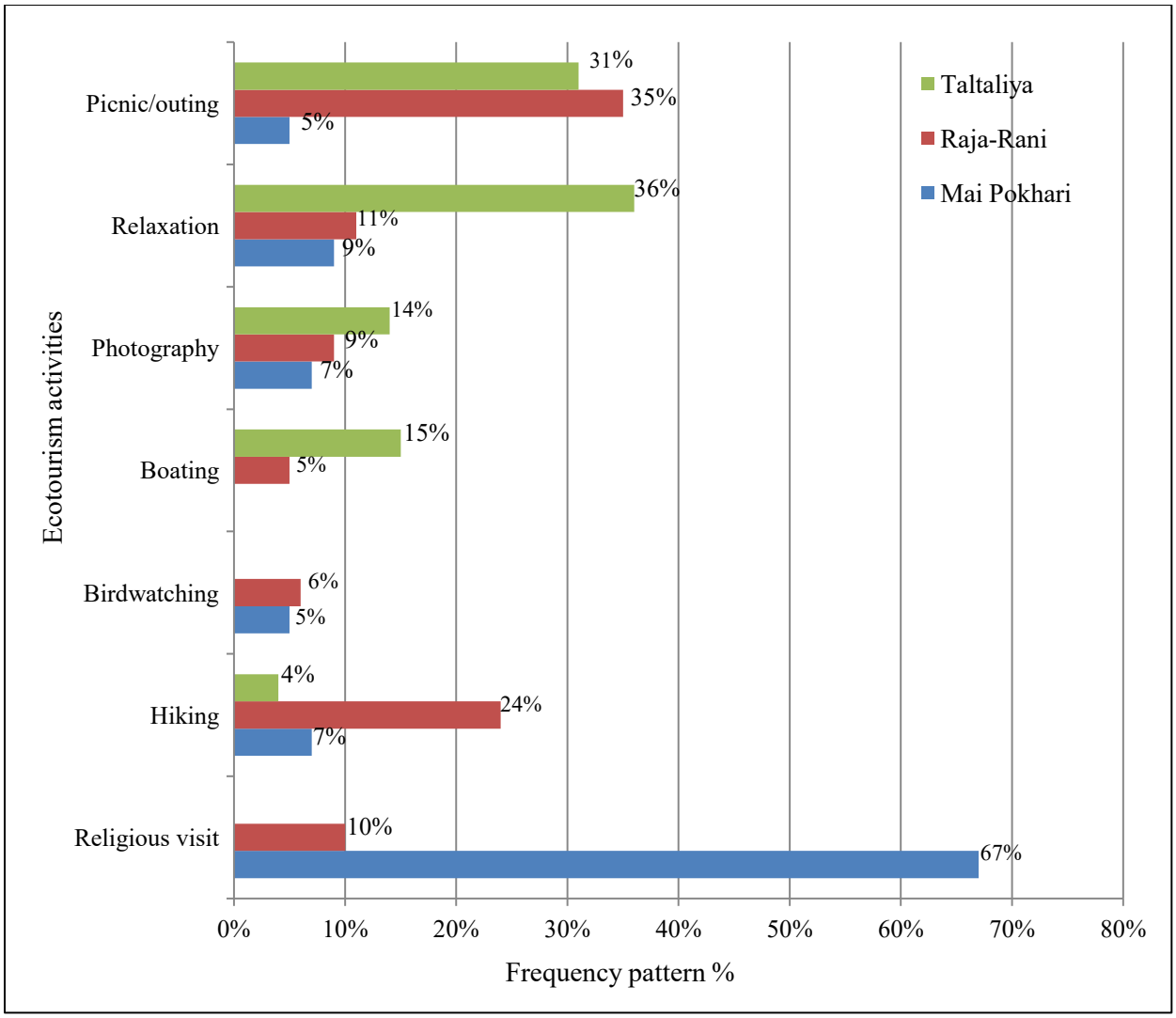

Figure 2. Visitors' activities and their frequency patterns for different ecosystem services of the lakes

Environmental quality of the lakes

The environmental quality of the wetlands showed varied visitor perceptions, as seen in figure 3. While "Taltalaiya" is rated mostly 'neutral" (over 60%), this may reflect its location near busy urban centers like Itahari and Dharan, where development may impact its natural appeal. It is neither heavily degraded nor exceptionally pristine but with acceptable water quality for recreation like picnic and boating. In contrast, "Raja-Rani" and "Mai Pokhari" receive more "positive ratings", with around 50% marking them as "good" indicating peaceful environment with clean water and rich biodiversity with minor human alterations."Mai Pokhari" standing out with nearly 40% of visitors rating as "excellent" is completely natural and pristine with clean water and rich biodiversity with nature dominated soundscapes. These ratings reflected relatively the well-maintained environment and higher eco-tourism readiness of Mai Pokhari. Only a negligible proportion of visitors rated the environmental status of these lakes as poor with visually unpleasant conditions resulting from inadequate maintenance.

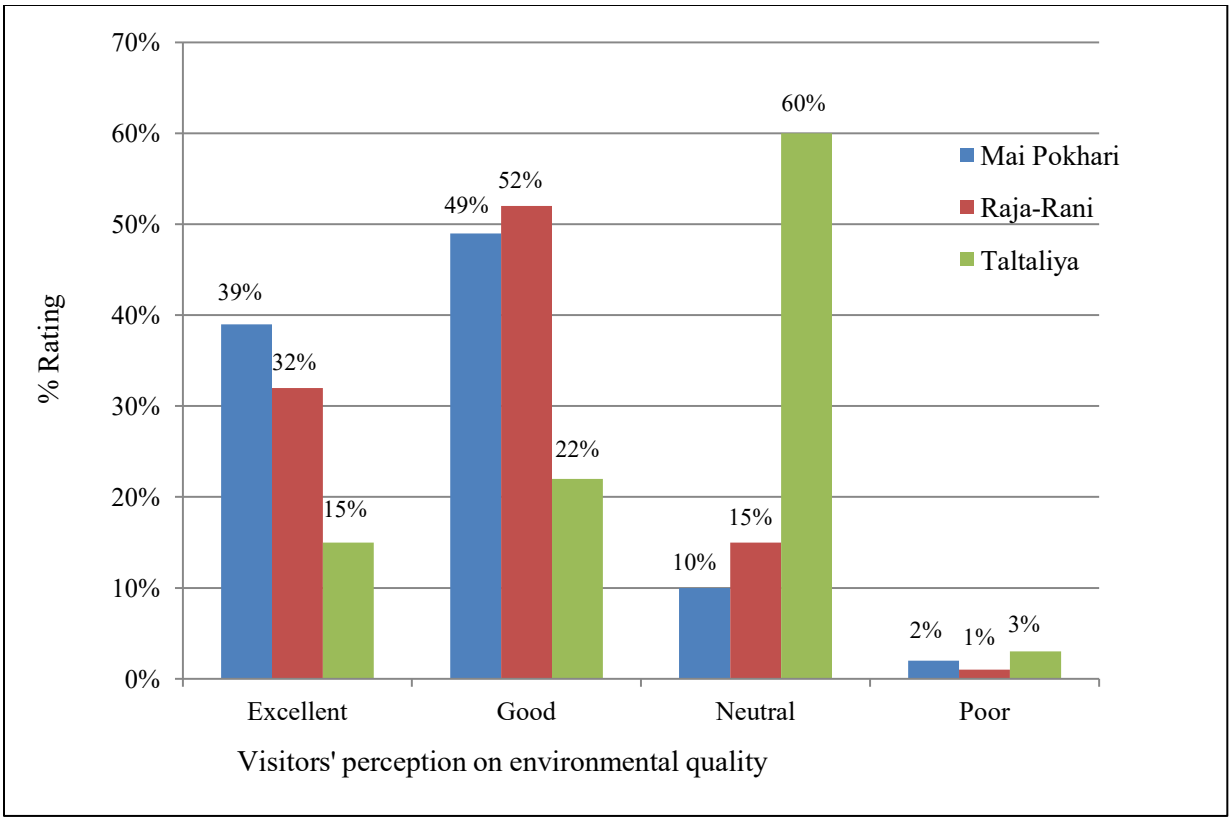

Figure 3. Environment quality status rated by visitors

Payment for Ecosystem Services (PES) schemes

The income differences among the three lakes, viz; Taltalaiya, Raja-Rani and Maipokhari can be largely attributed to the differences in available services, location advantages, and accessibility (Fig. 4). Taltalaiya stands out with a remarkably higher income which can be linked to several key factors. Unlike Mai Pokhari and Raja-Rani, Taltalaiya offers a variety of recreational services, including boating, a zoo, and picnic facilities. These additional attractions not only draw more visitors but also encourage longer stays and repeat visits, thereby increasing overall revenue. In contrast, absence of such services at Raja-Rani and Maipokhari limits their appeal, which typically generates lower income. Furthermore, Taltalaiya is in or near a major urban hub, offering better infrastructure, easier access through public and private transport and greater flow of both local and outside visitors. This urban proximity significantly boosts visitor's numbers, particularly during weekends and holidays, enhancing its income generating potential.

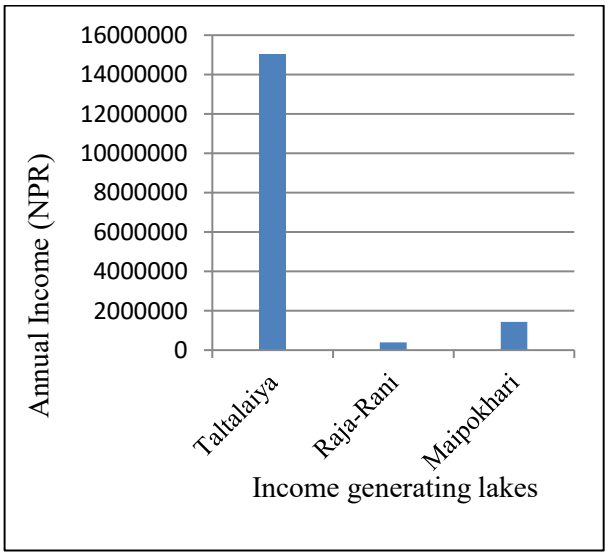

Figure 4. Annual income generated from visitor's ticket fees of three lakes of eastern Nepal

On the other hand, Raja-Rani and Maipokhari are located in more remote or less urbanized regions which restrict their accessibility and visitors flow. Additionally, the limited recreation facilities make them less attractive for general tourism, family outings and group events. Taltalaiya's higher income is not solely dependent on ticket sales, but is instead a result of a comprehensive tourism offering backed by strong logistical and geographical advantages. This comparison highlights the importance of integrated service development.

The lakes of eastern Nepal, including Mai Pokhari, Raja-Rani, and Taltalaiya, offer significant opportunities for the implementation of Payment for Ecosystem Services (PES) schemes. These ecosystems provide essential services such as water purification, erosion control, biodiversity conservation, scenic beauty, spiritual value, and carbon sequestration (Table 4). With the increasing attraction of these lakes for tourism, ecotourism-linked PES offers potential to reinvest visitor fees into ecosystem conservation and support for local livelihoods. Spiritual PES can be promoted in culturally and religiously significant lakes by involving local communities in managing pilgrims and preserving cultural values. Additionally, carbon sequestration PES can be implemented through the conservation and restoration of aquatic and riparian vegetation to enhance carbon storage, contributing to climate. The integration of such PES schemes can promote sustainable lake management ensuring economic benefits and environmental stewardship.

Table 4. Possibilities of payment for Ecosystem Services (PES) schemes in the lakes of eastern Nepal.

PES type	Target ecosystem services	Working principle
Watershed protection PES	Water quality and erosion control	Payment to upstream farmers/communities for conservation practices.
Biodiversity	Wetland biodiversity and habitat preservation	Providing incentives for communities to protect species habitat, prevent poaching and removal of invasive species.
Ecotoursim-linked PES	Scenic beauty, recreation and community benefit.	Tourist fee support conservation and ecosystem services.
Spiritual	Maintaining cultural and spiritual values.	Community managed pilgrimage.
Carbon sequestration	Climate regulation through carbon storage.	Payment to community for planting aquatic or riparian vegetation.

Discussion

Findings from this study highlight the immense potential of wetland-based ecotourism in eastern Nepal, particularly through the unique ecological, cultural, and recreational features of lakes. These wetlands, located across diverse topographies from the Tarai plains to the mid-hill regions, collectively serve as hubs of biodiversity, spiritual significance, and local livelihood opportunities. The ecotourism potential of these lakes is closely tied to their biological richness, especially the diversity of vascular macrophytes and associated flora and fauna. For instance, Taltalaiya, despite being located adjacent to a major highway, hosts varieties of vascular macrophytes and supports resident bird populations (Pandey, 2003) making it suitable for both leisure and academic tourism. Similarly, Raja-Rani lake, with rich macrophyte species (Siwakoti *et al.,* 2024) and variety of floral species (Shakya and Bajracharya, 2005; Chaudhary and Niroula, 2017; Sharma *et al.,* 2020; Chettry *et al.,* 2021; Ojha and Niroula, 2021) supporting migratory birds (Basnet *et al.,* 2005) stands out not only as a biodiversity hotspot but also as a culturally rich sacred landscape for the Dhimal community. Findings of the present work are in accordance with the report of KC *et al.* (2015)

who emphasized the integrative role of ecotourism in promoting environmental conservation, socio-economic development, and green economic growth.

The cultural and spiritual values embodied in lakes such as Chulachuli and Maipokhari further reinforce the multidimensional appeal of wetland ecotourism. Chulachuli, though less documented officially, is locally revered as a spiritual site, reflecting the untapped potential of integrating intangible cultural heritage into ecotourism development. Maipokhari, as a Ramsar site, represents a model example of ecotourism tied to both conservation and community involvement, with documented species richness including rare orchids and mosses (Bhattarai, 2018; Pradhan and Heimstad, 2018), vulnerable Himalayan salamander (Thakthake) and diverse birdlife (Pradhan and Shah, 2020). Its status demonstrates the value of formal recognition and conservation-backed tourism strategies. The current state of tourism infrastructure and visitor engagement, however, reveals disparities across sites. While some sites like Maipokhari offer structured ecotourism activities including botanical gardens and research-based tourism, others such as Taltalaiya and Chulachuli lack formalized ecotourism infrastructure like homestays or guided nature experiences. Fortunately, the increased flow of tourists coincides with the larger size of the lake.

Figure 2 further supports the uneven distribution of visitor frequency and purpose, suggesting a need for more balanced promotion and development across all four wetlands. Homestay initiatives that embrace local culture, serve organic food, and involve community-based hospitality enhance visitors' experiences while simultaneously supporting the local economy (Acharya and Halpenny, 2013; Regmi *et al.,* 2023). Homestay services available at around 0.1 km to 1 km distance from the Maipokhari has contributed significantly to ecotourism in Maipokhari but are absent in Taltalaiya and Raja-Rani. Recently, Raja-Rani has introduced a small scale night camping and homestay services accommodating around 5–10 people, but visitors are unaware of this service. Close proximity of Taltalaiya to major cities like Itahari and Dharan may reduce the demand for homestays, as visitors prefer day trips over overnight stays. This explains the limited success of homestays in the area. Drawing inspiration from the Tharu community's successful homestay models, similar approaches could be adapted to these sites, tailored to the respective cultural contexts and ecological offerings (Tharu, 2023; Devkota, 2024). In addition, the interconnection between ecotourism and conservation is evident across all study sites.

The presence of rare species, endemic flora and fauna, and migratory bird populations signals high conservation value, which in turn can attract eco-conscious visitors. However, there is also a need to address challenges such as the spread of invasive species like *Pontederia crassipes* and *Alternanthera philoxeroides* and unregulated recreational activities, which may threaten the ecological integrity of these wetlands if not properly managed. The Fikkal-Kanyam-Maipokhari circuit through Mechi Highway encompassing extended lush green scenery of tea plantation area holds great potential to be recognized among Nepal's top 100 travel destinations. Promoting regular tourism festivals and strategic branding efforts of local products could position the wetland region as a prominent ecotourism hub. Further, enhancing cross-border connectivity of the Mechi Highway to the Siliguri and Jogbani border points of North Bengal and Bihar through the Mahendra Highway could significantly boost international tourism in Maipokhari. The proposed connectivity would ease accessibility for Indian religious and ecotourists from neighboring states. This cross-border connectivity has already been recognized as a

long-term strategic priority under Koshi Province Tourism Development Master Plan to promote sustainable tourism, with Maipokhari as a key node. While the awareness of Chulachuli is limited only to the local people, the lake has yet to receive local government prioritization for broader regional and national recognition.

Overall, the study emphasizes that wetland-based ecotourism in eastern Nepal holds significant potential when integrated with watershed and biodiversity conservation, cultural preservation, infrastructure development, and community empowerment by direct payment mechanisms. Sustainable planning with active involvement from local stakeholders and government bodies can transform these wetlands into thriving ecotourism destinations while safeguarding their ecological and socio-cultural fabric.

Conclusion

Ecotourism as a leisure time recreational activity is gradually gaining popularity in eastern Nepal. Diverse topography combined with rich biodiversity and cultural diversity in and around these lakes creates an ambient environment in making eastern Nepal an ideal region to attract ecotourists and promote ecotourism. Road access, good accommodation and powerful internet are the key components for successful ecotourism in any destination. However, slippery and muddy roads in Raja-Rani and at some places to reach Chulachuli during monsoon season account for the low rate of tourist flow. Similarly, lack of homestays in Taltalaiya and Chulachuli and low standard homestays with poor sanitary systems and internet service around Raja-Rani and Maipokhari lake area are among the major challenges. If these challenges are properly implemented by the stakeholders in the respective ecotourism domain, it would help boost up the existing ecotourism in eastern Nepal.

Acknowledgements

The authors are grateful to the Head, Department of Botany, Degree Campus, Biratnagar to provide the facility of Regional Herbarium during the plant identification. Similarly, authors are also thankful to the National Herbarium and Plant Laboratories, Godavari, Kathmandu for the technical help provided during confirmation of the identified macrophyte species. The support of Mr. Sudip Rai (Biodiversity Research and Conservation Society, Nepal) during the field work is also acknowledged.

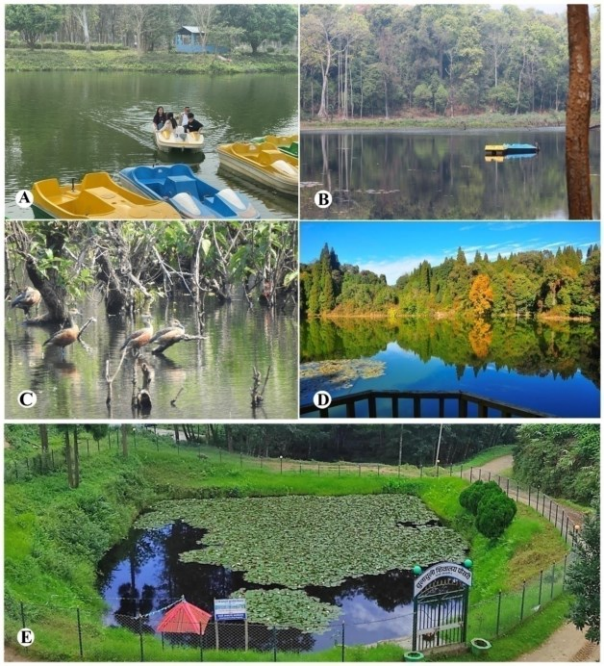

Plate 1: A. Boating in Taltalaiya. B. Boating in Raja-Rani. C. Lesser whistling duck (*Dendrocygna javanica* Horsfield.) in Raja-Rani. D. Scenic view of Maipokhari E. Chulachuli lake.

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