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Ecosystem services, threats, and management practices of wetlands in Morang District of Nepal

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Abstract

Wetlands are gaining much attention recently as they are threatened by multiple stressors; however, detailed ecological and socio-economic studies on these wetlands are limited. In this study, we present an inventory and assess ecosystem services, and conservation status of the wetlands of Morang district in Eastern Nepal. We used the remote sensing data - Google Earth Imagery and official topographic maps – for preparation of inventory and conducted a rapid field survey using a questionnaire, Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). Provisional and cultural services were analyzed based on field observations and the questionnaire survey. Twenty-four wetlands of 29.4 ha area, ranging from 0.017 to 7.5 ha were recorded. The Sunbarsi wetland is located in the lowest (87 m) and the Chuli Pokhari in the highest (677 m) elevation. Rajarani wetland of Letang (7.5 ha) is the largest wetland in the district. Ten wetlands have high religious value. Wetlands in Morang district are also productive ecosystems providing different types of ecosystem services. They contribute in local economy providing job and business opportunities to locals. Bhulkey wetland of Pathari-1 provides drinking water to 1,938 families. Further, these wetlands are used for irrigation. The wetlands are also providing services to livestock farming, fishing, boating, commercial activities (hotels and shops), and tourism. Cultural, recreational and ecotourism activities in the wetlands are generating revenue locally.

Keywords: *Conservation, ecosystem services, inventory, tourism, wetland.*

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Introduction

Wetlands occupy >5% of total land area of Nepal and provide a range of ecosystem services to wetland dependent communities. Wetlands provide ecological services of direct and indirect uses (Scott, 1989). Wetlands are essential chemical, biological, and genetic material sources, sinks, and transformers. They are the most productive ecosystems and vital life-supporting systems, giving a wide range of advantages (Zedler and Kercher, 2004). Wetlands work to maintain a rich agricultural and wild diversity as well as provide environmental services, such as flood protection, nutrient and sediment retention, ground water table maintenance, and so on. Because of their roles in the hydrologic and chemical cycling, as well as sinking waste from both natural and human causes, wetlands are frequently referred to as "the kidneys of the landscapes" (Watkins and Parish, 1999). Wetlands discovered a way to clean contaminated streams, avoid floods, and replenish groundwater aquifers (Tatu and Anderson, 2017). The Ramsar Convention on Wetlands of International Importance particularly as waterfowl habitat, an intergovernmental treaty signed on February 2, 1971 defines wetlands in a

broader sense. “For the purposes of this Convention, wetlands are areas of marsh, fen, pet lands, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt, including areas of marine water the depth of which at low tide does not exceed six meters, and may incorporate riparian and adjacent to the water,” according to Article 1 of the text of the Convention (Gardner and Davidson, 2011).

Wetlands ecosystems represent roughly 6% of the total world land area, with 2% lakes, 30% bogs, 26% fens, 20% swamps, and 15% floodplains (Gardner and Davidson, 2011). Tropical and subtropical regions account for more than 56% of these wetlands. Birds, mammals, reptiles, amphibians, fish, and invertebrates are found in abundance in wetlands. More than 40% of the world's 20,000 species of fish reside in freshwater. Plant genetic material is stored in large quantities in wetlands. Rice, for example, is a common wetland food that is consumed by more than half of the world's population (Lambert, 2003).

Around one-third of the world's wetlands are located in Asia, with 120 million hectares of internationally significant wetlands (Laishangbam, 2005). Indonesia has the most 'fully protected' wetlands (2.9 million hectares), while Cambodia, Laos, Malaysia, and Vietnam have fewer than 1% of their major wetlands completely protected (Watkins and Parish, 1999; Scott, 1989). Asia's wetlands have a great biological richness, and the region is the worldwide center of diversity for several ecosystems or species (Kafle, 2007). Wetlands and their preservation have long been an important component of Asian culture and ethos. As a result, the region's wetlands are defined by their intimate connection with local human groups.

Biological invasions have posed a severe danger to global biodiversity, resulting in environmental change around the world (Sharma *et al.,* 2018). Many human activities (agricultural, aquaculture, recreation, and transportation) hasten the purposeful and unintentional spread of species, disrupting natural dispersal processes. The key variables to consider for environmental conservation around the world are biological invasion control, prevention, and eradication. Invasive alien species have ecological, evolutionary, and economic consequences, particularly in agriculture and forestry (Pimentel *et al.,* 2000). Aliens such as water hyacinth (Eichornia crassipes), Kumbhika (Pistia stratiotes), Karaute Jhar (Leersia hexandra), and Mothe (*Cyperus* sp.) are also a serious impediment to wetland conservation in Nepal (Sharma *et al.,* 2018).

Wetland ecosystem services have the highest value per hectare of any ecosystem, and the entire value of wetland ecosystem services accounts for 47% of the global ecosystem value (Costanza *et al.,* 1997). As a result, it is one of the most vital and productive ecosystems on the planet (Smardon, 2009; Mitsch and Gosselink, 2015). In previous centuries, however, humans saw wetlands as a breeding ground for mosquitoes, disease carriers, and sources of death, rather than as a source of life (Giblett, 1996).

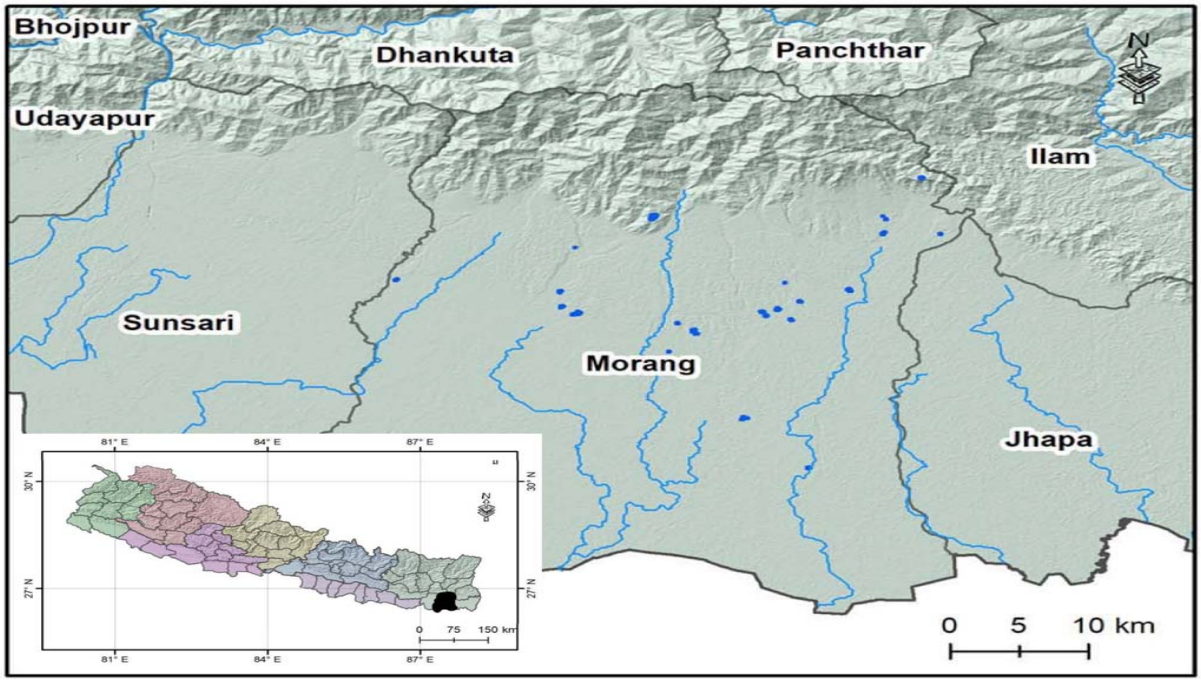
Nepal is rich in terms of wetlands, but the wetland outside the protected areas and small wetlands of Terai area are rarely discussed and assessed. Therefore, this study prepares an inventory, assesses the provisional and cultural services of the wetlands, and identifies threats and conservation practices of the wetlands of Morang district.

Materials and Methods

Study area

The study wetlands lie in Morang district of Koshi Province (Figure 1). The majority of the land is used for rice and jute farming, but there are still sections of Sal woodland in the district's northern part, where the plains meet the hills (Barnekow *et al.,* 2005). It is situated between latitudes 26°20' to 27°53'N and longitudes 87°16' to 87°41'E. The annual precipitation of the district is 1891.82 mm in 1981-2010 (CBS, 2021). The district has an area over 1,855 km^2 which comprises lower tropical (80.9%), upper tropical (11.55%), subtropical (7.4%) and temperate (0.2%) region (CBS, 2021). The lowest and highest altitudes of the district recorded are 60 m and 2410 m, respectively. The district covers both Terai and Southern slope of Mahabharat Hills encompassing Churiya Hills where wetlands are located in these areas. Most of the rivers of this district take their origin from the foot of the Mahabharat Hills and Churia Hills and make their courses towards south (CBS, 2021). About 80% of its total land surface is in Terai region.

Figure 1. Study area showing the Morang district in the map of Nepal and the wetlands located in



Methods

Data collection

Rapid field survey using the KIIs, Questionnaire, and FGDs was performed for the data collection. Earth Observation (EO) approach is readily used by wetland managers to understand and address the ongoing loss and degradation of wetlands, as well as information which can be used to address reporting requirements at the national and international scales (Davidson and Finlayson, 2007; Rebelo *et al.,* 2018). We used open-access Google Earth Pro (Amani *et al.,* 2019) for the inventory of the wetlands. After preparing an inventory of the wetland (lake), a field survey of all 24 wetlands was conducted from 30th October to 19th November 2020. During the field, direct observation was made for the wetland's current situation, types of benefits/services and other site information, including collection of GPS points for validation of wetland inventory from the remote sensing.

KIIs were completed in all the wetlands based on the checklist. People directly involved in the wetland management committee and other knowledgeable individuals were considered for the KII. The FGD was carried out based on the structured questions and selecting about 6-8 participants in each FGD from surrounding areas, representing Wetland Management Committee farmers, visitors, business persons. Journal Articles, annual reports of the Management Committees were reviewed to know the actual tourist flow, income, investment, expenditure of the wetlands.

Data Analysis

During the data analysis Google Earth Pro, ArcGIS, R-studio, MS-Excel was used. The Google Earth pro images helped to know the presence and absence of wetlands in different years. Further, the boundary of the wetlands was obtained from Google Earth and exported to ArcGIS for further processing.

Ecosystem Score number and Threat score number was given on the number of ecosystem services type and number of threats. Wetlands with 12 different types of Cultural and Provisioning Services were assigned an Ecosystem Score of 12 and a Threat Score of 5 for having 5 different sorts of threats. The type of wetland was classified based on Google Imagery. Presence and absence of ponds based on GPS points in Google earth was the criteria for identifying the type of wetlands. R-studio was used for making the boxplot for comparison between the type of ecosystem services. Income source was calculated based on an annual report and questionnaire of KII. Management activities were

identified through direct observation and validation to the respondents, budget allocation for management practices.

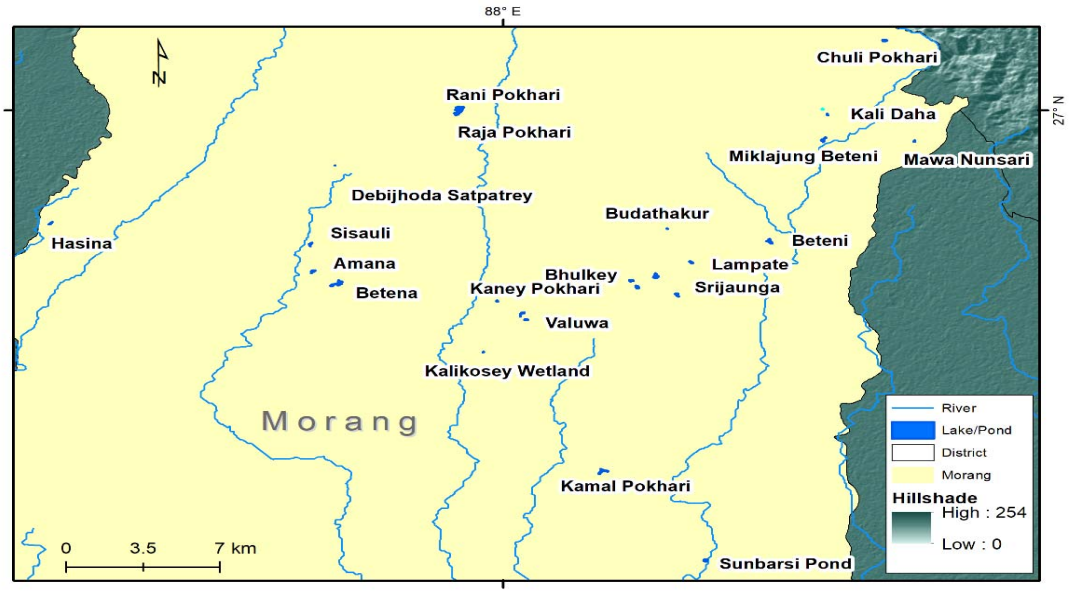
Results

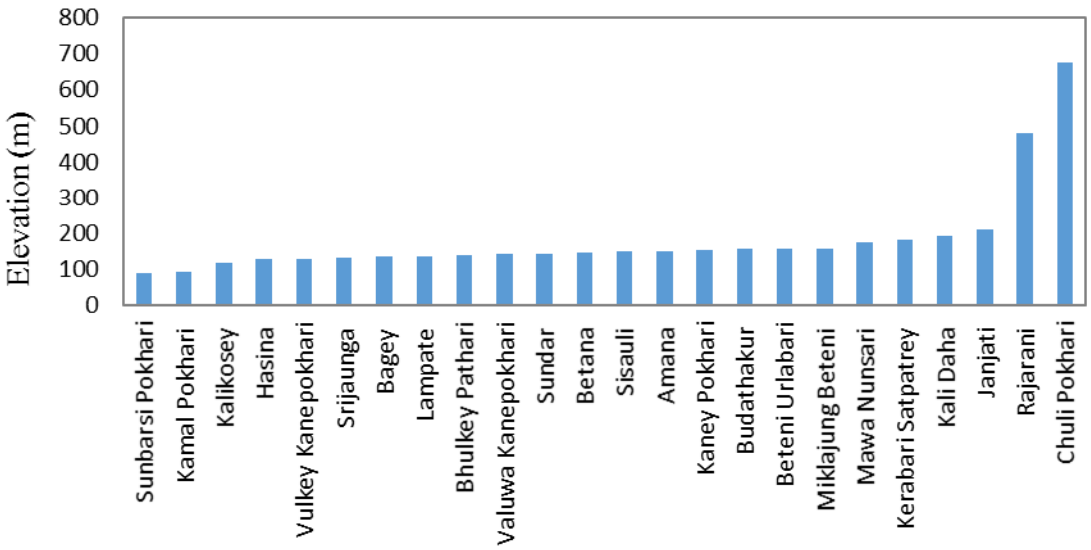
Wetlands in Morang District

A total of 24 wetlands are identified in Morang District with a total surface area of 29.4 ha (Figure 2). The average size of a wetland is 1.23 ha. The wetlands are located at an altitude of 87 to 677 m ranging in size from 0.017 ha to 7.5 ha in area. Sunbarsi wetland is at the lowest elevation and has a surface area of 1.31 ha, whereas Chuli Pokhari is at the highest elevation (677 m) and has an area of 0.99 ha. The smallest wetland, Janjati, is 0.02 ha in size located at an elevation of 210 m. The Rajarani wetland is the largest, encompassing 7.51 ha. (Details in annex-1).

Wetlands are found in 10 of the 17 local levels of the district. They are located within the core jungle, along rivers and watersheds. Sunbarsi and Kamal Pokhari wetland lies below 100 m, 19 are between 100 and 200 m, and the remaining three are at 210 m, 481 m, and 677 m.

Construction wetlands were discovered in greater numbers than natural wetlands in the district. In the district, there are 14 man-made wetlands and 10 natural wetlands.





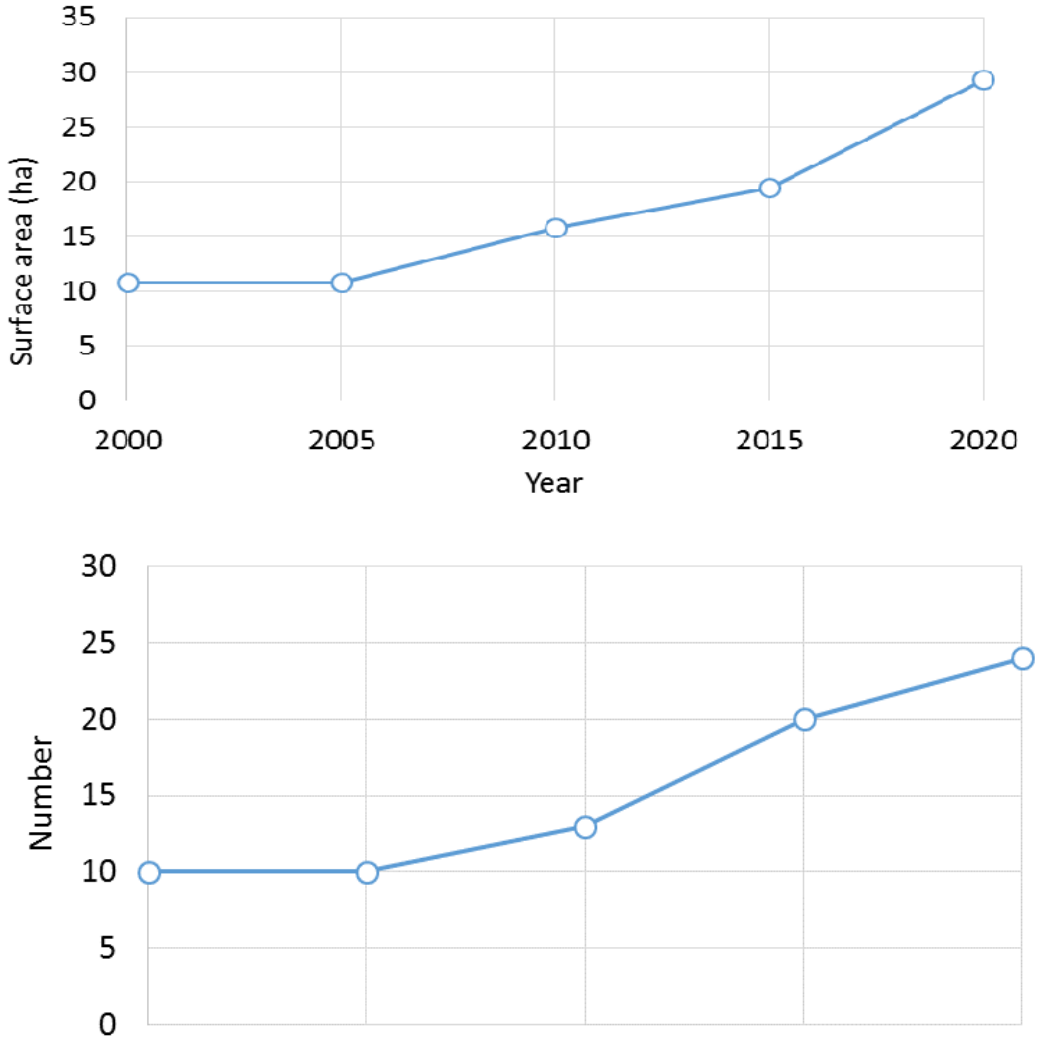


Figure 3. Number and surface areas of wetlands in Morang district from 2000 to 2020

In the same way, the wetlands area has increased by 171% in the last two decades. In the year 2000, the district's entire wetland area was 10.8 ha. The total area reached 29.4 ha in 2020.

Ecosystem services

Worship, scenic beauty, children's park, education, swimming/bathing, picnic, boating are the major 7 types of cultural services found. Similarly, drinking water, washing clothes, irrigation, cattle feedings, fishing and plants/vegetables are the 6 types of provisioning services accessed in the wetlands. The type of cultural and provisioning services from the wetlands are presented in Figure 4. Four wetlands provide drinking water facilities. Among them, Bhulkey wetland of Pathari Municipality provides drinking water facility to 1,938 family members. Washing clothes in 5 wetlands are found. Irrigation is found from 18 wetlands (75%) where 4,795 ha of land in the district are irrigated. Cattle feedings are found in6 wetland ponds which is 25%. In 9 wetlands fishing is done which is 37.5% of total wetlands of the district. Including Kanepokhari, valuwa, Bulkey 14 wetlands (58.33%) provide vegetables like, *Diplazium esculentum* Common name 'Nihuro'.

Picnic, scenic beauty, worship, children's park, education, swimming and boating are found as Cultural Services in the district wetlands. Worshiping activities in 11 wetlands (45.83%) are found. Indigenous people like Dhimals worship in Sunbarsi, Rajarani and Buda Thakur wetlands. Kirat Community worship in Kamal Pokhari wetland in the district.

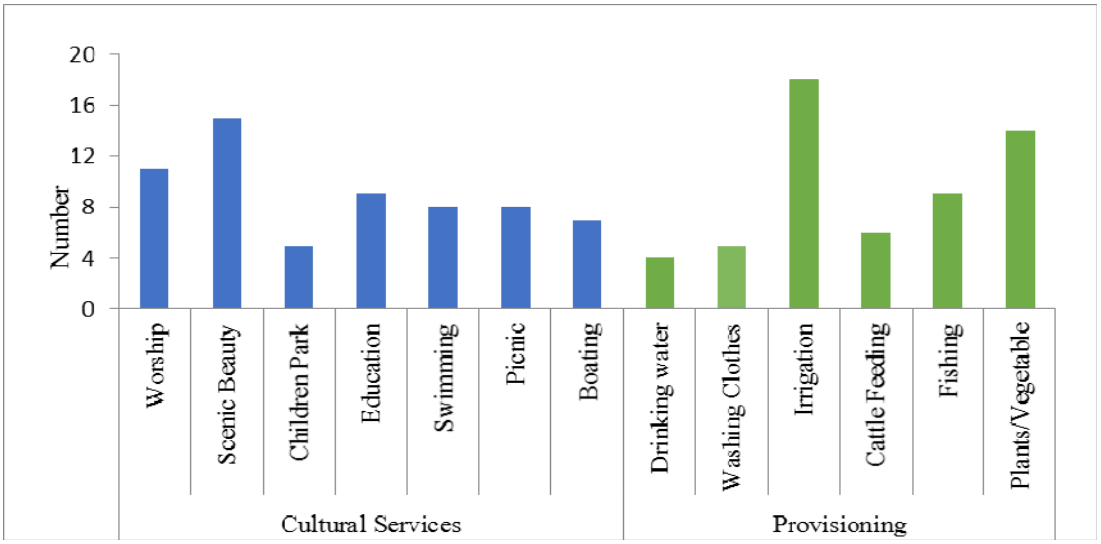
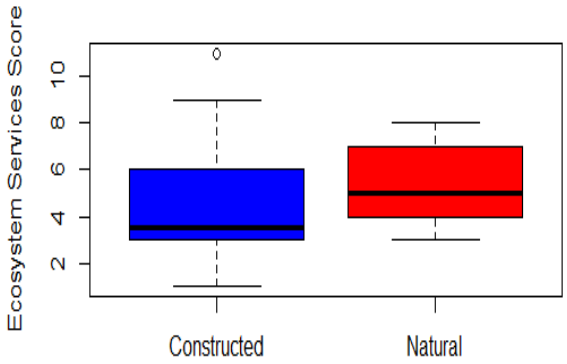


Figure 4. Ecosystem services of wetlands

A total of 15 wetlands are visited to see the scenic beauty and for photography. Children's parks are found in 5 different wetlands. Swimming and picnic activities are in 8 wetlands. Nine wetlands (37.5%) are visited for education, excursion and research. From the Month of November to the first week of March, People visited 8 wetlands for picnics. Boating activities inside the wetland pond are recorded in 7 wetlands.

The number of provisioning and cultural services found in the district wetlands is 13. Bhulkey wetland of Pathari has the highest score 11. It provides 11 different types of ecosystem services. Kalikosey wetland area of Kanepokhari Rural Municipality only provides the cultural benefits to the people and has the score 1 (Table 1).

Natural wetlands provide more ecosystem services than that of constructed wetlands. They have more ecosystem service scores than that of constructed wetlands (Figure 5).



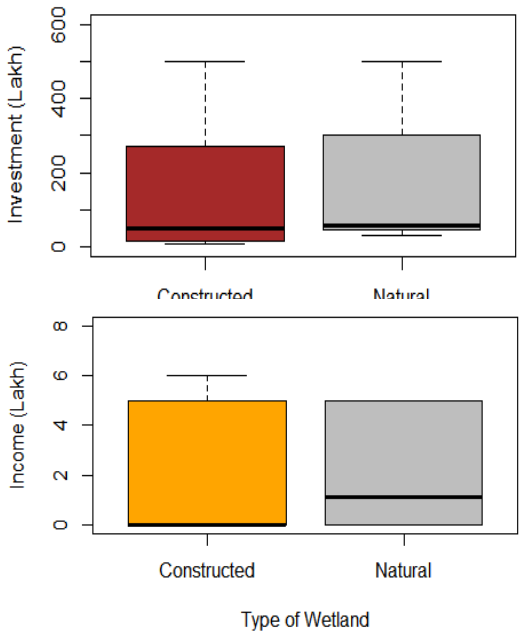


Figure 5. a) Ecosystem services score and wetland type, b) Investment in Wetland, c) Yearly Income and wetland type

Table 1. **Services Score of Wetlands**

SN	Wetland	Services Score
1	Bhulkey Pathari	11
2	Bagey	9
3	Srijaunga	8
4	Sundar	8
5	Lampate	8
6	Budathakur	7

Contd….

7	Beteni Urlabari	7
8	Miklajung Beteni	6
9	Kali Daha	5
10	Janjati	5
11	Mawa Nunsari	5
12	Chuli Pokhari	4
13	Rajarani	4
14	Sisauli	4
15	Amana	4
16	Betana	4
17	Kamal Pokhari	3
18	Sunbarsi Pokhari	3
19	Kalikosey	3
20	Bhulkey Kanepokhari	3
21	Valuwa Kanepokhari	3
22	Kaney Pokhari	2
23	Hasina	2
24	Kerabari Satpatrey	1

The investment in the wetland is high in natural wetlands. The total investment in these wetlands in 20 years is around 42 crores. Total investment in natural wetlands is 21 crore 43 lakhs and the rest in constructed wetlands.

Yearly income in natural wetlands is more than that of constructed. The wetlands generate the incomes from entry fee, fishing, and boating. Natural wetlands in the district have an annual income of 1 crore 15 lakh 70 thousand. Constructed wetlands generate 73 lakhs 51 thousand as the source of income.

The sources of income of wetlands are from entry fee, fishing, boating and management contribution from local and provincial governments. One crore 3 lakhs 40 thousand Nepalese rupee was collected from entry fee in wetlands. With increase in budget allocation has shown the increase in tourist flow in the wetlands (Figure 6)

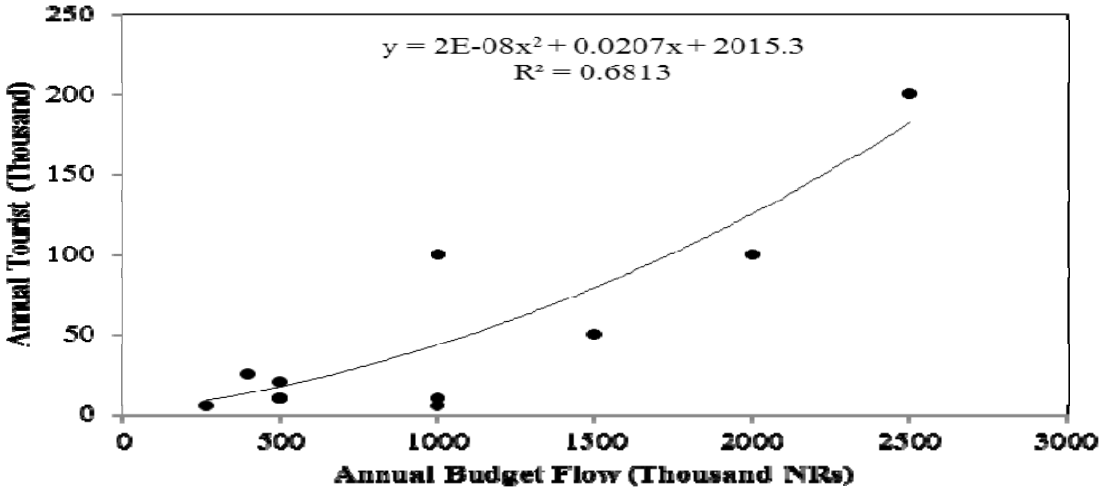


Figure 6. Budget Flow and Tourist

With the increase in budget allocation in the wetlands has shown the flow of tourists in the wetlands. The R^2 value of budget flow and tourism in the wetlands is 0.6813 which indicates that the increase in budget in the wetlands is contributing to the flow of tourists.

Wetlands threats

Figure 7 shows that the invasive species are found in21 wetlands. As a result, invasive species pose a threat to 88 percent of Morang wetlands. *Mikenia micrantha* and *Hydrilla* were found in 16 wetlands, *Echornia* in 12 wetlands, *Pistia* in 5 wetlands, and *Parthenium* in 9 wetlands. Three wetlands had river cutting/flooding. During the dry season, the water level in six wetlands drops. Siltation was detected in two wetlands, while land encroachment in eight. Three wetlands have illegal activity (poaching) and 8 wetlands have pollution. Most threats are found in natural wetlands than in constructed wetlands (Figure 8).

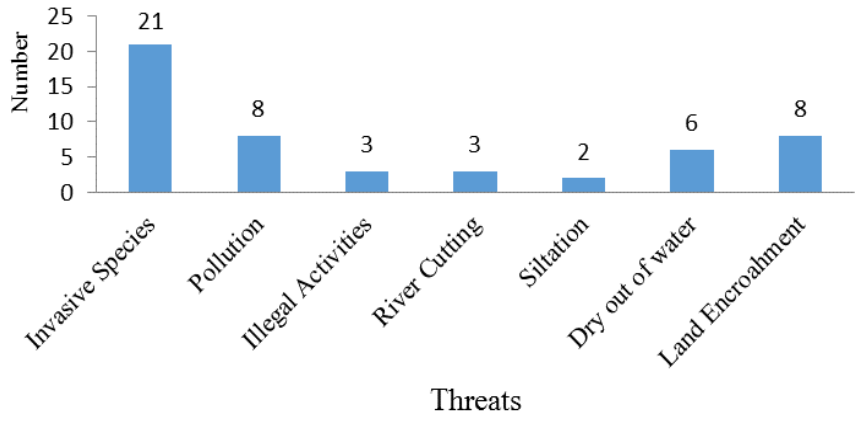


Figure 7. Threats to wetlands

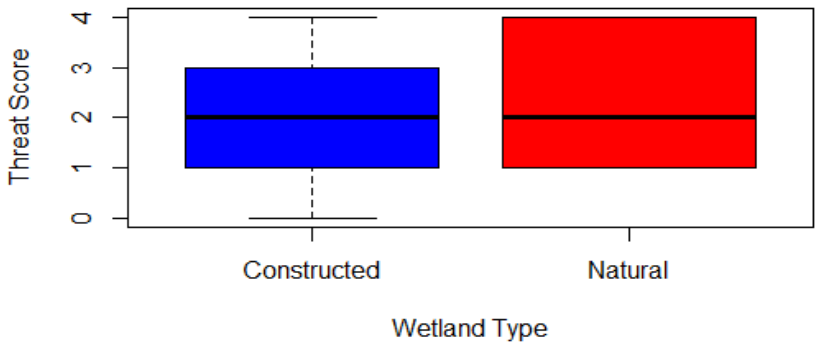


Figure 8. Threat score and wetland type

Management activities

Wetland management committee is formed in all the wetlands. Fencing, removing bushes/invasive species, cleaning campaigns, plantation, awareness and wildlife rescue are the major managerial activities (Figure 9). Wildlife rescue is perfomed in 5 wetlands. Fencing was built in 16 wetlands, awareness in 7 wetlands. 12 wetlands are removing the invasive species and bushes. In 14 wetlands clean the ponds. 20 wetlands are doing plantation.

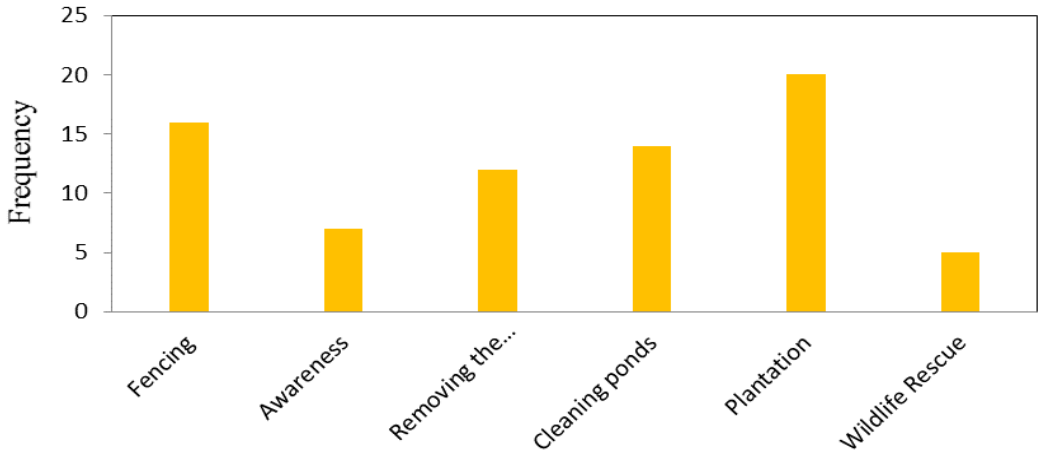


Figure 9. Management activities

Nepal's lakes are thought to store 3% of the country's accessible inland water (Sharma, 1997). The first inventory of glacier lakes in Nepal was prepared by the Water and Energy Commission Secretariat (WECS) in 1986. A total of 194 were documented in the report. In 1998 IUCN identified 163 wetlands locations in the Terai including 78 lakes and ponds, 13 marshes, 5 swamps, 53 flood plains, 6 reservoirs, and 8 canals. They occupy a total area of 724,257 hectares. There were 46 wetlands with an extent greater than 8 ha (IUCN, 1998). In Terai, there are at least 28 natural ponds (each measuring less than 8 ha) according to the report. Later, the government counted 634 lakes in Nepal, including glacier lakes (DHM, 1998).

Six wetlands were identified in Morang district during the preliminary survey of Nepalese wetlands (IUCN, 1998). However, there was no mention of the locality, location, or altitude was made in the paper. There were was no latitudinal and longitudinal information on the site. The wetlands Beteni, Kamal Pokhari, Kechana Jill, and sunbarsi appear in the paper (Bhandari, 2009).

A list of 5,358 lakes was compiled in Nepal using topographical sheets (Bhuju *et al.,* 2009). The paper shows the 1,539 wetlands were identified using Topographical sheets and 96 using district maps. Among them, 185 were identified in Morang District; 184 from topographical sheets and 1 from district map. Okhaldhunga is the only district in the study that has no wetlands. 2,712 lakes in the terai were recorded with the range below 500 m. 1,270 wetlands below 100 m and 1,442 ponds between 100 to 499 m. The percentage of total lakes covered was 50.62%.

Four wetlands were identified in a prior investigation conducted by the President Chure Conservation Committee in 2012. The National Lake Conservation Development Committee's (NLCDC) lake database has cited the same database and includes Betana Tal, DhanpalGadi, Rajarani Pokhari, and Sunbarsi Pokhari in the report.

Previous report NLCDC (2021) had reported 11 wetlands in Morang. The previous study and database have counted 11 wetlands lakes in the district. With a total size of 7.2 ha, Betana is the largest and Dhanpalgadi is the smallest (0.2 ha) according to the report. Nepal's lakes are thought to store 3% of the country's accessible inland water (Sharma, 1997). The present study shows the total number of wetlands in the district has increased to 24 from 11, which is 118.182% increase from the previous study. Dhanpalgadi was not recorded in the present site. During the field visit, the area was covered with bushes and rubbish with concrete structures. The area of Betana wetland in this study records 4.75ha and Rajarani wetland is the largest with 7.5 ha in area. The smallest wetland recorded in this study is Janjati wetland (0.02 ha).

Budget increase and restoration-related efforts have resulted in an increase in the number of wetlands in the district. Between 2010 and 2015, the number of wetlands increased from 13 to 20, owing to an increase in conservation operations and forest user community groups. With the new federal government structure, local governments are investing in tourism promotion and related activities, expanding the water bodies inside wetlands areas playing a key role.

The study suggests that people frequently visit the wetlands for cultural reasons. Wetlands rely greatly on income from cultural and recreational activities, like tourism and boating. Langtang National Park and The Annapurna Conservation Area both demonstrated Nepal's strong reliance on tourism (Baral *et al.,* 2008; Thapa and Getzner, 2014). The marsh resources made a considerable contribution to the local economy of the people who lived near the Begnas wetland (Thapa *et al.,* 2020). With the growth in budget flow in the wetlands, the annual visitor flow is on the rise. Water is mostly used for irrigation, boating, fishing and other purposes. Summer and winter crops such as paddy, wheat, maize, and vegetables are largely irrigated with water. Each season, the Jagdaishpuri reservoir demonstrated its ability to irrigate 6070 ha of farmland (Baral, 2016). In comparison, the entire district's wetlands irrigate 4715 ha, which is significantly less.

Food and vegetables are also derived from the wetlands. *Diplazium esculentum* is mostly used for vegetables. The indigenous people rely on the wetlands to meet their daily demands. Wetlands provide intangible benefits such as cultural, spiritual, artistic, and educational aspects. Wetlands assist local communities and national economies by producing large revenues from a variety of recreational and ecotourism activities (Ramsar, 2016). Tourism, scenic beauty, religious belief, children's park, education, swimming, boating are the major cultural services provided by the district's wetlands. The foremost service is religious belief.

Water sources are taken as holy places by Hindus and the Indigenous People. Rajarani, Kamal Pokhari, Sunbarsi, Bhulkey and the Buda Thakur wetland areas have high religious value.

Conclusions

This study on the wetlands of Morang districts provides the status of the wetland for benefiting their management and further improvement. A total of 24 wetlands of touristic importance are documented that have an area of 29.4 ha with the size of 0.017 ha to 7.5 ha and situated from 120 to 200 m elevations above sea level. These wetlands have religious, cultural and ecological importance with significant contributions to the livelihood of local people. The wetlands are also famous for recreation activities and have gained more attention. Most of the wetlands are manmade and the trends of using concrete materials in wetland is also increasing, this need to be a rethought and made through proper research and assessing the need. These wetlands are threatened by natural and man-made causes. Flooding/river cutting, invasive species, drought/dry out of the water, illegal activities, pollution, agricultural runoff are the major threats here. Threats of invasive species is high here. We recommend making effective management plans for the management of wetlands, action plans for removing invasive species, focus on plastic management and focus on promoting native species populations in wetlands.

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