High Altitude Wetlands of Nepal

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Contents

Keywords

High altitude wetlands • Biodiversity • Ecosystem service • Conservation threat • Ramsar • Nepal

Introduction

Currently there is no precise definition available in the scientific literature for the term high altitude wetlands (HAWs), however Chatterjee et al. (2010) describe HAWs as "areas of swamp, marsh, meadow, fen, peat land, or water located at an altitude above 3,000 m, whether natural or artificial, permanent or temporary, with

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water that is static or flowing, fresh, brackish, or saline and are generally located at altitude between continuous natural forest border and the permanent snow." HAWs include different categories of water bodies, such as lakes, ponds, rivers, glaciers, and glacial lakes. They are characterized by a unique diversity of water sources, habitats, species, and communities and generally have not been subjected to rampant human interference compared to other wetland ecosystems. Nepal is blessed with the highest peak in the world, Mt. Everest, along with another ten of the fourteen highest peaks, all over 8,000 m. These mountains are the source of many glaciers and lakes in the high altitude regions across the country. Most of the high altitude wetlands in South Asia, including Nepal, lie within the Hindu Kush Himalayan Region that extends over 3,500 km and covers approximately 3.5 million sq. km., acting as a fresh water reservoir to the major river basins such as the Ganges, Indus, Yangtze, Mekong, Amu Darya, and Hilmand (Gujja 2005).

Of the nine wetlands that have been declared as Ramsar sites (Wetlands of International Importance) in Nepal, four are high altitude wetlands (Fig. 1, Table 1). All four HAWs are located in the Palearctic biogeographic region in central Himalaya and were ratified in 2007.

Apart from the abovementioned four Ramsar listed and six non-Ramsar HAWs shown in Fig. 1, there are numerous other HAWs distributed across Nepal. Some of these are Panch Pokhari, Dudh Pokhari, Surya Kunda, Bhairav Kunda, Salpa Pokhari, Titi Tal, Damodhar Kunda, Parbati Kunda, Sundaha, Kyangjing, and Khaptad Daha. There are many other smaller HAWs in the high altitude region, either within or outside of protected areas, that bear ecological, economic, and cultural significance; however, many of these have yet to be inventoried and hence

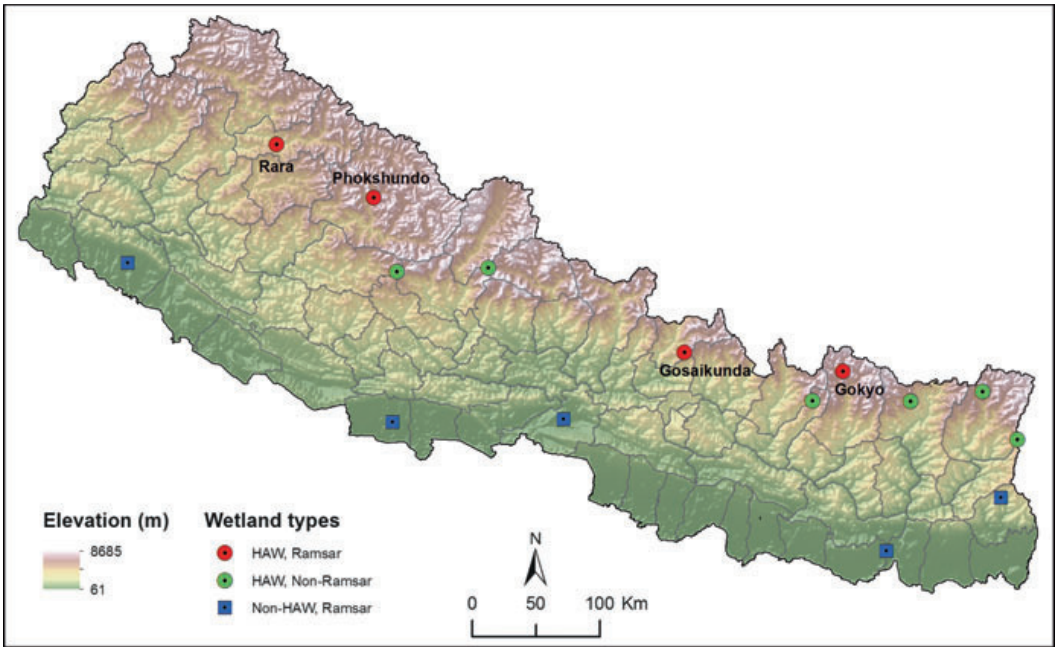

Fig. 1 Map of Nepal showing the locations of ten high altitude wetlands, four of which are Ramsar sites, together with other Ramsar sites

Table 1 Ramsar listed high altitude wetlands (HAWs) of Nepal

Name	Area (ha)	Location	Approx. Altitude (m)[a]	Headwaters
Gokyo and associated wetlands	7,770	Sagarmatha National Park, Solukhambu	4,710–4,950	Dudhkoshi River, a major tributary of Saptakoshi River
Gosaikunda and associated wetlands	1,030	Langtang National Park, Rasuwa	4,054–4,620	Trishuli River, a major tributary of Narayani River
Phoksundo wetland	494	Phoksundo National Park, Dolpa	3,610	Bheri River
Rara wetland	1,583	Rara National Park, Mugu	2,900	Karnali River

[a]The elevation range is for the series of wetlands that form the wetland complex

little information exists. This article therefore focuses on the HAW Ramsar Sites that have been studied to some extent.

Hydrology

The Phoksundo wetland is an alpine freshwater oligotrophic lake that drains into the Phokhsundo River. The Lake is 4.8 km in length and 1.3 km in width, with a depth of 145 m. The main source of water for this wetland is from the mountains located on the northern side. The water flows through different tributaries, such as Chisa, Baulaha, Dekhutaichu, Jagatilumba, and Chollapu Rivers, before entering the wetlands. The water volume of the lake is approximately 408 M m^3 and the discharge rate is 3.7 cubic meters per second.

The Gosaikunda wetlands are a series of lakes formed by glacial water in the eastern and central Himalayas and remain frozen for at least 6 months of the year (Lacoul and Freedman 2005). The lake surface area is 13.8 ha, water volume nearly to 1.5 M m^3, and the maximum depth is around 24.1 m (Niraula 2011). It is one of the world's highest alpine oligotrophic freshwater lake systems, with a water discharge rate of 60 l per second.

Rara wetland is an alpine oligotrophic freshwater lake and is considered the largest lake system of Nepal, having a shoreline of 14 km and a depth of 167 m. Water volume of the lake is approximately 0.99 M m^3. It has 34 inlets, with only one outlet that discharges into the Karnali River, a tributary of the Ganges.

The Gokyo wetlands are a series of lakes that are moraine dammed glacier lakes with grassland, boulder/rocks, glaciers, moraines, and eroding debris present in the wider catchment (Sharma et al. 2010). The major source of water for this wetland series are the direct melting glacier snow from the Himalaya as well as small stream channels from the nearby surrounding forest lands (WWF Nepal 2010a).

Wetland Ecosystems

The most common characteristics of HAWs are the extreme cold, dry, and alpine climatic conditions due to low air temperatures and high ultraviolet radiation. Rara and Phokshundo wetlands lie in the Western Himalayan Temperate Forest ecoregion, as defined by WWF Global (2015a). This ecosystem comprises mainly Himalayan broadleaved and subalpine conifer forests with high altitude flora, such as Blue Pine (*Pinus wallichiana*), Spruce (*P. smithiana*), and Fir (*Abies pindrow*), as well as fauna such as Snow Leopard (*Uncia uncia*), Musk Deer (*Muschus chrysogaster*), and Red Panda (*Ailurus fulgens*). Similarly, Gokyo and Gosaikunda wetlands lie in the Eastern Himalayan Alpine Meadows ecoregion, as defined by WWF Global (2015b). This ecosystem is characterized by high elevation meadow and shrub habitats, suitable for flora such as Rhododendron (*Rhododendron nivale*) and different medicinal orchids and fauna such as Snow Leopard, Himalayan Black Bear (*Ursus thibetanus*), and Red Panda (*A. fulgens*) as well as many high altitude birds.

Biodiversity

Flora

Most of the plant species found in Nepal's HAWs are endemic to each site, a characteristic of such wetlands. More than 80 species of flowering plants have been recorded from the Gokyo wetlands (WWF Nepal and DNPWC 2006); endemic species include *Kobresia fissiglumis*, *K. gandakiensis*, *Pedicularis poluninii*, and *P. pseudoregelina* while rare and vulnerable plant species include *Neopicrorhiza scrophulariifolia*, *Swertia multicaulis*, *Saussurea gossipiphora,* and *Meconopsis horridula*.

In Gosaikunda wetlands, around 100 species of flowering plants have been recorded (WWF Nepal and DNPWC 2006). Endemic plant species, such as *Meconopsis dhwojii*, *M. taylorii*, *Heracleum lallii*, *Primula aureata*, *P. sharmae*, *P. pseudoregelian,* and *Rhododendron cowanianum* are found in this wetland. Threatened species, based on the IUCN categories, include *Aconitum spicatum* (Vulnerable), *H. lallii* (Endangered), *Jurinea dolomiaea* (Near Threatened), *M. dhwojii* (Near Threatened), *Nardostachys grandiflora* (Vulnerable), *N. scrophulariifolia* (Vulnerable), *Rheum australe* (Vulnerable), and *R. moorcroftianum* (Near Threatened).

In Phoksundo wetlands, more than 150 plant species have been recorded (WWF Nepal and DNPWC 2006). Threatened species include *N. scrophulariifolia* (Vulnerable), *Dactylorhiza hatagirea (Critically Threatened)*, *Dioscorea deltoidea* (Critically Threatened), *Aconitum spicatum* (Vulnerable), *N. grandiflora* (Vulnerable), *Podophyllum hexandrum* (Vulnerable), and *Megacarpea polyandra* (Vulnerable).

In Rara wetland, endemic plant species found are *Mecanopsis regia*, *Primula poluninii*, and *Cirsium flavisquamatum* (WWF Nepal and DNPWC 2006). The lake border is filled by reeds (*Phragmites* spp.), rushes (*Juncus* spp.), and sedges

(*Fimbristylis* spp.), while *Polygonum* spp. and *Myriophyllum* spp. occupy shallow portions of the lake. Some of the threatened species include *D. hatagirea*, *N. grandiflora,* and *N. scrophulariflora*.

Fauna

While some mammals and birds are found in all HAWs in Nepal, others are recorded only at specific sites. Alpine Musk Deer (*Muschus chrysogaster*) is found in all four HAWs, while Red Panda (*Ailurus fulgens*) is recorded only in Gosaikunda and Rara wetlands. Snow Leopard (*Panthera Uncia*) and Tibetan Wolf (*Canis lupus chanco*) have been found in Phoksundo wetlands while Smooth Otter (*Lutra perspicillata*) and Himalayan Black Bear (*Selenarctos thibetanus laniger*) are found in Rara wetland. Similarly, Common Coot (*Fulica atra*) has been recorded in Gokyo, Phoksundo, and Rara wetlands, while Ruddy Shelduck (*Tadorna ferruginea*) and Eurasian Wigeon (*Anas penelope*) are found in both Gokyo and Phoksundo wetlands. Common Teal (*Anas crecca*), Tufted Duck (*Aythya fuligula*), *and* Common Merganser (*Mergus merganser*) are found in Gosaikunda and Rara wetlands. Globally threatened Cheer Pheasant (*Catreus wallichii*) is found in Rara wetland, while Wood Snipe (*Gallinago nemoricola*) is found in the catchment area of Gokyo and Rara wetlands. Bar-headed Goose (*Anser indicus*) and Brown Dipper (*Cinclus pallasii*) are found in Gosaikunda and Phoksundo wetlands.

Apart from the above fauna recorded in more than one HAW, there are individual species found in each of the HAWs. For instance, Gokyo wetland harbors additional species such as Northern Pintail (*Anas acuta*), Common Pochard (*Aytha ferina*), Eurasian Woodcock (*Scolopax rusticola*), and Great Crested Grebe (*Podiceps cristatus*), while Gosaikunda has species such as Ruddy Shelduck (*Tadorna ferruginea*), Bar-headed Goose, Northern Pintail, Brown Dipper, White-capped Water Redstart (*Chaimarrornis leucocephalus*), and Plumbeous Water Redstart (*Rhyacornis fuliginosus*). Red-crested Pochard (*Netta rufina*), Common Moorhen (*Gallinula chloropus*), White-throated Dipper (*C. cinclus*), and White-throated Redstart (*Phoenicurus schisticeps*) are commonly seen birds in Phoksundo wetlands. Gadwall (*Anas strepera*), Mallard (*Anas platyrhynchos*), Northern Shoveler (*Anas clypeata*), Common Goldeneye (*Bucephala clangula*), and Solitary Snipe (*Gallinago solitaria*) are bird species recorded in Rara wetland.

Conservation Status

All the HAWs designated as Ramsar sites are located within national park boundaries and hence protected under various national acts within the jurisdiction of Ministry of Forest and Soil Conservation, Government of Nepal. Though they became party to the Ramsar Convention on Wetlands in 1988, the much needed Nepal National Wetland Policy was formulated and approved in the year 2003, and this provides a framework and direction for the conservation and sustainable

utilization of all the wetlands in Nepal. As the country does not have a wetland related act, the National Wetland Policy (2003) is supported by the following acts: the National Conservation Strategy (1988), Master Plan for the Forestry Sector (1989), Nepal Environmental Policy and Action Plan (1993), Forestry Sector Policy (2000), Water Resource Strategy (2002), Wildlife Protection Act (1958), Aquatic Animal Protection Act (1961), National Parks and Wildlife Protection Act (1973), Soil and Watershed Management Act (1982), Electricity Act (1992), Water Resource Act (1992), Forest Act (1993), Environment Protection Act (1997), and Local Self-Governance Act (1999). Special conservation emphases are being given to these wetlands, from both government and non-government organizations, since they were listed as Ramsar sites. Five-year site-specific management plans have been developed for all the Ramsar listed HAWs of Nepal. These plans will help in identifying field-based conservation and management problems and suggest remedial measures for sustainable use and conservation of wetlands.

Ecosystem Services

Human habitation is generally very low in all the HAWs of Nepal due to the difficult terrain and remote location. Therefore, most of the ecosystem services that such wetlands provide fall in the categories of regulating, cultural, and supporting compared to that of provisioning. Therefore, HAWs in Nepal are important for services such as climate and water regulation; spiritual, recreational, and aesthetic; as well as nutrient recycling. The local people residing in the high hill and mountainous areas of Nepal use the catchment and surrounding areas of HAWs for collecting Yarsa Gumba (*Ophiocordyceps sinensis*), a species of entomopathogenic fungi that parasitizes moth larvae known for its medicinal properties that fetches high value in the local market and is considered as a major source of livelihood, in the winter season.

The Gosaikunda wetlands bear cultural significance and are a shrine for Hindu and Buddhist pilgrims. In the event of Janaipurnima (full moon festival in August), thousands of devotees travel to these lakes, especially from Nepal, India, and some other South and South East Asian countries. Tourism is a vibrant industry in this area as thousands of trekkers visit this wetland series every year, helping to create employment opportunities for the local people of the area.

The human habitations near the Phoksundo wetland are very low compared to other Ramsar sites in Nepal and are mostly Buddhist communities. The water in the wetland holds religious significance and is worshipped by the Buddhist communities. Resources harvested to sustain their livelihood include fuelwood, timber, and medicinal herbs. The pasture land around the wetland is used for cattle and sheep grazing. Tourism is another important service of Phoksundo wetland as thousands of national and international tourists visit the lake each year.

Rara wetland also bears cultural and religious significance and local people worship the lake during most of the religious festivals. The wetland complex includes dense forest and pasture land and local people depend on the extraction

of fuelwood, fodder, timber, and medicinal herbs. Tourism is also a potential source of income but visitor numbers are low compared to other Ramsar-listed wetlands.

The Gokyo wetlands, containing ten lakes within a small periphery, bear cultural and religious significance, similar to the other HAWs discussed above.

Threats, Future Challenges, and Remedial Measures

Some of the international nongovernmental organizations in Nepal, such as the International Centre for Integrated Mountain Development (ICIMOD) and World Wildlife Fund (WWF) Nepal, are undertaking pioneer research work in the HAWs, especially from the perspective of climate change and community livelihood. They have inventoried and listed many HAWs in the high altitude region and have implemented adaptation and conservation programs. For example, WWF Nepal selected Gosaikunda and Gokyo wetlands as priorities under the Sacred Himalayan Landscape project. However, it is important to note that HAWs are the least studied ecosystems in Nepal due to their remoteness and limited provision of ecosystem services. Moreover, HAWs are sensitive to climate change because of their small catchment size, scant vegetative cover, low nutrient content in surface water, and shallow soil and low bedrock weathering rate (Strang et al. 2010).

Fragility and sensitiveness are the main characteristics of HAWs and any small change in the water chemistry, either naturally or through anthropogenic disturbances, could lead to large impacts on their ecosystems, directly affecting the flora and fauna in them. Acid deposition during the spring season is a major threat to most of the HAWs in Nepal (Bhuju et al. 2012); and the mercury and cadmium in the Gokyo wetlands is thought to result from long range transport by monsoon precipitation originating from industrial areas of lowland parts of the country, including that of India (Sharma et al. 2012). Water pollution, mainly from hotels and lodges and religious rituals, also affects water chemistry. Most of the wetlands located in the Himalayan region of Nepal are contaminated by fecal pollution, mainly from uncontrolled tourism activities (Sharma et al. 2005). Raut et al. (2012) reported the presence of chlorine ions in Gosaikunda wetlands, possibly due to discharge of waste water from the lodges in the area. Similarly Ghimire et al. (2013) reported the presence of nitrogen and phosphorous in the lake water of Gokyo wetlands from anthropogenic activities, such as excess agricultural fertilizer and human waste.

Karki et al. (2007) found three common pressures on all HAWs of Nepal, viz., grazing, over extraction of fuelwood, timber and non-timber forest products (NTFP), and pollution. Excessive pasture grazing by cattle and sheep around the wetlands has led to soil erosion and threatens siltation in HAWs. The heavy influx of trekkers and hikers, together with their recreational activities, such as camping, in the Himalayan region could be one potential reason for the degradation and depletion of forests and water resources, triggering soil erosion and landslides, shrinking of wildlife and medicinal plant habitat, and drying up of water sources in and around HAW catchments. Similarly, uncontrolled extraction of fuelwood for cooking, timber for

rural building construction, and NTFP for medicinal and livelihood uses are common practices, endangering the existence of biodiversity.

Baral and Bhandari (2011) reported the importance of HAWs as breeding and staging areas for many globally threatened wetland birds, such as Baer's Pochard (*Aythya baeri*), Baikal Teal (*Anas formosa*), Marbled Teal (*Marmaronetta angustirostris*), and the elegant Black-necked Crane (*Grus nigricollis*), and emphasized the need for conservation of this fragile ecosystem from climatic and anthropogenic threats through in-depth scientific studies. However, a lack of understanding of such fragile ecosystems and climatic and anthropogenic disturbances on them could seriously threaten the overall HAW biodiversity of Nepal in the future.

The knowledge gap and a lack of available baseline information are the major issues that hinder conservation efforts of HAWs in Nepal. Most of the wetlands in Nepal are located in the lowland Terai and Mid-Hill regions that are easily accessible, and so have been inventoried. However, due to difficult terrain, harsh climatic conditions, and inaccessible locations of HAWs, researches have difficulty in gathering information about them. There are a range of issues concerning HAWS, such as status of biodiversity, climate change impacts on the hydrology and biodiversity, and identification and quantification of ecosystem services that demand immediate investigation from the scientific community. For instance, many of the HAWs that are not listed as Ramsar sites lack basic information, such as exact location and elevation, water quality and hydrology, biodiversity and ecosystem services. However, based on the limited information available, it can be assumed that these Non-Ramsar HAWs are important in terms of their ecosystem services and human welfare in the high altitudinal areas of Nepal. The WWF Nepal (2010b) reported that there is evidence to suggest the existence of Alpine Musk Deer (*M. chrysogaster*), Barking Deer (*Muntiacus muntjak*), Ghoral (*Naemorhedus goral*), Snow Leopard (*Uncia uncia*), Common Leopard (*P. pardus*), Red Panda (*A. fulgens*), and Wild Cat (*Felis chaus*), in addition to numerous rare and endangered medicinal herbs and bird species, in these Non-Ramsar HAW catchment areas. Thus, this clearly indicates the immediate need for a coordinated effort from all conservation stakeholders to focus on landscape level conservation, corridor connectivity preservation, and site-specific management for such a fragile but valuable ecosystem.

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