

Review Article

Ramsar Lakes in the Foothills of Himalaya, Pokhara-Lekhnath, Nepal: an overview

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Abstract

Wetlands are the most dynamic ecological units on the earth delivering voluminous ecosystem services. Pokhara-Lekhnath has prosperous wetland ecosystems with nine lake clusters nominated as 10th Ramsar site of Nepal in 2016 that act as diverse and, distinctive biodiversity hot spot and habitat. These wetlands afford abundant ecosystem services and assist vulnerable, endangered and critically endangered species. However these lakes are under tremendous pressure due to rapid urbanization, natural erosion, encroachments, land use changes in the catchment and anthropogenic inputs resulting in the shrinkage of area and deterioration in the hydrological, economic and ecological characteristics.

Keywords: Pokhara-Lekhnath; Ramsar sites; Biodiversity hot spot; ecosystem; lentic

Introduction

As per the definition by EPA, the wetland is an area where either water covers soil or remains in the proximity of soil for at least one season. Basically, the wetland is land area saturated with water and is ecologically

sensitive and adaptive system. Wetlands are considered as intermediate ecosystems between land and water incorporating water, soil and organism that are adjusted to the distinctive wet environment resulting in one of the most dynamic ecosystem.

In order to conserve, perspicacious use, and encourage the member countries to list ecological, botanical, zoological, limnological or hydrological significant wetlands as Ramsar sites, Convention on Wetlands of International Importance was signed in Ramsar nominated as Ramsar convention Iran on February 2, 1971 (Ramsar Convention 1971). After successful 17 years of first Ramsar Convention, Nepal signed Ramsar Convention on April 17, 1988 (Kafle & Savillo, 2009). Till, January 2016, more than 2,220 wetlands with area 2.14 million square kilometers (4-6% of the total land surface in the world) from 169 member countries have been designated for inclusion in the List of Wetlands of International Importance. Currently, in Nepal, there are 10 Ramsar sites of international importance. Among them, Koshi Tappu wetland is first nominated Ramsar site in Nepal (1987) while Lake clusters of Pokhara Valley are the last nominated Ramsar site (2nd Feb 2016) (Ramsar Convention Secretariat, 2016).

Both natural and artificial wetlands are included in Ramsar site of international Importance. Lakes, ponds, riverine floodplains, swamps, and marshes are natural wetlands, while water storage areas and deep-water agricultural lands are artificial wetlands in Nepal. Ramsar sites in Nepal harbor various types of ecosystems and have been providing ecosystem services since many decades (Facility, 2002; Kafle & Savillo, 2009; Rodrigues, Pilgrim, Lamoreux, Hoffmann, & Brooks, 2006; Sah & Heinen, 2002). Nepal wetlands are not only very rich in biodiversity but also are rich sources of water for drinking, fishing, and irrigation. Wetlands/Ramsar sites of Nepal host endangered species i.e. Asiatic wild buffalo, water buffalo, Greater one-horned rhinoceros, Gangetic dolphin, Swamp deer, Ghadial, Bullfrog. Wetlands are recreation places for migratory birds like Demoiselle crane, cinereous vulture, common greenshank, common

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teal, Eurasian Curlew, good wall, great cormorant, greater spotted eagle, imperial eagle, Kentish Plover (Bhandari, 2008). In Nepal wetlands have been reported to harbor more than 25% of total bio diversities (Facility, 2002) . Nepal wetlands (swamp in Kapilvastu) harbor 3 wild species of rice and DNA of these is used frequently to produce hybrid varieties of rice in Nepal (Bhandari, 2008). Wetland ecosystems support diverse and unique habitats. These wetlands provide numerous ecological services but are under tremendous stress due to rapid urbanization, industrialization and agricultural intensification, manifested by the shrinkage in their areal extent, and decline in the hydrological, economic and ecological functions they perform

The objectives of this study are to: a) review the Ramsar Site/wetland of Pokhara – Lekhnath Metropolitan city, b) describe the significance and threats of Ramsar Sites in terms of their geographic distribution and extent, ecosystem benefits and ecological integrity which are considered as biodiversity hub that play crucial role in ecosystem services.

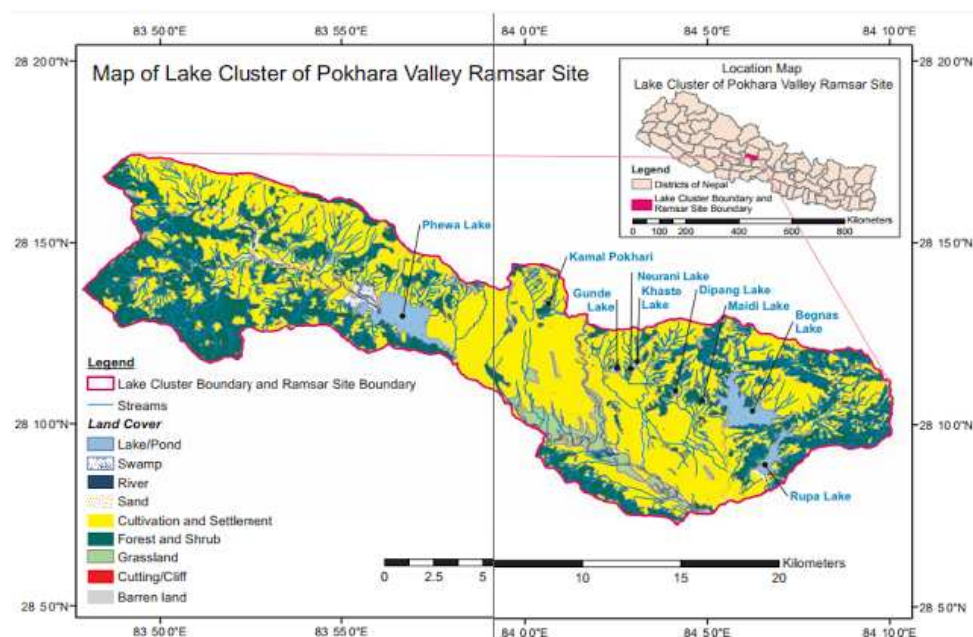
Data and Methods

Pokhara Lekhnath is a naturally attractive and historical Metropolitan City in Nepal. It is the Headquarter of Province no 4, and is situated 200 kilometers west from Kathmandu, the capital city of Nepal. Recently, it is declared as the biggest Metropolitan city, occupying an area of 464.24 sq. km which is 9, 18 and 2.5 times larger than Kathmandu, Lalitpur and Bhatarapur metropolitan city respectively (<https://en.wikipedia.org/wiki/Pokhara>). It has population of 414,141 with population density of 892.1/Km² (<https://en.wikipedia.org/wiki/Pokhara>, Planning & Secretariat, 2012). The altitude varies from 827 meters (2,713 feet) in the southern part to 1,740 meters (5,710 feet) in the northern part (UNDP/ERRRP, No, 2013). It lies in the Mahabharata Range, Midlands and the Great Himalayan Range of Nepal between longitudes 83°48'E and 84°13'11"E and latitudes 28°4'39"N and 28°36'18"N (Oli 1996).

Pokhara Metropolitan City is one of the most rapidly urbanizing city of Nepal residing mixture of climatic conditions within the Seti river

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watershed. The climatic conditions of the central part of the basin ranges between sub-tropical to cool temperate, whereas the climatic deviations in the northern part ranges from temperate to alpine with high precipitation rate, around 3000 mm per year (Rimal et al, 2013; Tripathee et al., 2016). This city encompasses nine cluster lakes (Phewa, Begnas, Rupa, Dipang, Maldi, Khaste, Neurani, Kamalpokhari and Gunde) of ecological importance listed as 10th Ramsar Site/ Wetlands (no 2257) bearing an international gratitude and safeguarding the livelihoods and ecosystem.



Lake cluster of Pokhara valley

(Adopted from IUCN, Nepal, 2016)

The information's for the study were collected through review of existing literature, research papers, reports and other relevant online materials through national and international efforts. The study focuses on present location, status, importance and threats of Ramsar Lakes in Pokhara – Lekhnath Metropolitan City.

Table 1
List of Ramsar Sites in Nepal

Name of Ramsar site	Location	Area in hector	Elevation in Meter	Ramsar Designation Date
Beeshajari and associated lakes	Chitwan	3200	285	2003/08/13
GhodaGhodi Lake	Kailali	2563	205	2003/08/13
Gokyo lake and associated wetland	Solukhumbu	7770	5000	2007/09/23
Jagadishpurresevier	Kapilvastu	225	195	2003/08/13
Lake cluster of Pokhara(8-lakes)	Kaski	26106	827	2016/02/02
Mai Pokhari	Ilam	90	2100	2008/11/27
Gosaikunda and associated lakes	Rasuwa	1030	4700	2007/09/23
Phoksundo lake	Dolpa	494	3610	2007/09/23
Koshi Tappu	Sunsari	17500	90	1988/12/17
Rara	Mugu	1583	2990	2007/09/23

Source : (https://en.wikipedia.org/wiki/Ramsar_Convention, 2017)

Phewa Lake

Phewa Lake is the largest lake of Pokhara valley situated in the foot hills of Himalaya at an elevation of 782 m a.s.l., symbolizing a lake with intense anthropogenic burden from various pollutant and contaminants sources. It bears an external area of 4.35 Km² and extreme depth of 22.5 m (Sharma et al., 2015). The major source of water is surrounding catchments and Harpan Khola that flow west to east into the lake. It is regarded as very easy access lake in southern slope of central Himalaya with great anthropogenic density due to various human uses and activities like agricultural inputs (fertilizers and pesticides), fisheries, domestic wastes, recreation and sedimentation, etc. Indigenous anthropogenic events in the watershed of Phewa Lake like traffic, waste burning, agricultural, grazing, fishing, Paragliding etc. are also creating threats on to the aquatic ecosystem (Rupakheti et al., 2017; Sharma et al., 2015). Landslides from

territory of lake, erosion, fragile geology and siltation might drastically alter the chemical composition of lake water influencing the quality of water, lentic and lotic environment and ecosystem (Rai, 2000).

Begnas Lake

Begnas Lake is the second biggest lake in the Pokhara Valley located in the foot hills of Himalaya at an elevation of 650 m a.s.l. covering an area of 3.28 km² containing water volume of 17.96×10⁶ m³ and extreme depth of 10 m (Rai, 2000 & Rai, A. K. 1995). The chief foundation of the lake water is the catchments and Syankhudi Khola that runs west to south into the lake. It is a versatile Lake and is applicable for irrigation, commercial level fishery and recreation which encompasses dynamic role in lentic ecosystem and environment. However, the lake basin is susceptible to anthropogenic events for instance agricultural inputs, urbanization, boating and human settlements. Moreover, it is a eutrophic lake (Watanabe & Bhandary, 1988) vulnerable to the regional chemical weathering and atmospheric precipitation inputs that governs the lake chemical feature influencing the ecology integrity and lentic environment (Khadka & Ramanathan, 2013).

Rupa Lake

Rupa Lake is the third largest and densely polluted lake of Pokhara-Lekhnath Metropolitan city. This Lake is located in the foot hills of Himalaya at an elevation of 600 m a.s.l. with an area of 1.35 Km² and average depth of 3m (Rai et al. 1996). This small progressing eutrophic lake (Shrestha, 2017) has Talbesi Khola, as the major source of the lake with sole outlet Tal khola. The existence of 450 diverse species of flora and fauna exposes its diverse biodiversity (Oli,1996). This lake assists the large varieties of floral and faunal species and is under the stress of innumerable anthropogenic elements. Biodiversity's of this lake are under numeral threats including trapping, hunting, fishing, natural soil erosion, sedimentation and agricultural inputs, human disturbance, pollution and eutrophication deteriorating the aquatic environments and ecosystem (Jha, 2008). Major floods and landslides have dumped enormous sediments in the lake and its adjoining wetlands, and substantial deforestation around the

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lake consequences in the degradation of lentic environment (Kunwar & Devkota, 2012; Lake, 2008; Rai, 2000; Shrestha, 2017).

Depang Lake

Depang Lake is the third biggest freshwater Lake of Pokhara Metropolitan City situated between green hills with an area of 3.24 Km² and 3-5m depth. It is in an elevation of 562m from sea level. This is famous for fishing purpose (“Seven Lakes” lekhnath.com). This lake is also influenced by anthropogenic activities, natural erosion and sedimentation.

Khaste Lake

Khaste Lake is the freshwater lake situated in the Pokhara- Lekhnath Metropolitan city with an area of 2.4 Km² and elevation of 764m from sea level. The water body covers 1.37 Km² and is used for fish rearing and agriculture. It is also represented as ‘Bird Wetland’ and famous for observing birds. Its inflow source is Neureni Lake and outflows is Taal Khola. The region is a prospective research midpoint for the inspecting of the birds as diverse species of birds visited this lakes. This indicate its biodiversity importance. It is also affected by fishing, irrigation and agriculture inputs (“Seven Lakes” lekhnath.com).

Maidi, Niureni, Gunde and Kamal Pokhari Lakes

These are tiny lakes located in Pokhara-Metropolitan city and also play vital role in aquatic ecosystem. These lakes bear area of 0.01 Km², 0.02 Km², 0.08 Km² and 0.02 Km² respectively. Despite of being small, these lakes are significant from the view of ecosystem and environment as they play major role in ecosystem services. They are also highly influenced by anthropogenic activities disturbing the biodiversity (“Seven Lakes” lekhnath.com).

Importance

Wetlands are reflected as distinctive ecological characteristics providing abundant amenities to humanity and ecosystem (Prasad et al., 2002). Ecosystem imports delivered by the wetlands are water system for

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irrigation, fisheries, forest products, water supply for households and recreation.

Multiple ecosystem services comprise carbon sequestration, flood control, ground water recharge, nutrient removal, toxics retention and biodiversity maintenance (Bergh, Barendregt, Ecological-, & Maltby, 2000).

Multiple-use water services

Wetlands such as ponds, lakes, and reservoirs affords several and extended use water services that comprises water for irrigation, domestic desires, fisheries and recreational practices, groundwater restore, flood governor and silt detention. Commercial level fish rearing are most common in the lakes of Pokhara.

Carbon sequestration

Swamps, peat lands and marshes area involve in the significant role of carbon cycle. Wetland sediments/deposits are the durable supplies of carbon and donate nearby 40% of the global methane emissions bearing the uppermost carbon density in terrestrial ecosystems and comparatively higher dimensions to sequester supplementary carbon dioxide (Lal, 2004; Pant, Rechcigl, & Adjei, 2003; Upadhyay, Sankhayan, & Solberg, 2005; Zedler & Kercher, 2005).Wetlands sequester carbon in high proportions of organic residue inputs and decline the rates of decompositions(Pant et al., 2003).

Pollution reduction

Wetlands action as descend for pollutants in numerous agricultural and urban landscapes. It is recommended as a low cost measure to decrease point and non-point pollution from environments (Bergh et al., 2000). Riparian wetlands, diminish the nutrient constituent's load from inflow water by discarding nitrate and phosphorus components from surface and subsurface runoff (Verhoeven, Arheimer, Yin, & Hefting, 2006).

Flood regulator

Wetlands perform an imperative character in flood regulation and control. It traps suspended solids particles and nutrient components that assist to diminish the effects of flooding by arresting water resulting in the decrease of flood water movements (Boyd & Banzhaf, 2006, 2007).

Biodiversity hotspots

Unlike, other natural habitat, wetlands are also essential region for biodiversity. It support species diversity by creating natural habitat for sustainable life. Many vertebrates and invertebrates rely on wetlands for completion of life cycle where as some others partly associate with such habitat in particular periods of life cycle. It acts as platform for photosynthesis and recycling the nutrients that display a vital role and assist the food chains. Wetlands are significant breeding regions for wildlife and afford a shelter for migratory birds and aquatic animals (Juliano, 1999). Diverse aquatic plant in the Lake Cluster of Pokhara were sub-merged, free floating, rooted floating and other emerged plant species.

Emergent threat to wetland ecosystem

Wetland are utmost profoundly used, depended upon and exploited ecosystems for sustainability and welfare of living beings (Molur, Smith, Daniel, & Darwall, 2011). Loss in the wetland area consequences the adverse effect on the main functions of the ecosystem goods and services accomplished by wetlands (Sah & Heinen, 2002; Zedler & Kercher, 2005). Globally, the foremost causes of wetland loss are urbanization, land use changes, reckless irrigation, unscientific infrastructure development, industrial effluent, agricultural runoff and climate change inconsistency (Dudgeon et al., 2015; Jha, 2008; Weber, 1995). In Pokhara, extreme unscientific infrastructure development, land plotting around the periphery of Lakes increases anthropogenic inputs and, decreases the life of biodiversity and aquatic ecosystem. Traffic related emission and sounds influence the chemistry of lakes and threats birds and fishes. Natural erosion, sedimentation, rapid advancement of water Hyacinth and connection of sewage in lakes decrease dissolve oxygen and threatened the

life of lentic environment. Researcher analyses the limnological condition and water chemistry of Phewa, Begnas and Rupa Lake identifying their controlling mechanism in temporal scale. Identifying ions, mercury and trace elements load is important as they transfer and biomagnified (Hg and Trace metals) when passing through one trophic level to another (Khadka & Ramanathan, 2013; Sharma et al., 2015). So wetlands conservation is important in order to conserve ecosystem to protect life of human, plants, birds, fish and other aquatic life forms.

Conclusion

Ecosystem assists diverse and distinctive habitats. Wetland ecosystems benefit topographic and climatic regimes. They are regarded as dynamic measure of hydrological cycle and are extremely fruitful systems in nature. Wetlands not only act as biological diversity hot spot but also deliver a wide array of ecosystem goods and services. In Pokhara, Lakes afford numerous services, comprising irrigation, domestic water supply, freshwater fisheries and recreation. They play central role in groundwater recharge, flood control, and carbon sequestration and pollution abatement (Bassi, Kumar, Sharma, & Pardha-saradhi, 2014). Still, management of wetlands has received inadequate attention. As a result, the wetlands are subjected to massive anthropogenic pressures, including land use changes in the catchment, pollution from industry and households, encroachments, tourism and over exploitation of their natural resources. Research work on sustainable wetlands management must be associated to the limnological aspects, ecological/environmental economics, hydrological and land-use changes in the catchment and socio-economic processes.

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