The Lake Cluster Pokhara Valley: An Overview of Lake Basin Environment and Governance Improvement

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Abstract

Lake Cluster of Pokhara Valley (LCPV) comprises nine lakes in Pokhara Valley in Province-4, and 10th Ramsar Site of Nepal covering a basin area of 262 km^2 with 9 km^2 of surface water across the Chitwan Annapurna Landscape. The nine lakes in the cluster are Phewa, Begnas, Rupa, Khaste, Neureni, Gunde, Dipang, Maidi and Kamalpokhari. Each lake supports significant biodiversity, provides important ecosystem services and sustains local livelihoods and makes Pokhara the globally known tourism destination in Nepal.

All lakes are sub-surface drainage basin type and have 362 species of plants including 10 endemic ones so they are considered as an Orchid Garden. Among wildlife 128 species are vertebrates (mammals: 32 species, birds: 40 terrestrial and 52 water dependent species, reptiles: 24 species, amphibians: 11 species, fish: 27 species including 6 alien species). The cluster hosts a wide variety of globally threatened migratory birds like the critically endangered Baer's pochard and Indian vulture, and mammals like the vulnerable clouded leopard, and the endangered Indian pangolin. These biological resources are key assets of LCPV which would be instrumental for the Gandaki State and Pokhara Metropolis, which are engaged in making efforts to declare the Pokhara City as the Lake City of Nepal in addition to its hub name as the Garden City of Lakes, the Treasure Land of Orchids and the Tourism Capital of Nepal. However, the lake cluster is severely facing problems many associated with the anthropogenic activities including climate change with noted impacts to distress the structure, function and stability of lake ecosystems such as encroachment, siltation, pollution, and invasion by exotic species. Therefore the lakes are conditioned to be under degradation. This condition if aggravated further may hinder the initiatives of state and local governments promoting LCPV as a globally and nationally known destination for lake tourism and biodiversity.

After the federal restructuring of Nepal, the efforts that the Gandaki State has been undertaking for lake environment conservation are very encouraging. The state and local governments are making progress to manage the lake cluster by consolidating the basin level governance following the spirit of Integrated Lake Basin Management (ILBM) approach. This initiative fully complies with the setting of the National Wetlands Policy (2012), 4th Ramsar Strategic Plan (2016-2021) and Nepal's National Ramsar Strategy Plan and Action (2018-2024). The Gandaki State has establishment a Lake Conservation and Development Authority backstopped by the Forests and Watershed Policy of the Gandaki State-2018, and the Lake Conservation and Development Authority Act-2018. However, lake basin governance at all levels is still weak. Institutional responsibility for the lakes and wetlands is scattered. There is wider level of participation but efforts are ad hoc based and uncoordinated. Information and technology are conventional. There seems to be fiscal resources in place, though minimal. With the Lake Conservation and Development Authority in place, the state and local governments in LCPV have a legally empowered institution to restore lake environment and biodiversity following the recently prepared government's first document to implement lake basin initiative entitled Integrated Lake Basin Management Plan of Lake Cluster of Pokhara Valley, Nepal (2018-2023) making the dream true for the prosperity in the days to come.

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This paper describes the overview of lake cluster basin environment in the context of ongoing consolidation of lake basin governance in the Gandaki State of Nepal. The contents of paper are based on the scientific assessment of LCPV while Conservation Development Foundation was assigned to prepare a plan of the Pokhara Valley.

1. Overview

Integrated Lake Basin Management (ILBM) is the lake basin governance to improve lake environment for safeguarding biodiversity for the sustainable development[19]. Nepal has been involved in ILBM activities from the first exposure of National Lake Conservation Development Committee (NLCDC), the lake management authority of the Government of Nepal at the 12th World Lake Conference held in Jaipur/Rajasthan, India in 2007 [28]. At the conference it was emphasized that Nepal's lakes and wetlands are Himalayan wetlands irrespective of size or geographical location[29]. Thereafter, Conservation Development Foundation (CODEFUND) has been engaged in implementing ILBM in Nepal, for example, in preparing integrated lake basin management plans of wetlands including the ILBM Plan of Lake Cluster of Pokhara Valley (LCPV), Kaski, Nepal in 2018 for the government of Nepal. CODEFUND also extended technical assistance to state government in the Gandaki State in a process of establishing the Lake Conservation and Development Authority, which is has responsibility for improving lakes/wetlands by adopting basin governance approach. Within this context, this paper has been constructed to describe the extent of lake basin environment and governance improvement based on recent lessons from LCPV.

LCPV is located in the mid-hill region of Nepal in Pokhara Metropolitan City (PMC), the second largest city known as the tourism capital of Nepal [25] in Gandaki State, Western Development region (Figure 1). The valley is the base for the globally famous Annapurna Circuit trek in Nepal's first community managed biodiversity hotspot; the Annapurna Conservation Area, and stands in perfection of the natural beauty with glaring and magnificent views set against the backdrop of the Annapurna Himalaya Range which has three out of the ten highest mountain peaks in the world, namely, Dhaulagiri, Annapurna First and Manaslu. These peaks add to the spectacular scenic beauty of the lake cluster, making the area an acclaimed tourist attraction. LCPV was designated as the 10th Ramsar Site on 6th February 2016 (Site No. 2257), and the only site representing the mid-hill environment of Nepal. The area is located about 200 km west of Kathmandu. LCPV contributes the highest number (43%) of all Ramsar sites in Nepal.

The cluster consists of nine diverse lakes (i.e., Phewa, Kamalpokhari, Gunde, Khaste, Neureni, Dipang, Maidi, Begnas, and Rupa) in a range of sizes (Table 1). All lakes are subsurface drainage basin type and cover a total basin area of 262 km^2, and about 9 km^2 of core water body. The riparian and watershed areas are important for maintaining lake integrity, thus included as an integral section within the ambit of the valley. Lake Phewa is the largest lake in cluster and 2nd largest lake of Nepal by area. Other lakes are shallow and smaller. Lakes are scattered across valley at varying altitudes over Karst limestone plates dissected sharply into deep river gorges [33].

The valley consists of a peculiar mosaic of sub-tropical and temperate broad-leaved forests represented by Hill Sal (*Shorea robusta*) in south, mixed broadleaf riparian forests along the banks of the Seti River and its tributaries, *Schima-Castanopsis* forests in the north and west that transition into Quercus-Castanopsis-Rhododendon forests in the upper hills. Each lake supports significant biodiversity, provides important ecosystem services and sustains local livelihoods.

The Site hosts a wide variety of globally threatened migratory birds such as the critically endangered Baer's pochard (*Aythya baeri*) and Indian vulture (*Gyps indicus*), and mammals such as the vulnerable clouded leopard (*Neofelis nebulosa*) and the endangered Indian pangolin (*Manis crassicaudata*). Further, its floors are intensely cultivated. Over 35% of the land is covered with forests and shrubland and 48% is under cultivation. Water bodies, including lakes, swamps, ponds, and rivers, account for 4%. Phewa alone accounts for over 69% of the total basin area, followed by Rupa and Begnas. The built-up areas in key cities cover about 4% [25].

Pokhara is the key urban center with hundreds of satellite bazars and market places in the valley. All lakes are surrounded by both urban and semi-urban structures with diversities of features and their consequential impacts.

Table 1. Characteristics of individual lakes of LCPV [25]

SN	Name	Latitude	Longitude	Altitude (m)	Area (km^2)	Water Body (Km^2)	% Water Body
1	Phewa	28.1943-28.2902	83.8004-83.9898	763-2482	119.39	4.33	3.6
2	Begnas	28.1621-28.2167	84.0814-84.1332	647-1447	18.6	3.13	16.8
3	Rupa	28.1390-28.2061	84.1004-84.1699	580-1420	26.02	1.11	4.3
4	Khaste	28.1908-28.2115	84.0449-84.0603	739-1186	2.69	0.13	4.8
5	Dipang	28.1777-28.2025	84.0645-84.0821	687-1269	2.39	0.14	6.2
6	Maidi	28.1753-28.1952	84.0785-84.0895	672-1123	1.6	0.007	0.4
7	Gunde	28.1889-28.2001	84.0392-84.0476	741-948	0.61	0.08	13.1
8	Neurani	28.1889-28.1950	84.0465-84.0533	742-866	0.18	0.027	15.0
9	Kamalpokhari	28.2169-28.2377	84.0102-84.0217	822-1440	1.35	0.013	1.0
	Note: This table does not cover riparian area of the cluster			Total	172.8	8.97	5.19

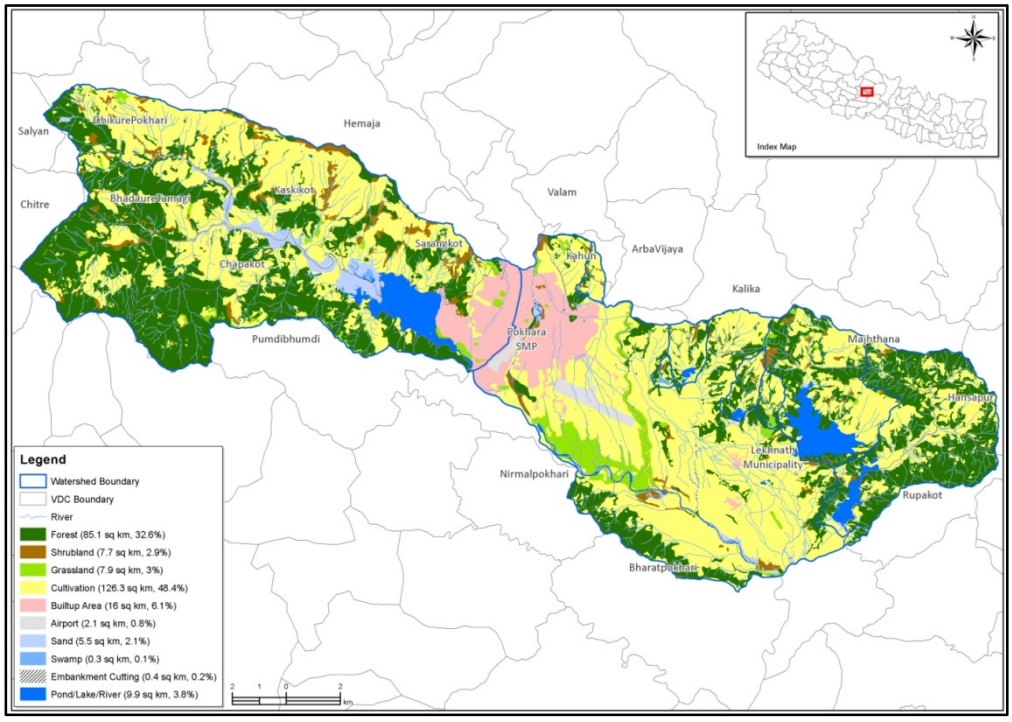

Figure 1. Location and Landuse Map of Lake Cluster Pokhara Valley

2. Lake Basin Environment

2.1 Physical Environment

LCPV represents the transitional zones of the Palearctic and Oriental zoogeographical realms and the Circumboral and Paleotropical phyto-geographical kingdom, which contributes to its rich biodiversity. The Panchase region in particular is one of Nepal's biodiversity hotspots, and is known for the high orchid diversity so it is regarded as *'Orchid Garden'*. The valley occupies a key geographic and socio-ecological position in the Chitwan-Annapurna Landscape, serving as an important corridor link between the southern and northern ecosystems and climate refuges. Elevation varies greatly, ranging from 622 masl in Rupa Lake to the highest point at 2,482 masl in the Panchase Mountain in the Phewa lake basin. Almost 35% (93 km^2) of the total area lies between 1,000 to 2,000 masl and 1% is above 2,000 m. About 64% (165 km^2) of the area is below 1,000 m. Most of the area (83%) has moderate to gently sloping terraces. About 64% of sloped areas are below 1,000 masl. Flat valley floors are intensely cultivated (Figure 2) [25].

The valley sits atop a gigantic debris fan from a cataclysmic flashflood caused by the Seti River bursting through a landslide or avalanche dam in its headwaters below Annapurna IV about 800 years ago [6]. It consists of a 7,000 m thick section of para-autochtonous crystalline rock with mostly unfossiliferous sedimentary and meta-sedimentary rocks like shale, sandstone, slate, conglomerate, phyllite, schist, quartzite, limestone, and dolomite. Morphologically, LCPV is made of five major land units, including alluvial plains and fans, alluvial plains, ancient river terraces (tars), and moderate to steep mountain slopes. Agriculture is concentrated in alluvial plains and river terraces [15].

The lake areas consist of layered clastic deposits with gravel, silt, and clay from the Quaternary age, eroded from the Annapurna range by series of catastrophic debris flow [5].The Seti River and its tributaries have carved out river terraces and deep gorges in the clastic sediments, where most (25-65% by volume) of the substrate is easily soluble calcareous materials. Karst structures i.e., sub-surface flow channels, solution cavities and chimneys, sinkholes, and pinnacles are widely distributed [43]. The geology and landscape of LCPV is unique.

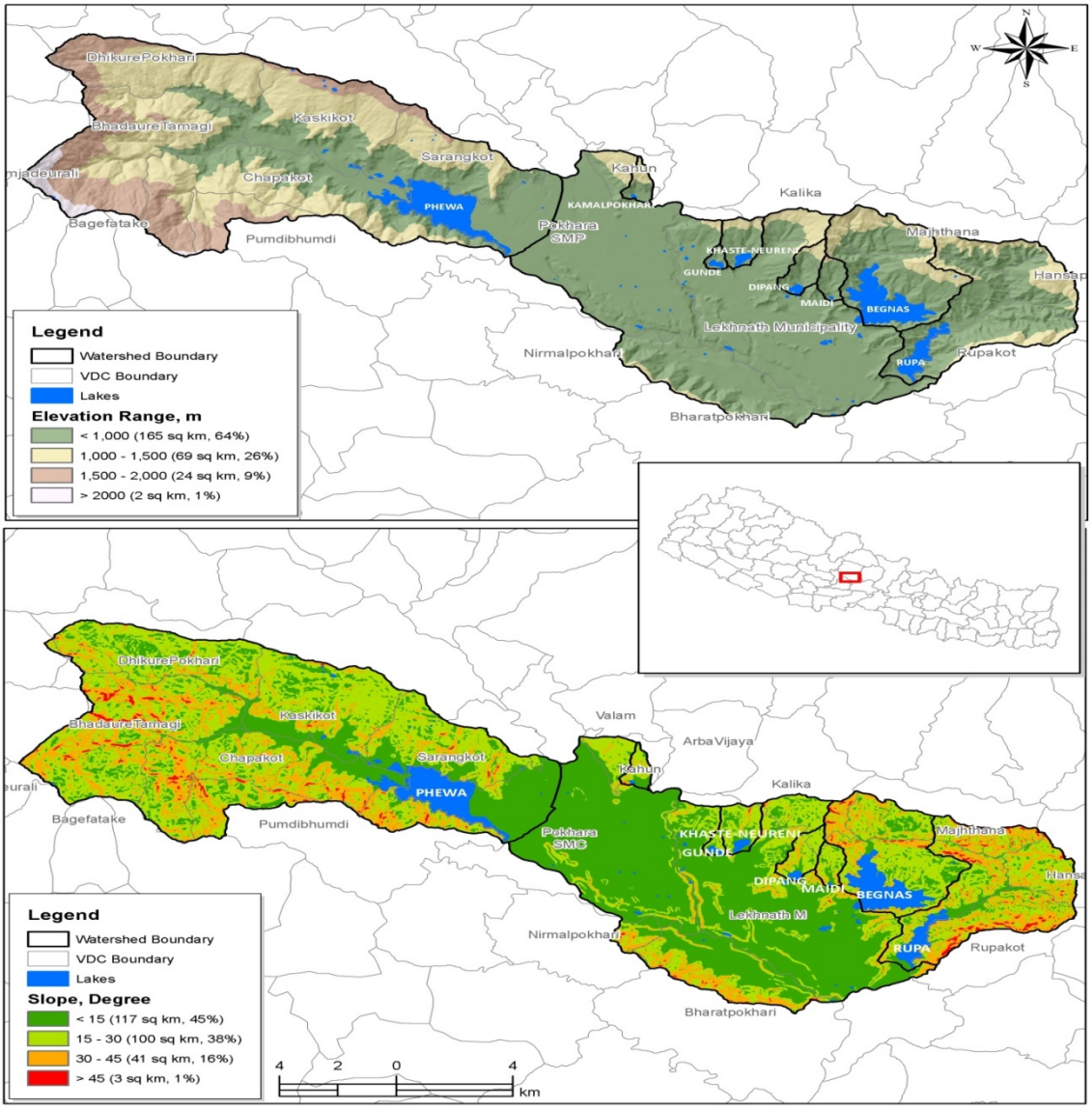

Figure 2. a) Elevation (Up) and b) Slope features (Below) of LCPV

2.2 Hydro-Climatic Environment

The LCPV demonstrates converging features of sub-tropical, cool temperate and warm temperate climatic zones at varying altitudes. Temperature ranges from 15–20^{0}C in the sub-tropical zone (<1000 masl), 10-15^{0}C in warm temperate zone (1000-2000 masl) and lower temperature in the cool temperate zone (2000-2500 masl). Mean annual air temperature in the cluster ranges from 20^{o}C to 25^{o}C, and average annual maximum and minimum temperatures are 21^{o}C and 11^{o}C (1981-2011), respectively [12]. Similarly, Pokhara is known to receive the highest rainfall in the country with a reference record of 4,000 mm annual precipitation in Lumle, so it is also regarded as the *Cherapunji* of Nepal. Therefore the cluster valley may have a significant role in regional hydrological balance including groundwater recharge, flood control and sediment trapping.

LCPV is the perfect reflection of the lentic-lotic system with the demonstration of complex hydrological network in the basin representing two hydrologic zones based on climatic features and the basin response, such as the Mountain Catchment in the Seti River that has its headwaters

in the high Himalaya region, and the Pokhara tributary [42] in the Harpan and *Andheri Khola*s. Table 2 illustrates key rivers and seasonal streams in each lake basin.

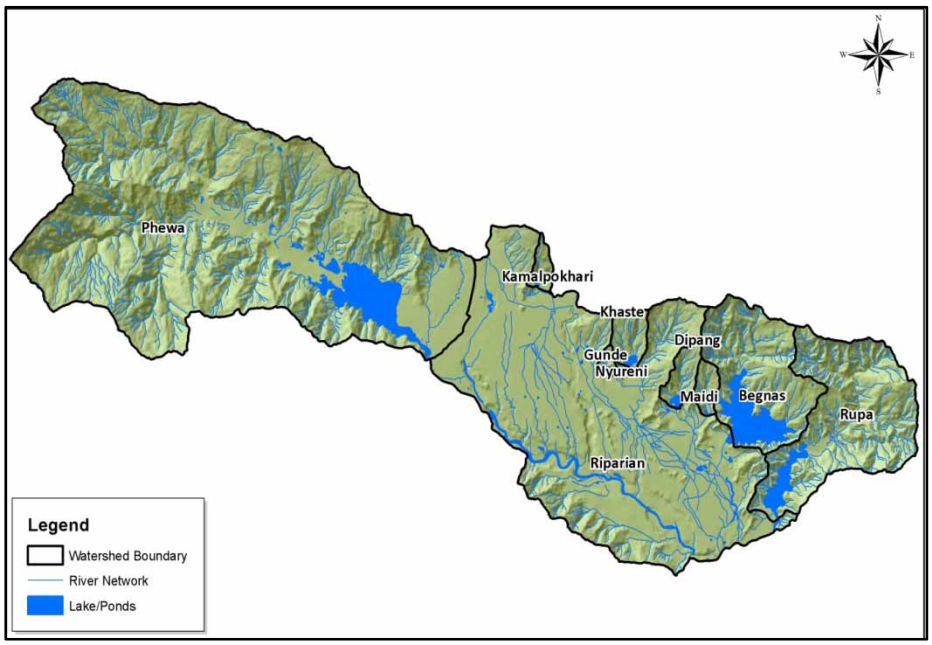

Figure 3. Hydrological networks showing lentic-lotic linkage in LCPV

Sidhane, Hadi, and Marse *Khola*s are roots of Harpan *Khola* feeding into Phewa lake whereas *Andheri Khola* is a major silt carrier to Phewa. Balaundi and Phirke flowing from the north across the Metropolitan City are the most polluting rivers carrying an enormous load of sewage and solid waste into the lake. Similarly, the Seti River flows for 223 km from north to south at the heart of Pokhara City where it narrows to form a gorge of several tens of meters in depth. It does not feed any lake, but widens in Ramghat and becomes part of the Ramsar site.

Bijayapur Khola is the next prominent river system which drains the Seti River, the basin of Kamalpokhari. The Bans Khola is the major inlet of Kamalpokhari. An outlet canal from this Pokhari drains to Khau *Khola*. In western flank of basin of Bijayapur Khola is shared by Khaste-Neureni and Gunde lakes. Khaste-Neureni, Gunde, Dipanag, and Maidi lakes do not have perennial inputs from streams but Begnas and Rupa are fed all seasons by Syangkhudi and Dovan Kholas, respectively.

Table 2. Key rivers and streams associated with lake system in Lake Cluster Pokhara Valley [25]

Lake Basin	Major River	Major Stream	Others
Phew	Hadi, Marse and Sidhane Khola (Harpan) and Adheri Khola	Khahare. Laurek, Betani, Ghuetro, Kanjire, Khahare (Bhakunde), Khapaudi, Balaudi, Phirke, Machha Pokhari, Bhumdi, Mure, Sasurke, Bhupan Kholas etc	Pardi, and Phusre Khola, and Seti River
Kamalpokhari	Bans Khola	Thado Khola	Kahu Khola
Gunde			Soto
Khaste	Thulo Khola	Nuwara and Rote Khola	Gadua Khola
Neureni			Gadua Khola
Dipang	Khatre and Kusunde Khola	Kahur and Kaure Kholas	Deurali Khola
Maidi		Piple, Bhudrung, Baskot, Raule and Saunne Kholas	Maidi Khola
Begnas	Syangkhudi	Kanmarang, Dud, Dhandhunge, Baguwa, Banspani and Khahare Kholas	Chyanladi and Khudi Khola
Rupa	Dovan	Chisa, Sanophadi, Dholphadi, Bhangara, Karaundi and Kalaundi Kholas	Tal Khola

3. Socio-Ecological Features

Socio-Economy: LCPV has a total population of 378,800 with an average household size of 3.8 people[5]. The rural, upstream areas had negative population growth rate during the inter-census period from 2001 to 2011, whereas the urban areas had a positive growth[2]. Similarly, the numbers of households in urban areas such as Pokhara and Lekhnath has increased by 83% and 60%, respectively. These figures reinforce the observed pattern of rural to urban migration that has implications on waste management and pollution in the lake, especially Lake Phewa. The average sex ratio in 2001 was 96, but 92 in 2011, less than the national average of 94 which is attributed to the outmigration of male youth for foreign employment. Such decline in sex ratio may have significant socio-economic implications including for the resource management at local levels, changing gender roles, and in the rural economy[25]. Figure 5 shows some demographic changes that occurred in the valley.

[2] The negative growth in rural areas ranged between -0.31 in Bharatpokhari to -2.33 in Hansapur, whereas the growth in urban areas ranged between 6.34 in the Pokhara 4.22 in the Lekhanath. Only 2 former VDCs, Sarangkot and Kahun, had positive population growth rates, of 2.63 and 0.76, respectively. Although 11 former VDCs witnessed negative growth rate, only four had a net decline in household numbers, indicative of outmigration [5].

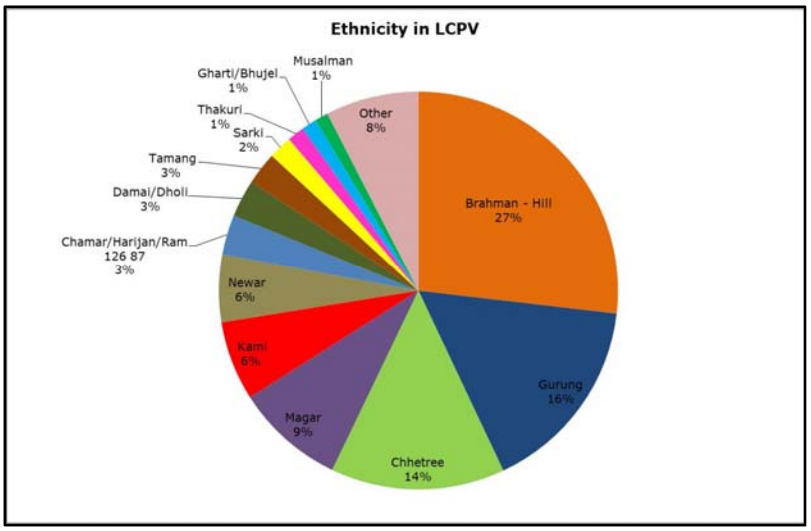

Figure 4. Ethnicity in lake basin of Pokhara Valley

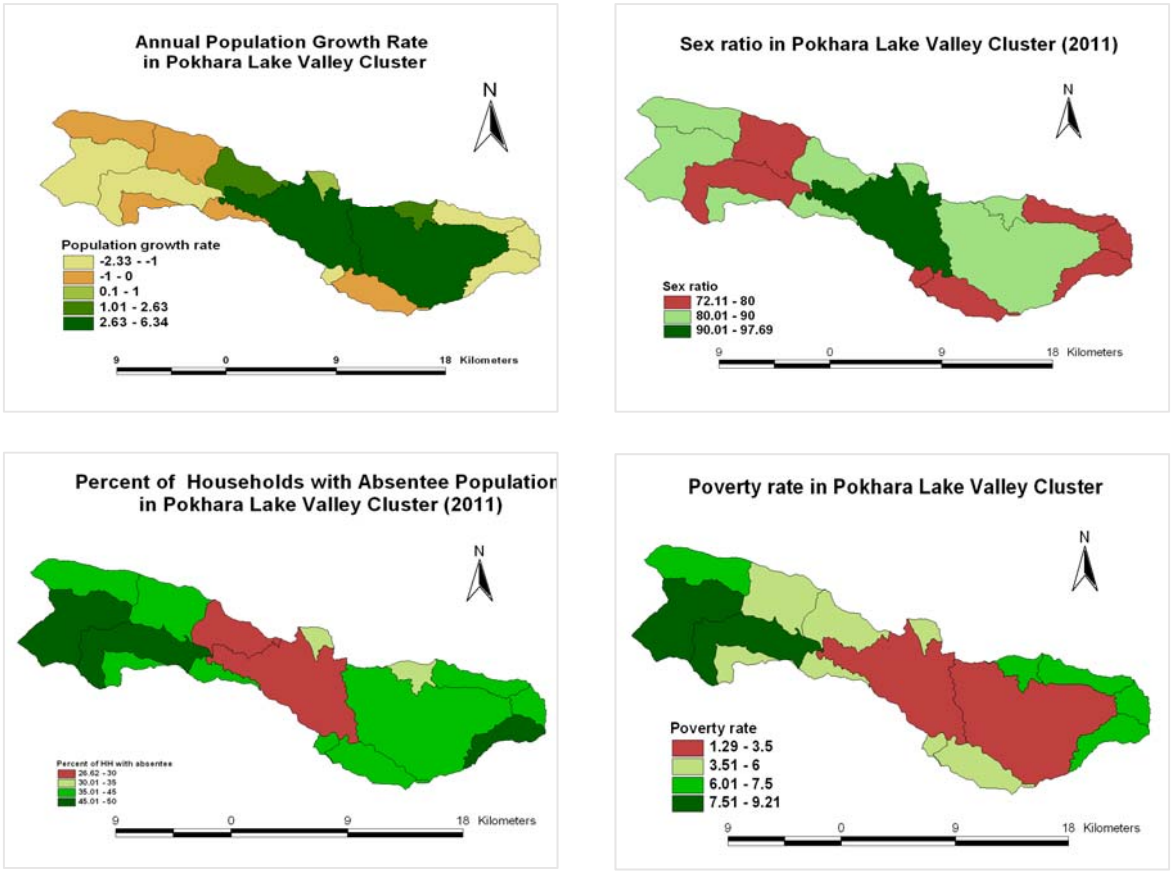

Figure 5. Demography feature of lake cluster basin of Pokhara Valley

The population in LCPV has heterogeneous composition of 101 ethnic groups with the majority of the Brahmin (27%), Gurung (16%) and Chhetri (14%). Other 89 groups are below <1% of the population. Overall, 67 languages are spoken with Nepali being the common language. Hinduism (>82%) and Buddhism (>13%) are the major religions.

The agriculture is the main stake for livelihoods of 53% of the population apparently supplemented by animal husbandry mainly in the rural centers. Agri-farm is conventional with

low proportion of agricultural inputs, such as about 0.8 kg of chemical fertilizers per Rapani [24]. The Jalhari, Majhi, and Pode depend primarily on fishing in Phewa, Begnas and Rupa lakes. Remittances from overseas are the main source of income and the backbone of the rural economy. However, over 145 large industries with an investment of over NPR 1,380 million are limited to urban centers particularly in Pokhara provide employment to over 3,600 persons. Similarly, many community cooperatives are in operation that includes 60% of cooperatives for savings and credit facilities, 19% for agriculture extension and support, 6% for consumers, 4% for dairy products, 2% for coffee, 2% for multi-purpose, 1% for media, and others like livestock, fishery, NTFP, bee keeping, tea, tourism, and health [8]. Ninety two (92) households of Jalahari in Phewa own cooperatives for fishery activities.

Pokhara is the gateway to the Annapurna Circuit, which has more than 20 trekking destinations and is also known as the 10th tourism destination in the world famed for lake tourism and adventure tourism from the para-gliding and ultralight flying to zip-lining, mountain biking, rock climbing, and white water rafting. About 40% of foreigners visiting Nepal make Pokhara their choice destination, and the number of tourists has been increasing at about 5% in the last 35 years from 1976 to 2010, with a dramatic increase of 20% from 2007 to 2011[16] (Figure 6). Tourism in Pokhara contributes to the annual income of the retail trade, including 87% of the travel, food and lodging sectors and 13% of the total number of businesses [36].

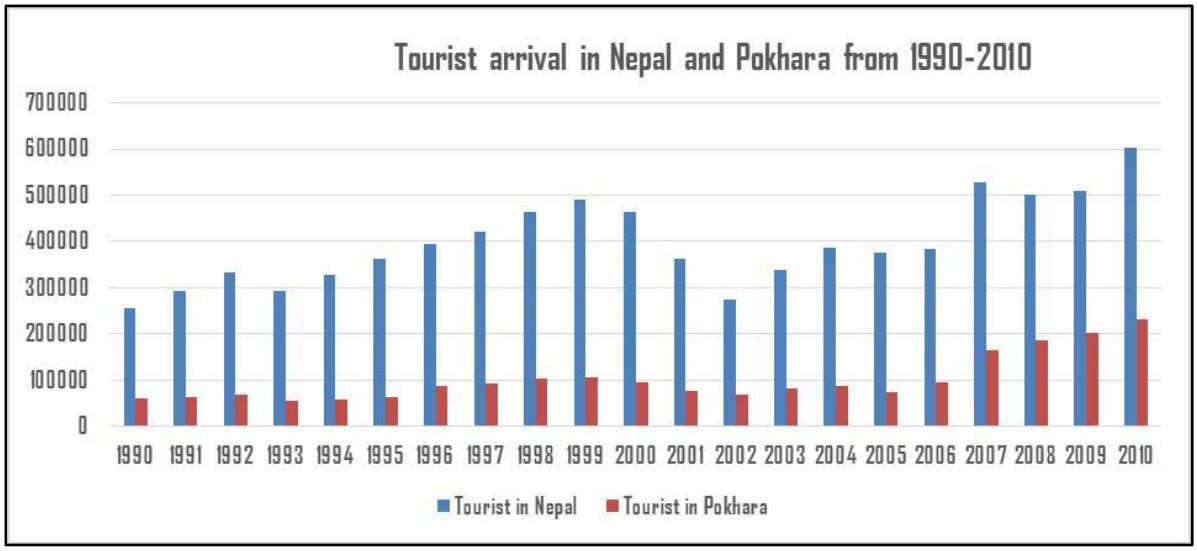

Figure 6. Number of tourists visiting Nepal and Pokhara from 1990-2010

The female population outnumbers the male population in the cluster basin and about 39% of households are female-headed [5]. Women are organized into 404 committees, 2,647 women groups, 359 *Dalit* groups, and 423 groups of *Janajati* women for paralegal services, skills against drug abuse and domestic violence, and child care. These groups have a collective fund of NPR 800 million[13]. They are well represented in the major political parties from the local to provincial governments. Very systematic inclusion of these groups has been recognized in natural resource management; about 32% of women hold executive positions in community forest management. Conservation initiatives in Kamlpokhari were begun by the women leader of *Dalit* in the Pokhara metropolis. There is a women's lake conservation committee established as an NGO for Gunde and Khaste-Neureni. The Rupa Lake Restoration and Fishery Cooperative (RLRFC) has women representation in its executive body. The wetlands dependent women, especially the *Jalahari*, also have savings and credit mechanism in Phewa and Begnas, and are

engaged in boat operation. As a result, the Gender Development Index in Kaski is ranked 3rd in the country (Figure 7)[94].

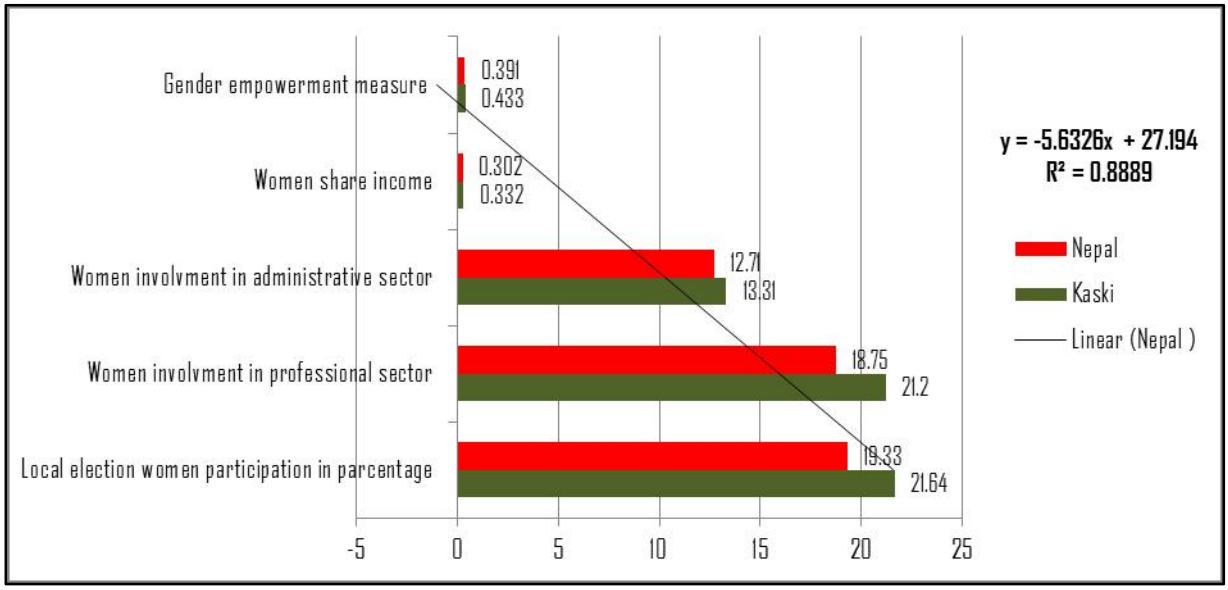

Figure 7. Status of Gender and Social Inclusion in LCPV (Kaski District)

LCPV fares well in national economic indices with reference to Kaski District. The Human Development Index is 0.576 against the national average of 0.490 (2014 data). Similarly, the Human Poverty Index is 16.5% against the national average of 31.1% and the *Per Capita* income of the district is USD 1,561 against the national average of USD 1,160 [16].

Ecosystem and vegetation diversity: LCPV is the conjecture of the Eastern Himalaya Temperate Broadleaf Forests, Himalayan Subtropical Pine Forests, and Himalayan Subtropical Broadleaved Forests eco-regions[26] having representative natural ecosystems of mid hill Nepal such as the wetlands, rivers, forests, and grasslands. However, each lake in the cluster has a diverse mosaic habitat consisting of an open water body, adjacent marshes and swamps, various forest types, and agricultural fields.

The cluster has four main forest types like sub-tropical and lower temperate forests dominated by *Shorea robusta* (Sal), *Schima* spp. *Castanopsis* spp. (Chilaune-Katus), *Daphniphyllum himalense* and *Alnus nepalensis*. Several aquatic macrophytes, hydrophytes and helophytes add to the biodiversity[20]. In Phewa Lake, the sub-tropical forests are on the western side (Raniban), and have a mix of both deciduous and evergreen species dominated by *Schima* spp. and *Castanopsis* spp. Chir pine and oak are dominant species in the subtropical pine and temperate forests, respectively. A major part of the Panchase Protected Forest[3] falls in the Harpan sub-watershed of Phewa lake, and includes the historic *Lek* called 'Panchase' which is rich in endemic orchids. Begnas and Rupa lakes are dominated by sub-tropical vegetation with the hill Sal forest and Chilaune-Katus forests. The other small lakes have their basins with the vegetation compositions as similar as of Phewa, Begnas, and Rupa at corresponding altitudes between 1000 and >2000 masl.

[3] With an area of 57.8 km^2, Panchase is full of biological, cultural, and religious diversities and natural beauty, and represents an important middle mountain ecological zone, and the only corridor linkage to lowland Chitwan–Nawalparasi and Annapurna Himalaya range.

Floral diversity: Floristic diversity of each lake is not available yet. However, 362 species of plants have been recorded from the lake cluster, with 286 terrestrial species under 83 families and 184 genera, and 61 aquatic species under 22 families and 26 genera. These include 32 orchids, of which 10 are endemic[4] and over 146 species of NTFPs in use including many from the Panchase Area in the upper basin area of Phewa lake. Of these, 82 species represents plants important for agrobiodiversity. This enumeration is underestimated than what had been reported earlier[27].

The submerged, emergent, floating-leaf and free-floating aquatic macrophytes constitute an important component of the lake cluster biodiversity. Rupa is the habitat of wild rice *Oryza rufipogon*. Besides wild rice, other common but kry aquatic macrophytes of lakes are *Trapa quadrispinosa; Trapa bispinosa; Nelumbo nucifera; Eichornia crasssipes* and *Ceratophyllum demersum.* Similarly, *f*loating hydrophytes include lotus and water lily, and emergent hydrophytes like *Alternanthera sessilis; Ipomoea aquatica* (swamp-cabbage); *Persicaria barbata; P. hydropiper* (hydropiper); *Ranunculus scelerates* (celery-leaved buttercup); *Typha angustifolia* (cat tail)*; Stellaria patens* (stitchwort); *Cyperus difformis; C. digitatus*. Of these aquatic flora *Nelumbo nucifera; Nymphaea noucholi; N. stellata* (lotus); *Nymphoides indica* (water-lily)*; Trapa quadrispinosa; T. bispinosa* (water chest-nut); *Eichhornia crassipes* (water hyacinth); *Lamna minor; L. perpusilla* (duck weed), *Pistia stratiotes* (water cabbage); *Azolla imbricate, and Sagittaria guyanensis* (arrowhead) are abundant species; whereas species like *Hydrilla verticillata* (water fern); *Utricularia aurea* (bladderwort); *Vallisneria natans; V. spiralis* (ele grass)*; Potamogeton crispus;* and *Ceratophyllum demersum* belong to the predominant submerged group. By growth form, the emergent species have the highest richness, followed by submerged and rooted floating species [1, 38, 39]. *Dischidia bengalensis* from Raniban and Harpan and *Phreatia elegans* from Chapakot are new species recorded [24].

Faunal diversity: The site holds 128 species of vertebrates including 32 species of mammals (18 families and 32 genera); 24 species of reptiles (2 orders and 9 families); 27 species of fish; 11 species of amphibians (3 families and 8 genera); and 140 species of birds (37 families and 101 genera). Lakes are reported to hold 21 native fish, 6 alien fish and 13 zooplankton species. Of birds, 52 species are wetland birds (17 families and 38 genera). Thirteen species of zooplankton have also been recorded from the lakes. Felidae and Muridae are the most species-rich mammal families. Corvidae, Accipitridae, Passeridae, and Silviidae are the bird families with the highest species, with 17, 13, 12, and 12, respectively [25].

The known biodiversity of the Phewa lake basin includes 104 bird species (43 water birds and 14 migratory species), 34 mammals, 16 fishes (4 exotic), 14 reptiles, and 6 amphibians (IUCN, 1995a). The known fauna of Begnas includes 36 water birds. The Rupa Lake basin has 6 amphibians (2 toads and 4 frogs), 29 fishes (22 nativeand 7 exotic), 14 reptiles, and 104 birds (including 17 species of rare birds and 14 migratory species) and 34 mammals [27, 40]. The European otter *Lutra lutra* (Kalo Ott) is found in Rupa and Begnas lake and smooth-coated Otter *Lutrogale perspicillata* (Khairo Ott) occur along Vijayapur Khola of Pokara Valley (Bhandari Jyoti and Subedi Nabin, 2006). Smooth-coated otter is in CITES Appendix-I and categorized as Vunerable in IUCN Red List. Population of otter is declining all over the world including Nepal [33].

[4] Of 113 species of Nepal's orchids ten are endemic which includes Oberonia nepalensis; O. eridifolia; Papilionantheteres sp, Panisea panchasensis; Eria pokharensis and Rhynchostylis retusa, and others such as Arisaema tortuosum, Cissampelos pareira; Berberis aristata; Asparagus racemosus, Reinwardtia indica and Ficus neriifolia (IUCN 2013). Panisea panchanensis and Eria pakhrerensis are endemic to Panchase. Other plant species that contribute to biodiversity of the site are Brachycorythis obcordata (The reverse Heart-Shaped Brachycorythis), Bulbophyllum plyrhiza (Orchid), Liparis plantaginea (The Plantago-like Liparis), Rhynchostylis retusa (Fox tail orchid) [33].

Some of the fauna that qualified the lake cluster for Ramsar site are *Turdoides nepalensis, Panoepyga immaculata, Panoepyga pusilla* (Wren babbler), and the globally threatened *Sarkidiornis melanotos (*Comb duck, CE-IUCN), *Aythya baer (*VU-IUCN), and *Aythya nyroca* (Ferruginous Duck, NT-IUCN).

Recently, 49 species of butterflies, 157 species of insects other than butterflies and 152 species of birds (13 orders and 51 families with 10 species Globally Threated) were reported from the basin of Dipang lake. Of birds of Dipang, *Sarcogyps calvus* (Red-Headed Vulture), *Gyps bengalensis* (White Rumped Vulture), *Gyps tenuirostris* (Slender-Billed Vulture) and *Emberiza aureola* (Yellow-Breasted Bunting) are Critically Endangered, and *Neophron percnopterus* (Egyptian Vulture) and *Aquila nipalensis* (Steppe Eagle) are Endangered species. Similarly, *Ciconia episcopus* (Asian Woolly-Neck Stork) is Vulnerable, and *Gyps himalayensis* (Himalayan Vulture), *Aegypius monachus* (Cinereous Vulture), *Aythya nyroca* (Ferruginous Duck) are Near Threatened species in IUCN Red List 2018[5].

Invasion of alien species: All lakes are reported to hold alien species of plants and fishes, however the history and magnitude of such invasion is unclear. Of fishes, there are six alien invasive species, and *Tilapia nilotica* (Tilapia) and *Clarias gairiepinus* (African Catfish) are common in all lakes. Bighead Carp, Silver Carp and Grass Carp are exotic species introduced to augment fishery but have depressed native fish populations. For instance, these species have contributed to 42% decline of native fish in Begans lake. Similarly, *Parthenium hysterophorus, Mikenia macrantha, Eichornia crasssipes, Leerisa hexandra* and *Pistia stratiotes* are common alien plants which are claimed to reduce agricultural productivity [2] and damage the ecosystem and environment in the lake cluster and the basin.

Endemism: The adjacent Annapurna Conservation Area[6] that may have spill over impact on endemism in LCPV is often marked as one of the notable hotspots for endemism, especially the orchids. Similarly, endemic birds like *Turdoides nepalensis* (Spiny babbler) and *Panoepyga immaculata* (Wren babbler) which have limited distribution in Nepal are known to occur here.

[5] Unpublished report of Conservation Development Foundation from Dipang lake in 2020 under the funding of Hariyoban Program/WWF Nepal/USAID and Kidanaren Nature Conservation Fund/Japan.

[6] Annapurna Conservation Area is often regarded as the richest endemic box in Nepal, which claims to hold the highest endemism in Nepal. LCPV is the southern front of this conservation area

4. Use and Economics of Lake Cluster Resources

An economic assessment of Phewa Lake has been estimated as USD 279,000 [7, 33]. The total economic valuation of the entire lake system has not yet done. Other ecosystem services from the lake cluster are indicated in Table 3 and described briefly below.

Irrigation: Only 17% of agricultural land has access to all season irrigation in LCPV. Of this, 95% of irrigation canals managed by farmers. Phewa Lake irrigates 320 ha of land and Seti River irrigates 1,030 ha. Similarly, Bijaypur Khola irrigates to 1,280 ha, Begnas 580 ha, Sisuwa 50 ha, Kimbesi/Begnas 50 ha, Sadhikhet/Bhadauretamagi 30 ha, Gaduwa/Lekhnath 50 ha, Aiseluchaur/Chapakot 55 ha, Harpankhola/Bhadauretamagi 10 ha, Tarikhet/Bhadauretamagi 5 ha, Sheraphant/ Pumdibhumdi 10 ha, Kimbesi/Lekhnath 20 ha, and so on.

Freshwater: Phewa, Begnas and Rupa Lakes have water storage capacities of $46X10^6$ m^3; $17.9x10^6$ m^3 and $3.25X10^6$ m^3, respectively. Harpan Khola that meanders for about 5 km in the lakehead of Phewa has a mean flow of 5.58 m^3/s[28]. Chandi, Dandhunge, Dudh, and Baguwa Kholas triangulate to originate at the Syankhudi inlet of Begnas, with Khudi Khola forming the outlet. Dovan and Kurlung Kholas are inlets and Sistani Ghat is the outlet of Rupa Lake. Kahu Khola characterizes the Kamalpokhari Lake Basin that contributes to Bijayapur Khola. Gadhuwa Khola travels north to south in the Khaste-Neureni Lake Basin. All these water networks supply freshwater for multiple purposes. For example, about 33% of water from Phewa is used for domestic purposes and Phewa Lake also generates 1 MW of hydropower at Pardi, Birauta [25].

Grazing and Fodder: LCPV has 2.2 km^2 of grassland, with the highest extent in Phewa (1.7 km^2), Begnas (0.3 km^2) and Maidi (0.2 km^2). These grasslands provide forages to livestock mainly through open grazing in all lakeshores and basins, and are sources of grasses such as *Imperata cylindrica* (Blady grass), *Themeda villosa*, *Saccharum spontaneum* (Thatch grass), *Paspalum species* (Dallis grass), and *Cynodon dactylon* (Bermuda grass)[25]. The available quantities and nutritional status of the grass are not known[25].

Fishery: Commercial cage fisheries using Bighead carp, Silver carp, Grass carp, Tilapia, and African Catfish are common practices in cluster basin. Phewa Lake alone provides benefits from 98 metric tons of annual turnover of cage culture and open water recapture fisheries. Begnas, Rupa and Khaste produce 48, 18 and 8 mt of fish annually. The Rupa Lake Restoration and Fishery Cooperative which has more than 600 household members has reaped benefits worth NPR 10 million from fisheries over the last 15 years. However, fisheries are still not considered an organized practice to maximize benefits from the lakes. *Pode* or *Jalahari* are indigenous communities specialized for the traditional fishing and boating. There are groups of 92 households (HHs) in Phewa, 22 HHs in Begnas and 15 HHs in Rupa who rely solely on fishery for their livelihoods [25].

NTFPs and Medicinal and Aromatic Plants (MAPs): Over 360 species of plants with food, medicinal and ornamental value are found in LCPV. These include 8 fiber-yielding species, 23 species used to extract natural dyes, 18 wild species with floriculture potential (excluding the 32 species of orchids), and 98 edible fern species (Subedi 2006). *Paris polyphylla* (Himalayan Paris), *Swertia augustifoila* (Felwort), *Saxifraga ligulata* (Pakhanbed), *Tinospora cordifolia* (Guduchi) and *Lycopodium clavatum* (wolf's claw) are commonly used by traditional Ayurvedic healers for common health ailments (MDO 2012). Other medicinal plants include *Swertia chirayita* (Chiraito), *S. nervosa* (Tite), *Bergenia ciliate* (Pakhanbed), *Tinopsora sinensis* (Gurjo), and *Lycopodium phlegmaria* (Nagbeli) [25].

Table 3. Ecosystem Services from Lakes & Basin of LCPV 2-16 [25]

Services		Phewa	K. Pokhari	Gunde	Khaste	Neureni	Dipang	Maidi	Begnas	Rupa
Provisional	Drinking water supply	**	-	-	-	-	-	-	**	**
	Irrigating water supply	**	***	***	***	*	**	*	***	*
	Domestic water supply	**	-	*	-	*	-	-	-	-
	Industrial water supply	-	-	-	-	-	-	-	-	-
	Fish supply	**	*	-	*	-	*	-	**	***
	Timber supply	**	*	*	*	*	**	**	**	**
	Fiber supply	-	-	-	-	-	-	-	-	-
	Fuel wood supply	**	*	*	**	*	**	**	**	**
	Fodder/forager/grass	***	**	*	**	*	**	**	***	***
	Food (plants and animals)	**	-	-	*	*	*	*	*	*
	Medicine	**	-	-	*	-	*	*	**	**
	Hydropower	*	-	-	-	-	-	-	-	-
	Mining and extraction	**	-	-	-	-	-	-	*	*
	Handicraft material	*	-	-	*	-	*	-	*	*
	Genetic material	**	-	-	-	-	-	-	**	**
Cultural	Aesthetic/scenic service	***	-	-	-	-	*	-	**	**
	Religious/spiritual service	**	*	-	*	-	-	*	-	*
	Historic site	**	-	-	-	-	-	-	*	*
	Recreational/tourism	***	-	-	-	-	*	-	**	**
	Educational services	***	-	-	-	-	*	*	**	**
	Festivals/hat bazzar/mela	**	*	*	*	*	*	*	**	**
Regulatory	Water recharge	***	***	***	***	***	***	***	***	***
	Flood mitigation	*	-	-	-	-	-	-	*	*
	Desertification mitigation	**	**	**	**	**	**	**	**	**
	Biodiversity	***	*	*	*	*	**	**	***	***

- = No; * = Low; ** = Moderate; ***= High

***Religio-Cultural Values*:** LCPV is well regarded for its historical, religious, environmental and cultural values. It is a key destination for both the tourists and pilgrims including the 200-year-old Shraban Kumar temple in Panchase. Phewa has the Barahi temple, Kamalpokhari has Sitaladevi Mandir and Nagdev, Khaste-Neureni has Barahai temple, and Rupa has the Devi Temple. Some of the important historical temples in Phewa include Bindeshari Mandir, Kalika Mandir, Sunapdeli Mandir, Chandi Mandir, Santaneshwari Mandir, Kahu Baudhha Gumba, Bhairab Mandir, Gopeshowar Mandir, Matikhana Mandir Bahakot Devi Mandir, global Peace Stupa, Ramchedevi Mandir, and Armalakot Mandir. Bhadauretamagi VDC is famous for Kyulubarahasthan, Siddhabaraha and Devisthan Mandir, Kaskikot VDC for Guptakali Mandir, Rupakot VDC for Baraha and Chisapani Mandir, Hansapur VDC for Deurali, Bhmesthan, Saraswati Mandir, and Autarimaisthan [10]. The lake specific religio-cultural values are shown in in Table 4.

Table 4. Religio-cultural and social values of each lake in LVPV

Lake	Socio –Cultural significance
Phewa	Tal Barahi temple is situated in the middle of the lake. Hindu people worship Goddess Durga during festivals.
Begnas	Barahi tempe of Begnas is visited by Hindu people in full moon and Teej festivals. Religio-cultural performance is done before and after paddy cultivation.
Rupa	Rupa is historically known as being a site where famous Rishi Chewan practiced yoga at the bank of the lake. Devi temple is also present. Shiva temple at the middle of the lake is visited in the Shivaratri.
Dipang	Local people believe water is holy for God and Goddess.
Khaste	People take a holy bath in Ekadasi, Ram Nawami and New Year.
Maidi	People take a bath in New Year.
Gunde	Gunde lake is considered as sacred and people take bath during Teej, Ekadasi, Ram Nawami and New Year. It is also a cremation site.
Kamalpokhari	Also called Buddha lake, People worship Snake God during Nag Panchami.

Lake Tourism: Lake tourism is one of the top 10 tourism activities, and the cluster makes Pokhara most popular lake destination in Nepal. The cluster connects outstanding pilgrimage places such as Muktinath temple in the Annapurna Conservation Area in north, the 200-year-old Shraban Kumar temple in Panchase and many other vantage sites in Pokhara like Sarangkot, Chapakot, Rupakot, Paudurkot, David Fall, Harihargufa, Mahendra Gufa, Mahadevgufa and deep gorges of Seti and Kaligandaki rivers. As a result, the area is most visited by 40% of foreigners who visit Nepal making Pokhara their destination with a dramatic increase of foreign visitors each year.

5. Threats to Lake Basin Environment

LCPV faces threats and vulnerabilities similar to those faced by other lakes in the world. Many proximate threats prevail in LCPV, for examples Table 5 shows the threats and trends in individual lakes as perceived by communities. Of the prevailing threats in Table 5, some pertinent ones are described below.

Table 5. Proximate threats in each lake of LCPV [25]

	Summary of the threats in LCPV	Note:	Low	Medium	High	V. high	None			
SN	Threats	Phewa	K. Pokhari	Gunde	Khaste	Neureni	Dipang	Maidi	Begnas	Rupa
1	Chemical fertilizers and pesticides use	↑	↑	↑	↑	→	↑	↑	↑	↑
2	Human encroachment	↑	→	→	→	→	→	↑	→	↑
3	Landslide	↑	→		→		→	↓	→	→
4	Siltation due to flood	↑	→	↑	↑		→	→	↑	↑
5	Disposal of sewage and liquid waste	↑							↑	↑
6	Solid waste and plastic products dumping	→	→	↓	↓	↓	→	→	↑	→
7	Over-harvesting of fish and illegal poaching	↑	↑	↑	↑	↑	↑		↑	→
8	Invasive alien plant species	↑	↑	↑	↑	↑	↑	↑	→	→
9	Invasive alien animal species	↑	↑	↑	↑	↑	↑	↑	↑	↑
10	River, stream and flood	↑	→	→	↑	→	→	→	↑	↑
	Total threats	**10**	**9**	**8**	**9**	**7**	**9**	**8**	**10**	**10**
		Trend:	→	Constant	↑	Increasing	↓	Decreasing		

Encroachment: Encroachment and reclamation are common and topmost threat in all lakes, which is very serious in Phewa and Rupa Lakes due to the rapid reclamation, conversion and reservation for urbanization and related structures, and agriculture practices. As a result, there has been a significant reduction in the lake area. Up and downstream of Rupa has been reclaimed for agriculture. Infrastructure, including concrete buildings and road networks are being constructed to the south of Satmuhane Bazaar. Encroachments for agriculture and real estate are also spreading in Maidi and Kamalpokhari. The evidence of encroachment is serious to the extent that the Supreme Court in 2018 issued the order to clear all uncertified encroachments on the shoreline of Phewa Lake[25].

Siltation: Deforestation in the watersheds, poorly constructed infrastructure, diversion of water, and extraction of gravel and stone mining in ecologically sensitive areas have enhanced siltation in the cluster, especially in Phewa, Khaste-Neureni, and Rupa. Phewa is the sink of Harpan and Andheri Khola. Phewa alone had 269,752 m^3 sediment load from road networks thereby 25,593 m^3 from the induced landslides, with an average of 1,024 m^3 per landslide [17, 18]. Further, the Seti Canal, Bulanudi and Phirke Khola are the key carriers of urban garbage. As a result, Phewa has been reduced by more than 50% within 5 decades [22]. In Rupa, Dovan and Khurlung Khola discharged tons of silt so the water body shrunk down to 0.12 km^2 by 2000 [14, 23]]. Siltation is less in Begnas, Kamalpokhari, and Maidi.

Pollution: Agricultural chemicals, sewage, other liquid and solid waste are prevalent in all lakes. Phewa is the most polluted lake in the cluster because of sewerage outfalls, solid waste disposal, and agricultural run-off. *E. colii* counts in the lake was 39-123 units/100 ml, while over 125 mt of solid waste is dumped into the lake together with >100 kg of soaps and detergents from laundry activities in the lake [23]. In 1990s, eutrophication in Phewa caused an algal bloom that resulted in mass fish kills and health impacts to local communities [31].

Invasion by exotic species: The spread of alien invasive plants and animals is increasing in the cluster thereby enhancing threats that rank higher in Gunde, high in Khast-Neureni, Dipang, Maidi and Kamalpokhari, and moderate in Begnas and Rupa. The most colonizing plant species are the water hyacinth, *Lantana* and *Parthenium spp* and morning glory, and such colonizing

fauna are the African Catfish and Tilapia that have threatened the ecosystem and biodiversity especially the native fishes [6]. Exotic fish have led to the disappearance of indigenous fish from the small lakes. The overall rank for threats from invasive species is 'Very High' in the cluster.

Unsustainable fish harvest and wildlife poaching: Over-harvesting of fish and wildlife poaching is high in Kamalpokhari, Neurini, Begnas, Phewa, and Dipang but lowest in Rupa. These practices have depressed fish populations, and have affected the presence of birds, especially the migrant populations that depend on fish for food. Poaching of wildlife is reported to be depressing wildlife species in the cluster.

Climate change and impacts: Temperature in the cluster has been increasing at the rate of 0.04°C per year and average winter temperature has increased slightly with its impacts expected to increase in the drought period [12]. Kaski District, where the cluster is located, ranked low in the drought vulnerability index i.e., 0.181-0.331 [32]. Similarly, the average total precipitation proximate to Pokhara valley over 25 years (1985-2010) is 4,062 mm, with an average of 128 rainy days annually and a maximum of 164 rainy days in 1985 [11].

Anthropogenic activities like road connectivity, tourism and infrastructure development, encroachment, pollution, siltation, invasive species, algal blooms and land degradation have increased the risk of climate vulnerability and disasters. Vulnerability of Kaski District is ranked moderate (0.356-0.600) but high for landslides [31]. The moderate vulnerability does not mean healthy socio-ecological system, it may add complexities to the *Himalayan Dilemma* from the effects of climate change [21, 37]. Table 6 shows the perceptions of the community about the risk of climate vulnerability, and corresponding scenarios, sensitivity and impacts identified.

Table 6. Community perception about climate vulnerability of LCPV[25]

Indicators	Scenario	Sensitivity	Impacts	Response
Temperature	Increasing	Increase drought, forest fire, evapotranspiration high, weathering	Water level declined	Ecosystem based adaptation
Rainfall	More erratic, intensive	Decrease water sources, increased erosion and landslides	Quality and quantity of lake water decreased	Water source protection, conservation of upland, forest management and river training
Sediment flow	Likely increase	Highly affected	Decreased lake area and depth	Gully control, stream bank protection
Evaporation	High in dry months	Change in water budget	Decreased water level	Forests and water conservation
Invasive species	Likely to increase	Highly affected	Impact on water quality and aquatic life	Upland farming, city waste management.
Eutrophication	Likely to increase	Likely increased algal population and invasive species	Impact on water quality and aquatic life	Upland farming, city waste management, green enterprise
Non-Climate encroachment	Likely to increase	Decrease lake water from siltation	Impact on lake management	Lake boundary, Strong lake governance

Climate change has been contributing to the enormousness of stresses in lakes, and exerted pressure to communities for additional effort, energy and investment in adapting measures to cope with the stresses.

Overall impacts of above might have significant impacts on landuse change in the basins of individual lakes. In general, cultivated land has reduced from 88 km^2 to >71.2 km^2, while there has been an increase in forested lands from 66.9 km^2 to 73.5 km^2, shrubland from 2.2 km^2 to 6 km^2, and grassland from 1.3 km^2 to 2.2 km^2. The grassland cover in the basins of Phewa and Begnas has increased by 0.45% and 0.85%, respectively, since 1996. Grasslands have also increased considerably (>9%) along the Maidi shoreline. However, the river and stream area has decreased (0.7 to 0.08 km^2) in the Phewa basin, with an increase in sand and sediment areas. But there is also an increase in built-up areas, and other community infrastructure. This is especially significant in the Phewa basin, were infrastructure development in the Pokhara Metropolis has expanded (Table 7). Some of the key land use-land cover changes are as follows:

- Core water areas in Phewa, Begnas, Maidi, Kamalpokhari, and Gunde Lakes have decreased over the past 20 years. The trend is greatest in Phewa and Begnas with 4% and 17% decreases, respectively. There has been an increase in sand and sedimentation from 1.3% in 1996 to 4% in 2016 in Phewa.
- The core water areas in Rupa, Dipang, Khaste, and Neureni have increased over the past 20 years. The water area in Rupa has increased from 1.1 to 1.2 km^2, with a decrease in sand and sediment deposition. The extent of Dipang has almost doubled in area, from 0.06 to 0.15 km^2.
- Forests, grasslands, and shrublands have increased in all lake basins. Land abandonment, which is becoming a common practice, has also resulted in natural regeneration.
- Cultivated land is decreasing in all lake basins.
- Intense urbanization in all lake basins, especially along the shorelines is growing. In Phewa, the extent of built-up structures has increased from 0.02% to 5.2% over the past two decades. Similar changes are happening in the areas downstream of Gunde, Khaste-Neureni, Dipang, Maidi, Begnas, and Rupa.

Table 7. Landuse change in LCPV from 1996 to 1997 [25]

Lake Basin	Built up area (km^2)				Cultivation				Forest			
	1996	%	2016	%	1996	%	2016	%	1996	%	2016	%
Phewa	0.03	0.02	6.20	5.20	62.00	52.69	48.58	40.67	45.57	38.15	49.19	41.19
Kamalpokhari					0.85	83.40	1.03	76.07	0.15	14.60	0.21	15.23
Khaste					2.10	78.00	1.87	69.55	0.42	15.60	0.60	22.51
Neureni					0.10	57.30	0.08	44.54	0.06	34.10	0.07	40.84
Gunde					0.41	67.70	0.28	46.53	0.12	18.70	0.19	30.96
Dipang					1.38	57.40	1.19	49.55	0.89	37.00	0.97	40.45
Maidi					1.13	70.70	0.90	56.29	0.46	28.60	0.54	33.74
Begnas					9.53	51.30	8.46	45.49	5.30	28.50	6.04	32.47
Rupa					10.54	40.50	8.78	33.74	13.90	53.40	15.65	60.16
Total	0.03		6.20		88.04		71.17		66.86		73.47	
	Pond or lake				River/Streams				Sand			
	1996	%	2016	%	1996	%	2016	%	1996	%	2016	%
Phewa	4.52	3.78	4.42	3.70	0.73	0.61	0.09	0.08	1.58	1.32	4.21	3.53
Kamalpokhari			0.01	0.94	0.00				0.00			
Khaste	0.10	3.50	0.13	4.82	0.00				0.00			
Neureni	0.02	8.80	0.03	14.62	0.00				0.00			
Gunde			0.08	13.40	0.00				0.00			
Dipang	0.06	2.40	0.15	6.20	0.00				0.00	0.00		
Maidi	0.01	0.60	0.01	0.44	0.00				0.00			
Begnas	3.23	17.30	3.13	16.85	0.00				0.00		0.04	0.2
Rupa	1.07	4.10	1.15	4.43	5.40	0.20			0.37	1.40	0.19	0.74
Total	8.99		9.11		6.13		0.09		1.95		4.45	
	Grassland				Shrub land				Swamp			
	1996	%	2016	%	1996	%	2016	%	1996	%	2016	%
Phewa	1.15	0.96	1.68	1.41	1.67	1.39	4.93	4.12	1.27	1.06	0.14	0.12
Kamalpokhari	0.00	0.00	0.01	0.68	0.00	0.00	0.10	7.08	0.02	2.00		
Khaste	0.00	0.00	0.001	0.04	0.08	2.90	0.08	3.08	0.00			
Neureni					0.00				0.00			
Gunde	0.00	0.00	0.01	1.74	0.00	0.00	0.05	7.36	0.08	13.60		
Dipang	0.01	0.20	0.001	0.04	0.07	2.90	0.09	3.76	0.00			
Maidi	0.00	0.00	0.15	9.14	0.00	0.10	0.01	0.38	0.00			
Begnas	0.16	0.90	0.33	1.75	0.32	1.70	0.59	3.18	0.00	0.00	0.01	0.03
Rupa	0.00	0.00	0.01	0.03	0.07	0.30	0.23	0.89	0.00	0.00	0.003	0.01
Total	1.32		2.18		2.21		6.07		1.37		0.15	

6. Consolidating Lake Basin Governance in LCPV

Lake basin management in Nepal is gradually evolving after the establishment of NLCDC and its first exposure to the World Lake Conference in 2007. International Lake Environment Committee Foundation (ILEC) and the Research Center for Sustainability and Environment (RCSE) of Shiga University, Japan have made many efforts through training, workshops and exposure to improve the technical capacities of Nepal for lake basin governance for the sustainability of lentic-lotic aquatic ecosystem and biodiversity. As a result, the Gandaki State has been demonstrating proactive response towards Integrated Lake Basin Management (ILBM) approach to address the issues of lentic-lotic water system in Nepal. The next sections describe the state of lake basin governance in general followed by the case in LCPV.

6.1 Policy

The Constitution has divided the sovereign powers and state functions among three tiers of governments i.e. federal, state and local level (Article 56) envisioning a cooperative, coexistent and coordinative system of federal governance (Article 232). For clarity, the Constitution has divided jurisdictions of the state functions categorically where 'wetland conservation' is under federal jurisdiction. But wetland functions and services like electricity, irrigation, drinking water, navigation, and tourism are primarily spread over all the tiers (Schedules 5 to 9). In addition to that, it has stated that the rights not specified in the schedules fall under the prerogative rights of the federation (Article 58).

Whatever is provisioned in the Constitution, the water sectors is cross-cutting under the many prevailing strategies and policies[7]. The Water Resources Strategy (2002) and the National Water Plan (2005) have the concept of Integrated Water Resources Management (IWRM). Though the Water Resources Strategy calls for integrating water, land and other resources for sustainable development, the habitats of flora and fauna in and around lentic-lotic system have not yet received ample attention. At the setting of these strategies/policies, over two dozen of Acts prevail, and the most relevant to wetlands among these are Aquatic Animal Protection Act (1960), National Parks and Wildlife Conservation Act (1973), Soil and Watershed Conservation Act (1982), Mines and Minerals Act (1985), Pesticide Act (1991), Water Resources Act (1992), Solid Waste Management Act (2011), Irrigation Act (?), and Self Governance Act (1999). Besides many Acts, a few environmental standards and guidelines that relate to wetlands/ponds also prevail[8].

[7] Key strategies and policies related to water management in Nepal include the National Biodiversity Strategy (2002); Hydropower Development Policy (2002); Water Resource Strategy (2002); National Agriculture Policy (2004); National Water Plan (2005); Tourism Policy (2009); National Industrial Policy (2011); Climate Change Policy (2011); Irrigation Policy (2013); National Energy Strategy of Nepal (2013); National Agriculture Development Strategy (2014); National Land Use Policy (2015); Forest Policy (2015); Forestry Sector Strategy (2016); National Urban Development Strategy (2017); National Mineral Resource Policy (2017) etc. However, the National Wetland Policy (2012); National Biodiversity Strategy and Action Plan (2014-2020); Nature Conservation National Strategic Framework for Sustainable Development (2015), and National Ramsar Strategy and Action Plan (2018-2024) are the most proactive guiding documents.

[8] Some environmental standards that relate water management in Nepal are Nepal Water Quality Guidelines (2005); Industry Specific Tolerance Limits for Industrial Effluents to be Discharged into Inland Surface Waters for Tannery, Wool Processing, Fermentation, Vegetable Ghee and Oil, Paper and Pulp (2001); Industry Specific Effluents Standards to be Discharged into Inland Surface Water for Dairy, Sugar, Cotton, and Soap Industries (2003); Generic Effluents Standard for Discharging into Open Sewerage (2003); Generic Effluents Standard to be Discharged from Treatment Plant to Inland Water (2003), and Generic Standard Tolerance Limits for Industrial Effluents to be Discharged into Inland Surface Waters (2008), etc.

NLCDC in 2013/14 initiated the development of the National Lake Strategy under the support of ILEC/RCSE/Shiga University under National Biodiversity Strategy Initiative. This strategy has entered a very long review process, and has not been able to deliver a final outcome.

Based on above legal footprint, and provisions set by the Constitution of Nepal 2015, the Gandaki State has been very proactive to respond with policy and legal framework for the basin level sustenance of lentic-lotic water system. The state has formulated the *Forests and Watershed Policy of the Gandaki State-2018*, which is the core policy framework to address all the issues of forests, flora and wildlife, biodiversity, watershed, wetlands, and grasslands of the state. This policy strongly spelled out for the climate resilient and sustainable management of wetlands ecosystem (Bullet 2 under *'Ka'*)[9], integrated management of lakes, wetlands, rivers and glaciers of the state (Bullet 5 under *'Ka'*)[10], and for the environmental harmony of the state (*'Kha'*). Next but very outstanding one, the enactment of *Lake Conservation and Development Authority Act-2018* which aims to conserve, restore and manage lakes and their basins for the biodiversity and environment conservation for sustained development and prosperity in the state. In addition, the act entitled *Bar, Pipal and Chautari Act (2018)* is the contributing act dedicated to manage roadside plantation of trees that have value on the religio-culture in the State.

The enactment of Lake Conservation and Development Authority Act is the first and historic initiative made at the state level in Nepal to demonstrate stepwise gradual progress on the lake basin governance. With this Act executed, the environmental condition of the lentic-lotic wetlands in the state is anticipated to improve gradually together with enhanced benefits.

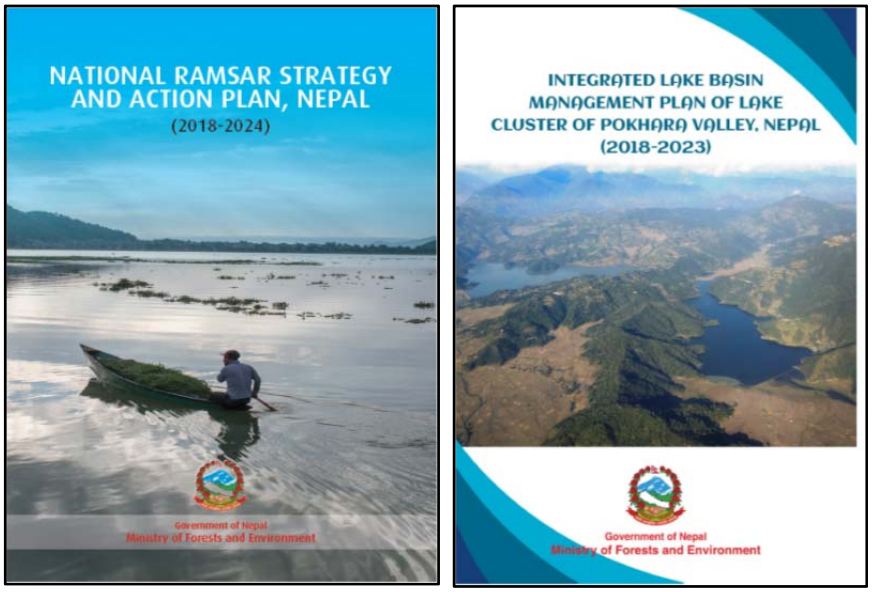

Figure 8. The most recent policy and management documents guiding intervention in LCPV

6.2 Institutions

Federal level institutions: All water bodies including lakes and wetlands in Nepal fall within the jurisdiction at federal level particularly to the Ministry of Forests and Environment (MoFE). However, the ministry has no lake and wetlands specific department a committee (NLCDC) having a general mandate of taking care of issues of all lakes in Nepal. NLCDC has many limitations to recognize its execution even within the lake-regime. In addition, MoFE has the National Wetlands Coordination Committee (NWCC) presided by the ministry itself to coordinate wetlands activities. MoFE has two focal units for lakes and wetlands, one being the Ramsar Administrative Authority under the Department of the National Parks and Wildlife Conservation (DNPWC). DNPWC does not have legal say if lakes, wetlands and other water bodies are not within the Protected Area system (PAs). DNPWC administers all Ramsar sites, particularly within PAs.

The other focal unit is the Department of Forests and Soil Conservation (DoFS) which has a focal 'Wetlands Desk' but wetlands is not a focus sector for the department. Interestingly, wetlands are also cross divided within other units of the government like irrigation, aquaculture and fishery, hydropower and so on but these have hardly the interventions safeguarding wetlands. However, the Department of Water Resource and Irrigation has the Rupa Tal Conservation Integrated Development Project since 2017 to increase water level of the lake by 4 m from existing 620 m height and improve other natural amenities.

State and local level institutions: The Constitution of Nepal has provision for the state and local governments to manage lakes, wetlands and rivers. Following this spirit of the constitution, the Gandaki State has already made progress of establishing a Lake Authority empowered by *Lake Conservation and Development Authority Act-2018*. This Authority is devised for the basin governance approach and is anticipated to arrest consolidated impacts in the days to come. Similarly, Pokhara Metropolis has been executing *'Phewa Conservation Project'* with its limited capability in Phewa lake. This project also has been making small scale interventions in other lakes.

Community level institutions: LiBird is a NGO engaged in agriculture biodiversity research and development at the local level. Since 1996, LiBird has helped communities organized under the Biodiversity Resource Conservation Movement Organization (BRCMO) with three satellite cooperatives i.e., RLRFC, Pratigya Cooperative and Farmers to Farmers Cooperative (Figure 9). While the RLRFC has been able to leverage benefits to the local communities and restore the condition of Rupa Lake environment, other cooperatives are still struggling but BRMCO is now pretty non-functional. There are more than one hundred non-governmental organizations, associations and business organizations linked with lake conservation and management in LCPV.

The Seed Foundation is promoting the *Kisan* to *Kisan* program that engages communities in agriculture, livestock, bee-keeping, and vegetable farming. The Pragya Cooperative implements NTFP-related activities, and has a nursery in the Begnas lake basin. The Machhapuchre Development Organization is engaged in biodiversity-based livelihoods, including orchid conservation in the Panchase area. The Boat Associations in Phewa and Begnas provides recreational boating services in their respective areas.

Each lake has community run institutions for the management of the respective lake like RLRFC, and those institutions are united under an umbrella - The Pokhara Valley Lake Conservation Committee. The institutions in Gunde, Khast-Neureni and Dipang are active and

have been successful to access funding from different sources and execute accordingly but others are not active. Most of these institutions also receive grants from the NLCDC. Phewa and Begnas Lakes have association of boat operators.

Figure 10 shows results of assessment of lake basin governance capacity of institutions of each lake using a tool developed by RCSU and ILEC 2014, though such governance is still emerging. The community insitutions in LCPV have weak governance in view of institutional capacity, enforcement of formal and informal policies, stakeholders' participation, generation and dissemination of information and financial capabilities. Lake governance in Rupa is comparatively better than governance of other lakes.

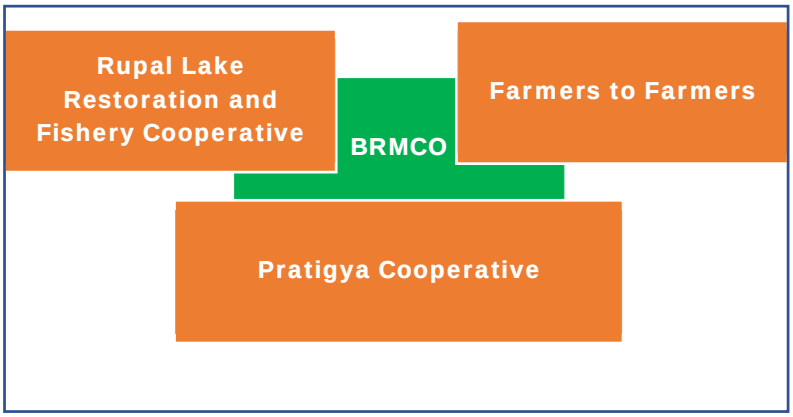

Figure 9. Three Satellite Cooperatives under BRCMO in Rupa-Begnas of LCPV

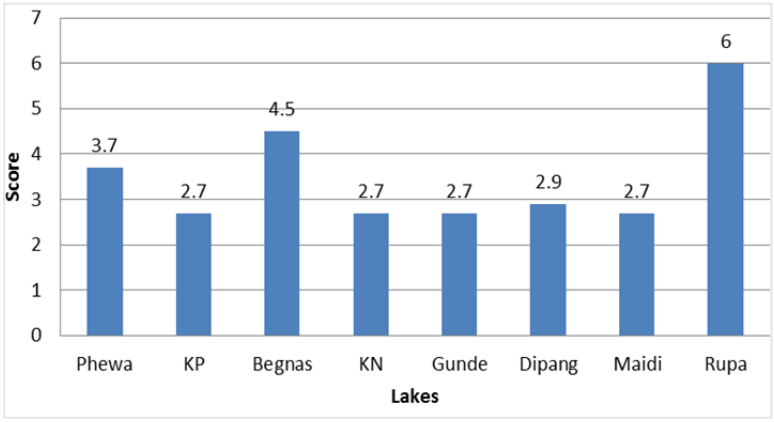

Figure 10. Community level basin governance
(results of assessment using a tool developed by RCSU and ILEC, 2014)

6.3 Participation

As manifested Section 6.2 above, there has been increasing trend in the participation of communities and their organizations, NGOs, governmental units and international cooperation

for improving the lakes and wetlands environment in LCPV. In 2016, there was an overwhelming mass of communities in Pokhara in a procession welcoming the declaration of LCPV as the 10th Ramsar site of Nepal. It was the first event where communities welcomed the establishment of a Ramsar site in Nepal in mass (Figure 11). The Greater Citizen Movement for the Sanitation of Pokhara has been in operation from 2017, and it has significantly enhanced the awareness level among the public and people for the cleanliness of city centers, lakes and wetlands. As a result, there are many governmental, non-governmental, business and trade organizations, educational entities, cooperatives, women and Community Forest Users Groups and so on developing nexus together to consolidate their actions for the synergy in LCPV.

Figure 11. Historic procession of declaring LCPV as the 10th Ramsar site in Nepal
(Left: Procession in progress, Right: Certification of Ramsar site to former Minister of the Ministry of Forests and Soil Conservation, Feb 2, 2016)

6.4 Information and Technology

Nepal's wetlands basically follow the guidelines of Nepal especially the 4th Ramsar Strategic Plan (2016-2021), the CEPA Strategy of Ramsar (2011-2015) and the Nepal's National Wetlands Policy (2012). These strategies and policy intend to produce a range of products and tools to generate conservation education and public awareness. Academic centers like Tribhuvan University and Kathmandu University have curricula based graduate programs for research based information generation. The Resource Himalaya, an NGO, conducts annually a Graduate Symposium including wetlands component. IUCN Nepal, WWF Nepal and ICIMOD are knowledge generating institution with research based knowledge publication and dissemination. In addition, some non-governmental organizations like Conservation Development Foundation, Botanical Society, Bird Conservation Nepal, Green Governance and so on also conduct field based research and organize symposia. However, there is a need of consolidated mechanism in Nepal in generating issues based information about wetlands as the basis for management intervention at basin level. Besides, some media regularly disseminate issues of lakes and wetlands. CODEFUND announced the publication of the Himalayan Wetlands Journal in 2018, but it has not yet come out.

Most of the lakes and wetlands at grass-root are being managed conventionally using indigenous technology and tools. In the past, JICA and ADB made efforts to improve the environment and sanitation of Pokhara City including the sewage management of Phewa Lake, but these mega projects terminated before completion. Recently for some years, lake and wetland basins are damaged elsewhere due to the use of heavy equipment for constructing road networks and

transmission lines. These practices if uncoordinated and on ad-hoc basis may have severe consequences on lakes and wetlands. It is utterly important to understand the lakes and wetlands as dynamic ecosystems that follow the law of science. Wetlands friendly technology and knowledgeable expertize are therefore necessary to intervene in these ecosystems by adopting hardware, software and heartware approaches.

6.5 Finance

The Government of Nepal has been in discussion for a separate national budget code for any investment in lakes and wetlands. However, there has been a tremendous progress in allocating government budget for the lakes and wetlands in Nepal including in the LCPV[11]. The government fund from its executing institutions has the objective of promoting lakes for lake tourism and sustainability of the biodiversity in lakes and their basin, therefore the funding on lakes and wetlands from these institutions would follow the government's fiscal plan regularly. Besides, the Department of Water Resources and Irrigation is the next special project of government that has been investing in the Rupa lake through its integrated project aiming to improve lake and basin environment[12]. NLCDC also provides funds to specific projects for some lakes, though these funds are small and not regular but extremely important to keep pride of community initiatives.

There are some projects supported by Hariyoban Program (WWF), Nepal (USAID), and the Kidanaren Nature Conservation Fund (Japan) directly to the communities' initiative of improving lake basin governance particularly to Khast-Neureni, Gunde and Dipang Lakes. Funding in LCPV is encouragingly available and seems adequate, however use of these funds may need to strictly follow strategic directions and guiding principles of the 4th Ramsar Strategic Plan (2016-2021) and Nepal's National Ramsar Strategic Plan and Action (2018-2024), and the spirit of the Integrated Lake Basin Management Plan of Lake Cluster of Pokhara Valley, Nepal (2018-2023) for the synergy. Having the provisions set by these documents will greatly reward the Gandaki State and Pokhara Metropolis for their current effort of declaring Pokhara city as the *Lake City in Nepal*. In this regard, the international cooperation such as from the Ramsar Secretariat (Switzerland), ILEC (Japan), Wetlands International and other institutions, and the cooperation from institutions working in this field in Nepal will remain very instrumental to ILBM implementation at the different tiers of government in Nepal.

7. Conclusion

LCPV is the 10th and only Ramsar site in the mid-hill region of Nepal that has been adding value in devising Pokhara as a very special lake-tourism vantage, *'City of Lake Garden'* also frequently referred 'Nepal's Tourism Capital'. Each lake differs in habitat mosaics, water body and species diversity.

The cluster hosts a rich floral diversity with 362 species including 32 species of orchid with 10 endemic, and is regarded as 'Treasure Land for Orchids'. New records of *Dischidia bengalensis* and *Phreatia elegans* from Phewa basin opens avenue for the need of extensive research to

[11] For example, the government of the Gandaki State from its focal ministry the Ministry of Tourism, Industry, Forests and Environment has allocated about US $ 1 million for the Lake Authority in addition to US $ 1.1 for different lakes in 2019/2020. Pokhara Metropolis through its regular fiscal allocation has about US$ 2 million for environment and climate change plus US$ 1 million for the silt-trap project in Phewa lake alone for 2019/2020.

[12] This project is the largest project of government making such a big sum US $ 9 million for lentic water system in 2016/17. This project is in progress of increasing its investment worth US$ 28 million by 2020.

explore wider spectrum of biodiversity. Further, the cluster hosts 128 species of vertebrates including a number of noteworthy mammals like vulnerable clouded leopard, endangered Indian pangolin, and birds like critically endangered Baer's pochard and Indian vulture, globally threatened Comb duck, *Aythya baer* and Ferruginous Duck. The Eurasian otter is found in Rupa and Begnas, smooth coated otter in Vijayapur Khola, and indigenous fish Mahseer, Golden Mahseer, Katle and Rewa in Phewa, Begnas and Rupa. Rupa, Begnas, Dipang and Khaste harbor wild rice Oryza nivar, and maintain wild gene pool of cultivated rice. *Tinospora sinensis* and monogeneric species of *Ceratophyllum demersum, Trapa natans* and *Typha angustifolia* are important agrobiodiversity of the cluster. The information on biodiversity is based on verification of those during one season assessment, so biodiversity treasures of LCPV may go higher once the cycle of scientific assessment gets done.

There has been significant change in landuse in the past 20 years. The forest and shrubland has been increased. River and stream area has decreased with an increase in sand and sediment areas in Phewa basin. Water bodies in Phewa, Begnas, Maidi, Kamalpokhari, and Gunde have decreased but increased in other lakes, with Dipang almost doubling in area. Similarly, cultivated land is decreasing in the cluster with the increase in built up areas and urbanization. The significant change in landuse in the past might have implications in quantitative and qualitative characteristics of lake ecosystem and its biodiversity in the cluster which needs further enquiry. All lakes are degrading due to anthropogenic activities leading to the encroachment, siltation, pollution and invasion of alien species in parallel with impacts of climate change.

There exists so many lakes and wetlands related policies and strategies including dozens of acts backed by regulations and environmental standards. Conservation and management of lakes and wetlands falls under several institutions, with overlapping mandates. The government of Nepal has recently devised the Integrated Lake Basin Management Plan of Lake Cluster of Pokhara Valley in 2016 and the National Ramsar Strategy and Action Plan (national policy framework to guide the implementation of Ramsar) in 2018. These documents are very useful in the context of improving weak lake basin governance by the state and metropolis, therefore strengthening basin governance in LCPV is the next immediate priority to implement a drive of the *Lake City of Nepal* making Pokhara a combined key of tourism and biodiversity destination in Nepal. While doing this, the government and local communities may need to fully internalize the strength of Integrated Lake Basin Management Plan of Lake Cluster of Pokhara Valley. This will help consolidating all pillars of ILBM within the organogram of the Lake Authority, which is expected to be in full operation soon. The Lake Authority itself is the response of the state for the basin governance in LCPV. Further, funding seems not to be a problem in LCPV. In this view, a collaboration with likeminded international and national entities may help delivering synergy.

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