特集論文

Integrated Lake Basin Management (ILBM) for the Sustainable Conservation of Himalayan Lakes of Nepal

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Himalayan lakes of Nepal have different conservation pictures. High mountain lakes in Nepal are virgin in terms of human intervention. Lakes in mid-hill and Terai are subjected to different kinds of natural and human pressures that have impacts on degradation and loss of habitat, loss of ecological integrity, and depletion of species abundance and diversity. An alarming problem that the Himalyan lakes are facing is the threat imposed by climate change - over 26 lakes of Nepal are under threats due to GLOF. Their conservation is urgent to serve human civilization since they are sources of freshwater supply to billions of people; they are the gene pools of nationally and globally significant biodiversity; they are sternum of national economy, religio-culture; and ecotourism; and the only means of survival for 10 percent wetlands dependent ethnic community of Nepal. ILBM is a globally accepted management tool propounded by ILEC which NLCDC see very applicable to address the Himalayan issues. NLCDC has been implementing ILBM from the development of strategic framework of lake conservation to lake inventory and execution of lake restoration programs in Nepal. This paper explains about the Himalyan lake issues, their global significance, trans-Himalayan nature, biodiversity values and their threats; and finally focus on ILBM application in Rupa lake, Pokhara. ILBM helps improving governance through strengthening policy, institution, practices, finance, information and technology. Rupa is one of the best demonstrations of ILBM integration for better lake health - better livelihoods.

Keywords: Biodiversity, Conservation, Governance, Himalayan, ILBM, Lakes, Wetlands

1. Introduction

At a stretch of 3000 km of eco-regions of the Eastern Himalaya, in between China and India, Nepal occupies a space of 1,47,181 km^2 (84^0 4' to 88^0 12' longitudes and 26^0 22' to 30^0 27' latitudes). Nepal's total land area compares with 0.03 and 0.3 percent of the globe and Asia respectively. The country has east-west mean length of 885 km, and north-south mean breadth of 193 km. Altitude varies from 70 m to the Mt. Everest (8848 m) - the highest peak of the world. The country has an extreme topography and climate that varies as altitudes vary from south to north from sub-tropical to tundra. In terms of physiography, the country characterized with its five physiographic zones - High Himal (23 %), High Mountains (20 %), Mid-Mountains (30 %, Siwalik (13 %) and Terai (14 %). Administratively, country is divided into 75 districts, 3912 Village Development Committee, one metropolis, four sub-metropolitan cities, and 53 municipalities. Country's population is 2.6 million with a growth rate of 2.25 percent in 2007. Over 80 percent of the total population lives in rural areas and are engaged in subsistence agriculture farming. Literacy rate is 54.1 percent on an average (Male: 65.5 ; Female: 42.8 %).

Lake in Nepal does not have a technical definition. However, Nepal's National Wetlands Policy (2003) defines wetlands as *"natural or artificially created areas, such as*

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swamp, marsh, riverine floodplain, lake, water storage area and agriculture lands containing water from underground water resources or atmospheric precipitation that may be permanent or temporary, static or flowing, and freshwater or saline". This definition recognizes lake as a type of wetlands. National Lake Conservation Development Committee (NLCDC) defines lake in a very loose form as *"all kinds of Tal, Talaiya, Daha, Kunda and Pokhari"*[1]. Nepal is famed for its biological hotspots and is also enriched with over 6000 rivers including, 3252 glaciers, 2323 glacial lakes, 23000 ponds, 163 wetlands and over 2700 lakes of ox-bow-types in the Terai, and over 480 tectonics lakes in the middle mountains. Many lakes in high mountains are of smaller sizes and are often called *Kunda* or *Pokhari*, where as in alluvial flatlands of Terai, they are *Pokhari*. Lakes provide water for irrigation as in Begnas. It maintains biodiversity i.e., Rupa, Rara, and Mai Pokhari. Many lakes have religio-cultural importance as in Gosainkunda, Jatapokhari and Salpapokhari. A total of Nepal's 10 percent of indigenous and ethnic communities' population of *Tharu, Mushar, Kewat, Dusadh, Mallah, Kumal, Majhi, Danuwar, Dhangar, Bantar, Darai,* and *Bote* have sole dependence on lakes/ wetlands resources (Pokharel and Adhikari 2009).

1.1 Nepal's Lakes of International Importance

A total of 9 lakes of Nepal have been designated into the Ramsar list. They are: the Koshi Tappu (17,500 ha); Beeshazari Tal (3,200 ha); Jagdishpur Reservoir (225 ha); Ghodaghodi Tal (2563 ha), Rara Tal (1,036·ha), Sheyphoksundo Lake (452 ha), Gokyo Lake Cluster (42.69 ha), Gosainkunda Lake Cluster (13.80 ha) and Mai Pokhari. Of this, four lakes represent flatland tropical to sub-tropical ecosystem with domination of *Shorea robusta* and *Lagerostromia parviflora* forest. Remaining five lakes represent high altitude ecosystem with temperate to sub-temperate vegetation. These lakes contribute 0.05 percent of total coverage of lakes of the global significance.

1.2 Potential Himalayan lakes of international significance

Table 1 shows potential Himalayan lakes of Nepal of international significance. They are unique in terms of geographical representation, biodiversity hotspots, and religio-cultural and high hydrological values claiming to the Ramsar enlisting. Others such significant lakes are Raja Rani of Morang district, Jata Pokhari of Dolakha district, and lake-cluster of Pokhara valley. Raja Rani is significant due to habitats of rare orchids, butterflies and origin place of an ethnic community called *Dhimal* who later migrated to areas south towards Jhapa and Morang districts. Lake-cluster of the Pokhara valley bears unique geography, higher biodiversity, religio-cultural values and ecotourism in the mid-hills of Nepal. Chimdi lake in Sunsari district is biological hotspots for nationally important avifauna, amphibians and reptiles. Jata Pokhari is well famed for its religio-cultural values for the *Hindu, Buddhist* and other religious communities of Nepal. Azingara lake in Kapilvastu is renowned for habitats of wild rice, fishes and amphibians. Potentials of many other Himalyan lakes are still unexplored therefore requires further investigation.

Tab. 1 Potential Himalayan lakes of global importance

Name	Location	Height (m)	Area (ha)
Tilicho lake	Annapurna CA	4848	400
Dudh Pokhari	Dolpa	4633	32
Jata Pokhari	Upper Khimti	3500	24
Jageshwar Kunda	Trisuli basin	4380	
Surya Kunda	Trisuli basin	4609	5
Bhairab Kunda	Trisuli basin	4261	17
Panch Pokhari	Makalu Barun NP	4971	NA

1.3 Trans-Himalyan lakes of Nepal

Many lakes of Nepal being the origin of rivers have trans-boundary characters. River systems link Nepal with China, Bangladesh and India. For examples, Koshi, Gandaki, Karnali and Mahakali are perennial sources of water to downstream population of Nepal, India and Bangladesh. Any changes made - naturally or artificially- in glacial features in the Himalaya would also impacts on

[1] 'Tal' is a Nepali terminology that denotes 'lake' in the English. Similarly 'Talaiya' is a rhetoric form of 'Tal' commonly used together with 'Tal' as Tal-Talaiya. 'Daha' are water bodies or pockets formed by rivers in their routes. 'Kunda' means small water pockets especially in mountain watersheds, and is main source of drinking water supply for the mountain communities. Several 'Kunda' in Nepal have pertinent socio-economic-cum-religious values.

Tab.2 Trans-boundary Himalayan lakes of Nepal

Name	Location	Height (m)	Area (ha)
Rara	West Nepal	2990	1036
Gosainkunda	Langtang NP	4360	14
Tilicho	Annapurna CA	4848	400
Sheyphoksundo	Shephoksundo NP	3650	452
Dudh Pokhari	Dolpa	4633	32
Jata Pokhari	Upper Khimti	3500	24
Jageshwar Kunda	Trisuli basin	4380	
Surya Kunda	Trisuli basin	4609	5
Bhairab Kunda	Trisuli basin	4261	17
Gokyo	Sagarmatha NP	4734	43
Panch Pokhari	Makalu Barun NP	4971	NA

ecological behavior of rivers therefore to the livelihoods of billion of people residing at downstream areas in India, Bangladesh and Nepal. Many trans- Himalayan lakes of Nepal falls in north of Nepal and are close to the Tibet, their downward flow along with other water bodies having their sources in lesser mountains and mid hills is a common concern of India & Bangladesh as well. Table 2 shows trans-boundary Himalayan lakes of Nepal. Scientific information is fairly available in many of these lakes like Rara, Sheyphosundo, Gosainkunda and Gokiyo which also are the lakes of global significance. However, a comprehensive information requires to explore in remaining other lakes. An opportunity already has been explored because of the Ramsar Convention that provides a framework for the Himalayan Initiative: Conservation and Wise Use of Himalayan Mountain Wetlands. All these four countries are the contracting parties of the Convention, and they owe maximum opportunity for international cooperation from raising funds to the implementation of trans-Himalayan wetlands initiatives. Further, ILEC has been promoting ILBM throughout globe including India, Nepal, Malaysia, Indonesia, the Phillipines, South Korea, Mexico, Russia and China which provides greater opportunities to the South Asian nations to integrate their development by integrating lake basin management of their lakes.

1.4 Himalayan lake biodiversity in Nepal

Himalayan lakes are storehouse of nationally and globally significant biodiversity. It is believed that 25 percent of Nepal's vascular plant species are lake/wetland dependent. Of 246 endemic plants, about 26 species are considered as lake/wetland dependent (IUCN, 2004). Of 91 nationally threatened plant species, 10 are lake/wetlands dependent (CAMP 2001) including the **Endangered** *Aconitum balangrense, Crateva unilocularis, Operculina turpethum; and, Vulnerable Alstonia scholaris, Butea monosperma, Neopicrorhiza scrophulariifolia, Valerina jatamansii, Piper longum, Panax pseudo-ginseng,* and *Delbergia latifolia*. Four wetlands macrophytes - *Spiranthes sinensis, Cyathea spinulosa, Sphagnum nepalensis, Pandanus nepalensis* - are also considered nationally endangered (Joshi and Joshi, 1991). Endemic species like *Kobresia fissiglumis, K. gandakiensis, Pedicularis poluninii,* and *P. pseudoregelina* reported from Gokyo lake, and 9 endemic species from Gosaikunda lake. An endemic bryophytes *Sphagnum nepalense* reported from the Mai Pokhari (Joshi *et al.*, 2007).

Of 207 mammals of Nepal, the key globally threatened mammals that are lake/wetlands dependents include the **Critically Endangered** Pygmy Hog (*Sus salvanius*), this species is believed to be extinct now; **Endangered Gangetic** River Dolphin (*Platanista gangetica*); Wild Water Buffalo (*Bubalus bubalis*), Greater One-horned Rhinoceros (*Rhinoceros unicornis*) and Elephant (*Elephas maximus*); **Vulnerable** Indian Smoothed-coated Otter (*Lutrogale perspicillata*), and Common Otter (*Lutra lutra*), Fishing Cat (*Prionailurus viverrinus*) and Barasingha (*Cervus duvaucelii*). Nepal documents 863 species of birds of which 193 species (22.5 percent) are lake/wetlands dependent - including 187 species of birds dependent to the Terai wetlands. As many as 39 species of these are identified as threatened on a national level (Baral *et al.* 1996). Table 3 shows 12 species of globally threatened lake/wetlands birds of Nepal.

Of total 185 species of fishes of Nepal, 8 are endemic. Of this, 27 species are reported to be nationally threatened including **Endangered** Sahar (*Tor putitora*), Jalkapoor (*Clupisoma garuwa, Ompak bimaculatus*); **Vulnerable** Katle (*Neolissocheilus hexagonolepis*), Patharchatti (*Chagunius chagunio*), Zebra (*Danio rerio*), Asala (*Schizothorax richardsonii*), Bucche Asala (*S.*

Tab. 3 Globally threatened Himalyan lake/wetlands dependent birds of Nepal

Common Name	Scientific Name	Status
Pink-headed Duck	*Rhodonessa caryophyllacea*	CE
Greater-adjutant	*Leptoptilos dunius*	E
Lesser Florican	*Sypheotides indica*	E
Baikal Teal	*Anas farmosa*	V
Swamp Francolin	*Francolinus gularis*	V
Baer's Pochard	*Aythya baeri*	V
Grey Pelican	*Pelecanus phuilippinensis*	V
Sarus Crane	*Grus antigone*	V
Indian Skimmer	*Rynchops albicollis*	V
Black-necked Crane	*Grus nigricollis*	V
Lesser Adjutant	*Leptoptilos javanicus*	V
Band-tailed Fish Eagle	*Haliaeetus leucoryphus*	V

plagiostomus), Chuche Asala (*Schizothoraicthys progastus*), Rajabam (*Anguilla bengalensis*); and 17 species listed as **Rare**. Similalry, Himalyan lakes are habitats for several herpetofauna including a primitive amphibian Himalayan Warty Newt (*Tylototricton verrucosus*), type locality species Lekali Khashare (*Bufo himalayanus*), and endemic species Jhikre Bhayguto (*Limnonetes nepalensis*) reported from Mai Pokhari of Ilam district (Joshi *et al.*, 2007). A little is known about butterfly diversity, though 64 species of butterflies including an endemic sub-species *Parnassius epaphus* and suspected species *Mesoacidalia clara shieldsii* to be an endemic are reported from lake Rara and its vicinity (Khanal 2007).

1.5 Threats to the Himalyan lakes of Nepal

High mountain lakes in Nepal are virgin in terms of human intervention. However, lakes of the middle mountain and the Terai are subjected to different kinds of human and natural pressures that have impacts on degradation and loss of habitat, loss of ecological integrity, and depletion of species abundance and diversity. Lake encroachment is heavily associated with human activities. Some other threats are:

Lake drainage and reclamation: Draining out of water from lakes for dry-season crop irrigation is widespread in Nepal. Many lakes in the Terai do not have water-feeding inlets. So, draining out of water ultimately led to the subsidence of lakes. Conversion of sites for aquaculture, road construction, solid-waste disposal, discharge of sediments, commercial and industrial development, dam construction, eutrophication, etc. normally accelerate soil reclamation process. Phewa lake is the best manifestation of it showing a decrease in area from 10 km^2 (1956/57), to 5.5 km^2 ('76) and 4.4 km2 ('98). There has been more than 50 percent reduction in area within 5 decades (JICA/SILT, 2002).

Habitat fragmentation: Mid-hills and Terai support the highest human population density settlements in Nepal, and resources for them readily comes from forests in the form of timber, fuelwood, fodder, litter and other products. Settlements and agriculture fields are made available at the cost of clearing forests that also has survival impacts on lakes. Fate of lakes also depends upon fate of forests. Forests connectivity decreases with increased habitat fragmentation, thereby creating barriers to wildlife movements; decreasing safety; reducing food availability; and enhancing poaching. Ultimately, it diminishes mega-population of wildlife-particularly of mammals and herpetofauna- into genetically isolated sub-population with a high risk of loss of viable population of wildlife.

Non-integrated intervention: Lakes represent complex and dynamic ecosystem with high ecological productivity which has not been internalized into management approaches. For example, Aquatic Protection Act (1961) imposes restriction on harvesting of certain types and sizes of fishes, but vegetation, water quality, irrigation, and ecological integrity are no more concerns under this provision. Similarly, irrigation activities often deal with water use provision. Other several activities undertaken in and around lakes quite often ignore the lake values and functions thus impacting on structure and functions of lake ecology.

Hydro-power development: With a total estimated hydropower potential of 83,000 MW, Nepal has yet harnessed only 550 MW, and a very little of it is generated from lakes like the Tsho Rolpa (15 KW), Kulekhani reservoir (92MW), and Phewa (1 MW). It has been observed that hydropower developments have several positive socio-economic impacts on the livelihoods; it may have some consequences on the formation of new

lakes. Some anecdotal evidences - particularly in river basins (Koshi, Karnali, Mahakali) - showing ecological impacts of hydropower dams on reducing viable population of aquatic *flora*, fishes and ungulates. Nepal has 15 ungulate species dependent on lake/wetlands. Koshi Tappu, the only site with a viable population of Asian Wild Buffalo, has lost over half of its endemic ungulate species. Dam once combined with unregulated grazing, over fishing, deforestation, expansion of settlements, solid waste and sewage disposal, water harvest etc., further aggravate impacts on ecological integrity of lakes.

Irrigation: Himalyan lakes are natural water-feeder to downstream, and are headwater for rivers in Nepal. Himalyan lakes are of comparatively smaller water bodies that favor short-cycle irrigation needs, and require much time to refill water volume. However, unregulated irrigation alters micro-climate of lake ecosystem by sudden and frequent fluctuation of water chemistry thereby impounding impacts on aquatic life. Conversion of the Chimdi lake in Sunsari district has displaced some 200 fisheries family, and has questioned upon the survival of many potter communities (Gachhadar *et al.* 2004). Water from Rajarani Pokhari of Morang district is used to irrigate farmlands of over 65 families. The Begnas is the only lake in Nepal with huge dam structure made for irrigation. Once productive agriculture and marshy fields around Begans is now subjected to rapid conversion into dense suburb and semi-commercial areas, and high density population of eel fish of the Begnas is no more in existence.

Agriculture run-off: Agriculture will remain as active sector for many years in Nepal to sustain increasing population. Pesticides like Phoret, Thiodan, Methyl Parathion and Cypermethrin are used for poisoning birds to prevent crop predation as well as for bird hunting. Though banned, DDT, Dieldrin, Aldrin, and Endrin are also in use. An estimated 2,600 tons of pesticides and 1.15 million tons of chemical fertilizers are dumped annually in the Ganges river system (IUCN 2004). Agriculture-run-off affected 69 percent of wetlands of Nepal's Terai. Impacts are bio-accumulation in higher-level animals leading to high concentration of toxic products causing death, sub-lethal effects and reduce reproductive capabilities (Pesticide poisoning led 300 people admitted to 10 hospitals in 1992); widespread occurrence of Epizootic Ulcerative Syndrome, a disease caused by the fungus *Aphanomyces invadans* in fishes causing their mortality in Koshi Tappu (1983) and Ghodaghodi lake (1998); lake conversion from mesotrophic to eutrophic in Koshi Tappu; natural succession aggravated by overgrowth of aquatic macrophytes like water Hyacinth and Trapa as commonly seen in many lakes of the Terai and mid-hills.

Sewege Disposal: Himalyan lakes in urban and sub-urban are treated as sink for the disposal of untreated domestic sewerage, septic tanks and untreated effluents. All ponds in Kathmandu valley are extremely polluted. Media reports on concurrence of chronic diarrhea and dysentery in the Terai often caused by the use of highly contaminated pond water with faecal coliform bacteria. Over 100 numbers of toilets directly exposed into holy lakes of Janakpur - the Ganga Sagar and Dhanusha Sagar. The Phewa lake is reported to have $8X10^6$ coliform per 100 ml (Khatiwada 2008). Similarly, a free washing of clothes and cooking utensils by hotels, restaurants and households discharge 100 kg of soaps and detergent every day into this lake.

Sedimentation: Landslide, sheet erosion, soil erosion, and draining of water from agriculture fields often are sources of sedimentation in the lakes of mid-hill and high mountains. 69 percent of the Terai wetlands are threatened by sedimentation. Dry surface area in the lake-head of the Phewa and Rupa lakes have appeared due to sediment deposition carried by the Harpan Khola and Dovan Khola respectively at the cost of reduced water coverage. In 1961, the area of the Phewa was 10.35 km^2 that came down to 5.8 km^2 by 1981.

Fishing: Aquatic Life Protection Act (1961) prohibits the ban on certain species of fishes and turtles with respect to their prescribed sizes. Though, over-fishing often multiplied by destructive fishing practices has caused reduction fish population of many species under breeding-size. The trend of fish poisoning with Thiodine

and Phoret is widespread in the Terai including Koshi Tappu and Ghodghodi lake. Other mal-practices for fishing include elctro-fishing, use of small-mesh nets, draining out of water, and use of explosives. Such practices have caused a mass killing of aquatic *fauna* as well as affected food chain of ecosystem. For example, over-fishing in the Rupa and Begnas lakes declined the population of sahar (*Tor spp.*) thereby reducing fish-eating bird population.

Grazing: Himalyans lakes are subjected to open grazing for yaks, sheep and goats around in Damodarkunda, Gokyo, Gosainkunda, (Karki *et al* 2005, Karki 2007, Shrestha 2005). Over 12,600 cattle are recorded grazing along shoreline forests of the Ghodaghodi lake and some 15,000 to 20,000 in Koshi Tappu, every day. IUCN (2004) reports on impacts of over-grazing and livestock movement resulting to soil erosion and high inputs of nitrogenous nutrients into lakes, accelerating eutrophication and over-growth of aquatic macrophytes, which again leads to destruction of suitable habitats of birds and aquatic *fauna*. Overgrazing also correlates with livestock health due to poor nutrients, inadequate food supply and high population pressure, making livestock exposed to diseases like liver fluke associated with marshland snails. Such disease when transmitted as epidemics to wild ungulate causes extinction of species[2].

Deforestation: Over 75 percent of the energy resources and over 40 percent of fodder supply comes out from forests. Further, the forests in Terai are completely cleared for the settlements, urban development and agricultural activities except in some places and within PAs. Forests in the mountain areas not accessible for all-season transportation are still either managed by communities or government. In either case, forest around the lakes, and their upstream areas are often subjected to deforestation leading to landslides and soil erosion, which leads to the loss of suitable habitats of birds, fishes, amphibians and aquatic *flora*. Condition of lakes even worsens when deforestation combines with sedimentation, chemical pollution, sewage disposal, excess draining out of water, over-fishing, gazing, and so on.

Climate Change: In 1999, a report by the International Commission for Snow and Ice (ICSI) states *"glaciers in the Himalaya are receding faster than in any other parts of the world and, if the present rate continues, the livelihoods of ... disappearing by the year 2035"*. Similar prediction indicates that *"glaciers in the region will vanish within 40 years as a result of global warming"* and the flow of Himalayan rivers will eventually diminish, resulting in widespread water shortage (New Scientist 1999; 1999, 2003). In Nepal, warming rates increases progressively with elevations (Liu and Chen 2000; Shrestha *et al.* 1999). High warming causes rapid deglaciation that alters hydrological regime of the river basins such as increase in floods and drought frequency and magnitude; some time formation of glacial lakes in the open area around exposed end moraines; and increases vulnerability of glacial lakes to GLOF. Nepal already faced 25 GLOF in the past (Shrestha, 2007), and 26 glacial lakes have potential threats of the GLOF including the Tsho Rolpa (largest glacial lakes of Nepal grew from the area of 0.23 km^2 in 1957 to 1.76 km^2 in 2006) and the Imja Tsho. Similarly, climate change pushes forest line towards polar region and their composition and extinction of species, including bird species (Baral 2002). Tropical wet forests and warm temperate rain forests would disappear, and cool temperate vegetation would turn to warm temperate vegetation. With the marginal increase in temperature may prolong dry-crop period in the Terai that may demand more water for irrigation at the cost of increased risk on lake conversion and loss of aquatic biodiversity.

2. Conserving the Himalyan lakes of Nepal

Lake conservation gradually evolves in Nepal with the issues of forest and biodiversity conservation. The government brought all forests under its suzerainty during the first three Five-Year Plans (1956-1971) in which high emphasis were given to improve infrastructure development like boundary demarcation;

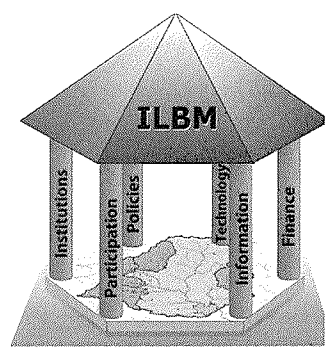
[2] Population of Asian Wild Water Buffalo in the Royal Chitwon National Park in the early 1960s may have become extinct due to diseases transmitted by domestic cattle and buffaloes brought in by immigrants settling around the park areas.

forest survey; construction of the fire lines; nursery and plantation; forest roads and buildings; and preparation of management plans (Sharma *et al.*, 2004). Lakes conservation was no more a concern until this period. A notion of environmental degradation was realized first time with the formation of new Moore islands in the Bay of Bengal. This concern was high since silt load transported to the Bay was evidenced at a high cost of landslides, erosions and floods associated with intense deforestation in Nepal. Hence from 1972 to 1978, Nepal had next priority on forest management to address environment issues through first National Forestry Plan (1976) and community forestry (1978). As a result, watersheds, rural development, livelihoods, capacity and institutional strengthening, and research components were integrated in forestry sector (Sharma *et al.*, 2004). In this period, Nepal also became a party of the Ramsar Convention in 1972 and established its first Ramsar site-the Koshi Tappu Wildlife Reserve in 1976.

An extent of progresses Nepal made in conservation is guided through its commitment in international conventions and treaties like Ramsar (1972); Convention on Protection of Wildlife and Cultural Heritage (1972); Convention on International Trade of Endangered Species (1973); CBD (1992); and Convention on Climate Change. As responding to these conventions, Nepal developed and implemented the National Conservation Strategy (1987), Nepal Environment Policy and Action Plan (1993), Water Resource Strategy (2002), Nepal Biodiversity Strategy (2002), Nepal Biodiversity and Action Plan (2002), Wetlands Policy (2003), Nepal Biodiversity Sector Implementation Plan (2006) and so on. Lake conservation formally begins in Nepal from 1976 with establishment of the Koshi Tappu Wild Life Reserve. Otherwise, issues of lake remained completely ignored until staging of Nepal Biodiversity Strategy (2002) which first time pledged for the need of unified national wetland policy and legislation. Consequently, National Wetlands Policy (2003) came into effect as a keen response to conserve wetlands resources wisely and sustainably with a successive formation of NLCDC in 2007. This is the only government institution aiming to coordinate national and international bodies; formulate and implement policies and programs; and build national and international partnership with respect conserving Himalayan lakes of Nepal.

2.1 ILBM in conserving Himalayan lakes

Lakes have integrating nature, long retention time, and complex response dynamics. Individually these characteristics are not unique to lakes - for example, ground water also has a long retention time, and estuaries can have complex dynamics. But the combination of all these characteristics makes lake unique. Further, Himalyan lakes of Nepal are special, because their origin follows diverse topography varying from subtropical to tundra climate; they are the Asian water towers; they support conventional agrarian socio-economy and complex ethnic society; and forms religio-cultural foundation for the *Hindus, Buddhist* and other communities. Within these complexities, the Himlayan lakes are exposed to several threats (see 1.5). Their sustainable conservation is urgent to serve human civilization since they are sources of freshwater supply to billions of people; they are the gene pools of nationally and globally significant biodiversity; they are sternum of national economy, religio-culture; and ecotourism; and the only means of survival for 10 percent wetlands dependent ethnic community of Nepal. ILBM is a comprehensive management tool that advocates on lake governance. It has six induction governance pillars *i.e.,* institutions, policies, participation, technology, information and finance. Integration of these components fairly harmonizes lake issues. Since 1990s, Nepal has been practicing management of forest, pasturelands, watersheds and water through integrated approach by involving local people and institution. Better experiences from these sectors could be a value addition on ILBM to address the issues of Himalayan lakes. For this cause, NLCDC has been working with Japan based ILEC since 2007. ILEC has been facilitating NLCDC to convene its



lake conservation cases in international forum; enabling it to undertake assessment of the Himalyan lake conservation; providing technical inputs and guidance; and enhancing technical capacities. In May 2009, NLCDC had influenced CAP-Net workshop organized by Bangladesh Center for Advance Studies (BCAS) with an outcome of establishing the South Asian Forum for Integrated Wetlands Conservation. In August 2009, ILEC in collaboration with Indian Association of Aquatic Biodiversity had NLCDC to share its strengths in a sequence meeting in Bhopal, Udayapur, Ajmer and Jaipur.

In a process of integrating ILBM, NLCDC has completed a preliminary reviewing of the status of Himalayan lakes with the finding of 5300 lakes in Nepal, now ready to conduct field inventory to verify the validity. NLCDC would apply lake brief guideline adopted by ILEC with a little modification on it for the purpose of lake inventory. A national level core group of lake experts has been formed and operational to provide technical inputs for lake conservation programs. Development of strategic plan for the sustainable conservation and wise use of lakes has entered to the district level of consultation process in collaboration with IUCN Nepal, National Counsel for Science and Technology and National Trust for Nature Conservation. Further, it has extended technical and financial supports to restore and conserve habitats of over 50 representative lakes in different locations within the Nepal's geography. A scientific study for designating lake-cluster of Pokhara valley in the Ramsar list is in a steady progress with a financial assistance of SGP/Ramsar, this initiative would add contribution in the Ramsar with a count of 10th Ramsar site in Nepal. NLCDC has been playing an intermediary role between Action in Mountain Communities (AMC) and SGP/UNDP to integrate ILBM in an initiative of Community Safeguarding Rupa Lake in Pokhara. Here in this article, authors have made efforts to explain how six pillars of ILBM have been integrated in addressing the issues of Rupa lake based on cumulative impacts of different programs implemented by Local Initiative for Biodiversity Conservation and Research (LiBIRD), IUCN Nepal, Lekhnath Municipality, Rupa Lake Restoration and Fishery Cooperative (RLRFC).

2.2 ILBM in Rupa lake, Pokhara

Rupa is a small advancing eutrophic lake with marshes and paddy field along its shores. Lake covers an area of 115 ha in its watersheds basin is 30 km^2 and has humid upper tropical and lower subtropical climate. The mean annual temperature is 19.3^{0}C and precipitation is 3157 mm. Administratively, Rupa lake basin falls in 4 different VDCs and Lekhnath Municipality. Betani, Libiyani, Syaglung, Tal Bensi, Majhi Gaon, and Devithan in the north, Panchbhaiya and Sundare Danda in east, Bhangara and Jagunkune Gaon in west and Talpari in the south are major settlement areas. A total of 49749 people reside in the basin areas with its 47 percent male and 53 percent female population (CBS 2058). Brahmin/Chettri are dominant ethnic groups followed by Janajati and occupational groups. The major occupation is subsistence agriculture (Oli, 1996).

Rupa is recognized for 8 main vegetation types with 379 genera and 128 families that comprise 128 tree species and 85 herbs and shrubs that comprises to 25 endangered, 13 threatened, 5 rare and 2 vulnerable species of wetlands plants. Lake is a hotspot of a native of wild rice i.e., *Oryza nivara*. Species of 2 toads and 4 frogs; 14 reptiles, 104 birds including 14 migratory birds and 34 mammals also are known to occur in Rupa. Of birds, 90 species are endemic (Oli, 1993).

2.2.1 Issues

Ill-fate of Rupa environment is high sediment input fed by the Talbesi, Dovan and Khurlung Kholas and other streams. Two temporary roads under construction in east and west are carriers of silt-load into the lake. As a result, Rupa lake has lost its >60 percent of original water body (IUCN, 1996). There exist visible proofs of uncertified and intensive agriculture use along shorelines of lake.

Deforestation in Rupa watersheds follow a history of construction of the Prithivi Highway during 1960s and subsequent urbanization at lake basin areas at the cost of denudation of the primeval forest in accessible areas which became even intense during 1970-1979 (Oli, 1976). The denudation process continued to accelerate until it

reached its peak during the referendum in Nepal in 1992.

Major urban settlements are found rapidly increasing. Settlements like Sudare Danda; Talbesi and Dihibazar and Bhangara are expanding. There are no intervention adopted to regulate domestic disposals, discharge of used water, and overflow and seepage from septic tanks and latrines resulting higher organic loads and microbial growth in lake.

2.2.2 Action undertaken

Policy pillar: Conservation of Rupa has been influenced by several policies and legal instruments. They include: the National Conservation Strategy, 1987; the Nepal Environment Policy and Action Plan 1993; the Nepal Biodiversity Strategy, 2002; Water Resource Strategy 2002; National Wetlands Policy (2003); National Parks and Wildlife Protection Act - 1973 (amended 4 times) for fauna; the Forest Act - 1993 for flora; and the Aquatic Animals Protection Act - 1961 for some specific aquatic species; Pokhara Town Development Plan (1973); Town Plan Implementation Act (1972) and Conservation Action Plans and Guidelines (1996).

Institution pillar: Issues of Rupa is governed by national and local levels institution. National level institution includes: National Planning Commission; several ministries and their departments; and NLCDC. Local institution includes: District Development Committee (DDC), Kaski; Lekhnath Municipality; Village Development Committees (VDCs); Chamber of Commerce; and Rupa Lake Restoration and Fisheries Cooperative (RLRFC)

Participation pillar: Users as managers approach has been adopted in conserving Rupa through a collaborative management of local government, NGOs and local groups. They include: DDC; VDC; Chambers of Commerce; LiBIRD; AMC; RLRFC; a network "Jaibik Shrot Samranchan Sanstha" of 14 community based organizations and 17 community forest users groups. Currently, > 3000 members under this network are functional in biodiversity conservation and livelihoods by addressing social exclusion, gender balance and inequity.

Information pillar: An information center in Rupa that maintains low cost documentation of community resources like wetland museum, conference hall and library where community discuss, review and share information. Group members are trained on various fields of lake issues, livelihoods and environmental friendly income generation activities. Centre is preparing an electronic database on wetland resources; traditional knowledge and biodiversity register; aquarium of indigenous fish diversity; live garden of floral diversity; specimen of wetland resources; photographs; paintings; posters; video documentary and traditional museum of fishing technology. Annapurna FM a local radio airs "Samrakcchan" bulletin every Saturday on lake issues.

AMC and Codefund have recently initiated Lake Education Center in Rupa lake in collaboration with Lekhnath Municipality and NLCDC. In this center, each month 120 students would have opportunity to comprehend biological, hydrological, socio-economic and religeo-cultural values of lake and wetlands. This education center aims to grow its scale gradually to influence others members of society.

Finance pillar: Sustainable financing mechanism for conserving Rupa has been realized and practiced at community level through a cooperative mechanism *i.e.,* RLRFC being run by 600 users. This cooperative has an annual income of 7 million Rupees from fishery alone, certain proportion of which is annually goes to lake conservation. In 2008, RLRFC had US $ 1500 input used in demarcating lake area and manual removal of aquatic weeds. Further, Lekhnath Municipality, DDC and VDC annually contribute funds and community trust fund as project inputs from LiBIRD and AMC is in use to implement business plans of the communities.

Technology pillar: This pillar is fairly weak to address higher scale issues of Rupa lake like desiltation; dam construction; solid waste management and pollution treatment. Though, communities have been adopting local technology in energy management; fishing; value addition on crop/fruit products; and biodiversity conservation.

2.2.3 Impact of Actions

Proactive local governance: "Jaibik Shrot Samranchan Sanstha" – a conservation network - has been emerged out at grass-root level. This has strengthened "institutional pillar" of ILBM. This network has classified

conservation action under 3 groups. They are - conservation of wetlands; conservation of agriculture and horticulture resources; and conservation of NTFPs. RRFC is undertaking management lead of wetlands conservation with the involvement of wetland dependent communities including *Jalahari* and with collaborative inputs of district/VDC level government and NGOs. Pratigya cooperative is another local institution responsible to coordinate all livelihoods related activities. This cooperative facilitates activities by direct linkages with wetlands conservation through promotion of pro-environment agriculture and horticulture practices in partnership with the Lekhnath Municipality. This cooperative also promotes environmentally sound NTFPs cultivation in Rupa watersheds.

Organized biodiversity conservation: An innovative approach to conservation of floral and faunal species has been used in Rupa lake area by establishing conservation blocks for water birds, white lotus, Narkat, wild rice, otters and local *Sahar* fish. The conservation blocks provide wilderness areas for the species which also help to protect marsh/swamp ecosystem. These conservation blocks have played a role of community-managed gene banks. Inventories and community biodiversity registration have documented 69 species of wetland dependant plants, 22 species of indigenous fishes, 11 species of improved variety of fishes, 36 species of waterbirds, and 24 species of wetland dependant reptiles in Rupa lake area (Regmi *et. al.*, 2008).

Searching value addition technology and options: Communities have been able to identify different products from wetlands plant resources such as *Kamlagotti* (seeds) and *Kokre* (stolen part) of White lotus (*Nelumbo nucifera*) as alternative income generating sources which retain medicinal values. Local conservation groups have collected and utilized more than 25kg of lotus seed in 2007. Similarly, *Simalkande* (*Trapa sp.*) was identified for marketing. The cooperative is now preparing community based sustainable harvesting plan for *Simalkande* with the good experience of managing white lotus. Recently, RRFC has adopted solar drying techniques to dry local fish, package it and sell to markets. Cooperative has earned $ 1500 in 2007 (Regmi *et. al,* 2008).

Upstream-down stream linkage: In 2002, environment payment system was initiated in Rupa lake areas with a provision of 10 percent of fund allocation made by cooperative from its net income to integrate upstream-downstream relation. The payment mechanisms were in the form of cash, community contribution, capacity building and collaborative activities. The EPS is basically targeted to poor, resource dependent, vulnerable communities around the lake, wetland and watershed areas. Most attention is given to support the conservation and income generation activities in the watershed areas.

Emerging lake education center: Success of ILBM pillars in addressing lake issues of Rupa has also impacts on information system through lake education center. National and local government institution gradually started providing their supports and inputs to strengthen local knowledge through lake education center. For this, Lekhnath Municipality has provided building infrastructure; NLCDC has provided 1 million Rupees for laboratory supports; Codefund is to provide technical inputs worth of 1 million Rupees and AMC has US $ 10,000 from SGP/UNDP to operationalise the center.

Better lake health better livelihoods: There are visible evidences that lake health has been improved with improved local economy and livelihoods. For example, there is a significant reduction on deforestation reciprocated by aforestation and fruit plantation; biodiveristy resources are improved; weed control has been manually managed; lake demarcation has been well done; local conflicts have been mitigated; income level through fishery, crop, livestock and business operation, and value addition of lake products has been improved. Lake has been generating financial strength that has also enabled youth to fetch remittance from their services extended to the Gulf countries. However, impacts of commercial fishery have yet to face by the community, a local dam is in a process of construction may have additional implications on lake environment especially biodiversity. Lake environment is obviously improved in Rupa lake, though siltation has remained next immediate

issue that higher level management has to think sincerely.

3. Conclusion

Himalyan lakes of Nepal are special in terms of their nature and functions. Himalayan lakes have global significances; they have potential for trans-Himalyan conservation; they sustain higher biodiversity hotspots; they support socio-economy of large section of people; and they form foundation for religious and cultural development. There are 5300 such kinds of lakes alone in Nepal. However, they are under threats of anthropogenic and natural origins. Their conservation is urgent for the survival of human civilization and biodiversity.

NLCDC has foreseen ILBM as appropriate management tool to address issues of Himalayan lakes that helps improving governance structure. The maturity of NLCDC is too early to depict ultimate impacts of ILBM in Nepal, though series of intervention done earlier in Rupa lake by different institution is a valid example to experience the strength of ILBM. Different inputs invested in Rupa has strengthened institutional, participation, financial and information pillars so local governance has remained proactive in sustainable conservation and improved livelihoods in Rupa area. Rupa lake conservation is probably one of the best governance demonstrations of ILBM to address Himalayan lake issues in Nepal. ILBM is still evolving and needs more time and efforts to mature its gravity at global scale.

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