2 Introduction

Authors: Laxmi Dutt Bhatta[1], Sunita Ranabhat[1], Ram Prasad Chaudhary[2], Jah P Sah[3], Tanya Marree Doody[4], Nakul Chettri[1], Khadga Basnet[5], Ugan Madandhar[6], Hem Baral[7], Ishana Thapa[8], Tek Bahadur Gurung[9], Karan Bahadur Shah[10], Shambhu Paudel[11], Subodh Sharma[12]

2.1 The Koshi Basin

The Koshi River Basin (Koshi Basin herein) is one of the most important transboundary river systems between China, Nepal and India, originating from the Tibetan Plateau in China, and ending at the Ganga (Figure 2-1). The Basin covers six geological and climatic belts varying in altitude from 21 m (low alluvial plains) to above 8800 m (high mountain), including the Tibetan plateau, the Himalayas, the Himalayan mid-hill belt, the Mahabharata Range, the Siwalik Hills and the Terai.

Figure 2-1 The Koshi Basin lies between the basins of the Ganges (which it joins downstream of Nepal) and the Brahmaputra. Approximately 46% of the Basin lies within Nepal

The Basin contributes one of the largest tributaries of the Ganga River and consists of seven major sub-basins: the Indrawati, SunKoshi, TamaKoshi, Likhu, DudhKoshi, Arun, and Tamor (Figure 2-2). This is the reason that it is commonly referred to as 'Sapta Koshi' in Nepal. These rivers drain a catchment area of over 87,000 km^2, approximately 46% of which lies in Nepal.

[1] International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal
[2] Executive Director, Research Centre for Applied Science and Technology (RECAST), and Professor, Central Department of Botany, Tribhuvan University, Kirtipur, Nepal
[3] Research Associate, Southeast Environmental Research Center, Florida International University Miami, USA
[4] CSIRO Land and Water, Adelaide, Australia
[5] Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu
[6] World Wildlife Fund, Nepal Office, Kathmandu
[7] Zoological Society of London, Nepal Office
[8] Bird Conservation Nepal, Kathmandu
[9] National Animal Science Research Institute (NASRI) of Nepal Agricultural Research Council (NARC)
[10] Professor of Zoology, Natural History Museum, Tribhuvan University, Swoyambhu, Kathmandu
[11] Senior Research Officer (Freshwater), The Himalaya, Kathmandu
[12] Aquatic Ecology Centre, School of Science, Kathmandu University

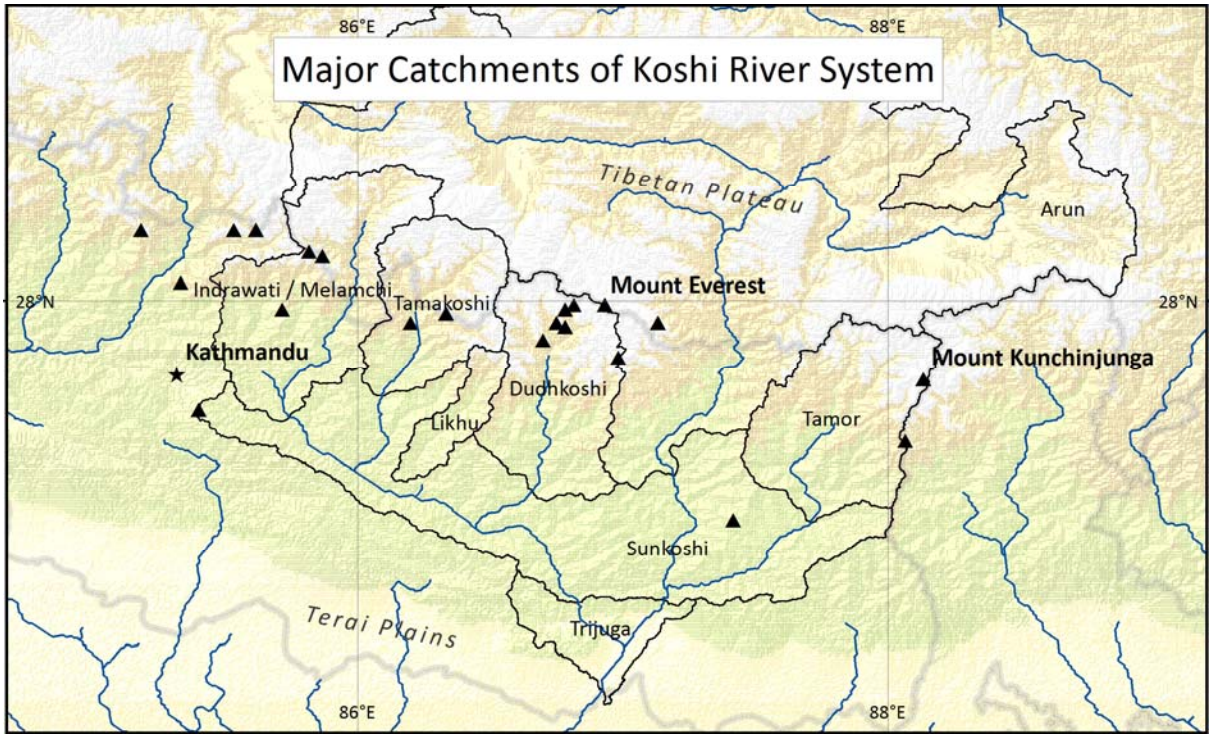


Figure 2-2 The seven rivers of the Sapta Koshi and their catchment boundaries

The Basin has an average discharge of 1931m^3 sec-1 (Dixit 2009) where the catchment of the Arun River occupies more than half of the Basin, and provides one-third of the total discharge (Kattelman 1991). Further hydrological information can be found in Chapter 3.

With altitudinal variations (Figure 2-3), almost all climatic conditions of the world are found in the Basin and range from humid tropical in the Terai to arctic on the High Himal (Dixit 2009). In the Mountain and Hill regions, the average daily maximum temperature is highest in June (about 27°C in Mountain and 32°C in Hills) and lowest in December–January (less than 0°C in Mountain and 5°C in Hills) (Agarwal et al. 2015).

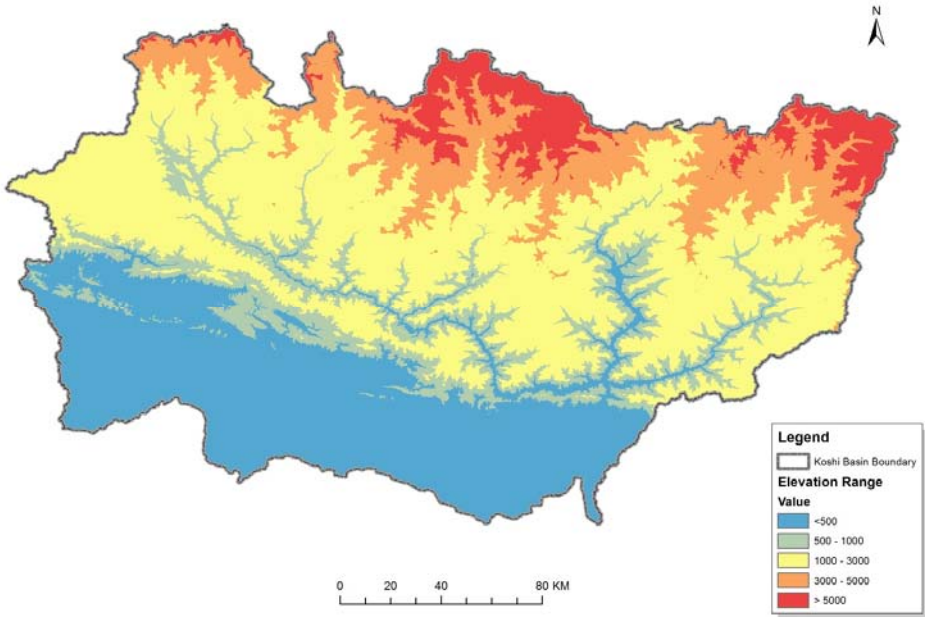


Figure 2-3 Elevation gradient of the Koshi River Basin

Precipitation also varies with topography and monsoon (Chaudhary et al. 2015). In the Basin, precipitation increases with elevation (from the Terai to the mountains) but decreases at higher elevation in the rain shadow region of the high mountains and the Himalayas (Agarwal et al. 2014). Additional climate information can be found in Chapter 3.

2.2 Socio economics and demography

According to the latest 2011 census, the total population of the Koshi Basin is just over 11.5 million, 49.6% men and 50.4% women. This is 44% of Nepal's total population and has grown by 17% since 2001. The Basin includes 27 of Nepal's 75 districts. Population density is lowest in the mountain regions as compared to the hills and Terai regions (Annex: Table 2-2). The average household size is just under 5. The average literacy rate was 62% in 2011 which is below the national average of 66% (88.6% for those between 15 and 24 years) – however, it has increased by 18% in males and 31% in females over the last two decades. To contrast this with districts outside the Basin – Kathmandu district has the highest literacy rate for both males (92%) and females (80%), whereas Rautahat district has the lowest for both males (52%) and females (32%) (CBS 2012).

Firewood has been and remains the main source of energy. Of all households in the Basin, 51% depend on firewood for cooking, while consumption of other sources of fuel such as LPG and electricity are increasing in urban areas. Biogas is becoming a major alternative energy source for cooking in the Mid-Hills. In rural areas, more than 90% of the population are dependent on biomass energy (CBS 2014b). Electricity provides services to about 61% of households for lighting (CBS 2014b), however, acute power cuts reduce electricity use.

Agriculture-forest based livelihoods are dominant in the Basin. In urban centres, people have multiple sources of income for their livelihoods. Paddy, maize, millet, buckwheat and wheat are the major cereal crops traditionally grown. The trend in production has been decreasing in recent years except for maize (MoAD 2014). Production of cash crops such as oilseeds and potatoes has increased over the same period of time (CBS 2013). Besides agriculture, about 15% of the population relies on small scale enterprises for livelihood, including the cottage industry, transportation, business and service (CBS 2014b). In recent years, remittance from sources other than agriculture has become a major source of income for many households in the Basin. Additional livelihoods information can be found in Chapter 5.

2.3 Land use and land use change in the Koshi Basin

Agriculture is the dominant land use (35% in 2010) with a 1% increase in area in 30 years (Table 2-1), followed by grassland (27%) and forest (23%). In the Terai and the lower altitude regions, agricultural land use is dominant whereas in the hills and at higher altitudes, forests and shrublands are dominant (Figure 2-4). Nearly 6% of the Basin is occupied by snow-covered mountains while 8% of the land in the Terai region is barren.

Forest area has decreased slightly in 30 years. A recent forest survey indicates a decrease in forest cover in the Terai districts, except in Siraha district (DFRS 2014). However, several (earlier) studies reported an increase in forest cover in the mid hills (Virgo and Subba 1994, Gautam et al. 2003), which is the result of a successful community forestry programme (Nepal 2012). Gautam et al. (2003), in his limited study, showed an increase in broad-leaved and conifer forest, and lowland agriculture, but a decrease in shrubland, grassland and upland agricultural area. Similarly, a

comparison of forest cover in the Mahabharat and the middle mountain region of the Basin during 1964–1965 and 1978–1979 showed that forest cover has increased by nearly 1.5% (Sharma et al. 2000).

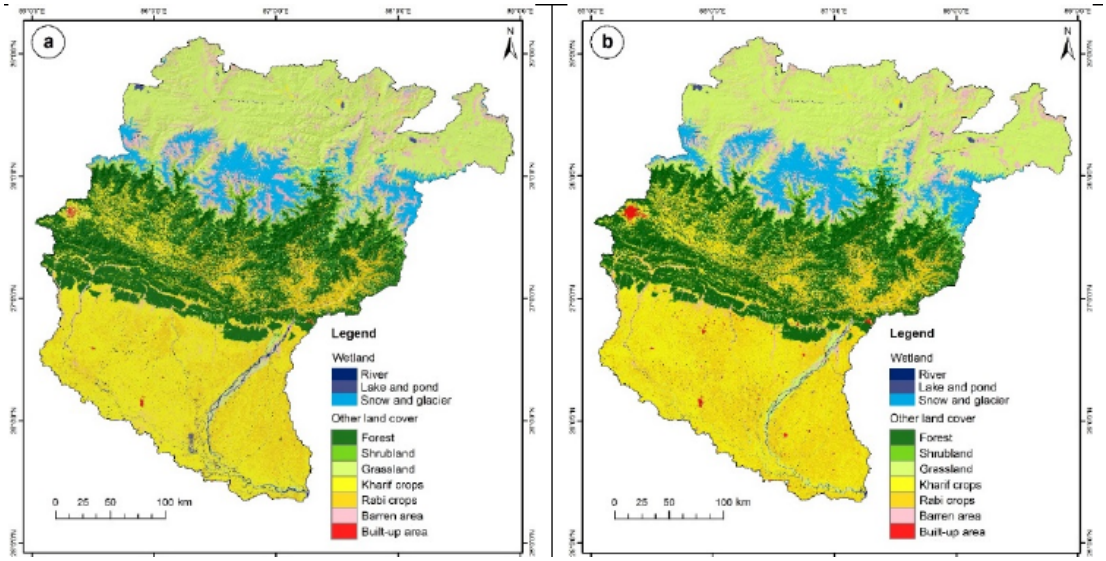


Figure 2-4 Land use in 1990 (a) and 2010 (b) highlighting the distribution of wetland, vegetation, crop and built-up areas in those years. The maps also identifies land use change between 1990 and 2010 (Source: Uddin et al. 2015)

The Basin has witnessed a 200% increase in built-up area especially around Kathmandu (Figure 2-4) and a loss of 27% of freshwater ecosystems (Table 2-1). Similarly, soil loss from different land cover classes in 1990 and 2010 was estimated to be of the order of 40 million tonnes (Uddin et al. 2016). Barren land contributes the highest soil loss of 22 t ha^{-1} yr^{-1} (Table 2-1). Soil loss occurs predominantly through monsoon flooding and wind erosion.

Table 2-1 Land cover and estimation of erosion rate in Koshi Basin from 1990 until 2010 (Source: Uddin et al. 2015)

Land cover	Land cover area (km)	Land cover area (km)	Annual soil loss (.000t)	Annual soil loss (.000t)	Mean erosion rate (t/ha/yr)	Mean erosion rate (t/ha/yr)
Year	1990	2010	1990	2010	1990	2010
Forest	20,032	19,827	601	991	0.3	0.5
Shrubland	679	670	231	261	3.4	3.9
Grassland	23,463	23,486	10,793	11,743	4.6	5
Agricultural land (Kharif)	17,927	15,691	4,482	5,335	2.5	3.4
Agricultural land (Rabi)	11,708	14,715	5,269	8,240	4.5	5.6
Barren land	8,245	7,081	18,057	15,437	21.9	21.8
Built up area	99	268	0.5	2	0.05	0.08
Water bodies	793	572	56	11	0.71	0.19
Snow/glaciers	4,595	5,235	5	5	0,01	0.01
Total	**87,541**	**87,545**	**39,495**	**42,025**		

2.4 Ecosystems and biodiversity

High altitudinal variations across short distances (21 m to over 8800 m) lead to diverse climatic conditions and associated physiographic variations. The Koshi Basin thus harbours important habitats for many floral and faunal species, including aquatic species.

Ecosystems

Figure 2-5 *Typha angustifolia* and *Tamarix dioica* association in the floodplain of the Koshi Tappu Wildlife Reserve provide habitat for wild boar and birds

As mentioned previously, the Koshi Basin consists of bioclimatic belts ranging from Tropical zone in the Terai to alpine zone (above 4000 m) in the Mountains. The Koshi Basin is characterised by various types of ecosystems and habitats such as glaciers; snow; rock; wetlands; alpine meadows with grasses and sedges, floodplains (Figure 2-5) to name a few.

Forest remains the dominant ecosystem in the Koshi Basin. Bhuju et al. (2007) found that all major forest ecosystems ranging from Khair-Sissoo (*Acacia-Dalbergia*) forest, deciduous mixed riverine forest and lower tropical Sal forest to eastern Himalayan Conifer forest (Figure 2-6), upper alpine and trans Himalayan steppe, all exist in the Basin. Following Miehe et al. (2015b), vegetation and forest types in the Koshi Basin have been described under two broad categories: (i) vegetation of the southern slopes of the Himalayas, and (ii) the vegetation of the inner valleys across six bioclimatic belts (See Chapter 6 for details).

Figure 2-6 Eastern Himalayan Conifer forest, Kanchenjunga Landscape, Nepal

Rangeland is considered a very important ecosystem, particularly for local livelihoods in upper altitude regions and pastoral communities. The Government of Nepal have estimated that about 12% of the country's land consists of rangeland ecosystems which include grasslands, pastures, shrublands and other grazing areas (MoFSC 2014). About 98% of rangelands are located in the Mountains and Himalayas with less than 2% located in the Terai region (Pande 2010). However, there are very few studies on the rangelands ecosystems of the Basin. Small scale research such as that undertaken by Yonzon (2000) found that around 7590 km^2 of rangelands are located inside the protected areas of the Koshi Basin.

Wetlands are considered of high ecological significance, as they not only harbour habitat for many flora and faunal species, including migratory birds, they also play an important role in water recharge and purification. Many of the traditional and tribal communities in Nepal, such as the Majhis and Tharu, are heavily dependent on wetlands for their livelihoods (IUCN 2004). The Basin

houses the second highest number of wetlands in Nepal, after the Karnali River Basin (Bhandari 2009). Ten of the country's wetlands are listed as Ramsar sites, two of which are in the Koshi Basin (Koshi Tappu, and Gokyo and Associated lakes). Key wetlands of the Terai or Siwalik region include the Koshi barrage, the Koshi River, Titriganchi Tal, Kamalpur Tal and Bhagalpur Tal which all provide habitat for key species such as Asian Wild Water Buffalo, Ganges River Dolphin, Gharial, Marsh Mugger, and the Smooth Coated Indian Otter (Scott 1989).

Biodiversity hotspots

The Koshi Basin is considered as an important part of the 'Himalaya Global Biodiversity Hotspot' – one of the 34 global Biodiversity Hotspots (Myers et al. 2000, Mittermeier et al. 2004). Faunal and floral diversity (species richness and endemism) in the Eastern Himalaya, including the Koshi Basin, is rich mainly because it lies at the junction of both Indo-Malayan and Palearctic Realms and includes several globally significant ecoregions and centres of plant diversity (Yonjon 2000). In general, habitat heterogeneity is a major structuring agent of ecological assemblages promoting beta diversity and overall higher global diversity (McClain and Barry 2010). The wide coverage of habitats found within the Koshi Basin has supported *in situ* conservation of many primitive, for example *Magnolia campbellii* (Figure 2-7), threatened and rare species (Shrestha 1989) (See Chapter 6 for details). The Basin is also rich in medicinal and food plants and their wild relatives.

Figure 2-7 *Magnolia campbellii*, a primitive species

Ecoregions

An ecoregion is a large unit of geographical land with a distinct assemblage of species, natural communities and environmental conditions. The Himalaya, particularly the Hindu Kush Himalaya, is considered as one of the high biodiversity areas with four global biodiversity hotspots, 60 ecoregions, 488 protected areas, 13 world heritage sites and 27 Ramsar sites (www.geoportal.icimod.org/symposium2010). The Koshi Basin represents four ecoregions: (i) Eastern Himalayan alpine shrubs and meadows; (ii) Eastern Himalayan conifer forests; (iii) Eastern Himalayan broadleaved forests; and (iv) Terai-Duar grasslands and savannas (Figure 2-8). Conservation status of these ecoregions have been in transition due to various natural and human induced activities.

Figure 2-8 Terai-Duar grassland, Koshi Tappu Wildlife Reserve, Nepal

Protected areas

The establishment of Protected Areas (PAs) has been fundamental to the conservation of biodiversity globally and in Nepal. These support healthy ecosystems and threatened species and also provide multiple benefits to people (Bertzky et al. 2012). The PA system of the Koshi Basin includes two national parks, namely Sagarmatha (Everest) National Park and Makalu-Barun National Park, two conservation areas namely Kangchenjunga Conservation Area and Gaurishankar Conservation Area, and one wildlife reserve namely Koshi Tappu Wildlife Reserve (Annex: Table 2-3). The Kangchenjunga Conservation Area and the Makalu-Barun National Park and Conservation Area are of particular significance as both PAs are important models of community-based biodiversity management. The PAs within the Koshi Basin cover a total of 8315 km^2 (Annex: Table 2-3) which represents 24% of the total area of PAs in Nepal. The Koshi Tappu Wildlife Reserve (17,500 ha) and Gokyo and Associated Lakes (7770 ha) have been designated as Ramsar sites, indicating they are wetlands of international importance.

Important Plant Areas (IPAs): Important Plant Areas (IPAs) are sites of exceptional botanical importance for medicinal and aromatic plant species richness, threatened plant species, habitats and vegetation in general (Anderson 2002). In the Koshi Basin, the IPAs complex include: (i) Upper Bagmati (Sindhupalchowk district); (ii) Upper Janakpur (Sindhuli district); (iii) Udaypur (Udaypur district); (iv) Upper Sagarmatha and Kangchenjunga Complex (Solukhumbu, Sankhuwasabha and Taplejung districts); and (v) Lower Kangchenjunga Complex (Terahthum and Panchthar districts). The maximum number of IPAs are found in the Upper Sagarmatha and Kangchenjunga Complex with a total of 36 IPAs (Hamilton & Radford 2007). Commonly found medicinal plant species in the Basin are often found in these IPAs (Figure 2-9).

Figure 2-9 Kangchenjunga landscape, rich in medicinal plant species; *Swertia chirayira*, a medicinal plant transported for trade

Important Bird and Biodiversity Areas (IBAs): Important Bird and Biodiversity Areas (IBAs) are globally recognised important areas for the conservation of birds and their habitats. The IBAs in the Koshi Basin include: (i) Sagarmatha National Park; (ii) Makalu-Barun National Park; (iii) Kangchenjunga Conservation Area; (iv) Tamur Valley and Watershed; (v) Dharan forest; and (vi) Koshi Tappu Wildlife Reserve. Khandbari-Num Forest is also regarded as a potential IBAs (Baral and Inskipp 2005). The Koshi Basin with diverse habitats provides shelter for some restricted range species, globally threatened species, Eurasian High Montane biome species, Sino-Himalayan temperate forest biome species and Sino-Himalayan subtropical forest biome species.

Wildlife corridor and connectivity: A wildlife corridor is a conservation tool that maintains connectivity among PAs and other important wild habitats within a country and/or across the border

between countries. The conservation objectives are achieved by developing a network of corridors to provide additional resources like food and space to wildlife species and the opportunity of exchanging genes among several populations within the network. Thus, corridors are meant for the successful conservation of biodiversity (CBD 2011).

Despite a number of interventions, various ecosystems in the Basin are under threat. Both climatic and anthropogenic drivers such as over and unsustainable harvesting, alien and invasive species, illegal hunting, river flow alteration, sedimentation, over grazing, channelling, damming and conversion of forest land to other forms of land use are considered most important drivers creating unfavourable ecosystem changes in the Basin. A vulnerability assessment indicates that most of the Basin has a moderate to high ecological vulnerability (Figure 2-10).

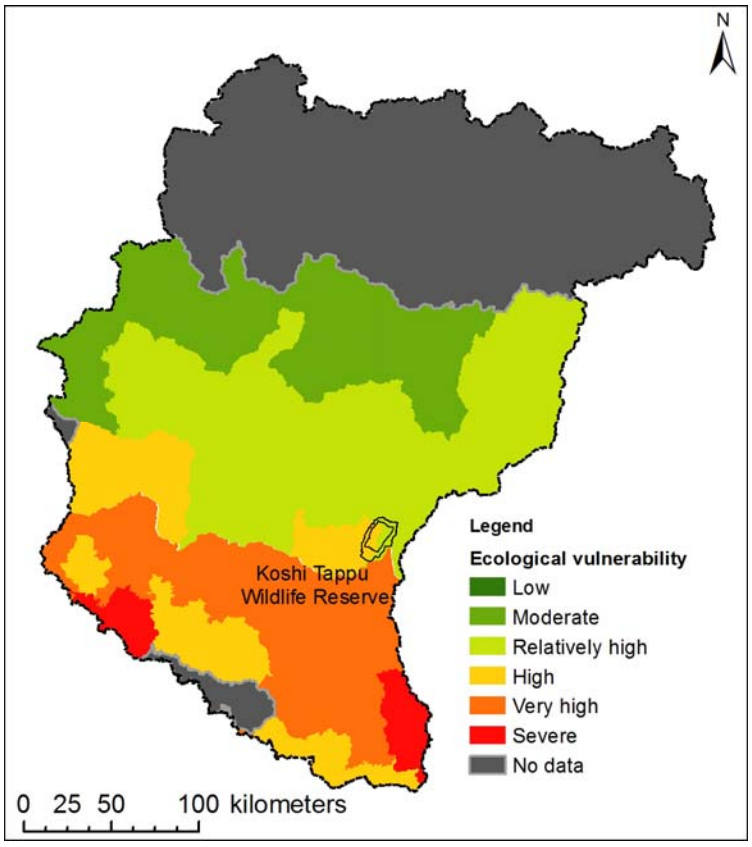


Figure 2-10 Ecological vulnerability of the Koshi Basin and Koshi Tappu Wildlife Reserve (Source: Neupane et al. 2013)

2.5 Koshi Tappu Wildlife Reserve

The Koshi Tappu Wildife Reserve is a Ramsar wetland of international importance as it has been supporting and protecting natural systems and processes in the area. Additionally, it is evident that the Reserve offers a wide range of services such as firewood, fodder, foods including irrigation, water storage, carbon sequestration, ollution control etc. to a substantial population living in the Buffer Zone. This dependency is directly contributing to the subsistence livelihoods of people living in the Buffer Zones and helping them to reduce poverty (Shrestha and Alavalapati 2006, CSUWN, 2009). Past analysis shows that dependency of the local people on the Reserve, particularly on provisioning and cultural services, is extremely high (CSUWN 2009, Chaudhary et al. 2014, Sharma et al. 2015).

The Reserve is a heavily studied location in the Koshi Basin and features in several forthcoming chapters.

2.6 Sustainability of the Koshi Basin and the Koshi Tappu Wildlife Reserve

The Koshi Basin is an important contributor of fish diversity in the Himalayas with a high proportion of threatened and endemic species (Allen et al. 2010). The Koshi Tappu Wildlife Reserve is a cornucopia of biodiversity supported by numerous wetland, forest and alpine ecosystems within the

Koshi River Basin (Figure 2-11). It is to be noted that the diverse upstream ecosystems are the lifeline for the Reserve and its rich biodiversity as well as a source of valuable ecosystem services that sustain the lives and livelihoods of millions of people (van Oort et al. 2015). However, the Basin has been witnessing changes in the fresh water ecosystems (Uddin et al. 2015) due to land use and land cover change (Uddin et al. 2016) with loss of habitat for many aquatic and terrestrial species (Figure 2-10; Chettri et al. 2013). Moreover, the reserve lost 94% of its original forest cover over a period of 34 years (1976–2010) with 79% increase in grassland during the same period (see Chettri et al. 2013).

The Koshi Basin is an important contributor to the Ganga Basin in terms of water flow (Lutz et al. 2014). However, the increasing trend of precipitation and flows (Agarwal et al. 2014, Bharati et al. 2016, Nepal 2016, Rajbhandari et al. 2016b); variations in glacier dynamics (Wang and Zhang 2014); increasing risk from Glacial Lake Outburst Flood (Khanal et al. 2015); seasonal as well as mean annual minimum and maximum temperature projected for future scenarios (see Smadja et al. 2015, Agarwal et al. 2016); are bringing additional challenges for the future health of the Reserve.

In addition, the persistent and ongoing dependency of people on water and biotic resources in the Reserve (MoFSC 2009b, ICIMOD & MoFSC 2014, Chaudhary et al. 2014) and the Basin as a whole (van Oort et al. 2015, Rai et al. 2015) is making the Reserve vulnerable (Chettri et al. 2010). Bhatt et al. (2014) report that as vulnerability increases, crop production systems are visibly impacted, adding to the food security challenge common in developing countries.

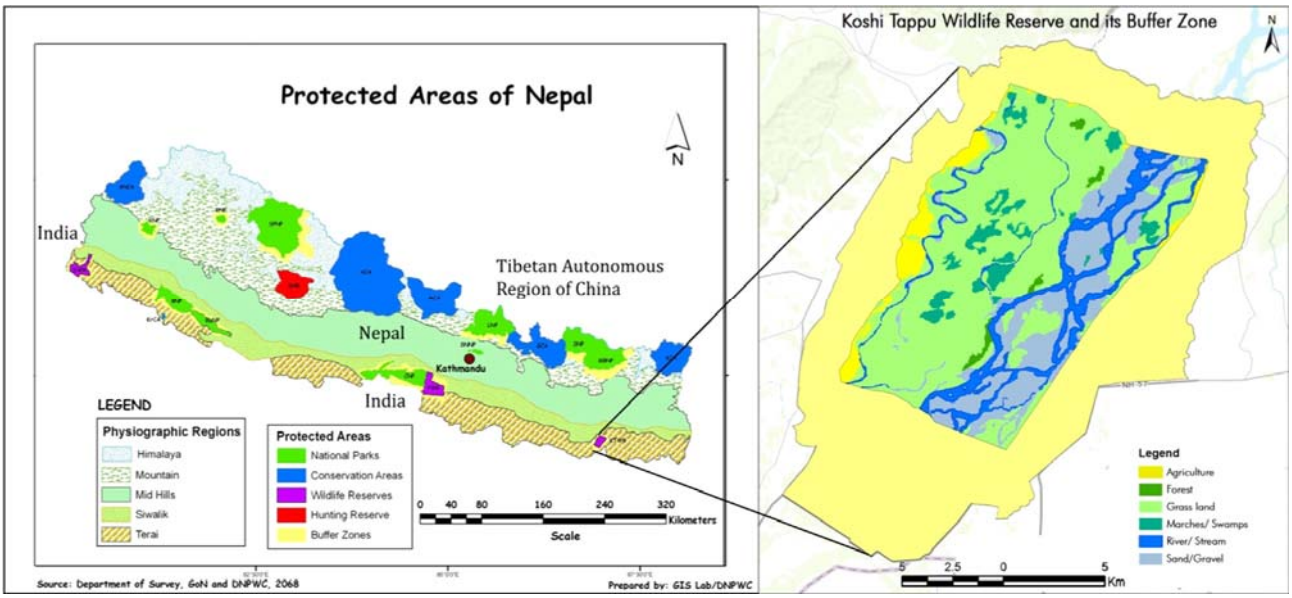


Figure 2-11 Protected areas of Nepal illustrating land cover distribution in the Koshi Tappu Wildlife Reserve (Source: Sharma et al. 2015)

2.7 Water use

Availability of water and its wise use has been the major point of discussion in recent years in the Basin. In the Mid-Hills and Mountains, natural springs are the main source of drinking water whereas in the Terai, underground water extracted via tubewells and hand pumps provides water for drinking (CBS 2014a). The Government of Nepal's survey data reveals that around 84% of the Basin's population use improved water sources, included piped, tubewell and well water (CBS 2014b).

However, due to multiple sources of consumption and the possible impact of climate change, natural springs are drying up.

Irrigation and hydropower are considered priorities in the Government's development plan. However, the Basin has not been able to fully utilise the potential water available from the Koshi River. The only large irrigation facility that the country has harnessed is the Morang-Sunsari irrigation schemes that provide irrigation facility to nearly 66,000 ha of agriculture land downstream (Fish et al. 1986). Within the Indo Nepal agreement, India receives irrigation water from the Koshi River to support a command area of 969,119 ha through the Koshi Barrage (Figure 2-12).

Figure 2-12 Koshi Barrage established at Sunsar-Saptari district in Nepal connects to India through water flow

The potential for hydropower development in the Basin is therefore primarily untapped. A study commissioned by the Government of Nepal, estimated that 48 billion cubic metres of water is available annually in the Koshi Basin. This water can potentially generate about 10,086 MW of economically feasible power, while also irrigating approximately 500,000 ha of agricultural land (WECS 1999). Similarly, Jha (2010) observed the power potential of the Koshi Basin is 17,008.3 MW.

However, from knowledge gathered around the world, increases in irrigation abstraction and hydropower development lead to altered flow regimes in the rivers and streams that are targeted for their water resources. Flow regime changes occur as a result of damming and over-extraction (Magilligan & Nislow 2005) resulting in ecological degradation and loss of biological diversity to the point where the rivers can no longer sustain healthy ecosystems which provide important ecosystem services (Poff et al. 1997).

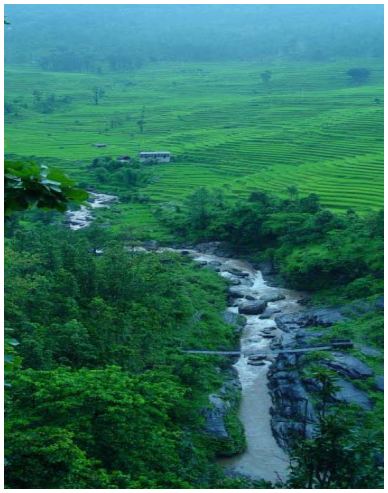
2.8 Policy, governance and institutions

To protect aquatic resources in the future as development increases, it is important to understand the volume of water that is available and when (seasonal differences) and how much is required to meet human and environmental demands. This is best done within an Integrated Water Resource Management (IWRM) framework, which is a process of coordinating development, management and conservation of water, land and related resources across sectors within a given river basin, in order

to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems (2000).

Nepal lacks a legislation to manage river basins in a holistic way as the existing sectoral policies and planning approaches do not support such a management approach. Nevertheless, Integrated River Basin Management (IRBM) is discussed in many policies and plans although these policies and plans require a thorough analysis on their effectiveness as an approach. There are however, a number of existing legislative frameworks which collectively support an Integrated River Basin Management approach. These include but are not limited to:

- Forest Policy 2015
- National Wetland Policy 2012
- Irrigation Policy 2013
- Water Resources Strategy 2002
- Hydropower Development Policy 2001
- Rural Water Supply and Sanitation National Policy 2004.



Under these sectoral policies and legislation, a number of institutions are contributing towards river management. For example, the Ministry of Forests and Soil Conservation, under its Soil Conservation and Watershed Management Department, has been supporting catchment conservation and management.

There are eight ministries directly working with water related issues in Nepal at the central level (Sudardiman et al. 2015). These include:

- Ministry of Irrigation (MoI)
- Ministry of Energy (MoE)
- Ministry of Urban Development (MoUD)
- Ministry of Agriculture Development (MoAD)
- Ministry of Forests and Soil Conservation (MoFSC)
- Ministry of Physical Infrastructure and Transport (MoPIT)
- Ministry of Federal Affair and Local Development (MoFALD)
- Ministry of Population and Environment (MoPE).

District Development Committees (DDCs) are local governments that function at the district level, with support from other department offices. These Committees are responsible for the coordination and implementation of all development activities at the district level. Sudardiman et al. (2015) stated that at the village level, the Village Development Committee (VDC), Non-Government Organizations and Water User Associations (WUAs) are the important formal water institutions. Community-based natural resource management institutions such as community forestry user groups (CFUGs), leasehold forestry user groups (LFUGs), water user groups, conservation area user

groups, and Buffer Zone community forest user groups are the formal community level institutions actively engaged in different sectors within river basin management in the Koshi Basin. Although a comprehensive analysis of these local level institutions would be useful, a number of small scale studies suggest they are effective in conservation and maintaining livelihoods. For example, Sharma et al. (2010) concluded that these institutions are most effective for conservation, development and utilization of natural resources in the Hindu Kush Himalayan region.

With the recent political change and the new constitution in Nepal and with anticipated federal states, it is too early to comment on the possible roles and responsibilities of various institutions at federal, provincial and local levels in relation to water, and river basin management. However, the new constitution of Nepal does attempt to delineate roles, rights and responsibilities of various institution in all three levels.

2.9 Summary

Water from river systems is a key element for economic and social development, and for a country like Nepal with huge water resources, water forms a large part of the economy. Water resources play an important role in driving hydropower development and agriculture production as well as provision for drinking, domestic and industrial use. Water is also important to support many dimensions of the environment, such as ensuring contiguity of rivers, wetlands, ecosystems and to maintain ecological biodiversity. It is therefore very important to use these water resources sustainably to ensure environment integrity. It is also critical to understand and maintain environmental flow requirements – the flows required to support water quality, quantity and timing for individual river systems. If water is not used wisely, what is a boon for Nepal in particular, could result in a recourse.

The remainder of this report will focus on building the knowledge base in the Koshi Basin (transferrable to the greater Nepal region and surrounding countries) with respect to understanding the links between river regimes, aquatic ecosystems and livelihoods. Through this process, knowledge gaps are identified which once addressed, will improve our understanding of aquatic ecosystems and their environmental water requirements. The importance of aquatic ecosystems to the maintenance and improvement of livelihoods in the Basin is discussed in many chapters, highlighting the need to preserve ecosystem integrity in the face of future river flow changes to support hydropower and irrigated agricultural development.

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The views and interpretations presented in this chapter are those of the authors and are not necessarily attributable to their organisations.

Annex: Tables

Table 2-2 Number of households, population (2011) by gender and population density by region – mountains, hills and Terai (adapted from CBS 2012)

District	Total	Male	Female	Total of country (%)	# of h'holds	Average h'hold size (#)	Area (km^2)	Pop'n density / km^2)
Mountain								
Dolakha	186,557	87,003	99,554	0.70%	45,688	4.1	2,191	85
Sankuwasawa	158,742	75,225	83,517	0.60%	34,624	4.6	3,480	46
Sindhupalchowk	287,798	138,351	149,447	1.09%	66,688	4.3	2,542	113
Solukhambhu	105,886	51,200	54,686	0.40%	23,785	4.5	3,312	32
Taplejung	127,461	60,552	66,909	0.48%	26,509	4.8	3,646	35
Hills								
Bhaktapur	304,651	154,884	149,767	1.15%	68,636	4.4	119	2,560
Bhojpur	182,459	86,053	96,406	0.69%	39,419	4.6	1,507	121
Dhankuta	163,412	76,515	86,897	0.62%	37,637	4.3	891	183
Kathmandu	1,744,240	913,001	831,239	6.58%	436,344	4.0	395	4,416
Kaverpalanchowk	381,937	182,936	199,001	1.44%	80,720	4.7	1,396	274
Khotang	206,312	97,092	109,220	0.78%	42,664	4.8	1,591	130
Lalitpur	468,132	238,082	230,050	1.77%	109,797	4.3	385	1,216
Okhaldhunga	147,984	68,687	79,297	0.56%	32,502	4.6	1,074	138
Panchthar	191,817	90,186	101,631	0.72%	41,196	4.7	1,241	155
Ramechhap	202,646	93,386	109,260	0.76%	43,910	4.6	1,546	131
Terhathum	101,577	47,151	54,426	0.38%	22,094	4.6	679	150
Terai								
Bara	687,708	351,244	336,464	2.60%	108,635	6.3	1,190	578
Dhanusa	754,777	378,538	376,239	2.85%	138,249	5.5	1,180	640
Mahottrai	627,580	311,016	316,564	2.37%	111,316	5.6	1,002	626
Makwanpur	420,477	206,684	213,793	1.59%	86,127	4.9	2,426	173
Rautahat	686,722	351,079	335,643	2.59%	106,668	6.4	1,126	610
Saptari	639,284	313,846	325,438	2.41%	121,098	5.3	1,363	469
Sarlahi	769,729	389,756	379,973	2.91%	132,844	5.8	1,118	469
Sindhuli	296,192	142,123	154,069	1.12%	57,581	5.1	2,491	119
Siraha	637,328	310,101	327,227	2.41%	117,962	5.4	1,118	536
Sunsari	763,487	371,229	392,258	2.88%	162,407	4.7	1,257	607
Udayapur	317,532	149,712	167,820	1.20%	66,557	4.8	2,063	154
Total	**11,562,427**	**5,735,632**	**5,826,795**	**43.6%**	**2,361,657**	**4.9**	**42,329**	

Table 2-3 Protected Areas (PAs) in the Koshi Basin, Nepal (Source: modified after Chaudhary 1998; Bajracharya et al. 2015; Chaudhary et al. 2015b)

Protected area	Core+buffer zone area (km^2)/ altitude (m)	Year of notification (core zone)	IUCN mgmt category	Notable biodiversity, forest type /vegetation	Notable biodiversity, fauna	Major problems
National Parks						
Sagarmatha (World Heritage Site 1979)	1,148+275 2945-8848m	1976 1979	II X	Blue pine, fir, juniper scrub, alpine meadows	Red panda, snow leopard, goral serrow, Himalayan musk deer, Himalayan Black bear, Indian muntjac, pheasant, robin accentor	Environmental pressure from tourism, waste disposal, tree felling, heavy grazing by yak and sheep
Makalu Barun	1,500+830 435-8463m	1991	I, II, VI	Sal, pine, Schima-Castanopsis, Macaranga, Castanopsis, oak-laurel, Berberis, Rhododendron, oak, birch, fir, junipers	Snow leopard, red panda, musk deer, weasel, Himalayan marten, marmot, woolly hare, thrush, tesia, monal, Darjeeling pied woodpecker	Excessive human encroachment, slash & burn agriculture, poaching for bears, collection of medicinal plants, illegal transboundary timber trade
Conservation Areas						
Kangchenjunga	2,035 1200-8598	1997	VI	Larch, juniper, oak, *Magnolia*, fir & hemlock	Snow leopard, red panda, musk deer, blue sheep	Grazing, poaching for musk deer, hunting, collection of medicinal plants, illegal transboundary trade
Gaurishankar	2,179 1000-7200m	2010	VI	Riverine, *Schima-Castanopsis*, pine, alder, oak, temperate mixed-broadleaved, *Rhododendron*, birch	Snow leopard, musk deer, blue sheep, red panda, Himalayan tahr, Ibisbill	Grazing, poaching for musk deer, hunting, collection of medicinal plants
Wildlife Reserves						
Koshi Tappu (Ramsar site 1987)	175+173 80-100m	1976	IV	Khair-sissoo, tropical mixed deciduous riverine, grassland, wetland	Wild water buffalo, leopard, fishing cat, Gangetic dolphin, otter, deer, wild boar, swamp francolin, gharial, python	Grazing, genetic erosion of wild buffalo population, over-fishing, high tension electrical transmission, flooding situation