Chapter 5

Water Resources

Introduction

Water is the most plentiful natural resource in Nepal. The major sources of water are glaciers, rivers, rainfall, lakes, ponds, and groundwater. Of these, rivers are the largest source in terms of water volume and potential development. There are over 6,000 rivers in the country with an estimated total length of 45,000 kilometers (km) (DHM 1998). All large rivers are fed by snowmelt from the Himalayas and hence they are a renewable water resource. The country has 660 lakes of more than 1 hectare (ha). Big lakes are used for irrigation, hydropower generation, fishing, and others. About 75% of the total annual rainfall (average 1,700 mm) falls during the summer monsoon season (June–September) during which major agricultural activities take place. Groundwater remains an important source of water, particularly in the Terai region and Kathmandu Valley.

Surface Water Discharge

Surface water is the major source of drinking water in Nepal (WECS 2004). The major rivers of Nepal are the Koshi, the Gandaki, the Karnali, and the Mahakali, all of which originate in the Himalayas. Table 5. 1 shows the catchment area and discharge of selected major rivers. The Koshi river basin is the largest, covering a catchment area of 60,400 km^2, of which 46% lies in Nepal and the remainder in Tibet Autonomous Region of the People's Republic of China. It has an average runoff equivalent to 1,409 cubic meters per second (m^3/sec) at Chatara. Some 23% of Nepal's population live in this river basin. The Gandaki river basin in the central region includes about 90% of the river's total catchment area. The Karnali and the Mahakali river basins lie in the west of Nepal. Some 22% of Nepal's population live in the Karnali basin, which has a population density of 92 persons per km^2. The Mahakali River acts as the border between Nepal and India. About 34% of its catchment area lies in Nepal.

The Babai, Bagmati, Kamala, Kankai, and West Rapti are medium-sized rivers originating from the Mahabharat range. These rivers, like the Himalayan rivers, are perennial. The innumerable southern rivers originating from the Siwalik hill range are shallow and mostly dry up during the dry season. These rivers are used by the managed irrigation schemes of small-scale farmers for seasonal supplementary irrigation. They often swell and overflow due to monsoon rains, destroying land and lives. The forests once covering most of the Siwalik hills have become degraded (Chapter 4). Every year flooding affects the Siwalik land including the forests. A study by The World Conservation Union (IUCN 2000) indicates that due to forest degradation, surface runoff rates have increased in areas exposed

Table 5.1: Water Discharge of Rivers, Nepal

River Basin	**Catchment Area** (km^2, estimated) Total	in Nepal	**Average Discharge** (m^3/s)	**Annual Discharge** (billion m^3/year)
1. Himalayan rivers				
Koshi	60,400	27,863	1,409	45.0
Gandaki	34,960	31,464	1,600	50.0
Karnali	43,679	41,058	1,397	44.0
Mahakali	15,260	5,188	573	18.0
2. Mahabharat rivers		17,000	461	14.5
3. Siwalik rivers		23,150	1,682	53.0
Total		**145,723**	**7,122**	**224.5**

km^2 = square kilometer, m^3/s = cubic meters per second, m^3/year = cubic meters per year
Source: WECS (2004)

to intense weathering, and percolation rates have decreased. The Siwalik watershed areas are now impoverished and water recharge into the soil has been reduced. During the rainy season, the heavy rainfall coupled with the soft rock results in maximum sediment loads to rivers and streams. A decline in the level of the groundwater table has been reported, and desertification has begun in the Terai due to deforestation in the Siwalik range. In the Siwalik area of eastern Nepal, forest coverage declined by nearly 13% between 1979 and 1999, and 68 ha of land was damaged as a result of landslides (IUCN 2000).

Use of Water Resources

Table 5.2 shows the water availability and use by sectors in 1995 and 2001. The country has about 224 km^3 of annual renewable water, and the annual per capita water supply in 2001 was 9,600 m^3, down from 11,000 m^3 in 1995 (DHM 2001). In 1995, the total annual withdrawal of water for consumptive uses (domestic, agriculture, and industry) was 14 km^3 and per capita annual withdrawal of water was 690 m^3. Although the total annual withdrawal of water increased in 2001, most of the increase went to agriculture, while the percentage used for domestic purposes decreased (UNEP 2001). Agriculture used about 96% of the total withdrawal in 2001, mostly for irrigation, with the domestic sector's share less than 4%. The use of water by the industrial sector is insignificant. The estimated total annual water requirement for irrigation in the cultivated area is 67 km^3, which makes up nearly 30% of the total water potential of 224 km^3.

Current annual withdrawal of groundwater is about 0.756 km^3 for irrigation and 0.297 km^3 for domestic uses (WECS 2004). Groundwater is the best alternative source of water supply, particularly in the Terai region and Kathmandu Valley. The total ground water potential of the country is 12 km^3, of which 5.8 to 11.5 km^3 can be extracted annually without any adverse effects. However, the level of groundwater in Kathmandu Valley is already dropping due to overexploitation, as described in the next section. The Bhabar zone with dense forest cover, a contiguous area of the Terai, is the recharge area for the Terai's groundwater.

Table 5.2: Water Availability and Use by Sectors, Nepal

Description		1995[a]	2001[b]
Total annual renewable water resource (km^3/year)		224.0	224.0
Per capita renewable water resource ('000 m^3/year)		11.0	9.6
Total annual withdrawal (km^3/year)		14.0	18.5
Per capita annual withdrawal (' 000 m^3/year)		0.69	0.8
Withdrawal (percent)	Domestic	3.8	3.6
	Industry	0.3	0.3
	Agriculture	95.9	96.1

km^3/year = cubic kilometers per year, m^3/year = cubic meters per year
Note: 1 billion m^3 = 1 km^3.
Source: [a]UNEP (2001); [b]WECS (2004)

In addition to these uses, river water is also used for generating hydropower. The country has 83,000 megawatts of potential hydropower generation, of which 42,000 megawatts are economically viable. At present, total electricity generation is around 559 megawatts (WECS 2004). Further, microhydropower plants are operated in several parts of the Hill and the Mountain regions, although their contribution to total hydropower generation remains small at 1.2%. Local streams and rivulets are also important sources of energy for agro-processing in the Hill and Mountain regions. Operation of water mills (ghattas) for grinding grain has existed for centuries; it is environmentally sound though not very economically profitable. There are about 25,000 water mills in Nepal (MOPE/REDP 2002).

Sources, Quantity, and Quality of Drinking Water

The quantity and quality of water directly and indirectly affect human activity, health, and sanitation. These in turn depend on the water sources. Normally a person requires two liters of water per day for basic physiological processes (WHO 1996). Water quality refers to the suitability of water to sustain living organisms. For humans, it is used for drinking, bathing, washing, irrigation, and industry. Changes in water quality are reflected in its physical, biological, and chemical conditions, and these in turn are influenced by natural and anthropogenic activities.

Sources of Drinking Water

Nepal is a mountainous country with diverse physiographic regions, and thus different sources of drinking water are available for people in different areas (Table 5.3). Tap water is the most important source, providing drinking water to almost 53% of all households. Tap water refers to water piped directly from a source as well as to centrally distributed and pretreated water. The second most important source is tube wells. These two sources are important in both urban and rural areas. The relative share of tap water in urban and rural areas is 65% and 51%, respectively, followed by tube wells with 23% and

Table 5.3: Type of Water Sources Used by Households

Drinking Water Source	Total Households		% of Total U/R hh		% of Total M/H/T Households (hh)		
	Number	%	Urban	Rural	Mountain	Hill	Terai
Tap water	2,209,760	52.9	65.4	50.6	72.2	72.2	30.8
Tube well	1,184,156	28.4	23.1	29.4	0.0	2.4	58.6
Well	377,241	9.0	5.9	9.6	6.2	12.0	6.5
Stone spout	267,180	6.4	3.3	7.0	17.1	10.1	1.1
River	61,400	1.5	0.5	1.7	3.4	2.0	0.6
Other	74,721	1.8	1.8	1.8	1.0	1.2	2.5
Households	**4,174,457**	**100.0**	**664,505**	**3,509,952**	**285,217**	**1,950,345**	**1,938,895**

hh = households , M/H/T = Mountain, Hill, or Terai, U/R hh = urban or rural households
Source: CBS (2002) Table 1.

Table 5.4: Household Access to Drinking Water Sources (%)

Region	Piped to House	Piped Outside of House	Covered Well	Open Well	Other	Total
Mountain	10.5	61.8	1.2	2.5	24.1	100
Hill	23.5	46.3	4.1	4.6	21.5	100
Terai	6.2	8.5	74.6	5.1	5.6	100
Rural	6.7	32.5	39.6	4.9	16.2	100
Urban	53.3	14.3	25.3	3.4	3.9	100
Nepal	**14.4**	**29.5**	**37.2**	**4.7**	**14.2**	**100**

Source: NLSS (2004)

29%. While tap water is the dominant source in the Mountains and Hills, tube wells dominate in the Terai. All the sources of water listed in Table 5.3 are used by some households in all three regions, except tube wells which are not available in the Mountains.

Access to Drinking Water Supply

According to the latest survey (NLSS 2004), the share of households with access to piped water in 1995/96 was 32%, which increased to 53% in 2003/04 (Table 5.4). The latter consists of households with water piped to the house (14%) and households with piped water outside of the house (30%). About 39% of all rural households have access to piped water compared with 68% in urban areas. Access to piped water is lowest in the Terai; 75% of Terai households have access to covered wells (tube well), whereas 62% of the households in the Mountains have access to piped water outside the house (community tap). Other water sources include rivers, streams, and ponds.

Water Quantity

Table 5.5 summarizes the water supply and demand condition within and outside Kathmandu Valley, as well as water treatment and leakage problems in general. The share of total production capacity of drinking water in the region outside Kathmandu Valley increased from 31% in 1999 to 42% in 2001. The relative demand and average daily production of water show a similar situation. The Valley's water tap connections constitute slightly over three fifths compared with two fifths of the outside valley area, but the relative share of the latter increased between 1999 and 2001. Treated water represents about 50% (NWSC 2001).

To date, about 72% of the country's total drinking water demand has been met (NPC 2002). Access to safe drinking water in rural areas has increased compared with that in urban areas due to the relative decrease in rural population growth compared with urban population growth. Each year the drinking water demand grows, and as a result, pressure on the existing output of water is intense. Over the last few decades, the population has grown at a rate of over 2% per annum. The area of agricultural land has also increased, demanding additional irrigation water. Natural factors such as landslides and floods have also put pressure on water resources by damaging reservoirs and irrigation canals.

The pressure on drinking water sources is intense in large cities due to rapid urbanization. For example, most of the surface water sources in Kathmandu Valley have been tapped for water

Table 5.5: Water Supply and Water Treatment Plant s

Description	1999	2001
Production capacity million liters per day (mld)	182	228
Inside Kathmandu Valley (%)	68.7	57.9
Outside Kathmandu Valley (%)	31.3	42.1
Water demand (mld)	214	275
Inside Kathma ndu Valley (%)	74.77	64.36
Outside Kathmandu Valley (%)	25.23	35.64
Average daily production (mld)	155	204
Inside Kathmandu Valley (%)	67.74	54.90
Outside Kathmandu Valley (%)	32.26	45.10
Total tap connections	162,254	188,250
Inside Kathmandu Val ley (%)	65.77	60.45
Outside Kathmandu Valley (%)	34.23	39.55
Water leakage (waste) (%)	38	37
Population served by NWSC in 28 municipalities	1,638,000	1,825,000
Number of drinking water treatment plants	13	15
Total water treatment (mld)	90	100
Total water treatment (%)	58.1	49

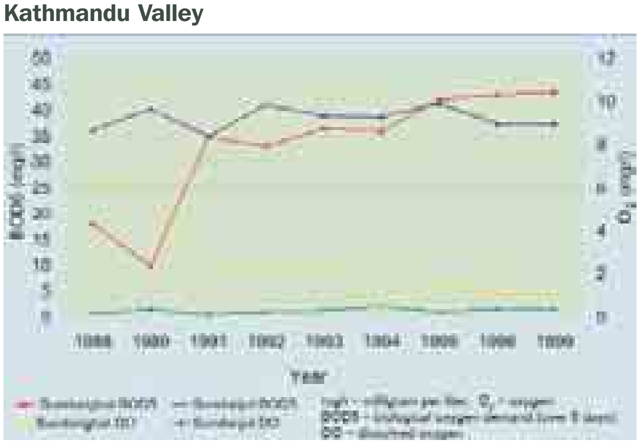
mld = million liters per day, NWSC = Nepal Water Supply Corporation
Source: NWSC (2001)

Table 5.6: Water Quality of Major Rivers During Dry Season

Sample Sites of Major Rivers in Different Parts of Nepal	pH	TDS (mg/l)	DO (mg/l)	BOD (mg/l)
Mahakali at Pancheswar, far west	8.8	110.0	5.0	<2
Karnali at Chisapani, far west	8.9	264.0	10.5	1.5
Bheri at Chatgaon, mid west	7.8	208.0	9.3	1.1
Seti at Ramghat, west	8.2	2.2	9.3	<2.5
Rapti at Sauraha, centre	7.8	213.0	8.7	—
Arun, east	6.5	200.0	—	—
Kankai, east	7.7	60.0	—	—
Mechi, east	8.3	30.0	—	—
WHO Guidelines	6.5-8.5	100.0	>5.0	3.0

— = not available , mg/l = milligram per liter, BOD = biological oxygen demand, DO = dissolved oxygen, TDS = total dissolved solid s, WHO = World Health Organization
Source: CBS (1998)

Figure 5.1: Water Quality Change in the Bagmati River, Kathmandu Valley



Source: UNEP (2000)

supply, and much of the groundwater is being used. The groundwater level in the Valley is lowering due to excessive use for drinking purposes. The total sustainable withdrawal of groundwater from the Valley's aquifers is approximately 26.3 million liters per day (mld), but the groundwater currently extracted is about 58.6 mld (Stanley 1994; Metcalf and Eddy 1999). The groundwater level has lowered from 9 meters to as deep as 68 meters. Unfortunately there is little support from the surrounding watershed areas to replenish the groundwater resource in the Valley, as much of the surrounding area has been turned into agricultural land.

Water Quality

Table 5.6 shows the water quality of eight major rivers across the country. The water of these rivers is used for different purposes including drinking, bathing, washing, swimming, irrigation, and disposal of cremated human bodies. In most cases, pH values are within the World Health Organization (WHO) guidelines; three sites have total dissolved solid amounts below the WHO value; all sites show a dissolved oxygen (DO) level equal to or above the WHO value; and all four sites have biological oxygen demand (BOD) values below the WHO value. On the whole, the water quality of the selected river sites is good compared with the WHO guideline values.

The situation is very different in urban areas. The Bagmati is the major Kathmandu Valley river in terms of drinking water source, irrigation source, and religious importance. Now it is also known as the most polluted river. Figure 5.1 shows the quality of water in terms of BOD5 (BOD over 5 days) and DO before (Sundarijal headwater) and after (Sundarighat end point) the Kathmandu urban area, analyzed from 1988 to 1999 (UNEP 2001). The water at the latter site, particularly since 1994, is highly polluted, as indicated by the high value of BOD5 and low value of DO, as a result of the high concentration of domestic and industrial effluent. Some 21,000 kg of domestic sewage is discharged daily into the Bagmati River from Kathmandu Valley's cities—42% of the total BOD load produced. The total industrial BOD load discharged directly into the river is 3,151 kg per day (CEMAT 2000).

Other sources of drinking water also show poor quality. All the sources of water shown in Table 5.7 are used for drinking purposes in Kathmandu Valley. None of the groundwater sources such as dug wells, deep tube wells, and stone spouts, or surface water including ponds and rivers, or even piped water were found to be consistently free from fecal contamination. The degraded quality of groundwater in the Valley is due to polluted surface water, leachate, and sewage.

Groundwater is the main source of drinking water in the Terai region, meeting over 90% of the demand. But a recent study carried out by the Nepal Red Cross Society (NRCS 2003) indicated that all 20 Terai districts of Nepal have shown arsenic contamination in groundwater. According to the WHO guidelines, water from about one third of the total 29,804 tube wells tested is not acceptable for human consumption as it contains arsenic concentrations over 10 parts per billion (ppb). According to the Nepal Interim Standard of 50 ppb, water from 7% of the tube wells tested is not acceptable for consumption (Table 5.8). Based on water analysis of sample tube wells in four Terai districts (Nawalparasi, Parsa, Bara, and Rautahat), NRCS (2003) has found an arsenicosis prevalence rate of 2.2% among the risk population who are consuming water above 50 ppb. It is estimated that around 0.5 million people in the Terai are living at risk of arsenic poisoning (>50μg/L).

Table 5.9 shows the mineral and bacteriological contents of water from tube wells at selected sites in the Terai region. The concentration of iron and manganese is on the whole higher than the WHO standard. The water is also not free from coliform bacteria.

The reports show that the quality of both surface and groundwater sources in different parts of Nepal is degraded. This is the result of contamination by domestic and industrial waste, human-induced natural disasters, and agro-chemicals, and the effects of changes in land use patterns. All domestic sewers are discharged directly into rivers without treatment. Although this is primarily an urban problem, it also affects neighboring rural areas. Industrial waste is also a major cause of surface water pollution—40% of the country's 4,271 industrial units are reported to be water-polluting industries (CBS 1998). In terms of relative contribution of BOD load, the major polluting industries include vegetable oil, distillery, and leather. The average use of chemical fertilizers, such as nitrogen, phosphorous, and potassium (NPK) per hectare has increased tremendously from 7.6 kg in 1975 to 26.6 kg in 1998. However, the concentration of these nutrients is within the permissible level for river water quality. Finally, landslides, soil erosion,

Table 5.7: Bacteriological Water Quality of Different Water Sources, Kathmandu Valley

Fecal Coliform/ 100 ml	Value as % of Sample Units (n =16)								WHO Guideline Value
	Dug Well	Tube well	Deep[a] Well	Spring	Stone Spout	Pond	River	Pipe Water	
0	0	60	80	40	20	0	0	60	0
1–100	40	30	15	30	40	0	0	20	
101–1,000	30	5	5	30	40	0	100	20	
>1,000	30	5	0	0	0	100	0	0	

ml = milliliter, n = number, WHO = World Health Organization
Source: Pradhan (2000); [a]NWSC (2000)

Table 5.8: Arsenic Sample Tests in Nepal by Different Agencies

Source of Data	Arsenic (ppb)			Total Samples Tested	% of Samples Tested
	<10	>10-50	>50		
DWSS	6,769	2,023	1,217	10,009	33.58
NRCS	6,536	2,709	503	9,748	32.71
RWSSSP/ FINNIDA	3,131	306	191	3,628	12.17
NWSC	16	14	0	30	0.10
NEWAH	235	85	29	349	1.17
Plan International	2,778	2,171	70	5,019	16.84
RWSSFDB	887	122	12	1,021	3.43
Total Samples Tested	**20,352**	**7,430**	**2,022**	**29,804**	**100.0**
%	**68.29**	**24.9**	**6.78**	**100**	

ppb = parts per billion, DWSS = Department of Water Supply and Sewerage, FINNIDA = Finnish International Development Agency, NEWAH = Nepal Water for Health, NRCS = Nepal Red Cross Society, NWSC = Nepal Water Supply Corporation, RWSSFDB = Rural Water Supply and Sanitation Fund Development Board, RWSSSP = Rural Water Supply and Sanitation Sector Program
Source: Sijapati et al. (2003)

Table 5.9: Water Quality of Shallow Tube Wells in the Terai Region						
Sites (District)	**Chloride** (mg/l)	**Ammonia-N** (mg/l)	**Nitrate-N** (mg/l)	**Iron** (mg/l)	**Manganese** (mg/l)	**Coliform** cfu/100ml
Panchgacachi (Jhapa)	15.4	0.70	0.2	6.0	0.8	11.1
Baijnathpur (Morang)	16.4	0.50	0.2	4.5	0.5	15.9
Bayarban (Morang)	17.6	0.50	2.4	6.0	0.6	0.5
Takuwa (Morang)	21.0	1.00	1.0	10.4	0.4	45.9
Shreepur Jabdi (Sunsari)	37.2	0.90	0.2	8.0	0.6	25.5
Bandipur (Siraha)	195.6	0.70	3.5	0.4	0.4	1.0
Naktiraipur (Saptari)	54.5	1.20	0.3	12.0	1.3	16.0
WHO Standard	250.0	1.24	10	3.0	0.5	nil

cfu = coliform units, mg/l = milligram per liter, WHO = World Health Organization
Source: ENPHO (1990)

and floods have often caused turbidity of river water. In the absence of proper protection, drinking water sources are polluted due to the floods during summer rainfall, which add turbidity and various nutrients to the river water.

Sanitation

Sanitation can be measured in terms of availability of sewerage and toilet facilities. Access of households to sanitation facilities increased from 6% in 1991 to 25% in 1999 and 46% in 2001. However, the majority of the population still practices open defecation. This is the major reason for the contamination of water sources, particularly in rural areas. There is a marked variation in access to sanitation between rural and urban areas. In urban areas, access to sanitation increased from 34% in 1991 to 67% in 1999, but in rural areas only from 3% to 18% (NPC 1992; NPC 1997; RWSSP 1999).

On the basis of water use per person per day, NPC (1997) estimated the wastewater generated to be 90% of the total per capita water consumption of both rural (45 liters per capita) and urban (60 liters per capita) areas. This means an estimated total wastewater generation per day of 807 million liters in rural areas and 174 million liters in urban areas. As there are no treatment plants outside the valley, this wastewater is assumed to be discharged directly into water bodies. There are effectively no wastewater or sewage treatment facilities in Nepal. Nominally there are four treatment plants in the country, all in the cities of Kathmandu Valley, but of these four, one is partly functioning and the remaining three are not functioning at all (Table 5.10). Thus in parts of Kathmandu Valley, there are sewerage lines, but the sewerage is discharged directly into the river. In 2001 it was planned to bring the defunct sewerage treatment station at Dhobighat into operation and construct an additional sewer line to extend the service in urban areas. However, as of 2006, the treatment station is still not in operation. In other cities and towns, there is storm drainage but no sewerage system.

Table 5.10: [Theoretical] Sewerage Coverage in Nepal			
Description	**1999**	**2000**	**2001**
Total Length of Sewers (km)	220	225	232
Interceptors	33.7	38.7	40
Laterals	186.3	186.3	192
Number of Treatment Plants	4	4	4
Population Served	390,000	400,000	420,000
Population Coverage (%)	40	40	40

Source: NWSC (2001) p. 11.

Public Health Impacts

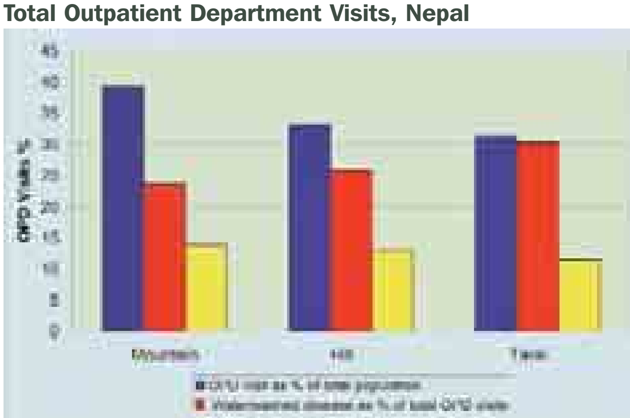
Water pollution is the most serious public health issue in Nepal. There is a vital connection between water and health. The rivers have become major places for urban solid waste disposal and dumping, and for industrial effluents, all of which are responsible for deteriorating the river water quality and contributing to waterborne diseases. In major urban areas, particularly in Kathmandu Valley, vegetables are cleaned with polluted river water, and during the dry summer season polluted river water is used for bathing and washing clothes, which may have adverse effects on human health. The inadequate amount of drinking water is also responsible for disease.

The total treatment capacity of drinking water in Nepal is much lower than the average amount of water produced (NWSC 2001). This means that the quality of drinking water is substandard. As noted in Chapter 2, water-related diseases are among the top ten leading diseases in the country. Of these, waterborne diseases (such as diarrhea, dysentery, cholera, and typhoid, resulting from consumption of contaminated water) and water-washed diseases (due to poor sanitation such as worm infestation and skin diseases) account for 18% and 27% of the total outpatient department (OPD) visits in the country respectively (DOHS 2005). The proportion of OPD visits related to waterborne diseases ranges from as high as 24% in Dailekh and Arghakhanchi (hill districts) to 14% (Bhaktapur, Lalitpur, Jhapa, Parsa and Rupandehi). The proportion of visits related to water-washed diseases was highest in Parsa (Terai district) at 40%, and lowest in Dadeldhura (hill district) at 12%. These water-related diseases are generally caused by poor sanitation and poor water quality (DOHS 2005). Recent data from the Department of Health Services (2005) show that the incidence of diarrhea among children under five years of age is 222 per 1,000, up from 131 per 1,000 in 1996 (DOHS 1996). The reported mortality rate due to diarrhea was 0.34 per 1,000 children under five years of age in 1996, but has been reduced to 0.05 (DOHS 2005). This indicates a greater focus on curative aspects of the health services than on improvements in the quality of the water supply. The hospital records for Sukraraj Tropical Infectious Disease Hospital in Kathmandu show about 16% of all deaths as due to waterborne diseases (STIDH 2004).

Figure 5.2 shows the incidence of waterborne and water-washed diseases among outpatient visits to hospitals (DOHS 2003). Waterborne diseases refer to diseases due to consumption of contaminated water such as diarrhea, dysentery, and cholera; whereas water-washed diseases are due to poor sanitation conditions. The state of these two types of water-related diseases is usually used to describe the sanitation and health of any area. Among the regions, the proportion of water-related diseases is highest in the Terai.

The combined effects of land, soil, water, and air degradation on public health are significant,

Figure. 5.2: Proportion of Water-related Diseases to Total Outpatient Department Visits, Nepal



OPD = Outpatient Department
Source: DOHS (2003)

particularly for the rural poor. These effects have a great impact on their livelihood activities, because the poor already suffer from poor health as a result of inadequate diets, low income, and degraded living areas.

Wetlands

Nepal's wetlands provide habitat for a number of endemic and threatened biological species, as well as for humans. Many ethnic groups rely on wetland resources for their livelihood. Wetlands are therefore valuable for the overall socioeconomic development of the country. Unfortunately, most of the wetlands and their rich biological resources, especially those in the Terai, are facing several threats due to the growing demand of the population for land and a variety of products and services. The threats include siltation, eutrophication, overexploitation of wetland resources, over fishing, hunting and poaching, overgrazing, illegal harvesting of wetland resources, encroachment, water pollution, developmental activities in adjoining areas, drainage, introduction of invasive species, and floods. Due to conflicts among the local people in claiming the resources in and around wetlands, and the absence of an effective mechanism to ensure the efficient local management of these valuable resources, valuable biological species are gradually becoming extinct.

Wetlands also provide habitat for thousands of water birds every year flying over an arduous 2,500-mile migratory journey from Siberia. Unfortunately, a crucial wetland resting point for these migrating flocks is drying up. The Koshi flood plain is flowing below its original capacity, at a level that is barely able to support the local birdlife population, let alone the 50,000 waterfowl that make up a spectacular migratory showcase in the Koshi River during the winter months each year (IUCN 1997).

The conservation of Nepal's wetlands should also call for promoting collaborative efforts such as community forestry programs and buffer zone management programs that have been successful in managing natural resources in the country.

Aquatic Biodiversity

Nepal is rich in aquatic floral and faunal biodiversity. Aquatic fauna species include fish, amphibians, and reptiles. Among aquatic fauna species, 34 are threatened and 61 are insufficiently known (Shrestha 1997). In Ilam in the eastern hills, katle (*Neolissocheilus hexagonolepis*) and silver mahseer (*Tor tor*) are reported to be endangered and threatened, respectively (MOFSC 2002). Three fish species are reported to be endangered, five species threatened, and seven species restricted in the Gandaki River, west Nepal (Shrestha 1999). Over 100 dolphins (*Platanista gangetica*) were sighted recently in the Karnali River in western Nepal and around 20 more at the confluence of the Pathariya and Mohana rivers, the tributaries of the Karnali River, which lies 12 km southwest of Tikapur (Kailali district) in the western Terai region (MOFSC 2002).

The indigenous fish stocks have been declining due to over-fishing, harmful fishing practices (electro-fishing, dynamiting, use of chemicals), pollution, and development work (Shrestha 1999). Development works like river damming or hydropower projects have major impacts on river ecology and aquatic flora and fauna. The Government has made environmental impact assessments (EIAs) compulsory since 1993 under the EIA National Guidelines for all hydroelectric projects above 5 MW.

Compared with fish, there are very few studies on characteristic features of aquatic insects in Nepal. It is not yet known how many aquatic insects and animals are threatened or extinct.

There is a close association between quality of water and abundance and type of aquatic animals. In general, as the intensity of organic pollution increases the diversity of animals decreases and sensitive organisms are replaced by pollution-tolerant animals. The rivers of Nepal flow through diverse geographic environments and possess a variety of aquatic macro-invertebrate species. Most of them are pollution indicators and can be used to determine the quality of river water. The diversity and abundance of benthic macro-invertebrates indicates the specific characteristic features of different sites of a river. As the quality of a water body changes, the aquatic macro-invertebrates in that particular area will also change. They are either washed away or die depending upon their sensitivity to pollution. Therefore, benthic macro-invertebrates are very important in terms of classifying the quality of a water body. For example, the headwater region of the Bagmati River and its tributaries in Kathmandu Valley are rich in aquatic biodiversity, but poor where the rivers flow through the core city area because of organic pollution. Table 5.11 shows the comparative picture of aquatic macro-invertebrates in Kathmandu Valley and Nepal as a whole. This information can provide a baseline for future studies for comparison in terms of decrease or increase in the types of taxa, although as yet, no efforts are being made in this direction.

Table 5.11: Aquatic Macro-invertebrates in Kathmandu Valley and the Country

Aquatic Macro-invertebrate	Number	
	Kathmandu	Nepal
Coleoptera	15	181
Diptera	55	202
Ephemeroptera	33	29
Megaloptera	1	—
Odonata	5	2
Oligochaeta	5	—
Trichoptera	14	59
Gastropoda	7	—
Heteroptera	7	—
Plecoptera	9	67
Hirudinea	2	—

— = not available
Source: Pradhan (1998); Sharma (1998)

Efforts in Water Supply and Sanitation Improvement and Management

Attempts by government, nongovernment, community, and private organizations are underway to better develop, manage, conserve, and utilize water resources in Nepal, either through indigenous efforts or through economic and technical assistance from international and bilateral agencies. Two major efforts are noteworthy.

(i) The Water Resources Act 1992 is of great significance, as it vests ownership of all water resources with the State. Private ownership is disregarded. The Act has appropriately recognized drinking water as the first priority in terms of order of use, followed by irrigation, farming enterprises like animal husbandry and fisheries, hydroelectric power, cottage industry, water transport, and others.

(ii) The National Water Resources Strategy 2002 aims at developing and managing water resources for sustainable use, while ensuring conservation and protection of the environment in a holistic and systematic manner. The strategy not only takes into account water uses such as hydropower and irrigation but also recognizes other uses in areas such as tourism and fisheries. The current Tenth Plan (2002–2007) considers the river basin approach as the basis for the development and management of large rivers.

Drinking water is the basic minimum need of all human beings. Provision of convenient, safe, and adequate drinking water is the declared commitment of His Majesty's Government of Nepal. The Tenth Plan document states a goal of meeting 85% of the total water demand by the end of the plan period (2007) with gradual improvements in service levels, providing appropriate sanitation services in rural and urban areas through community awareness programs, and reducing infant mortality by bringing about a reduction in water-related diseases. The following efforts are underway to increase people's access to drinking water: (i) Rainwater harvesting programs in feasible areas; (ii) Community based water supply and sanitation sector projects, particularly in the mid and far-western regions; (iii) Rural water supply project and water resources management programs by national and international NGOs in different areas; (iv) Community based rural water supply and sanitation programs; (v) A small town water supply and sanitation program; (vi) A water quality improvement program; and (vii) A sanitation education and hygiene promotion program.

In addition, the Irrigation Policy 2003 has adopted many significant initiatives to exploit groundwater for irrigation, particularly in the Terai region. The policy has also addressed the issue of arsenic contamination in groundwater used for irrigation.

Analyzing the National Water Supply Sector Policy's objectives, policies, and programs related to drinking water leads to several observations. First, they emphasize enlarging the drinking water coverage, but mere emphasis will not be adequate unless the quality (potable) and quantity (per capita) aspects of drinking water are considered. These two aspects of water are vital in terms of health and sanitation. Second, the health and sanitation education program to reduce water-related diseases will not be effective unless the water sector defines a Nepalese potable water standard. Further, the living standards of general rural communities must be raised by providing income-generating activities. This will enable them to pay ever-increasing water and sanitation tariffs. However, this issue is not only relevant to the drinking water sector, but interlinked with many other sectors related to water, sanitation, and health. It requires a coordinated effort to be made at national, sub-national, and local levels because water-related diseases relate to all of them.

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