

5 SOUTH ASIA

5.1 South Asia and its Water Resources

South Asia has several transboundary rivers which are among the largest rivers in the world. The subcontinent is drained by four major transboundary river systems: Indus, Ganges, Meghna and Brahmaputra, which all originate from the Himalaya mountain range. These rivers have many characteristics in common including e.g. great variability in flow discharge, floods during the monsoon, drought in dry season, considerable hydropower potential and high population densities in the basin areas (see table 5.12).

The transboundary rivers are covered separately in the following sub-chapters. The national water resources of each South Asian countries are slightly discussed in the country reviews (Chapter 5.2).

5.1.1 Indus

Indus River is the eastest river of the great trans-Himalayan rivers of South Asia. It originates from the Southwestern Tibet and flows northwest across Jammu and Kashmir in North India, then bends to the southwest and pours onto the hot, dry plain of the western Punjab in Pakistan. The Indus receives its most notable tributaries from Punjab, called the land of five rivers. The five rivers are Jhelum, Chenab, Ravi, Beas, and Sutlej.

Indus River, the lifeline of Pakistan, plays a crucial role in the economy of Pakistan. Farmers of the area have used Indus waters since prehistoric times. Irrigation from the Indus and its tributaries makes possible the cultivation of the arid land along their courses. Besides the irrigation, the Indus Basin generate almost half of the electricity produced in Pakistan.

The river's volume is greatest from July to September, when snows are melting in the mountains and the southwest monsoon brings rain. Embankments are used to prevent flooding, but occasionally they give way and floodwaters spread rich alluvial soils over vast areas of the plain.

The use of Indus water is defined in the Indus Water Treaty between India and Pakistan. According to the treaty, signed in 1960, all the waters of the eastern rivers, i.e. the Sutlej, Beas and Ravi rivers taken together, shall be available for the unrestricted use of India. All the waters, while flowing in Pakistan, of any tributary which in its natural course joins the Sutlej main or the Ravi main after these rivers have crossed into Pakistan shall be available for the unrestricted use of Pakistan. This flow reserved by treaty is estimated at 11.1 km³/year.

According to the Indus Basin Studies (WAPDA, World Bank Consultants) conducted in the early sixties, the Indus System has over 30,000 MW of economically developable hydropower potential. Presently, the hydropower generating capacity of the entire Indus River System is slightly under 5000 MW.

5.1.2 Ganges

The Ganges River's headstreams all rise in northernmost Uttar Pradesh state in India. The river continues flowing southeast through the Gangetic plain and the Indian states of Bihar and West Bengal. In central Bangladesh the Ganges is joined from the north by the great Brahmaputra and from the northeast by the Meghna River. Their combined waters (the Lower Meghna) empty into the Bay of Bengal through an extensive and ecologically diverse delta. With a width of 320 km, the delta covers an

area of ca. 60,000 km² in Bengal and is mostly located in the territory of Bangladesh (EB, 2000).

The Ganges Basin is densely populated. The basin area is nearly 1 million km²

while it carries 420 million people or one third of the Southasian population. Agriculture is intensive in the basin area; 71 % of the Ganges watershed is cultivated (Kuusisto,1998; WRI, 2000).



Map 1: South Asia and its Major River Systems

Source:

http://www.lib.utexas.edu/Libs/PCL/Map_collection/middle_east_and_asia/Asia_ref_2000.jpg

The water supply of the Ganges system is dependent partly on the rains brought by the monsoon winds from July to October, as well as on the flow from melting Himalayan snows in the hot season from April to June. Although Nepal's share of the basin area is just 14 %, it contributes about 60 % to the annual discharge of the Ganges. The main tributaries of Ganges,

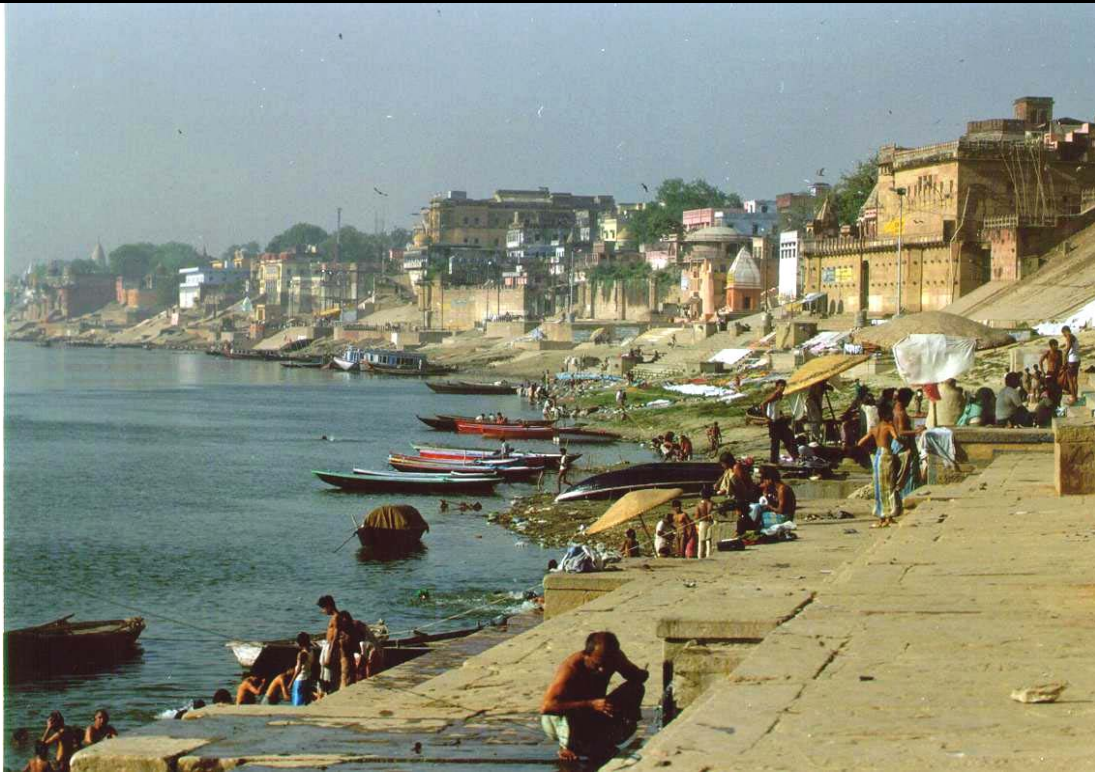
originating from Nepal are the Karnali, Gandak and Kosi Rivers.

The mainstem of the Ganges was unregulated until 1974 when the Farakka Dam was constructed. India built the dam unilaterally to increase the discharge and flush the silt in the Hooghly River. This was necessary to sustain the commercial

viability of Calcutta port. The Farakka Dam is discussed as a case study in the country review of India (Chapter 5.2.3).

In the Ganges River Basin, effective water resource management is constrained by the lack of data sharing among neighboring countries. The security of millions of people is endangered through increasing water

scarcity, floods, excessive sedimentation, drastic changes in river morphology, reduced dam safety, salinization of fresh waters, loss of arable lands, and environmental degradation of unique habitats such as the mangrove forests of the Sundarbans in the Ganges delta (CMC, 2000).



Picture 1: *Middle Reaches of the Ganges River and the Holy City of Varanasi During the Dry Season in April 1999.*

Photo: Tommi Kajander

Besides the problems referred to above, water quality problems of the Ganges have reached a critical level. The heavy population concentration, the absence of strict environmental rules, and the failure to enforce whatever rules that exist, have resulted in the Ganges being one of the most polluted rivers in the world. 114 cities pour untreated sewage

into India's most important river. The Ganges' tributary Yamuna alone drains 200 million litres of sewage and 20 million litres of industrial waste from Delhi to the mainstream. The poor water quality correlates with the occurrence of waterborne diseases such as hepatitis, amebic dysentery, typhoid, and cholera.

Table 5.1: *Characteristics of the major river basins in South Asia***Sources:** ADB, 1996; Bastola, 1994; FAO: Aquastat, 2000; WRI, 2000;.

River	Annual Average Discharge (m³/s)	Length (km)	Basin Area (km²)	Population Density (people/km²)	Large Dams
Brahmaputra	18,960	2,580	580,000	174	0
Ganges	16,650	2,510	977,500	375	6
Indus	5,644	2,900	978,000	145	10
Meghna	5,160	950	80,200	N/A	0

5.1.3 Brahmaputra

Brahmaputra is the biggest trans-Himalayan river system. It stretches from the northern slopes of the Himalayas through Tibet, China and India to enter Bangladesh. From the border it flows south for 270 km to join the Ganges River at Aricha, about 70 km west of Dacca in central Bangladesh. The unified rivers form a mighty stream called Padma River which continues a further 100 km to receive the waters of Meghna River at Chandpur. The Lower Meghna then flows south for 160 km and discharges into the Bay of Bengal through the biologically diverse Meghna estuary. The discharge of the Lower Meghna (the combined discharge of the three main rivers, Brahmaputra, Ganges and Meghna) is among the highest in the world. Peak discharges exceeding 160,000 m³/s have been recorded (FAO, 2000).

Floods are an annual phenomena with beneficial and adverse impacts (see the country review of Bangladesh, Ch. 4.2.1). For the agriculture purposes floods do have a positive effect. Part of the sediment is deposited as a thin layer over the delta, thereby renewing the fertility of the soils. Some sediment is deposited at the oceanward edge of the delta, where it creates new islands. Each emerging delta island is colonised by farmers desperate for

new land. The Brahmaputra has flooded more often and with greater severity in recent years due to the rapid deforestation in the Himalayas.

The Brahmaputra is navigable as far as Dibrugarh in India about 1,100 km from the Bay of Bengal. The growth of heavy river transport has been important to the continuing development of the economic resources in the lower Brahmaputra valley, including tea estates, forests, and oil, coal, and natural-gas deposits in Assam and jute in Bangladesh. In Tibet, the river is navigable for a distance of about 640 km (EB, 2000).

5.1.4 Meghna

With an annual average discharge of about 5,000 m³/s, Meghna River is the smallest South Asian major river system. The 210 km long river is the major watercourse of the Ganges-Brahmaputra delta, in Bangladesh. The name is properly applied to a channel of the Old Brahmaputra downstream from Bhairab Bazar, after it has received the waters of the Surma (Barak) River in Northeast Bangladesh. Flowing almost due south, the Meghna receives the combined waters of the Ganges and Brahmaputra rivers near Chandpur. After a course of 264 km it enters the Bay of Bengal by four principal mouths. The

major tributaries of the Meghna are the Dhaleswari, Gomti, and Fenny Rivers.

A river of great depth and velocity, the Meghna is sometimes split up into several

channels and sandbanks of its own formation. The river is navigable, but dangerous, all year. At spring tide the sea rushes destructively upriver in a single 6 m-high wave.

5.2 Country Reviews

5.2.1 Bangladesh

Bangladesh is a South Asian country located between India and Myanmar. With an area and a population of 143,998 km² and 128 million respectively, it is one of the most densely populated country in the world.

The country receives an annual average precipitation of 2,320 mm which brings about total renewable water resources of 1,211 km³/year (FAO,2000). There are 230 rivers (including tributaries), out of which 57 are transboundary. The water resources are dominated by the three mighty rivers: Brahmaputra, Ganges and Meghna (see table 4.1). Together they form the majority of the country's floodplain, which covers 80 % of Bangladesh. In addition this river system, which is world's largest sediment dispersal system, forms the most extensive delta region in the world (Passmore, 1997).

The flow of the rivers is highly seasonal and fluctuates widely during the monsoon and the dry months. As a consequence, two major hazards are confronted with: severe scarcity of water during dry seasons and floods during the monsoons. As the lowest riparian of Brahmaputra, Ganges and Meghna, Bangladesh has to suffer from the continued development of upstream basins. Due to the deforestation in the upper watersheds, floods are worsening and causing serious environmental degradation and erosion. In 1998 the floods continued for more than two months, from the middle of July until late September. Three quarter of the country was submerged by flood. 860,000 ha of farmland and more than half of Dhaka, the capital city, were inundated. In total, more than 40 million people were affected.

During the dry season (October-May) the upstream withdrawals are causing severe water shortages across the country. In

addition the decreasing low flow has devastating effect on the ecology: fish populations are threatened and the delta region is decaying due to the increased salinization (ADB, 1996).

Due to the flatness of the country there are no appropriate sites for large dams. Today there is one large dam in operation on Karnafally River in the southeast of the country. It was constructed in 1962 mainly for generation of hydropower. No large dams are under construction or planned. The total water storage capacity of all dams is 5.36 km³ (The Inter..., 1999).

5.2.2 Bhutan

Bhutan, with an area of 47,000 km², is a small kingdom located on the eastern ridges of the Himalayas, neighbored by Tibet in the north and India in the south. Most of the 637,000 inhabitants live in the fertile river valleys and southern flatlands, where the land is fertile and cultivable. Water resources are abundant in Bhutan. The average precipitation is roughly estimated around 4 000 mm/year. There are four major river basins, which all discharge into the Brahmaputra River in the plains of India. The total mean flow of the rivers is estimated at 1,325 m³/s (UN, 1995).

Besides being the main source of water, the rivers carry a huge potential for hydropower development. Bhutan's theoretical hydropower potential is equivalent to 20,000 MW of capacity, out of which as much as 16,000 MW is economically feasible. 100 potential sites for large or medium plants have been identified. So far, only 355 MW is developed. In 1995, hydropower generated 1,710 GWh of electricity, representing 99.6 % of national power production.

The biggest hydro project under construction is the 1,020 MW Tala hydro project. It should be in operation in 2004. Two further project are planned: the 180

MW Bunakha and the 900 MW Wang Chu. Tala and the planned hydro projects are located in the Wang Chu river valley (Inter...,1999).

Great bulk of Bhutan's export earnings come from power sales to India. In 1997 power exports provided Bhutan revenues of US\$ 35.5 million (ADB, 1999).

5.2.3 India

India is a land of many rivers and mountains. Its geographical area of about 3.29 million km³ is criss crossed by a large number of small and big rivers. The annual precipitation including snowfall is estimated to be 4,000 km³. By the latest estimates of Central Water Commission,

considering both surface and ground water as one system, natural run off in the rivers is about 1,869 km³/year of which appr. 1,122 km³/year is estimated to be utilizable.

The water resources of India are unevenly distributed. Brahmaputra and Barak basin with 7.3 percent of geographical area and 4.2 percent of population of the country has 31 percent of the annual water resources. Water scarcity (less than 1000 m³ per capita/year) is faced in Cauvery, Pennar and Sabarmati basins. In Sabarmati basin the per capita annual availability of water is as low as 360 m³. Other water scarce river basins include the east and west flowing rivers. The major river basins of the country are represented below in table

Table 5.2: Major River Basins of India

Source: FAO, 2000; Ministry of Water Resources of India, 2000

Name of the River	Origin	Length [km]	Catchment Area [km ²]	Average annual run-off [m ³ /s]
Indus	Tibet	1,114	321,289	2,320
Ganges	Uttar Pradesh	2,525	861,452	16,650
Brahmaputra	Tibet	916	194,413	17,040
Barak & other rivers Flowing into Meghna, Like Gomti, Muhari, Fenny etc.			41,723	1,530
Sabarmati	Rajasthan	371	21,674	120
Mahi	Madhya Pradesh	583	34,842	350
Narmada	Madhya Pradesh	1,312	98,796	1,450
Tapi	Madhya Pradesh	724	65,145	470
Brahmani	Bihar	799	39,033	900
Mahanadi	Madhya Pradesh	851	141,589	2,120
Godavari	Maharashtra	1,465	312,812	3,505
Krishna	Maharashtra	1,401	258,948	2,477
Pennar	Karnataka	597	55,213	200
Cauvery	Karnataka	900	81,155	680
Total			2,528,084	49,810 m³/s

India has a vast potential for hydropower generation, particularly in the northern and northeastern region. As per an estimate of Central Electricity Authority, the economically exploitable hydropower potential in the country is 84,000 MW of which 22,000 MW has been installed. A further 8,910 MW of hydro capacity is

under construction and 3,557 MW planned. Most of the schemes are multipurpose schemes.

India has about 2,481 large dams in operation, of a total of about 4,000 dams. The several major dams under construction are listed below in table 5.14.

Table 5.3: Major dams under construction in India in 1999

Source: The International Journal on Hydropower & Dams, 1999

Dam Name	River	Height	Purpose
Tehri	Bhagirathi	261	I, H
Kishau	Tona	236	H
Lakhwar	Yamuna	204	I, H
Sardar Sarovar	Narmada	163	I, H
Ranjit Sagar	Ravi	168	I, H
Karjan Lower	Karjan	100	I
Indira Sagar	Narmada	94	I, H
Doyang	Doyang	88	H
Vyasi	Yamuna	88	I, H
Kallada	Kallada	85	I
Shrinagar	Alakhnanda	85	H
Dudhganga	Dudhganga	74	I
Tillari	Tillari	72	I
Nathpa Jhakri	Sutluj	68	I, H
Godriver Medium	God	67	I
Dulhasti	Chenab	65	I, H
Upper Indravati	Indravati	65	I, H
Ranganadi	Ranga	62	H

Note: Irrigation (I), Hydropower (H)

Farakka Dam

Negotiations on sharing of Ganges water at Farakka was started from 1960 at the time of signing of Indus Water Treaty between India and Pakistan. India decided to construct a barrage across the Ganges at Farakka in 1951 in order to divert 1,133 m³/s of water to a Ganges tributary called the Hooghly River. Due to the sedimentation, the Ganges had changed its course and the low-flow in the Hooghly had decreased. The port of Calcutta was facing

serious problems since the siltation had risen the river bed. Salinization of soil was another problem faced in the delta region.

Construction of the Farakka Barrage was started unilaterally by India in 1960. The 2,240 m long dam was designed for a maximum design discharge of 76,500 m³/s with a head regulator for diversion capacity of 1,133 m³/s. In 1974, the Indian Government completed the dam at Farakka, 19 km upstream from the India-Bangladesh border (Engineers Association of Bangladesh, 1997).

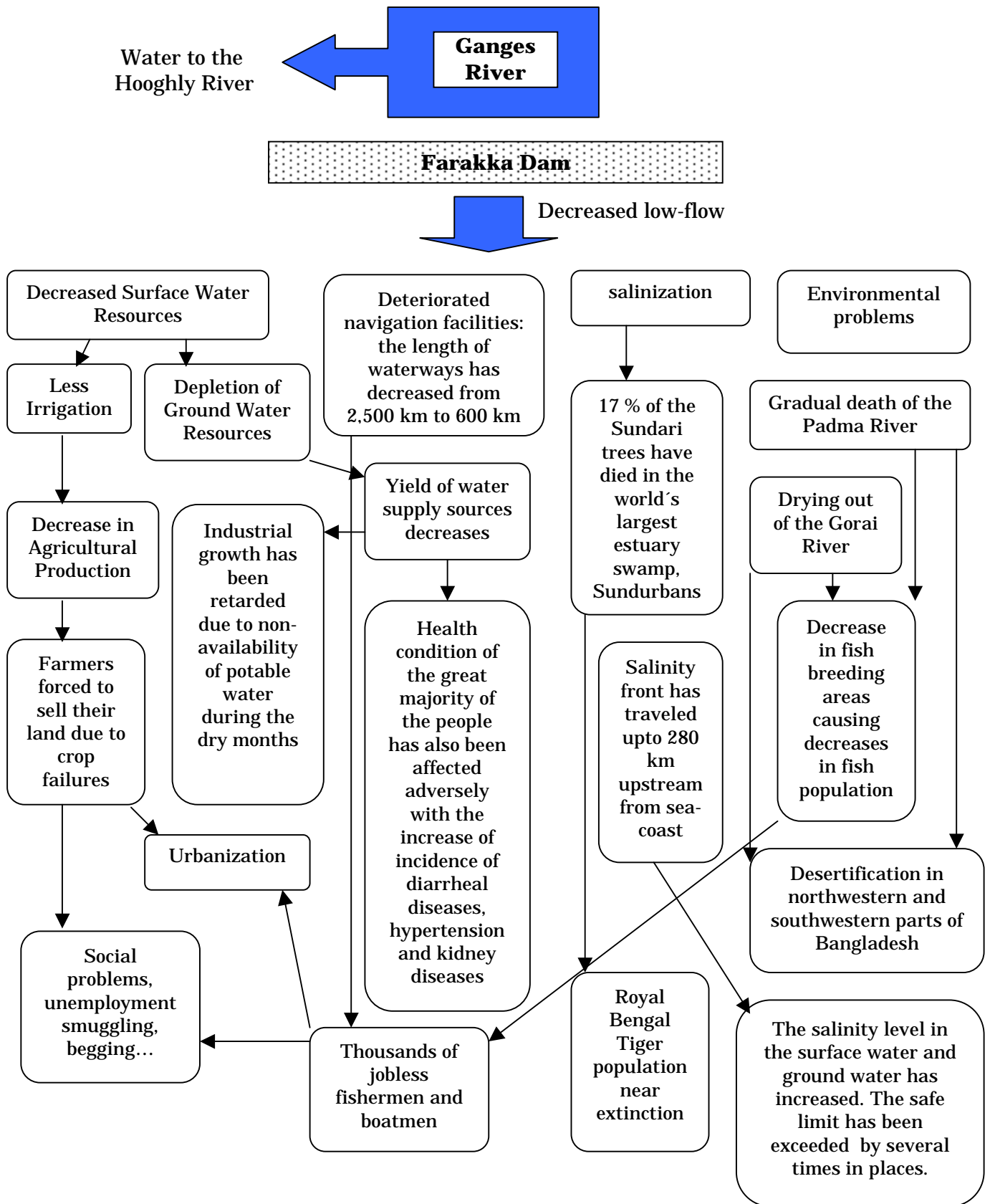


Figure 5.1: Downstream adverse impacts of the Farakka Dam

Source: Ahmed et Amin, 1998; Engineers Association of Bangladesh, 1997

Farakka Dam is a good example of negative downstream effects that construction of a large dam can create. The figure 5.1 above summarizes the adverse impacts and their consequences caused by the decreased dry season discharge in the Ganges Basin in Bangladesh.

Several agreements regarding the water sharing of the Ganges at Farakka has been made. The first one was announced in 1975 which was followed by the five year agreement signed in 1977. In 1982 a Memorandum of Understanding (MOU) came into effect. It was replaced by another one in 1985 which was valid up to 1988. From 1988 to 1996 no agreement existed between India and Bangladesh on the sharing of the Ganges water.

At present the two countries follow the treaty of 1996. It established a new formula for sharing the Ganges waters at Farraka in the dry season from 1 January to 31 May. According to the new arrangement both countries receive 50 % of the discharge if the Ganges flow at Farakka is $1,982 \text{ m}^3/\text{s}$ or less. With a flow of between $1,982$ and $2,124 \text{ m}^3/\text{s}$ Bangladesh receives $990 \text{ m}^3/\text{s}$ and India the rest of the flow. When the flow exceeds $2,124 \text{ m}^3/\text{s}$ India receives $1,132 \text{ m}^3/\text{s}$ and Bangladesh receives the balance. Further provision is made for the situation where the flow falls below $1,415 \text{ m}^3/\text{s}$. The sharing arrangements are to be reviewed every five years (Sands, 1996).

Although all the agreements between India and Bangladesh have had as their main objective the allocation of the available water there is simply not enough water for the competing demands and needs of India and Bangladesh. Since 1977 there has been discussion between the neighbors about the augmentation of the flow of the Ganges. India's solution for the increase of low-flow at Farakka is water withdrawal from the Brahmaputra River. Bangladesh has rejected the proposal due to the environmental, social, political and economic consequences of the link canal

between the Brahmaputra river and the Ganges. Bangladesh has proposed construction of storage reservoirs at the upper reaches of the Ganges in India and Nepal to store water during the monsoon for release in the dry season. India rejects the proposal; it wants to reserve the upstream waters of the Ganges for the future needs. In addition, India prefers the bilateral approach and doesn't want to regionalize the issue thus involving Nepal in the discussion (Salman, 1998).

Due to the difficulties in co-operation, Bangladesh has started developing its own options for augmenting the dry season flow of the Ganges by reviving the idea of the Ganges Barrage. Although the barrage project was first conceived in 1961, it was not found to be practical without a permanent or long-term agreement on the sharing of the Ganges water between Bangladesh and India. The signing of the 30-year Ganges water sharing Treaty in December 1996 has opened up the prospect of implementation of the long-cherished Ganges Barrage Project. Bangladesh now plans to build a dam at Pangsha, 145 km west of Dhaka, to store the wet season flow of the Ganges for use during dry season. The barrage is expected to irrigate an area of 1.35 million ha of land, and to protect another 1.44 million ha from floods. If the idea of the Ganges Barrage comes true, it could assist in dealing with some of the main challenges of the Ganges; it could finally end the fruitless discussion between India and Bangladesh on a joint plan for augmenting the flow of the Ganges during the dry season (Salman, 1998; Mirza, 1998).

Narmada Valley Development Program

Narmada river is the largest west-flowing river in India. It carries an annual average flow of $1,450 \text{ m}^3/\text{s}$ and drains an area of $98,800 \text{ km}^2$. The basin area covers some of the poorest states of India. It is inhabited

by 40 million people and is subject to an intense population growth. Due to water and electricity shortages, living conditions are worsening. This leads to increased migration to cities (Vakkilainen & Varis, 1997).

The Government of India has prepared ambitious plans to solve the water related problems in the Narmada Valley. The Narmada Valley Development Program includes the building of 30 large, 135 medium and 3000 small dams to harness the waters of the Narmada and its tributaries. The proponents of the dam claim that this plan would provide large amounts of water and electricity which are desperately required for the purposes of development in the Narmada Valley.

Opponents of the dam question the basic assumptions of the Narmada Valley Development Plan and believe that its planning is unjust and inequitable and the cost-benefit analysis is grossly inflated in favour of building the dams. According to an international coalition of individuals and organizations, the Friends of River Narmada, the plans rest on untrue and unfounded assumptions of hydrology and seismicity of the area and the construction is causing large scale abuse of human rights and displacement of many poor and

underprivileged communities. They also believe that water and energy can be provided to the people of the Narmada Valley, Gujarat and other regions through alternative technologies and planning processes which can be socially just and economically and environmentally sustainable (Friends of River Narmada, 2000).

The first survey's of the Narmada Valley began in the mid-40s. The first dam of the project was the Bargi dam which was conceptualised in 1968 and completed in 1990. It submerged 162 villages and an area of 268 km². The dam project was carried out without proper assessment of how many people would be affected. Many of the resettlement sites built by the government got submerged when the reservoir was filled. Displaced people were just given cash with no means of sustenance.

The Bargi dam is not delivering the benefits that were promised by the government. Against the promised irrigation of 437,000 ha, irrigation of only 24,000 ha is achieved. There is no money to build the irrigation canals (Dharmadhikary, 1998).

Chronology of Narmada Development Project

1946 - 1969

Planning of 30 large (Sardar Sarovar and Narmada Sagar being the largest), 135 medium and 3,000 small dams in Narmada Basin. All the proposed dams are located in Madhya Pradesh, except the Sardar Sardovar in Gujarat.

1979

The central government authorizes the construction of Sardar Sardovar to the height of 138 m and makes the sharing of benefits (irrigation water and electricity) between the states. 75,000 km of canals are planned to irrigate 1.8 million ha in Gujarat and about 73,000 ha in Rajasthan. Emergence of the opposition movement.

1985

The World Bank grants a loan of US\$ 450 million for the construction of Sardar Sardovar.

1988	Construction works start. Medha Patkar takes the lead of the opposition movement called the Narmada Bachao Andolan (NBA). Convinced of the inequitable resettlement, NBA takes officially an anti-dam position.
1990	Completion of the first dam in Jabalpur confirms the problems concerning the resettlement. Pacific demonstrations and hunger strikes take place.
1992	An independent commission Morse, established by World Bank, accomplishes a report which impugns the quality of the feasibility studies.
1993	World Bank recedes from the project.
1994	A hunger strike of 23 days, carried out by six militants, ceases when the state of Madhya Pradesh retreats from the project. Development in Gujarat and Maharashtra continue. The vigorous summer monsoon causes significant material damage on the dam site.
The Beginning of 1995	The construction of Sardar Sarovar is suspended at the height of 80 m.
The End of 1997	The dam opponents celebrate the 3 year-long interruption of Sardar Sarovar project. 25,000 people target the next construction site: the Maheshwar dam site.
1998	The government of Madhya Pradesh insists the termination of Maheshwar Dam Project.
January 1999	The legal action taken place in Supreme Court concerning Sardar Sarovar ends. The court permits the continuance of the dam construction to the height of 93 m.
May	Arundhati Roy, anti-Narmada Project activist, offers his Booker Prize to NBA and publishes a synthesis on the unacceptable human costs of the project.
Monsoon	Militants from all over the country gather to the Narmada Valley to face the rising water and oppose the inundation of new land areas.
23 November	The Ministry of Water Resources of the Government of India visits the Narmada Valley for the first time in 12 years.

Source: Blasco, 2000



Map 2: The Narmada River and its Main Dams

Source: IRN, 2000

5.2.4 Nepal

Nepal is a relatively small kingdom on the southern slopes of the Himalayas. It is strategically located between the two giants: India and China. The country is topographically very diverse. The subtropical southern parts of the country, called Terai, belong to the Gangetic Plain while the northern Nepal is dominated by the Himalayan Massif and has the world's highest peak Mt. Everest.

Nepal is one of the least developed countries in the world. The annual per capita Gross National Product (GNP) is only US\$ 220. Its growth has been less than 2 % per year for many years, which means that Nepal will remain the poorest country of South Asia for a long time.



Picture 2: The steep Himalayan river valleys do have a considerable hydropower potential.

Trisuli River in the Langtang Valley during the low-flow.

Photo: Tommi Kajander

Nepal's water resources are abundant. The average annual precipitation is 1,700 mm of which 80 % occurs during the monsoon season from June to September. The total annual average run-off from Nepal's 6,000 rivers is 174.2 km³.

Surface water resources are distributed in the river system consisting of four major rivers (the annual average discharge in brackets): the Mahakali River basin (580 m³/s), the Karnali River basin (1,400 m³/s), the Gandaki River basin (1,600 m³/s) and the Kosi River Basin (1,500 m³/s). All of them drain into the Ganges. Overall, the rivers of Nepal contribute more than 40 % of the total flow of the Ganges. During the

dry season Nepal's contribution to the low-flow of the Ganges is as high as 70 %.

Water storage potential in Nepal is 88 km³. Nepal's theoretical hydropower potential is 83,290 MW of which 43,442 MW is technically feasible. So far the hydropower development has been slow. Due to the high dam construction costs, and lack of infrastructure and capital only 262 MW (0.6 %) of hydrocapacity is installed.

At present 93 dam sites have been identified and 66 of these (42,000 MW in total) are found economically feasible. Some data about the largest planned dam schemes in Nepal is provided below in table 5.15.

Table 5.4: Data about the largest planned dam schemes in Nepal.

Sources: Kathmandu Post, 1997; Onta, 1998

Name	Location	Height (m)	Installed Capacity (MW)	Total Estimated Cost (US\$ billion)	Other
West Seti Hydropower Project	West Seti River	195	750	1.2 (1997)	Almost all the power produced will be exported to Uttar Pradesh and Bihar states in India. Power purchase agreement with India is under negotiations.
Pancheswor Project	Mahakali River	315	6,480	2.98 (1995)	Irrigation benefits to Nepal: 930 km ²
Karnali Project (Chisapani Dam)	Karnali River	270	10,800	4.89 (1989)	

In Nepal one of the major problems in storage projects is the inflow of sediment which leads to the depletion of storage volume. The Kulekhani reservoir in the close proximity of Kathmandu lost 5 % of its storage volume due to one cloudburst in 1993! In general the Himalayan rivers are known to carry heavy sediment loads. The total sediment load of Nepali rivers is estimated to be 726 million tons annually. Due to the deforestation and mismanagement of the river basin areas the annual sediment load is expected to

increase in forthcoming years (Pandey, 1998).

Water resources development of Nepal cannot be accelerated to the expected level without foreign investment. The foreign investment can not be attracted without solving the international river related issues. Till now none of the concrete agreements have been reached with India concerning the use of waters of major river basins of Nepal. The major river basins on the issue are Karnali, Kosi, Mahakali and Gandak.

5.2.5 Pakistan

Pakistan can be considered as a water scarce country. Most of the country is subjected to a semi-arid climate. The average annual precipitation is just 494 mm and the internal renewable water resources are estimated at 248 km³/year, while the population of the country has exceeded 140 million.

Pakistan is one of the largest nations in the world that depends on a single river system. The water from the Indus River and its tributaries supports the bulk of the agricultural water supply.

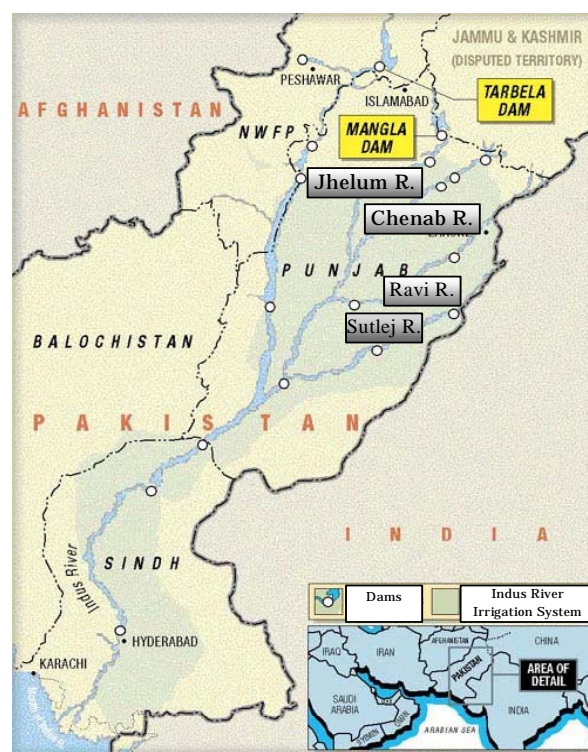
Dams on the main stem of the Indus River and its tributaries produce most of the electrical energy for Pakistan (45%) (Khan et al., 2000).

Mangla and Tarbela Dams

The Mangla and Tarbela dams play an important role in the economy of Pakistan. Not only do they provide water for irrigation, but also help to generate cheap hydroelectric power. The Tarbela and Mangla Reservoirs have power generating capacities of 3500 MW and 1150 MW, respectively. Since irrigation demand has the first priority on water released from the Mangla and Tarbela Reservoirs, the production of energy at these power plants occurs either as a by-product of irrigation releases or when surplus water for irrigation needs is available.

The reservoir levels start rising by the end of March and end of April for Mangla and Tarbela respectively and reach their maximum level by the end of August. The maximum drawdown occurs in March. The Chashma Reservoir is in fact a barrage with some storage capacity, and provides about 0.5 km³ of storage. This is a very important regulation point in the system. Water released for irrigation from the Tarbela Reservoir to the four provinces is

regulated at the Chashma Reservoir. Presently, a hydropower plant is also under construction at the Chashma Reservoir.



Map 3: The Indus River Basin and its Main Dams

Source: WCD, 2000

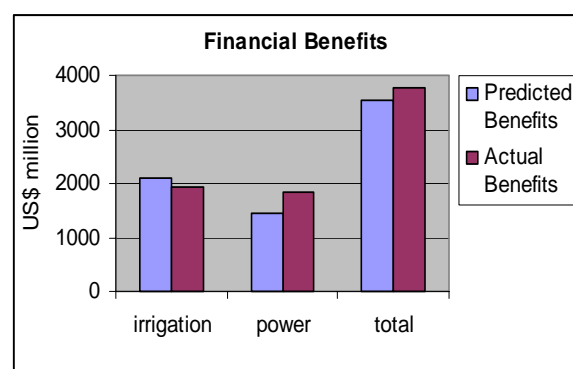


Figure 5.2: Irrigation and Power Benefits of the Tarbela Dam Over the Period 1975 - 1998

Note: Benefits are calculated according to the value of money in 1998.

In 1998 prices, the overall estimated water (storage) and power financial benefits were

US\$ 3782 million (see figure above). As compared to this, the total capital expenditure was about US\$ 4388 million. This performance over 23 years (about half of the originally estimated useful life of 50 years) was quite impressive.

All the outcomes (negative and positive) gained by the construction of the Tarbela dam could not have been predicted. Below are listed some issues with the unexpected outcomes occurred.

Table 5.5: *Unexpected outcomes gained by the construction of the Tarbela dam*

Source: WCD, 2000

Issue	Outcome
Schedule	Major problems experienced with seepage through upstream blanket, damage to tunnels, low level outlets and spillways.
Project costs	Overrun due to cost of remedial works.
Irrigation	Additional diversions lower than expected as other dams not constructed. Major expansion of groundwater irrigation from 31.6 km ³ in 1972 to 62.2 km ³ in 1997. Number of tubewells increased by 400 %. Shift in cropping patterns to sugarcane, cotton, rice, and wheat. Lower productivity of land and water.
Water logging and salinity	Low irrigation efficiencies.
Hydropower generation	Power optimization study undertaken leading to increased installed capacity.
Flood control	Reduction of flood flows to wetland areas downstream.
Sedimentation	Advance of sediment delta to within 14 km of the dam requiring modification of operating rules.
Resettlement	Continuing claims for settlement after completion resulted in establishment of a new commission; considerable number of indirectly affected people not eligible. Still 1953 affectees who hold valid allotment letters have not been given land due to non-availability. Sindh government decided in 1974 to withhold 7,826 ha of land originally promised for allotment to Tarbela Affectees.

5.2.6 Sri Lanka

Sri Lanka, an island covering a land area of 65,610 km², is located in the Indian Ocean. It is predominantly an agricultural country with a rural population making up almost 80 % of a total 18.8 million.

The country is endowed with water resources through intermonsoonal climatic directions from the southwest and northeast during two seasons of the year. With an average annual precipitation of 2,000 mm, the total amount of water available for use in the country is 127

km³/year out of which 50 km³ is surface water run-off.

Economic development, population pressure, and growing demands for electric power and adequate water and sanitation services are placing increasing pressure on water resources.

Mahaweli Project

Large dam projects have arisen discussion in Sri Lanka for many years. The Mahaweli Project, completed five years delayed in 1991, has been controversial among the people of Sri Lanka. The project, including

several large dams, has benefited people by providing irrigation and hydropower. By 1986 almost all the major multi-purpose dam projects had been completed. They generated 1,442 GWh of power by the end of 1993, which was equivalent to 52 % of the power generated in Sri Lanka. The dams also act as storage tanks for the irrigation systems which serve over 100,000 hectares of new lands within the project area. In addition, the Mahaweli waters irrigate 68,000 hectares of farmland in other areas by augmenting existing water supplies. In 1991, 20 % of the rice and 55 % of the chilli consumption of Sri Lanka was produced in the Mahaweli command area.

Today many of the farmers are however facing various problems. Until the end of April 1992 more than 700,000 people were resettled by the Mahaweli Project. They lost their homelands. According to

Environmental Foundation Ltd., Sri Lanka, the project has failed to bring the promised benefits, thus providing adequate water for the farmers. Environmental implications such as increased onsite soil loss rates, degradation of downstream water quality, loss of natural forest cover and change of seasonal flow regimes of rivers are critical. The reservoirs are facing sedimentation problems and water shortages. The total electricity generation from hydro plants was reduced by 28 % in 1996 due to dry weather. During the same year, the area of cultivated land in the project area decreased as well by 13 % to 119,100 ha (Withanage, 1998).

There are 47 large dams (more than 15 m-high) under operation. The technically feasible hydropower potential of Sri Lanka is 2,175 MW of which about 56 % has been developed. The total water storage capacity of all dams is 7.2 km³ (The Inter...,1999).

5.3 References

ADB, 1996, *Towards Effective Water Policy in the Asian and Pacific Region, Volume II: Country Papers*, Asian Development Bank, Manila.

ADB, 1999, *Key Indicators of Developing Asian and Pacific Countries 1999*, Volume XXX, on-line version.

http://www.adb.org/Documents/Books/Key_Indicators/1999/

Ahmed I. et Amin A. M., 1998, *Bangladesh: Waiting for a Miracle*, People & the Planet, Vol. 5, Number 3.

Bastola S., 1994, *Water Resources Development of the Mighty Himalayan Rivers*, Kathmandu, Nepal

Blasco P., 2000, *Narmada, un barrage contre l'oubli*, Globe-Mémoires N°3, 2000

CMC, 2000, Cooperative Monitoring Center, *South Asia Water Resources Workshop: An Effort to Promote Water Quality Data Sharing in South Asia*, Kathmandu, Nepal, 12-14 September 1999.

Dharmadhikary S., 1998, *Large Dams – Destruction not Development: the Experience of the Dams in the Narmada Valley in India (with the exception of Sardar Sarovar)*, Paper presented at the first Regional Consultation of the World Commission on Dams, Colombo, Sri Lanka, 10-11 December 1998.

http://www.dams.org/submissions/sub_sa72.htm

EB, 2000, Encyclopaedia Britannica – On-Line, Keywords: *Brahmaputra River, Ganges River*, <http://www.britannica.com/>

Engineers Association of Bangladesh, 1997, *Ganges Water Sharing Treaty – A Critical Evaluation*, Compiled and Edited by the Engineers Association of Bangladesh from the Ganges Water Treaty Meeting by the Shotonagoric Committee held on the 31st January 1997, at the Press Club, Dhaka, Bangladesh.

<http://www.cyberbangladesh.org/ganges.html>

FAO, 2000, Food and Agriculture Organization of the United Nations, Aquastat, an on-line database of statistics on freshwater availability in agriculture and rural development.

<http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/aquastat.htm>

Friends of River Narmada, 2000, <http://www.narmada.org/introduction.html>

IRN, 2000, <http://irn.org/programs/narmada/map.html>

Kathmandu Post, 1997, *West Seti : Some unresolved issues* by S.N. Sharma, 31 July 1997

Khan A.R. et al., 2000, *Water Availability and Some Macro Level Issues Related to Water Resources Planning and Management in the Indus Basin Irrigation System in Pakistan*

<http://www.oieau.fr/riob/ag2000/pakistan.htm>

Kuusisto E., 1998, *International River Basins and the Use of Water Resources*, A Report to the Ministry for Foreign Affairs, Finnish Environmental Institute.

Ministry of Water Resources of India, 2000, <http://wrmin.nic.in/resource/default3.htm>

Mirza M.M.Q., 1998, *Ganges Barrage Project: Hydro-environmental Aspects*, The Daily Star, Vol.1, No. 204. Online version.
<http://www.dailystarnews.com>

Onta I.R., 1998, *Large Dams and Alternatives in Nepal – Experience and Lessons Learnt*, Paper presented at the first Regional Consultation of the World Commission on Dams, Colombo, Sri Lanka, 10-11 December 1998.

Pandey B., 1998, *Dams and Civil Society in Nepal*, Paper presented at the first Regional Consultation of the World Commission on Dams, Colombo, Sri Lanka, 10-11 December 1998.
http://www.dams.org/submissions/sub_n5.htm

Passmore J., 1997, *Construction of a dynamic GIS tool kit for the visualization, analysis and prediction of bankline movement along the Jamuna River, Bangladesh*
http://www.geog.nottingham.ac.uk/~thorne/msc_diss.htm

Salman S., 1998, *Co-management of Resources: The Case of the Ganges River*
<http://gurukul.ucc.american.edu/maksoud/water98/present1.htm>

Sands P., 1996, *Bangladesh-India: Treaty on Sharing of the Ganges Waters at Farakka*
<http://www.asil.org/india.htm>

The International Journal on Hydropower & Dams, 1999, World Atlas & Industry Guide.

UN, 1995, *Integrated Water Resources Management in Asia and the Pacific*, United Nations, Water Resources Series, No. 75, New York, 1995.

Vakkilainen P. & Varis O., 1997, *Riittääkö ruoka, riittääkö vesi*, 80 vuotta salaojitusta itsenäisessä Suomessa, Salaojakeskus, 1997.

WCD, 2000, World Commission on Dams, Case Study, *Pakistan: The Tarbela Dam and Indus River Basin*, <http://www.dams.org/studies/pk/>

Withanage H., 1998, *Upper Kotmale Hydropower Project. Will it Be another Disaster?*, Paper presented at the first Regional Consultation of the World Commission on Dams, Colombo, Sri Lanka, 10-11 December 1998.
http://www.dams.org/submissions/sub_sl1.htm

WRI, 2000, Research Center: Maps & Indicators: Watersheds, World Resources Institute.
<http://www.wri.org/watersheds/ww-asia.html>