CHAPTER 4

AQUATIC ECOSYSTEM

Aquatic Ecosystem

4.1 Introduction

The aquatic environment in Pakistan can be divided into inland waters, estuarine waters and marine water. The inland water bodies include the rivers, streams (mainly those of the Indus System), lakes and other wetlands as well as groundwater. The estuarine water occupies the lower delta of the river Indus, which splits into numerous distributaries and is often inundated by tidal floods. The Exclusive Economic Zone (EEZ) of Pakistan is about 240,000 square km, with an additional continental shelf area of about 50,000 square km. As such, the total maritime zone of Pakistan is over 30 percent of the land area (NIO, 2012). The aquatic environment resources include both renewables and non-renewables. The renewables include a) fresh water resources, b) fisheries (both from inland waters and marine environment), c) mangroves and related vegetation and d) other aquatic flora and fauna. The non-renewable resources include minerals such as petroleum, manganese nodules, metalliferous sediments, phosphorites and common salt. This chapter discusses the status and trends of aquatic resources of both inland water bodies and the marine environment in terms of quantity and quality (including pollution load and its characteristics). It then examines the policy measures and programmes that have been undertaken in the country to conserve the aquatic resources and protect them from intensifying pollution.

4.2 Inland water Resources: Status and Trends

4.2.1 Freshwater Quantity: Status and Trends

Inland water is the main freshwater resource of Pakistan, which includes surface water of rivers and their tributaries, local rainfall and useable groundwater. This resource is central to many critical environmental issues in Pakistan. On the one hand, the vast Indus Basin system sustains the life and livelihoods of the majority of the population; on the other hand, shortage of water and the uncertainties of rainfall dictate the patterns of activity in most non-irrigated areas. Approximately 170 billion cubic metres (BCM) of water enters the Indus Basin annually. Of this, 128 billion cubic metres are diverted for irrigation purposes to the canal heads, leaving 42 BCM to flow to the sea. Although this flow is needed to maintain a viable river ecosystem especially in the Indus estuary, experts agree that much of it could be stored for irrigation. Yet, Pakistan currently lacks the necessary storage capacity, in part because of heavy silting of reservoirs. Besides the water supply from the Indus Basin system, Pakistan also has about 62 BCM of groundwater. Private and public sector tube-well irrigation uses 56 BCM water for agriculture, twice the average annual rainfall.

The major source of surface water is the Indus River and its major tributaries, the Kabul, Chitral, Swat and Panjkora Rivers on the right bank; and the Jhelum, Chenab, Ravi, Beas and Sutlej on the left Bank. With the implementation of the Indus Water Treaty (World Bank 1960) between Pakistan and India, among the tributaries on the left bank only Jhelum and Chenab have fallen to the share of Pakistan, while Sutlej and Beas have gone to India. The Indus and its tributaries on the left bank flow in shallow meandering channels across the vast alluvial plain, which gently slopes towards south to south-west along the river with extremely flat gradients from about 0.02 percent (2 meter per 10 km) in the Punjab to as low as 0.01 percent (1 meter per 10 km) in Sind. The rivers have individual flow characteristics but they all rise in the spring and early summer with the snowmelt and monsoon rainfall and have a combined peak discharge in July or August. In winter, during the November-February period, flows are much lower at less than one-tenth of those in the summer monsoon. The winter flows consist almost entirely of regeneration or bank storage returning to the river after the summer has ended with the fall in the river stages. Because rainfall is heavily concentrated during the monsoon months, there is a notable fluctuation between maximum and minimum discharge rates for each river. The Indus, which is primarily supplied by glaciers, is subject to the least seasonal variation, though its maximum flow is more than fifty times its minimum (Table 4.1).

Table 4.1 Pakistan: Discharge and Characteristics of Indus System

River	Catchment Area (square km)	Length (km)	Location	Discharge (x 100 ^{m3})/sec		
				Average	Minimum	Maximum
Indus[c]	1,047,850	3,290	Attock	26	0.48	115
Chenab[a]	61,000	1,355	Marala	20	0.11	32
Jhelum[a]	63,500	890	Mangla	22	0.11	28
Sutlej[a]	86,000	1,619	Sulemanke	14	0.08	17
Beas[b]	25,900	445		10	0.06	16
Ravi[a]	11,600	1,053	Baloki	7	0.03	9

(a) The Chenab, Ravi, and Sutlej are partly in India, the Jhelum originates in disputed territory.

(b) Outside Pakistan.

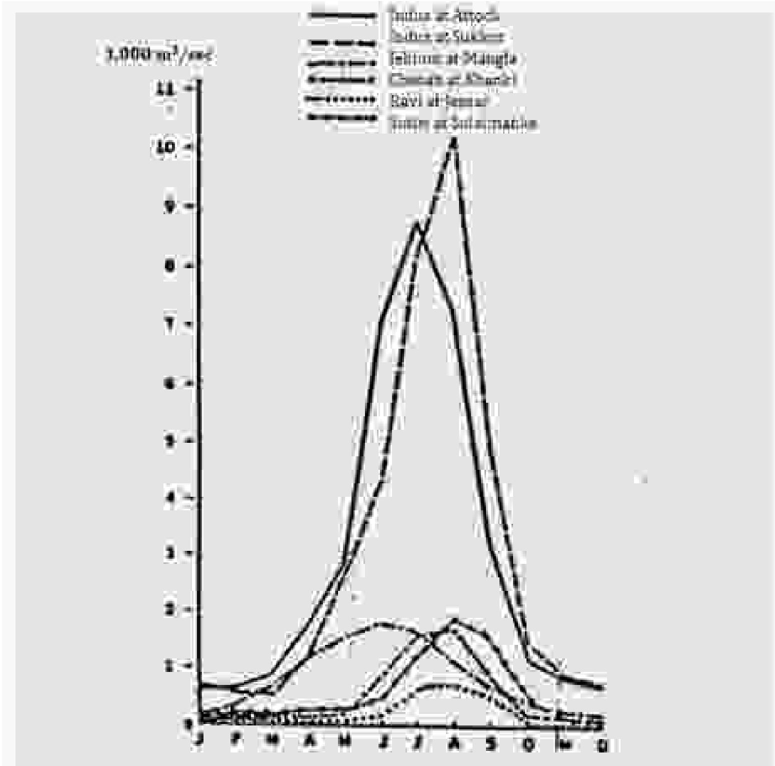
(c) Includes Kabul River.

The volume of water flow in the Indus, Chenab, and Jhelum increases markedly by April but only by June for the remaining rivers. The maximum flow is achieved during the June to September period, during which more than two-thirds of the annual discharge is carried (Fig. 4.l). Throughout the year the evaporation accounts for significant water losses, particularly in the plains.

Pakistan has an agrarian economy that is heavily dependent on the water from its rivers for various purposes ranging from agriculture to power generation. According to an estimate, the Indus River irrigates about 14 million hectare out of about 21 million hectare of agricultural land (GOP, 2010a). Over the years, various demands on the River Indus, the most important being water extraction for irrigation purposes, has led to substantial pressures on Pakistan's water resources. The country's current water usage is about 1,000 m^3 per person (WAPDA 2010) and that puts Pakistan in the category of 'high stress' countries. In the light of a growing population, rapid urbanization and increased industrialization and extended periods of drought, it has been estimated that an additional 48 cubic kilometres of water is required to meet the growing demands of agriculture and the country's economy. This requires the judicious use and management of the available water resources.

More than two thirds or 69 percent of "inland water” in Pakistan is being used for irrigation. Another 23 percent is utilized by industries, while the remaining 8 percent goes into the municipal water supply for

Fig. 4.1 Pakistan: Mean Monthly Discharges in the Indus System

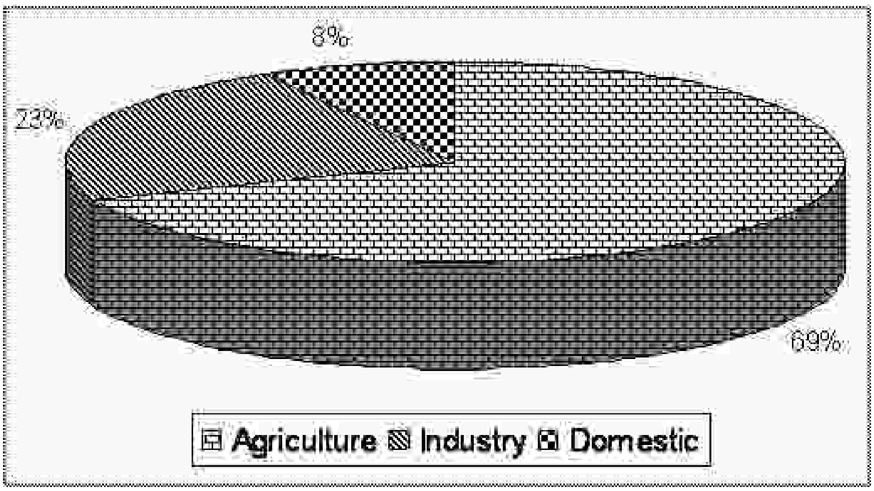


Source: Kureshy, 1977

domestic consumption (Fig. 4.2). Since independence there has been a great increase in man-made reservoirs for irrigation, generation of electricity, water supply and flood control. Tarbela, Mangla, Warsak, Tanda, Baran, Khanpur, Rawal, Hub and Chashma are some of the examples of these reservoirs.

One of the oldest methods employed for irrigation in Pakistan was the use of natural floodwater. There is evidence that as early as the 3rd century B.C. floodwaters were diverted by means of man-made channels.

Fig. 4.2 Pakistan: Sectoral Consumption of Water



Source: GOP 2010b

Muslim rulers in India also promoted a public works policy in 16th and 17th centuries, which included construction of canals. Inundation canals intended for seasonal use during the monsoon, were dug along the active and meander flood plains of the Indus basin. This mode of irrigation continued during the first half of 19th century. By 1861 the British Government felt the need to extend the limits of irrigation beyond the brief flood season. This led to the development of perennial irrigation through the construction of barrages such as Guddu and Sukkur, which enabled canals to flow year-round. The upper Bari Doab Canal was the region's first perennial canal followed by others. At present, a web of canals, which bring river water to inter-fluvial areas and link the rivers themselves, covers the entire Indus basin.

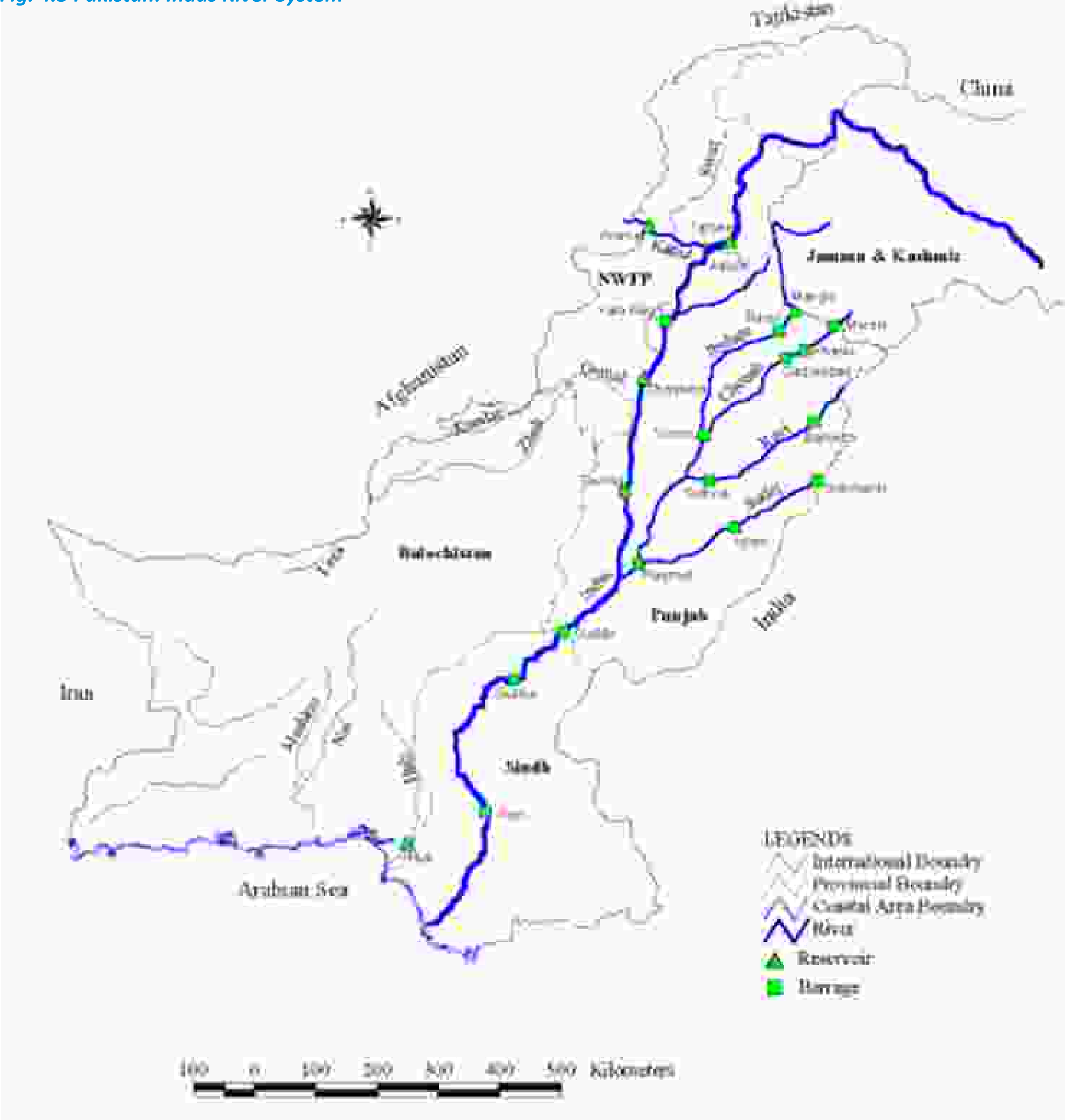
The present irrigation network from surface flow in Pakistan (Fig. 4.3) comprises three major storage reservoirs, 19 barrages or head works, 43 main canals with a conveyance length of 57,000 km, and 89,000 watercourses with a running length of more than 1.65 million km (IRIN 2001). In addition, some 600 km of link canals of very large size have also been constructed. On the average about 128 BCM of the river flows is diverted to the canal system. The combined diversion capacity of the main canals system is nearly 7,000 m^3 per second (250,000 cusecs) with individual capacities up to 439 m^3 per sec (15,500 cusecs). The diversions are generally limited in the high flow season (summer) by the capacity of the canal system and in the low flow season (winter) by the availability of water supply. The gross area commanded by the irrigation system (within the Indus Plain) totals about 14 million ha or about two third of cultivated land (GOP, 2010a).

With water diversion for irrigation the amount of water in the Indus River has decreased dramatically from around 185 cubic kilometres per annum in 1892 to about 42cubic kilometres per annum at present. The most recent flow was determined by way of the Indus Water Accord in 1994, whereby the allocation of water between the Provinces of Pakistan was decided (IUCN 2009). As a result of upstream water abstraction, by the time the Indus reaches the Kotri Barrage (some two thirds of the way into Sindh Province, or 200 km from the Arabian Sea), there is inadequate flow to maintain the natural ecosystems of the Indus Delta (Box 4.1).

The fresh water discharge from the Hub River has also been disrupted as a result of construction of the Hub Dam. The river estuary thus remains mostly dry (Pak EPA 2011). It is only during heavy rainfall or flood season that the estuary has fresh water. As a result the biodiversity has also been affected. Manora Channel situated near Karachi Fish Harbour has lost oysters. There is a declining trend of Palla (*Tenualorailisha*), Bombil (*Harcadonnehereus*), Bambore (*Sillagosihama*), Dangri (*Latescalcarifer*), and Mallah (*Letchrinus spp.*) fish catch in Sindh. According to one official, freshwater dolphins also once came into the Karachi Harbour.

In addition to problems arising from river water withdrawal, improper irrigation has created several ecological problems. The most important adverse impacts are the result of sub-optimal use of water in a badly managed irrigation system. Due to age, overuse, and poor maintenance canal water delivery is extremely poor. As a result, average delivery efficiency is 35 to 40 percent from the canal head to the root zone, with most losses occurring in watercourses (Faruqee, 1999). The loss of such large portion of water reduces its availability for crops, raises the need for more water diversion from the Indus River System and contributes to water logging and salinity. Historical data shows that water table has risen due to seepage from reservoirs and irrigation channels at an average rate of 15 to 35 cm per year since modern irrigation was introduced. In an area where the underground water has a salinity of 1,000 ppm (which is acceptable for all crops), evaporation at the rate of about half a meter per year (which is a typical value where water table is high) will raise the salt content of top one meter to about one percent (10,000 ppm) in 20 years (Spooner, 1982). The side effects of irrigation are therefore evident in waterlogging, salinization, alkalinisation, increased incidence of diseases such as malaria, loss of forest cover and genetic diversity as well as consequences associated with these.

Fig. 4.3 Pakistan: Indus River System



Keeping in mind these high losses, the Government has initiated water conservation through rehabilitation and remodelling of irrigation systems and lining of canals and watercourses. Integrated programme approaches are adopted like the "National Program for Watercourses Improvement in Pakistan and Flood Protection Programme." This programme is a joint venture with farmers and launched simultaneously in all the provinces of the country in 2004, aiming at the lining of 86,000 watercourses to save about 10 BCM water (GOP, 2008).

Besides the river water some 56 BCM of pumped groundwater is also used for irrigation in the country. Pakistan has a long tradition of using groundwater for agricultural purposes. Baluchistan in fact was one of the first regions in the world to tap sub surface aquifers (US MAB, 1981). Farmers here have been using underground channels known as 'Karez' for thousands of years to irrigate their land. The utilization of groundwater potential in the Indus Basin on a large scale started only after 1920. The deep alluvial deposits of the Indus Plain form an extensive ground water aquifer. The physical characteristics of the alluvium are generally favourable to groundwater development. Hence there has been a massive expansion of private and public sector tube-well irrigation in Pakistan (56 BCM or 30 percent of agricultural water, which is twice the average annual rainfall). Ironically while water logging is increasing in some areas, over-pumping of ground water is resulting in a decline of water tables in other areas particularly beyond the Indus Basin. For example, the water table has been declining continuously in Baluchistan province. Studies suggest that the deficit in the Quetta sub-basin is about 26 million cubic meter (21,000-acre feet) per year, which may exhaust the aquifer storage within 20 years. In some places groundwater is depleting at the rate of one meter per year especially in the Pishin-Lora Basin. The Zhob and Nari river basins are not available for further groundwater

Box 4.1 Impacts of Upstream Water Diversion on the Ecology of Indus Delta

The upstream water diversion for irrigation has serious ecological effects on natural and social conditions downstream Indus particularly on its Delta. The annual flow reaching the Delta before the 1994 Indus Water Accord between provinces was about 42 cubic kilometre. Even at this level the amount of freshwater reaching the Delta was argued to be insufficient to maintain healthy natural ecosystems, and resulted in severe saltwater intrusion and salinization. The amount has now reduced further. The loss of freshwater flow, and consequent saltwater intrusion, has had devastating effects on the ecology and economy of the Indus Delta.

A considerable area in the delta has become unsuitable for agriculture, and potable water sources have become very scarce or have disappeared altogether. In Thatta, a predominantly agricultural district in Sindh Province, which is situated where the Indus River flows into the Arabian Sea, almost a third of land has been affected by saltwater intrusion. It is estimated that up to 0.5 million ha of fertile land in Thatta and adjoining areas, or about 12% of total cultivated area in the entire Sind Province, is now affected by salt water intrusion causing crop losses. This also results in severe damage to livestock through rangeland depletion, shortage of fodder, pasture and watering areas, and a resulting mass migration of both livestock and human populations out of the area.

Historically, the abundant freshwater discharges and nutrient-rich sediment load supported a highly productive coastal ecosystem, including mangrove forests and fisheries, on which local communities depended for their livelihood. The Delta is also important from a biodiversity perspective, with 10 species of mammals, 143 species of birds, 22 species of reptiles, over 200 species of fishes, and many invertebrate species, including 15 species of shrimp. The Indus River is also home to one of the few species of freshwater dolphin, Platanista minor and to the fishing cat, which have also been affected by freshwater losses. The decline in freshwater has led to a general reduction in the health of the floodplain and Delta ecosystems. Of key importance are the mangrove forests, which provide habitats for fish and shrimp and, together with the tidal mudflats, support a rich variety of flora and fauna and are particularly important as resting and feeding grounds for migratory birds. Habitat degradation has resulted in a range of economic losses, including the depletion of fisheries, loss of agricultural and forest products. Surveys conducted in two districts of Sindh (Badin and Thatta) suggest that the human toll has been substantial. Seawater intrusion may have affected over 135,000 people and led to losses in excess of US $125 million per year.

Sources: Meynell and Qureshi 1993, GOP 2001, IRIN 2001, IUCN 2003, IUCN 2009 development. The lowering of the water table is a matter of great concern as it can have negative effects on all spheres of life (IUCN, 2012).

Along with irrigated farming, there is a large tract in Pakistan that is totally dependent on rainfall for agriculture. Commonly termed as "Barani" or rainfed area, it is about five million ha. Sustainable land management is very important in this area, which is susceptible to soil erosion. In the past inappropriate land preparation and cultivation techniques in many parts of this area have reduced water retention and infiltration capacities. Furthermore these contributed to soil erosion, which not only decreases farm productivity but has also resulted in the siltation of canals, watercourses and reservoirs.

4.2.2 Freshwater Quality: Status and Trends

Water quality has become a problem in Pakistan due to pollution from silt, salt, and inadequate sewage treatment infrastructure and industrial waste. The increasing number and size of human settlements in the vicinity of water bodies is a major cause of severe stress on the aquatic resources. The total wastewater discharges in Pakistan are estimated to be 7,590 million cubic meters (MCM) per annum (21MCM per day). Thirty percent of these discharges are from the industries (6.25 MCM per day). The municipal/domestic discharges are more than half of these discharges. It is projected that both municipal and industrial discharges will have doubled by 2025 (Khan 2010). Presently only 1 percent of urban wastewater is treated in Pakistan. The rest is dumped into ravines, streams and rivers (GOP, 2007). This is apparent from an increasing organic and biological pollution in the inland and estuarine waters near the urban centres due to dumping of un-treated or partially treated domestic waste. The effluent from industries released into waterbodies is no less hazardous. There are more than ten fully functional industrial estates in Pakistan. In addition about ten new industrial estates are at different stages of development. The major industries located in the urban industrial estates are oil refineries, textile, pharmaceutical, chemicals (organic and inorganic), food industries, ceramics, steel, oil mills and leather tanning. The largest concentrations are located in Karachi and Central Punjab.

All major industrial cities of Pakistan with the exception of Karachi are located along the rivers. The pollution by municipal and industrial sources has affected the rivers of Pakistan to different degrees. The Indus and Jhelum rivers are slightly affected by the wastewater discharges owing to relatively high flows and a lower number of discharge sources. Selected reaches of rivers Ravi and Sutlej are seriously impacted due to the presence of large urban settlements and industrial areas along these rivers and very low river water flows. Small sections of the rivers Chenab and Kabul are also severely impacted for the same reason (Tables 4.2 and 4.3).

The organic and chemical loads deplete oxygen levels in water. It is estimated that industrial effluents containing 3,286 tons of Biological Oxygen Demand (BOD), 6,510 tons of Chemical Oxygen Demand (COD) and 3,100 tons of total dissolved solids (TDS) are discharged every day, on a total BOD, COD and TDS of 5,490, 12,353 and 60,024 per day. Ninety percent of these pollution loads are estimated to find their way into the inland water bodies. Besides affecting water quality, there are serious impacts on biodiversity. For example, extreme pollution of river Ravi has destroyed the once existing 42 species of fish while bird life has migrated to other areas.

The Pakistan Council for Research in Water Resources (PCRWR) carried out a national water quality study in 2001. In the first phase of the program, covering 21 cities, all samples from 4 cities, and half the samples from 17 cities indicated bacteriological contamination. In addition, arsenic above the WHO limit of 10 parts per

Table 4.2 Pakistan: Length of Major Rivers Where Water Quality is affected by Human Activity

River	Total length in Pakistan (KM)	Severe impact (KM)	Moderate impact (KM)	Slight impact (KM)	No Impact (KM)
Indus	2,750	-	-	80[a]	2,670
Jehlum	610	-	-	40[a]	570
Chenab	730	88[b]	-	30[a]	612
Ravi	680	62[c]	-	-	612
Sutlej	530	127[d]	-	20	383
Kabul	170	15[e]	15[e]	8[e]	132
Swat	150	-	-	8	142
Total	5,620	292	15	186	5,127
%	100	5.2	0.3	3.3	91.2

Source: Ministry of Water and Power, "Pakistan Water Sector: National Water Sector Profile", Volume 5, October 2002
Notes: a-Lenght of the river reaches adjoining to cities and villages
b-12% length of the river reported to have depleted DO
c-Lenght of the river reach between Lahore and Byalloki
d-24% of length of the river reported to have no DO during low flow period, which is prevalent except for the monsoon season
e-Length of the river reaches between Peshawar and Nowshehra

billion was found in some samples collected from 8 cities. The same study also indicated how the uncontrolled discharge of industrial effluent has affected surface and groundwater, identifying the presence of lead, chromium and cyanide in groundwater samples from industrial areas of Karachi, and finding the same metals

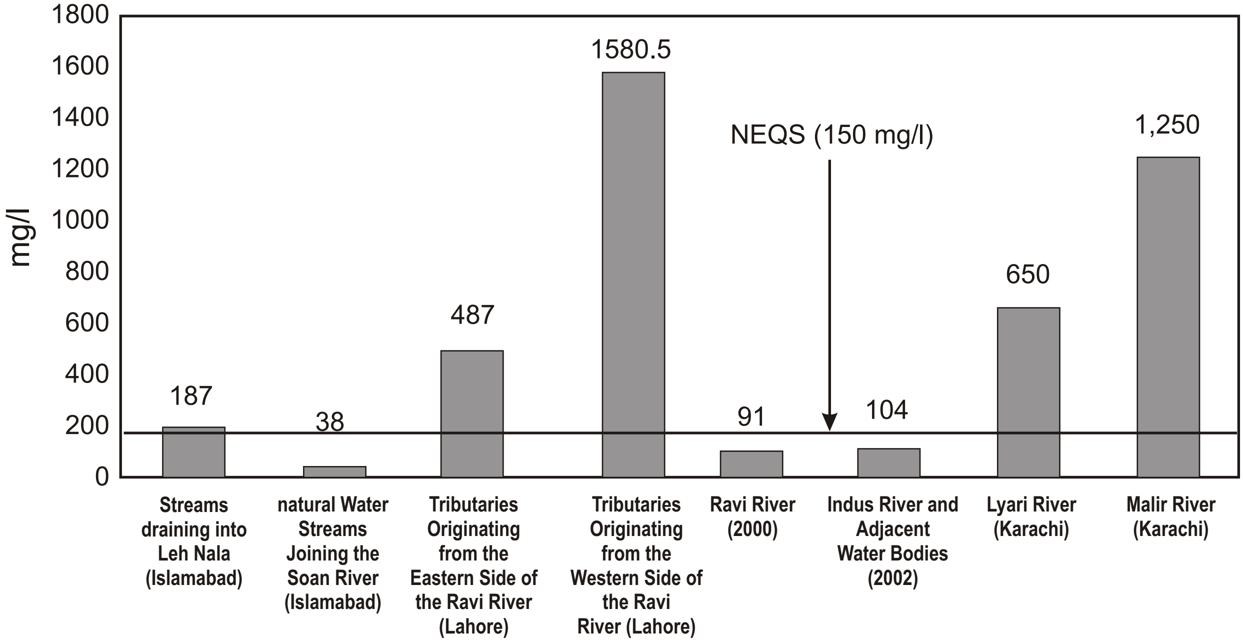
Table 4.3 Pakistan: Length of Major Rivers Where Aquatic Ecosystems are Affected by Human Activity

River	Total length in Pakistan (KM)	Severe impact (KM)	Moderate impact (KM)	Slight impact (KM)	No Impact (KM)
Indus	2,750	-	-	218[a+g]	2,532
Jehlum	610	-	-	58 [a+h]	552
Chenab	730	88[b]	56[f]	66[a+g]	520
Ravi	680	62[c]	34[g]	20h	564
Sutlej	530	127[d]	-	47[a+g]	356
Kabul	170	38[e]	17[i]	17[i]	115
Swat	150	-	-	18	132
Total	5,620	315	107	444	4,754
%	100	5.6	1.9	7.9	84.6

Source: Ministry of Water and Power, "Pakistan Water Sector: National Water Sector Profile", Volume 5, October 2002
Notes: a-Lenght of the river reaches adjoining to cities and villages
b-12% length of the river reported to have depleted DO
c-Lenght of the river reach between Lahore and Byalloki
d-24% of length of the river reported to have no DO during low flow period, which is prevalent except for the monsoon season
e-Length of the river reaches between Peshawar and Nowshehra

in the Malir and Lyari rivers flowing through Karachi and discharging into sea (World Bank, 2006). A second PCRWR study was launched in 2004, and its results indicated no appreciable improvement, while a separate study reported that in Sindh almost 95 percent of shallow groundwater supplies are bacteriologically contaminated. Fig. 4.4 below summarizes the organic load data from a number of these studies. A comparison of the quality of surface water (using COD variable) with the national environmental quality effluent discharge standards clearly demonstrates the extent of pollution due to the discharge of industrial and municipal effluents.

Fig. 4.4 Pakistan: COD in Selected Rivers/Streams



Source: World Bank 2006

The fifth and final phase of the National Water Quality Monitoring Programme by PCRWR was completed in 2005-2006. It covered the water quality analysis of 23 major cities, and 23 water bodies including 8 rivers, 6 dams, 4 lakes, 2 canals, 2 drains and 1 reservoir. Among cities besides Islamabad, eleven were from the Punjab, four from Khyber Pakhtunkhwa, four from Balochistan, and three from Sind. The locations for the sample collection in all cities were selected, keeping in view the source from where most of the population consumed water for drinking purpose. In total 357 permanent locations from 23 cities were selected for the collection of the water samples. The water quality parameters for which the samples were analyzed included physical and aesthetic, major inorganic constituents, trace and ultra trace elements and bacteriological contaminants. The analyzed data for cities revealed that Bacterial; Arsenic, Nitrate and Fluoride contamination are common in the water supply of all major urban areas of Pakistan. An overall picture of the water samples that had parameters beyond the permissible limits in cities is given in table 4.4

The highest percentage of unsafe water sources was found in Bahawalpur, Kasur, Lahore, Multan, Sheikhupura and Ziarat, where none was safe for drinking purpose. Based on the complete information, generated through this Water Quality Monitoring Programme, PCRWR concluded that 13% out of a total of 357 water sources, are “Safe” and the rest of the 87% are Unsafe” for drinking purposes.

Table 4.4 Pakistan: Water Quality Status in Cities

S.No	Parameters	Total Samples	Number of Samples Beyond Permissible Limit	%Age
1	Turbidity	357	40	11
2	Ca	357	108	30
3	Mg	357	6	2
4	Hardness	357	20	6
5	Na	357	36	10
6	K	357	16	4
7	Cl	357	21	6
8	SO_4	357	29	8
9	NO_3	357	49	14
10	TDS	357	43	12
11	As	357	86	24
12	Pb	357	3	1
13	Fe	357	78	22
14	F	357	17	5
15	Coliforms	357	246	69
16	E.coli	357	178	50

Source: PCRWR 2007

Out of 23 surface water bodies, 22 were evaluated, as the Right Bank Outfall Drain (RBOD) had dried out (Table 4.5). The samples collected from these were analyzed for detailed water quality parameters including Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO). It was found that all samples were contaminated with Coliforms and *E.Coli* (Table 4.5). Seventy three percent of the samples had a high level of turbidity. Only three samples were found with a high concentration of ions i.e. Ca, Mg, Hardness, Na, K, Cl, TDS, SO_4 and NO_3, Similarly, 27% of the samples showed an excessive concentration of Fe and F. Two lakes i.e. Hamal & Manchar were found with higher levels of Ca, Mg, Hardness, Cl, Na, K, SO_4, and TDS. The LBOD drain was found with higher levels of Ca, Mg, Hardness, Cl, Na, K, SO_4, and TDS.

Water quality trends based on data of the five phases of the NWQMP also provide useful insight for future planning and improvement of water quality, by implementing remedial measures. PCRWR analyzed these trends on the basis of safe and unsafe water samples (microbiologically or chemically contaminated). The trend for Pakistan is shown in table 4.6. The data analysis shows that 85% of the water samples were contaminated and range of unsafe water sources was 82-87 percent during the period 2002-2006. An overall comparison of the four provinces (Fig. 4.5) reveals that the highest percentage of contamination in drinking water was in the province of Sind 87% in 2002, 96 % in 2003 and 2004,and 95 % in 2006; the only exception was the year 2005, when the highest level of contamination was recorded in the Punjab Province.

Solid and liquid excreta were the major sources of water pollution from urban areas, the bulk of which went into water bodies polluting them. Only three cities Karachi (2), Faisalabad (1) and Peshawar (1) had treatment plants but they were working under capacity and did not meet the National Environment Quality Standards (NEQS). The Capital Development Authority (CDA) had installed a modern wastewater treatment plant in Islamabad, which complied with NEQS. Besides domestic sources, untreated wastewater from industries further aggravates the situation. About 70 percent of the biological load is generated by textile and beverage industries. Industries that have the largest wastewater discharges mostly comprise of textile, tannery, paper

Table 4.5 Pakistan: Quality Status of Surface Water Bodies

S.No	Parameters		Total No. of Samples	Number of Samples Beyond Permissible Limit	%Age
1	Turbidity	(NTU)	22	16	73
2	Ca	(mg/l)	22	3	14
3	Mg	(mg/l)	22	3	14
4	Hardness	(mg/l)	22	3	14
5	Na	(mg/l)	22	3	14
6	K	(mg/l)	22	3	14
7	Cl	(mg/l)	22	3	14
8	NO_3	(mg/l)	22	3	14
9	SO_4	(mg/l)	22	3	14
10	TDS	(mg/l)	22	3	14
11	Fe	(mg/l)	22	6	27
12	F	(mg/l)	22	6	27
13	Coliforms	(MPN/100 ml)	22	22	100
14	E.coli	(MPN/100 ml)	22	22	100

Source: PCRWR 2007

and pulp factories. About 40 billion litre of wastewater are daily discharged into water bodies in Punjab and Karachi. Some treatment plants have been installed by the industries (about 133 in Punjab, 207 in Sindh and 2 in Khyber Pakhtunkhwa). In rural areas generally there is a limited availabilityof systems for disposal of solid and liquid wastes. Therefore the water quality in rural areas is also deteriorating.

Environment Protection Agencies (EPAs) are randomly checking pollution levels of industry and municipal waste and filing cases in the Environmental Protection Tribunals. Whether used as habitat or to meet drinking and irrigational demands, maintaining the quality of water is crucial for the survival of life. Due to increasing siltation and biological contamination by agents of human diseases, animal and plant pests and chemical pollution the quality of water is constantly deteriorating. Researchers of the National Institute of health, Islamabad and Pakistan Medical Research Council have revealed that a large proportion of diseases in Pakistan are caused by the use of polluted water.

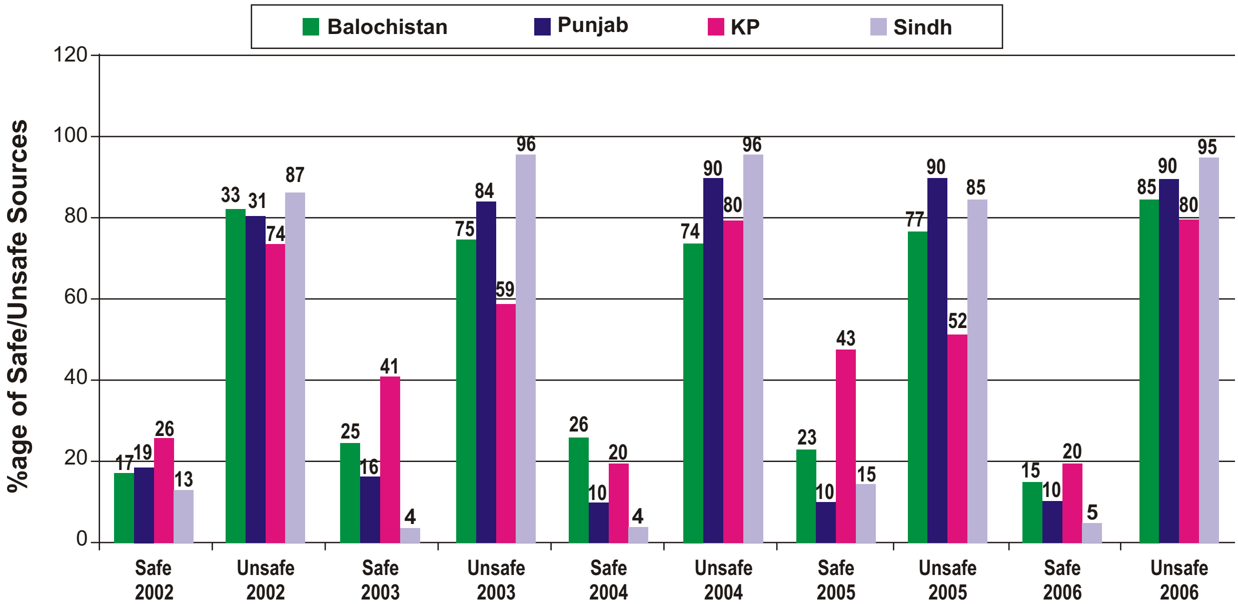
Even large rivers like Ravi and the Chenab are heavily polluted today, let alone rivers like the Lyari and the Leh, which pass through the dense urban areas of Karachi and Rawalpindi respectively. In these cases community

Table 4.6 Pakistan: Overall Water Quality Status and Trend 2002-2006

Sr. No.	Year	No. of Samples			%age of Samples	
		Total	Safe	Unsafe	Safe	Unsafe
1	2002	295	54	241	18	82
2	2003	287	53	234	18	82
3	2004	319	42	277	13	87
4	2005	326	48	278	15	85
5	2006	330	38	292	13	87
Total		**1557**	**235**	**1322**	**15**	**85**

Source: PCRWR 2007

Fig. 4.5 Pakistan: Water Quality Status and Trends for Four Provinces 2002-2006

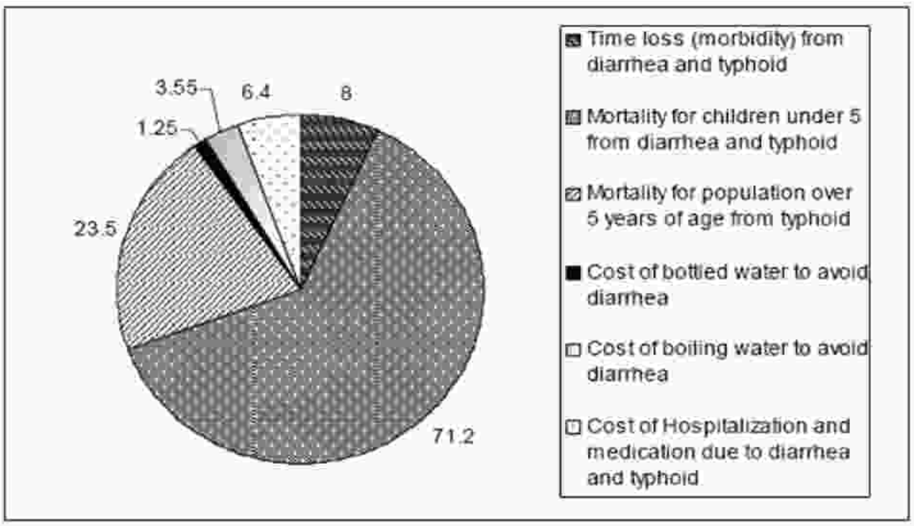


Source: PCRWR 2010

wastes from human settlements are much higher, as compared to waste added by industrial effluents. While domestic sewage and garbage are full of microbes, the industrial wastes often release toxic substances. The implication is extremely serious. According to estimates of the Planning Commission 40 percent of deaths in Pakistan are related to water-borne diseases such as typhoid, diarrhoea and infective hepatitis. The extensive change in Pakistan's hydrological environment through irrigation has also caused an increase in anthropod activity and some of the diseases introduced by them have increased.

According to the World Bank (2006), Pakistan's total health costs are estimated at Rs 114 billion, approximately 1.81 percent of GDP. Figure 4.6 brings out a strikingly high cost due to premature child deaths, followed by the mortality impacts of typhoid in the elderly population. Water pollution also has severe effects on aquatic life. Use of pesticides in the agricultural fields along river banks and release of industrial pollutants

Fig. 4.6 Costs from Water-Related Mortality and Morbidity (Rs. Billion per year)



Source: World Bank 2006

into water bodies has become a common feature in various parts of the country. This has sometimes resulted in fish kill and destruction of lower aquatic forms.

4.2.3 Inland Fisheries

Pakistan has 198 freshwater fish species, including 15 introduced species. The fish fauna is predominantly south Asian, with some west Asian and high Asian elements. Among these are the nine species of snow trout (sub-family *Schizothoracinae*) that occur in the rivers of the northern mountains; they are representatives of an ecologically interesting group of fish endemic to snow fed rivers and lakes of the high Asian region. Species richness is highest in the Indus river system, in the Kirthar range and in the Himalayan foothills, while the river systems of northeast Baluchistan have the highest levels of endemism (GOP, 2009a).

A total of 32 fish species and sub-species are known to be endemic to Pakistan. These are not yet recognized as endangered at the national level. However, at least two species are threatened due to their great commercial importance and may soon become endangered if steps are not taken to conserve them (GOP, 2006). One is (*Tor putiptora*), which migrates from the flood plains to the Himalayan foothills for breeding. The construction of the Mangla and Tarbela Dams has blocked its migration. The other species is Pala (*Tenualosailisha*), which requires a 200 km northward run for spawning from the coast in the Indus River. The migration of this fish has been blocked by the construction of barrages and the fish ladders provided have proven to be ineffective for migration (GOP, 2009a). The blind Indus dolphin (*Platanista minor*) is a resident of the Indus River and estuary. It is also effected by barrages construction, but it is encouraging to note that lately the efforts to recover river dolphin in Indus is bearing fruit (Box 4.2)

Fishing in inland waters is widespread in Pakistan, occurring in all provinces and regions. The lakes, ponds and barrages along the Indus and its tributaries within the Punjab and Sind, as well as reservoirs in the two provinces are the chief breeding areas and principal producers. Over the past few decades, the total inland production increased substantially (from 7,000 metric tons in 1947 to 70,606 metric ton in 1984 and 284,000 metric tons in just nine months of 2010 (July-March). The share of inland fisheries in total fish production increased from 21 percent in 1947 to 30 percent in 1960, but then fell to 23 percent in 1984. It has risen again to almost 30 percent in July-March 2009-2010 period (GOP, 2010). It is estimated that some 180,000 people in Pakistan are involved in inland fisheries for their livelihoods (GOP, 2009a).

The main sites for freshwater fishing activities are: Manchar, Kalri and Haleji Lakes in Sind, the barrages at Gudu, Kotri, Sukkur and Thatta on the Indus River; the barani tract in the Punjab; the artificial lakes created by dams at Warsak and Tarbela as well as the Chitral, Kaghan and Swat valleys in Khyber Pakhtunkhwa. Endemic species of carp such as mahasheer (*Barbusmosal*), rohu (*Laboerohita*), mori, and thaila have been supplemented with imported breeds such as the common carp (*Cyprinuscarpio*) and rainbow trout (*Salmogairdnerii*). In addition to providing a source of protein and a means of livelihood for thousands, fish hatcheries are expected to retain beauty of several picturesque northern mountain streams and thereby boost tourism and sporting in these areas.

4.3 Coastal and Marine Resources: Status and Trends

Pakistan has a coastline along the Arabian Sea that stretches over 1050 km (990 Km measured as a straight line) (GOP, 2009a). It consists of sandy beaches that are interrupted by rocky protruding points. The country's coastal ecosystem is rich in resources and comprises numerous deltas and estuaries with extensive intertidal mudflats and their associated wetlands (the Indus Delta has an estimated 3,000 square kilometres of delta

Box 4.2 Recovery of Dolphin in the Indus

The Indus River dolphin (Platanista minor) is the second most endangered freshwater river dolphin and one of the world's rarest mammals. Approximately 1,275 specimens of this species live today in a small fraction of their former range, the lower reaches of the Indus River in Pakistan. The population of this species has gradually declined in the past, because of various factors including water pollution, poaching, fragmentation of habitat due to barrages, and dolphin strandlings in the irrigation canals. Although no authentic data are available, it is commonly believed that their numbers dramatically declined after the construction of the irrigation system in the Indus.

Lately, the population of dolphins appears to have increased. World Wide Fund for Nature (WWF) Pakistan coordinated the largest survey of the species ever in 2001 in collaboration with partners, when the dolphin population was estimated at 1100. The survey was repeated in 2006 using the same methods as in 2001 and found that their number had increased to 1275. This recovery of the population may have resulted from a number of factors, which included the ban on dolphin hunting implemented in the Sind Dolphin Reserve, conservation activities by Sind Wildlife Department and WWF Pakistan and migration of dolphins through the Guddu barrage from Punjab. In 2006, the overall abundance of the Indus River dolphin was estimated to be 1400-1600.

Sind Wildlife Department and WWF have also been involved in rescuing dolphins trapped in canals in the last few years. The “Blind Indus Dolphin Rescue”, a $50,000 UNDP fund is helping the Sind Wildlife Department to rescue the endangered species. A well-trained team of Wildlife officials and local fishermen based at Sukkur carry out these rescue operations on a regular basis. Pakistan is the third country, after the USA and Japan, where Dolphin rescues are being carried out locally.

Source: GOP 2010, Sind Wildlife Department 2004

marshes); sandy beaches; rocky shores; mangroves; corals and sea grasses. The area around Pakistan is the richest in phytoplankton and zooplankton in the Arabian Sea region (IUCN, 1993). The interaction of riverine and deltaic ecosystems has created a rich resource base that has sustained coastal communities.

4.3.1 Marine and Coastal Biodiversity

A taxonomic assessment of marine flora and fauna is not readily available. The most important flora are the mangroves. Mangrove ecosystems are biodiversity rich. Eight mangrove species are reported along the coast of Pakistan. *Avicennia marina* is the most dominant species, while *Ceriopstagal* and *Rhizophoramucronata* occur in localized patches. Over 48 species of macro fauna have been reported from mangrove forests along the coast of Pakistan. The fauna consist of various species of crabs, polychaetes and molluscs.

According to available reports, gastropods dominate the rocky shore fauna followed by decapod crustaceans and polychaete worms. The Zoological Survey of Pakistan in 1973 compiled a list of the fauna of the beaches of Pakistan. There are occurrences of approximately 21 intertidal seaweeds. Fifteen green seaweeds and six brown red marine macro algae were found from sandy shores. Almost 800 species of marine fish have been recorded in Pakistan's coastal waters (GOP, 2009a), however no analysis of their population status and distributional range is available. Large pelagic such as the tuna are common in the waters of Baluchistan. Palla fish (*Tenalosailisha*), which is considered a delicacy, is an anadromous fish that swims up the Indus River to breed.

The green turtle (*Cheloniamydas*) and the olive ridley turtle (*Lepidochelysolivacea*) are both found in Pakistan. Until recently, they were indiscriminately killed on the Makran coast. Eight species of oysters occur in Pakistan (GOP 2009a). Squid are abundant, but surprisingly echinoderm populations are very small. Sandy stretches from Karachi (Sindh Coast) to Gadani and up to Jiwani (Baluchistan Coast) are favourite nesting habitats of the marine turtles. Both the green turtles and the Olive Ridley have been declared endangered species by the International Union for Conservation of Nature and Natural Resources (IUCN). The Sind Wildlife Management and the World Wide Fund for Nature (WWF) have initiated a protection and research program to conserve the turtles, their eggs and hatchling (Box 4.3).

Box 4.3 Marine Turtle Conservation in Pakistan

Marine turtles are endangered throughout the world. Out of seven marine species, the Green turtle (Cheloniamydas) and Olive Ridley (Lepidochelys olivacea) are found on the beaches of Pakistan. The country has declared the turtles as protected species and adopted the following legal provisions for their safeguard:

- The second schedule of the Sind Wildlife Protection Ordinance 1972 and the Sind Wildlife Protection Act 1993 provide the status of protected animal to all marine turtles in the Sind province.
- Clause 5 (export restriction) in the Pakistan Fish Inspection and Quality Act 1997 of the Federal Ministry of Food, Agriculture and Livestock, Government of Pakistan, forbids the export and domestic consumption of Aquatic Turtles.
- As a signatory to the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Pakistan banned the trade in turtles and their products. The Government of Pakistan acknowledges the IUCN Red List of Threatened Species, which includes the green turtle.
- The international requirement for protection of turtles is fulfilled as the shrimp trawlers are required by law to use turtle excluding devices (TED) on the shrimp trawl nets that allows turtles caught in the net to escape.
- The research and conservation activities on turtles have been promoted for the last 30 years. So far more than 700,000 baby turtles have been released in the open sea. More than 7,000 turtles were tagged for monitoring of their migratory route. Satellite tracking of marine turtles, in collaboration with WWF and Environmental Research and Wildlife Development Agency (ERWDA) Abu-Dhabi has helped in understanding the habitat use by the turtles.
- A programme for captive rearing of hatchlings has been launched to increase the size of hatchlings and to reduce mortality on the open beaches. Educational visits to the area are arranged for the school children and campaigns are organized for mass awareness. 2006 was also celebrated as "Year of the Turtle" under the Indian Ocean South East Asian Marine Turtle programme as a part of awareness raising campaign.

Source: GOP 2009a, UNDP and Shehri 2012

Approximately 56 species of birds have been reported in the Sindh coastal waters. The most common are Gullbilled Tern, Oystercatcher, Sand Plover, Golden Plover, Kentish Plover, Sanderling, Dunlin, Marsh Sandpiper, Curlew and Whimbrel. Among the invertebrates, crustaceans dominate; they include crabs, isopods, carides, juveniles of penaeid shrimps, squilla, amphipods, sergestids and barnacles. Many other animals live on trunks and roots of mangroves, which serves as a substrate (GOP 2009a). Information on micro fauna in the region is sparse. Certain species of micro fauna are indicators of good environmental health. However, baseline information on species and their numbers has yet to be established.

Corals have recently been discovered along the coast of Baluchistan (Jewani, and Astola Island). Coral communities although not widespread, appear in patches at Astola Island and Gwadar, where a vast fossilized coral reef is present. Soft coral such as seafan (*Gorgonia sp*.), and brain coral are also present south of Astola Island. A variety of coelenterates and bryozoan colonies are found in most parts of the Balochistan coast.

A preliminary survey of four areas along the Balochistan coast of Pakistan found 25 species of Scleractinian coral and 77 species of reef fish. Astola Island situated approximately 37 km off the Baluchistan coast stood out for its diversity of corals and fish. This site is unique within Pakistan, and in view of growing pressure from fisheries, commercial and other developments, there is an urgent need for its designation as a Marine Protected Area. A project on environmental Education with reference to Coral and Coral Reefs in Marine and Coastal Area at Jiwani, Baluchistan was successfully implemented recently with the financial assistance from UNEP through the South Asia Co-operative Environment Programme (SACEP).

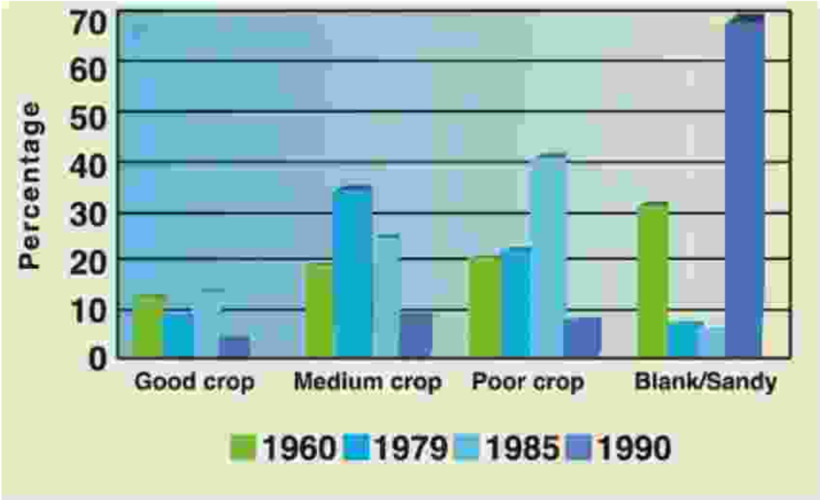
4.3.2 Mangrove Forests

The area of mangrove forests in Pakistan was estimated at 249,486 ha in the 1960's (Khan 1966). The Indus delta ranked as the fifth or sixth largest single mangrove cluster in the world; second on the Indian sub-continent after Sundarbans (with an area of more than 850,000 ha). Historical records indicate that the distribution of mangroves in the Indus delta has significantly changed during the past several hundred years. Earlier, the major spill rivers of the Indus emptied through distributaries close to Karachi. Around that time the mangroves were tall and healthy and their growth was dense and extensive (Khan 1966). It is believed that at the time of the last major shift in the Indus towards the Rann of Kutch, these mangroves experienced a process of deterioration but simultaneously rapid development of extensive forests occurred in the delta areas of the new, more southerly, spill rivers. This broad pattern of change is consistent with the observations of geomorphologists (e.g. Thorn 1967; Thorn et al 1975), who have documented the sequential appearance of mangroves associated with temporal and spatial changes in coastal fluvial deltaic processes.

The Indus delta mangroves play a very important role in economic terms. They support local fishery enterprises (pomfrets, anchovies and *Hilsa ilisha*), a commercial shrimp fishery that contributes to the export market, and area source of forest products for local use. In addition, the leaves of the dominant genera Avicennia serve as dry season fodder for domestic camels. It is also reported that when Avicennia leaves are stall fed to dairy cows, the butterfat content of the milk is increased.

The Indus delta mangroves have degraded considerably due to human intervention during the last century (Fig 4.7). One such intervention include upstream withdrawal of Indus River water for irrigation which reduces river flow downstream, causing seawater intrusion resulting in meandering and erosion of creeks. Other anthropogenic factors such as marine and coastal pollution, browsing by camels and grazing by cattle, fodder harvesting, woodcutting and effluents from industries also contributed to loss and degradation of mangroves (WWF, 2007a).

Fig. 4.7 Pakistan: Change in Mangrove Forest Cover 1960-1990



Source: WWF 2007a

Snedaker, who visited the Indus twice - once in 1977 (as a representative of UNESCO's Division of Marine Sciences) and again in 1984 (during the U.S. Pakistan Workshop on Marine Science), made some important observations in this regard. Comparing the conditions in the 1980's with historic records, he wrote, "It is apparent that the tall and extensive forests of the Indus delta (cited in colonial records) are no longer present. Instead, the existing forests generally reflect the imposition of an environmental stress associated with reduced fresh water availability that led to hyper salinity and nutrient impoverishment" (Snedaker, 1984). Apparently the best developed trees occurred only along well-flushed tidal channels, whereas the interiors of the deltaic islands (poorly flushed areas) were sparsely inhabited by the dwarf form of *Avicennia spp.* "The village of KetiBunder showed dramatic evidence of the effects of hyper salinity (e.g. surface salt accumulation and corrosive deterioration of domestic structures) that presumably led to the associated partial collapse of fishing industry" (Snedaker 1984). These observations are consistent with other reports on mangrove degradation due to reduction in freshwater discharge from the Indus because of upstream diversion and use in agricultural irrigation (GOP, IUCN &WWF 2000, GOP 2009a). At present, the Indus has a significant discharge only during the southwest monsoon while in the low water season upstream dams and barrages divert most of the fresh water. Snedaker also pointed out that the deterioration of the Indus delta mangrove ecosystem was much more extensive and severe than with its counterpart the Ganges delta (India) which was experiencing accelerated hyper salinity (Snedaker 1984) However, concerted efforts have been made in recent years towards the restoration of mangroves in the Indus Delta (Box 4.4) and along the coast of Balochistan.

The analysis of satellite images revealed that although the mangrove forest cover had further declined from 1992 to 2000 with a loss of approximately 50, 000 hectares but expansion to 104, 799 hectares was recorded between 2000 and 2011, an increase of approximately 33, 000 hectares (Figs 4.8 and 4.9). The increase in forest cover is approximately close to the claims of planting around 40,000 hectares of additional mangrove forest along Indus delta during 2007-08 by Sindh Forest Department, Sindh Coastal Development Authority and the IUCN.

4.3.3 Wetlands

Wetlands (both natural and manmade) cover approximately 10% of the total area in Pakistan (WWF, 2007b). The country is a signatory to the international RAMSAR Wetlands Convention and has adopted the

Box 4.4 Mangrove Restoration in Indus Delta

The mangrove forest serve the multiple functions of stabilizing the coastline, protecting ports against natural disasters, supporting the economy of coastal communities, and providing fuel wood, fodder and various other products. Mangroves constitute a significant part of the productivity base of several important fisheries. Pakistan has a large and lucrative fishery, generating annual revenues of around US$ 200 million: during the year 2010-11 (July-March), exported fish and fishery products earned US$ 234 million. An estimate cites that 70 percent of the Pakistan prawn fishery alone is dependent upon mangroves. The situation is similar with respect to fish. Over 150 species of fish have been recorded in the mangroves of Pakistan, many of them of commercial importance. Despite their important contributions, the mangroves had been disappearing due to anthropogenic activities. However, lately, governmental organizations such as the Ministry of Environment (now Climate Change Division) as well as Sind Wildlife Department and NGOs such as IUCN and WWF have made successful efforts towards mangrove restoration and management.

Within the Government, Sind Forest and Wildlife Department has large mangrove afforestation activities in projects funded federally under Public Sector Development and Annual Development Programmes. On July 15th 2009, Pakistan set a new Guinness World Record on tree planting by local communities at Keti Bandar, Distrct Thatta, Sind. Ministry of Environment organized this effort in collaboration with its other partners. During this attempt three hundred planters from the local community planted 541,176 propagules of mangroves over 322 hectares on an island in the Indus Delta.

Among NGOs, IUCN Pakistan has been actively involved in the conservation and management of mangroves since 1997. So far about 6.5 million seedlings and a network of container plants nurseries have been established under a mangrove rehabilitation programme. Some species (Rhizophora mucronata, Ceriops tagal, and Aegiceras corniculatum) along with Avicennia marina have been reintroduced to bring genetic variation and vibrant sustainability of the plants and larger ecosystem. Some virgin estuarine areas have created new world records for high growth rates of these mangroves. Besides Sind, efforts are underway to rehabilitate and regenerate mangrove forests all along the coastline in Balochistan. In this regards, IUCN has been working with various partners and stakeholders. On similar lines, WWF is also implementing a mangrove rehabilitation program with close collaboration of local communities. Mangrove management has also markedly improved following the establishment of Coastal Forest Division in Sind Forest Department and Coastal Ecosystem Unit in IUCN-Pakistan along with afforestation and reforestation activities.

Source: GOP 2011, GOP 2009b, IUCN 2005

comprehensive wetlands definition used by the parties to this Agreement: “Areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres” (WWF, 2007b). The wetland habitats have been classified into 22 types (Table 4.7) with their own flora and fauna.

Fig. 4.8 Mangrove forest cover along Indus Delta 2011

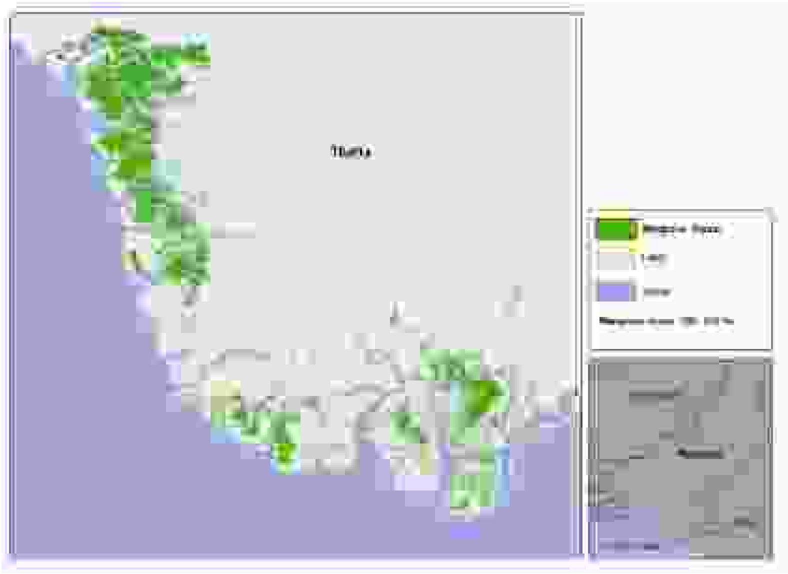


Fig. 4.9: Change in mangrove forest cover 1992-2011

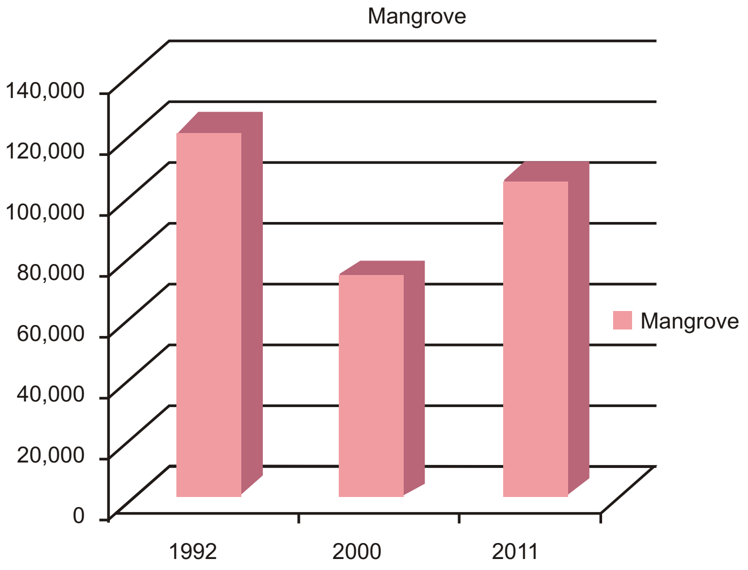


Table 4.7 Pakistan: Types of Wetland Habitats

S.No.	Types
1	Sea bays and straits (under 6 metres at low tide)
2	Estuaries, deltas
3	Small offshore islands, islets
4	Rocky seacoasts, sea cliffs
5	Sea beaches (sand, pebbles)
6	Intertidal mudflats, sand flats
7	Mangrove swamps, mangrove forest
8	Coastal brackish and saline lagoons and marshes
9	Saltpans (artificial)
10	Shrimp ponds, fish ponds
11	Rivers, streams-slow-flowing (lower perennial)
12	River, streams-fast-flowing (upper perennial)
13	Oxbow lakes and riverine marshes
14	Freshwater lakes and associated marshes (lacustrine)
15	Freshwater ponds (under 8 ha), marshes, swamps (Palustrine)
16	Salt lakes, saline marshes (inland drainage systems)
17	Water storage reservoirs, dams
18	Seasonally flooded grassland, savannah, palm savannah
19	Rice paddies
20	Flooded arable land, irrigated land
21	Swamp forest, temporarily flooded forest
22	Peat bogs

About 225 significant wetlands are identified in Pakistan. Out of these, 19 have been recognized as being of international importance and are designated as RAMSAR Sites, with a total surface area of 1,343,627 ha (WWF, 2007). The diverse assortment of natural freshwater and marine wetlands in Pakistan supports many unique combinations of biodiversity. Their rich biological resources are however threatened by over-exploitation, habitat destruction and pollution. The main causes for wetland degradation are ineffective management, poor stakeholder participation and lack of coordination of management strategies (Kashif and Naseem, 2006). Growing population pressures and habitat loss induced by climate change, as well as water diversion for irrigation and the drainage of wetlands are other major causes of wetland deterioration in Pakistan. It is feared that these wetlands may not be able to take on much more pressure, which is being generated through enhanced pollution.

4.3.4 Marine Fisheries

Pakistan has rich fisheries resources in its marine environment. According to FAO's estimate, the North-West Part of the Indian Ocean/Arabian Sea in which Pakistan is situated contains one of the largest potential resources of marine fish. About 800 species of fishes have been recorded in this region (2009a). Out of these many species of fish are exploited on economic scale and are of economic importance. At the time of Pakistan's independence, in 1947, the total production of marine fish was 32,893 metric tons (GOP, 1987). In 1960 it was 62,157 metric tons and by the early eighties the production reached 272,000 metric tons (IUCN, 1984), which went up by July-March 2009-2010 to 668,000 metric tons (GOP, 2010b). According to FAO estimates, the maximum sustainable yield (MSY) of marine fish (except mesopelagic species, biomass of this type of fish in Pakistan offshore waters is estimated to be about 10 million metric tons, however, technology for its harvesting and utilization has not yet developed) in Pakistan's water is between 450,000 (low estimate) and 725,000 (high estimate) metric tons. On the basis of these estimates the fish catch is already exceeding the low estimate carrying capacity of the system.

Catches of fish species along the coast tend to increase from west to east. The main species are Indian salmon, eel, jewfish, catfish, croakers, pomfret, red snapper, grouper, sharks and rays, which are found along the entire coast including the western and northern part of the Arabian Sea. The pelagic fish comprise the major part of the commercial catches in Pakistan with Indian mackerel and oil sardines being the most important species. Pelagic species such as sardines, mackerel and anchovies are mainly found off the coast of Pakistan during the northeast monsoon season, which extends from October to June, sardines and anchovies are mainly caught along the beach. Tuna fishing has also developed in Pakistan, and shrimps are widely caught with a yield of over 18,000 metric tons. Shrimp catches have the biggest value because of the high price in the international market. Three main varieties of shrimps locally known as "Jaira" (large size), "Kalri" (medium size) and “Kiddi” (small size) are caught, processed and exported. The exports of fish and fishery product fetched 5.6 billion Rs in 2009-2010. (GOP, 2010b).The Pakistan fish and fisheries related sector also engages 1 percent of the country's population and generates 1.3 percent of Pakistan's GDP.

Fisheries of Pakistan are threatened by pollution and use of tidal trap nets, locally known as "bhola," "gujja," and "katra". These nets do not spare even the juvenile fish. They are a serious threat to sustainable fishery. Although banned by the government, these nets are still used. Fishermen are worried over diminishing catches like oyster from Manora channel and the extinction of several valued fish species over the years. The adverse effect of prohibited nets is not the only danger to sustainable fishery in Pakistan. A greater threat is posed by deep-sea trawling. These trawlers have been combing the territorial waters of Pakistan for a long time, indulging in poaching, under-reporting and throwing by-catch (unwanted species) into the sea. For example thousands of dead fish appeared on the shore of Karachi near Keamari on 15 August 2004. The military government banned deep-sea trawling for a while but the ban has been lifted again.

Pollution also continues to threaten the marine resources. Its intensity could be gauged from the fact that over 2.7 billion litres per day of water is consumed at Karachi, where the wastewater treatment facility only caters for about 0.9 billion litres per day and the plants almost never operate to full capacity. As a result over 1.8 billion litres of used wastewater with untreated industrial and municipal waste finds its way into the Arabian Sea.

4.3.5 Minerals

Offshore mineral extraction is still in the exploratory stages in Pakistan. Efforts have increased to search for crude petroleum and gas. Manganese nodules are not economically feasible for mining at present but at some point in the future may prove an important potential source of precious minerals such as nickel, cobalt, copper and manganese. Likewise alluvial gold washing in Indus sand has continued for hundreds of years. Placer deposits in the Indus River also have radioactive minerals. Sand and common salt is being obtained presently from the coastal areas. Sand removal is causing some problems producing scars in the landscape and needs to be controlled to maintain the beauty of the beaches and landscape.

4.4 Coastal and Marine Pollution: Status and Trends

The status of marine pollution varies in different coastal zones of Pakistan. The coastal area adjacent to

Karachi urban area is the most affected with pollution. The effluents received here include land-based domestic wastes and industrial effluents as well as sea-based waste discharges from ships. A passage in a report of the Karachi Development Authority (KDA) describes the nature of pollutants getting into the Karachi Sea in the following words, "The Monora channel receives effluents from several sources; domestic wastes are received from four island populations namely Manora, Baba Bhit and Shamspeer as well as other drainage outfalls in the vicinity; oil wastes from oil tankers, cargo ships, mechanized boats and trawlers and oil jetties, metal scrap and rust from a ship building yard and oil liquid wastes and effluents from fish processed in processing plants at the fish harbour. Throughout the year the channel also receives an unending supply of industrial waste from the industrial areas."

Municipal discharges represent about 70% of total wastewater discharges. It is estimated that total wastewater discharges in the sea are about 900 MCM per annum (about 12% of the total national wastewater discharges) out of which industrial discharges are about 180 MCM per year (Khan, 2010). About 45% of the industries of the country are located in Karachi, a city of over 15 million (City Mayors Statistics 2011). It is estimated that the water borne pollution generated by the industries is around 1,046 tons BOD/day (GOS and IUCN, 2007). Wastewater from industrial sources carries pollutants such as heavy metals, organic matter (including benzene and toluene), oils and greases and other toxic chemicals that are directly discharged into the mangrove mud flats of Karachi creeks. In addition, Karachi Steel Mill discharges, between 550 to 750 m^3/hr of hot wastewater directly into the Gharo creek. This causes thermal pollution in the ocean waters (Khan, 2010).

The metropolitan city of Karachi has major industries at four places - Sind Industrial Trading Estate (SITE); Landhi Industrial Trading Estate (LITE); Korangi and West Wharf. The SITE area alone has several hundred industrial units, which discharge their wastewater into the Lyari River. Similarly all the industries in the LITE area drop their effluents into the Malir River. These industrial effluents are the major cause of the absence of plants and other aquatic life in the heavily polluted Malir and the Lyari rivers. Korangi Creek receives a heavy load of effluents by the Malir River.

Land based pollution is a growing problem in the country. The organic and chemical effluent load (Table 4.8) depletes oxygen levels in water and indirectly reduces the diversity of animal and plant life. Many creeks and coastal waters in the Karachi area exhibit increased organic load in coastal water resulting in an increased consumption and depletion of oxygen in the water column near the bottom (harmful to benthic shrimps such as penacids and ground fishes) potentially giving rise to blooms of noxious phytoplankton species. Mortality through red tide or phytoplankton blooms was not known to occur on the coast of Karachi, though Hornell (1917) reported mortality of fish in the Monara Channel due to "sulphureted" water. However, more recently Heil et al (2001) reported a number of conditions that may have led to the first documented fish kill in the Arabian Sea in September 1999. The paper describes that meteorological conditions, increased nutrient concentrations and associated algal blooms may have resulted in the mass fish mortality that was observed (Heil et al., 2001)

Table 4.8 Pakistan: Estimated National Averages for Pollutant Concentration of Discharges into Sea

Parameters	National average for discharges into sea
Biological Oxygen Demand (BOD) (mg/l)	360
Chemical Oxygen Demand (COD) (mg/l)	810
Total Dissolved Solids (TDS) (mg/l)	770

Source: Khan, 2010

Blooms of microorganisms have been seen off and on in these waters. A bloom of the diatom *Skeletonema coatatum* was observed during October - November, 1976; long patches, of Noctiluca blooms were observed during a May 1977 cruise of R.V. Dr. Fridtjff Nansen near salt-water creeks and during February 1977 blooms of exclusively Noctiluca were observed in Manora Channel (Ahmad, 1977). More recently Chaghtai and Saifullah (2001) reported the occurrence of harmful algal bloom organisms including four records from the Northeastern Arabian Sea in Korangi Creek, Manora Channel and the continental shelf of Pakistan (Chaghtai and Saifullah, 2001).

There is a dearth of baseline data in Pakistan that could be used for the monitoring of marine pollution in its coastal environment. The Institute of Marine Biology at Karachi has initiated some studies. However many more studies are needed on marine pollution particularly with respect to their impact on fisheries and other aquatic life. It may be mentioned here that as far as 35 years back Qureshi (1975) had warned that various industrial effluents of the Lyari River were slowly poisoning the offshore waters with the result that shrimps and fishes which were once abundant near Manora and Hawkesbay were receding into deep waters. Shrimp fishermen of Karachi area have made similar complaints.

The toxicity of industrial waste and agrochemicals discharges cannot be over-emphasized. Both inorganic and organic chemicals even in extremely low concentrations may be poisonous to fish and other smaller aquatic microorganisms. Highly complex organic compounds produced by the chemical industry for textile and other products have also proved toxic to fish life. Invariably, salts some even in low concentrations are toxic to certain forms of aquatic life. There are many metals that are of special interest with respect to their toxicological importance to human health. Lead and mercury continue to be the most important but many others such as arsenic, beryllium, cadmium, manganese, chromium, nickel and vanadium have been of increasing toxicological importance. Certain ions such as nitrates, fluorides and sulphates also have negative health effects. Moreover effluent from industries such as tanneries and slaughterhouses also contain bacteria. An example is the anthrax bacillus originating in tanneries where hides from anthrax-infected animals are processed. Vegetable and fruit canneries may also add bacterial contamination to streams leading to sea, which may be extremely harmful.

Considering the wide variety of the industry established in Pakistan any of the above mentioned pollutants could be suspected to be present in the natural bodies of water. However, to what extent their presence is harmful can only be determined through sustained programmes of monitoring.

It may be noted here that severe pollution in Karachi harbour caused by untreated industrial affluent and municipal waste is not only taking its toll on marine life and civilian population but also causing $1 billion worth of losses to Pakistan Navy (PN) every year. According to PN sources, all the navy platforms including surface ships, fleet tankers, mine hunters and missile boats berthed at Karachi's upper harbour and PN Dockyard had been severely damaged by the seawater, the composition of which has changed for the worst due to severe pollution in recent years (Statement of Navy representative to senate standing committee on defence March 2007). It is important to note that such damage is not limited to navy ships, but will affect any ship using the Karachi harbour, making the loses much higher.

Besides industrial and municipal sources two main ports of Pakistan namely Karachi and Port Qasim also contribute towards coastal pollution. They handle the majority of the country's seaborne trade. An estimated 90,000 tons per year of oily discharges are pumped out from ships and boats within the port limits. Marine pollution from sea-based sources, particularly from oil spills has occasionally contaminated many estuaries and the sea. Moreover, wastes from tankers and ships in the coastal waters are discharged in large quantities due to weaknesses in the institutionalized system to deal with this source of pollutants. Cumulatively over the years the quantity has been estimated to run in millions of tons, which threatens the very life of marine fauna and flora. Since many landlocked Central Asian countries and China are beginning to view Pakistan as a conduit to ship out their exports, the ports activities are likely to increase and so will the pollution. The government is now faced with the dilemma of encouraging upswing in trade to foster economic growth while at the same time contain the environmental damage that ensues with the new opportunities. The increased shipping activities can also increase the hazard of accidental pollution like that of Tasman Spirit (Box 4.5).

A common environmental problem associated with the shipping industry is dredging, which also has a major impact on the environment. Dredging is the process of removing the silt build-up in the port to facilitate the entering and exiting of the ships. The dredged material is dumped out on sea. However, there is no system for monitoring heavy metals in the dredged spoil, which is likely to further deteriorate the environment. Moreover, a significant percentage of the coastal pollution is contributed when the export industries ship their goods through the Karachi Port.

The port induces polluting industries to set up shops nearby in order to expedite exportation. The pollution from these industries is affecting the environment because much of the factories effluent is untreated and released directly into the port area. The 1991 Pakistan National Environmental Action Plan estimated that three main coastal industries located near the port with the largest volumes of effluents were the steel-mill, power plants, and refineries and noted that many smaller industrial units were also significantly polluting the marine environment.

The mode of marine pollution in the province of Balochistan is similar to that of Sind but with lesser intensity. The main sources of oil pollution include the fishing boats and the large number of merchant vessels and oil tankers that clean bilge and tanks as they pass through the EEZ of Pakistan. As a result tar balls are found on the beaches, and wastes from the coastal villages and industrial estates also eventually enter the sea to be redistributed by the long shore currents. Although industries in Balochistan are not too large in number, they discharge their effluents untreated into the water bodies ultimately entering the sea.

4.5 Policies and Programmes

4.5.1 Inland Waters

As pointed out in Vision 2030 of Pakistan (GOP, 2007), the country has not managed its water resources with care and hence is now becoming increasingly water-stressed. The country's current storage capacity at 9 percent of average annual flows is very low compared with the world average of 40 percent. By increasing the storage capacity, it could conserve a large part of 43 BCM of water that flows into the sea annually during the flood season. It could save extensive damages that result from flooding on the one hand and use the stored water during droughts on the other. Without additional storage it has been estimated that the water shortfall during the last decade increased by 12 percent. Increasing storage capacity thus is an important part of a water strategy. It is planned to increase storage capacity by 22 BCM (about 7 BCM for replacement of storage lost to silting / sedimentation and 15 BCM of new storage) in order to meet the projected requirements. The large storage facilities will be complemented by a comprehensive programme of small dams and other measures for recharging (GOP, 2007).

In terms of cost, minimal water charges are levied on treated domestic water or on agricultural water in

Box 4.5 Oil Spill from Tanker Tasman Spirit

The oil tanker Tasman Sprit grounded in the channel of Karachi Harbour at about 1.5 nautical miles from the seashore on 27th July 2003 while cruising in the curved entry of the channel. The vessel was loaded with 67,535 tons of Iranian light crude oil for Pakistan Refinery Limited in Karachi. Significant oil was spilled when the Tasman Sprit broke in two on 13th August 2003. As the oil spilled, it spread promptly due to rough sea conditions and high wind speed. It mostly spread towards the eastern side and due to the proximity of the grounded tanker to the coast the spilled oil hit the Karachi coastline.

Strong oil vapours caused headaches, nausea, and dizziness to the affected population. Seventeen schools located in the vicinity of the accident had to remain closed for a week. Shoreline oil was spread in a 16-kilometer radius around the grounded tanker. The beach had to be closed for about two and a half months and a three-month fishing ban was imposed to eight kilometres offshore. With the passage of time the spilled oil went through various stages: evaporation, stranding, emulsification, oxidation, spreading, sedimentation, dispersion, dissolution and bio-degradation. During these long processes it adversely impacted the marine eco-system.

The Natural Resources Damage Assessment Phase I studies revealed that the total area of marine waters impacted by oil was more than 2,000 square km. An estimated 11,000 tons of volatile organic compounds (VOCs) were released into the air from the oil spill. The worst impacted areas of the Karachi Coast included the most popular recreational beaches of Clifton and Defence Housing Authorities covering about 16 km of coastline. Residential areas along the Clifton and Sea View coast, up to 6 km inland, remained affected with air having high concentrations of VOCs for about three weeks. Despite a large beach cleaning operation, the oil on the beaches and adjacent seawater remained prominently visible for the next 6 months and somewhat visible for 12 months after the accident. This spill severely damaged the marine ecosystem of Karachi Harbour and Clifton and Defence Housing Authority coastline up to Bundal Island on the west.

Short-term impacts of the Tasman Spirit Oil Spill included large-scale mortalities of benthic fauna, flora, and fisheries, including commercial fish and marine invertebrate species. Injuries to birds, mammals, sea turtles, and mangroves were documented in the oil-impacted zone. In socio-economic terms, particularly public health, about 300,000 people were affected in the area.

Regarding recovery, the assessment concluded that it was likely to take 5-10 years for the marine ecosystem injury to recover. The public health impacts were expected to take more than 10 years for recovery.

Source: IUCN, UNEP, UNDP, GOP and GOS, 2003; Alrai and Rizvi, 2005

Pakistan. Furthermore, there is no restriction on the extraction of groundwater for any purposes. Under this scenario conservation of water resources does not get priority. While the agriculture sector will remain the predominant user of water in the future, the requirements for industrial and domestic use will continue to increase. It is therefore necessary to enhance efficiency for all uses of water, including re-cycling and re-use. There is a dire need for aggressively pursuing all resource conservation technologies for sustainable agriculture. The existing irrigation methodologies, based on gravity flow, are extravagant and unsustainable and need to be changed by sprinkler and drip and trickle technologies.

To improve the water quality, sewerage and industrial toxic waste needs to be treated. Weak enforcement of the National Environmental Quality Standards (NEQS), lack of cost effective indigenous technology and resource constraint are the main factors behind low treatment of wastewater. The most important element is the disinterests of municipal authorities to address this issue. Some Water and Sanitation Agencies (WASAs) have planned treatment plants for Rawalpindi, Lahore, Faisalabad and Multan with the assistance of Asian Development Bank, but financing is the main constraint. Treatment of sewage and utilizing treated water for cultivation could be a good option for an agricultural country like Pakistan. Another constraint is the non-availability of locally manufactured cost effective pollution control technologies. Furthermore, little work has been done in Pakistan to assess the assimilative capacity of natural watercourses. This is partly due to financial and technical constraints, and to a large extent because of the misconception that most of the bodies of water used for dumping wastes offer adequate dilutions while their natural regeneration capacity is not overtaxed. However, it is important to realize that due to increased industrial discharges and municipal waste waters the self-purification capacities of the rivers can no longer be relied on and there is an immediate need to deal with this vital issue. It is important to note that in order to provide safe drinking water to people, the government has built hundreds of local water purification plants. The plan is to build more than 6,500 such plants across the country under the Clean Drinking Water for All Programme.

4.5.2 Fisheries and Biotic Resources

A Fisheries and aqua culture development policy and strategy were formulated in 2006 taking the environmental concerns into account. The policy emphasizes the need to rehabilitate marine environment damaged by pollution and resource degradation and seeks to promote sustainable management of aquatic resources and establish protected areas and fish sanctuaries for conservation of fish biodiversity. The policy also supports fisheries conservation in all coastal area management and planning processes through a mechanism of cross-sectoral integration and participatory decision-making (GOP, 2010a). The policy combines marine and inland capture fisheries production with coastal and inland aquaculture based on an environmentally sound and sustainable production along with related processing. It envisages a 10 percent annual growth and targets $ 1.0 billion export earnings from the sector by 2015. With assistance from the Norwegian Government and the FAO, deep-sea fish resources are being surveyed and charted. A project costing Rs 2.0 billion ($ 20 million) has been prepared to promote investments through a public-private partnership, strengthen regulatory systems, promote coastal aquaculture, promote farm fisheries and trout and other cold water fisheries in the mountainous regions and improve marketing and processing of fish. The implementation of this project is being entrusted to a private sector led Fisheries Development Board being set up under the Companies Ordinance. To enforce quality control, laboratories of the Marine Fisheries Department have been upgraded and their international accreditation has been achieved.

Fish production is increasing in Pakistan for both domestic demand and export. However, inadequate work has been done on ensuring the sustained yield over the longer term. Similar concerns over sustained yields apply to the coastal mangrove areas, where fish and crustacean production as well as the forest viability in many places is under threat from coastal development and pollution.

4.5.3 Wetlands

The Climate Change Division, which also looks after the environment, in collaboration with UNDP, WWF and other partners is implementing a Wetland Programme. As it is being implemented under the umbrella of the long-standing RAMSAR Convention, the Programme aims to promote the conservation of the country's freshwater and coastal wetlands and their associated biodiversity. Creation of an enabling environment for the conservation of these wetlands is one of the primary outcomes of the project (WWF, 2007). Project activities are being carried out in the following areas:

- Strengthening of appropriate institutions for the sustainable management and conservation of wetlands;
- Development and implementation of a comprehensive National Wetlands Conservation Strategy;
- Enhancement of planning and management capacity for wetlands conservation by the introduction of decision-making tools such as Geographic Information Systems;
- Enhancement of the technical capacity within key government agencies and communities to conserve wetlands;
- Improvement of public awareness and support for wetlands conservation; and
- Development of effective financial sustainability mechanisms.

The Programme aims to create and implement a National Wetlands Conservation Strategy. Sustainable wetland conservation measures will be developed at each of the four demonstration sites, carefully selected to represent conditions in four broad wetland ecological zones of Pakistan including a coastal wetland zone, an arid wetland zone, a semi-arid wetland zone and an alpine wetland zone. Pakistan lacked a comprehensive database on wetlands. To fill the information gap, a GIS-based Wetlands Inventory (PWGIS) is being developed to serve multiple scientific, decision-making and awareness purposes. In addition to basic mapping, a standardized watershed database of Pakistan has been developed that can be aggregated with global and regional databases. Watersheds for 150 significant wetlands were delineated with special focus on 19 RAMSAR sites. Land cover studies of 28 out of 47 Protected Wetlands have been completed. These studies describe habitats through geographic, physical, and biotic components. Web-GIS application of the inventory has been developed for data entry and interactive visualization (WWF, 2007).

4.5.4 Water Pollution

Lack of compliance on the release of effluents from both municipal and industrial sources is primarily because of lack of effective control due to weak institutional capacities and their weak political clout. Moreover, faltering economic growth and fluctuation in the performance of the industrial sector, is leading the Government not to strictly enforce compliance with the NEQS. Pakistan's environmental legislation has been prepared over a period of 13 years, with contributions of relevant stakeholders. Nevertheless, major lacunas exist in the legislation with respect to spatial location and industry specific ambient standards. Authorities fail to enforce the discharge based NEQS due to financial, technical and institutional limitations, varying from province to province and even within the same province of the country. These factors are discussed in detail in Chapter 8 on Institutional and Policy Response.

One major constraint often pointed out for non-implementation of many programmes is the lack of funds. However, a dilemma has been created by the non-utilization of allocated resources for many programmes. For example the Mid Term Development Framework (MTDF) 2005-2010 allocated Rs. 28.3 billion ($28.3million) for the environment. An allocation of Rs. 19 billion was made available during the last four years of the plan period, but only 60 percent of the funds could be utilized due to lack of capacity, non-availability of funds for outsourcing, late release of project funds, paucity of financial resources with the federal government, and lack of monitoring of MTDF progress. In the wake of these problems, a note of success was the development of an oil spill contingency plan (Box 4.6).

Box 4.6 Oil Spill Contingency Plan of Pakistan

In October 2007 Pakistan's Prime Minister in principle approved the proposed National Marine Disaster Contingency Plan, drawn up in the wake of the 2003 Tasman Spirit (see box 4.5) incident. The Plan has been divided into 3 major areas to deal with spillage (including Hazardous and Noxious Substances), search and rescue operations and salvage operations. The overall responsibility for oil pollution incidents within Pakistan's 200-mile Exclusive Economic Zone lies with the Director General of the Maritime Security Agency (MSA). The MSA, under the control of the Ministry of Defence, has practical control over pollution related accidents. The port authorities control spill response within the port limits. However, since their response resources are relatively limited, they are likely to call for assistance from the MSA. When oil impacts the coastline the relevant Provincial Government is responsible for clean-up, although it is likely that they too would turn to the MSA for assistance. In a major accident, the spiller would be called upon to provide resources and equipment.

However specialized, oil spill response equipment is limited to that held by the Karachi Port Trust (KPT), which would be deployed and operated by MSA on-board their patrol vessels (dispersant, spraying equipment and skimmers). There is a helicopter dispersant application system available too. A number of KPT, MSA and military personnel have received oil spill response training. Since the Tasman Spirit spill a Mutual Oil Spill Auxiliary Committee (MOSAC) has also been formed. This comprises a group of oil-handling companies that, under direction of the Director of Ports and Shipping, have been requested to maintain a Tier 1 stockpile of oil spill response equipment (boom, skimmers, sorbent) enough to deal with a few tens of tons of spilled oil.

Source ITOPF 2010

4.6 Conclusions

Water resources form the lifeblood of Pakistan's economy. However, a critical limit has reached in their utilization through excessive water withdrawals, which is creating ecological problems in the Indus Delta. The country's current storage capacity at 9 percent of average annual flows is very low compared with the world average of 40 percent. By increasing the storage capacity, it could conserve bulk of 43 billion cubic meter of water that, on average, flows into the sea annually during the flood season. Further, in the absence of restrictions on the extraction of ground water resources, there is a tendency to over abstract water. The water table is lowering particularly in Baluchistan due to over-pumping. In terms of sectoral use, agriculture is and will remain the predominant user of water in future. Simultaneously, the requirements for industry, and municipal and domestic use will continue to increase. This makes it necessary to enhance efficiency for all uses of water, including re-cycling and re-use.

The present average delivery efficiency of irrigation water is 35 to 40 percent from the canal head to the root zone, with most losses occurring in watercourses. The loss of such a large proportion of water reduces its availability to crops, raises the need for more water diversion from the Indus River System, contributes to water logging and salinity and also deteriorates the ecology of the Indus Delta. Historical data shows that the water table has risen due to seepage from reservoirs and irrigation channels at an average rate of 15 to 35 cm per year since modern irrigation was introduced. Simultaneously, excessive water withdrawal, according to estimates, has resulted in seawater intrusion, affecting over 135,000 people and leading to losses in excess of US $125 million. It brings forward a dire need for aggressively pursuing all resource conservation technologies for sustainable agriculture. The existing irrigation methodologies, based on gravity flow, are extravagant and unsustainable and need to be changed by sprinkler and drip and trickle technologies.

Water quality has also been gradually degrading by a combination of factors including sewage and industrial effluent discharges, urban and agricultural runoff as well as saline water intrusion. Water pollution caused by organic matter, pathogenic agents and hazardous and toxic wastes is serious. Pollution loads discharged into inland water bodies have been estimated to double by 2025. The coastal and marine environment faces pollution threats from both land and sea based sources, which may weaken the ability of marine flora and fauna to survive a toxic bloom. Such blooms, which have only recently been noticed, could cause damages to both food from marine resources and to mangroves. Treatment of sewerage and industrial toxic waste is necessary to improve the water quality. Weak enforcement of NEQS, lack of cost effective indigenous technologies and resource constraints are the major factors responsible for not treating wastewater. The accidental oil spill from the Oil Tanker Tasman Spirit was the worst environmental disaster in Pakistan's history but hopefully with the development of the Oil Spill Contingency Plan such disasters will be manageable in the future.

Fisheries, mangroves, coral reefs and sea grass are important resources of the marine ecosystem. Their conservation and sustainable use is extremely important. Recovery of the Indus Dolphin, conservation of turtles and mangrove restoration in the Indus Delta are encouraging examples of successful measures in resource conservation and augmentation. The main issues in the management of aquatic resources are the lack of adequate legislation, lack of control on release of hazardous wastes, fragmented and overlapping institutional responsibilities among agencies responsible for management, weak planning, lack of public awareness and inadequate stakeholder participation in resources management.

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