CHAPTER FOUR

INTRODUCTION

Freshwater is a critical resource for the people of the Asian and Pacific Region. The abstraction of freshwater from rivers, lakes and underground reservoirs is increasing in line with population growth, urbanization and economic expansion. The increasing abstraction is causing a growing imbalance between supply and demand that has already led to shortages and depletion of reserves. Moreover, the scarcity of water is being accompanied by deterioration in the quality of available water due to pollution and environmental degradation.

This chapter discusses the status and supply of inland water resources, highlights the environmental impacts of unsustainable water withdrawal and the degradation of water quality in the region. The policies and programmes undertaken promoting sustainable development of water resources are also reviewed.

WATER RESOURCES: STATUS AND AVAILABILITY

A. Sources and Status of Supply

Table 4.1 presents the distribution and utilization of freshwater resources across the region. The variation in the availability and consumption of water is determined by the individual country’s physical topography, climate and catchment size as well as the accessibility of water resources and the level of socio-economic development (ESCAP 1997a). For example, the distribution of precipitation in the region is extremely varied both geographically and seasonally. Precipitation is abundant on the southern slopes of the Himalayas, western slopes of the mountains of India and Indo-China and the islands of Indonesia, all of which receive from 1 500 mm to in excess of 3 000 mm of rain annually. By contrast, almost the entire northwestern part of the region is extremely dry, with an annual precipitation of less than 200 mm (Figure 4.1). In the countries bordering the Indian and Pacific Oceans, cyclical monsoon rainfall is the dominant pattern, with distinctive dry and wet seasons; during the long dry season, temporary water shortages are experienced in many river basins, whilst the wet season is often accompanied by flooding (ESCAP 1997). The total run-off per year in the Asian and the Pacific region is approximately 13 260 km$^3$, a third of the global total (ESCAP 1997). In absolute terms, the annual renewable water resources are considerable in many developing countries of the region, although not all of this is available for exploitation. The highest absolute quantities of water resources are in People’s Republic of China, Indonesia and Pakistan.

However, on a per capita basis, a different picture emerges; the variation in the annual per capita internal (within the territory of a country) renewable resources of the region is shown in Figure 4.2. In Southeast Asia, annual per capita internal renewable water resources range from about 172 m$^3$ a year in Singapore to more than 21 000 m$^3$ in Malaysia. Singapore is currently meeting its freshwater demands by importing some of its supply from Malaysia and People’s Republic of China (SEPA 1997). In South Asia, India, the Islamic Republic of Iran, the Republic of Korea and Pakistan, freshwater supplies are between 1 400 and 1 900 m$^3$ per capita per year, which is considerably below the supply in Malaysia.

### Table 4.1 Water Resources and Use in Selected Countries of the Asian and Pacific Region

<table>
<thead>
<tr>
<th>Country</th>
<th>Water resources (m$^3$/yr)</th>
<th>Water resources use (m$^3$/yr)</th>
<th>Water use as a percentage of overall water resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>60</td>
<td>26</td>
<td>43</td>
</tr>
<tr>
<td>Australia</td>
<td>398</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>115</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>Bhutan</td>
<td>95</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Cambodia</td>
<td>88</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PR China</td>
<td>2 812</td>
<td>500</td>
<td>18</td>
</tr>
<tr>
<td>Dem. People’s Rep. of Korea</td>
<td>67</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>Fiji</td>
<td>29</td>
<td>&lt;1</td>
<td>3</td>
</tr>
<tr>
<td>India</td>
<td>1 142</td>
<td>552</td>
<td>48</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2 986</td>
<td>49</td>
<td>2</td>
</tr>
<tr>
<td>Islamic Republic of Iran</td>
<td>130</td>
<td>75</td>
<td>58</td>
</tr>
<tr>
<td>Japan</td>
<td>435</td>
<td>90</td>
<td>21</td>
</tr>
<tr>
<td>Lao People’s</td>
<td>270</td>
<td>1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Dem. Republic</td>
<td>356</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Malaysia</td>
<td>25</td>
<td>&lt;1</td>
<td>4</td>
</tr>
<tr>
<td>Mongolia</td>
<td>606</td>
<td>4</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Myanmar</td>
<td>207</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Nepal</td>
<td>397</td>
<td>2</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Pakistan</td>
<td>247</td>
<td>180</td>
<td>73</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>801</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Philippines</td>
<td>356</td>
<td>105</td>
<td>30</td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>70</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>Solomon Island</td>
<td>45</td>
<td>&lt;1</td>
<td>2</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>47</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Thailand</td>
<td>210</td>
<td>33</td>
<td>16</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>318</td>
<td>65</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: ESCAP 1996a and ESCAP 1999
and some other Southeast Asian countries. By contrast, Bhutan and Lao People’s Democratic Republic have around 50 000 m³ per capita and Papua New Guinea an enormous 174 000 m³ per capita a year (WRI, UNEP, UNDP and World Bank 1998).

1. Surface Water

Rivers, lakes and man-made reservoirs are the main sources of surface water abstraction. The Asian and Pacific Region has several important river systems (Figure 4.3) with 400 major rivers in India, 200 in Indonesia, 108 in Japan, 50 in Bangladesh and 20 in Thailand. International rivers in the region include the Mekong which flows through Viet Nam, Lao People’s Democratic Republic, Cambodia, Myanmar and Thailand; and the Ganges, Brahmaputra and Meghna River Systems which are shared by India, People’s Republic of China, Nepal, Bangladesh and Bhutan. The region is also endowed with a substantial number of lakes; amongst the largest and most utilized are Dongting – hu in People’s Republic of China, Tonle Sap in Cambodia, Lake Toba in Indonesia, Kasumigaura in Japan, Laguna de Bay in the Philippines, and Lake Songkhla in Thailand and Lake Issy Kul in Kyrgyzstan.

The development of reservoirs has usually been for irrigation, flood control and hydropower. There are over 800 major reservoirs in the region with a total capacity of about 2 000 km³, with thousands of small reservoirs particularly in People’s Republic of China, India, Sri Lanka and the Russian Federation (Avakyan and Iakovleva 1998).
2. **Groundwater**

Groundwater in the region occurs in many different rock types, ranging from ancient crystalline basement rocks (which store relatively small quantities of water in their shallow weathered and jointed layers) to alluvial plain sediments (which may extend to depths of several hundred metres and contain substantial volumes of water) (BGS, ODA, UNEP, and WHO 1996). Certain parts of the region contain vast groundwater reservoirs that receive extensive amounts of water from the abundant rainy season recharge. Bangladesh, India, Indonesia, Nepal and Myanmar have particularly large and deep aquifers. Many countries in the region are dependent on groundwater exploitation to supplement scarce surface water resources; this dependency reaches 30 to 35 per cent of the total supply in Bangladesh, India and Pakistan (ADB 1998).

In small island nations of the South Pacific, such as Cook Islands, Fiji, Maldives, Niue, Papua New Guinea, Samoa, Solomon Islands and Tonga, groundwater exists in freshwater lenses above saline water tables. The formation of these lenses on low-lying islands, particularly the coral atolls and the small limestone islands, is influenced by the amount and distribution of the recharge to groundwater. The size and shape of the island, the permeability of the sediments and reef rock, and the magnitude of the tides also constitute important factors in this respect (UNESCO 1992).

**B. Water Scarcity and Stress**

Countries that use 10 to 20 per cent of the available water resources are classified as being under moderate water stress; while those countries that use between 20 to 40 per cent of their renewable water resources are under medium to high stress, and countries using more than 40 per cent of renewable resources are classified as under high water stress. Water scarcity occurs when the amount of water withdrawn from lakes, rivers or groundwater is so great that water supplies are no longer adequate to satisfy all human or ecosystem needs and bring about increased competition among potential consumers. Scarcities increase if demand per capita is growing due to changes in consumption pattern or population (ADB 1998).

On the basis of these definitions, there are several areas in the region that are under high water stress, including north China, the Aral Sea Basin in Central Asia and a number of islands in the Pacific and Indian Oceans (ESCAP 1998a).

With the current population of the region estimated at 3.7 billion, overall average water per capita has been estimated at about 3 700 m³ per year. The per capita water resource is considered as being low and has been declining at the rate of 1.6 per cent per annum as a result of expanding demand within the region. The estimates for changes in the amount of water resources per capita by subregion over the period 1950-2000 are presented in Figure 4.4 (ESCAP 1997); due to the increasing population, the amount of per capita water resources available is considerably less in 2000 compared to that in 1950 (Figure 4.5).

A widely accepted threshold for water adequacy is 1 600 m³ of renewable freshwater per capita per year. Countries with freshwater resources in the range of 1 000-1 600 m³ per capita per year

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**Figure 4.4 Estimates of Annual Water Resources Per Capita in the Asian and Pacific Region**

![Figure 4.4](image)

Source: Shiklomanov 1997

**Figure 4.5 Decline in Water Resources Per Capita in the Asian and Pacific Region**

![Figure 4.5](image)

Source: Shiklomanov 1997
face water stress, with major problems occurring in drought years. When annual renewable water resources are less than 1 000 m³ per capita, countries are considered water scarce. When these criteria are applied to the countries of the region, it is apparent that the Republic of Korea is currently approaching water stress, Singapore is already water scarce and the Maldives has chronic water scarcity, with the figure of 114 m³ per capita per year (FAO 1999). In India, water scarcity is expected to intensify as the country’s population is predicted to exceed 1.4 billion by 2025 (United Nation’s medium projection). People’s Republic of China, the most populous nation (1990 annual per capita water resources: 2 427 m³), will only narrowly miss the water stress benchmark in 2025, according to the United Nations’ projections (Das Gupta 1996). In that year, according to the medium scenario, People’s Republic of China’s projected 1.5 billion citizens will have water resources amounting at 1 818 m³ per person (Figure 4.6). It should also be noted that not all the renewable resources are available for use due to various constraints to the exploitation of the water resources.

Current freshwater use is increasing rapidly in almost all countries of the region and is expected to continue to rise in the future, leading to critical shortages in some areas. Agricultural, municipal/domestic and industrial sectors are the main consumers, although the annual water withdrawal for agriculture (84 per cent) is far more than that for industrial (10 per cent) and domestic (6 per cent) purposes (Table 4.2). As illustrated in Figure 4.7, amongst the subregions, Central Asia will push the upper limits of withdrawals as a proportion of its total available water by the year 2020, whereas South Asia’s projected withdrawal will be about 70 per cent of the total available.

### C. Sectoral Use and Conflicts

With the continuing economic expansion, the competition for water and the potential for conflicting demands between various sectors are increasing (see Figure 4.8). The control of water competition and the resolution of potential conflicts are increasingly being subjected to the assessment of consumption trade-offs on the basis of utilization efficiencies. For example, a thousand tonnes of water used in agriculture produces about a tonne of wheat worth US$200, whilst the same amount used in industry could expand its output by US$14 000, thereby producing financial gains that are 70 times greater. Similarly, if the goal is to produce jobs, using scarce water in industry is far more productive than using it for irrigation. Since the economics of water use do not favour agriculture, that sector is generally assigned lower priority (Brown, et al 1999). However, financial gain is seldom the primary consideration in water resource management and a range of political, cultural and social considerations provide sufficient weight to ensure that agriculture or “food security” are given greater priority in the water resource planning of many of the region’s water resources (Chapter 10).

#### 1. Agriculture/Food Production

Irrigation remains the largest consumptive use of water in the region and accounts for between 60 and 90 per cent of annual water withdrawals in most countries. The Indian sub-continent in South Asia and islands of the South Pacific have the highest level of water withdrawals for agriculture accounting for 92 and 90 per cent of the total consumption, respectively. These two areas together account for 82 per cent of the total irrigated land in Asia (FAO 1999). Of the countries within these geographic areas,

<table>
<thead>
<tr>
<th>Subregion</th>
<th>Agricultural m³</th>
<th>% of total</th>
<th>Domestic m³</th>
<th>% of total</th>
<th>Industrial m³</th>
<th>% of total</th>
<th>Total Withdrawal m³</th>
<th>% of Asia</th>
<th>m³ per inhab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Sub-continent</td>
<td>510.7</td>
<td>92</td>
<td>27.2</td>
<td>5</td>
<td>15.5</td>
<td>3</td>
<td>553.4</td>
<td>38</td>
<td>500</td>
</tr>
<tr>
<td>East Asia</td>
<td>418.3</td>
<td>77</td>
<td>26.8</td>
<td>5</td>
<td>95.5</td>
<td>18</td>
<td>540.1</td>
<td>37</td>
<td>428</td>
</tr>
<tr>
<td>Far East</td>
<td>73.5</td>
<td>64</td>
<td>23.2</td>
<td>20</td>
<td>18.4</td>
<td>16</td>
<td>115.1</td>
<td>8</td>
<td>674</td>
</tr>
<tr>
<td>Southeast</td>
<td>82.1</td>
<td>88</td>
<td>3.9</td>
<td>4</td>
<td>7.0</td>
<td>8</td>
<td>93.0</td>
<td>6</td>
<td>476</td>
</tr>
<tr>
<td>Pacific Islands</td>
<td>127.9</td>
<td>90</td>
<td>10.4</td>
<td>7</td>
<td>4.3</td>
<td>3</td>
<td>142.6</td>
<td>10</td>
<td>483</td>
</tr>
<tr>
<td>Asia and the Pacific</td>
<td>1 212.5</td>
<td>84</td>
<td>91.5</td>
<td>6</td>
<td>140.2</td>
<td>10</td>
<td>1 444.2</td>
<td>100</td>
<td>476</td>
</tr>
<tr>
<td>World</td>
<td>2 310.5</td>
<td>71</td>
<td>290.6</td>
<td>9</td>
<td>652.2</td>
<td>20</td>
<td>3 253.3</td>
<td>100</td>
<td>564</td>
</tr>
<tr>
<td>Asia and the Pacific as % of the World</td>
<td>52.2</td>
<td>31.5</td>
<td>21.5</td>
<td>44.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: FAO 1999
only in Bhutan and Malaysia was the share taken by agriculture below 60 per cent.

The main sources of irrigation water are rivers and lakes, although in some countries, such as India and People’s Republic of China, groundwater is a significant source (BGS, ODA, UNEP and WHO 1996). The spread of privately owned wells and the increased water requirements of new high yielding crop varieties have led to an increase in demand for irrigation, particularly during the dry season. For example, until recently farmers in India and Pakistan required irrigation only during drought periods. However, the new improved varieties of seed have now resulted in increased irrigation throughout the year. Whilst significantly increasing food output, it has resulted in exhaustion of cheap supplies of water and the resultant water scarcity is likely to become a major constraint on increased food production in these countries (Asian Media Information and Communication Centre 1997).

2. Household/Domestic/Municipal

Household water consumption is typically for drinking, cooking and personal hygiene supplemented by a range of additional uses including flushing toilets, laundering of clothes and general domestic usage. Being relatively clean, groundwater is the most popular source for domestic supplies and in most countries of the region supplies more than 50 per cent of requirements. In the arid and semi-arid zones of the region and small islands where surface supply is deficient or unsuitable, groundwater is the only source of water (BGS, ODA, UNEP and WHO 1996). Water consumption for domestic purposes ranges from 20 to 200 litres per person per day, depending on the level of affluence of users and the availability of water. The significant variation in

Figure 4.6 Annual Renewable Freshwater Per Capita Under Three Long-Range United Nations Population Projections: India and People’s Republic of China

Source: Adapted from Engelman and Le Roy 1993

Figure 4.7 Water Withdrawals Against Water Resources (1900-2000)

Source: Shiklomanov 1997
domestic water consumption in selected cities of the region is shown in Figure 4.9. Increases in domestic demand are expected to be in the range of between 70 and 345 per cent between 1995 & 2025 (ADB 1998). In the urban areas of the region, domestic water supply and sanitation investments are unable to keep pace with population growth (see Chapter 7).

3. Industrial

Many industrial processes require significant quantities of water. This water is eventually released back to the environment, but is often contaminated in the process and can be recycled only after treatment. Industrial water supply in the region is provided by both surface water and groundwater sources. However, groundwater is the major source as it is usually cheaper and more reliable (BGS, ODA, UNEP and WHO 1996). Normally, water-consuming industries are located near water-bodies in order to have access to an inexpensive and reliable water supply. If water is readily available and tariffs are low or non-existent, industries tend to use...
CHAPTER FOUR

“once-through” technologies and simple cooling ponds instead of more water efficient but expensive technologies. Often, small and medium sized industries located in metropolitan areas utilize high quality drinking water from public supply systems and, in the older industrial city areas, the proportion of potable water used for industrial purposes is estimated to be as high as 40 per cent of the total water consumption. Elsewhere, industries are concentrated in special zones that are supplied with low quality water; in Thailand raw water is supplied to fast growing industrial zones in the country’s eastern seaboard by the East Water Company, which was specifically set up for this purpose (ESCAP 1998a).

With continued industrialization, the industrial water requirement is certain to increase over the next decade. However the rate of water consumption per unit of industrial output is expected to decline as technological improvements are introduced with the expanding application of regulatory and economic measures (ESCAP 1998a).

4. Other Uses

Freshwater is also an important non-consumptive resource for nature conservation, hydropower developments, inland fisheries, tourism and recreation, transportation and flood control (UNEP 1994). Hydropower accounts for over 50 per cent of the electricity generated in Bhutan, Nepal, Afghanistan, Democratic People’s Republic of Korea, Lao People’s Democratic Republic, New Zealand and Sri Lanka, and is also a key source of energy in Central Asia. Fish and other aquatic macrophytes from the region’s rivers, natural lakes and reservoirs provide the main sources of dietary proteins in countries such as India, People’s Republic of China, Sri Lanka, Viet Nam, Cambodia and Lao People’s Democratic Republic (Avakyan and Iakovleva 1998) and the total inland water fishery catch in the region amounted to 15.6 million tonnes in 1996 (ESCAP 1998c).

The use of inland water for the transportation of people and goods is widespread within the region and Bangladesh, India, Myanmar, Thailand and Viet Nam rely upon their rivers as major transportation arteries. In the Philippines, Laguna de Bay Lake has become an important transportation alternative to Manila’s worsening road traffic congestion.

Lakes and reservoirs are also used extensively in the regulation of river flows and the management of floodwaters. For example, in the rainy season the Cambodian lake of Tonle Sap holds and stores excess water and sediment from the Mekong River and thereby maintains a constant flow regime in downstream Cambodia and Viet Nam, enhancing the biological and economic productivity of the river system.

WATER QUALITY: GROWING POLLUTION AND ITS IMPACTS

The threats to freshwater quality in the region come from a range of sources and the type and extent of water pollution varies by location, ecosystem characteristics, land-use and the degree and type of development. The relative severity of water quality problems in the subregions is summarized in

Figure 4.9 Domestic Water Use in Selected Cities in the Asian and Pacific Region as a Percentage of the Overall Water Use

Source: ADB 1997
Table 4.3 while selected cases of water pollution have been highlighted in Figure 4.10. Among the rivers of the region, the Yellow River (People’s Republic of China), Ganges (India), Amu and Syr Darya (Central Asia) top the list of the world’s most polluted rivers according to a report of the World Commission on Water (The Independent 1999).

A. Pathogens, Organic Matters and Nutrients

Pathogenic bacteria and viruses are found in areas where untreated sewage and effluents from intensive animal husbandry operations drain into waterways. They also enter water supplies from stormwater run-off, or as a result of leaching from open solid waste dumpsites or agricultural areas where untreated wastewater is used on crops (UNEP 1991). The level of pathogens is usually in direct proportion to the density of population and level of socio-economic development in proximity to the water. The sewerage systems in many of the developing countries of the region are poorly developed and only 10 per cent of wastewater undergoes any form of treatment (Sweden’s Ministry of Foreign Affairs 1999).

Many of the region’s rivers contain up to three times as much bacteria from human waste (fecal coliform) as the world average and more than ten times the standards set out in the OECD guidelines. The reported median fecal coliform count in the rivers of the Asian landmass, for instance, is 50 times higher than the WHO guidelines and is even more serious in the Southeast Asian subregion (ADB 1997). Drinking or bathing in water contaminated by animal or human excreta facilitates transmission and proliferation of disease vectors. The most common water-borne infectious and parasitic diseases include hepatitis A, diarrhoea diseases, typhoid, roundworm, guinea worm, leptospirosis, and schistomiasis (WRI 1999).

Organic matter also constitutes a significant pollutant in the water bodies of the region, with industries such as pulp and paper, textile, tanneries and food processing contributing substantially. The geographic distribution of organic matter pollution largely coincides with that of pathogenic contamination (Goluveb 1993). Growth in biological pollution in total water pollution loads in high-growth areas of the region has been projected to increase 18 times between 1995 and 2005 (UNIDO 1996).

Many rivers and lakes in South Asia, Southeast Asia, and People’s Republic of China are severely polluted by organic matter from sewage and industrial processes (Box 4.1). In India, for example, 114 towns and cities dump raw sewage into the Ganges, whilst the Vrishabavathi River near Bangalore receives substantial amounts of human and industrial waste, which eventually flows into Byramangala Lake, a traditional feeding ground for thousands of waterfowl. In People’s Republic of China, during the mid-1990s, the Huaihe River received 7 million tonnes of untreated domestic and industrial waste each year, rendering the river water...
unsuitable for both domestic consumption and agricultural purposes (Asian Media Information and Communication Centre 1997).

Organic matter has also been the cause of groundwater pollution in many cases. Pollution sources include leachates from unsanitary dumping of refuse and other solid waste, and from the excessive use of fertilizers. In India, groundwater pollution of the Chennai urban aquifer is caused by a range of pollutants including nitrates, heavy metals, and micro-organisms (Somasundaram et al 1993), whilst in the Jaffna Peninsula of Sri Lanka, latrines contribute to the increasing nitrate problem of the shallow groundwater aquifer (Hiscock 1997).

Agricultural inputs, including fertilizers, pesticides and animal wastes, are another growing source of freshwater organic pollution in the region, particularly in People’s Republic of China and the countries of South and Southeast Asia. In New Zealand, the increase in dairy farm and fertilizer use is intensifying pollution in groundwater as well as shallow lakes and streams (Smith, et al 1993). In New South Wales, it is estimated that around 90 per cent of rivers currently experience water quality problems due to excessive nutrients.

Among the rivers of the region, approximately 50 per cent have exceedingly high levels of nutrients while another 25 per cent have a moderate problem where nutrient levels occasionally exceed desirable levels (ESCAP 1998). In Central Asia, nutrients from the excessive use of fertilizers, herbicides, pesticides and defoliants is leading to health hazards due to water resource contamination (Mainguet and Letolle 1998 and Kharin 1996).

**Box 4.1 Water Quality in People’s Republic of China**

Seven large river systems, lakes, reservoirs, and underground water in some regions of People’s Republic of China were polluted to varying degrees in 1997. The arid and semi-arid regions in the north as well as many cities suffered from serious water shortage. Seventy eight per cent of rivers which flowed through cities could not be used for potable supplies, and 50 per cent of the groundwater in cities was polluted (1996 State of Environment Report, People’s Republic of China). The deficiency of water resources and the pollution of water systems according to the report had become one of the main factors affecting China’s social and economic development.

In terms of effluents the total amount of discharged wastewater was 41.6 billion tonnes, of which 22.7 billion tonnes was industrial wastewater and 18.9 billion tonnes was municipal wastewater. With regard to industrial wastewater, industries at the county level and above discharged 18.8 billion tonnes, while TVIE (Township and Villages Industrial Enterprises) discharged 3.9 billion tonnes. In discharged wastewater, the total amount of Chemical Oxygen Demand (COD) was 17.6 million tonnes, including 10.7 million tonnes of COD discharged with industrial wastewater and 6.8 million tonnes of COD discharged with municipal wastewater.

In order to cope with situation, People’s Republic of China has enhanced the dynamic of pollution control measures along its rivers and it has listed, (in its environmental plan within its ninth Five-year plan) the water control project of the “Three Rivers and Three Lakes” as the most important undertaking. In addition, the following steps have been taken to solve the problem.

- Deadlines have been set for enterprises to comply with the state standards industrial pollution control and treatment has been strengthened.
- An investment loan of 250 million yuan has been arranged to support 28 key pollution control projects. With the support of the central government and joint efforts of the governments at all levels in the river basin, the problems of drinking water supply in heavily polluted areas are being gradually addressed.
- The treatment rate of industrial wastewater was 79.1 per cent in 1997. Moreover, during the implementation of China’s Trans-century Green Project Plan, 99 projects for water pollution treatment were completed and 325 projects for water pollution prevention and treatment are under construction.

These measures are gradually improving the quality of water and it is expected that their strengthening will lead to further improvements in future.

*Source:* SEPA 1997
B. Heavy Metals and Toxic Chemicals

The measured concentrations of heavy metals (such as arsenic, cadmium, mercury and lead) exceed basic water quality standards in many of the region’s water bodies. The concentrations of DDT, PCB’s, industrial solvents and other toxic chemicals, which originate primarily from mining, oil refineries, chemical works and in textile, wood pulp, and pesticide factories, are also rising.

Within the region, the water bodies of the Southeast Asian sub-region are the most heavily polluted with heavy metals and toxic chemicals (ADB 1997). For example, sixteen rivers in the Johor State in Malaysia were found to have mercury levels exceeding the national standard, whilst in other rivers, the mercury, lead, cadmium, zinc and copper levels exceed the national standards. Heavy metal pollution in Malaysian rivers is caused mainly by industrial discharge or mining (Encyclopaedia of Malaysia 1997). An extensive survey of river water quality in Thailand revealed heavy lead contamination (in a number of major rivers including the Pattani and Colok in the south, the Moon river in the Northeast, the Pa Sak river in the north and the Mae Klong river in the central region), mercury contamination (in the lower central region’s Pranburi River, the Mae Long, Chao Phraya and Petchburi rivers of the central region and the Wang River in the northern region), cyanide and mercury used in gold mining are severely polluting the rivers and waterways of the Philippines’ mountain provinces and islands and other areas including Malaysia and Papua New Guinea. One of the major lakes on the island of Mindanao had been declared biologically dead, since its basin was converted into a tailings pond by a copper and gold mining company in 1979. In Bangladesh, the recent case of slow poisoning from arsenic-contaminated water supply has gained worldwide attention (Box 4.2).

C. Sediments and Salts

With increasing deforestation and land conversion, soil erosion is exacerbating the natural process of siltation of water bodies and greater quantities of sediment are accumulating in the rivers, dams and reservoirs of the region. For example, in the Ganges, Brahmaputra and Yellow River basins, erosion is responsible for an annual yield of over 1 000 tonnes of sediment per square kilometre of land. The siltation in Pakistan’s Tarbela Dam on the Indus River accumulates 200 million cubic metre of silt each year filling the reservoir at a rate of two per cent per year (Asian Media Information and Communication Centre 1997). In Cambodia, heavy siltation of Lake Tonle Sap, resulting from deforestation in the upper catchment, is significantly reducing the lake’s depth and this has effected the yield of the lake’s fisheries. In Malaysia, the Dungun River in Kuala Terrengganu has been polluted by sandy sediments, exacerbated by dredging activities along the river (Encyclopaedia of Malaysia 1997).

Increasing salinity of ground and surface waters renders land unsuitable for agriculture and leaves water unsuitable for domestic and industrial use (ESCAP 1998). Increasing salinity in the region is occurring not only as a consequence of excessive irrigation but also due to rapid deforestation and mining and other industrial activities that mobilize salts, naturally present in groundwater, rocks and soil, and contributes to their concentration in surface waters and groundwater aquifers. Moreover, the effluents from power stations and industrial cooling systems, paper mills and other industrial processes are also sources of salt accumulation in receiving water bodies. Other causes of increasing salinity are rising water tables due to excessive seepage of water from canal systems and capillary rise and evaporation of saline groundwater. Inadequate availability of water from rains or excessive irrigation without adequate drainage is also one of the important causes of salinity. According to FAO (1990), the Asian and Pacific Region has the world’s greatest concentration of salt affected soils (see Chapter 1).
CHAPTER FOUR

ENVIRONMENTAL IMPACTS OF UNSUSTAINABLE WATER USE

A. Surface water

1. Diminishing Supply/Over-abstraction

Over-abstraction can cause serious environmental degradation. Water abstraction from the Aral Sea in Central Asia (Box 1.1) has reduced the lake’s surface area by 40 per cent and its volume by as much as 60 per cent, resulting in the loss of almost all of the native fish species. Similar symptoms have been reported from other arid zone lakes, including Lake Balkhash in Kazakhstan and Lake Chinghai in People’s Republic of China.

The adverse effect of surface water mismanagement is also apparent in the hill districts of Uttar Pradesh in India where 2 300 of the 2 700 drinking water projects have failed as surface water sources have dried up. In the southern state of Tamil Nadu, the custom of celebrating the mid-August arrival of freshwater floods on the Amaravathi River is no longer practised as the flow is now reduced to a mere trickle of water. This is a result of the construction of a major dam 50 kilometres upstream and the development of a sugar mill in the vicinity that utilizes substantial amounts of water (Asian Media Information and Communication Centre 1997).

2. Declining Productivity of Land

Irrigation has increased food productivity by many folds but often it has resulted in the degradation of croplands and water quality. In particular, the neglect of the need to remove water and salt from confined or slowly draining alluvial basins has led to a loss in land productivity and to environmental degradation (see Chapter 1 and Chapter 10).

Box 4.2 Millions in Bangladesh Face Slow Arsenic Poisoning

Millions of people in rural areas of Bangladesh are being slowly poisoned as they drink water contaminated with small but potentially fatal quantities of arsenic. Estimates by World Bank and other experts claim that from 18 to 50 million people out of a total population of about 120 million in the country are at risk. Thousands are already showing symptoms of poisoning. Nineteen rural districts covering an area of 500 km² near the border of Bangladesh and India have arsenic-contaminated wells. Many villages adjacent to the capital city, Dhaka, are also affected. In the neighbouring Indian state of West Bengal, an estimated 6 million Indians are drinking contaminated water and 300 000 are showing signs of poisoning. Many victims are children (45 per cent) who have been consuming the poisoned water since birth. The contaminated water comes from underground tube wells introduced widely over the last 20 years as a cheap alternative water supply to prevent outbreaks of diseases such as diarrhoea and cholera. Tube wells are steel cylinders sunk into the ground to varying depths to provide underground water for irrigation and drinking.

The United Nations Children’s Fund (UNICEF) initiated well-drilling as a means of providing clean water in rural areas in Bangladesh. When the programme began, no water or soil tests were carried out. It was estimated that there are now 5 million tube wells, providing 95 per cent of all water to over 120 million people. Testing is meant to be carried out on new installations but mainly takes place at government installed wells. Of the 20 000 tube wells tested so far, 25 per cent have dangerous levels of arsenic, 40 per cent have unsafe levels and only 35 per cent were safer or below 0.01 milligrams/litre of arsenic. The World Health Organization recommends a level of 0.01 mg/L of arsenic but the governments of Bangladesh and India regard 0.05 mg/L – a level five times higher – as acceptable.

Various theories for the contamination have been advanced. According to one theory, overuse of the water supply has increased oxygen levels in underground waterways, resulting in higher rates of leaching of minerals containing arsenic. Other scientists say that biological processes may be involved. In 1997, the Bangladesh Centre for Advanced Studies hypothesized that only the upper 150 metres of sediment contained high levels of arsenic. Some experts consider long term and sustained use of pesticides and the waste products from industry as the main contributing factors.

Concerns over arsenic-contaminated water first began to emerge in 1980s in West Bengal but efforts on testing were so little that most of the danger warnings were dismissed even until early 1990s. Despite the mounting evidence of widespread water contamination, little has been done to identify the extent of the problem let alone provide any solutions. Facing a growing health crisis, a conference to bring together international specialists and medical experts were organized by Dhaka Community Hospital to find solution in 1994. A regional consultation was also held in New Delhi in April 1997. In August 1998, WHO, UNICEF and other international agencies, including the World Bank, agreed to provide funds to conduct more research and attempt to find alternative supply to safe drinking water. Some cheap solutions and interim measures are now under consideration.

There is no lack of water as Bangladesh forms a huge river delta system, though flooding afflicts the country, yet the most obvious solution – a long term plan to control the flow of river and water treatment plants to provide clean drinking water – remains far off reach in the wake of deficient financial resources.

Source: Government of Bangladesh
3. Negative Effects of Dams and Reservoirs

Dams and impounded reservoirs form an essential part of many water management systems, enabling hydropower, irrigation, flood control and providing water resources regardless of the seasons. However, the construction of many dams has resulted in high environmental, economic and social costs.

In recent years, the construction of dams and reservoirs has resulted in the loss of increasingly shrinking wilderness areas with high levels of biodiversity. In Malaysia, the Temenggor Dam flooded valuable forests and threatened the survival of 100 species of mammals and 300 species of birds. In India, a network of canals, proposed as part of the Sandar Sarovar Project, disrupted much of the wild ass sanctuary by destroying the vegetation of the species’ primary grazing and breeding areas and the changes in irrigation, land-use patterns and soil moisture regimes threaten the survival of other species such as blackbuck, desert fox and indigenous plant species which are xerophytic and salt tolerant (Asian Media Information and Communication Centre 1997).

In the Russian Federation, eight million hectares of highly productive land has been lost to inundation by man-made lakes. These have resulted in a deterioration in water quality, the disruption in the hydrological regimes of downstream rivers, the interception of nutrients by dams, a rise in groundwater levels, the translocation of people and the disruption of traditional economic activities and fisheries (Goluveb 1993).

B. Groundwater

1. Land Subsidence

Since the early 1980s evidence has been accumulating of the substantial and widespread breakdown of the piezometric surface in many Asian cities, as a result of heavy exploitation of aquifers (Ramnarong and Buapeng 1991 and Sharma 1986). In many areas falling water tables signify that groundwater withdrawals have exceeded the rate of renewal. For instance, in some parts of India extraction exceeds recharge by a factor of at least two (Seckler, et al 1999). Water tables are falling throughout much of the Punjab and Haryana States, whilst in Gujarat groundwater levels declined by 90 per cent during the 1980s. In People’s Republic of China, the water table in parts of Beijing has dropped 37 metres over the last four decades (Asian Media Information and Communication Centre 1997). In Japan, an estimated 12 per cent of habitable land, mainly in the industrial regions along the coast, is affected by subsidence.

2. Saline Intrusion

Pakistan is probably the country most severely affected by saline water because of the high salinity of much of its soils. With limited natural drainage from the primary agricultural areas, levels of salinity in the major rivers are progressively concentrated such that the water is rendered unusable for downstream users (Seckler, et al 1999).

In some coastal cities of the region, over-pumping has resulted in the movement of salty seawater inland. Known as “saline intrusion”, this occurs when water levels in freshwater aquifers are lowered to a point where salt-water can invade through the water-bearing beds in the direction of the wells. For example, in Dhaka and Metro Manila seawater intrusion into aquifers presents a major problem, whilst in the major river basins and coastal plains of Viet Nam, the average salinity of groundwater is approximately 3 000-4 000 ppm, a level unsuitable for drinking (Asian Media Information and Communication Centre 1997). Saline intrusion has also occurred in Indian state of Gujarat, where irrigators have heavily overpumped local aquifers near the coast (Postel 1996).

Policies and Strategies for Sustainable Water Management

A. National Level

Traditionally, governments’ policies and strategies on water management have been aimed at the expansion of supply in order to meet the ever-increasing water demands of the domestic, agriculture and industrial sectors. However, increasingly policy frameworks are focused on an integrated approach to water resources management by placing emphasis on demand management, water-use efficiency, conservation and protection, institutional arrangements, legal regulatory and economic instruments, public information and interagency cooperation. An integrated approach, as articulated in Agenda 21, implies the use of a
dynamic, interactive, iterative and multi-sectoral approach to water resources management and advocates the integration of sectoral water plans and programmes within the framework of national economic and social policies.

Many countries of the region have reviewed or revised their national policy on water resources development and management. Common elements in the national policies and strategies adopted include the integration of water resources development and management into national socio-economic development; the assessment and monitoring of water resources; the protection of water and associated resources; the provision of safe drinking water supply and sanitation; the conservation and sustainable use of water for food production and other economic activities; institutional and legislative development; and public participation. In 1997, ESCAP conducted a survey to report on the progress achieved in the implementation of Agenda 21 on freshwater resources management. The results of the survey showed that although the implementation levels of the elements outlined above were not fully realized, some encouraging progress had been made in a number of areas including an increase in the potential for regional cooperation.

1. Integration of Water Resources Management into National Development Plans

In a number of countries in the region, national water resources action programmes or water master plans have been prepared with a scope that ranges from single-purpose to more comprehensive development strategies. In Bangladesh, the National Water Plan II for the period of 1990-2010 has been prepared as an updated continuation of the National Water Plan, which covered the period between 1985 and 2005. In the Islamic Republic of Iran, the Second Five-Year Socio-economic and Cultural Development Plan (1995-1999) included a number of objectives related to the environment and water resources. In the Maldives, an action plan has been developed which gives priority to the wise use of groundwater resources.

In several countries, the preparatory work for the formulation or revision of national action plans has also been initiated, often with the assistance of international organizations. For instance, Mongolia is currently planning an update to the national Water Master Plan, first prepared in the early 1970’s, to reflect the social and economic changes associated with the country’s transition from a centrally controlled to a market economy. Sri Lanka is to formulate a national action plan for water resources management that will synthesize and use the results of a series of comprehensive sub-sectoral plans. The action plan is expected to have a positive effect on the quality of investments in irrigation, water supply, power generation and environmental protection and to strengthen their linkage with national development goals (ESCAP 1997).

The concept of water resources management within a river basin or water catchment area, with a focus on the integration of land and water related issues, has also been applied in some countries including Australia, People’s Republic of China and Japan. In India, the national water policy asserts that water resources planning be undertaken for a hydrological unit, such as drainage basin or sub-basin. In Indonesia, institutions for water resources management have been established for some river basins, although these are yet to become fully functioning. The current challenge to many countries of the region is to overcome fragmented sub-sectoral approaches and to design and implement integrated mechanisms, particularly for the implementation of projects that transcend sub-sectors. The largely fragmented approach that has traditionally been applied has allowed conflicts and competition, and has led to the over-exploitation of scarce water resources.

2. Assessment and Monitoring of Water Resources

An essential pre-requisite to the integrated management and sustainable development of water resources in the region is the assessment of the quantity and quality of available surface and groundwater resources. The inadequacy of quantitative and qualitative information for planning and decision-making has often resulted in over-estimation of water resources potential and the development of agricultural and industrial projects that were constrained by water scarcity. It has also allowed complacency, and consequential wastage, in the use of water resources. In many small island countries, such as the Maldives, the lack of information on the assessment of groundwater reserves has also been identified as a major constraint for future planning and decision-making.

The main challenges to water resources assessment in the region are coordination in the collection and processing of data on water resources, standardization of assessment and monitoring procedures, and integration of information on current and future uses of water and related resources, including catchment protection under development scenarios. Comprehensive water resource assessment also necessitates local and community participation in the assessment to contribute and validate information, verify assumptions and develop effective resource management modalities (ADB 1998).
The problem of assessment and monitoring of water resources is aggravated by extremely uneven density of hydrometeorological observation networks, varying from the comprehensive network established in Japan, to the scattered gauges available over the vast areas of eastern China and the Himalayas and to occasional solitary gauges on a Pacific atoll. In view of the lack of information on water resources, a number of governments have devised strategies to develop comprehensive data and information system on water resources to assist in policy formulation and decision-making. Sri Lanka, for example, proposes to undertake a complete reappraisal of the available water resources and devised a strategy for their future development and conservation in a national water master plan. In India, a project is being implemented for undertaking systematic collection and analysis of hydrological data. Mongolia is also undertaking action to develop an adequate information system for both surface and groundwater, in terms of both water quantity and quality. An integrated, nation-wide initiative called the Urban Water Programme (UWP) in Australia highlights the importance of water assessment, flow mapping and modelling (Speers 1999) as a major step towards the country’s drive for efficiency in water service provision and water allocation.

3. Protection of Water Quality and Associated Resources

Several countries of the region are implementing large-scale and ambitious programmes and action plans aimed at rehabilitating degraded and depleted water sources. These programmes and plans are typically given legislative or statutory authority such as that provided by Thailand’s National Water Quality Act, the Philippines’ Water Quality Code, India’s Environment Protection Act, China’s Water Law or the Republic of Korea’s Water Quality Preservation Act (ESCAP 1999a).

Success stories with respect to the rehabilitation and protection of water quality of rivers come from those countries where water policies promote a multi-sectoral and multi-disciplinary approach to the management of water resources (ESCAP 1999a). Clean up campaigns for rivers, canals, lakes and other water bodies have become widespread throughout the region (see Table 4.4). Initiated by a range of organizations, including government bodies, business associations, NGO’s, national or international development agencies and community groups, the programmes have often been successful in achieving water quality improvement and occasionally have led to the adoption of new water quality standards, water-use regulation, creation of governing bodies, delineation of responsibilities, allocation of resources, and promotion of sectoral and public awareness and participation (see Box 4.3). There has also been an increase in awareness regarding the reduction of pollutant loads through proper wastewater treatment, reuse and recycling of domestic sewage and industrial wastewater, introduction of appropriate low-waste technologies and strict control on industrial and municipal effluent. Programmes on protection and rehabilitation of lakes have been initiated through coordinated efforts of the government, industries, NGO’s and the general public in a range of countries including People’s Republic of China, Japan and the Republic of Korea.

A number of success stories have been documented regarding water reuse and recycling in the industrialized countries of the region attributed to the emergence of various corporate environmental management approaches such as cleaner production,

<table>
<thead>
<tr>
<th>Country</th>
<th>Programme</th>
<th>River</th>
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<tbody>
<tr>
<td>Australia</td>
<td>Murray-Darling Basin Agreement</td>
<td>Murray- Darling River</td>
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<tr>
<td>Bangladesh</td>
<td>Save Buriganga Programme</td>
<td>Buriganga River</td>
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<td>PR China</td>
<td>Pollution control plan on three rivers</td>
<td>Huihe, Haihe, Liaohe rivers</td>
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<tr>
<td>India</td>
<td>Ganges Action Plan</td>
<td>Ganges River</td>
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<tr>
<td>Indonesia</td>
<td>Prokasih</td>
<td>Various rivers in Indonesia</td>
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<tr>
<td>Malaysia</td>
<td>Operation Clogged Drains Love Our Rivers Campaign</td>
<td>Sungai Merliwan, Malacca</td>
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<tr>
<td>The Philippines</td>
<td>Ilog Ko, Irog Ko (My River, My Love)</td>
<td>Pasig River, Metro Manila</td>
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<td></td>
<td>Sagip Pasig Movement (Save Pasig Movement)</td>
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<td>Piso Para sa Pasig (A Peso for Pasig)</td>
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<tr>
<td>Thailand</td>
<td>Clean Up Chao Phraya River and Bangkok Canals</td>
<td>Chao Phraya River and Bangkok Waterways</td>
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<tr>
<td>Singapore</td>
<td>Clean River Programme</td>
<td>Singapore River and Kallang River</td>
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Source: ESCAP 1999a
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environmental management systems, ISO 14000, environmental auditing and reporting and industrial eco-zoning (see Chapter 13).

Despite improving corporate performance and stricter enforcement of environmental regulations, a major challenge to the ongoing protection of water quality remains the management of catastrophic pollution events (see Box 4.4).

4. Provision of Safe Drinking Water Supply

Considerable progress was made in improving and extending the provision of water supply and sanitation during the International Water Supply and Sanitation Decade (1981-1990). Millions of people gained access to safe water and adequate sanitation for the first time (ESCAP 1998a). A regional consultation organized by World Health Organization (WHO) in 1996 also provided an impetus to countries in the region to draw up their own Action Plan for the Development of National Drinking Water Quality Surveillance and Control Programmes. The plan was intended to provide guidelines, within a regional framework, for implementing national drinking water quality surveillance programmes (WHO 1996).

5. Conservation and Sustainable Water Use for Food Production and other Economic Activities

Demand side management policies have led to the promotion of efficiency, conservation, rationalization of prices and the involvement of

Box 4.3 Pasig River Rehabilitation Programme in the Philippines

The 27-kilometre Pasig River in Metro Manila, Philippines is directly connected to the Laguna Lake and Manila Bay, and cuts through the heart of heavily urbanized Metro Manila. It is considered as one of the most polluted rivers in the region. As only seven per cent of Metro Manila’s households are connected to a piped sewerage system, the river receives the direct discharge of untreated wastewater from the 11 municipalities located within the river basin, raising the biochemical oxygen demand (BOD) far above the absorptive capacity of the river. Likewise, the indiscriminate discharge from industrial sources and the dumping of solid wastes contribute to the severe level of pollution. The areas along the riverbanks and adjacent to the river are lined with squatter settlements, estimated to be around 12 000 families. These people are exposed to flooding, and major public health risks such as cholera, gastroenteritis, dysentery and intestinal parasites.

The President of the Philippines, on January 6, 1999, signed Executive Order No. 54 creating the Pasig River Rehabilitation Commission (PRRC) to oversee and coordinate all activities related to the rehabilitation and development of the river. Its overall objective is to restore the river water quality to Class C standard, which is capable of sustaining aquatic life, supporting secondary contact sports like boating, and, after treatment, may be used for industrial processing as a potable source. Among the major activities of PRRC are: massive dredging and de-silting; removal of derelicts clogging the waterways; construction of river walls and flood control structures; and construction of waterfront facilities, roads and walkways along the riverbanks in order to provide recreational areas and contribute to the environmental enhancement of these areas. The government also plans to build larger and better ferry service and terminals not only at several points along the river system but also along the Laguna Bay, thus providing an alternative transport system for Metro Manila. Resettling riverside squatter families is among the key environmental targets of the PRRC.

In terms of coordination and participation, the Metro Manila Development Authority Chairman was delegated to coordinate all government and private efforts at reviving the Pasig River and its major tributaries. Lead government agencies supporting PRRC include: Departments of Budget and Management, Environment and Natural Resources, Tourism, the Public Works and Highways; Housing and Urban Development Coordinating Council; and the Philippine Ports Authority. Partnerships with private organizations were also developed to support the PRRC. For example, the Department of Environment and Natural Resources (DENR) has forged ties with Coconut Industry Investment Fund (CIIF) Group of Companies for an effective waste management and pollution reduction systems. General public participation is also being promoted through awareness and education programmes and projects like the "Lakbay Ilog" (River Travel) and "Task Force Sagip-Ilog" (Save the River Task Force).

The project is estimated to cost some 12 billion Pesos (US$468 million) and will take about six to seven years to complete. Technical and financial assistance were also solicited from Danish International Development Assistance. The ADB is also currently studying a US$350 to US$400 million loan for a five-year development plan of Pasig River.

There has been some observed improvement in the quality of water in the river since the project started. The volume of floating debris has been reduced, sunken derelicts have been removed, clearing of illegal structures is ongoing, works on riverwalks are also on-going and 14 riverside parks have been developed. Some 4 104 families have already been resettled to safer grounds in anticipation of the effects of heavy monsoon rains. These relocated families have also been given livelihood support. With the PRRC’s optimistic beginning, the programme shows that a decisive political will, effective focalized coordination among all agencies involved, private and public participation as well as international support are critical success factors towards rehabilitating a river like Pasig.

Source: Compiled from news at http://home.ease.lsoft.com/BALITA News
stakeholders in water conservation and management. Such policies include the promotion of efficiency in the use of irrigation water and in food production, consumption and leakage reduction programmes and encouragement of industries to reduce and recycle process water.

In view of the current low efficiency of irrigation water use, many countries are adopting policy measures for improving irrigation and taking steps towards the modernization of technologies and the improvement of existing methods of irrigation. For instance, in India the National Water Board of the Ministry of Water Resources has recently finalized the draft of an irrigation management policy for consideration and adoption by the National Water Resource Council. The policy aims at improving water application efficiency through the use of modern technologies such as drip/sprinkler irrigation and better on-farm irrigation methods. It also envisages providing adequate finances by linking provision of such finances to irrigation revenues earned. In Pakistan, where about 10 per cent of the best agricultural land is already adversely affected by salinity, Phase I of the National Drainage

Box 4.4 Prevention of Water Pollution Accidents in the Republic of Korea

With the rise in industrial activity, more and more oil and hazardous substances are being handled and transported in the Republic of Korea resulting in more frequent water pollution accidents. A total of 75 water pollution accidents occurred in 1996 alone. An analysis of these accidents revealed that 52 of these were the result of traffic collisions and carelessness in handling and transporting oil and hazardous substances, or water pollution due to illegal dumping or emission of polluted wastes or toxic substances by industrial sites, while eight per cent involved negligence of persons in charge of handling toxic substances, including the collision of vehicles.

In response to increasing accidents, the government formulated “Integrated Guidelines on Water Quality Control” on 30 May 1994 by Prime Ministerial Directive No. 196. In addition, a system of cooperation between the related ministries responsible for water quality control and construction of dams and other water-resource supply related works was established. A Water Quality Control Consultation Committee for each water system around the four major rivers (Han, Nakdong, Keum, and Youngsan) was also constituted, and responsibilities for taking preventive measures against water pollution accidents were assigned to each of the appropriate authorities.

For effective surveillance under the new system, 1 932 government officials were assigned to 1 559 locations where the danger of water pollution accidents was greatest. To further strengthen the public water surveillance system, the Military Manpower Management Office provided 1 712 public service personnel to be assigned the duties of surveillance and protection of water supply sources in 1996, which were further increased in 1997.

Under the strengthened water quality analysis system, 43 locations were identified where water pollution accidents were most likely to occur and water quality analysis was done one to three times a day to detect water pollution accidents as early as possible and to take prompt response to such accidents.

During the drought season when even the flow of small amounts of pollutants into rivers may cause water pollution, administration was strengthened to control effluent discharges. The Water Quality Preservation Act was revised in December 1995 and put into effect on 1 July 1996. In an accident case involving water pollution, it required the polluter to file a report and take preventive measures. In addition, legal grounds for punishment of polluters were provided. The law aims at inducing operators of businesses to make voluntary efforts to prevent water pollution accidents.

The comprehensive measures adopted in the Republic of Korea to prevent water pollution accidentally has enabled the country to avoid a major disaster in terms of water pollution and maintain the quality of its valuable and limited water resources.

Source: Government of Republic of Korea 1997
Water pricing has been a very successful instrument in controlling wastage of water in the domestic sector. For example, in Bangkok, introduction of appropriate water charges led to reduced use and a lowering in pumping rate of groundwater by one per cent per year. Differential prices have also been used as a mechanism in People’s Republic of China to save water from fragile sources such as groundwater.

A major problem in water conservation is unaccounted water or distribution loss, which is high in urban areas averaging about a third of the total volume. However, Singapore and Bangkok have excellent records for reduction in transmission losses. Leak detection programmes, metering of production and consumption, regular maintenance and repair and replacement of defective metres have been keys to success.

The main challenges confronting many countries with respect to conservation and efficient water use are: how to increase investments in new water delivery systems that will efficiently meet customer demands in different uses and also include cost recovery for water services provided; how to upgrade and manage existing systems to reduce demand and run more efficiently including the maintenance of large common assets with long economic life expectancies; and how to safeguard social equity by ensuring the provision of basic affordable water services to all consumers.

6. Institutional Development, Legislation and Public Participation

Some countries in the region have created major national institutions with comprehensive responsibilities for water resources assessment, planning and development and other related functions (ESCAP 1997a). However, most countries retain institutional responsibilities for water resources development, management and conservation amongst a number of fragmented, sectoral agencies and central and provincial authorities; this fragmentation has been a major obstacle to the introduction of integrated water resources management.

In some countries, such as People’s Republic of China, India, the Philippines and Thailand, the integration of these separate administrative and functional authorities has been addressed through the creation of inter-agency coordination committees and groups composed of high-ranking representatives of various agencies and ministries dealing. For example, in the Philippines the National Water Resources Board coordinates the activities of eleven government agencies with functions that directly relate to water resources management (Baltazar 1996). A similar approach is taken in India where the role of coordinating surface water management resides with the Central Water Commission, which is within the Central Ministry of Water Resources (Rao 1996).

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Box 4.5 From Effluent to Affluent: A Case in Thailand

The Ban Pong Tapioca Starch Flour Company Ltd., in Ratchaburi Province, Thailand, is showing ways to turn waste effluent into marketable products. It has done so in harmony with its environment and at a profit.

The first innovation taken by the company was to introduce a filtration system that separates the cellulosic pulp from the pentose sugar-rich wastewater generated by the cassava starch plants. The pulp is then dried on concrete slabs and sold to local feedmills as cheap raw materials with good nutritive value for ruminant feed pellets. The second development was a collaboration with King Mongkut Institute of Technology, Thonburi (KMITT) to build an anaerobic digester to convert the organic-rich wastewater into biogas as fuel for the plant’s boiler. After successfully testing a smaller, upflow anaerobic sludge blanket digester, the plant installed a scaled-up system capable of handling the entire effluent load from the plant. When operating at full capacity, the digester produces enough fuel gas to meet the plant’s energy requirements. The third innovation was to use the nutrient-rich effluent from the digester to grow algae in oval raceways. *Spirulina* is in demand as a health food and feed ingredient because of its high protein (60-65 per cent) high fat (12-25 per cent), and rich content of the orange pigment, *Beta carotene*. Effluent discharged after the algae harvesting, has a BOD of 15-20 mg per litre, well within the EPA standards. The effluent canal supports a rich population of flora and fauna and is linked with the irrigation system serving the area.

The innovations of this company provide a lesson that protecting the environment makes business sense. The proactive stance of the company shows that the wastewater can be another resource for another system to gain value added effects. The waste that could have been dumped into the rivers or elsewhere is transformed through technological creativity into useful by-products which are safe, cost effective, and environmental friendly.

Source: Asian Media Information and Communication Centre 1997
Decentralized water management is also being encouraged particularly in large countries such as People’s Republic of China and India. In People’s Republic of China, the regional rights in the development and management of water resources have been reinforced and the city/provincial authorities have been assigned the appropriate power to enable direct management of water resources. In India, multi-disciplinary units in charge of preparing comprehensive master water plans have been established in some states.

Water pollution control legislation has set standards for water usage and effluents and has established regulatory units to oversee the implementation and enforcement of standards. For example, implementing rules and regulations made under the Water Code of the Philippines impose permits for surface and groundwater use, pollution control measures and restrictions on disposal of wastewater. Although most countries of the region have adopted water legislation, there is a need in some countries, especially those with the economies in transition, to review the existing water legislation in order to incorporate relevant provisions associated with the economic value of water and its rational use as well as protection of the aquatic environment, etc.

Stakeholder participation is also being increasingly promoted in the management of water resources. Experience with small-scale managed irrigation projects in countries such as People’s Republic of China, Indonesia, the Philippines, Sri Lanka and Thailand has been extremely positive especially where water users associations have taken the managerial responsibility. Similarly, by involving the benefiting communities in the development and maintenance of water supply, sanitation and pollution control facilities the cost of supply have been greatly reduced. The involvement of the private sector has also reduced the financial burden on the government in implementing water development programmes, particularly in People’s Republic of China, Malaysia and Viet Nam, where French and British companies have been actively seeking to invest in water supply projects (ESCAP 1997).

Public awareness and participation is also receiving greater priority in water resources management. For example, the National Land Agency in Japan organizes various activities and initiates public campaigns aimed at enhancing the public understanding of the limited availability of water resources and the importance of sustainable water resources development.

Each year, since its inauguration in 1993, World Water Day (22nd March) has been increasingly observed throughout the region and awareness building activities carried out in connection with this Day are targeted at both urban and rural population. Non-governmental organizations are also taking initiatives on public awareness. Popular in the city of Bangkok is one such initiative called the “Magic Eyes Campaign” which has brought about a higher degree of social consciousness not only towards cleaner water but overall environmental protection.

B. Regional/International Level

1. Transboundary Water Cooperation

Although managing or resolving transboundary water resources problems and conflicts in the region is a slow and cumbersome process, some headway has been made particularly in Southeast and Northeast Asian subregions where integrated basin-wide management approaches have been promoted. Such an approach is beneficial to the management of a large number of transboundary water systems through cooperation in the formulation and implementation of development plans. For example, the Mekong River Commission is identifying and implementing various projects from the Indicative Plan for the development of land, water, and related resources in the Lower Mekong. A similar approach is being adopted in Northeast Asia, where the Tumen River Area Development Programme has fostered participation and cooperation between People’s Republic of China, the Democratic People’s Republic of Korea, and Russian Federation.

The Indus Basin water sharing accord between India and Pakistan, the “Water Sharing Treaty” between India and Bangladesh (Box 4.6), the India-Bhutan cooperation in hydropower development and India-Nepal cooperation in harnessing transboundary rivers are further positive examples of transboundary cooperation on water management in the region (South Asia Technical Advisory Committee 1999).

In Central Asia, the agreed management of transboundary waters in the Aral Sea Basin by Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan is also being strengthened and enhanced through consultation and coordination. The 1994 Aral Sea Basin Programme is founded on an agreed Regional Water Resources Management Strategy, aimed at achieving sustainability of water resources in the Aral Sea Basin through increased water use efficiency and improved water quality.

2. Roles and Programmes of International Organizations

International organizations have played a range of roles in water resources management within the region through undertaking sustainable water
resource development and management programmes as well as investment projects with related activities for irrigation and drainage, flood control, fisheries, hydropower, water supply, sanitation, urban drainage, inland navigation and port development.

The United Nations Development Programme (UNDP) promotes capacity building for sustainable water resources development. The World Meteorological Organization (WMO) supports assessments and forecasting of water resources potential, and helps the development of information systems for better planning and decision-making. The Economic and Social Commission for Asia and the Pacific (ESCAP) has carried out studies on water resources assessment, management, water pricing, investment promotion, dissemination of water-saving technologies and the involvement of women in water conservation and development. Moreover, ESCAP has been serving as the secretariat of the Inter-agency Sub-committee of Water for Asia and the Pacific, which was established in 1978. The United Nations Educational, Scientific and Cultural Organization (UNESCO) funds the International Hydrological Programme to monitor hydrological data at regional and national levels, whilst the Food and Agriculture Organization (FAO) focuses on irrigation and water for food production and has developed guidelines for water policy review and strategy formulation as well as pioneering water legislation in many countries (ADB 1998).

The United Nations Environment Programme (UNEP) focuses on environmental legislation, legal training and data collection on water quality. One notable programme is the Environmentally Sound Management of Inland Water (EMINWA), a comprehensive approach to management and development of freshwater resources on a basin-wide scale (UNEP Freshwater Programme 1995). The programme is designed to assist governments to integrate environmental considerations into the management and development of inland water resources with a view to reconciling conflicting interests and ensuring the regional development of water resources in harmony with the environment (David et al 1988; and Tolba 1988).

The ADB is assisting countries to meet the challenges of water problems through investment and assistance in effective policy formulation and implementation. The recent important milestone of ADB is a series of Regional Water Policy Consultations, which serve as the venue for in-house analysis and dialogue among policy stakeholders which include governments, private sector and non-government organizations (NGOs), external support agencies like United Nations and World Bank, international private sectors, international research institutes, and experts from the region and beyond. The consultation defined ADB’s role in redirecting its water operations and targeting water sector in long-term investment, as well as catalyzing partnership and cooperation in the region (ADB 1998).

On the financing side, the World Bank has played an important role by primarily investing in many countries, with recent focus on the operation and maintenance of irrigation systems ensuring water supplies and improving water quality.

The international professional organizations that are active in the water sector include the

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### Box 4.6 Ganges Water Sharing Treaty

The Farakka transboundary water dispute between India and Bangladesh has come to an end with the signing of the long-awaited Ganges Water Treaty Between India and Bangladesh. The treaty has recently been signed by the Prime Ministers of the two countries in New Delhi. Putting aside the legal parlance of the treaty, the agreement in general has enkindled a hope that the problems and sufferings that ensued from the upstream withdrawal will end soon.

The treaty provides a formula for sharing of the Ganges water from January 1 to May 31 in 10-day periods. According to the formula, when the flow is more than 75,000 cu sec (CFS), India’s share will stand at 40,000 cu sec, Bangladesh receiving the rest. When the flow is between 70,000 and 75,000 cu sec, Bangladesh will receive 35,000 cu sec and India will receive the rest. When the water available at Farakka is 70,000 cu sec or less, India and Bangladesh will share equally. If the water availability at Farakka falls below 5,000 cu sec, the two countries will meet immediately to decide the shares. The sharing is based on the recorded average water availability in these 10-day periods from 1949-1988. The focal point of this treaty is to ensure 35,000 cu sec of water for Bangladesh in alternate 10-day periods during the least water available period (March 1 to May 10). However, the “guarantee clause” of the previous 1977 agreement in Bangladesh’s favour has not been included in the treaty.

The Ganges water-sharing treaty has finally broken the deadlock in the water sharing negotiations between the two countries and created a favourable atmosphere for agreement on sharing of the water of 53 other common rivers. The treaty is a manifestation that cooperation for mutual benefit can be attained through negotiation and strong political will of the involved parties.

*Source: IFCDB 1996*
International Water Resources Association, the International Commission on Irrigation and Drainage, the International Commission on Large Dams, the International Water Users Association, and the International Water Supply Association. The International Water Management Institute (IWMI) in Colombo has recently broadened its mandate from irrigation to water management. Two new initiatives recently undertaken are the Global Water Partnership (GWP) and the World Water Council (WWC). Launched with the support of the World Bank, UNDP, and the Swedish International Development Agency (SIDA), GWP aims to build a network for sustainable water management that brings together developing countries and external support agencies, to direct programmes in the water sector more effectively and efficiently.

The World Water Council (WWC) founded in 1996 is a water policy think tank that draws on international agencies, governments, and private groups from both developed and developing countries, to raise awareness on the need for reforms at governmental level. An important undertaking of the WWC that would spell the future of water resources development, management and policy is the establishment of the World Commission on Water for the 21st Century with the support of the FAO, UNEP, UNDP, UNESCO, WHO, WMO and the World Bank.

The main task of the Commission is to guide the development of the “World Water Vision” – the long-term vision on water, life, and environment for the 21st Century that WWC is preparing. The primary objective of the vision is to develop a widely shared concept on the future actions required for tackling water issues globally and regionally. The visioning exercise, which was started in September 1998, is ongoing with a series of studies, regional consultations, and promotions. The first interim results were discussed at the 1999 World Water Day meeting in Cairo and the August 1999 Stockholm Water Symposium. The final results were presented at the 2nd World Water Forum and Ministerial Conference which was held from March 17-22, in the Hague, The Netherlands (World Water Council 1998).

To date, various visions have been formulated at country and subregional levels in Asia and the Pacific; a selection of these is provided by Table 4.5.

### CONCLUSIONS

Growing population, urbanization and economic development are putting great pressure on the quantity and quality of the region’s freshwater, whilst massive withdrawals from rivers, lakes and underground reservoirs have led to an imbalance between supply and demand. Sectoral competition and conflicts have become critical. Due to excessive abstractions, the volume of water in some rivers and lakes has depleted while water tables in underground aquifers have sunk leading to land subsidence and salt water intrusion.

Unfortunately, the growing scarcity of water is accompanied by deteriorating water quality due to

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<table>
<thead>
<tr>
<th>Subregion</th>
<th>Water Vision</th>
<th>Main Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aral Sea</td>
<td>Formulated</td>
<td>Improvement of health; sufficiency in food supply; guaranteed security against floods and droughts; secured shelter in winter (energy from hydropower for heating); safeguard of environment; and increase of wealth from efficient water use in industries, services and agriculture.</td>
</tr>
<tr>
<td>South Asia</td>
<td>Formulated (July 1999)</td>
<td>Poverty eradication and upliftment of living conditions of people to sustainable level of comforts, health and well-being through coordinated and integrated development and management of water resources.</td>
</tr>
<tr>
<td>The Russian Federation</td>
<td>Formulated (April, 1999)</td>
<td>All encompassing approaches to address the aspects of water availability and demand in Russian Federation focusing on the conventional water world, water crisis, and sustainable water world.</td>
</tr>
<tr>
<td>PR China</td>
<td>Formulated (May 1999)</td>
<td>Conventional way with appropriate technology and institution catching up with fast economic growth of the country. Control of catastrophes and water-related multiple disasters affecting food, health and society, and sustainable way with tapping alternative water resources and self-reliant water environment.</td>
</tr>
<tr>
<td>Australia</td>
<td>Formulated</td>
<td>Equitable sharing of the water resources; efficiency in water use and re-use; sustainable water resource management; governance and integrated national policy.</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>Formulated (November 1999)</td>
<td>Safe water for life: political commitment and institutional strength to sustainably manage its water resources for efficient use and equitable access and distribution.</td>
</tr>
</tbody>
</table>

pollution and environmental degradation. Discharges of waste, sewage and effluents from domestic, industrial and agricultural sources have rendered water from many rivers, lakes and some aquifers unsuitable for human consumption. Environmental damage to aquatic ecosystem through loss of biodiversity, sedimentation and siltation have also resulted in big economic losses through loss of production and increased costs of control or remedial measures.

The main policy and management issues in the water sector in the region in recent years have been: the lack of adequate legislation including water rights or entitlements; fragmented and overlapping responsibilities in water management projects; lack of coordination in implementing water-related projects; ineffective water resource planning and management; insufficient political and public awareness; lack of public and stakeholders participation, and a general shortage of institutional capacity to meet the increasing needs in service delivery and resource management. Responses to these issues have been through both national and international actions and water policies and management measures undertaken in many countries of the region have focused on integrated and holistic approaches. Such integrated approaches have led to review or refocus of national water policies with a view to integrating the concepts and principles articulated in Agenda 21.

Common elements in the revised or new national water policies adopted include the integration of water resources development and management into national socio-economic development; assessment and monitoring of water resources; protection of water and associated resources; provision of safe drinking water supply and sanitation; conservation and sustainable use of water for food production and other economic activities; institutional and legislative development; and, undertaking measures to promote public participation. Underpinning each element are actions and programmes that have been implemented, to various degrees, by countries of the region.

The role of regional and international organizations in support of these efforts has been extremely important, particularly by providing technical and financial assistance in the conservation and efficient utilization of water, mitigating scarcity, restoring water quality and adopting appropriate policies and management approaches.

Despite the remarkable achievements of a number of transboundary groupings and individual member countries in recent years, significant challenges remain in the improvement of water resources management in the region.