CHAPTER SIX

WATER

6.1 Introduction

6.1.1 Water resources are sources of water that are useful or potentially useful to humans. Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. 97% of water on the Earth is salt water, and only 3% is fresh water of which slightly over two thirds is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is mainly found as groundwater, with only a small fraction present above ground or in the air. Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world and as the world population continues to rise, so too does the water demand.

6.1.2 India is rich in surface water resources. Average annual precipitation is nearly 4000 cubic km. and the average flow in the river system is estimated to be 1880 cubic km. Because of concentration of rains only in the three monsoon months, the utilizable quantum of water is about 690 cubic km. However, conditions vary widely from region to region. Whereas, some regions are drought affected, others are frequently flooded. In India also, with the rapid increase in the population, the demand for irrigation, human and industrial consumption of water has increased considerably, thereby causing depletion of water resources.

6.1.3 The following **table 6.1.1 indicates the projected water demand in India for different sectors.**

Table 6.1.1 Projected Water Demand in India
(By Different Use)

Sector	Water Demand in Km3 (or BCM)								
	Standing Sub-Committee of MOWR			NCIWRD					
	2010	2025	2050	2010		2025		2050	
				Low	High	Low	High	Low	High
Irrigation	688	910	1072	543	557	561	611	628	807
Drinking Water	56	73	102	42	43	55	62	90	111
Industry	12	23	63	37	37	67	67	81	81
Energy	5	15	130	18	19	31	33	63	70
Other	**52**	72	80	54	54	70	70	111	111
Total	**813**	**1093**	**1447**	**694**	**710**	**784**	**843**	**973**	**1180**

Source: Basin Planning Directorate, CWC, XI Plan Document.
Report of the Standing Sub-Committee on "Assessment of Availability & requirement of Water for Diverse uses-2000"
Note: NCIWRD: National Commission on Integrated Water Resources Development
BCM: Billion Cubic Meters

6.1.4 **The details of water availability in India is presented in table 6.1.2 which shows a reduction of 228 Cu.M in per capita availability of water in 2010 compared to 2001.**

Table 6.1.2 : WATER AVAILABILITY IN INDIA

Sl.No	Items		Quanitity
1	Annual Precipitation (including snowfall)		4000 BCM
2	Average Annual Availability		1869 BCM
3	(i) Per Capita Water Availability (2001) in cubic metres		1816Cu.M
	(ii) Per Capita Water Availability (2010) in cubic metres		1588Cu.M
4	Estimated Utilizable Water Resources		1123 BCM
	(i)Surface Water Resources	690 BCM	
	(ii) Ground Water Resources	433 BCM	

Source: Central Water Commission

6.2 Rain Water

6.2.1 India is home to an extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The nation's climate is strongly influenced by the Himalayas and the Thar Desert. The Himalayas, along with the Hindu Kush mountains in Pakistan, prevent cold Central Asian katabatic winds from blowing in, keeping the bulk of the Indian subcontinent warmer than most locations at similar latitudes. Simultaneously, the Thar Desert plays a role in attracting moisture-laden southwest summer monsoon winds that, between June and October, provide the majority of India's rainfall.

The **table 6.2.1 gives the detailed information about the monsoon performance in the Country**.

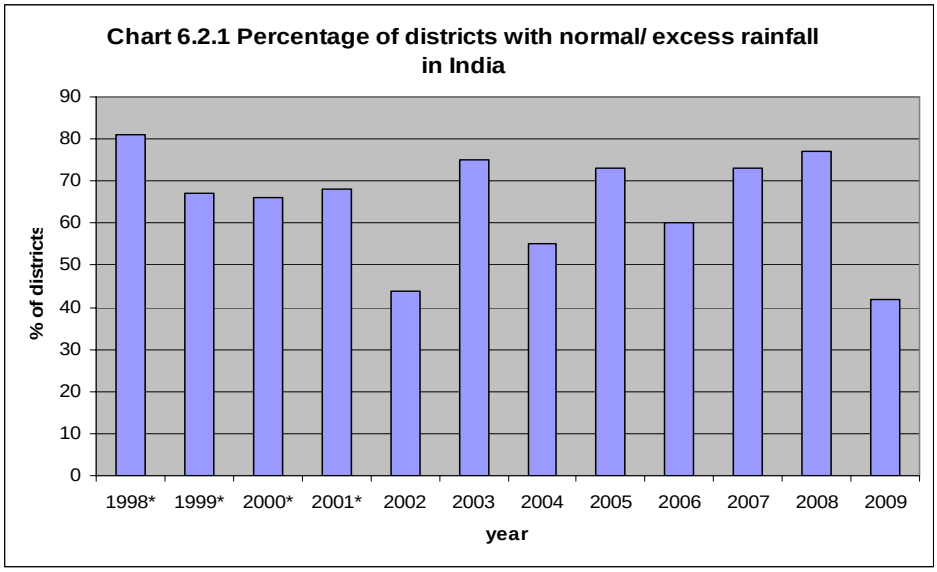
TABLE 6.2.1 MONSOON PERFORMANCE

(June-September)

Sl. No.	Year	Number of Meteorological Sub-Divisions			Percentage of Districts With Normal/Excess Rainfall	Percentage of Long Period Average Rainfall for the Country as a Whole
		Normal	Excess	Deficient/Scanty		
1	2	3	4	5	6	7
1	1998*	20	13	2	81	106
2	1999*	25	3	7	67	96
3	2000*	23	5	7	66	92
4	2001*	29	1	5	68	92
5	2002	14	1	21	44	81
6	2003	26	7	3	75	102
7	2004	23	0	13	55	87
8	2005	24	8	4	73	99
9	2006	21	6	9	60	100
10	2007	18	13	5	73	106
11	2008	31	2	3	77	98
12	2009	11	3	22	42	78

Source : India Meteorological Department

As it is evident from the diagram chart 6.2.1, the rainfall in India fluctuated considerably in the past.



6.2.2 **The record of rainfall received over the years - State/ UT wise is in table 6.2.2 at annexure 6.** A glance at the **State wise distribution of districts as per the rainfall received in table 6.2.3 annexure 6** shows, during June –September 2009, excess rain was reported only from 46 districts falling in 14 States of the Country. 171 districts reported normal rain during this period. **The list of districts with deficient/ scanty rainfall is in table 6.2.4 at annexure 6. The table 6.2.5 gives the trend of rain fall in India as per meteorological sub divisions during June –September.**

TABLE 6.2.5 : NUMBER OF METEOROLOGICAL SUB-DIVISIONS WITH EXCESS/ NORMAL AND DEFICIENT/SCANTY RAINFALL (JUNE-SEPTEMBER)

Sl. No.	Year	No. of Sub-Divisions	
		Excess/Normal	Deficient/Scanty
1	2	3	4
1	1991	27	8
2	1992	32	3
3	1993	31	4
4	1994	25	10
5	1995	33	2
6	1996	32	3
7	1997	32	3
8	1998	33	2
9	1999	28	7
10	2000	28	7
11	2001	29	6
12	2002	15	21
13	2003	33	3
14	2004	23	13
15	2005	32	4
16	2006	27	9
17	2007	31	5
18	2008	33	3
19	2009	14	22

Source : India Meteorological Department

6.2.3 Rainwater harvesting can enable households, factories, schools and offices to overcome their problems of irregular and inadequate water supply or water supply of poor quality. The process involves storing rainwater that falls within one's premises and re-using it after basic treatment. By using equipment that is easily available, rainwater is diverted towards existing underground tanks or terrace fitted tanks and then supplied to the taps. The purification methods used by households, factories and offices can be used to treat rainwater. Treated

rainwater is safe not just for cleaning and washing but also for cooking and personal consumption. The amount of rainfall notwithstanding, people living and working in various types of geographical terrains can harvest rainwater. In the long run, rainwater harvesting will replenish the India's rapidly depleting ground water levels, and lead to water security and sustainability.

6.3 Surface water -River and other Inland water sources

6.3.1 Rivers are the lifeline of majority of population in cities, towns and villages and most of these are considered as sacred. Every river stretch has a distinct water use like bathing, drinking, municipal supply, navigation, irrigation and fishing, sports, etc. **The annual Water availability in major rivers in India is depicted in Table 6.3.1.**

Table 6.3.1: WATER AVAILABILITY-BASINWISE

Sl.No	Name of the River Basin	Average Annual Availability (cubic km/year)
1	Indus (up to Border)	73.31
2	a) Ganga	525.02
	b) Brahmaputra, Barak & Others	585.6
3	Godavari	110.54
4	Krishna	78.12
5	Cauvery	21.36
6	Pennar	6.32
7	East Flowing Rivers Between Mahanandi & Pennar	22.52
8	East Flowing Rivers Between Pennar and Kanyakumari	16.46
9	Mahanadi	66.88
10	Brahmani & Baitarni	28.48
11	Subernarekha	12.37
12	Sabarmati	3.81
13	Mahi	11.02
14	West Flowing Rivers of Kutch, Sabarmati including Luni	15.1
15	Narmada	45.64
16	Tapi	14.88
17	West Flowing Rivers from Tapi to Tadri	87.41
18	West Flowing Rivers from Tadri to Kanyakumari	113.53
19	Area of Inland drainage in Rajasthan desert	Negligible
20	Minor River Basins Draining into Bangladesh & Burma	31
	Total	1869.35

Source: Ministry of Water Resources

6.3.2 In India, the total length of all the major rivers is 195210 km and the combined area of all other water bodies is 73.59 lakh hectares.

The State wise details of Inland Water resources of various types is presented in Table 6.3.2 at annexure 6. The table 6.3.3 shows the catchment area of major river basins.

TABLE 6.3.3 : CATCHMENT AREA OF MAJOR RIVER BASINS

Name of the River	Origin	Length (Km.)	Catchment Area (Sq. Km.)
Indus	Mansarovar (Tibet)	1114 (2880)	321289 (1165500)
a) Ganga	Gangotri (Uttaranchal)	2525	861452 (1186000)
b) Brahmaputra	Kailash Range (Tibet)	916 (2900)	194413 (580000)
c) Barak & other rivers flowing into Meghna like Gomti, Muhari, Fenny etc.	Manipur Hills (Manipur)		41723
Sabarmati	Aravalli Hills (Rajasthan)	371	21674
Mahi	Dhar (Madhya Pradesh)	583	34842
Narmada	Amarkantak (Madhya Pradesh)	1312	98796
Tapi	Betul (Madhya Pradesh)	724	65145
Brahmani	Ranchi (Bihar)	799	39033
Mahanadi	Nazri Town (Madhya Pradesh)	851	141589
Godavari	Nasik (Maharashtra)	1465	312812
Krishna	Mahabaleshwar (Maharashtra)	1401	258948
Pennar	Kolar (Karnataka)	597	55213
Cauvery	Coorg (Karnataka)	800	81155
		Total	2528084

Source : Central Water Commission

Note : Figures within bracket indicate the total river basin in india and neighbouring countries.

6.3.3 The details including catchment area, average water resources potential, utilizable surface water resources in major river basins of India are exhibited in Table 6.3.4.

TABLE 6.3.4: WATER RESOURCES POTENTIAL IN RIVER BASINS OF INDIA

(Unit :BCM)	River Basin	Catchment Area (Sq. Km.)	Average Water Resources Potential	Utilisable Surface Water Resources
1	Indus (Up to Border)	321289	73.31	46.0
2	a) Ganga	861452	525.02	250.0
	b) Brahmaputra	194413	537.24	24.0
	c) Barak & Others	41723	48.36	
3	Godavari	312812	110.54	76.3
4	Krishna	258948	78.12	58.0
5	Cauvery	81155	21.36	19.0
6	Subernarekha*	29196	12.37	6.8
7	Brahamani & Baitarni	51822	28.48	18.3
8	Mahanadi	141589	66.88	50.0
9	Pennar	55213	6.32	6.9
10	Mahi	34842	11.02	3.1
11	Sabarmati	21674	3.81	1.9
12	Narmada	98796	45.64	34.5
13	Tapi	65145	14.88	14.5
14	West Flowing Rivers From Tapi to Tadri	55940	87.41	11.9
15	West Flowing Rivers From Tadri to Kanyakumari	56177	113.53	24.3
16	East Flowing Rivers between Mahanadi & Pennar	86643	22.52	13.1
17	East Flowing Rivers between Pennar & Kanyakumari	100139	16.46	16.5
18	West Flowing Rivers of Kutch and Saurashtra including Luni	321851	15.10	15.0
19	Area of Inland drainage in Rajasthan	-	Negl	NA
20	Minor River Draining into Myanmar (Burma) & Bangladesh	36202	31.00	NA
			1869.35	690.1

Source: B.P. Directorate, Central Water Commission

Note *: Combining Subernarekha and other small rivers between Subernarekha and Baitarni.

The water flow in some of the important streams of the Country can be viewed in table 6.3.5 annexure 6.

6.3.4 In hydrology, discharge is the volume rate of water flow, including any suspended solids dissolved chemical species and/or biologic material which is transported through a given cross-sectional area. **The water discharge, sediment load, water discharge in monsoon & non –monsoon period in major river basins of India is presented in table 6.3.6, table 6.3.7 and table 6.3.8 at annexure 6.**

6.3.5 **Water ways are also an important mode of transport in India. The details of navigable water ways in India can be viewed in table 6.3.9 at annexure 6.**

6.4 Ground water

6.4.1 **Groundwater** is water that is found underground in the cracks and spaces in soil, sand and rock. Groundwater is stored in and moves slowly through layers of soil, sand and rocks called aquifers. Groundwater comes from rain, snow, sleet, and hail that soaks into the ground. The water moves down into the ground because of gravity, passing between particles of soil, sand, gravel, or rock until it reaches a depth where the ground is filled, or saturated, with water. The area that is filled with water is called the saturated zone and the top of this zone is called the water table. The water table may be very near the ground's surface or it may be hundreds of feet below.

6.4.2 The ground water availability estimates in various States/ UTs of India and Ground water resources and Ground water resource potential as per river basin are exhibited in Tables 6.4.1 & 6.4.2 at annexure 6.

6.4.3 The net annual ground water availability is 92.2% of the Annual replenishable ground water. The annual ground water usage for irrigation is 53.22% of the net annual ground water availability. However, not all the water abstracted is effectively used. There are sizeable losses in conveyance and application of irrigated water. A large part of water used by industry and domestic purposes is returned to the streams as effluent waste; and most of the water drawn by power station is used for cooling purposes and is available for reuse.

6.4.4 The main preoccupation of water resources development in the country is the extension and improvement of irrigation and hydel power generation. Water requirements for industrial and domestic use are met partly from reservoirs constructed and managed by the irrigation department. The agriculture production technologies have put a lot of stress on underground water resources.

6.5 Water quality

6.5.1 Simultaneously, rivers are also used as receptacle for discharge of industrial effluent, municipal sewage and dumping of solid wastes. The Water (Prevention and Control of Pollution) Act, 1974 is aimed to support the quality of various designated best uses of water bodies.

6.5.2 The Primary water quality criteria are as per the details given below.

Table 6.5.1: PRIMARY WATER QUALITY CRITERIA

Sl. No.	Designated Best Use	Class of Water	Criteria	
1	2	3		4
1	Drinking Water Source without Conventional Treatment but after Disinfection	A	1	Total Coliforms Organised MPN/100ml
				shall be 50 or less
			2	pH between 6.5 & 8.5
			3	Dissolved Oxygen 6mg/l or more
			4	Biochemical Oxygen Demand 5 days
				20°C 2mg/l or less.
2	Outdoor bathing (organised)	B	1	Total Coliforms Organism MPN/100ml
				shall be 500 or less
			2	pH between 6.5 & 8.5
			3	Dissolved Oxygen 5mg/l or more
			4	Biochemical Oxygen demand 5 days
				20°C 3mg/l or less.
3	Drinking Water Source after conventional treatment and disinfection	C	1	Total Coliforms Organism MPN/100ml
				shall be 5000 or less
			2	pH between 6 & 9
			3	Dissolved Oxygen 4mg/l or more
			4	Biochemical Oxygen demand 5 days
				20°C 3mg/l or less.
4	Propagation of Wild Life and Fisheries	D	1	pH between 6.5 & 8.5 Fisheries
			2	Dissolved Oxygen 4mg/l or more
			3	Free Ammonia (as N) 1.2 mg/l or less
5	Irrigation, Industrial Cooling, Controlled Waste disposal	E	1	pH between 6.0 to 8.5
			2	Electrical conductivity at 25°C
				Micro mhos/cm Max 2250.
			3	Sodium Absorption Ratio, Max 26
			4	Boron, Max 2mg/l

The water quality at any location is determined as the one which is satisfied at least 80% of time by all the criteria parameters. To further elucidate on this if at a location, 80% of the time Dissolved Oxygen, pH were in the range specified for class A, BOD for class B and total coliforms for class C, then the existing status is determined as C.

6.5.2 **The Biological water quality criteria is shown in table 6.5.2.**

TABLE 6.5.2: BIOLOGICAL WATER QUALITY CRITERIA (BWQC)

Sl. No.	Taxonomic Groups	Range of Saprobic Score (BMWP)	Range of Diversity Score	Water Quality Characteristics	Water Quality Class	Indicator Colour
1	**2**	**3**	**4**	**5**	**6**	**7**
1	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Diptera	7 and more	0.2 - 1	Clean	A	Blue
2	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Planaria, Odonata, Diptera	6 - 7	0.5 - 1	Slight Pollution	B	Light Blue
3	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Odonata, Crustacea, Mollusca, Polychaeta, Coleoptera, Diptera, Hirudinea, Oligochaeta	3 - 6	0.3 - 0.9	Moderate Pollution	C	Green
4	Hemiptera, Mollusca, Coleoptera, Diptera, Oligochaeta	2 - 5	0.4 & less	Heavy Pollution	D	Orange
5	Diptera, Oligochaeta, No Animal	0 - 2	0 - 0.2	Severe Pollution	E	Red

Source : Central Pollution Control Board

6.5.3 The Water Quality Atlas of the Indian River System has been prepared by CPCB on the basis of five major uses of the river water such as:

(a) Drinking water source without conventional treatment but after disinfection;
(b) Outdoor bathing organized;
(c) Drinking water source but with conventional treatment followed by disinfection;
(d) Propagation of wildlife, fisheries;
(e) Irrigation, industrial cooling, controlled waste disposal.

6.5.4 For maintaining the quality of river water, the pollution levels in rivers have been detected by monitoring limited number of the physico-chemical parameters, which could only determine the changes in chemical characteristics of water bodies. Deterioration in water quality, over the past several years has gradually rendered the river water quality unsuitable for various beneficial purposes. The Physico – chemical and biological water quality of polluted stretch of river Yamuna and Agra canal is given below.

TABLE 6.5.3 : PHYSICO - CHEMICAL AND BIOLOGICAL WATER QUALITY OF POLLUTED STRETCH OF RIVER YAMUNA AND AGRA CANAL

Sl. No.	Location	Water Quality Class		Water Quality (Biological)
		Physico - Chemical (PWQC)	Biological (BWQC)	
1	2	3	4	5
1.	Okhla Barrage (River Yamuna)	E	E	Severe Pollution
2.	Inlet of BTPP at Agra Canal	E	E	Severe Pollution
3.	Mixing of BTPP outlet at Agra Canal	E	E	Severe Pollution

Source : Central Pollution Control Board
BTPP : Badarpur Thermal Power Plant

6.5.6 **National Water Quality Monitoring Programme:** The Central Pollution Control Board in collaboration with State Pollution Control Board is operating the Water Quality Monitoring Network comprising of 1429 stations in 27 States and 6 Union Territories spread over the country for monitoring of aquatic resources. The monitoring is undertaken on monthly/quarterly basis in surface water and half yearly basis in cases of groundwater. The monitoring network covers 293 rivers, 94 lakes, 9 tanks, 41ponds, 15 creeks/sea water, 23 canals, 18 drains and 411 groundwater wells. This is done through three major schemes 1) Global Environmental Monitoring System (GEMS)- 2) Monitoring of Indian National Aquatic Resources (MINARS) - and 3) Yamuna Action Plan (YAP)

6.5.6 **The tables 6.5.4 a, 6. 5.4 b and 6.5.5 at annexure 6 present the water quality in major Indian rivers and selected major river basins. Table 6.5.6 at annexure 6 presents the river basin wise distribution of water quality monitoring centres.**

State-wise river quality is summarised as follows:

- It was observed that the average Dissolved Oxygen values are well within limit except Delhi in river Yamuna. The minimum value of dissolved oxygen also indicates that there are some stations in some states have lower value zero.
- It is observed that average pH in Indian rivers seems to be alkaline except Kerala and Meghalaya
- With respect to conductivity the average value reveals that most of the States have conductivity suitable for irrigation as well as water consumption. Higher values in Gujarat, West Bengal and Orissa are due to reflection of stations located in estuarine conditions.
- With respect to BOD except Delhi, Haryana, Punjab, Maharashtra and Uttar Pradesh values are well within the limit.
- With respect to fecal coliform it is observed that States like Delhi, Gujarat, Haryana, Punjab, Uttar Pradesh and West Bengal have high average value.

6.6 Water Pollution –causes

6.6.1 The types and sources of water contamination include "point" sources of pollution which usually refers to wastes being discharged from a pipe; and "non point" sources, which means all other sources such as storm water runoff (which picks up oils and other contaminants from various areas), irrigation (which carries fertilizers and pesticides into groundwater), leaks from storage tanks and leakage from disposal sites. The non-point sources are technically the most difficult to regulate in India.

6.6.2 Water pollution comes from three main sources: domestic sewage, industrial effluents and run-off from activities such as agriculture. Major industrial sources of pollution in India include the fertilizer plants, refineries, pulp and paper mills, leather tanneries, metal plating and other chemical industries. The problem of water pollution due to industries is because of the inadequate measures adopted for effluent treatment than to the intensity of industrial activities. The 13 major water polluting industries have been identified and are closely monitored by the Central Pollution Control Board. **A status report of the waste water generation, collection and treatment in metro cities is available in table 6.6.1 at annexure 6.**

6.6.3 An uncontrolled disposal of urban waste into water bodies, open dumps and poorly designed landfills, causes contamination of surface water and ground water. For industries, surface water is the main source for drawing water and discharging effluents. Industrial wastes containing heavy metals such as mercury, chromium, lead and arsenic can threaten or destroy marine life besides polluting aquatic food resources.

6.6.4 Water pollution from domestic and human wastewater is severely harmful for humans too. The most common contamination in the water is from the disease bearing

human wastes, which is usually detected by measuring fecal coliform levels. In some parts of the Country, the ground water is also found to be polluted. **As elaborated in table 6.6.2 at annexure 6, the occurrence of Arsenic in ground water has been reported from a number of Districts in various States.**

6.6.4 The diseases commonly caused due to contaminated water are diarrhea, trachoma, intestinal worms, hepatitis, etc. It is clearly evident that more stringent preventive and protective measures are required to tackle the impact of water pollution.

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