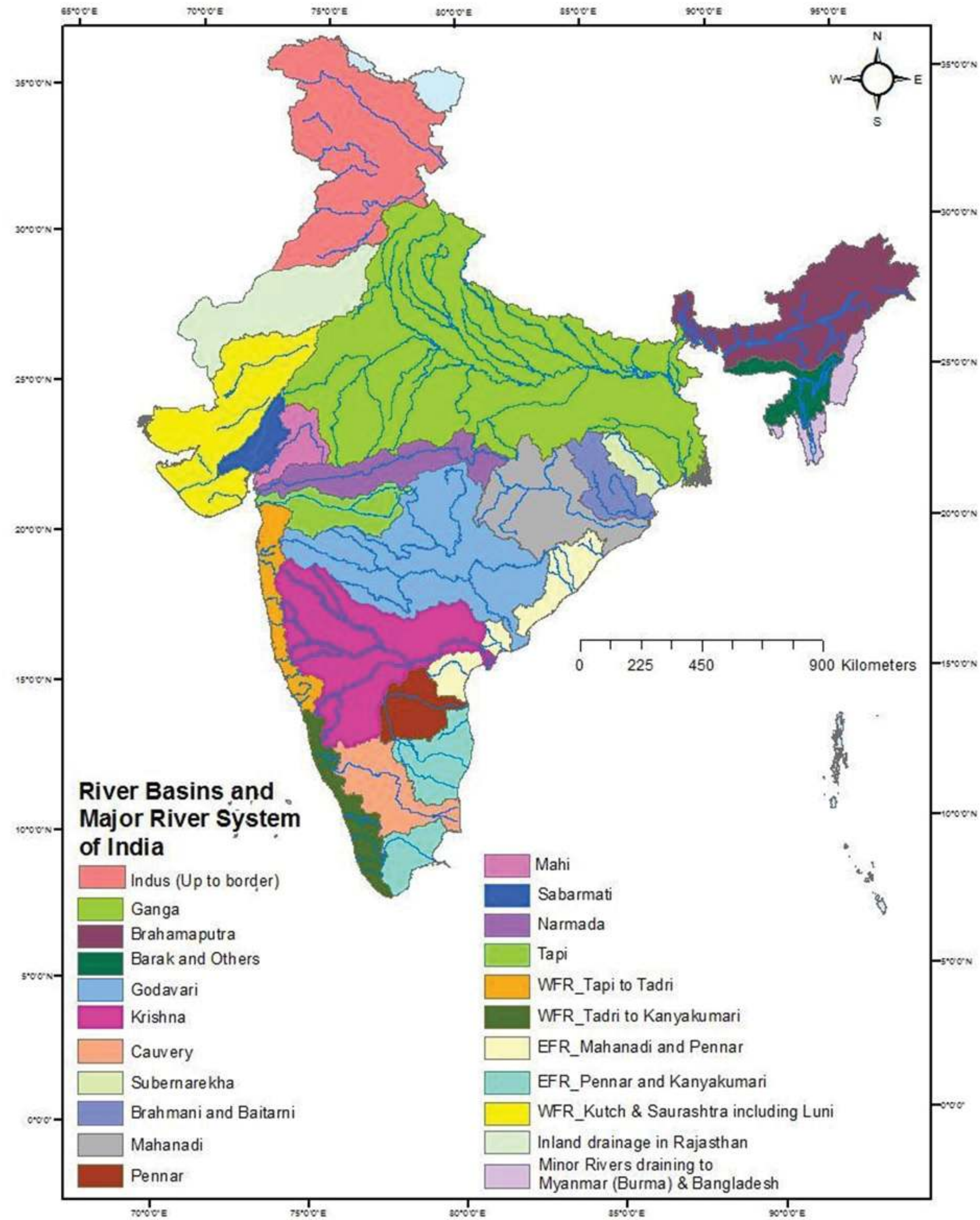
WATER - THE NECTAR OF LIFE

When the well is dry, we will know the worth of water
- Benjamin Franklin

River Basins and Major River Systems of India



CHAPTER 3

WATER-THE NECTAR OF LIFE

Introduction

Water, the magical substance from which all life springs forth, is essential to the very existence of every life form on earth. The role of water for the living organisms has not changed since life's first creation in water billions of years ago. It is, therefore, quite aptly referred to as the "nectar of life". The earth has an abundance of water, but unfortunately, only a small percentage (about 0.3 percent), is even usable by humans. The other 99.7 percent is in the oceans, soils, icecaps, and floating in the atmosphere. Still, much of the 0.3 percent that is useable is unattainable. Most of the water used by humans comes from rivers. The visible bodies of water are referred to as surface water. The majority of fresh water is actually found underground as soil moisture and in aquifers. Groundwater can feed the streams, which is why a river can keep flowing even when there has been no precipitation.

Physiography of India

With a geographical area of about 329 Million Hectare (M. ha) and annual precipitation of 4000 Billion Cubic Metres (BCM), India is a land of many mountains and rivers, with some being the mightiest rivers of the world. India may be divided into seven well defined regions on the basis of its river systems. These are:

i. The Northern Mountains comprising the mighty Himalayan ranges;
ii. The Great Plains traversed by the Indus, Ganga and Brahmaputra river systems;
iii. The Central Highlands, consisting of a wide belt of hills running east-west between the Great Plains and the Deccan plateau;
iv. The Peninsular Plateaus;
v. The East Coast, a belt of land of about 100-130 km wide, bordering the Bay of Bengal;
vi. The West Coast, a narrow belt of land of about 10-25 km wide, bordering the Arabian Sea; and
vii. The islands, comprising the coral islands of Lakshadweep in Arabian Sea and Andaman and Nicobar group of islands in the Bay of Bengal.

India has a great diversity and variety of climate which in turn affects the water resources and their utilization. Climate is influenced by the Himalayas in the north and the Indian Ocean in the south. India has rich surface water resources. However, there is a marked variation in the concentration of rains in the three predominant monsoon months across regions making them either drought prone or frequently flooded.

Supply-Side: Water Resources in India

Inland Water Resources

Inland water resources include both fresh and brackish water bodies. While freshwater is naturally occurring water with low concentration of salt, brackish water has a salt concentration varying between that of freshwater and marine water[1]. Inland Water Resources of the country are categorized as: rivers and canals; reservoirs; tanks, lakes & ponds; lakes and derelict water bodies; and brackish water[2].

In India, rivers and canals run throughout the country with total length amounting to 1.9 lakh kilometres and the total water bodies other than rivers and canal cover an area of around 7.31 Million Hectare (M. ha). The area of water bodies at an all-India level is given in **Table 3.1**.

Table 3.1: Inland Water Resources of India[3]

Rivers & Canals (length in km)	**195095**
Other Water Bodies (area in M. ha)	
Reservoirs	**2.93**
Tanks & Ponds	**2.43**
Flood Plain Lakes & Derelict Water bodies	**0.80**
Brackish Water	**1.15**
Total	**7.31**

The state-wise inland water resources are given at **Annexure 3.1**. As can be seen from the Annexure 3.1, Uttar Pradesh and Jammu & Kashmir have the longest length of rivers and canals of 28,500 kilometres and 27,781 kilometres respectively. The inland water resources are unevenly distributed across the states, with the expanse ranging from 9.89 lakh hectares in Odisha and 8.11 lakh hectares in Andhra Pradesh (including Telangana) to negligible amounts in the smaller States of Mizoram, Sikkim and Puducherry.

River basin is the most important unit of analysis for any water-related study. River basin, also called catchment area of the river, is the area from which the rain will flow into that particular river. India can be divided into 20 river basins. Central Water Commission (CWC) has the responsibility of planning, development and management of surface water resources of the country. **Table 3.2** depicts the river-basin wise catchment

[1] The System of Environmental-Economic Accounting: Central Framework (SEEA-CF),2012, United Nations Statistics Division
[2] Water and Related Statistics, CWC, 2015
[3] Annual Report 2016-17, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare

area, average water resources potential river-basin wise according to the Reassessment studies conducted by CWC. The total water resource potential, which occurs as a natural runoff in these rivers, is estimated to be about 1869 BCM. Water availability is highest in Brahmaputra basin (537.24 BCM) followed by Ganga Basin (525.02 BCM).

Table 3.2: River Basin Water Availability[2]

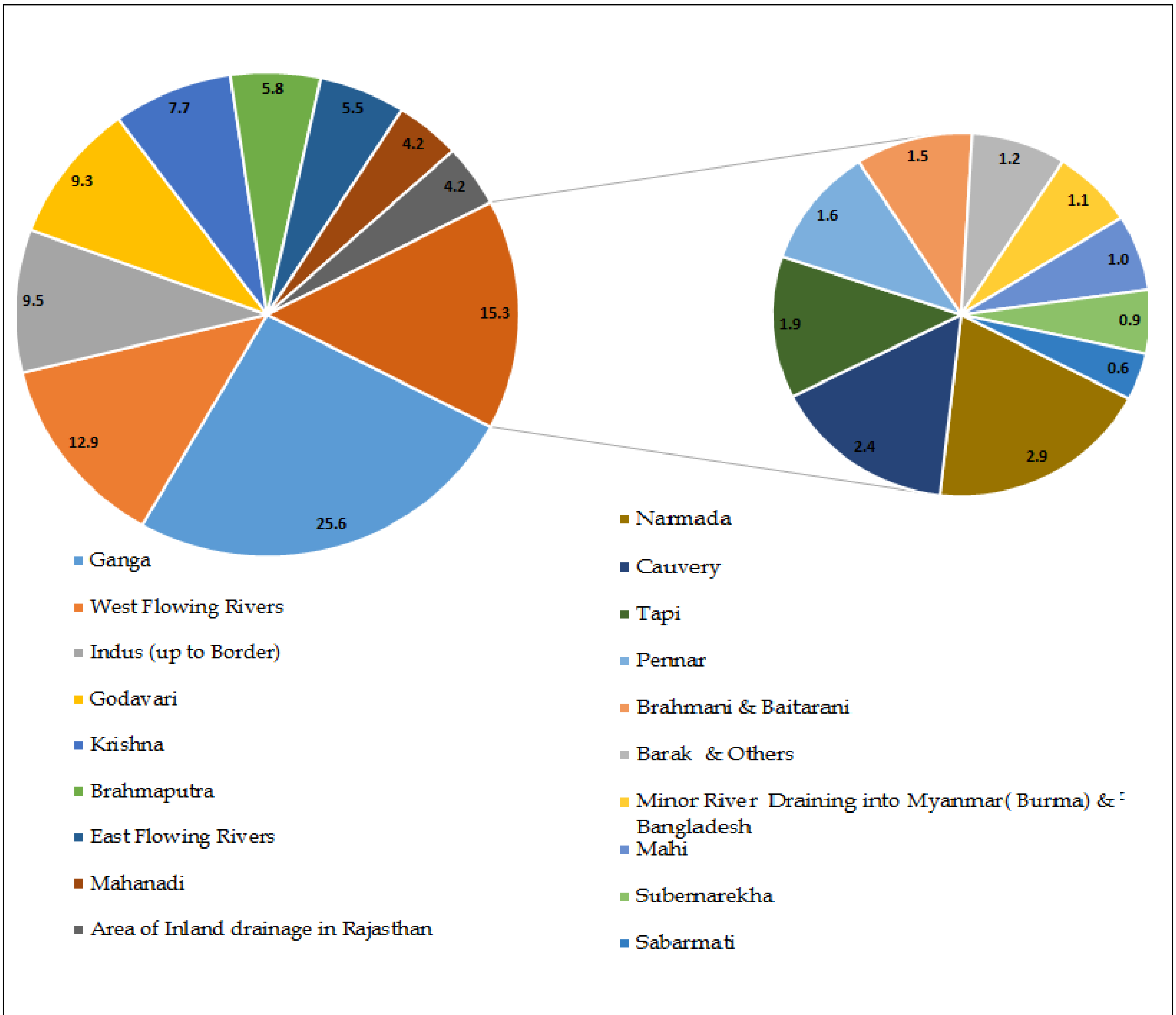
S. No.	Basin	Catchment Area[4] (sq.km)	Average Water Resource Potential (BCM)	Utilisable Surface Water Resources (BCM)
1)	Indus (up to Border)	3,21,289	73.31	46
2)	Ganga- Brahmaputra- Meghna			
	a) Ganga	8,61,452	525.02	250
	b) Brahmaputra	1,94,413	537.24	24
	c) Barak & Others	41,723	48.36	
3)	Godavari	3,12,812	110.54	76.3
4)	Krishna	2,58,948	78.12	58
5)	Cauvery	81,155	21.36	19
6)	Subarnarekha*	29,196	12.37	6.8
7)	Brahmani-Baitarani	51,822	28.48	18.3
8)	Mahanadi	1,41,589	66.88	50
9)	Pennar	55,213	6.32	6.9
10)	Mahi	34,842	11.02	3.1
11)	Sabarmati	21,674	3.81	1.9
12)	Narmada	98,796	45.64	34.5
13)	Tapi	65,145	14.88	14.5
14)	West Flowing Rivers from Tapi to Tadri	55,940	87.41	11.9
15)	West Flowing Rivers from Tadri to Kanyakumari	56,177	113.53	24.3
16)	East Flowing Rivers between Mahanadi and Pennar	86,643	22.52	13.1
17)	East Flowing Rivers between Pennar and Kanyakumari	1,00,139	16.46	16.5
18)	West Flowing Rivers of Kutch & Saurashtra including Luni	3,21,851	15.1	15
19)	Area of inland drainage in Rajasthan	1,39,917.04	Negligible	-
20)	Minor rivers draining into Myanmar (Burma) and Bangladesh	36,202	31	-
Total			**1869.37**	**690.1**

Note: *: Combining Subarnarekha and other small rivers between Subarnarekha and Baitarani

The largest river basin is that of Ganga-Brahmaputra-Meghna with a catchment area of about 11 lakh sq. km and annual water resource potential of 1111 BCM out of total 1869 BCM in the country. But the proportion of utilisable surface water to average water resources potential is found to be least in Brahmaputra sub-basin. State-wise drainage area for various river basins are given in **Annexure 3.2**.

The proportion of geographical area in the river basins is shown in **Figure 3.1**, where it can be seen that of the individual river basins, the Ganga basin accounts for about 25.6% of the country's area followed by the Indus and Godavari with a share of 9.5% and 9.3% respectively.

Figure 3.1: Percentage of geographical area in basin[4]



[4] River Basin Atlas of India, 2012, http://www.india-wris.nrsc.gov.in/wrpinfo/index.php?title=WRIS_Publications

Ground Water

Groundwater is defined as the water that collects in porous layers of underground formations known as aquifers. An aquifer is a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. Groundwater arises from rain, snow, sleet and hail that soak into the ground.

The assessment of presence of ground water as well as the potential is complicated in India, based on the occurrence of the diversified geological formations with considerable lithological and chronological variations, complex tectonic framework, climatological dissimilarities and various hydro chemical conditions. Hydrogeological units in India along with the type of aquifer and their ground water potential are given in **Table 3.3**.

Table 3.3: Aquifer System in the Country[5]

System	Coverage	Ground water potential
Unconsolidated formations -alluvial	Indo-Gangetic, Brahmaputra plains	Enormous reserves down to 600 m depth. High rain fall and hence recharge is ensured. Can support large-scale development through deep tube wells.
	Coastal Areas	Reasonably extensive aquifers but risk of saline water intrusion
	Part of Desert area – Rajasthan and Gujarat	Scanty rainfall. Negligible recharge. Salinity hazards. Ground water Availability at great depths.
Consolidated/semi-consolidated formations - sedimentaries, basalts and crystalline rocks	Peninsular Areas	Availability depends on secondary porosity developed due to weathering, fracturing etc. Scope for GW availability at shallow depths (20- 40 m) in some areas and deeper depths (100- 200 m) in other areas. Varying yields.
Hilly	Hilly states	Low storage capacity due to quick runoff

[5] Ground Water Year Book- India 2016-17, Central Ground Water Board, Ministry of Water Resources

The Central Ground Water Board (CGWB) has the mandate to make an assessment of groundwater. CGWB undertakes the measurement of groundwater four times in a year during January, pre-Monsoon, August and post-Monsoon through a network of wells drilled throughout the country. The pre-monsoon water level data is collected from all the monitoring stations during the months of March/ April/ May, depending on the climatological conditions of the region. For North-Eastern states, pre-monsoon data is collected during March, since the onset of monsoon is normally observed in April. Similarly, for Odisha, West Bengal and Kerala where monsoon appears early in May the monitoring is carried out during the month of April. For remaining states, pre-monsoon monitoring month is May. Water levels during August are monitored to access the impact of monsoon on the ground water resources. Post monsoon data collected during November reflects the cumulative effect of ground water recharge and withdrawal of ground water for various purposes. January water level data indicates the effect of withdrawal for rabi crops.

For assessment of ground water, Central Ground Water Board (CGWB) has drilled various types of bore wells in the country, forming a basis for planning the development and management of ground water resources. As on March 31, 2016, 18226 Exploratory Wells (EW), 7075 Observation Wells (OW), 5151 Piezometers (PZ), 3635 Deposit Wells (DW) and 364 Slim Hole (SH) (a total of 34451 Wells in all) have been constructed to assess the ground water potential in different hydrogeological settings. It has been estimated by CGWB that as on March 2013, the annual replenishable ground water is around 447 BCM[5].

Water availability

In India, industrialisation and urbanisation have not yet reached the peak levels considering ever increasing demands of the growing population. This translates to a mounting pressure on the freshwater in the country. The water resources are being increasingly stressed not only by over-abstraction, but also by pollution and climate change. So, the prospects arising from improved water management, both in terms of quality and quantity is indispensable in the context of Indian economy. However, the per capita availability of water has been estimated to decrease over the decades in India, as shown in **Table 3.4.**

Table 3.4: Per Capita Water Availability in India[6]

Year	Population (Million)	Per capita water availability (m^3/year)	Remarks
1951	361	5178	
1955	395	4732	
1991	846	2210	
2001	1027	1820	
2011	1211	1544	water stressed
2015	1326*	1441[$]	water stressed
2021	1345[a]	1421[$]	water stressed
2031	1463[a]	1306[$]	water stressed
2041	1560[a]	1225[$]	water stressed
2051	1628[a]	1174[$]	water stressed

*projected from 2011 census

Note:

a: Population figures for 2021 to 2051 are taken from projected population by Planning Commission available at http://planningcommission.nic.in/aboutus/committee/ strgrp/ stgp_fmlywel/sgfw_ch2.pdf

$: The per capita availability from 2015 onwards has been calculated from 2017 WRA estimate.

As per Falkenmark Water Stress Indicator, a per capita availability of less than 1700 cubic metres (m^3) is termed as a water-stressed condition, while if per capita availability falls below 1000 m^3, it is termed as a water scarcity condition. India is currently facing water stressed situation and is moving towards the water scarcity situation since the gap between water demand and water supply is gradually getting widened highlighting the dire need to manage water resources for a sustainable future.

Analysing the per-capita availability across the river basins of the country as given in **Annexure 3.3**, it is observed that Krishna, Cauvery, Subarnarekha, Pennar, Mahi, Sabarmati, Tapi, East Flowing Rivers and West Flowing Rivers of Kutch and Saurashtra including Luni are some of the basins, fall into the category of "water scarce"- out of which the scarcity can be said to be acute in Cauvery, Pennar, Sabarmati, East Flowing rivers and West Flowing Rivers of Kutch and Saurashtra including Luni with a per capita availability of water less than or around 500 m^3.

Demand-Side: Uses

The demand for freshwater for various purposes has been increasing and have been assessed by National Commission on Integrated Water Resources Development

[6] Government of India, 2009 (NCIWRD Report, 1999)

(NCIWRD) in 2000. This assessment is based on the assumption that the irrigation efficiency will increase to 60%. The demand for water by various uses is given in **Table 3.5**.

Table 3.5: Projected Water Demand in India (By Different Use)[7]

Sector	Water Demand in Km^3 (or BCM)								
	Standing Sub-Committee of MoWR, RD & GR			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**

As can be observed, irrigation is the key demand sector for water. Therefore, any water management policy has to incorporate the various aspects related to irrigation, including the irrigation potential of the country and the type of irrigation facilities to be put in place. The total Ultimate Irrigation Potential (UIP) in India is around 140 million hectares[2]. Efforts have been made in the different Five-Year Plans to attain this potential through Irrigation projects, which are generally classified in the Indian context as under:

- **Major project:** This type of project consists of huge surface water, storage reservoirs and flow diversion structures. The area envisaged to be covered under irrigation is of the order over 10000 hectares. These projects are generally planned for multiple purposes like irrigation, hydro-power generation, water supply for drinking and industrial purpose, flood control navigation etc.
- **Medium project:** These are also surface water projects but with medium size storage and diversion structures with the area under irrigation between 10000 hectares and 2000 hectares.
- **Minor project:** The area proposed under irrigation for these schemes is below 2000Ha and the source of water is either ground water or from wells or tube wells

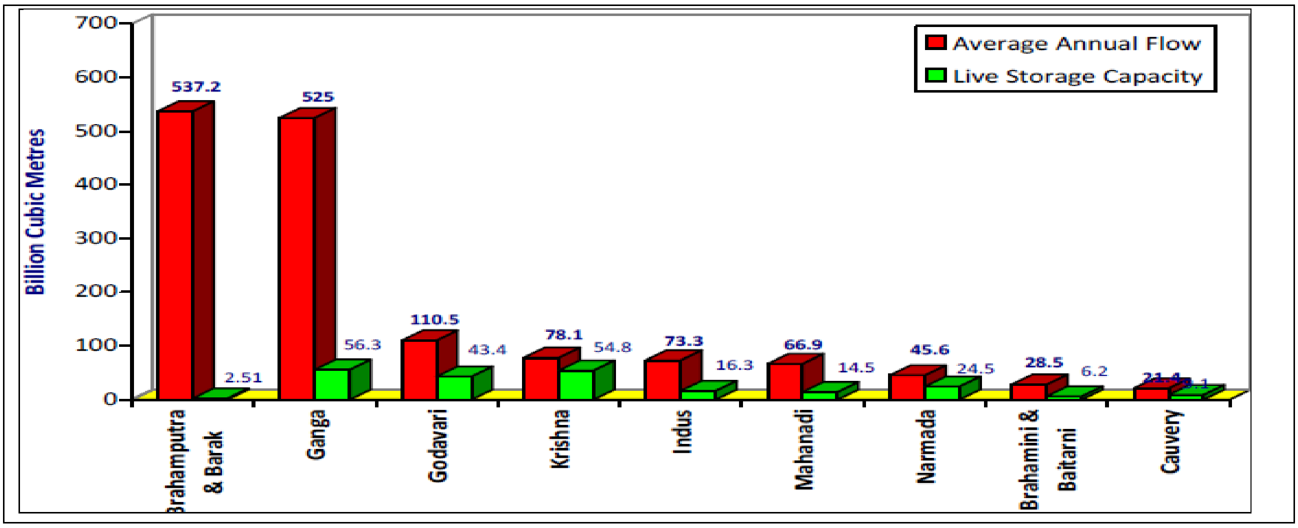
[7] Basin Planning Directorate, CWC, XI Plan Document; Report of the Standing Sub-Committee on "Assessment of Availability & requirement of Water for Diverse uses-2000"

or surface water lifted by pumps or by gravity flow from tanks. It could also be irrigated from through water from tanks.

It has been estimated that UIP for Minor Irrigation projects is 81.4 million hectares while that for Major & Medium Irrigation is 58.5 million hectares. Ground Water contributes more than 78% of the total ultimate potential through minor irrigation. State-wise details of ultimate irrigation potential are given at **Annexure 3.4,** while the State-wise information on Irrigation Potential created and utilised under Major, Medium and Minor Irrigation projects are given at **Annexure 3.5**.

In order to monitor the availability of water for irrigation and other uses, CWC keeps track of the storage in a set of major reservoirs in the country. Till 2015, a storage capacity had been created of about 253.4 BCM in the country under major and medium irrigation projects and an additional capacity of 51 BCM is likely to be created by the ongoing projects. So in totality, 304.4 BCM will be available storage once the projects are completed against the total availability in the river basin of 1869 BCM in the country[2]. Maximum storages are in Ganga basin followed by Krishna, Godavari and Narmada (**Figure 3.2, Annexure 3.6**).

Figure 3.2: Basin wise Flow & Storage Potential in India[2]



The Flows and Status: Precipitation and Groundwater Levels

Rainfall in India is dependent on the South-West and North-East monsoons, on shallow cyclonic depressions and disturbances and on violent local storms which forms in regions where cool humid winds from the sea meet hot dry winds from the land and occasionally reach cyclonic dimension. Rainfall is a major source of water in the country with estimated annual precipitation including snowfall of around 4000 BCM.

Table 3.6: South-West Monsoon and Annual Rainfall along with departure - India[8]

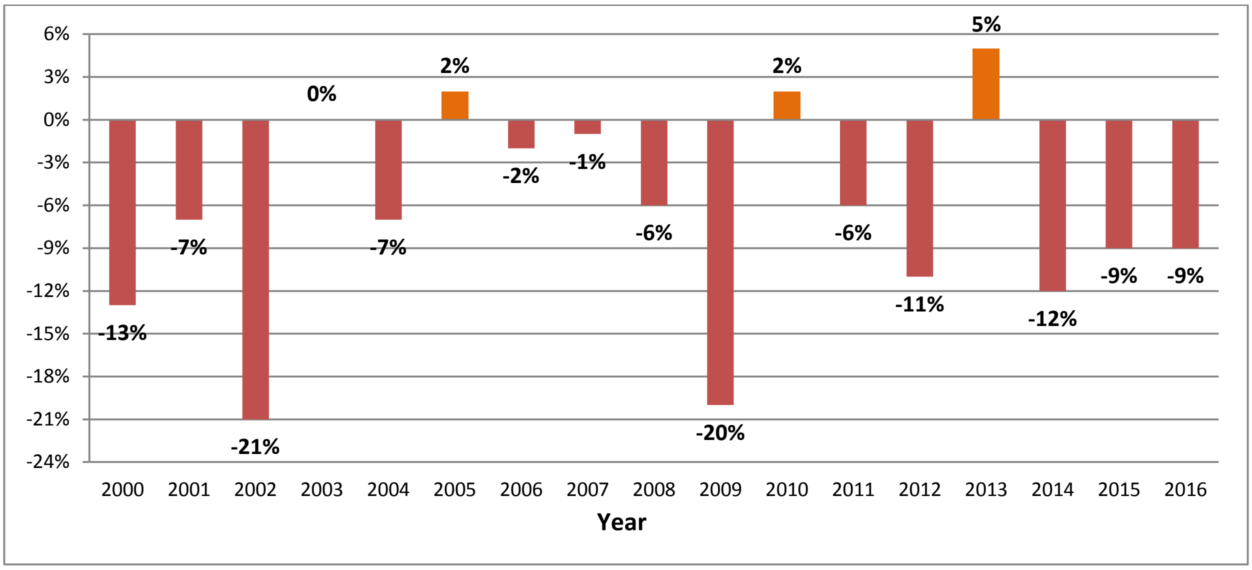
Year	SW-Monsoon Rainfall (mm)		Annual Rainfall (mm)	
	Rainfall	% Departure	Rainfall	% Departure
2000	798.1	-10%	1035.4	-13%
2001	818.8	-8%	1100.7	-7%
2002	700.5	-21%	935.9	-21%
2003	902.9	2%	1187.3	0%
2004	807.1	-9%	1106.5	-7%
2005	874.3	-1%	1208.3	2%
2006	889.3	0%	1161.6	-2%
2007	943	6%	1179.3	-1%
2008	877.8	-1%	1118	-6%
2009	698.3	-21%	953.7	-20%
2010	911.1	3%	1215.5	2%
2011	901.3	2%	1116.3	-6%
2012	823.9	-7%	1054.7	-11%
2013	937.4	6%	1242.6	5%
2014	781.7	-12%	1044.7	-12%
2015	765.8	-14%	1085	-9%
2016	864.4	-3%	1083.2	-9%

South-West and Annual rainfall of India for the period from 2000 to 2016 has been shown in **Table 3.6** along with their departures from the normal rainfall. As can be seen, most of the monsoon in India is under the influence of South-West monsoon from June to September. State-wise annual rainfall for the past five years has been given in **Annexure 3.7** from where it can be seen that on an average Meghalaya has received the highest rainfall of around 3179.74 mm of annual rainfall over the period of 2012 to 2016 followed by Goa and Andaman & Nicobar Islands.

Figure 3.3 shows the departure (%) in annual rainfall from the normal rainfall. It is observed from Figure 3.3 that rains have been deficient in most of the years – the only exceptions being 2005, 2010 and 2013.

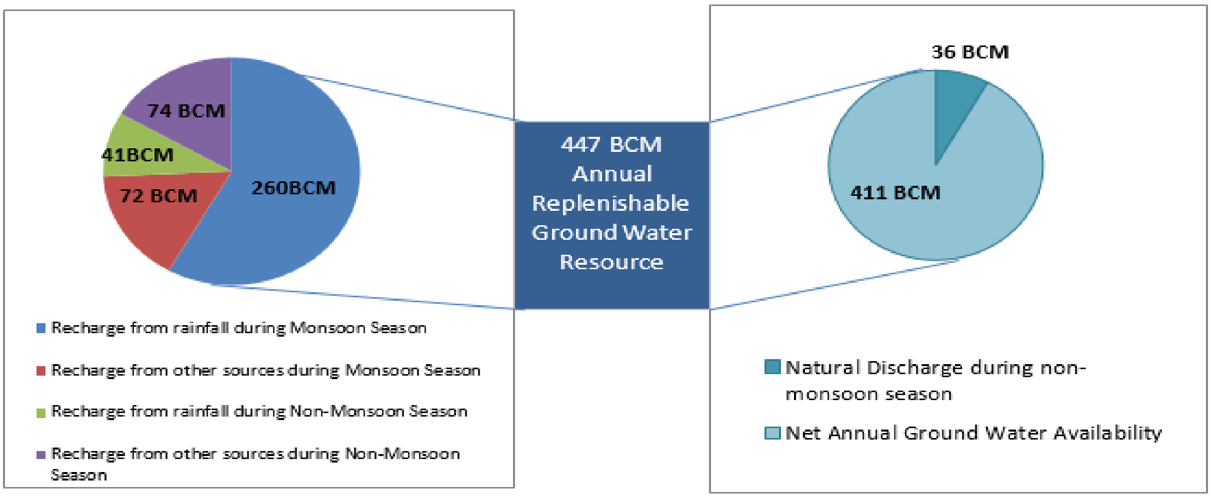
[8] Rainfall Statistics of India (2016), Indian Meteorological Department (IMD), Ministry of Science & Technology

Figure 3.3: Departures (%) in annual rainfall (2000-2016)[8]



This deficiency in rainfall is a cause of concern, since in India, monsoon rain is the major source of ground water recharge, contributing about 67% of the total annual replenishable resource (**Figure 3.4**). The Annual Replenishable Ground Water Resources of the area is the sum of recharge during monsoon and non-monsoon seasons and is used majorly for irrigation and domestic uses. Irrigation alone accounts for around 228 BCM usage of ground water whereas industrial and domestic uses in comparison hold a lower usage of around 25 BCM[9]. The amount of usage of ground water highlights its importance as a source of water and indicates the need for proper groundwater management.

Figure 3.4: Ground Water Resources Availability in India (in BCM)[9]

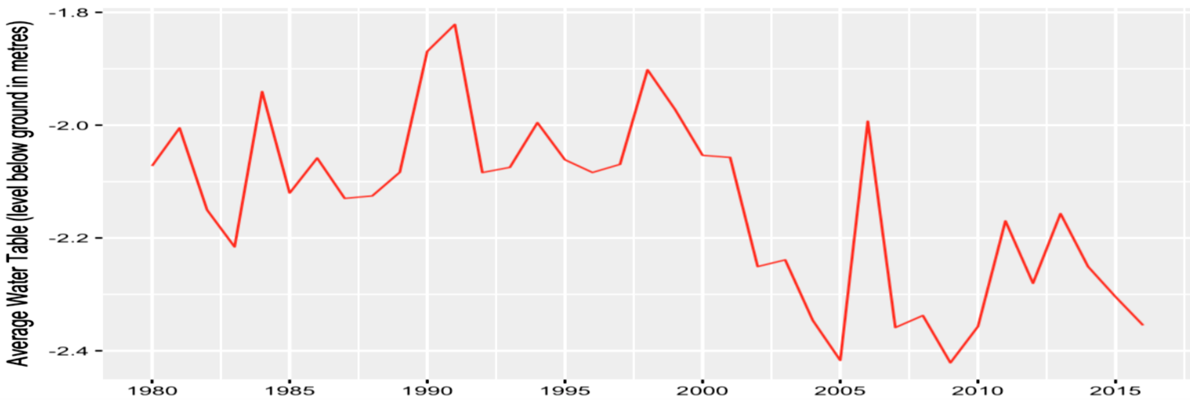


An indicator of whether or not the abstraction of groundwater is sustainable is the depth to water level. With more extraction of ground water, the depth to water level increases and the water table moves downward. Such a change is a cause of major concern for

[9] Dynamic Ground Water Resources of India (As on 31st March, 2013), Central Ground Water Board, Ministry of Water Resources

agriculture and irrigation in particular (scenario of groundwater depletion is depicted in **Figure 3.5**). In major parts of north-western states depth to water level generally ranges from 10-40 m bgl (below ground level). Water level of more than 40 m bgl is also prevalent in the north western part of the country. In the western parts of the country deeper water level is recorded in the depth range of 20-40 m bgl and more than 40 m bgl (**Figure 3.6**). The depleting groundwater is also negatively affecting India's farmland. According to Agriculture Census 2010-11[10], net area irrigated by groundwater is 63.63% (45.17% by tube wells and 18.46% by wells). Since in India, agriculture is dependent on irrigation which in turn is highly dependent on ground water resources, thus depleting resources are reducing the country's cultivated land hence, aggravating the water woes of the nation.

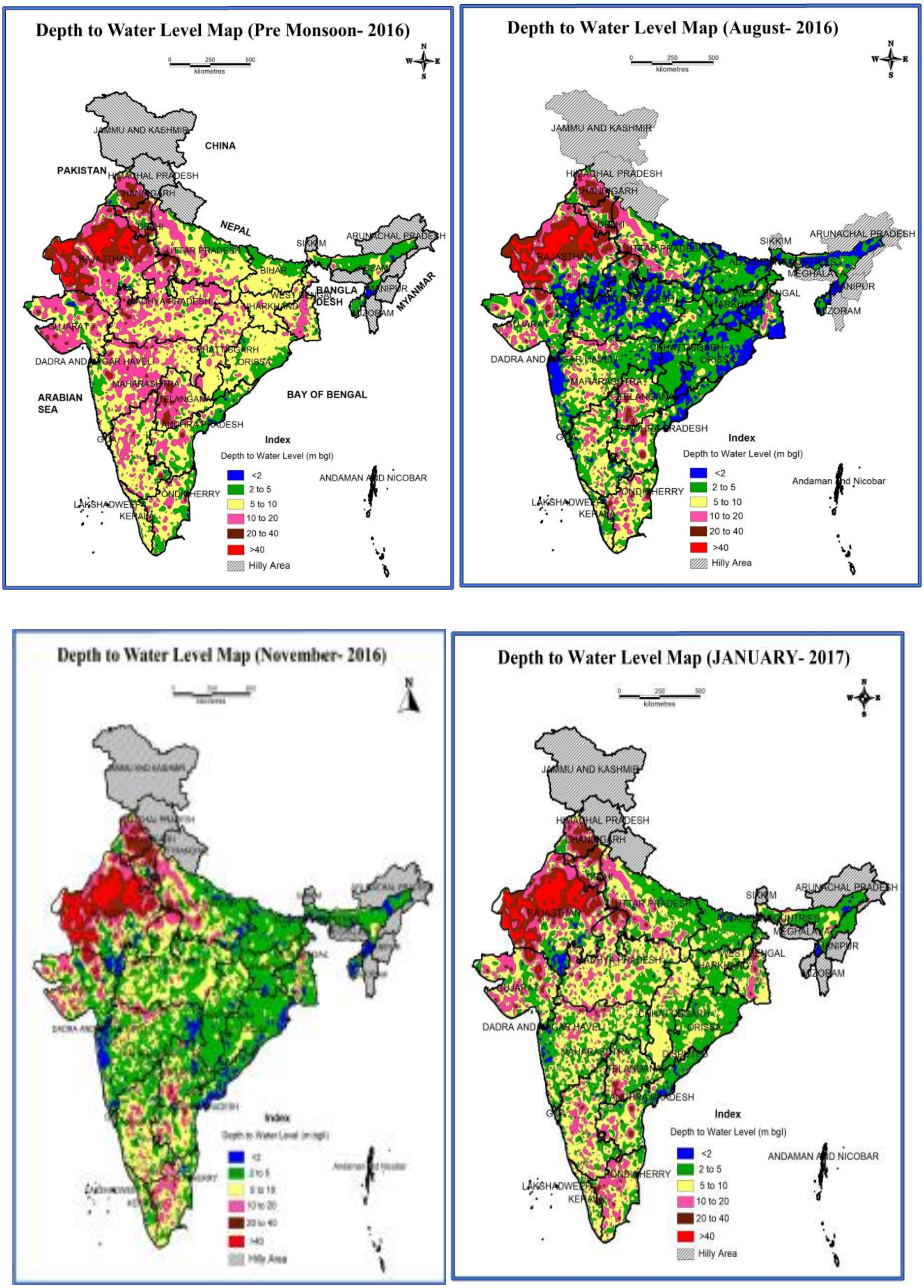
Figure 3.5: Groundwater Depletion in India[11]



[10] Agriculture Census 2010-11, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare

[11] Economic Survey 2017-18, Volume I

Figure 3.6: Depth to Water Level at a Glance[5]



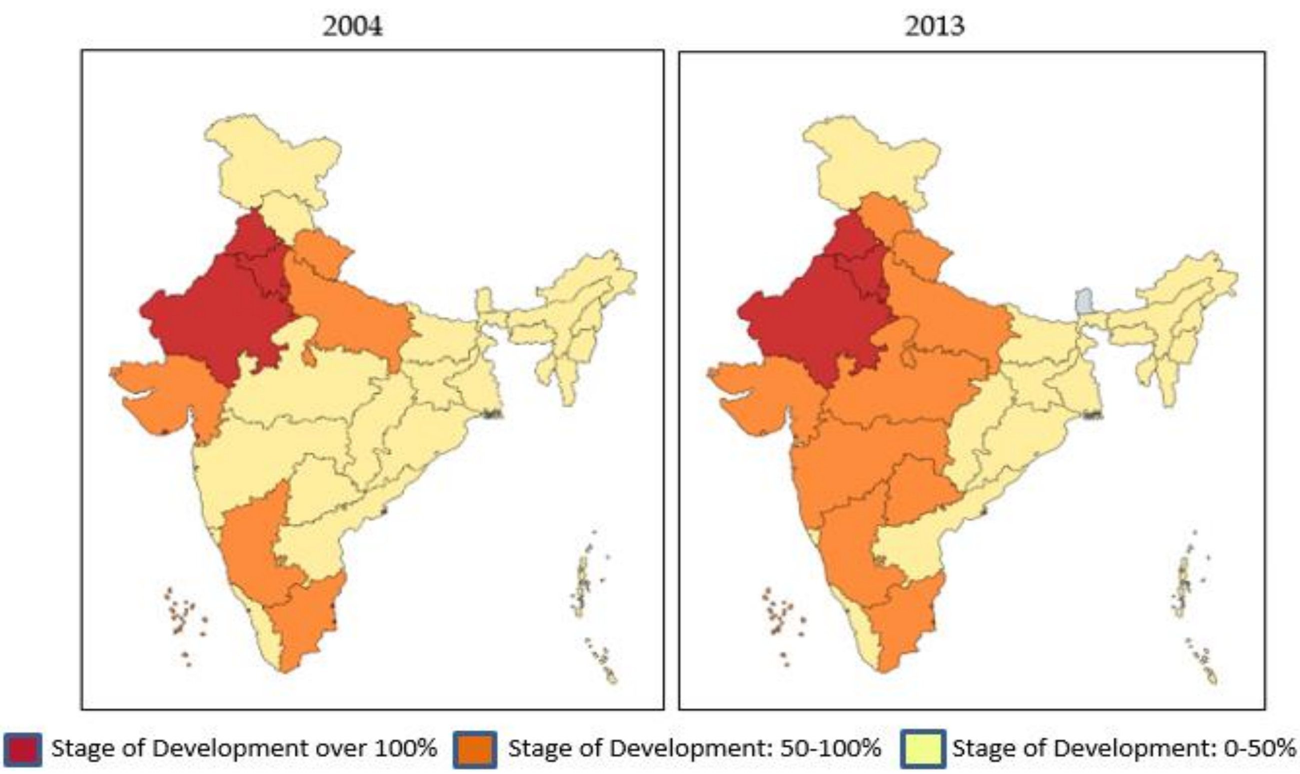
The decadal water level fluctuations of the monitored wells in the States of India are given in **Annexure 3.8.** Assuming that these monitoring wells represent the general scenario of the State, it can be said that more than 85% of the areas in the States of Tamil Nadu, Punjab, Kerala, Puducherry and Uttar Pradesh have witnessed a fall in depth to water. In the context of the level of fall, a maximum fall of about 19 metres was observed in Gujarat, Telangana, West Bengal and Rajasthan.

Another indicator of the stress on groundwater is the stage of ground water development, which is denoted by the percentage of utilization with respect to recharge and can be computed as:

$$\text{Stage of development} = \frac{ExistingGross\ Draft\ For\ All\ Uses}{Net\ AnnualGroundwaterAvailability} * 100$$

The overall stage of ground water development in the country is 62%. The stage of ground water development is very high in the states of Delhi, Haryana, Punjab and Rajasthan, where it is more than 100%, which implies that in these states the annual ground water consumption is more than annual ground water recharge. On comparing, the stage of development over the years, we observe that in some states like Madhya Pradesh, Maharashtra, and Himachal Pradesh the Stage of Development has increased and shifted to the orange region depicting the range of 50-100% (**Figure 3.7**).

Figure 3.7: Changes in the Stage of groundwater extraction[5,12]



[12] Ground Water Year Book- India 2009-10, Central Ground Water Board, Ministry of Water Resources

In order to allow for focussed interventions in areas (referred to as assessment units) where the ground water resources need attention, Central Ground Water Board has classified areas into safe, semi critical, critical and over exploited ground water resources based on two criteria, namely:

i. Stage of ground water development (percentage of utilization with respect to recharge)
ii. Long-term trend of pre and post monsoon water levels.

The long term ground water trend is computed generally for a period of 10 years and the significant rate of water level decline is taken to be between 10 and 20 cm per year depending upon the local hydrogeological conditions. The criterion for categorization is given in **Table 3.7.**

Table 3.7: Criteria for Categorization of Assessment Units[9]

Stage of Ground Water Development	Significant Long Term Water level Decline trend		Category
	Pre-Monsoon	Post-Monsoon	
<=90%	No	No	Safe
>70% and <=100%	No	Yes	Semi-Critical
>70% and <=100%	Yes	No	Semi-Critical
>90% and <=100%	Yes	Yes	Critical
>100%	No	Yes	Over-Exploited
>100%	Yes	No	Over-Exploited
>100%	Yes	Yes	Over-Exploited

Apart from the above four categories, one more category is used, where the entire assessment area is having poor quality and is demarcated as '*Saline*'.

Central Ground Water Board has classified the country into these categories; the proportion of safe units in the states are indicated in **Table 3.8** (Details in **Annexure 3.9**). It may be noted that the assessment units can be blocks, talukas, water-sheds, mandals, island, district or regions and are not uniform across the states.

Table 3.8: Classification of States by proportion of safe area units[9]

% of units	States
90+	Arunachal Pradesh, Assam, Bihar, Goa, Jammu &Kashmir, Jharkhand, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tripura, Andaman &Nicobar Islands, Chandigarh, Dadra & Nagar Haveli
75-90	Chhattisgarh, Gujarat, Himachal Pradesh, Kerala, Uttarakhand
40-75	Andhra Pradesh, Karnataka, Madhya Pradesh, Telangana, Uttar Pradesh, West Bengal, Daman & Diu, Lakshadweep, Puducherry
20-40	Haryana, Tamil Nadu
5-20	Delhi, Rajasthan, Punjab

Summary statistics based on the categorization of Assessment units over the years is presented in **Table 3.9**. Number of Over-exploited and Critical Assessment Units is significantly higher in Delhi, Haryana, Himachal Pradesh, Karnataka, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh.

Table 3.9: Summary Statistics of Categorization of Assessment Units over the years[13, 14, 15, 9]

	2004		2009		2011		2013	
Category	**No.**	**Share (%)**	**No.**	**Share (%)**	**No.**	**Share (%)**	**No.**	**Share (%)**
Total No. of Assessed Units	5723	-	5842	-	6607	-	6584	-
Safe	4078	71	4277	73	4530	69	4520	69
Semi-Critical	550	10	523	9	697	11	681	10
Critical	226	4	169	3	217	3	253	4
Over-Exploited	839	15	802	14	1071	16	1034	16
Saline	NA	NA	71	1	92	1	96	1

On comparing the status of assessed units (**Annexure 3.10**) across States, it is witnessed that percentage of over-exploited areas remains highest in the states of Punjab, Rajasthan and Delhi over 2004, 2009, 2011 and 2013. Moreover, on comparing 2013 with 2011, it is

[13] Dynamic Ground Water Resources of India (As on March, 2004), Central Ground Water Board, Ministry of Water Resources

[14] Dynamic Ground Water Resources of India (As on 31st March, 2009), Central Ground Water Board, Ministry of Water Resources

[15] Dynamic Ground Water Resources of India (As on 31st March, 2011), Central Ground Water Board, Ministry of Water Resources

observed that though the status of 349 units in India deteriorated, that of 343 units showed improvement and 5603 units showed no change (Details in **Annexure 3.11**).

The state-wise annual replenishable ground water potential is given at **Annexure 3.12**. The colour code depicts the range of Stage of Development, yellow is 0-50%, orange is 50-100% and red is over 100%. Uttar Pradesh (17.08%) ranks first among the various states in terms of share of replenishable ground water resources for the year 2013. **Annexure 3.12** presents the State-wise ground water availability, utilization and Stage of Development for 2004, 2009, 2011 and 2013.

The deteriorating status of groundwater is not unnoticed. Several water management techniques like rainwater harvesting, water conservation and harvesting, solar pumping methods, promotion of drip and sprinkler Micro- Irrigation (MI) techniques of irrigation, a unique irrigation technology called System of Water for Agriculture Rejuvenation (SWAR); SWAR shifts irrigation from surface to measure moisture at plant root zone and others[16] are being promoted both by the Union and State Governments. Several areas are being identified which are either prioritized for artificial recharge or delineated for water conservation and harvesting or identified as being suitable for ground water development (**Details in Annexure 3.13**). These efforts are likely to renew India's depleting water resources for sustainable future.

Conclusion

The surface water and groundwater resources play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities, etc; thus the increased demand pose challenges in the concerned sector. With the population in India estimated to grow to 1.6 billion by 2051, the water availability per capita is expected to fall to 1174 m^3 per year. Adding to the water woes, food requirements are also likely to increase i.e. annual food requirement in India are expected to exceed 250 million tons by 2050[17]. The situation is worsened by the fact that of the total annual availability of 1869 BCM in the river basins, only 1123 BCM (690 BCM being due to surface water resource)[2] can be put to beneficial use, due to topographical and other constraints like uneven distribution in space and time.

It has been clearly stated in Water Scarcity and security in India[17] that this increased demand is also associated with the following issues:

[16] Selected Best Practices in Water Management (August 2017), NITI Aayog, TERI University

[17] NG Hegde (2012), 'Water Scarcity and security in India', http://www.indiawaterportal.org/articles/water-scarcity-and-security-india

- *Over exploitation of ground water:* Over 20 million wells are pumping water with free power supply provided by some of the State Governments. This is resulting in depleting ground water resources which in turn affects the water table in the country which is dipping by 0.4 m every year.
- *Intrusion of sea water:* In the coastal areas, heavy intrusion of the sea water has made fertile agricultural land unfit for cultivation.
- *Sub optimal utilization leading to erosion:* Infrastructure development and investment in water sector has been low. The utilization of the created facilities in fact has also not been optimum resulting in soil erosion and siltation because of the poor catchment area development.
- *Inefficient water usage:* It is estimated that over 70% of the irrigation water is wasted depriving the dry areas of irrigation. Indian farmers have traditionally been practicing flow irrigation which has adverse effects like heavy soil erosion, leaching of fertilizers, increasing the infestation of pests, diseases and also suppressing the crop yields. Distribution of water in open canals, flood irrigation and charging for water based on area irrigated instead of quantity of water supplied are all causing this inefficient use of water resources.

The increasing competition for water in many river basins is narrowing down the gap between the rising water demand and available water supply thus, highlighting the need for better water governance for which water accounting is a key to move forward. The high dependence on water urges for its efficient use and sustainable water management for which maintaining the water accounts is a necessity.

Accounting for water can provide information on how the water supplies are changing as a result of changing climate, pollution, population, changing land use and others. It can also improve the water governance by providing information for decision-making which is in line with the phrase that 'We cannot plan and manage what we do not measure'.