FROST & SULLIVAN

50 Years of Growth, Innovation and Leadership

"Water For The Future - Challenges For India & Its Industries"

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Introduction

Water is one of the most critical elements for life form to exist on any planet. No wonder then, it is the most sought after element in man's quest for life in other planets. Without water, there would be no life!

Figure 1 - Earth from space (Rogers, 2008)

Our Earth has been blessed with 75 percent water mass, which is 1,386 Million km^3 in volume, giving it a magnificent blue appearance from space. It is the only planet in the Solar system that has this appearance and has abundance of water. With landmass covering the remaining 25 percent, Earth's 6.6 billion inhabitants, however, can use only 0.8 percent of this water! The rest is either very salty or frozen. And this water quantity is limited – it cannot be increased by any means. Hence, while Earth's population increases by 1.2 percent every year, its fresh water quantity for use by human beings remains fixed at 10.613 Million km^3 (10.613 Million BCM[1]). However, of this, only 4200 km^3 or 4200 BCM can be extracted for use.

With limited resources and a growing population specially in regions like Asia and Africa, water is becoming a scarce commodity with some areas facing water stress, that is, water availability per person is less than 100 liters per day for consumption. India is one such country.

India's total utilizable water resource is pegged at 1123 BCM (Central Water Commission, Government of India, 2012). With a population of 1.21 Billion (as of February 2011), the country has a per capita availability of 1720 M^3 of water, whereas the present water consumption is 761 BCM including all sectors and per capita consumption is 621 M^3 (as against a global average of 625 M^3) (Food and Agriculture Organization of United Nations, 2012). About 90 percent of this water is consumed in the agricultural sector, the balance being distributed among industrial (2.24 percent) and domestic use (7.4 percent).

A very conservative estimate forecasts India's water demand to grow to 838 – 850 BCM by 2025 assuming a population growth rate of 1.2 percent and GDP growth rate of 7 percent every year. These projections for water demand when compared to the estimated availability of 1123 BCM indicate an overall net marginal positive balance of only 273 BCM by the year 2025. However, given the uneven distribution of water, it is projected that the country will face water scarcity, with an average annual per capita availability of 750 M^3 by 2025. India will have to urgently take measures to curb scarcity of water in the future.

[1] *BCM – Billion Cubic Meters, equivalent to Million km^3*

This paper discusses the current and future water scenario in India, the challenges it faces and tries to present some solutions and measures it needs to adopt to avoid water scarcity.

Global Water Scenario

Total water available on Earth is 1,386 Million km^3 of which 97.6 percent is in the ocean and seas due to which it is saline in nature and cannot be used by human beings. About 1.5 percent of water is entrapped in the polar ice caps and glaciers, while the balance is in lakes, rivers and groundwater. This gives the World a useable water resource of 10.613 Million km^3, which remains constant.

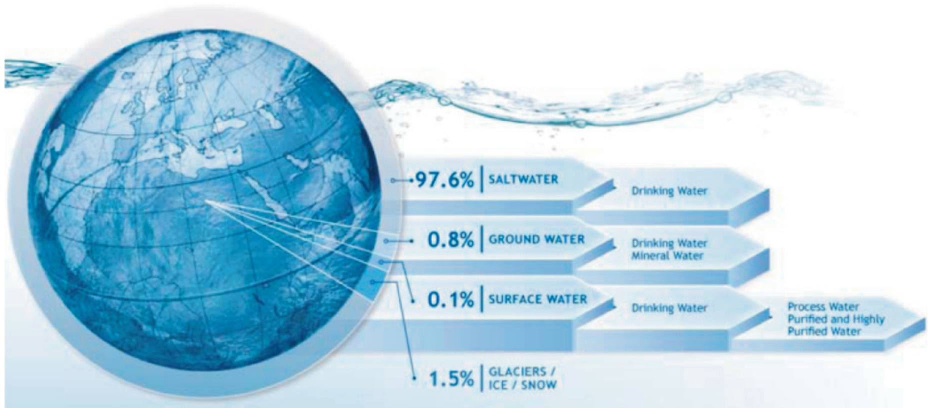


Figure 2 - Global Water Resources (Best Water Technology Company, 2012)

Global Water Resources

A. Sources of Water (Approximate)	
Item	Volume (Million BCM)
Salt Water in Oceans	1348
Fresh Water (includes frozen water and snow caps)	37.5

B. Sources of Fresh Water (Approximate)	
Item	Volume ('000 BCM)
Polar Ice and Glaciers	28200
Ground Water < 800 m deep	3740
800 - 4000 m deep	4710
Lakes and Rivers	127
Others (soil moisture and atmospheric vapours)	704

Table 1 - Global Sources of Water (Central Water Commission, Government of India, 2012)

The amount of precipitation (water from rain) falling on land is almost 110 000 km^3 per year. Almost two-thirds of this amount evaporate from the ground or is absorbed by vegetation (forest, rangeland, and cropland) and released back into the atmosphere. The remaining 40000 km^3 per year is converted to surface runoff (feeding rivers and lakes) and groundwater (feeding aquifers). These are called renewable freshwater resources. Part of this water is being removed from these rivers or aquifers by installing deep wells and pumps. This removal of water is called water withdrawal. Most of the withdrawn water is returned to the environment some time later, after it has been used. The quality of the returned water may be lower than what was originally removed.

Global water reserves are, however, limited and with growth in world population, according to UNO estimates, from 6.9 billion people today to 9.2 billion in the year 2050, increased average water consumption per capita will take place from the current 625 m^3 per year to disproportionate amounts in the future. This will cause serious social unrest across the globe with some social scientists calling water the 'Blue Gold' of the twenty first century. Chart 1 shows how in the next 40 years, demand will catch up with supply creating deficiency in water resources for the human population unless drastic measures are taken to conserve water use in all the sectors and by all the end users.

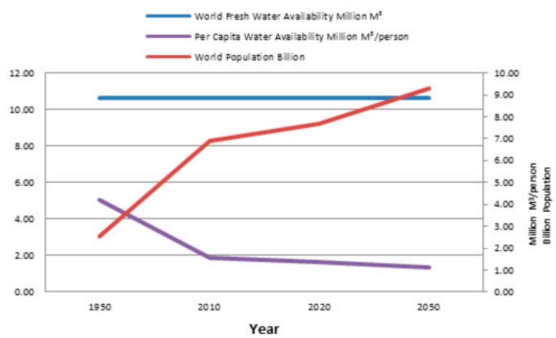


Chart 1 - Global Fresh Water Resources & Availability
Source: Frost & Sullivan Research & Analysis

Uses of Water

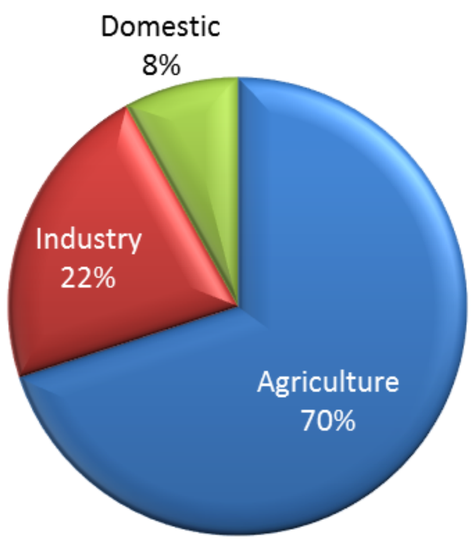


Chart 2 - Global Sectorial Use of Water

Water is used in three sectors:

1. Agriculture

2. Industry

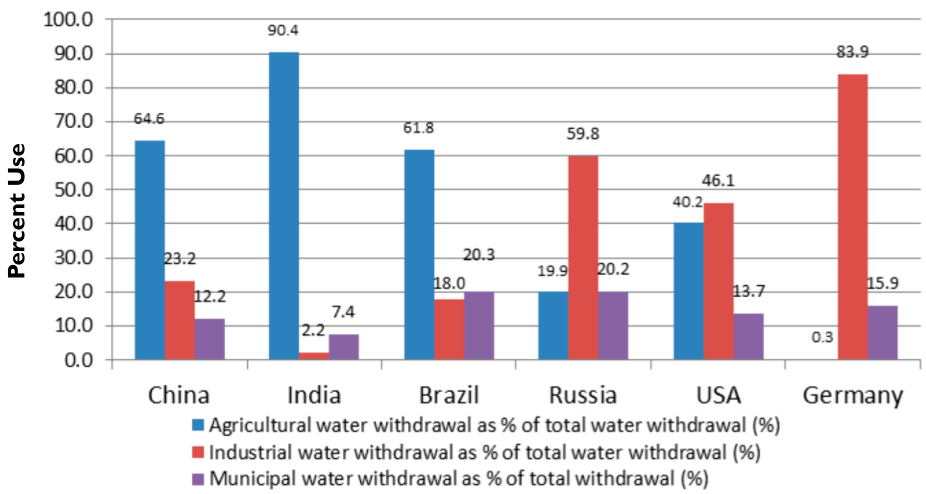
3. Domestic including municipalities

Globally, agriculture uses the maximum water followed by industry and domestic use. However, regionally, this distribution varies. For developing countries located in Asia, agriculture is the most prominent use followed by industries, whereas, in developed countries, domestic use of water is the highest followed by industries. Similarly, industrialized nations use more water for industries followed by domestic use. Belgium, for example, uses 80 percent of the water available for industry. This causes an unequal distribution of water demand pattern across the globe, as shown in Chart 3.

Freshwater withdrawals have tripled over the last 50 years. Demand for freshwater is increasing by 64 billion cubic meters a year.

- The world's population is growing by roughly 80 million people each year.
- Changes in lifestyles and eating habits in recent years require more water consumption per capita.
- The production of biofuels has also increased sharply in recent years, with significant impact on water demand. Between 1,000 and 4,000 liters of water are needed to produce a single liter of biofuel.
- Energy demand is also accelerating, with corresponding demands for water.

Chart 3 - Percentage of water used in various sectors
(Food and Agriculture Organization of United Nations, 2012)



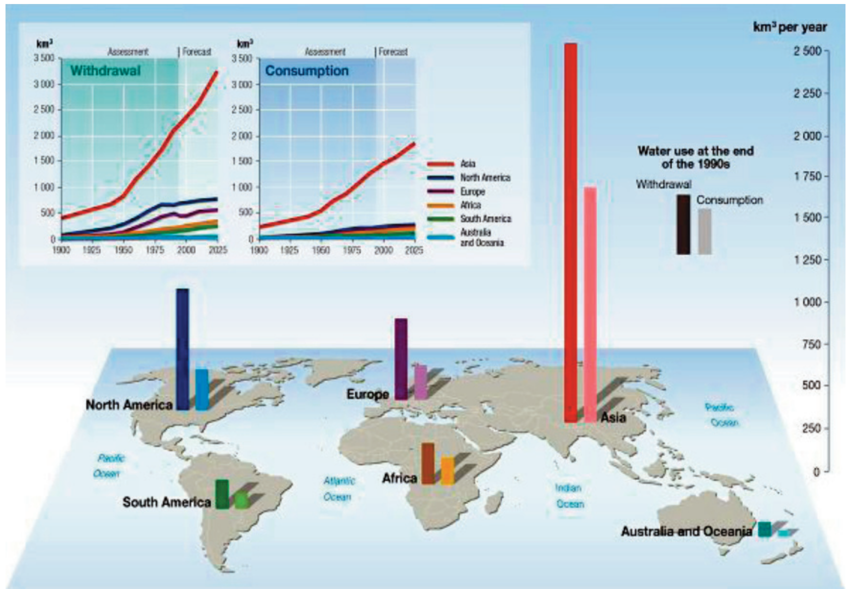
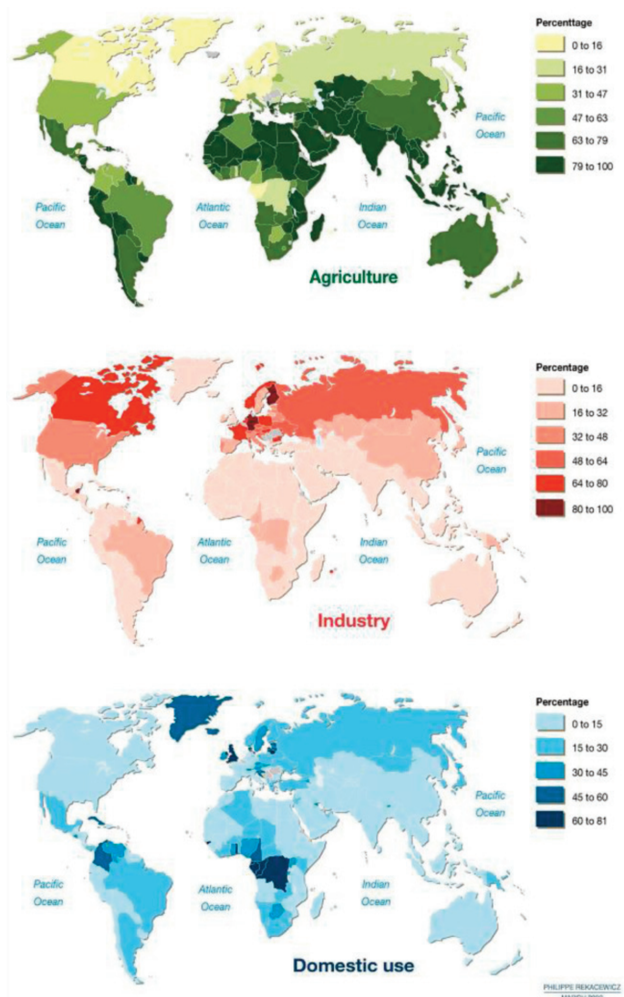


Figure 3 - World Water Withdrawal and Consumption (United Nations Environment Protection Program, 2008)



Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

Efficient use of water varies from country to country; one cannot generalize about developed countries using less water on per capita basis than developing countries. As shown in Chart 4, the US has the highest per capita water withdrawal and second highest water withdrawal for agricultural and industry output. India too uses more water per capita for its agricultural use than some of its peers like China, Brazil and Russia. If some consistency and discipline is brought in for end use of water, it will lead to better utilization and help in conserving this precious resource for generations to come. With the most populous countries also leading in economic growth, there would be higher pressure on water resources and if not controlled may lead to water stress and water scarcity that will lead to economic unrest.

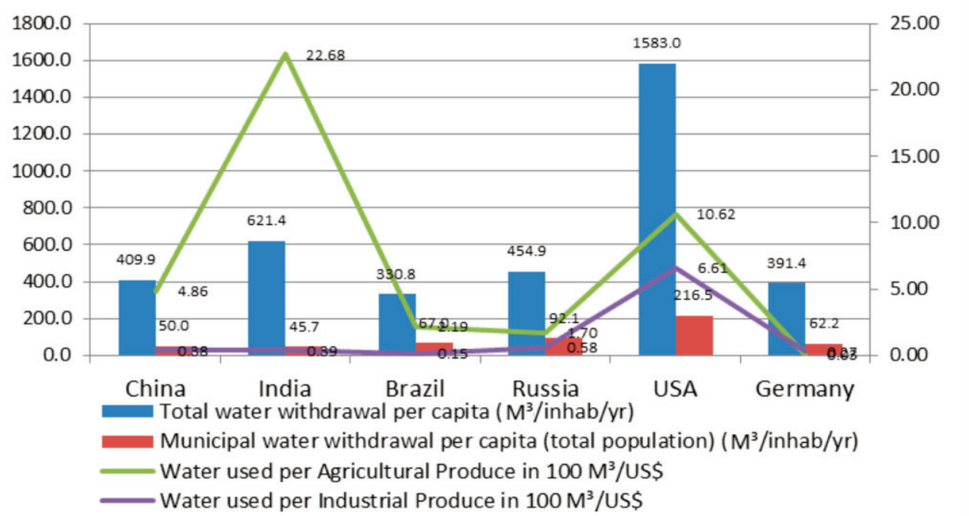


Chart 4 - Efficiency of Water use by select countries
(Food and Agriculture Organization of the United Nations, 2011)

Global Water Availability Footprint

Availability of water varies from region to region, country to country depending upon the level of water extractions from various resources and topography of the region or country. For example, water availability in the Northern African region is scare but availability in the western regions of Africa is good and sufficient

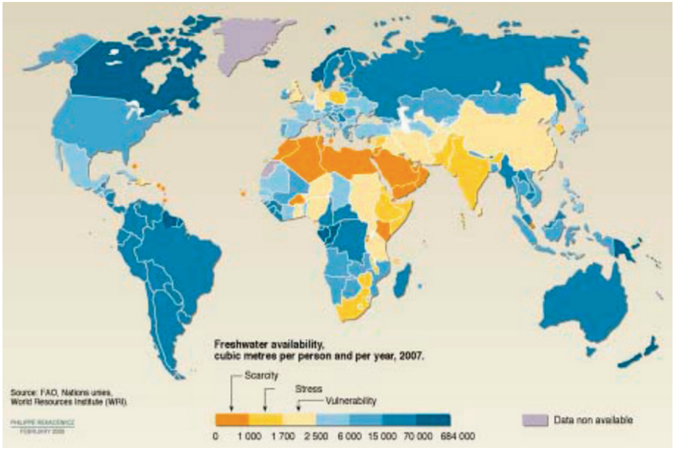


Figure 4 - Global Fresh Water Availability (United Nations Environment Protection Program, 2008)

Figure 5 - Fresh Water Basins of the World (United Nations Environment Protection Program, 2008)

But water accessibility for respective habitants in these regions is quite different. A look at water accessibility across the globe presents a different picture (refer figure 4). Large portions of Africa do not have access to fresh water sources, while India does have fairly good access to drinking water, even though it is water stressed. With proper planning and measures, India can have access to water resources for its need.

The global fresh water availability is given in Table 2.

Water source	Water volume, in KM³	Percent of fresh water	Percent of total water
Groundwater	2,34,00,000	--	1.7
Fresh	1,05,30,000	30.1	0.76
Saline	1,28,70,000	--	0.94
Soil Moisture	16,500	0.05	0.001
Ground Ice & Permafrost	3,00,000	0.86	0.022
Lakes	1,76,400	--	0.013
Fresh	91,000	0.26	0.007
Swamp Water	11,470	0.03	0.0008
Rivers	2,120	0.006	0.0002

Table 2 - Global Source for Fresh Water (Gleick & Schneider, 1996)

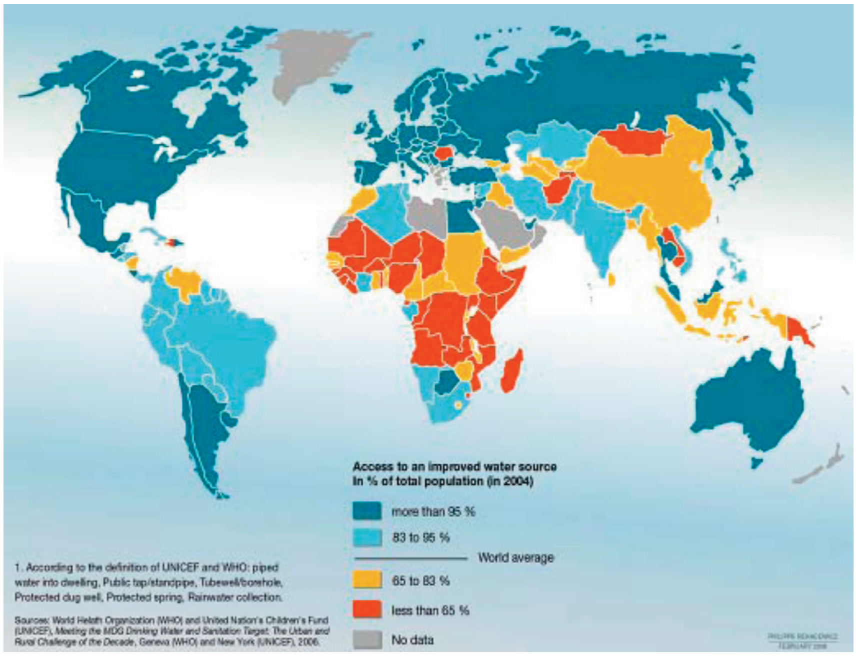


Figure 6 - Fresh Water Access (United Nations Environment Protection Program, 2008)

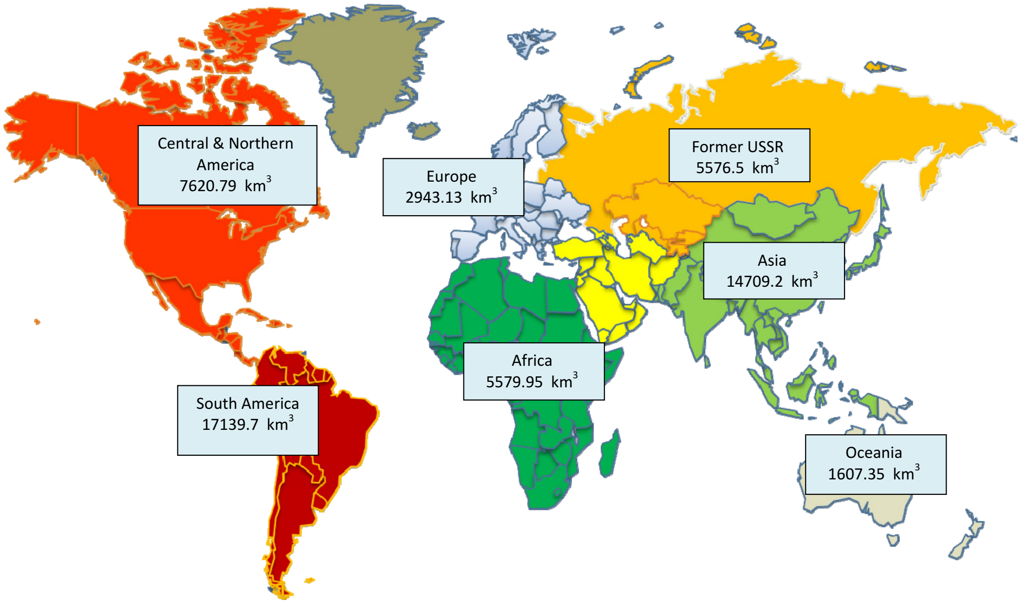


Chart 5 - World Fresh Water Footprint (Pacific Institute, 2007)

South America has the world's largest availability of fresh water followed by Asia. However, the demand in the latter is much higher than the former as more than one third of the world's population resides in this region and it has the world's two most populated countries. With landmass being very diverse in nature, there is a challenge in Asia to control the run-offs and rain river water, this region often being plagued by floods in the most fertile areas.

Future Prospects

With increasing population, the demand for water especially in the most populated regions will increase much more than the developed countries. The developing economies will demand more food to support larger population and that will therefore require more water. Typically, maximum water is used for agriculture (food production) than in any other activity by a developing economy. Following China and India, we will see the growth of new economies in Africa, countries like Kenya, Nigeria, Ghana, Sudan, Uganda and other emerging countries like Indonesia, Vietnam and Cambodia, which are typically agrarian economies will see higher demand for water than today. It is feared that if the present water use trend and policies continue into the future, farmers will not get sufficient water for food causing food scarcity. Therefore, the use of water and policies will have to change for the sake of meeting tomorrow's demand and the hardest hit will be the earth's poorest.

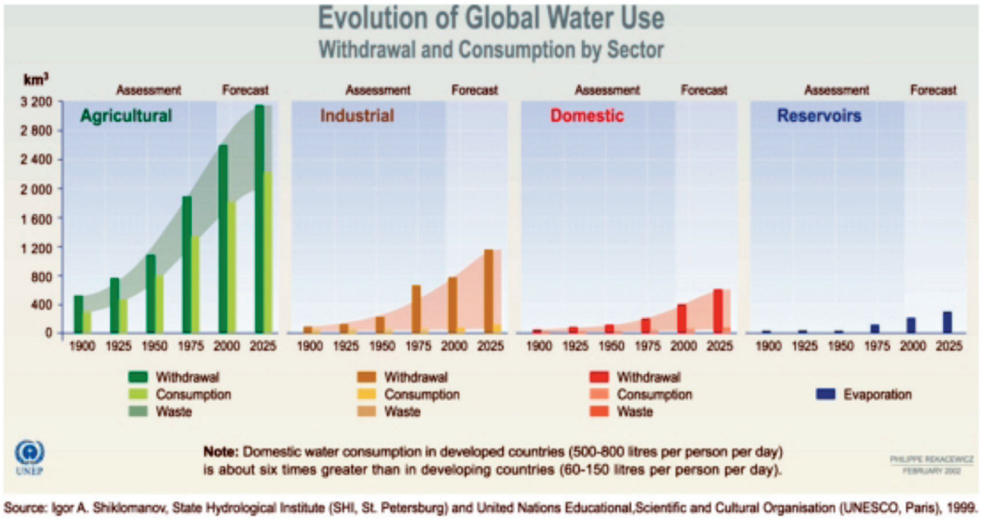


Chart 6 - Evolution of Global Water Demand (UNEP)

Demand Growth

In 2009 global water abstractions (water withdrawal) was 4500 Billion km^3, which is estimated to rise to 6900 Billion km^3 by 2030-32, resulting in a deficit of 2800 Billion km^3 by 2030 based on available water resources, that's about 50 percent shortfall of today's supplies as shown in Figure 7 (2030 Water Resources Group, 2009).

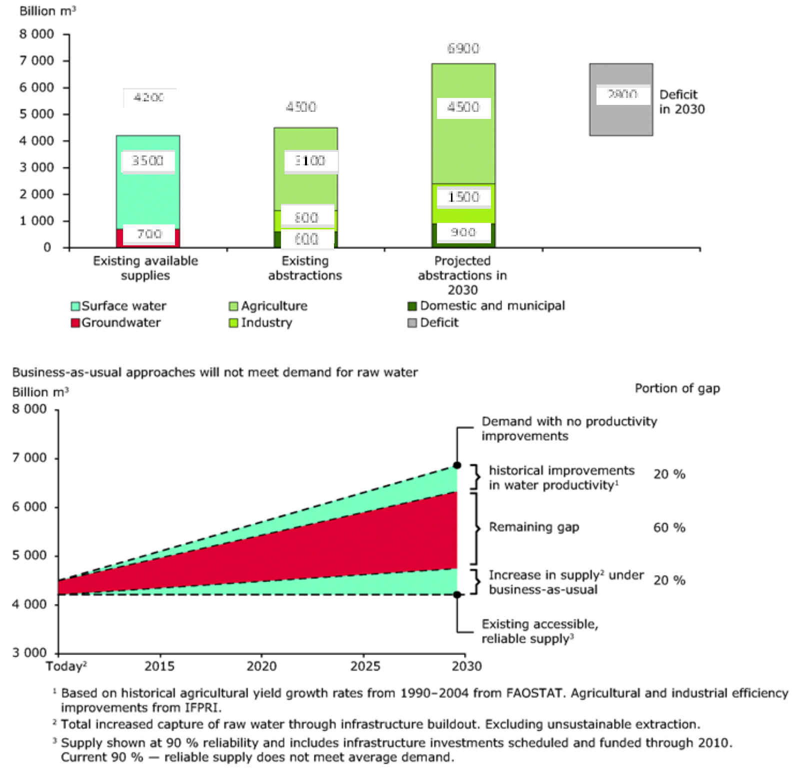


Figure 7 - Future Global Water Demands and Sources (2030 Water Resources Group, 2009)

Maximum demand will continue to come from Agriculture sector (68-71 percent) due to increase in food demand from developing countries with large populations, followed by emerging economies where the drop in mortality rates will result in a drastic increase in young population and therefore demand for food, which in turn will propel the need for more water. Unfortunately, these regions today have limited access to water and are also less industrialized and therefore challenges to meet the water demand will be more severe.

The rise in demand for agricultural water will raise the demand for domestic and municipal water due to higher rate of urbanization in today's expanding economies like China, India, Indonesia, Vietnam and Cambodia. So will the demand from newer growth countries of tomorrow like Mid Africa countries and other regions. These regions today have very low per capita consumption of water as compared to developed nations and the world average of 135 liters per person per day. An increase in per capita consumption to even a modest 90 liters per person per day will result in more than 200 percent increase in demand for domestic water consumption.

Population

The World's population is forecast to grow from 6.6 Billion today to 8.3 Billion by 2030[2] in which India and China will continue to be the most populous nations with a combined share of 33 percent of global population.

The next regions of population growth will be in Africa whose drop in mortality rates and increase in fertility rates would result in higher population growth than India and China whose growth rates by 2025 would have stabilized at 1.3 percent annually as shown in Chart 7.

Just per medium capita consumption of water and rise in population will result in higher water demands that will put more pressure on the limited water resources availability in these regions.

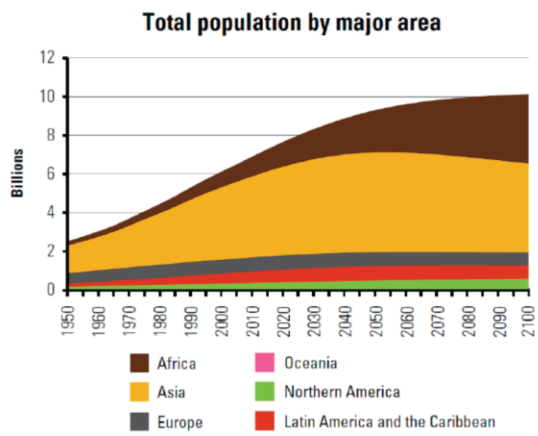


Chart 7 - Global Population Growth till 2100

The United Nations Department of Economic and Social Affairs – Population Division, 2010

GDP Growth

The World economy is estimated to grow from US Dollars 81,172 Billion in 2011[3] to US Dollars 1,63,235 Billion in 2032[4], that's an increase of over 100 percent in the next 20 years. Most of this growth is expected to come from the developing economies of today, China and India and the emerging economies of tomorrow – Indonesia, Turkey, Mexico and others. This would put pressure on the earth's water resources since populous nations like China, India and Indonesia are all agrarian economies and consume maximum amount of water. These economies are further expected to increase their industrial production thereby increasing their demand for water even more than before. Thus, just sheer economic growth would put higher pressure on water requirements in these regions (currently to 22 percent in future) and unless that is met, it could severely affect the local socio economic stability.

[2]The United Nations Department of Economic and Social Affairs – Population Division, 2010
[3]World Bank Databank accessed in August 2012 from their databank and web page www.worldbank.org
[4]PwC long term GDP Projections based on World Bank 2009 GDP data on PPP basis

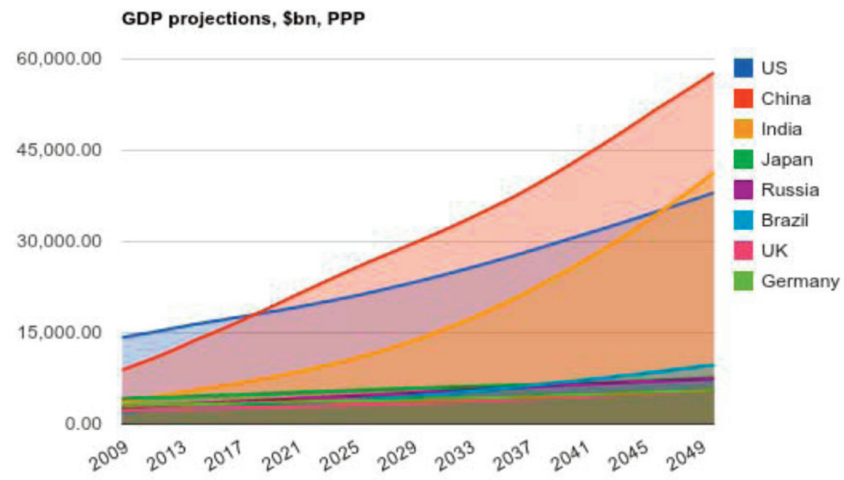


Chart 8 - GDP Projections (John Hawksworth and Gordon Cookson, 2008)

Regional Issues

Accessibility to water and its scarcity has several region specific issues besides the factors mentioned above. These issues vary from region to region and country to country.

India, for example, will need 1500 Billion M^3 of water by 2032, mainly for agriculture for growing basic food for its massive population, whereas the demand for industrial and domestic sector would be far less. As a result, the major river basins of India – Ganges, Brahmaputra, Yamuna, Krishna and Godavari will face the highest stress for water supply as well the stress of pollution from industrial and domestic waste leading to high toxic levels rendering water in these basins unfit for human use. India, therefore, has to think about proper use of its water resources if it has to survive the side effects of population and economic growth.

Indian agricultural activity is dependent largely on the monsoon to provide for its water for irrigation. With climate change progressively affecting its monsoon patterns, Indian water sources are also changing vastly with increasing pressure on ground water sources. This leads to higher electricity demands to run numerous pumps to draw water from greater depths putting tremendous pressure on power generation. The main grain baskets of India, Haryana and Punjab, have limited access to groundwater sources and have to depend on underground sources or draw water from surface water sources many kilometres away.

China on the other hand, will need 818 Billion M^3 of water during the same period, with only 50 percent of its demand coming from agriculture but its industrial demand will rise the fastest given the industrialization of its economy. A substantial amount of water (32 percent) will be used by its industry, mainly driven by the power sector demand of the country in 2032.

Brazil's water demand is equally shared between agriculture, industry and domestic. The large scale urbanization that's happening in this country is pushing for a better water source and its distribution system for the country. This in turn demands more electricity for driving pumps for distribution.

Thus, water demand has its own regional issues, variations and peculiarities that have to be dealt with differently and individually.

The Indian Water Scenario

Reusable water source in India is 1122 Billion M^3 (BCM or km^3) a year, of which the withdrawal is 681 BCM by the agricultural, industrial and domestic sectors. It is one of the highest for a country in the world. However, with population and economic growth of India, withdrawal demands are going to increase by almost 100 percent in the next 25 years, making India one of the water stressed regions of the world. Most of the water received through rainfall, runs off the surface and into rivers causing floods and silting every year affecting millions of its habitants each season.

Recently, beginning of August 2012, the Northern Plains of India, known as the 'Grain Basket of India' suffered electricity blackouts for two days at a stretch due to unexpectedly high withdrawal of electricity by the farm sector for its irrigation pump sets due to lack of ground water and insufficient rains in the region. This excess withdrawal of electricity had a cascading effect on the entire northern and eastern regions of the country leaving more than 680 Million without electricity for more than 20 hours.

The scarcity of water will also put a huge strain on its food resources and if India has to continue its food security and sufficiency, it has to urgently bring in reforms in this sector.

Water Resources

The sources for water in India are monsoon rains and snow melt from the Himalayas. Every year, monsoon rains add 4500 BCM of water. Of this, 250 BCM is currently stored in dams and reservoirs. Of the balance, about 500 BCM is absorbed in aquifers underground and the rest 'runs off' to the rivers and seas. Total water availability is 1869 km^3 a year. But of this, due to various constraints, only 1122 km^3 of water can be used for withdrawals[5] .

[5] *Source: Central Water Commission of India*

It is estimated that Himalayan melting contributes to 230 km^3 of run-off water every year.

The land and water resources of India may be summarized as follows.

Geographical area	329 million hectare
Natural runoff (Surface water and ground water)	1869 cubic km/year
Estimated utilizable surface water potential	690 cubic km/year
Ground water resources	432 cubic km/year
Available ground water resource for irrigation	361 cubic km/year
Net utilizable ground water resource for irrigation	325 cubic km/year

Table 3 - Land and Water Resources of India (IIT Kharagpur, 2010)

Water Basins

There are 20 water basins in India that provide surface water of 690 km^3 every year. These basins are fed by some of the largest and longest rivers of the world – Ganges, Yamuna, Indus, Narmada, Sutlej, Beas and Godavari that originate within India, and some like the Brahmaputra that originate from China, besides being fed by numerous other small rivers originating from Bhutan and Nepal.

While most of these rivers drain out to the seas on either side of the Indian coasts, some of the rivers like Indus that passes through Pakistan and Brahmaputra that passes through Bangladesh provide water for these countries basins too. Thus, a sizable portion of water from these two rivers is not available to India and the amount of water that India can utilize is governed by treaties signed by the countries with each other.

The Ganges, Brahmaputra and Godavari are the main fresh water providers for India, contributing to almost 65 percent of the water resource in India and therefore rightfully known as the 'Water Trough of India'.

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 and Others	585.60
3.	Godavari	110.54
4.	Krishna	78.12
5.	Cauvery	21.36
6.	Pennar	6.32
7.	East Flowing Rivers Between Mahanadi and Pennar	22.52
8.	East Flowing Rivers Between Pennar and Kanyakumari	16.46
9.	Mahanadi	66.88
10.	Brahmani and Baitarni	28.48
11.	Subernarekha	12.37
12.	Sabarmati	3.81
13.	Mahi	11.02
14.	West Flowing Rivers of Kutch, Sabarmati including Luni	15.10
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	NEG.
20.	Minor River Basins Draining into Bangladesh and Burma	31.00
Total		1869.35

Table 4 - Basin Capacities for India (Central Water Commission, Government of India, 2012)

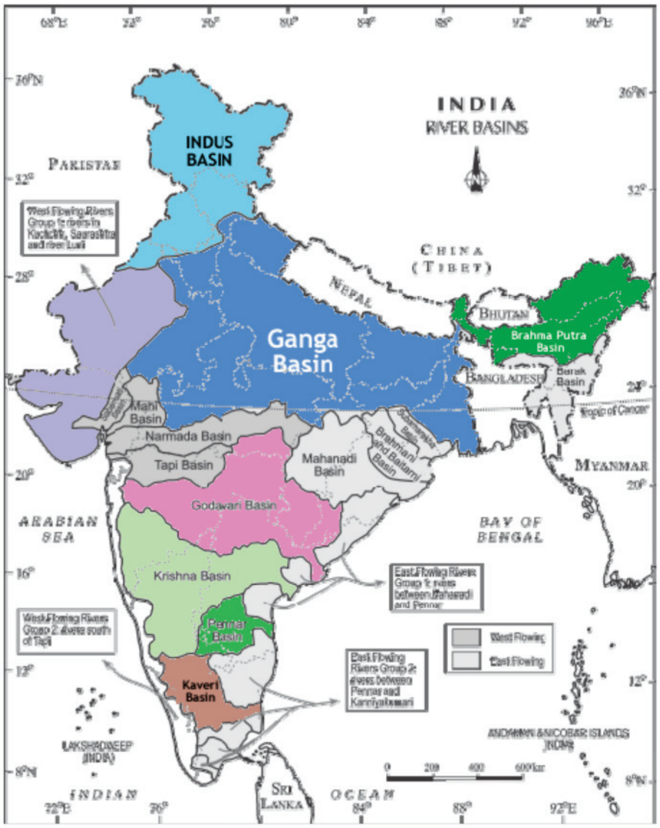


Figure 8 - River Basins of India (Narmada Control Authority)*

** Disclaimer: Line of Control not shown in the map above and does not represent true boundaries of the country*

Use of Water by Various Sectors – Agriculture, Industry & Domestic

India uses the highest quantity of water for its agriculture followed by Industry and Domestic use. As much as 621 km^3 of surface water and 370 km^3 of ground water is used by the agricultural sector every year, constituting almost 90 percent of the total water usage, while the industry uses 78 km^3 of surface water, which is 7 percent and the domestic sector uses merely 2 percent of the total water in India.

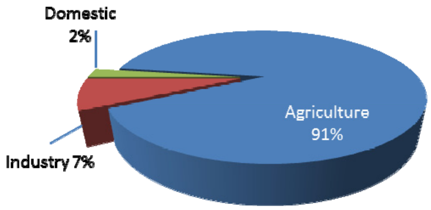


Chart 9 - Sectorial Water Use in India (Food and Agriculture Organization of United Nations, 2012)

In terms of per capita and per economic activity produced, India is the highest consumer making its economic activities very water intensive and hence the critical role water plays in the economic growth of the country.

Water consumption below 1990 M^3 per person is considered to be 'water scarcity' condition and below 1000 M^3 per person per year is considered to be 'water stress' situation. Not many years ago, India's average per capita consumption was 1998 M^3 per person per year. It has now fallen down to 621 M^3 per person per year, considered to be a 'water stress' situation.

Comparison with Global Usage Pattern

When compared to the global usage pattern of water, India consumes much higher quantity of water against world's average figure and leads in the developing countries.

Parameters	China	India	Brazil	Russia	USA	Germany
Total water withdrawal per capita (M^3/inhab/yr)	409.9	**621.4**	330.8	454.9	1583.0	391.4
Municipal water withdrawal per capita (total population) (M^3/inhab/yr)	50.0	**45.7**	67.0	92.1	216.5	62.2
Water used per Agricultural Produce in 100 M^3/US$	4.86	**22.68**	2.19	1.70	10.62	0.03
Water used per Industrial Produce in 100 M^3/US$	0.38	**0.39**	0.15	0.58	6.61	0.27

Table 5 - Global Water Usage in Different Sectors (Food and Agriculture Organization of United Nations, 2012)

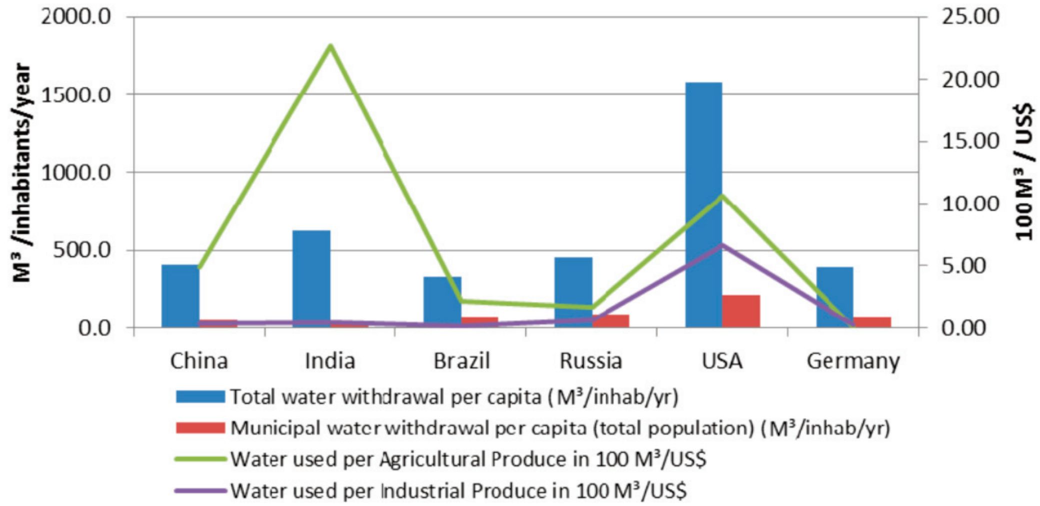


Chart 10 - Comparison of Specific Water Consumption
(Food and Agriculture Organization of United Nations, 2012)

If India has to avert the impending severe water crisis and help in its economic growth, it will have to look at more efficient water usage in all its sectors. To do this, it will have to adopt several measures for its water withdrawals, efficiency of its use and adopt modern techniques for water treatment, its use and reuse.

The reasons, perhaps, why in India the specific water consumption is higher than other countries are because there is no water pricing for the farm sector, no pricing mechanism based on usage in the domestic sector and free or subsidized electricity supply to the farmers. This leads to over use, wastage and pilferage of water in both these sectors, leading to a higher specific consumption.

In case of water usage and its efficiency in the industrial sector, although the specific consumption of water for industries in India is same as China and lower than some of the other countries, a deeper look at water usage in various industries shows a different picture.

Water Used in Various Sectors and its Issues

Water in Agricultural Sector – Over Use

India uses about 688 Billion M^3 (as on 2011) of water every year for its agricultural purposes. Rice, Wheat and Sugarcane constitute about 91 percent of its crop production and all these crops require large quantities of water. However, owing to the use of old methods of farm irrigation and water distribution methods, specific water consumption per crop is much higher than other countries of the world as shown in Table 6.

Water Footprint in thousands of liters/MT		
Crop	**India**	**Global**
Wheat	1654	1334
Rice	2850	2291
Sugarcane	159	175

Table 6 - Water Footprint of Crops in India (Grail Research, 2009)

As the above table elaborates, except for sugarcane, where Indian farmers have adopted modern techniques of irrigation, India's water consumption for its major crops is at least higher by 24 to 29 percent over the global average. And since these are the major crops, any improvement in specific water consumption for these will help solve water scarcity in a big way. Instead of using traditional farming techniques and irrigational systems, adoption of modern farming techniques and irrigation systems will go in a long way to help reduce water consumption in the agricultural sector.

There is a concept of 'Virtual Water' for crops and foods produced besides direct use of water for crops in irrigation. Virtual Water is the incidental water that is consumed for each crop that is grown and the food that is produced. A look at the virtual water consumption or, 'Water Footprint' as it is sometimes known as, for some of the common crops and food produced reveals a startling picture. There is a need to reduce the Water Footprint of these crops and food produced in order to achieve higher benefits of water efficiency thereby saving Billions of cubic meters of water in the process.

	U.S.	China	India	Russia	Indo nesia	Austra lia	Brazil	Japan	Mexico	Italy	Nether lands	World Average
Rice	1903	1972	4254	3584	3209	1525	4600	1822	3257	2506	-	3419
Wheat	849	690	1654	2375	-	1588	1616	734	1066	2421	619	1334
Corn	489	801	1937	1397	1285	744	1180	1493	1744	530	408	909
Soya beans	1869	2617	4124	3933	2030	2106	1076	2326	3177	1506	-	1789
Sugarcane	103	117	159	-	164	141	155	120	171	-	-	175
Cottonseed	2535	1419	8264	-	4453	1887	2777	-	2127	-	-	3644
Carton plaxel	5733	3210	18694	-	10072	4268	6281	-	4812	-	-	8242
Coconut		749	2255	-	2071	-	1590	-	1954	-	-	2545
Roast coffee	5790	7488	14500	-	21030	-	16633	-	33475	-	-	20682
Tea leaves		11110	7002	3002	9474	-	6592	4940	-	-	-	9205
Beef	13193	12560	16482	21028	14818	17112	16961	11019	37762	21167	11681	15497
Pork	3946	2211	4397	6947	3938	5909	4818	4962	6559	6377	3790	4856
Goat's meat	3082	3994	5i87	5290	4543	3839	4175	2560	10252	4180	2791	4043
Mutton	5977	5202	6692	7621	5956	6947	6267	3571	16878	7572	5298	6143
Chicken	2389	3652	7736	5763	5549	2914	3913	2977	5013	2198	2222	3918
Eggs	1510	3550	7531	4919	5400	1844	3337	1884	4277	1389	1404	3340
Milk	695	1000	1369	1345	1143	915	1001	812	2382	861	641	990
Milk powder	3234	4648	6368	6253	5317	4255	4654	3774	11077	4005	2982	4602
Cheese	3457	4963	6793	6671	5675	4544	4969	4032	11805	4278	3190	4914
Cow leather	14190	13513	17710	22575	15929	18384	18222	11864	40482	22724	12572	16656

Table 7 - Amount of Virtual Water Use for Crops and Food per country in 1000 liters per ton (Lenntech B.V., 2008)

As seen in Table 7, India's virtual water use is amongst the highest of all the leading economies for the same crop or food produced and higher than the world average for all the food items. If India has to manage its water scarcity for the future, it must learn to reduce its virtual water use in agricultural sector.

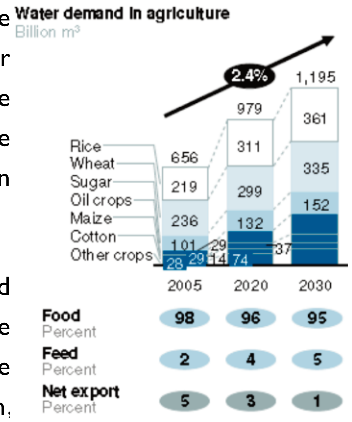


Chart 11 - Water Demand in Agriculture in India (2030 Water Resources Group, 2009)

Where there is scarcity of water, over exploitation of ground water takes place and that leads to its rapid depletion. The states in India with inadequate supply of surface water, like Haryana, Eastern Maharashtra, West Andhra Pradesh, Karnataka, Tamil Nadu, Chhattisgarh, and Madhya Pradesh face the prospects of depleting ground water by 55 to 65 percent by 2032 and by 75 percent by 2050.

Water in the Industrial Sector – Higher than the global average

In India, as industrial sector is not very developed like China or Brazil, water consumption is much lower than the world average. However, it is the second largest consumer of water and not very efficient at that.

As with other countries, largest industrial consumer of water in India is the Power Generation sector, consuming as much as 80 percent of the water consumed in the industry. For every MWh of electricity produced, 6.69 M^3 of fresh water[6] is consumed in India. While the present electricity generation capacity is nowhere near the required levels of sufficiency, rise in power generation capacity in India is imminent and unavoidable, thereby putting huge pressures on industrial water demand in the future.

The other large water consuming industries are Steel, Zinc, Copper, Fertilizers and Oil Refineries. Though their specific consumptions are lower than that for electricity generation, they still take a large share of water for consumption as compared to other industries.

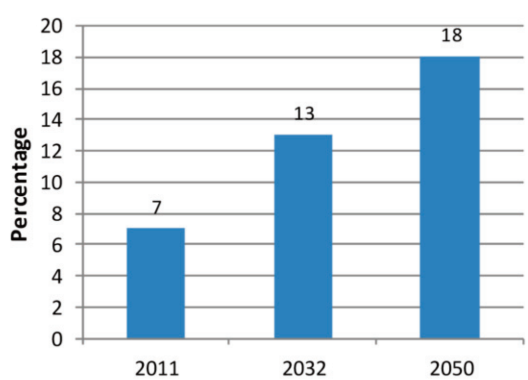


Chart 12 - Percentage Share of Industrial Water use in Total Water in India (Grail Research, 2009)

[6]*In the power generation industry, lot of water is reused through effective recycling technologies. This figure is for the amount of fresh or raw water consumed in a power plant.*

Industrial Sector	Annual consumption (million cubic meters)	Proportion of water consumed in industry
Thermal power plants	35157.4	87.87
Engineering (Mainly Automobiles)	2019.9	5.05
Pulp and paper	905.8	2.26
Textiles	829.8	2.07
Steel	516.6	1.29
Sugar	194.9	0.49
Fertiliser	73.5	0.18
Others	314.2	0.78
Total	40012.0	100.0
Note: For methodology see www.downtoearth.org.in Source: Estimated by CSE based on the wastewater discharged data published by CPCB in "Water quality in India (Status and trends) 1990 - 2001".		

Table 8 - Water Use in Indian Industry (Center for Science and Environment)

Country	Industrial water use (billion cubic metres)	Industrial productivity (million US $)	Industrial water productivity (US $ / cubic metre)
Argentina	2.6	77171.0	30.0
Brazil	9.9	231442.0	23.4
India	15.0	113041.0	7.5
Korea, Rep.	2.6	249268.0	95.6
Norway	1.4	47599.0	35.0
Sweden	0.8	74703.0	92.2
Thailand	1.3	64800.0	48.9
United Kingdom	0.7	330097.0	443.7
Source: *World Bank, 2001*			

Table 9 - Water Use Efficiency in Industry - Global Comparison (Center for Science and Environment)

Indian industry's water use efficiency is one of the lowest in the world when compared to many other countries. This makes Indian industry highly dependent on water as an important input for its manufacturing activity. If, water for the industry in India is priced to its true commercial value, many Indian industries would be non-competitive.

Some of the major users of water in the Indian industry are:

Power Plants

Power generation needs water to cool the huge electric generators for all types of power generation using conventional or nuclear energy. As much as 90 percent of the water requirement is used for cooling the steam to water and this is a very high quantity that cannot be reduced due to technical constraints.

A 1000 MW power plant requires 6,690 M^3 of fresh water every hour, considering a closed loop cooling system. For once through type of cooling in power plants, ones that are located on the coasts, this figure is as high as 59,000 M^3 of water every hour.

Power Plants also generate large quantities of effluent. Boiler blow down water, effluent from the Demineralization Plants and ash handling plants generate effluent waste water that causes pollution in the local area. While the effluent generated is much less as compared to the raw water requirement, using advanced water and waste water treatment technologies can help decrease this huge water need in power plants.

Minerals, Mining and Metals

Mining activity requires large quantities of water for its beneficiation process and generates equal amount of effluent and waste water that is unfit for use unless it is treated and reused. Depending upon the type of mineral being mined, this effluent water can be toxic too, containing dangerous carcinogenic elements like Arsenic that percolates to the ground water and contaminates the water for local or nearby inhabitants.

In steel making, a large quantity of water is required for various cooling and quenching processes. In India, for each ton of steel produced, 11.8 M^3 of water is consumed on an average. A recent two year study by the Center for Science and Environment found that some of the steel plants in India consumed as much as 32 M^3 of water for each ton of steel produced by them, whereas the global benchmark is 5 M^3.

Figure 9 - Effluent Discharge from a Steel Plant (Source : CSE Report on Steel Sector Efficiency)

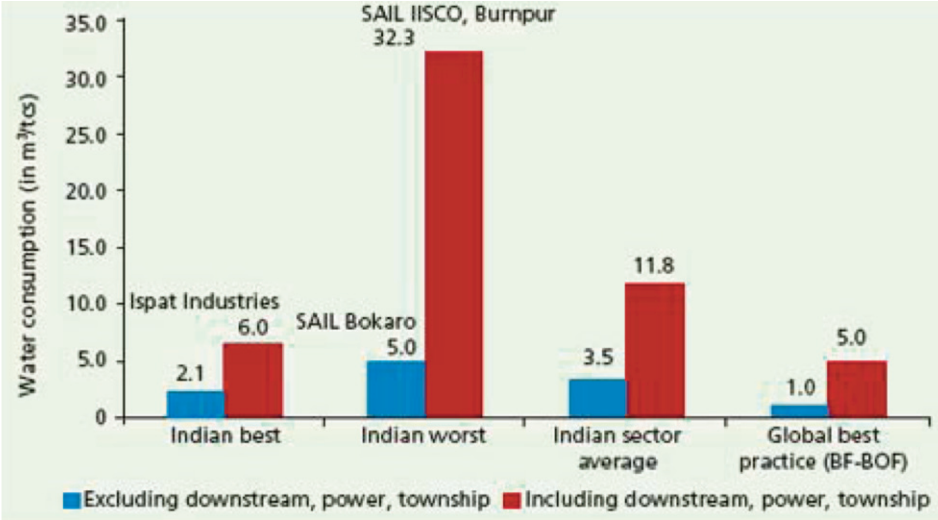


Chart 13 - Water used by the Indian Steel Sector (Center for Science and Environment, 2012)

This also generates dangerous and difficult effluent that needs elaborate treatment for it to be reused. However, looking at the quantity of water that is required for every ton of steel produced, it makes immense economic sense to recycle this water for reuse. There are technologies available today that can recycle the effluent to be used as raw water back in the steel making process thereby decreasing the fresh water requirement at least by half, saving precious water sources in the region and minimizing the chances of pollution.

Pulp and Paper

Large quantity of water is used in the paper industry to produce the pulp from which paper is made. Water is used for preparation of the pulp liquor and for steam generation to 'cook' the pulp. In turn, this produces one of the industry's worst effluents, called 'Black Liquor' that is very difficult to treat and is very toxic in nature. For every ton of paper produced, about 200 M^3 of water is used on an average by the Indian paper industry as against a world average of 25 to 75 M^3 and US average of 20 M^3 of water for every ton of paper produced. Due to large requirement of water, most of the paper mills in India are situated next to a surface water source, mostly perennial rivers. It is also the reason for high water usage since water is not priced commercially to these mill owners.

Through proper water use, modern equipment and techniques, water consumption in paper industry can be reduced drastically as results in the US have shown.

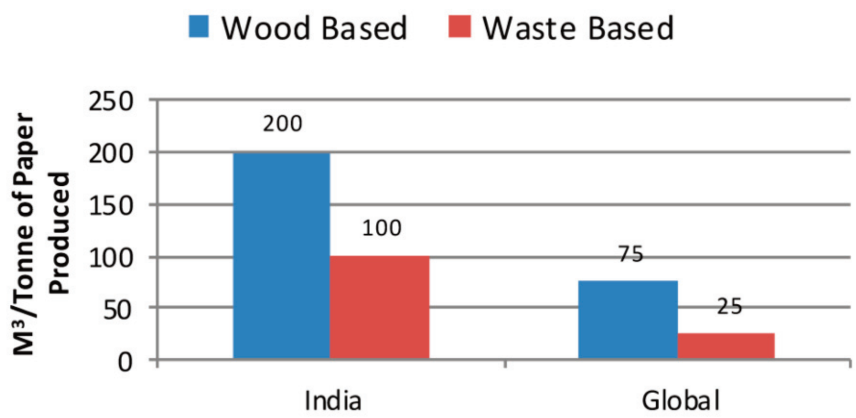


Chart 14 - Water used per ton of paper produced (Centre for Science and Environment, 2012)

Textiles Industry

The textiles industry is a large consumer of water; it is required for cleaning of raw material, preparation of dyes and washing the finished product. In turn it produces effluents that contain harmful chemicals, grease, oil and solvents along with difficult to remove colors that make treatment of these effluents one of the most difficult ones in the industry. For every ton of fabric produced, depending upon the type of fabric produced – cotton or manmade fiber, India uses 300-225 M^3 [7] of water for every ton of fabric produced. This is much higher as compared to the world average of 100 M^3 to 75 M^3 per ton of fabric used.

Sl. No.	Purpose	Percentage water use	
		Cotton Textiles	Synthetic Textiles
1	**Steam generation**	5.3	8.2
2	**Cooling water**	6.4	-
3	**Demineralized water for specific purpose**	7.8	30.6
4	**Process water (Raw water)**	12.3	28.3
5	**Sanitary use**	7.6	4.9
6	**Miscellaneous and Fire fighting**	0.6	28.0

Table 10 - Water Use in Indian Textile Industry (Chougule & Sonaje, 2012)

Through use of modern reagents, chemicals, which are environment friendly, processes, modern techniques and recycle and reuse of effluent, the Indian textiles industry can reduce its specific water consumption considerably thereby making it competitive and also helping the society upon which it depends for survival. Recycle and reuse is being slowly adopted by the industry more as a last resort rather than a proactive action from their side.

[7] *Source : CSE report "Down to Earth – To Use or to Misuse" and Case Study of Tirpur Textile Industry*

Indian Sugar Industry

Sugar industry is one of the largest industries of India giving livelihood to large numbers of farmers in Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. It requires large quantities of water for washing, cleaning, juice extraction and steam and power generation. Thus, the sugar industry is very water intensive. For every ton of sugarcane crushed, 2 M^3 (2,000 lt)[8] of water is consumed and 1 M^3 (1000 lt) of effluent is produced. An average sugar mill with a crushing capacity of 3500 tons of cane per day (3500 TCD) and producing 400 tons of sugar per day, will require about 7000 M^3 (or 7 Million liters) of water per day. While the global average standard is 0.8 M^3 of water per ton of sugar crushed.

Sugar production generates lot of hot juice which after proper treatment can be reused in the factory thereby reducing the water requirement by almost one-fifth of today's requirement. This will not only reduce the water requirement and effluent generation but also will reduce the energy demand to produce sugar making the industry more competitive.

Water used in the Domestic Sector – Higher in Urban, Low in Rural

Chart 15 - Daily Water use by an Urban Indian in liters (Grail Research, 2009)

The domestic sector uses a paltry 2 percent (Food and Agriculture Organization of United Nations, 2012) of the total water in India, it is unequally distributed; while the urban population consumption is at 195 liters per person per day (as against the global average of 135 liters), rural population of India consumes as low as 50 liters per person per day and in some villages of India, just sufficient water to drink (2 liters per person per day) and to cook (10 liters per person per day). Thus water for domestic sector in India is highly inequitably distributed.

The rural population faces the challenges of access to clean drinking water as laid down by the World Health Organization. Owing to non-existence of a distribution system, in many villages in certain parts of the country, water for drinking and cooking purposes has to be brought from as far as 6 kilometres away daily, the womenfolk often carrying out this difficult task. But with increase in per capita incomes of the rural population, villager's demand for clean drinking water has been increasing every day and is bound to increase further in the future. India will face the daunting task of supplying water to its rural population in a fair and equitable manner for all. This will put increased pressure on water availability and distribution systems. The rural population will have to resort to schemes for recharge of aquifers and wells in the rural sector, a proper distribution system and, a pricing mechanism that supports the true cost of distribution.

[8]*Source: Central Pollution Board magazine - Parivesh*

An urban Indian today uses 195 liters of water at home daily as against a global average of 135 liters. These cities have age old water distribution systems, in most of the cases laid down by the British. Water supply to the city areas is not priced based on use, but priced on a lump sum linked to the floor area of the dwelling. This has resulted in high water consumption without appropriate revenue coming from it.

The rapid urbanization growth has not been coordinated with proper utility planning. As a result, the new growth areas are without proper water supply lines or, even if they have, the capacity is inadequate and people resort to ground water sources causing depletion of water table levels in these cities.

Waste Water Generation and its use

For a nation that uses 73 Billion M^3 of water for its industry and domestic sector, there is lack of credible information about the waste water generated by these two sectors. The Central Pollution Control Board of India estimates that the total waste water generated is only 18 Billion M^3, which is 25 percent of the total water used! However, much of the sewage and effluent generated in India is not measured; hence the actual figures could be several times higher than this. In tier I cities, only 30 percent of sewage generated is treated and then discharged into rivers, in tier II cities, which are growing the fastest, only 7 percent of the sewage is treated! Sewage treatment and recycle can be a solution to the water supply shortage that many new cities in tier II and metros in tier I face. Recycle of all the domestic sewage could provide an additional 26 Billion M^3 [9] of water for use, that is 50 percent of present water quantity used. This presents a huge opportunity for companies to bring their latest technologies and methods into this sector and help in solving the water scarcity issues for urban India.

Extensive Use of Chemicals

Runoff from agricultural fields contains pesticides & fertilizers that pollutes surface water

- Use of pesticides increased from ~1 MM tons in 1948 to 52 MM tons by 2001
- ~47% of irrigated areas in India lie in the Ganges basin which contains chemicals such as HCH2DDT3, methyl malathion etc. in excess of international standards
- Use of fertilizers in India has increased from 0.55 Kgs/hectare in 1950 to 90.12 Kgs/hectare in 2001–2002
- High fertilizer use has led to eutrophication4in several water bodies, such as the Hussein Sagar in Hyderabad and Nainital in UP reused for agriculture causing health hazards

Ibid: (Grail Research, 2009)

[9] *Assuming that 80 percent of the domestic water is generated as sewage and that 60 percent of the sewage can be recycled for use*

Industry uses an estimated 17 Billion M^3 of water annually (Food and Agriculture Organization of United Nations, 2012) and the corresponding effluent generated is estimated at 4.2 Billion M^3, that is just 25 percent of the total water use, too low to be true. The norm for effluent generation at industries' aggregate level, (though it varies from industry to industry), is at least 60 percent of the water use, which would mean an effluent potential of 10 Billion M^3 a year. What therefore is required is stricter monitoring and regulations so that all the industries adopt effluent treatment methods, either at their own premises or at a Common Effluent Treatment Plant. Recycling of this effluent has the potential to generate another 6 Billion M^3 of water annually, for the industry's own use.

Untreated Waste Water

Untreated wastewater is responsible for polluting water resources

- Small and medium plants do not invest in effluent s e.g., over 3,000 units in Ankleshwar, Gujarat discharge ~270 MM liters of effluents each day
- Untreated domestic wastewater is reused for agriculture causing health hazards

Ibid: (Grail Research, 2009)

Water Use Challenges for the Future

a) Agriculture Sector

i) **Increased water demand for food production.** India's population is estimated to be one of the largest in the world 40 years from now. The demand for food is expected to increase by twice the population growth and hence the pressure on water for agriculture. Though, this expectation is based on the past trend that specific water consumption for crops in India will decrease, the absolute water quantity will still increase by 2 percent every year. The challenge would be to meet this demand through existing water resources and irrigation methods.

ii) **Water Distribution.** To meet this increased agricultural water demand, India will need to build more irrigation canals, check dams and develop an efficient distribution system for agricultural water. Equitable water distribution will be the key. While water is a state subject, it will need coordination between various states to develop a policy for water distribution and its use.

iii) **Efficient use of water for the crops.** How to use water more efficiently than what is being done today would be a challenge. Perhaps adoption of modern cropping methods, seeds and education to farmers would be crucial to decreasing the water footprint of these crops.

b) Industry

i) **Increased water demand to meet higher power generation and economic growth.** If India's economy has to grow at an average rate of 7 percent year on year for the next 30 years, then India's power generation capacity has to add more than 600 GW in the next 30 years. This will require large quantities of water. To meet this demand, power plants may require more advanced technologies and different plant configuration for water treatment. Perhaps integrated electricity and water treatment plants will have to be designed like the ones being used in the Middle Eastern region.

ii) **Increased effluent generation and its treatment.** As water usage by the industry increases, more effluents will be generated. A policy for regulation of effluent treatment norms and its monitoring will become a necessity.

iii) **Sludge disposal will become a huge problem.** As the industry adopts more modern and efficient methods of effluent treatment, it will result in larger quantities of sludge generation than what is being generated presently. A sludge disposal management and policy will be required to be put in place. Space required for sludge disposal has also to be thought of. Presently, there are space constraints for disposal of sludge, which is sometimes toxic and poses health hazards at storage sites.

iv) **Use of modern technologies.** Indian water and waste water treatment industry and its users still prefer to install old technologies that consume more space, electricity and are less effective than the modern technologies available overseas. Adoption of these technologies through statutory regulations will help in bringing in efficiency of treatment in a big way. Technologies that need less space, ability to handle fluctuations in input quality and quantity and treat water using fewer chemicals will have to adopted by the industry.

c) Domestic Sector

i) **Metering of Water.** Most of the domestic water supply in India is not metered. As a result, true consumption is not known and hence equitable distribution does not take place. If India has to meet the domestic demand, it has to adopt equitable water supply and hence installation of water meters is essential. This will be a huge requirement and will take time. Execution of installation of water meters also has political overtones and will therefore require political will for implementation.

ii) **Distribution System.** The water distribution systems in most tier I cities and some tier II cities are very old with no plans of the existing system. Building plans of the existing and new system will be a huge challenge – time consuming and resource intensive.

iii) **Prevention of pipeline leakages.** Pipelines being old and archaic, there are often leakages that lead to supply losses. Every time this happens, a short term repair approach is taken up. A systematic method for assessment of pipeline condition and repairs or replacement has to be taken up and the pipelines upgraded.

iv) **Pricing of Water.** This has been a contentious issue with both political and social implications. But it is unavoidable and must be implemented if water supply to the cities has to improve for better quality of service.

v) **Sewage treatment, recycle and reuse.** All city sewage must be treated and reused for non-critical use in the domestic sector. This will reduce the pressure on water supplies for the cities.

vi) **Adoption of Rain Water Harvesting by societies and Water Shed Programs.** This would be crucial to increase water availability for rapidly increasing urban habitats.

d) Waste Water Treatment

Pollution from industries and untreated sewage discharge has polluted 14 percent of the Indian rivers severely and 19 percent of the rivers to a lessor extent. This is hazardous for agriculture and livestock as they are dependent on this source for water. Additionally, this is causing health problems for human beings due to contamination by pesticides and dangerous chemicals. Adoption of sewage and effluent treatment plants would be critical to reduce this pollution and increase water availability in the country. Adoption of advanced technologies for effluent treatment by the industry and for municipalities for sewage treatment would be a challenge given the familiarity of existing technologies with consultants and plant manufacturers.

Recommendations

i) **Price electricity supply beyond 100 units** consumption per month per acre of land to be charged to the farmers at Rs. 2 per unit wherever it is being supplied free of charge. This will bring down overuse and misuse of water in this sector thereby reducing the water consumption as well. This should be done through participation of the farmers and a water pricing body which should be autonomous.

ii) **Water metering must be completed for all users in the domestic sector in the next five years.** Smart meters to be installed in tier I cities first followed by tier II cities. This will help in assessing the losses in distribution and true usage of water by each household. The funding can either be done through monthly bills, or in case of privatized supplier, by the utility company.

iii) **Water Regulatory Body to be formed immediately.** This important step has been long pending to bring in standards, policies, equitable distribution and fair pricing in to this sector. This Water Regulatory Body must be an independent body formed under the Ministry of Water Resources, Government of India, consisting of eminent economists, social scientists, agriculturists and NGO who will look in to the water withdrawal requirement sector wise and create an equitable distribution policy for water for all sectors. Since water is a state subject, a Central Water Regulatory Board can lay down the guidelines and policies based on consensus, whereas, the State Water Regulatory Board shall be responsible for allotment of water resources in the states.

iv) **A Water Efficiency Body.** Water is as important as energy and hence on the lines of Energy Efficiency, a Bureau of Water Efficiency to measure and regulate water use in the domestic and industry sector would help in bringing down the specific fresh water consumption in these sectors, thereby decrease the water withdrawal for these sectors. For example, per household, the highest star rating of 5 should be given to those who consume 125 liters of water per person per day and 1 star to those who consume 195 liters per day. Some of the major users of water like washing machines, car wash, power plants must have benchmarking for water use. This will also help in increasing reuse of water in domestic, commercial and industrial sectors.

v) **Fair Water Pricing** based on true delivered cost to the consumer and based on usage pattern, on lines of electricity pricing mechanism will help in making this sector attractive for investment and therefore its growth. The pricing of water should be the responsibility of the Water Regulatory body with the Central Body developing a mechanism for pricing and each state fixing the prices for each sector. Just like electricity is priced, each utility should present their Annual Rate of Returns (ARRs) to the regulatory body every year and the water priced should be fixed by the State Commission.

vi) **Increase the pace of water utility privatization.** Privatisation will bring in more financial resources for up gradation of technology and capacity enhancement required to meet the increased demands especially from the domestic and industry sector. Privatization has started in some of the city circles like Latur, Nagpur, Bangalore and some more tier II. However, the largest users of water, the Metro cities, have been left out. Metro cities since consume maximum water, metered and unmetered, must be privatized immediately as it will help implement latest distribution techniques that will help in curbing overuse of water and make sure the neglected segments are served. Large volumes will bring in more revenues that can be used by the utility services companies to address the less privileged and less served sectors.

vii) **Modern Technologies** will help in solving many of the current challenges being faced by this sector specially to treat more difficult water qualities, sewage treatment plants occupying less space and consuming less chemicals with lower operating cost. Some of the technologies that will help in faster implementation of waste water treatment and its recycle are Moving Bed Biofilm Reactor (MBBR), Membrane Bio Reactor (MBR), Sequencing Batch Reactor 9SBR), Fuildized Anaerobic Bed Reactor (FAB) and High Rate Media Assisted Clarifiers (HRMAC). These occupy less space, can handle a variety of waste water qualities and fluctuations in input of waste water quality, which the conventional technologies being used today cannot handle.

viii) **Implement the suggestions of the Indian National Water Policy 2012** specially that fair access of water to all the sectors, ground water development, allocation priorities to different sectors, fixing of water prices so that the value of supply is understood by the users, creation of water zones and water conservation be taken up on priority.

ix) **Compulsory Rain Water Harvesting** for all urban dwellings in tier I and II cities. This will ease the pressure on the Municipalities. While today many urban societies claim to have implemented rain water harvesting, the reality needs to be checked and a monitoring mechanism should be put in place to see that rain water harvesting is being used.

x) **Make Effluent Recycle compulsory** for all industries consuming large quantities of water in their process and adhere to Zero Liquid Discharge norms strictly through regulations, reward and recognition methods. Any extra water demand from the existing industries should be met as much as possible through waste water recycle method and only then should extra fresh water supply be considered.

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