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The Perfect Storm

Pathways to Managing India’s Water Sector Sustainably

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Authors

United Nations Resident Coordinator's Office (UNRCO) – Narae Kim, Swastik Das

Council on Energy, Environment and Water (CEEW) – Kangkanika Neog, Rudresh K Sugam (Formerly associated with CEEW)

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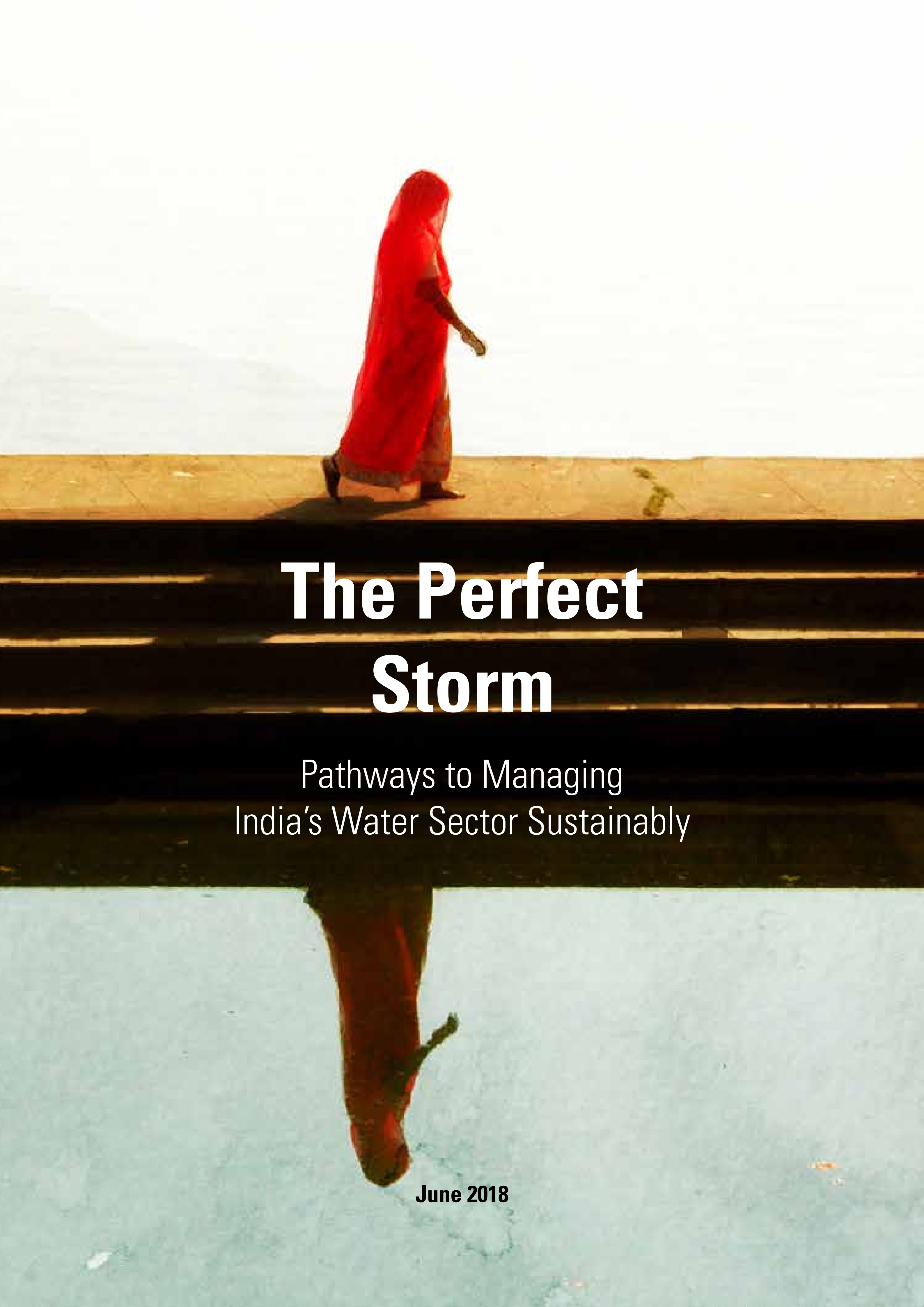

The Perfect Storm

Pathways to Managing India's Water Sector Sustainably

June 2018

Foreword

Water is the ultimate resource. Its impact on energy, agriculture, urbanization, infrastructure, manufacturing and human development is pervasive. India, which is home to about 17 percent of the world's population, has only 4 percent of its water resources. The rising challenges to water security from climate change and population growth have resulted in the demand for this all-important natural resource to far outweigh its supply. If the current pattern of water management continues, about half the water demand in 2030 will remain unmet.

This white paper presents a snapshot of the pressing issues faced by India's water sector, and recommends possible solution pathways towards sustainable management of India's water resources. The paper is the result of a partnership between the United Nations in India and the Council on Energy, Environment and Water.

Improved water management is essential to sustainable development, and this paper was motivated by, what we felt was, the urgent need for a holistic and strategic approach to the water sector in India. Continuing with a 'business as usual' attitude leaves this sector vulnerable to the crisis of mismanagement. By highlighting the crucial challenges and priority areas and offering recommendations to policy makers and planners, we hope to make a positive contribution to ongoing discussions on sustainable water management in India.

Yuri Afanasiev
United Nations Resident Coordinator, India

Arunabha Ghosh
CEO, Council on Energy, Environment and Water

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List of Abbreviations

Acronym	Description
ASCI	Administrative Staff College of India
AWD	Alternative Wetting and Drying
BCM	Billion Cubic Meter
CACP	Commission for Agricultural Costs and Prices
CEEW	Council on Energy, Environment and Water
CESC	Calcutta Electric Supply Corporation
CETP	Common Effluent Treatment Plant
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
CSO	Civil Society Organisation
CWC	Central Water Commission
DEWAT	Decentralized Wastewater Treatment System
DHAN	Development of Humane Action
DPC	Data Processing Centre
DWSS	Department of Water Supply and Sanitation
ESR	Elevated Storage Reservoirs
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GP	Gram Panchayat
HH	Household
HIS	Hydrological Information System
HUF	Hindustan Unilever Foundation
IFAD	International Fund for Agricultural Development
IIM	Indian Institutes of Management
ILA	International Law Association
IMD	India Meteorological Department
IPC	Irrigation Potential Created
IPCC	Intergovernmental Panel on Climate Change
IPU	Irrigation Potential Utilised
ISRO	Indian Space Research Organisation
IWMI	International Water Management Institute

Acronym	Description
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
JSYS	Jala Samvardhane Yojana Sangha
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoEFCC	Ministry of Environment, Forest and Climate Change
MSP	Minimum Support Price
NAQUIM	National Project on Aquifer Management
NASA	National Aeronautics and Space Administration
NBA	Nirmal Bharat Abhiyan
NABARD	National Bank for Agriculture and Rural Development
NRHM	National Rural Health Mission
NRW	Non-Revenue Water
NSSO	National Sample Survey Organisation
PH&ED	Public Health and Environment Directorate
PPP	Public-Private Partnership
SCADA	Supervisory Control And Data Acquisition
SCI	System of crop intensification
SDGs	Sustainable Development Goals
SEWA	Self-Employed Women's Association
SPCB	State Pollution Control Board
SSA	Sarva Siksha Abhiyan
TERI	The Energy and Resources Institute
ULB	Urban Local Body
UNCIW	UN Convention on the Law of the Non-Navigational Uses of International Watercourses
UNIDO	United Nations Industrial Development Organization
UWSS	Urban Water Supply and Sanitation
WTP	Water Treatment Plant

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Executive Summary

India, which is home to around 17 percent of the world's population, has only 4 percent of its freshwater resources. With rapid economic growth and a growing population, decreasing per capita average annual water availability in India has become a cause for concern, especially since the country has already entered the 'water stressed' category. Furthermore, unplanned urbanisation, untreated effluents emitted by industries have resulted in increasing water contamination at an alarming rate, while groundwater suffers from over-extraction and contamination. Along with other factors, climate change is also expected to pose serious challenges to the quality and quantity of water and lead to water-related natural disasters. This white paper attempts to succinctly, yet comprehensively present India's water-related characteristics, and suggest short-term and long-term policy reforms aimed towards sustainable water management. The pathways suggested, move away from viewing the water sector through fragmented lenses and move towards adopting a holistic approach of looking at the interlinkages between water and other sectors.

Water is a critical resource that lies at the heart of social and economic growth. Water is essential to survival, and its absence can impact the health, food security, and livelihoods of families across the world. Currently, global water demand has been estimated at approximately 4,600 km^3 per year and is expected to increase by 20-30 percent by 2050. In addition, the UN World Water Development Report 2018, Nature-based Solutions for Water, warned that, even at present, approximately 3.6. billion people live in areas that are potentially water-scarce, a number which could soar to 4.8-5.7 billion by 2050. The trends in water availability and quality are accompanied by increasing risks of water-related natural disasters such as flood and drought. Currently, an estimated 1.8 billion people are affected by land degradation/desertification and the population at risk from floods is expected to increase from 1.2 billion in 2018 to 1.6 billion in 2050. Water will not only have one of the biggest impacts on society in the coming decades but also one of the most drastic ones.

India's water resources are under immense pressure due to declining per capita water availability, lack of storage capacity, and spatial and temporal variation. In recent years, decreasing per capita average annual water availability in the country has become a cause for concern, especially since India has already been categorised as a 'water stressed', as per the United Nations classification. In addition, the issue of water contamination is also rapidly increasing due to large-scale, unplanned urbanization and untreated effluents emitted by industries. Surface water bodies have lost their ecological function. A rapid decline has also been observed in groundwater quality, with nearly half of India's groundwater being polluted with several poisonous contaminants including arsenic and fluoride. The above-mentioned challenges, along with the ever-present threat of their further intensification due to climate change, are poised to alter water supplies and intensify floods and drought in the future.

In a scenario where population growth and climate change present unprecedented complications, challenges to sustainable water management are inevitable. This white paper attempts to analyse water management challenges through two lenses- sectoral water management which covers the challenges faced by the major water use sectors; and governance and institutional challenges, which address the need for policy and implementation reforms.

In the coming years, the need for greater economic growth will require propelling from a multitude of resources, water being one of the key ones. Since all sectors in India are poised to grow simultaneously, this will result in commensurate inter-sectoral (and inter-state) competition for water. With traditional water supply augmentation options running their course, it is highly likely that India will struggle to manage both the quality and quantity of water requirements by different sectors. Thus, the scarcity of water could become a limiting factor for the country's socio-economic growth.

The complexity of water governance makes the task of water management all the more challenging. Water disputes surrounding the Indus, Ganges and Brahmaputra basins are unlikely to be resolved by maintaining the status quo of bilateral water sharing treaties with vague clauses and redressal mechanisms.

The water sector in India requires attention, which is holistic and strategic in nature. Continuing a 'business as usual' approach leaves the sector vulnerable to the crisis of mismanagement. By highlighting the crucial challenges and priority areas, possible pathways for sustainable water management are articulated in this paper from water resources management, wastewater management, sectoral reforms to data innovations, multi-institutional coordination and transboundary reforms.

In order to successfully navigate through the increasing demands on the available water resources and for finding solutions to the challenges faced, it is vital that a sound understanding of the nexus of water resources with other sectors – energy, food and agriculture, trade, health, human rights, education – is established.

Ensuring availability and sustainable management of water and sanitation for all is at the core of the Sustainable Development Goals (SDGs). The SDGs, which are an inclusive global agenda for development over the next 15 years, were adopted in 2015 by 193 member states of the United Nations, including India. This paper articulates why sustainable management of clean water is inextricably linked to all SDGs as well as India's national priorities on poverty eradication, food security, good health and well-being, gender equality, reliable energy, economic growth, resilient infrastructure, sustainable industrialization, consumption and production. It also aims to highlight the Government of India's commitment to the SDGs and sustainable water management.

Chapter 1

The Water Sector in India: An Introduction

India is home to around 17 percent of the world's population but has only 4 percent of its water resources. Inland water resources like rivers, canals, reservoirs, tanks, lakes, ponds, derelict water and brackish water, lie at the core of social and economic growth, and are crucial for supporting a large percentage of the population. Water resources provide a range of services not only for the industrial and manufacturing sector, but also for the poor and deprived communities who derive economic and non-economic benefits from it. With the Indian economy growing at an exponential rate and rising to the sixth position on the United Nations Industrial Development Organisation (UNIDO) scale of largest manufacturing countries, the dependence on water resources becomes increasingly significant.

"Water stressed" with decreasing water availability

Owing to the country's size, India experiences considerable spatial and temporal inconsistencies with regards to the availability of water resources. As a result, access to water in many regions is considerably lower than the national average. The per capita availability of water in the country reduced from 1,816 m^3/year to 1,545 m^3/year, during 2001 and 2011[1], which is concerning. The estimated values for 2015 and 2050 are 1,340 m^3/year and 1,140 m^3/year, respectively[2]. As per UN classification, an area experiences water stress when annual water supplies drop below 1,700 m^3/capita. Therefore, India's status as a "Water Stressed" country reiterates the need for sustainable water management.

The following section provides a brief overview of the characteristics of water sources in India, beginning with a description of Rainfall received.

Unequal temporospatial distribution of rainfall

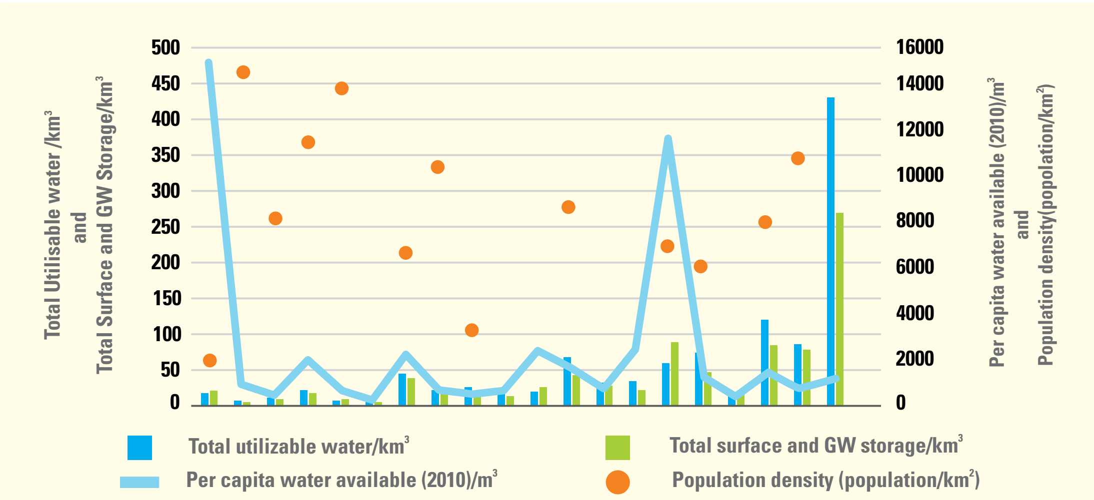
India receives an average annual rainfall of around 1,100 mm, but there is vast regional and temporal variation in its distribution. The country receives more than 80 percent of its rainfall between June and September. Aided by ice and snow melting from the Himalayan glaciers, the rivers originating from this mountain range such as the Ganges, Brahmaputra and Indus carry water all year round. As a result, more than half of India's water resources are located in various tributaries of these river systems. The

[1] Ministry of Water Resources [MoWR], 2015. Press Release: Per Capita availability of Water. [Online] Available at: http://pib.nic.in/newsite/PrintRelease.aspx?relid=119797

[2] Irrigation Management Organization. (2016). "Report on the spot study of Water situation in drought affected areas of the Country (2015-16)". New Delhi: Water Management Directorate

[3] Central Water Commission. (2015). "Water and Related Statistics". New Delhi: CWC

Figure 1.
Characteristics of water resources across river basins in India



Key *(from left to right): Minor river basins draining into Bangladesh & Myanmar; Subernarekha; Pennar; Brahmani & Baitarini; Mahi; Sabarmati Narmada; Tapi; West flowing rivers of Kutch, Saurashtra including Luni; East flowing rivers from Mahanadi & Pennar; West flowing rivers from Tapi to Tadri; Mahanadi; Cauvery; West flowing rivers from Tadri to Kanyakumari; Brahmaputra, Barak, others; Indus (up to the border); East flowing rivers between Pennar & Kanyakumari, Godavari, Krishna, Ganga*

Source: *Central Water Commission, 2015[3]* average productivity of water per unit area of the Himalayan rivers is approximately two times more than that of the south peninsular river systems, illustrating the contribution of these melting glaciers to India's water resources[4].

The unequal spatial distribution can be observed in the Brahmaputra and Barak basins. The basins cover only 7.3 percent of India's geographical area and 4.2 percent of its population, yet account for 31 percent of the annual water resources. Further the utilizable water resources are just 28 percent (1,123 Billion Cubic Meter, BCM) of the total water resources available in India (4,000 BCM). The Ganga basin is the largest basin in terms of both: population and area, and has the highest total utilizable water resources and surface and groundwater storage. However, due to high population density in the region, the per capita water availability is around 1,039 m^3, significantly lower than the national average. Alternatively, the Brahmaputra-Barak basins have 59 BCM and 88 BCM of total utilizable water resources and surface and groundwater storage respectively, but owing to its smaller size and population, the second highest per capita water availability (11,782 m^3/capita). Lowest per capita water availability is found in the Sabarmati basin, which also has the smallest catchment area, whereas, the highest can be found in the sparsely populated minor river basins draining into Bangladesh and Myanmar. These are just some examples that demonstrate how factors such as: population density, area, water resources and storage capacity, along with cropping pattern and urbanisation have a combined effect on determining the nature of water security in various regions. As a result India has witnessed instances where one state is experiencing floods while another is facing droughts.

In a study by Kumar et. al., monthly, seasonal and annual trends of rainfall were studied, using monthly data series of 135 years (1871–2005) for 30 sub-divisions (sub-regions) in India. They found that the northwest region of India not only receives the lowest rainfall but it also experiences maximum variation in precipitation, making it highly vulnerable to climate change. They also concluded that at the national level, annual and monsoon rainfall has decreased, while pre-monsoon, post-monsoon and winter rainfall has increased.[5]

Increasing groundwater extraction

India is the world's largest extractor of groundwater, followed by the United States of America (USA), China, Iran and Pakistan. Together, these 5 countries account for 67 percent of total abstractions worldwide. In rural India, groundwater supports more than 60 percent irrigation and 85 percent drinking water requirements. It is rightfully considered a lifeline for India, however, it is depleting at an unprecedented rate. Out of the total annual renewable groundwater resources of 433 BCM, the current estimated draft in India is around 250 BCM (63 percent). In 2011, of the total units (6,607) assessed by the Central Ground Water Board (CGWB) of India, 697 were reported Semi-Critical, 217 Critical, 1,071 Over-exploited and 92 Saline. Similar to the situation of surface water, groundwater availability and utilisation potential are uneven across the country, due to the varying geo-hydrological properties. In north western states of Punjab, Haryana, Delhi and western Uttar Pradesh, replenishable groundwater resources are high, but due to over-extraction the groundwater draft has crossed the annual groundwater recharge level. As per a National Aeronautics and Space Administration[6] (NASA) report, the estimated rate of water table decline in northwestern India is around 0.3 m per year. States such as Rajasthan and Gujarat have arid climate and therefore groundwater recharge is low. In the peninsular states such as Karnataka, Andhra Pradesh etc., the aquifer properties restrict groundwater availability. Whereas in eastern states such as West Bengal and Bihar, the groundwater potential is high but development of groundwater potential is low, largely due to the lack of power availability and water quality issues[7] . Overall, India in a real sense is mining groundwater and is way ahead, in terms of the total groundwater withdrawal of various countries (see figure no 2).

The Easement Act of 1882 provides every landowner with the right to collect and dispose of all water under the land and on the surface within his or her limits. The consequence of this law is that, the landowners can dig wells and extract water based on availability and their judgment. Additionally, landowners are not legally liable for over-extraction, which can result in damage to the water resource. The lack of regulation for over-extraction of water resource worsens the circumstances.[9]

In India, the availability of surface water is greater than groundwater. However, owing to

[4] Gangwar, S. (2013). "Water Resource of India: From Distribution to Management", International Journal of Infmoration and Computation Technology, Vol.3, No.8, pp. 845-850

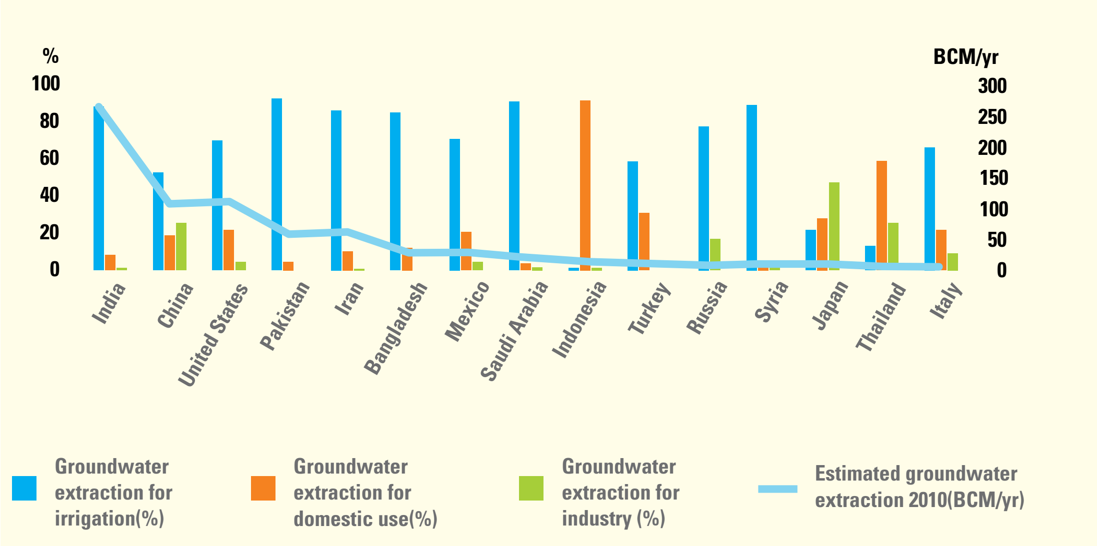
[5] Vijay Kumar, S. K. (2010)."Analysis of Long-Term Rainfall Trends in India", Hydrological Sciences, 55:4, 484-496. doi:10.1080/02626667.2010.481373

[6] NASA: The National Aeronautics and Space Administration is an independent agency of the executive branch of the United States federal government responsible for the civilian space program, as well as aeronautics and aerospace research.

[7] CGWB.(2014)."Dynamic Ground Water Resources of India, 2011".

Figure 2.

Top 15 nations with the largest annual groundwater extractions (2010)



Source: *Adapted from National Ground Water Association data, 2016* [8]

the easy accessibility of groundwater, it forms the largest share of India's agriculture and drinking water supply. The relative contribution of canal irrigation has been steadily declining over time while groundwater, especially that extracted through tube wells has rapidly grown in significance over the last 40 years.

Groundwater has supported India's growth over the last few decades; however, unregulated expansion of groundwater irrigation is leading to its rapid depletion and making it an unsustainable practice. Considering India's dependency on groundwater as a source of drinking water for the majority, a threat to this resource is a cause for concern.

Services of traditional water bodies and the need for their protection

India is characterized by its unique geographic variability and is endowed with vast reserves of finite natural resources. These include some very diverse and distinctive hydrological units, which are classified as lakes, marshes, estuaries, tidal flats, ponds, river floodplains, mangroves etc. These water bodies are amongst the most productive ecosystems with a rich repository of biodiversity and are known to play an essential role in carbon sequestration.

Given the differences in topography and agro-climatic conditions, structures to utilize and conserve water vary greatly across the

[8] National Ground Water Association.(2016). "Facts About Global Groundwater Usage". [Online] Available at: http://www.ngwa.org/Fundamentals/Documents/global-groundwater-use-fact-sheet.pdf

[9] Suhag, R, (2016). The status of ground water: Extraction exceeds recharge. PRS Blog. Available at: http://www.prsindia.org/theprsblog/?p=3639 [Accessed 24 April, 2018]

Figure 3.

Various services provided by traditional water bodies

Source: *Bassi et al., 2014*[13] *; Choi & Wang, 2004*[14]*; Sahu, 2015*[15] country. However, these water bodies are under continuous stress, caused primarily by demographic pressure and economic growth. In the last few decades, there has been a decline in both the quality and quantity of these water bodies. This has negatively impacted the ecosystem. These entities have been exploited to the extent that their potential to render various economic and environmental services has reduced drastically. The major reasons of vanishing water bodies in India are: unplanned urbanization[10], industrialization[11], chemical intensive agriculture, degradation of catchment areas, illegal mining activities[12], unplanned tourism activities (Dal Lake in Srinagar, Tso Moriri and Pangong Tso Lake in Ladakh), cultural misuse etc.

The recent floods in Chennai are an alarming reminder of the consequences of allowing traditional water bodies to fall prey to unplanned urbanisation. In India, water management was primarily done by the citizens and communities who collectively maintained the local water bodies. The introduction of the centralised system increased the dependence of the locals on the larger supply systems: canal and/or piped. This shift of control from communities to formal governance structures made the water management system weak and traditional water bodies suffer immensely.

Realising the importance of these water bodies, several interventions such as the Jal Yukt Shivar in Maharashtra, Mission Kakatiya in Telangana etc. have been initiated. For the creation of local water bodies, a sizable amount of funds has also been allocated under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA).

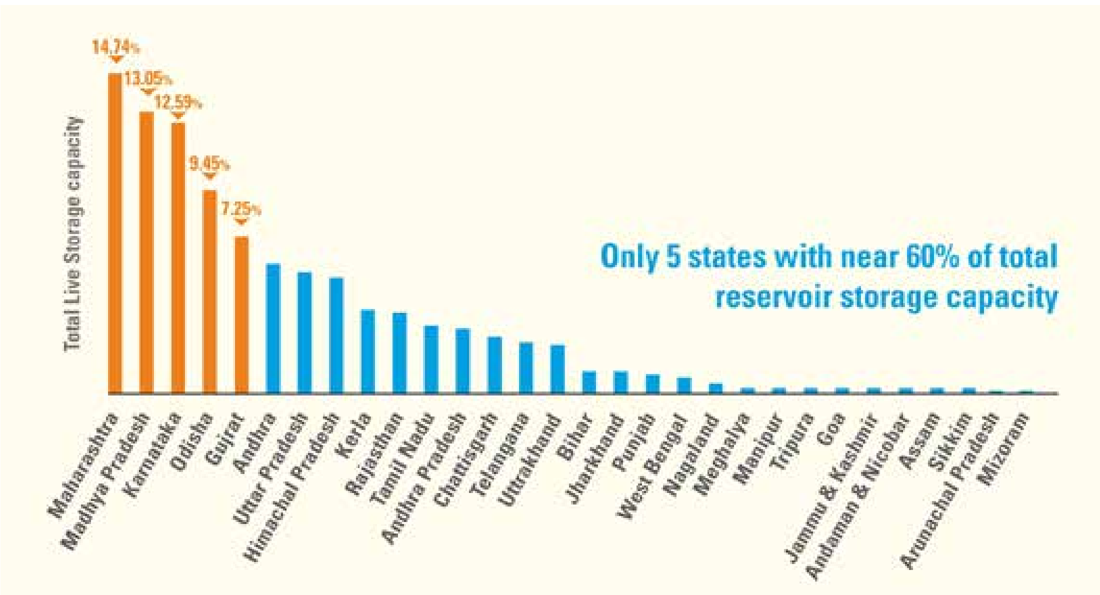
However, urban planning has shown little regard. The kind of urban development experienced recently has left major cities devoid of these important ecological entities. Similar experiences of rural areas demonstrate that, most of the traditional tanks and ponds have become sewage ponds, posing a grave threat to the health of the local community.

Limited and unequally distributed storage capacity

In every country, water storage structures form an important component of the water management system. In addition to providing a buffer against drought and floods, they have other benefits such as fisheries, hydro-electricity generation etc. The live storage capacity of dams in India is around 253 BCM, which is only 13 percent of the average annual flow. When compared to countries such as Australia (3,223 m^3) and the USA (2,192 m^3), the per capita water storage in India is quite low (209 m^3). To add to the complexity, reservoirs are also unequally distributed within India (see below, Fig. 4).

One of the major challenges impacting the longevity of dams is siltation. Silt deposition rapidly reduces the water storage capacity of such structures and can also have several other impacts, such as damaging the powerhouse turbines, increased evaporation losses and in some cases, increased backwater flooding. In 2015, the Watershed and Reservoir Sedimentation Directorate of the Central Water Commission of India conducted a survey of 243 reservoirs. The analysis of the survey suggests that in most reservoirs, the actual rate of

Figure 4.
State-wise distribution of India's live storage capacity of reservoirs (2015)



Source: *Adapted from Central Water Commission, 2015*[16]

[10]Charkop lake in Maharashtra, Ousteri lake in Puducherry, Deepor beel in Guwahati, Pallikaranai marshland in Bangalore are well known examples of encroachment

[11]Himayatsagar and Osmansager lakes in Hyderabad are now filled with toxic effluents discharged by the industries located nearby and same is the case with Bellandur lake in Bengaluru

[12]The Balsamand lake in Jodhpur, Surajkund lake in Haryana are suffering badly due to illegal mining activities

[13]Bassi, N., Kumar, D., Sharma, A., & Pardha-Saradhi, P. (2014, November). "Status of wetlands in India: A review of extent, ecosystem benefits, threats and management strategies", Journal of Hydrology: Regional Studies, 2, 1-19.

[14]Choi, Y. & Wang, Y.(2004)."Dynamics of carbon sequestration in a coastal wetland using radiocrabon measurements". Global Biochemical Cycles, Volume 18

[15]Sahu, R. K. (2015). "Mega Biodiversity of India". Ahmedabad, Gujarat, India

[16] Central Water Commission. (2015)."Water and Related Statistics". New Delhi: CWC

Table 1.
Rate of siltation of dams in different regions in India

S. No	Region	No. of reservoirs	Median values of rate of siltation (1000 $m^3/km^2/yr$)
1	Himalayan Region (Indus, Ganga and Brahmaputra basins)	**14**	**6**
2	Indo Gangetic Plains	**15**	**28**
3	East flowing rivers upto Godavari (Excluding Ganga)	**5**	**5**
4	Deccan Peninsular east flowing rivers including Godavari and south Indian rivers	**115**	**5**
5	West flowing rivers upto Narmada	**53**	**1**
6	Narmada and Tapi Basins	**10**	**1**
7	West flowing rivers beyond Tapi and south Indian rivers	**31**	**8**

Source: *Central Water Commission, 2015*[17]

sedimentation was more than the design rate of sedimentation. It was also found that the average annual percentage loss in gross storage due to siltation was 0.42 percent.

While large reservoirs do have certain positive impacts such as flood control, water supply and electricity generation, the decision to build new ones has always been contested. This is largely due to the negative externalities they create for the local ecology and communities. The UN World Water Development Report (2018) states that, large-scale water development projects have led to considerable human displacement yet achieved limited food security[18]. A Country Study of India conducted by the World Commission on Dams concluded that, a century or more of large-scale water development has resulted in major social and ecological impacts, including substantial human displacement, soil erosion and widespread waterlogging while, contrary to stated objectives, achieving only limited food security benefits. Another study[19] on the decommissioning of dams highlighted the lack of technical know-how India possesses in order to decommission the numerous large multi-purpose dams constructed.

As previously mentioned, current discussions related to water storage, hydropower and irrigation have focused on whether large dams should be constructed, what is the ultimate solution for large water storage, and in some cases electricity generation. In recent times, check dams and smaller reservoirs have emerged as the temporary solution. The reasons being their ease of construction with local resources, cost effectiveness, groundwater recharge, strengthening of eco-diversity and zero damage to local resources.

Another critical discussion focuses on the potential tension between India and other riparian (upstream and downstream) countries with regards to river water sharing. Most major rivers of India are transboundary in nature; therefore, disagreements are bound to occur if either India or the upstream countries opt for a large reservoir construction. This shall be discussed in detail in the section on transboundary rivers.

Water quality concerns: contamination at an alarming rate

Surface water quality

Large-scale, unplanned urbanization and untreated effluents from industries into numerous surface water bodies such as rivers, lakes, ponds etc., have reduced their ecological functions and left them in an abysmal state. This has had severe negative implications on the health of citizens. The consumption of such contaminated water has resulted in the outbreak of diseases such as cholera, tuberculosis, dysentery, jaundice, diarrhoea, etc. In fact, the consumption of polluted water causes nearly 80 percent of all stomach ailments in India.

The brunt of inadequate sewage treatment facilities in the country is often borne by surface water bodies like rivers and lakes. The results of the water quality monitoring tests carried out by the Central Pollution Control Board (CPCB),

[17] Central Water Commission. (2015)."Compendium on Silting of Reservoirs in India". New Delhi: Watershed and Reservoir Sedimentation Directorate, CWC

[18] WWAP (United Nations World Water Assessment Programme)/UN-Water. (2018)."The United Nations World Water Development Report 2018: Nature-Based Solutions for Water". Paris, UNESCO

[19] Anantha,L.(2013)."Planning for Dam Decommissioning as an Environmental Priority". California: International Rivers

[20] Central Pollution Control Board.(2015)."River Stretches for Restoration of Water Quality". New Delhi: CPCB.

[21] Central Pollution Control Board.(2009)."Status of Water Supply, Wastewater Generation and Treatment in Class I Cities and Class II Towns of India". Delhi.

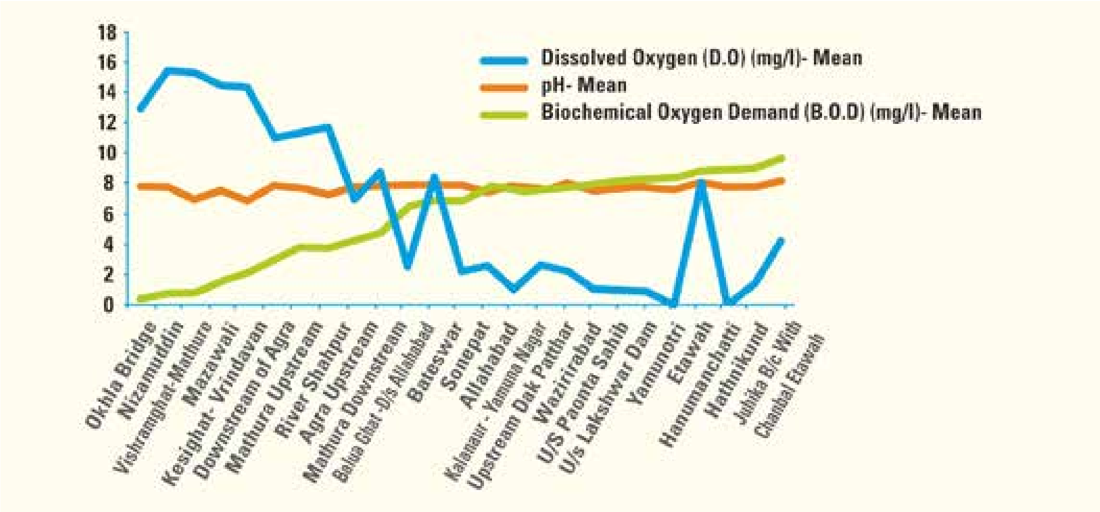
particularly with respect to the indicator for oxygen consuming substances (biochemical oxygen demand, BOD) and the indicator for pathogenic bacteria (total coliform and faecal coliform), do not look promising. While sewage generation is 61,948 Million Litres/Day (MLD), the treatment capacity is just 23,277 MLD. Thus nearly 38,600 MLD flows untreated, polluting 302 river stretches across 275 rivers in the country[21]. 650 towns have been identified along these polluted stretches and of the 45 metropolitan cities in India, 35 cities fall on the banks of these polluted stretches.

Table 2.
Distribution of polluted river stretches across Indian States

State	Cities/ Towns along polluted river stretches	Number of polluted river stretches
Andhra Pradesh	8	6
Assam	49	28
Bihar	8	5
Chhattisgarh	12	5
Daman & Diu	2	1
Delhi	1	1
Goa	9	8
Gujarat	38	20
Haryana	7	2
Himachal Pradesh	14	8
Jammu and Kashmir	18	9
Jharkhand	16	8
Karnataka	24	15
Kerala	22	13
Madhya Pradesh	37	21
Maharashtra	161	49
Manipur	17	12
Meghalaya	12	10
Nagaland	4	3
Odisha	20	12
Punjab	5	2
Rajasthan	20	8
Sikkim	11	5
Tamil Nadu	23	7
Telangana	18	7
Tripura	4	2
Uttar Pradesh	37	13
Uttarakhand	6	5
West Bengal	47	17
Total	**650**	**302**

Source: *Central Pollution Control Board, 2015*[20]

Figure 5.
Water quality of river Yamuna: From origin to confluence



Source: *Central Pollution Control Board, 2016* [22]

[22] Central Pollution Control Board.(2016)."Water Quality of River Yamuna in Delhi". New Delhi: CPCB.

[23] Vashishtha, A. (2015, May 5)."Over half of India's groundwater contaminated with poisonous substances". Retrieved from Mail Online India: http://www.dailymail.co.uk/indiahome/indianews/article-3067842/Over-half-India-s-groundwater-contaminated-poisonous-substances.html

[24] Central Ground Water Board. (2010)."Groundwater Quality in Shallow Aquifers of India". Faridabad: CGWB.

[25] Central Ground Water Board. (2015)."Name of the States/ Districts from where chemical constituents in ground water beyond BIS Norms have been reported". New Delhi: CGWB

One of India's most important and most critically polluted rivers is River Yamuna. In a study undertaken by The Energy and Resources Institute (TERI), analysing the river quality of Yamuna while it crosses Delhi, found that it is almost dead. CPCB also analysed the river's quality and found that, it is worse than sewage when it crosses Delhi (as shown in Figure 5). Vital Central Government missions such as Swachh Bharat and Namami Gange may never be achieved if wastewater and industrial effluents are not properly treated before being discharged into rivers.

Another important challenge to address is the lack of proper sewage treatment of water bodies in smaller towns and cities. While Tier-1 cities do have some capacity for the treatment of sewage, smaller towns are getting increasingly polluted. Water planning in India has never been about wastewater management. However, with the challenges becoming bigger and the consequences more evident, it is time that corrective measures are taken.

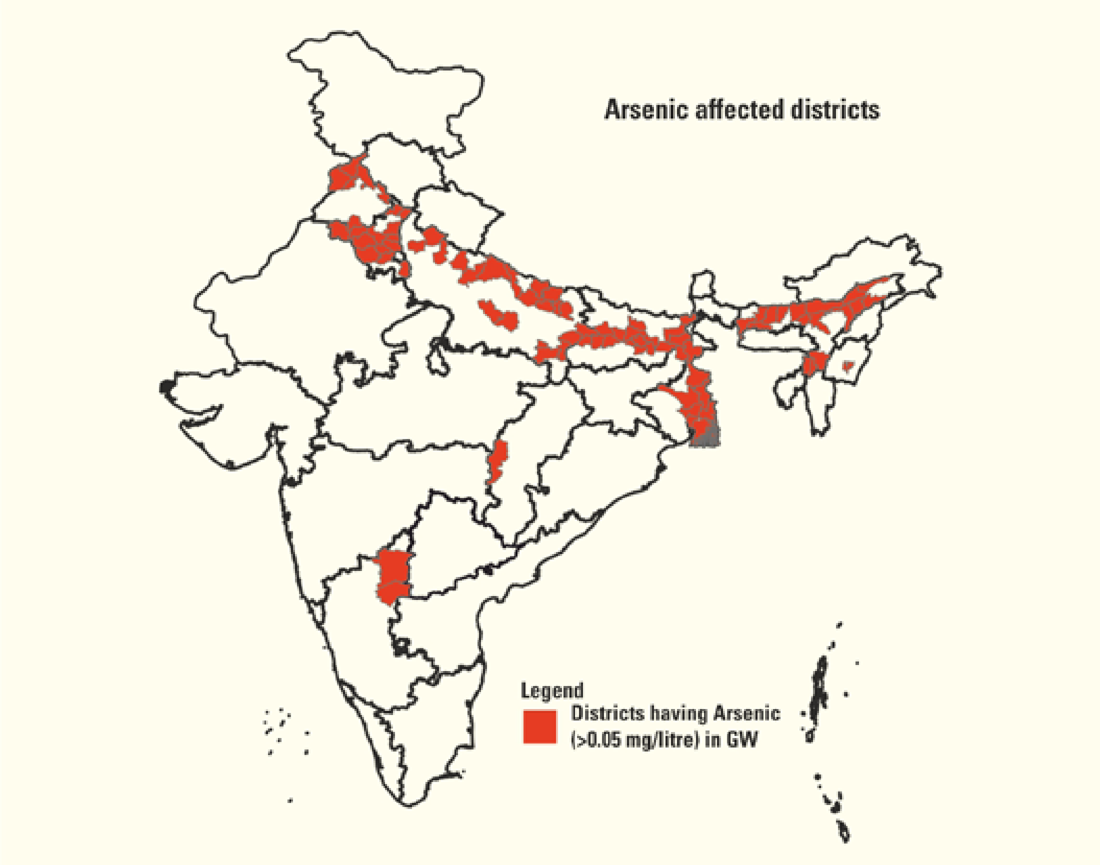
Groundwater quality

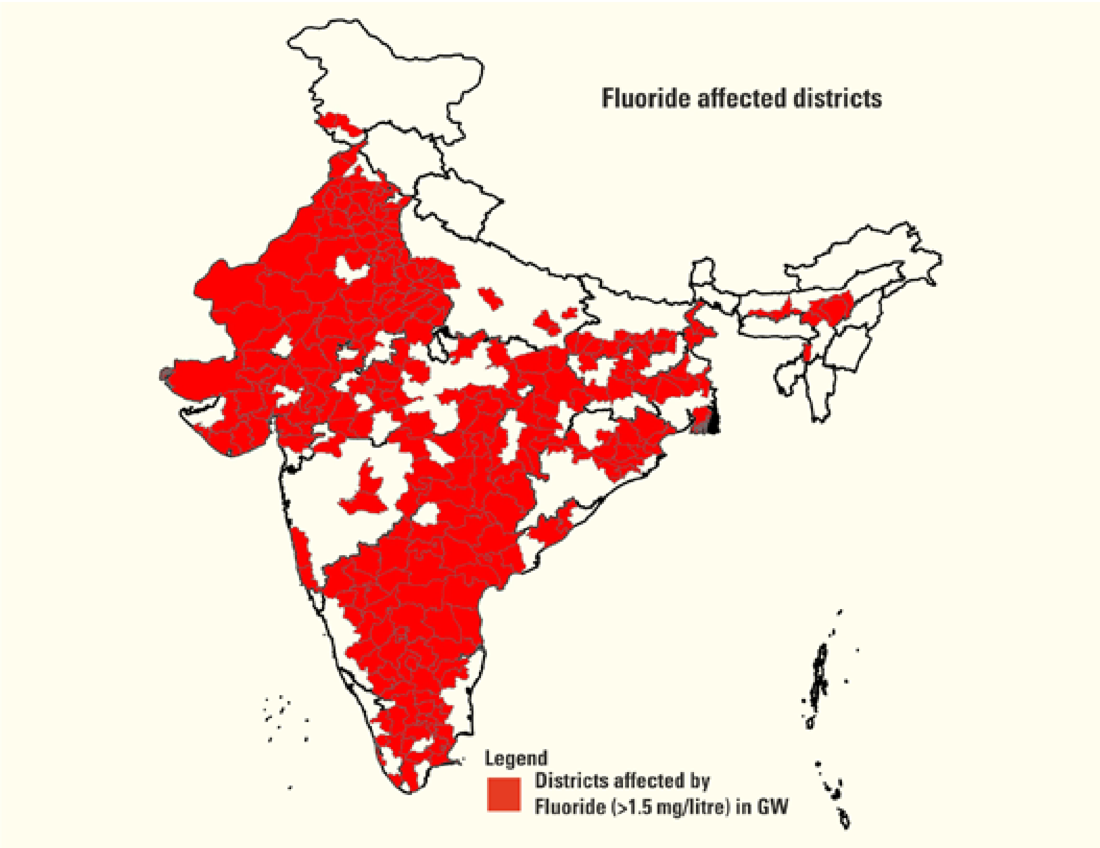
India is heavily dependent on its groundwater sources. Almost 60 percent of India's irrigation potential comes from groundwater and about 85 percent and 50 percent of the total rural and urban domestic water needs respectively are met by it. Unfortunately, groundwater quality has been rapidly declining with nearly half our groundwater resources being polluted with several poisonous contaminants[23]. Groundwater contamination is the presence of certain pollutants in groundwater that are in excess of the limits prescribed for drinking water. The sources of contamination include pollution by landfills, septic tanks, leaky underground gas tanks and the overuse of fertilizers and pesticides.

According to data from the CGWB, groundwater in 276 districts in 20 States is contaminated with Fluoride. High-levels of Arsenic contamination affect 86 districts in Assam, Bihar, Chhattisgarh, Haryana, Jharkhand, Karnataka, Manipur, Punjab, Uttar Pradesh and West Bengal. Similarly, 387 Districts in 21 States and 297 Districts in 24 States are contaminated with high-levels of Nitrate and Iron respectively. Heavy metals like Lead, Chromium and Cadmium have also found their way into groundwater with 113 districts in 15 States contaminated with at least one of these heavy metals. Districts like Bhiwani, Faridabad, Fatehabad, Hissar, Jhajjar, Jind, Karnal, Panipat, Rohtak, Sirsa, Sonepat, Yamunanagar in Haryana, Gurdaspur in Punjab, and Bankura, Bardhman in West Bengal are contaminated with all the four major contaminants: Fluoride, Arsenic, Nitrate and Iron[25].

Over-exploitation has catalysed the emergence of large-scale groundwater quality problems increasing the risk of health threats to the people, predominantly in rural India who use this resource and are heavily dependent on it. Salinity ingress in coastal regions and reduced river flows are also significant by-products of groundwater over-exploitation in many parts of the country.

Figure 6.
Arsenic and Fluoride affected districts of India





Source: *Central Ground Water Board, 2010* [24]

Chapter 2

Water Management Challenges

Water management challenges are inevitable in a scenario where population growth and climate change present unprecedented complications. Finding solutions to these challenges requires a better understanding and a closer inspection of the issue at hand. Here, the problem is analysed through two lenses: – sectoral water management, which covers the challenges faced by the major water-use sectors, namely, agriculture, domestic and industrial; and governance and institutional challenges.

Sectoral water management challenges: Access to services and efficient management

Water is used in India primarily for irrigation (more than 80 percent), industry (10 percent), drinking and other household purposes (10-15 percent). The ever increasing demands of a rapidly industrializing economy and fast urbanizing society like India comes at a time when the groundwater table is falling and the issue of water quality has increased in relevance. In this regard, it is important to discuss sector specific water challenges.

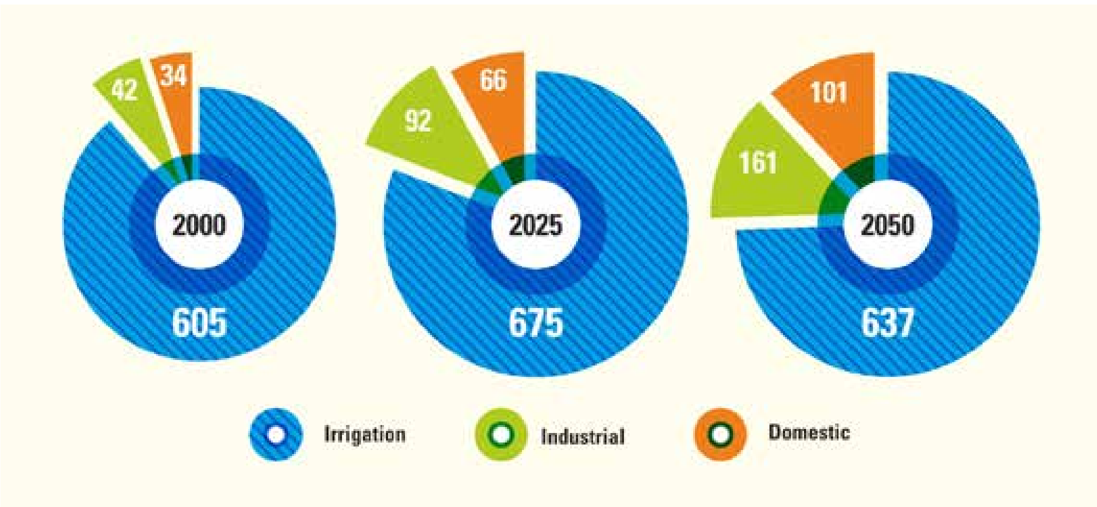
Agriculture

India is an agrarian economy. Over 58 percent of rural households dependent on agriculture as their principal means of livelihood and over 55 percent of the total number of workers secure employment in agriculture and allied sectors (fisheries, forestry and livestock)[27] . One of the major challenges currently faced by the Agriculture and allied sectors is the fall in its contribution to Gross Domestic Product (GDP). The GDP contribution has come down drastically, from 51 percent in 1951 to around 17 percent in 2017[28].

Access to irrigation services

As per the World Bank[29], only 36.7 percent of the total agriculture land in India was reliably irrigated in 2013. With significant investments in the construction of irrigation systems over the past 60 years, the major and medium Irrigation Potential Created (IPC) has grown considerably over time. In March 2012, IPC stood at 45.3 million hectares (Mha)[30] . However, a current gap of 23 percent between IPC and Irrigation Potential Utilised (IPU) indicates that utilisation

Figure 7.
Projected sectoral shift in water demand in India (in BCM)



Source: *Adapted from Amarasinghe et al., 2007* [26]

[26] Amarasinghe, U. A.; Shah, T.; Turral, H.; Anand, B. K.(2007)."India's water future to 2025- 2050: Business-as-usual scenario and deviations". Colombo, Sri Lanka: International Water Management Institute. 47p. (IWMI Research Report 123)

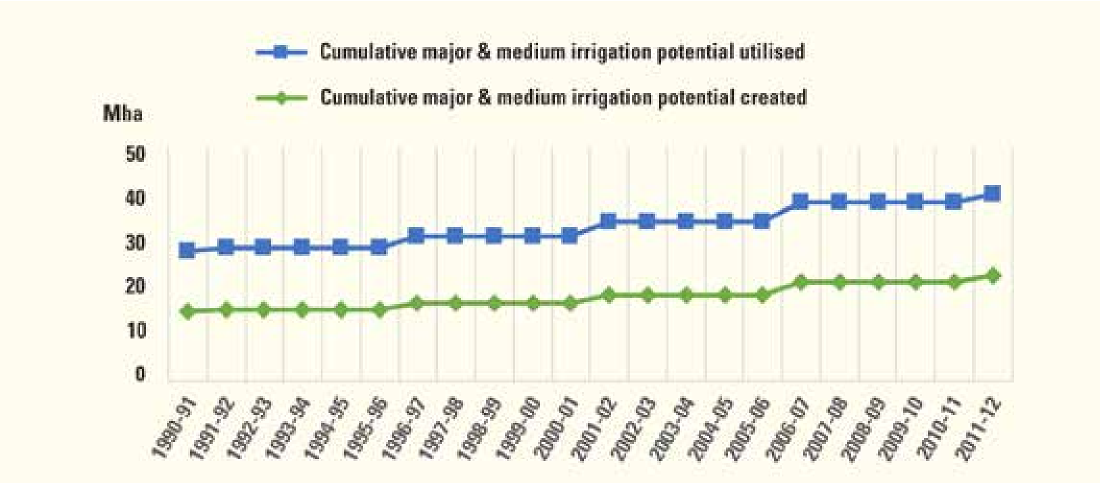
[27] Ministry of Statistics and Programme Implementation. (2016). Second Advanced Estimates, New Delhi: Central Statistics Office (CSO), MoSPI.

[28] As per the 2nd advised estimates by the Central Statistics Office (CSO), the share of agriculture and allied sectors (including agriculture, livestock, forestry and fishery) is expected to be 17.3 per cent of the Gross Value Added (GVA) during 2016-17 at 2011-12 prices

[29] Central Water Commission. (2015). "Water and Related Statistics" New Delhi: CWC

[30] World Bank.(2014). Data on Agricultural Irrigated Land. Available https://data.world-bank.org/indicator/AG.LND.IRIG.AG.ZS?end=2014&lo-cations=IN&start=2001[Ac-cessed 20 April, 2018]

Figure 8.
Change in area under IPC and IPU



Source: *Central Water Commission, 2015* [32]

[32] Central Water Commission. (2015). "Water and Related Statistics" New Delhi: CWC

[33] Programme Evaluation Organisation, Planning Commission. (2010)."Evaluation Study on Accelerated Irrigation Benefits Programme (AIBP)". New Delhi: Planning Commission

[34] Raju, K. V., Gulati, A. & Meinzen-Dick, R.(2003)."Innovations in Irrigation Financing: Tapping Domestic Financial Markets in India". Washington D. C.: International Food Policy Research Institute

[35] Ackermann, R. (2012). "New directions for water management in Indian agriculture". Global Journal of Emerging Market Economies, 4(2), 227-288

[36] Central Water Commission. (2015). "Water and Related Statistics" New Delhi: CWC.

[37] Central Water Commission. (2014)."Guidelines for Improving Water-Use Efficiency in Irrigation, Industrial and Domestic Sectors". New Delhi: CWC.

has not kept pace with the growth in IPC.

Studies conducted by the Indian Institutes of Management (IIMs) and others offer several hypotheses for the IPC-IPU gap. These include poor maintenance of systems, data and measurement challenges, farmers in the head-reaches switching to water-intensive crops, lack of coordination between government institutions, inadequate technical capacity, ineffective water user associations and small and marginal holding sizes[33 34].

Moreover, owing to its decentralised nature and subsequent ease of accessibility, groundwater has the largest share in India's irrigation system. In the last four decades, starting around the late 1970's, the relative contribution of canal irrigation has been steadily declining over time while groundwater extracted through tube-wells has significantly increased, thereby increasing the area under groundwater irrigation. Technological innovations have made pumping equipment cheap and affordable. Energy subsidies have made groundwater pumping a far more attractive option to farmers than relying on often-unreliable public irrigation systems.

However, groundwater's contribution towards poverty reduction must not be diminished[35]:

- It is a more "equitable" technology than public surface canal irrigation, and does not discriminate against small farmers the way government subsidies do (Minimum Support Price, fertilizer subsidies, etc.);
- By providing timely irrigation it gives greater drought protection to crops and by making irrigation possible during peak moisture stress, it reduces the risk of failure due to a change in the monsoon patterns;
- By providing year-round water, pump irrigation allows diversification and intensification to higher value foods (vegetables and fruits require dozens of small quantity watering a year) and dairying;
- At least in areas served by free or flat-rate electricity, an active water market allowed those too poor to afford their own irrigation pumps (or those who chose not to purchase pumps) to partake in the benefits of on-demand water, because pump owners can pump and sell extra water at little or no marginal cost.

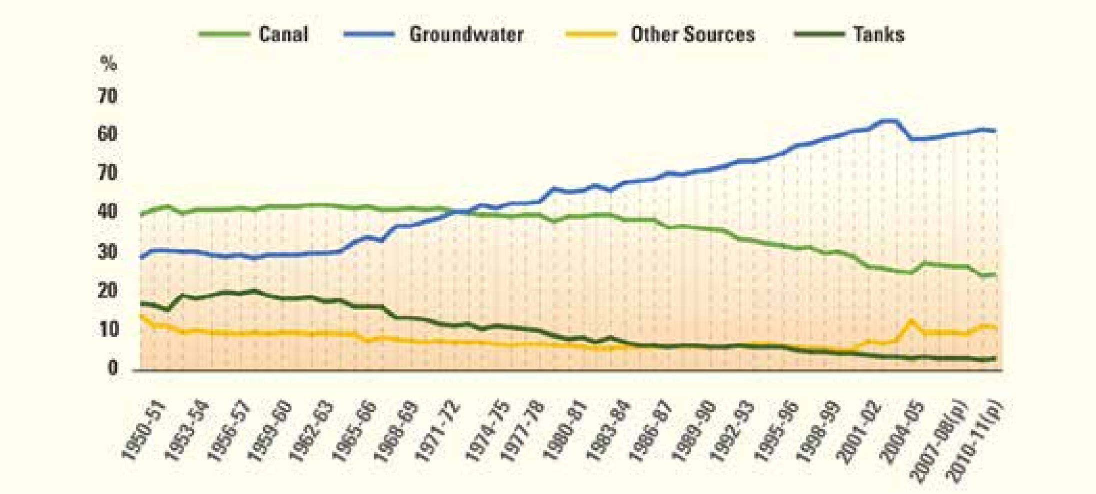
Rain-fed agriculture is still a widespread practice. The 'Net Irrigated Area' was only 65 Mha out of 141 Mha of 'Net Area Sown' as of March 2012[36]. A second crop is grown on less than 40 percent of cultivated area. In some states, this figure is below 25 percent. This can be attributed to lower crop intensity during the rabi season due to low water and moisture availability for crop production.

Water-use efficiency in agriculture

The 2014 report of the Central Water Commission (CWC)[37], titled 'Guidelines for Improving Water-Use Efficiency in Irrigation, Domestic and Industrial Sectors', notes that, the irrigation sector consumes about 80 percent of the total water used, which may reduce to about 70 percent by 2050 due to competing demands from other sectors. Given the quantum of use in this sector and the supply constraints, there is a tremendous potential and increasing need to achieve water savings through efficient irrigation water use.

Cross country comparison of water-use efficiency

Figure 9.
Trend of source-wise net-irrigated area (1951 to 2011)



Source: *DOEandS, Ministry of Agriculture and Farmer Welfare*

Table 3:
Efficiencies for various irrigation practices

Water use and methods	Efficiency (percent)
Conveyance efficiency	
Through unlined canal for surface water	**55-60**
Through lined canal for surface water	**70-75**
Application for both surface and groundwater	
Flood irrigation	**65**
Furrow irrigation	**80**
Sprinkler	**85**
Drip	**90**
Overall efficiency for surface water system	**30-65**
Overall efficiency for groundwater system	**65-75**

Source: *Central Water Commission, 2014* [38]

[38] Central Water Commission (2014)."Guidelines for Improving Water-Use Efficiency in Irrigation, Domestic and Industrial Sectors". Central Water Commission, Ministry of Water Resources, Government of India

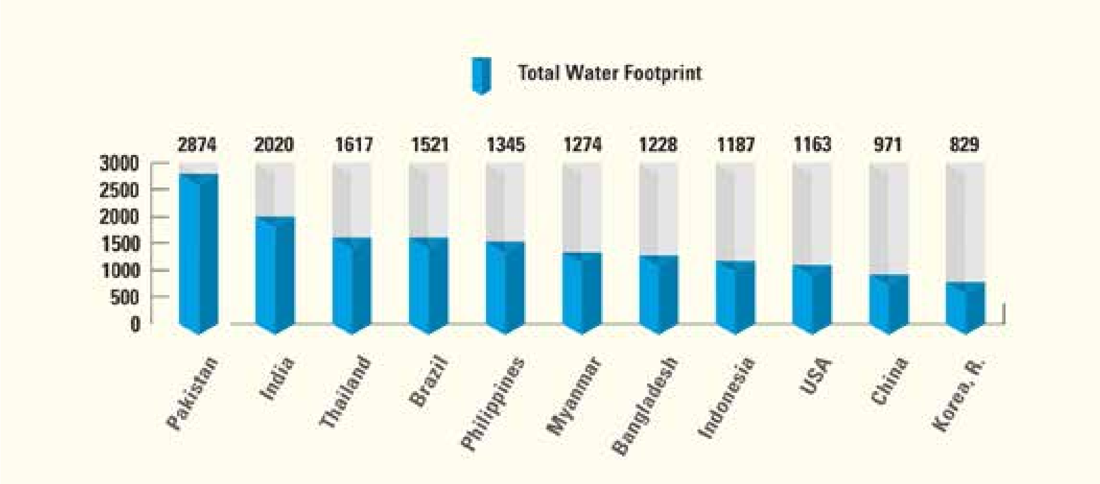
[39] Suhag, R, (2016). "The status of ground water: Extraction exceeds recharge". PRS Blog.

shows that, India uses two to three times more water to produce a unit of major food crops, in comparison to countries such as China, Brazil and the USA. There are mainly two reasons for such gaps in water-use efficiency. Firstly, power subsidies for agriculture have significantly contributed to decreasing the level of water in India. As power is a main component of the cost of groundwater extraction, cheap and subsidised power has resulted in the over-extraction of groundwater. In addition, electricity supply is merely metered and a flat tariff is charged according to the horsepower of the pump. Secondly, it has been witnessed that even though Minimum Support Prices (MSPs) have been announced for 23 crops, only wheat and rice have the effective price support in place.[39] This has created highly skewed incentive structures in favour of wheat and paddy, which are water intensive crops and heavily dependent on groundwater for their growth.

The Commission for Agricultural Costs and Prices (CACP), in its Price Policy for Kharif Crops report for 2015-16[41] has articulated that, the average Punjab farmer uses more than double the amount of water to produce 1 kg of rice, as compared to a paddy farmer from West Bengal. Paddy farmers in Assam, Bihar and Odisha, besides Karnataka and Andhra Pradesh, which are also more water-efficient in relation to their Punjab and Haryana counterparts. Policies bolstering inefficient resource use can explain this phenomenon. Punjab hardly gets 40 percent of the monsoon rainfall that West Bengal, Bihar or Odisha receive and just over 25 percent of Assam's seasonal average. Yet its farmers grow paddy, mainly by drawing groundwater during the summer months when evaporation rates are high.[42]

Rice is one of the most widely consumed crops globally and is a staple crop in diets across South Asia and Africa. The production of rice is highly water intensive and large irrigation

Figure 10.
Rice producers by water productivity



Source: *Commission for Agricultural Costs and Prices. (2015)* [40]

projects are often constructed to meet its water demand. This makes rice one of the largest water consumers in the world[43]. Fresh water used to produce rice globally can be classified into two different sources: irrigation water withdrawn from the ground, or; surface water (blue water) and rainwater (green water). The water footprint, a measure of water-use efficiency is the volume of water used to produce a particular good (paddy in this case), measured at the point of production. As we can see below, among the 13 major rice-producing countries in the world, only Pakistan is less water-efficient than India.

In order to improve water-use efficiency, the CACP report recommends the metering of electricity and water used in irrigation, along with fixing quantitative ceilings on a per-hectare basis. Cash incentives can also be provided for usage of electricity/water, which is less than the prescribed ceilings. This might also encourage water-use efficiency practices such as drip irrigation and direct-seeded rice production.

Influence of uncertainties like climate change

Findings of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) state that, human influence has been the primary cause of global warming since the mid-20th century. The Asian region as a whole experienced maximum weather and climate-related disasters in the world and suffered the second highest proportion (almost 30 percent) of total global economic losses. Researchers at Stanford University analysed 60 years (1951-2011) of Indian monsoonal trends through a comprehensive statistical analysis of precipitation[45]. Their findings showed that: (i) peak-season precipitation has decreased over the core monsoon region and daily-scale precipitation variability has increased; (ii) frequency of dry spells and the intensity of wet spells has increased; (iii) 1981-2011 had more than twice as many years with three or more dry spells as compared to 1951-1980, and the dry spell frequency shows an increase by 27 percent. Data released by the CWC in April 2016 shows

[40] Commission for Agricultural Costs and Prices.(2015)."Price Policy for Kharif Crops: The Marketing Season of 2015-16". New Delhi: Ministry of Agriculture

[41] Commission for Agricultural Costs and Prices.(2015)."Price Policy for Kharif Crops: The Marketing Season of 2015-16". New Delhi: Ministry of Agriculture

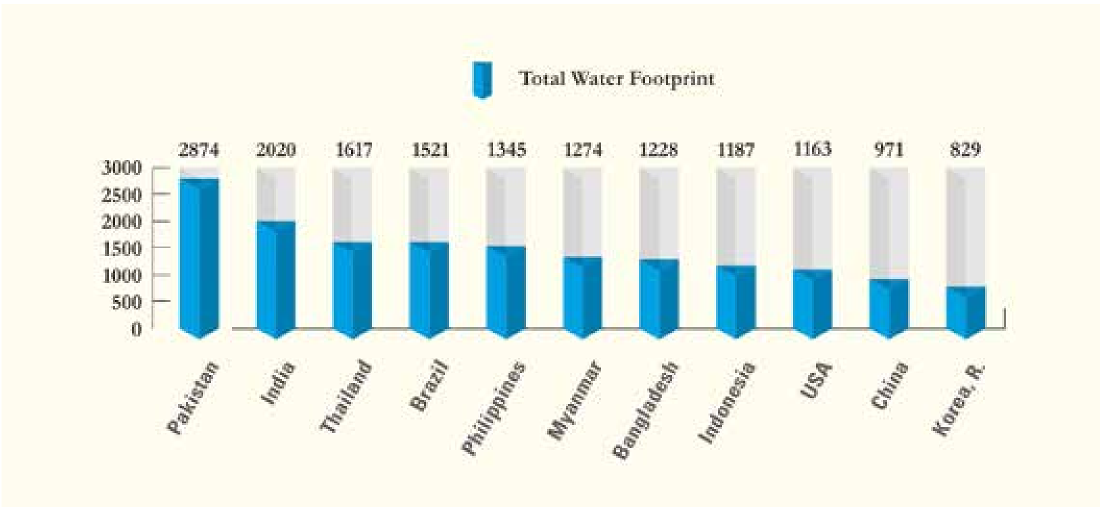
[42] Damodaran, H. (2015)."From 'per acre' to 'per drop'".The Indian Express

[43] Chapagain, A. K., and Hoekstra, A. K. (2011)."The blue, green and grey water footprint of rice from production and consumption perspectives". Ecological Economics, 70, 749-758.

[44] Chapagain, A. K., and Hoekstra, A. K. (2011)."The blue, green and grey water footprint of rice from production and consumption perspectives". Ecological Economics, 70, 749-758.

[45] Singh, D., Tsiang, M., Rajaratnam, B., and Diffenbaugh, N. S. (2014)."Observed changes in extreme wet and dry spells during the South Asian summer monsoon season". Nature Climate Change, 4(6), 456–461

Figure 11.
Water footprint per unit of paddy rice produced (m^3/t) in the 13 major rice-producing countries. Period 2000–2004



Source: *Chapagain, A. K., and Hoekstra, A. K. (2011)* [44]

[46]Sachitanand,R.(2017)."Is climate change the culprit behind floods and farming woes?" In The Economic Times. Accessed on 20 April 2018. https://economictimes.indiatimes.com/news/politics-and-nation/is-climate-change-the-culprit-behind-floods-and-farming-woes/articleshow/60342865.cms

[47] Grangier, Caroline, Qadir, Manzoor and Singh, Murari, (2012)."Health Implications for Children in Wastewater-Irrigated Peri-Urban Aleppo, Syria". Water Quality, Exposure and Health, 4(4), 187-195

[48]Sugam, R. and Ghosh,A. (2013)."Urban Water and Sanitation in India: Multi-stakeholder Dialogues for Systemic Solutions", CEEW-Veolia Report, November 2013

[49]Government of India. (2011)."Census of India". New Delhi

that, most of the reservoirs had lower levels of water in 2016 than the average of the last 10 years.

The Ganga basin covers more than a quarter of India's geographical area and provides shelter to over 450 million people. More than 60 percent of its population is dependent on agriculture for their livelihood. In a scenario where global carbon emissions continue to rise and remain high, the probability of flooding in the areas near Ganga can be expected to increase by six times, becoming a 1 in every 5-year event[46]. High carbon emissions will also increase the incidence of extreme drought affecting cropland, which could go up by about 50 percent in South Asia, affecting 7 percent of the cropland by 2050.

Research shows that climate change will result in significant economic losses for Indian agriculture. Production losses in rice, wheat and maize alone could go up to 208 billion US$ in 2050, rising to US$ 366 billion in 2100 respectively (in 2010 US$). Also, coastal regions, heavily dependent on fisheries, are amongst the most vulnerable areas. Several other issues such as a shift in the cropping system, new pest attacks, loss of crop diversity etc. could arise if there is significant temporal and spatial variation in temperatures and monsoons.

On the other hand, mono-cropping or cultivating a single variety of a crop, due to encouraging market prices of only few crops/varieties, makes the entire system less resilient to climate change impacts. For example, In the 1960s, India was estimated to have over 70,000 rice landraces. After 20 years, over 75 percent of India's rice production was coming from less than 10 varieties due to an aggressive push for modern, input-intensive hybrids by scientists and policymakers.

Modern agriculture practices such as the use of fertilisers, tractors, pesticides, High-Yielding Varieties (HYVs) etc., evolved as a solution for low productivity and higher food demands. These interventions radically increased production levels making India self-sustainable in major food crops. However, it had negative consequences as well. The promotion of such input-intensive farming practices are now causing a reduction in soil fertility, increased concentration of fertilisers and pesticides in food products, mono-cropping, loss of wild varieties etc. As an example, we can clearly see the negative consequences of extensive rice cultivation in Punjab, which is not naturally suited for growing rice. After reaching peak productivity levels by adopting modern agriculture practices and with the extensive use of chemical fertilisers and pesticides, the state is struggling to sustain its current levels of crop productivity. Therefore, there is a pressing need to work on the challenges mentioned above in order to ensure food security in the country.

Use of wastewater for irrigation

Farmers' use of wastewater is most prevalent in regions where there is significant water pollution and wastewater generation. In these circumstances, and due to a shortage of water supply, wastewater is a convenient alternative resource for irrigation, especially for high-value crops like vegetables, which often require more water than staple foods. Moreover, raw wastewater is sometimes preferred over fresh water, as it has a higher concentration of nutrients and therefore substantially reduces the requirement of purchased fertilisers.

However, this practice has negative externalities in terms of health. According to a scientific study by Grangier et. al. in 2012, the annual health cost per child in an untreated wastewater irrigated environment is approximately INR 4,000/annum (US$ 60), 73 percent higher than for freshwater irrigated areas.[47]

Domestic: Urban and rural water

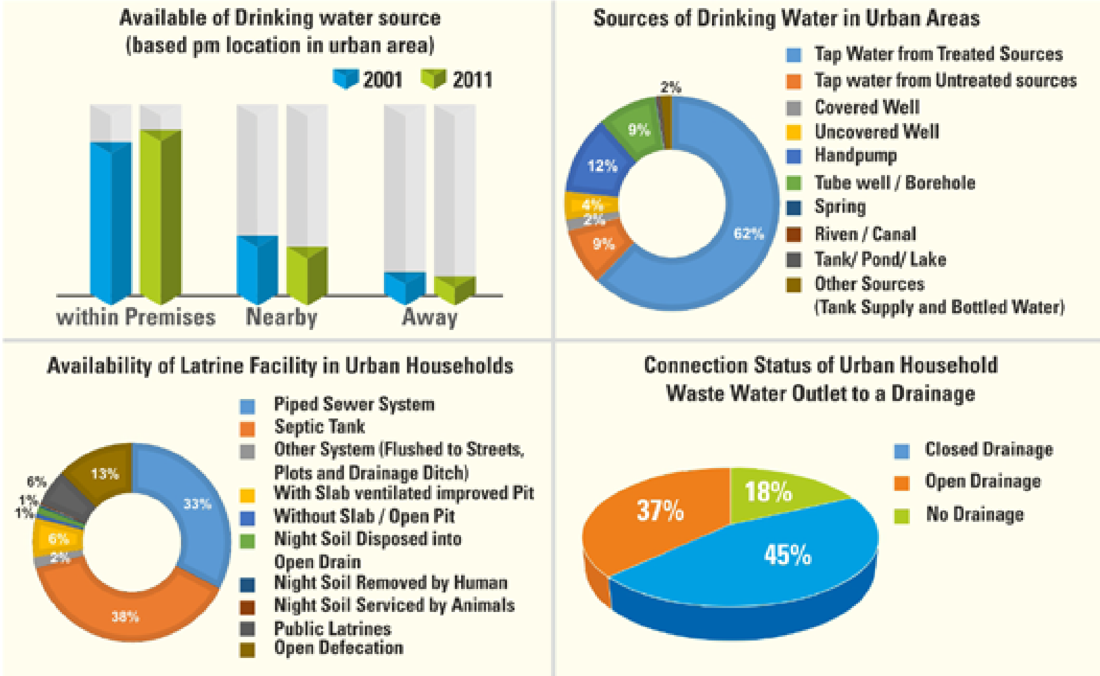
Urban[48]

Access to water services

In India, over the last decade, the urban population grew by 31.8 percent, reaching 0.37 billion, considerably higher in comparison to the national average growth rate of 17.64 percent[49]. The population growth rate has posed immense challenges to the water service provision capacity. According to the 2011 Census Report, 30 percent of urban Indian households do not have access to water within their premises and 18.6 percent do not have access to even the most rudimentary forms of sanitation facilities. Of the 70 percent urban population that receives water within their premises, only 62 percent receive tap water from treated sources. Large parts of urban areas remain unconnected to the wastewater treatment system as they live in unauthorised areas or slums, where state services fail to reach.

Moreover, households that are connected to the water supply network get running water for an average of just 4.5 hours daily[50], which leads

Figure 12.
Urban water services in India



Source: *Census 2011*

[50]Asian Development Bank. (2007)."Benchmarking and Data Book of Water Utilities in India". Asian Development Bank

[51]Central Pollution Control Board.(2009)."Status of Water Supply, Wastewater Generation and Treatment in Class I Cities and Class II Towns of India". Delhi

to the problem of excess storage and wastage. Currently, the demand of most cities is being met by transporting water over long distances. This is both inefficient and energy intensive. In the process, a lot of water is lost making the entire system highly inefficient.

Sewage management is another challenge facing urban India. Almost 80 percent of water supply flows back into the ecosystem as wastewater. If left untreated, this can be a critical environmental and health hazard. However, proper management could allow water managers to meet the city's water demand. Currently, India has the capacity to treat approximately 37 percent of its wastewater.[51]

Management challenges for the domestic sector

Water supply and sanitation management have always been a point of concern in Indian cities. Notwithstanding a few pilot projects and some areas of excellence, little of promise has been achieved so far to address this complex issue. Thus, Indian cities and towns struggle to cope with water demand and resources over-exploitation.

The management and optimal use of urban water resources require a different approach. An urban locality differs from a rural locality in several ways: higher population density, higher per capita water demand, huge industrial water demand, high waste in facilities like hospitals, educational institutions, railway stations, airports, bus terminals etc. The quality and quantity of wastewater generated is also a direct reflection of the consumption pattern. Current urban water use practice causes large-scale pollution resulting in polluted surface water bodies and increased pressure on already stressed groundwater resources.

In India, water supply and sanitation utilities are government owned bodies, which struggle to recover the costs incurred in operation and maintenance, let alone generate revenue for capital investment. The involvement of the private sector is limited. It is mostly limited to technical and management support rather than investment in infrastructure. In recent years, a few experienced private sector firms such as Veolia, Infrastructure Lending and Financial Services, JUSCO etc. have started signing long-term contracts or financing investments in the urban water sector. However, high degrees of trust deficit between utilities and private firms as well as consumers and civil society still remain. Any attempts at reforming urban water management in India must begin with a critical appreciation of the problems and the availability of rigorous data to inform public debate.

The urban water supply and sanitation (UWSS) sector in India is plagued by: low cost recovery, poor operation and maintenance, high non-revenue water losses, huge volume of untreated wastewater discharge, poor governance, low tariff and depleting groundwater. The biggest challenge is the disparity in water access between the rich and the poor. Even government water subsidies fail to reach the poor as they mostly live in informal settlements, which do not have a regular water supply connection. Thus, the management of informal water vendors is something that the government should seriously consider.

Water-use efficiency

The overall water supply and sanitation sector in India, not unlike the UWSS is also plagued by poor and inadequate investments, poor operation and maintenance (O&M) practices, high non-revenue water (NRW), uneconomic tariff structure/levels and poor financial management. It also lacks sound data systems, statistics on coverage, and the metering and production are not fully reliable.

Most often, problems related to water supply stem from inadequate monitoring and governance rather than the scarcity of water. The average value for non-revenue water i.e. water loss due to leakage, theft, illegal connections and improper/incorrect metering in India was found to be 39 percent[52]. As a result, the supply gaps caused by unaccounted water loss and wastage are increasingly being met through unregulated and unsustainable groundwater pumping, further burdening the already stressed resources.

Long distance water transportation to most major cities of India is a matter of serious concern. Not only does it involve huge infrastructure and power costs but also results in the loss of significant amounts of water. For example, Bengaluru losses more than half of the water transported as non-revenue water[53]. In certain localities, several households still await a connection to the formal water supply system. No city can afford to lose such a high volume of water on a daily basis.

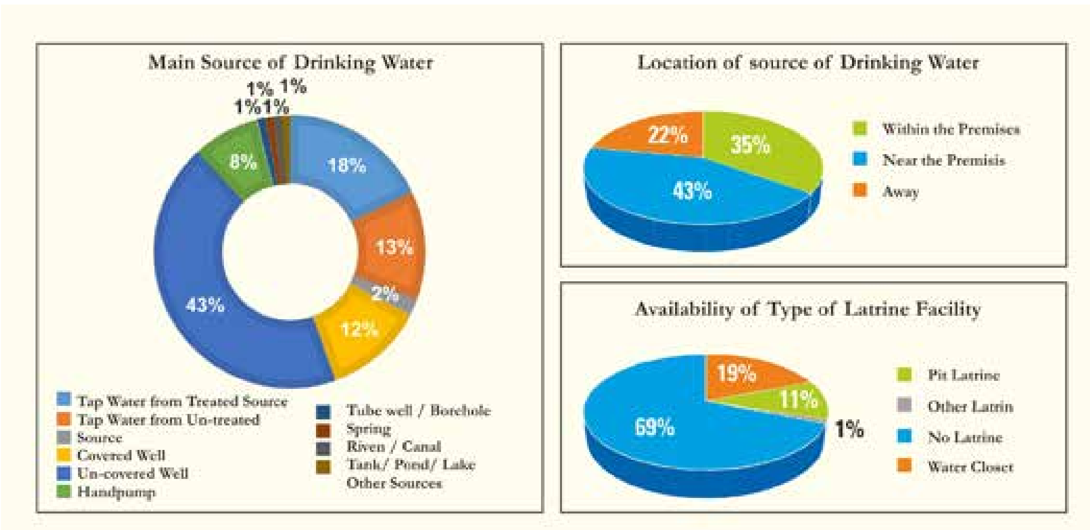
Even at the household level, water-use efficiency is low. There is no regulatory authority, which monitors the efficiency of water use in different consumptive practices; neither do any benchmarks exist for water efficient fixtures. In fact, there is no set efficiency standard for various urban water uses, leading to significant water loss. For instance, water efficient systems like dual-flush systems or high-efficiency toilets in new buildings could and should be mandated. These use 4-6 litres of water per flush as compared to traditional flushes used in India, which use 10-15 litres[54]. Also, as the water supply is non-continuous in India, people store water and then throw it once the fresh water comes. This is extremely wasteful. There is a huge potential to cut down water usage and create a more equitable water supply scenario in the domestic sector.

Rural

Rural regions in India, which primarily have agricultural and domestic water requirements, suffer from many challenges such as, lack of water supply infrastructure, inadequate sanitation facilities, insufficient irrigation facilities etc. Figure 13, below highlights the poor situation of drinking water supply and sanitation facilities in India.

Only 18 percent, (not a nationwide percentage, restricted to few states only) of rural households in India receive treated water supply. However, more than half of the households rely on groundwater sources and many of these face negative health impacts due to poor groundwater quality. Status of sanitation is even worse as

Figure 13.
The rural water supply and sanitation situation in India



Source: Government of India, (2011)[55]

[52]Ministry of Water Resources. (2012). "Leakage of Water". Press Information Bureau.

[53]Saldanha, A. (2016, September 16). "Bengaluru wastes nearly 50% water supply from Cauvery". Hindustan Times

[54]Sugam, R. and Ghosh,A. (2013)."Urban Water and Sanitation in India: Multi-stakeholder Dialogues for Systemic Solutions", CEEW-Veolia Report, November 2013

[55]Government of India, 2011. Census of India, Government of India: New Delhi

[56]Ministry of Statistics and Programme Implementation. (2017)."Sector-wise Contribution of GDP of India". s.l.: Statistics Times.

[57]India Today.(2016)."UNIDO places India at 6th Position in Top-10 Manufacturers List." India Today, 2 April.

[58]Central Water Commission. (2014)." Guidelines for Improving Water-use Efficiency in Irrigation, Domestic and Industrial Sectors", New Delhi: CWC

[59]Central Electricity Authority. (2014)."Recommendations on operation norms for thermal power stations: Tariff period 2014-19".New Delhi: CEA

[60]Ministry of Water Resources. (2016, August 4)."Progress of the Namami Gange Mission". Press Information Bureau.

[62]Orr,S.,Cartwright,A. and Tickner,D. (2009)."Understanding Water Risks: A primer on the consequences of water scarcity for government and business". WWF Water Security Series 4. WWF

[63]Agence France-Presse in Delhi.(2016)."Indian drought 'affecting 330 million people' after two weak monsoons". The Guardian, 20 April.

[64]Dasgupta, K.(2016)."Drought will cost India $100 bn. Here's how industry can weather the storm". Hindustan Times, 2 June.

nearly 70 percent of the households have no latrine facility, leading to large-scale open defecation.

Industry

Industrial growth is central to a country's development. At present, the industrial sector, which includes manufacturing (Registered and Unregistered), electricity, gas, water supply, and construction, contributes to 24.2 percent of India's GDP[56]. As per the World Bank report, India's industrial manufacturing GDP output in 2015 was the sixth largest in the world on current US dollar basis ($559 billion), and ninth largest on inflation adjusted constant 2005 US dollar basis ($197.1 billion). Moreover, according to the UNIDO scale, India is ranked sixth in the list of largest manufacturing countries[57]. With the current government's push of "Make in India", further enhancements in the manufacturing growth rate of the country seem inevitable. To support this development, sufficient resource availability is crucial.

One such crucial resource for industries is water. Manufacturing and other industries depend on water for their production process for either creating goods or for cooling equipment used for creating goods. Whereas agriculture-based industries are heavily dependent on high quality agricultural produce for which sufficient water availability is essential. Within industry, water is used for fabricating, processing, washing, diluting, cooling, and transporting goods; in smelting facilities; petroleum refineries; and in industries producing chemical products, food, and paper products.

As observed, the challenges of safe drinking water and waste management are perhaps even greater in urban India. Indian cities and industries must reinvent their water trajectory to both secure the water they need and do so in a way that minimises the scope for conflict between rural areas and agriculture. Indian cities and industries need to find ways to expand with minimal water and minimal waste. As important as the quantum of water to be supplied, is the problem of its management and equitable supply to all. By 2050, the projected water use by industries is expected to be 13 percent of the total projected water use, in contrast to the 8 percent currently employed. The overall demand of water for industries is expected to see an increase of 269 percent from 56 BCM (including Energy, mainly thermal power) in 2010, to 151 BCM by the year 2050[58]. Moreover, the issue of deteriorating water quality is another huge challenge.

Industries, at times, also face the risk of stricter regulations — higher water prices, reduced rations, stricter emission permits or obligatory water-saving technology. For instance, a notification issued by the Ministry of Environment, Forest and Climate Change (MoEFCC) in December 2015, mandates the existing thermal power plants to limit their specific water consumption to 3.5 m^3/h per MW by December 2017. For plants commissioned after January 2017, the maximum water consumption should be 2.5 m^3/h per MW[59]. Industries such as the Indian textile industry also face significant regulatory pressure to mitigate damage to water bodies. In 2015, approximately 900 textile units near Jaipur were forced to close because they hadn't installed effluent treatment plants. Similarly, the Namami Gange Programme, in order to achieve water conservation and zero liquid discharge by March, 2017[60], issued directives to five key industrial sectors namely: distillery, sugar, pulp and paper, tannery and textile, responsible for 90 percent of the inorganic load into the river system. While achieving higher efficiency and decreasing pollution are extremely important targets, there are several industries that do not have the capability to achieve these within the prescribed time limits. They require handholding, which is currently lacking. Furthermore, brands face a growing reputational risk because the public and media are becoming increasingly aware of the contribution of companies to unsustainable water use[62].

Water-use efficiency in the industrial sector

The impact of climate change is expected to aggravate water challenges across the country. Droughts, for instance, have become increasingly common. After two consecutive years of weak monsoons[63], nearly a quarter of the country's population across 10 States has been affected by it. Research suggests that, if civic bodies impose cuts on water supplied to industry across several states, the resultant shortage could pull down the Index of Industrial Production growth by around 40-50 basis points with the manufacturing sector alone taking a hit of about 50-75 basis points[64].

An analysis by UNICEF in 2013 concluded that, the water productivity of Indian industries is low in comparison to other countries.

A report by the CWC shows that, the industry sector in India consumes about 2 to 3.5 times more water per unit of production as compared

[65] Perveen, S., Sen, R., & Ghosh, M.(2012)."India's Deepening Water Crisis: Water Risks for Indian Industries". New Delhi: FICCI.

[66] Tewari, P. K., Batra, V. S., & Balakrishnan, M.(2009)."Efficient water use in industries: Cases from the Indian agro-based pulp and paper mills". Journal of Environmental Management, 90, 265-273.

[67] Saleth, R. Maria. (2004)."Strategic analysis of water institutions in India: Application of a new research paradigm". Research Report 79. Colombo, Sri Lanka: International Water Management Institute

to similar plants operating in other countries. Two major industries: Thermal Power Plants and Paper and Pulp industries are not water efficient in comparison to global standards. Indian thermal power plants consume 2-5 times more water than power plants in other countries. It is important to mention that very few incentives are currently provided to industries for efficient water use[65]. A study by Tewari et. al. in 2009[66], on the water-use efficiency of paper and pulp industry highlights that, the Indian pulp and paper sector is less competitive than in other Asian countries. In India, these industries use 200 percent more water than the set global standards.

India looks quite complex. This is because multiple departments working under different ministries are involved in the execution of any one component of the water management task. Table 5 is an indicative list of the number of departments that deal with macro water-related information and management tasks.

Water is a political issue, and the complexity of dealing with State versus Central institutions makes the task of water management all the more challenging. Thus, the debate on water management must go beyond the Ministry of Water Resources, River Development and Ganga Rejuvenation. A possible starting point could be the creation of a hydrological information system, sustained through the collective effort of government institutions along with industries, academia, Civil Society Organisations (CSOs) and end users. For understanding some of the rivers, support and/or coordination with international institutions or institutions in other countries would be required as most of India's major rivers are trans-boundary in nature.

Table 4.
Industrial water productivity

Country	Industrial water use (billion cubic metres)	Industrial productivity (million US$)	Industrial water productivity (US$/cubic metres)
Argentina	2.6	77,171.0	30.0
Brazil	9.9	231,442.0	23.4
India	**15.0**	**113,041.0**	**7.5**
Republic of Korea	2.6	249,268.0	95.6
Norway	1.4	47,599.0	35.0
Sweden	0.8	74,703.0	92.2
Thailand	1.3	62,800.0	48.9
United Kingdom	0.7	330,097.0	443.7

Source: *UNICEF, 2013 (adopted from World Bank (2001) cited in CSE (2004))*

Governance and institutional challenges

Multiple institutions to govern water

An analysis conducted by the International Water Management Institute (IWMI) on the institutional structure of water in India suggests that, the institutional environment is uniquely characterized by the overall physical, cultural, historic, socio-economic and political milieu of every country or region. The interactive effects of the legal, policy and organizational or administrative components and their constituent aspects define its institutional structure[67]. The study stated that, since most of the water institutions were developed during the period of a water surplus regime, their efficiency is now diminishing. Thus, institutions are struggling to keep pace with the changing water situation.

If we look at the institutional structure from a macro perspective, water governance in

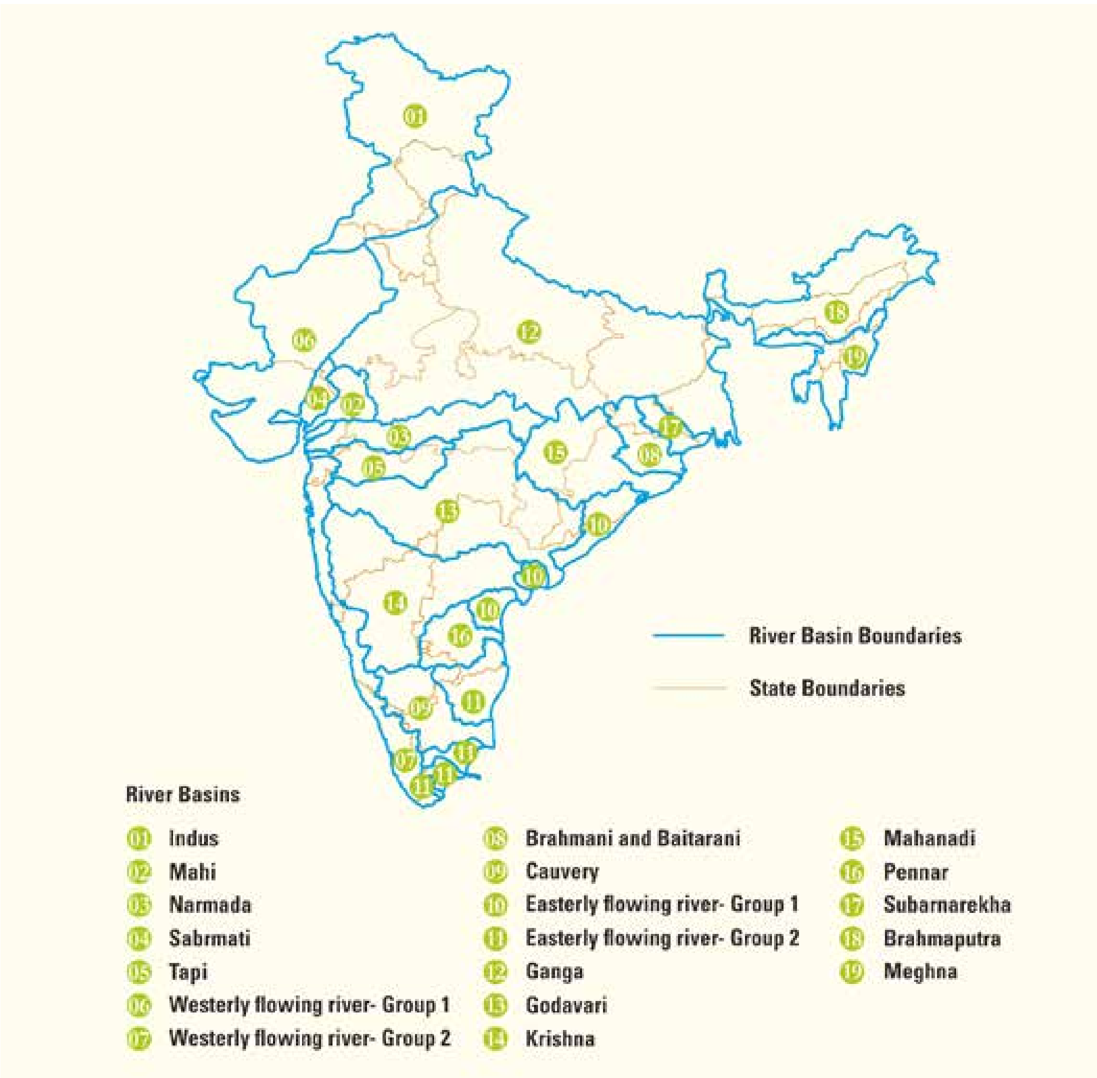
Inter-state water disputes: Conflicts and resolution

India's water security is at risk: per capita water availability is decreasing, water-use efficiency is low, groundwater resources are stressed, rainfall patterns are changing and water pollution is on the rise. The rate at which India is urbanising, inter-sectoral water conflicts are bound to intensify. India has its share of problems related to river trans boundary issues with neighbouring countries and other international water conflicts. However, it is currently grappling more with inter-state than international water disputes. It is yet to successfully mediate a single inter-state water dispute, which become more pronounced during droughts. Looking at Figure 14, one can clearly see that most of the major river basins in India cross multiple states.

As water is a State subject, water-related decisions are made by state administration; however, geographically, basin boundaries do not comply with or complement state boundaries, which makes the entire process of water sharing complicated. Any development in the upper catchment is ought to have implications for the downstream regions. Given this situation, the Central Government has established eight tribunals to resolve water disputes among the states under the inter-state River Water Disputes Act, 1956. The details of the tribunals are in table 6, below. In addition to these disputes, there are other States such as Bihar and Odisha, who demand the setting up of new tribunals for some other inter-state rivers as well. The problem is expected to aggravate if proper basin level water management plans are not developed. It is also critical that factors, which have the potential to trigger inter-state water disputes, are identified, to enable remedial actions.

In order to provide broad guidelines to State governments for framing their own laws relating to sustainable water usage, the Central Government has published certain framework laws or Model Bills. In 2011, the government published a Model Bill for Ground Water Management based on which States could choose to enact their own laws. In addition, it outlined a National Water Policy in 2012 articulating key principles relating to demand management, usage efficiencies, infrastructure, and pricing aspects of water. As recommended in this policy, the government published a National Water Framework Bill in 2013. So far, in response to the Model Bill, 11 States and four Union Territories (UTs) have adopted and implemented groundwater legislation. These are: Andhra Pradesh, Assam, Bihar, Goa, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, West

Figure 14.
Major basins of India



Source: *Amarasinghe et. al., 2004*

Table 5.
Departments/Ministries dealing with water issues

S.No	Water-related information	Major Department/Ministry
1	**Surface flow and storage**	CWC, Ministry of Water Resources, River Development and Ganga Rejuvenation
2	**Groundwater**	CGWB, Ministry of Water Resources, River Development and Ganga Rejuvenation
3	**Precipitation**	India Meteorological Department (IMD), Ministry of Earth Sciences
4	**Wetlands**	Indian Space Research Organisation (ISRO), Ministry of Human Resource Development
5	**Water quality**	State Pollution Control Board (SPCB)/Central Pollution Control Board (CPCB), MoEFCC
6	**Irrigation efficiency on farms**	Ministry of Agriculture
7	**Industrial demand and growth pattern**	Ministry of Industry and Commerce
8	**Health impacts of poor quality water**	Ministry of Health and Family Welfare
9	**Water access at household level**	Census, Ministry of Home Affairs
10	**Drinking water and sanitation in rural areas**	Ministry of Drinking Water and Sanitation
11	**Drinking water and sanitation in urban areas**	Ministry of Urban Development
12	**Climate related impacts on water resources**	Ministry of Environment, Forest and Climate Change
13	**Water losses in urban areas**	Utilities/Public Health and Environment Directorate, Ministry of Urban Development
14	**Water demand by thermal power plants (major user)**	Ministry of Power
15	**Basin and sub-basin level water maps**	Survey of India, Ministry of Home Affairs
16	**Cropping pattern, land use etc.**	Directorate of Economics and Statistics, Ministry of Agriculture
17	**Distributed water storage creation**	MNREGA, Ministry of Rural Development

Source: *Ministry of Water Resources, River Development and Ganga Rejuvenation, 2017*

Bengal, Telangana, Maharashtra, Lakshadweep, Puducherry, Chandigarh and Dadra and Nagar Haveli.

Based on a comprehensive literature review and historical experience, the following factors seem to be the critical triggers for inter-state water dispute:

- Creation of water storage or diversion infrastructure such as dams in the upstream region
- Reduction in water availability due to change in monsoon pattern
- Growth in population and hence water demand
- Large-scale groundwater extraction
- Reduction in groundwater recharge due to change in land use patterns
- Change in cropping pattern, shifting towards water intensive crops
- Large-scale pollution due to lack of proper wastewater and effluent treatment systems
- Absence of water sharing agreements between states
- Different political parties in power

The relationship between States and the Central Government should not be a zero-sum. Increasing the role of central institutions in dealing with

[68] Moha, N, S. and Routray, S. (2011)."Resolving inter-state water sharing disputes". Available at http://www.india-seminar.com/2011/626/626_shantha_&_sailen.htm [Accessed 04 April 2018]

[69] Biswas, A., Tortajada, C. and Saklani, U.(2017)."Running on empty: How water might dissolve the Indian Union if it can't resolve river disputes". The Times of India Blog. Available at https://blogs.timesofindia.indiatimes.com/toi-edit-page/running-on-empty-how-water-might-dissolve-the-indian-union-if-it-cant-resolve-river-disputes/ [Accessed 04 April 2018]

the sharing of transboundary rivers should not necessarily imply a reduced role in the states' power. Governments also need to creatively use existing tools - such as mediation and scenario building exercises - for managing water resources of inter-state rivers more effectively and democratically. Due to a lack of adequate legal and institutional mechanisms, resolution of disputes around transboundary rivers are becoming more complex.[68]Even the Government's recent move towards the interlinking of rivers could aggravate inter-state water disputes. The Central Government should endeavour to resolve these disputes through discussions amongst the States.

Failing this, under section 3 of the Inter State River Water Disputes (ISRWD) Act, 1956, the Central Government can constitute a River Water Disputes Tribunal for the adjudication of any water dispute. Thereafter, appropriate mechanisms, such as control authority, supervisory committee, or Boards are put in place to implement the Award of the Tribunal.

There are a number of challenges with the existing tribunal system. First of all, there are no uniform, logical and common processes. Tribunals have considerable discretion in terms of processes as well as establishing underlying concepts to arrive at settlements. Fundamental assumptions have often significantly varied from one tribunal to another. Secondly, tribunal results are non-binding to the States. Thirdly, the Centre has been reluctant to establish institutions for implementing the awards and lastly, there is no fixed or stipulated time frame for negotiations and adjudications.

With several States defying orders of tribunals and of the Supreme Court, water is becoming a matter of concern for India's social and economic development in the future. In the absence of functioning water institutions at Central and State levels and with a lack of political will to take tough decisions, inter-state water allocation problems will become increasingly more difficult to resolve.[69]

Transboundary considerations: Regional geopolitics, treaties & cooperation

The issues surrounding the trans-national river systems in South Asia are intrinsically linked to regional geopolitics. The countries that would be parties to any agreement formulated, are unequal in size and power, and have historically been involved in inter-state conflicts with one another. India shares all its major rivers with neighbouring countries.

India and Pakistan signed the Indus Water Treaty in 1960, which gave India control over the three eastern rivers of the Beas, Ravi and Sutlej, while Pakistan got control over western rivers of the Indus, Chenab and Jhelum. The resilience of the treaty, which has survived three post-independence wars, has been called into question in recent times. Pakistan is standing on the brink of water scarcity, and the situation is being exacerbated by climate change. This has had

Table 6.
Name of Tribunals and States Involved

S.No	Name of Tribunal	States concerned	Date of constitution
1	Godavari Water Disputes Tribunal	Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh and Odisha	April, 1969
2	Krishna Water Disputes Tribunal – I	Maharashtra, Andhra Pradesh, Karnataka,	April, 1969
3	Narmada Water Disputes Tribunal	Rajasthan, Madhya Pradesh, Gujarat and Maharashtra	October, 1969
4	Ravi &and Beas Water Tribunal	Punjab, Haryana and Rajasthan	April, 1986
5	Cauvery Water Disputes Tribunal	Kerala, Karnataka, Tamil Nadu and Puducherry	June, 1990
6	Krishna Water Disputes Tribunal -II	Karnataka, Telangana, Andhra Pradesh and Maharashtra	April, 2004
7	Vansadhara Water Disputes Tribunal	Andhra Pradesh and Odisha	February, 2010
8	Mahadayi Water Disputes Tribunal	Goa, Karnataka and Maharashtra	November, 2010

Source: *Ministry of Water Resources, River Development and Ganga Rejuvenation, 2017* dire implications on their agriculture sector and associated livelihoods. With the source or flow of all of Pakistan's rivers passing through India first, suspicions run high regarding hydropower projects carried out by India in any of the western rivers. In 2005, Pakistan challenged India's 450 MW Baglihar dam project before the World Bank. In 2011, both countries confronted again at the International Court of Arbitration (ICA) over India's 330 MW project in the Kishanganga project in Jammu and Kashmir.

India and China combined have more than a third of the world's population, but only a tenth of its water reserves. With their rapid rates of economic expansion, both countries are competing for access to the same yet limited water resources within the South Asian subcontinent. China has major hydropower dam projects on the river Yarlung Zangbo in Tibet, which crosses into India and eventually Bangladesh as the Brahmaputra. China has assured that these projects will not harm or obstruct the downstream flow of the rivers. The perceived lack of transparency, however, has irked India and the assurances have not allayed her fears. Both New Delhi and Dhaka worry that these dams will give Beijing the ability to divert or store water in times of political crisis.

There are 54 rivers shared by India and Bangladesh. Despite the setting up of a Joint River Commission for water management from 1972, tensions between both the nations on how to share resources has always been a matter of concern. India and Bangladesh signed that Ganges Treaty in 1996, to govern the dry season flow of the river and to seek ways to supplement flows in the Farakka barrage in the Indian side and Hardinge Bridge in the Bangladesh side. This was aimed at allaying some of the contentions held by Bangladesh regarding the construction of the Farakka barrage back in 1975, and the alleged reduction in flow of the river which has led to damage to agriculture fields, industry and ecology. Tensions between the two countries resurfaced in 2012, over the sharing of the water flow of the Teesta river which has its origin in Sikkim, and flows through the northern part of West Bengal in India, before it enters Bangladesh.

A 2015 report by The Asia Foundation notes that, in all four South Asia countries (Bangladesh, India, Nepal and Pakistan), data on transboundary rivers is not systematically collected at the basin level, and is done in a fragmented manner by different government departments. Crucial water information is shared in an informal and piece-meal manner within countries having better relations. For instance, China has signed a Memorandum of Understanding (MoU) with Bangladesh to share data on the water flow of the Brahmaputra and rainfall in its catchment area, but no such agreement has been signed with India. Efforts should be made to enhance public and institutional access to water-related data.

The water disputes surrounding the Indus, Ganges and Brahmaputra basins will not be resolved if the status quo of bilateral water sharing treaties with vague clauses and redressal mechanisms is maintained. The redressal lies in using the architecture of the international water governance framework, keeping regional considerations in mind. There is a need to formulate a basin wide approach to the sharing of water along the lines of the Mekong River Commission, the Nile River initiative, and the Water Convention of the United Nations Economic Commission for Europe (UNECE). The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) came up in 1992, with the intention of strengthening national measures for the protection and ecological sound management of the transboundary surface and groundwater. As of March 2016, countries outside the ECE region can accede to the Convention.

Chapter 3

Pathways to Sustainable Water Management

The water sector in India requires attention, which is holistic and strategic in nature. Continuing a 'business as usual' approach leaves the water sector vulnerable to the crisis of mismanagement. In this chapter, possible solution pathways for managing India's water sector sustainably will be articulated. By highlighting the crucial challenges and priority areas, various recommendations will be suggested ranging from water resources management, wastewater management and sectoral reforms to data innovations, multi-institutional coordination, and transboundary reforms.

[70] Sugam,R; Gupta, B. & Deka, D.(2015)."Working draft of the paper on Dying Traditional Water bodies in India".

Protection of traditional water bodies: Supporting decentralised development [70]

Traditional water bodies such as tanks and ponds have always been central to rural ecology and must be preserved before they completely vanish. CEEW did a study across 12 blocks of Meerut District in the State of Uttar Pradesh analysing geospatially and water quality in 120 ponds. It was found that, most of the small-scale yet vital water bodies are getting extinct, many having already been lost and degraded to the extent that they have left no trace behind. These water bodies serve as lifelines for the rural economy, cutting across almost all the districts and villages of India. Their economic and aesthetic value must be recognised in order to develop and adopt initiatives for their conservation. The centralisation of management of these water bodies has excluded the public, who are now reluctant to work towards the upkeep of these structures. However, in a systemic failure condition or drought situation, only these water bodies can be relied upon. It is therefore crucial that efforts to conserve these bodies are actively taken up by government and society, and initiatives to set up new ones are formulated. The following steps can be useful for conserving these water bodies and gaining a better understanding of their significance:

- **Mapping of the water bodies and assigning penalties** – water bodies should be digitised on a GIS platform, to keep track of numbers and extent and the data should be made publicly available. The accountability of local development agency/ government institution can go a long way in protecting and conserving these water bodies. Provisions should be made for the reporting of any construction/dumping activity being carried out, to local authorities. As a penalty, the institution should develop 1.5 or 2 times the area of wetland loss.
- **Water quality analysis** – consistent and regular water quality testing can facilitate better recording of pollution levels and accurately assess the utility of each water body.
- **Stringent measures against polluting sources** – targeted measures for monitoring water quality, while being difficult to implement, can reduce the chances of polluters to escape penalization. The target should not only be to conserve but also to enhance the quality of the water bodies.
- **Include water bodies in city development plans** – most cities in India are experiencing similar growth patterns like Meerut. At this initial city development stage itself, proper inventory of water bodies and inclusion of their conservation plans should be integrated into the city plans.
- **Volume estimation and annual plan** – water bodies should be made an integral part of the water management and allocation plan. If we have a proper understanding of the quality and volume of water available, the water budgeting could be done in a much more efficient way.
- **Conducting surveys to gauge public perception** – incorporating traditional knowledge of villagers for a holistic ecosystem viewpoint is important. Conducting ground surveys may be helpful in

[71] HUF.(2013)."Project report of Gundar basin". Hindustan Unilever Foundation, Bangalore, India

[72] Romit Sen and Ashish Bharadwaj. (2013)."Compendium of entries - FICCI Water Awards 2012". Federation of Indian Chambers of Commerce and Industry, August, 2013, Available at http://www.ficci.com/publication-page.asp?spid=20289 [Accessed 02 April 2018]

understanding the vital roles these entities play and also the reason behind public negligence towards these water bodies.

- **Setting examples and proper branding is essential** – government programmes such as the Swachh Bharat Abhiyan have positively influenced many people on the ground. It is still early to comment on their achievements but at least people are aware of the issues that require urgent attention. Similar interventions are required to protect these water bodies that could hardly stand the popularity of big rivers. Needless to mention, awareness generation and behaviour change should be at the core of the conservation plan.
- **Collective effort is the key** – a lot of inferences can be drawn but none can succeed without collective effort. The nexus can be several; it can be between the Government and Non Governmental Oragnisations(NGOs), public and private institution, private and NGOs, local community and NGOs, private and local community, local community and Panchayati Raj Institutions (PRIs), local community under a strong leadership etc. However, the sustainability of such interventions will always depend on the initiative shown by the local community. Thus, collective effort should be directed towards making people understand the long-term benefits of conserving and managing these water bodies.

Box 1.

A case study of the Gundar basin in Tamil Nadu

Gundar is a dry river basin receiving an average rainfall of 600-900 mm per year. The area of the basin is about 5,660km^2 with this land being used predominantly for agriculture. Out of the total population of nearly 500,000 families, more than 70 percent are dependent on agriculture and allied activities. The major irrigation source for these agricultural fields is tanks, which are around 2,300 in number.

Due to poor crop productivity and low income, issues like declining trend in agriculture, high weed infestation, increasing permanent fallow lands and migration started in Gundar basin. To address this issue, Development of Humane Action (DHAN) Foundation an NGO, Hindustan Unilever Foundation (HUF), the National Bank for Agriculture and Rural Development (NABARD) and the farming community started a collaborative project in April 2010 named Tank Cascades Development for Livelihood Security. This project targeted the rehabilitation of 250 tanks present in 13 cascades. The project aims to be a "model with scalability" for other regions of the country.[71 72] It was successful in reviving several water bodies and increasing farmers incomes. Few takeaways from this project are:

- Continued on-ground presence is important for collective action to succeed
- Active involvement of the funding partner in operations, not restricted to mere financial support is essential
- Government involvement is essential to speed up processes
- Developing a strong communication and conflict resolution strategy is necessary to build trust and achieve objectives
- Farmers should be considered active stakeholders and not simply beneficiaries. They should be encouraged to invest and develop a sense of ownership to ensure future gains
- Project design should take into consideration the local situation and adopt scientific methodology with the help of local experts
- Demonstration of success even at a small scale is essential to trigger the process

- **A proactive approach is required** – few States such as Maharashtra, Andhra Pradesh, Tamil Nadu etc., have started experiencing extreme water shortages and thus revival of these water bodies is being undertaken repidly. Other States should not wait for such a situation to react; experts should draft a proactive methodology of water conservation and management to counter natural calamities and the impact of climate change.

Groundwater management: Saving the lifeline

Saving groundwater is like saving the livelihood of millions in India. The use of groundwater was instrumental to the success of India's green revolution experienced in the last few decades,

[73] Burton, M. A., Grodon-Walker, S., Sen, R., Jalakam, A., and Ghosh, A.(2011)."National Water Resources Framework Study". New Delhi: CEEW.

[74] Verma, S., Krishnan, S., Reddy, A., and Reddy, K.(2012). "Andhra Pradesh Farmer Managed Groundwater Systems (APFAMGS): A Reality Check". IWMI.

[75] FAO: Food and Agriculture Organisation of the United Nations

[76] Mittra, S., Sugam, R., and Ghosh, A.(2014)."Collective Action for Water Security and Sustainability: Preliminary Investigations". New Delhi: CEEW.

[77] Burton, M. A., Grodon-Walker, S., Sen, R., Jalakam, A., and Ghosh, A.(2011)."National Water Resources Framework Study". New Delhi: CEEW

ensuring food security for the nation. Since then, the rate of ground exploitation has increased exponentially and its pollution is rampant. The nexus between groundwater and energy has implications not only for energy subsidies but also in order to prevent wastage and provide water for all. Thus, participation and participatory processes are essential for developing a robust groundwater governance framework. In addition, external factors such as energy as an instrument to regulate groundwater use patterns, crop choices to adjust to aquifer conditions and environmental fluxes are equally important for regulating demand.

Achieving effective and sustainable management outcomes depends on factors such as governance, the development model adopted and livelihood choices that a particular environment generates. Hence, groundwater governance must encourage and combine regulatory instruments, which integrate social norms, conventional legislation and adapt major reform to suit local needs. People's participation, along with strong partnerships with reformed government structures, will ensure the local action is successfully up-scaled to provide a viable solution to India's water woes.

NAQUIM (National Project on Aquifer Management). It deals with the delineation of aquifer disposition in 3-Dimension along with their characterization on a 1:50,000 scale in identified priority areas, the quantification of groundwater availability and assessment of its quality. The data procured should be in real-time and shared with decision makers and the community to increase awareness of existing challenges.

- Separation of agricultural feeder from rural domestic feeders, in order to provide a commercially viable continuous supply of electricity for household use in rural areas. This will also restrict the supply for agricultural use and facilitate the sustainable exploitation of groundwater. The conversion of all agricultural feeder lines with High Voltage Distribution System (HVDS) should be undertaken and all new agricultural connections should be provided with HVDS lines.
- Rationalise agricultural power tariff levels to make power utilities financially viable and reduce state subsidies on agricultural power supply. If politically feasible, metered tariff or rational flat tariff with synchronised power

Box 2.

A case study on participatory groundwater management

The Andhra Pradesh Farmer Managed Groundwater System (APFAMGS) project is an enabling intervention for managing groundwater overdraft through voluntary self-regulation.[74] In seven drought-prone districts of erstwhile Andhra Pradesh, nine NGOs (with BIRDS as the nodal NGO) along with the habitats of the districts, FAO[75], Royal Netherlands Embassy and government departments initiated the APFAMGS project in order to ensure a sustainable supply of groundwater through participatory demand-side management and knowledge creation. The project looked into technical and scientific capacity building of farmers, adoption of the Farmers Field School (FFS) approach for promoting eco-friendly farming system, facilitating the formation of Groundwater Management Committees (GMCs) for regular monitoring of groundwater levels, rainfall and discharge, promotion of Crop Water Budgeting (CWB) as a tool to empower farmers for deciding appropriate crop system to match available groundwater, and empowering the community to use appropriate initiatives in groundwater recharge measures[76]. In a majority of the project areas, the interventions have succeeded in initiating the building of a link between water availability and water use for agriculture. The remote sensing analysis for one selected Hydrological Unit showed that for the area under high water use, crops decreased by almost 11 percent from 2004-05 to 2007-08, whereas for areas under low water use increased by roughly the same amount. The APFAMGS project has done a commendable job in demystifying the science of groundwater dynamics for farmers and trained them to monitor groundwater status in their villages to facilitate collective decision-making on its utilisation[77].

Below are a few suggestive reforms for groundwater resources in India. [73]

- Proper monitoring of groundwater resources in the country. India has been developing the groundwater monitoring project called

supply to agriculture as per moisture stress and irrigation needs should be considered. Replacement of inefficient agricultural pump sets with BEE certified efficient pump sets should be undertaken.

- Formulation, implementation and maintenance of participatory groundwater management (PGM) projects in endemic groundwater depletion areas through appropriate policy and legislation and capacity building in relevant departments should be undertaken.
- Provision of agriculture extension services and marketing infrastructure to assist farmers in moving from water-intensive to other equally remunerative but less water-intensive crops.
- Support provision for the adoption of micro irrigation technology by farmers.
- Revision and enactment of groundwater legislation and enforcement of groundwater regulation legislation through the use of remote sensing and IT-enabled monitoring systems.
- Institutional strengthening and capacity building of groundwater agency.

Sectoral reforms based on understanding sector specific challenges

Agriculture

The present and future impacts of climate change require urgent attention at both: the national and local levels. India must start acting now to limit and reduce the intensity of climate change impacts and to develop a climate-resilient agriculture system. Some reforms suggested for the agriculture sector are prescribed below:

- **Understand location specific challenges** – agriculture patterns are location-specific and can vary within each district. It is necessary to develop climate models, which can analyse impacts at a more granular level. For this, India needs detailed location-specific databases for resources such as rainfall, groundwater, soil, crop diversity etc.
- **Develop capacity of communities** – an educated and informed community can use government incentives, natural resources and technologies in the best possible way to develop climate-resilient agriculture systems. Particular attention is needed for hilly, drought-prone and coastal states, as they are highly vulnerable to climate change impacts.
- **Create markets for diverse crops** – Council on Energy, Environment and Water's (CEEW) research on neo-traditional agriculture practices (a mix of traditional and modern agricultural practices) observes growing concerns amongst experts about decreasing crop variety. Crop diversity can give farmers more resilience in case of extreme climate events or pest attacks, therefore traditional agriculture knowledge must be conserved. Creating better markets for such crops and incentivising them for farmers, is essential for achieving this.
- **Strengthen institutions** – CEEW's work in agriculture and minor irrigation in Bihar discovered that, institutions such as irrigation departments, agriculture departments etc., which work with farmers directly, need strengthening. These departments not only need more human resources but advanced management and technical skills to deal with adverse situations. Linking day-to-day operations with regular assessments of climate risks would be necessary for institutions to remain relevant in the future.
- **Participatory approach** – whether for formulating policy at the national level or for collective action on water at the field level, there can be no bypassing the involvement of farmers in water resources management. Participatory water management can include collectively developing a resource inventory of villages, preparing crop plans, water budgeting exercises and conducting crop adaptation surveys at a community level.
- **A second green revolution** – the green revolution was launched fifty years ago. With the intensive use of fertilisers, pesticides, improved seeds and mechanisation, India has ensured food security with record outputs year on year. But the interventions have also had severe impacts on soil and water. In a world facing climate-related resource stress, now a second green revolution is needed: one that focuses on drought-resistant crops, lower water footprint, retention of soil carbon and increases crop diversity.
- **Adaptation resources** – in 2013-14, India spent US $91.8 billion on climate adaptation activities. This number is set to increase to US $360 billion in 2030. Much of these resources will be needed for strengthening agriculture and food systems. Thus, government budgets need to start reflecting

these priorities even as we seek international financial assistance.

Domestic sector

Utilities services across the world should be accountable for their services and equipped to provide equitable service to all sections of society. Most importantly, they should understand their stakeholders and ensure good communication with their consumers to assess needs. The target of "water for all" should be the ultimate aim and no distinction should be made on the basis of socio-economic background. In India, proper metering and a robust system to ensure asset inventory and management practices can go a long way in addressing the challenges of increasing non-revenue water loss.

In addition, political entities must recognise water both: as a basic human right and as a valuable resource to preserve. Therefore, while ensuring that a basic minimum amount of water is supplied to all households, water tariffs should be made rational in order to encourage sustainable consumption and prevent wastage. Utilities should also focus on increasing the efficiency of the billing and collection system, without which higher tariffs would be ineffective or impose disproportionate burdens.

Another fundamental problem is the link between water access and the legality of land tenures. This results in slum dwellers either not being counted or having little or no access to clean, potable and affordable drinking water. If public utilities and the private sector are serious about ensuring water for all, they will first need to reform these land-related policies. It is important to bear in mind that, the privatisation of water and the private sector's involvement are two distinct things. Regardless of whether the private sector or a public sector entity is operating/managing the WSS system, the responsibility of service provision ultimately lies with the public sector. The public sector's duty is to ensure that equitable services are being provided to all. Thus, the role of the government does not end after allocating a Public-Private Partnership (PPP) contract to a private partner.[78]

Interactions with several urban water sector experts and utility managers revealed that in general, there is no defined calendar for training programmes within utilities. However, some training is provided to higher officials mostly on project design and planning. These trainings are limited to city-scale utilities with little or no training for officials managing utilities in smaller towns. According to urban water experts, the following are among the major skill gaps and training requirements in urban local bodies (ULBs):

- Water management skills
- Skills to handle adverse situations
- Induction training
- Use of advanced instruments
- Knowledge of IT-enabled systems
- Water quality testing
- Communication skills

Box 3.

A case study on innovations in service delivery to the poor

Plumbing in slum areas will need some "unthinking", especially if we connect needs of water with sanitation. In Delhi and Agra, the Centre for Urban and Regional Excellence (CURE) has set up local water treatment plants with kiosks as business enterprises. Managed by women entrepreneur groups, these treatment plants provide door-to-door supply at affordable rates in water-shadow areas. While the plants themselves are generating incomes for poor women, by making water safe, they have also led to better health and productivity. CURE has plans to pipe this water to homes, depending upon the community's willingness. CURE has also helped families build household toilets connected to individual or cluster septic tanks. The Cluster Septic Tank in Savda Ghevra, Delhi is helping 320 families to have their own toilets. By linking toilets to Decentralized Wastewater Treatment Systems (DEWATs), CURE has helped generate water for recycling – housing construction, peri-urban agriculture and household use. More DEWATs on the city's other drains are planned to clean up the stormwater drainage system and reduce pollution in the River Yamuna. In Agra, CURE is also implementing a water conservation project that will recharge groundwater and revive the city's traditional water wells, enabling them to serve as water reservoirs. This process of social cohesion is bringing communities together to harvest rainwater, by engaging the primary stakeholders - the slum residents, and making them an integral part of the water management of the area.

Source: *Renu Khosla, CURE*

[78] Ghosh, A., Sugam. R and Sharma, U.(2013)."Urban Water and Sanitation in India: Multi-stakeholder Dialogues for Systemic Solution". CEEW Report, November 2013

- Training of field-level officers
- Analysis of market conditions

Nothing short of a paradigm shift is required in order to move towards sustainable solutions in the urban water sector. Investments in water supply must focus on demand management, reducing intra-city inequity and the quality of water supplied. To enable this, cities will be required to cut distribution losses through bulk water meters and efficiency drives. Each city must also consider local water bodies as their primary supply source. Therefore, the funding for water projects in cities shall depend on how optimally the water supply from local water bodies is accounted for and whether cities have been able to protect these water bodies and their catchments. This precondition will force protection and encourage the strengthening of infrastructure, which should not only create an efficient water supply system but also address sewage disposal. This will cut the length of the pipeline in two ways – one in supply and the other in taking back the waste. This also reduces the energy costs.

Making every drop count: Improving water use efficiency

Agriculture: Be irrigation smart

As mentioned previously, the use of chemical fertilisers and pesticides along with High Yielding Varieties of crops became an increasingly common means used for meeting higher food demands. However, these interventions had negative consequences as well. The way out is to rectify these mistakes and come up with holistic and innovative solutions. Some water efficient practices have been discussed below:

- **Micro irrigation systems** – micro irrigation systems such as drip, sprinkler etc., have high water saving potential. For example, drip irrigation provides an irrigation efficiency of more than 90 percent, whereas the current irrigation efficiency in India ranges from 50-70 percent. This also promises to enhance yield and reduce fertilizer use, saving input cost and increasing income at the same time. That said, it should not be considered a panacea and a sound understanding of crops and areas where such systems would be optimal is essential.
- **Laser Land Levelling** - the laser land leveller can be a good practice for water savings. Laser levelling is a precision land levelling technique, it smoothens the land surface (± 2 cm) using laser-equipped drag buckets. The benefits it brings are: smoother soil surface, reduced water and time requirements for irrigation, improved uniformity in water distribution and reduction in fertilizer inputs. However, this technique requires high input costs, skilled labour and requires considerably even-levelled fields to improve efficiency.
- **Conservation agriculture** – the principles of conservation agriculture requires: minimum disturbance to the soil (through tillage); maintenance of permanent organic cover on the soil (by leaving crop residues on soil surface); and the adoption of diversified cropping/agroforestry systems (through crop rotations, intercropping etc.) It promises to reduce water for irrigation by improving soil moisture and water intake rate. It also reduces runoff and erosion, decreases pollution and enhances groundwater recharge.
- **Understanding of soil moisture** – knowing when and how much water a crop requires

Box 4.

A case study on Eskom's application of dry cooling technology

Eskom is a global leader in manufacturing dry-cooled coal-fired power plants for more than 30 years. The company operates the world's largest direct-dry-cooled (Matimba Power Station) plants in South Africa. In 2010–2011, the Eskom consumed a total of 327 million m^3 of water for power generation. Without innovative, efficient cooling systems of the company, the consumption of water would have been 530 million m^3. In the case of Matimba Power Station, which is the world's largest direct-dry cooled power station, the plant cut the volume of water used to about 0.1 L/kWh (0.1 m^3/MWh), using direct dry cooling. Matimba uses around 3.5 million m^3 of water every year, compared to a corresponding size of traditional power plant using wet-cooling system, which would use 50 million m^3. This figure is around 19 times less than an equivalent wet-colling power plant.

***Source:** Bushart, S. (2014)*

Box 5.

A case study on the Calcutta Electric Supply Corporation (CESC), Budge Budge, West Bengal [79] [80]

The CESC Budge Budge is a 750 MW capacity (three 250 MW capacity units) power plant located in the South 24 Paraganas district of West Bengal. Despite using subcritical technology designed for 37 percent efficiency - far below that of the global best ultra-supercritical (USC) technology - the operating performance of the plant is exemplary. The plant's availability averaged 93 percent during 2010-13, indicating very good maintenance. The Plant Load Factor and the plant's efficiency also reflect good operating practices with steady improvements in the efficiency during the assessment period. Water use efficiency is the most remarkable feature of this plant. It consumes only 2.2m^3 of water per MWh power generation with seven cycles of concentration (COC) in its cooling towers indicating low water use. The plant also employs principles of a zero liquid discharge system (ZLD) ensuring that the water discharged from various uses is recycled. Fly ash is handled dry and boiler water is treated in an advanced system to allow reuse and reduce losses. Wastewater management is also in compliance with regulatory norms.

[79] Niyogi, S.(2015)."CESC Budge Budge plant named best thermal unit in Asia". Times of India, 13 November.

[80] CESC; RP Sanjib Goenka Group, n.d. Activities adopted for performance improvement: CESC Budge Budge. s.l.:CESC.

can save a huge quantity of water and energy. Use of tensiometers (typically a sealed, water-filled tube with a ceramic porous cup and a vacuum gauge at the top) can be extremely helpful in providing estimates of soil moisture. Remote sensing based study can also be used for this.

- **System of crop intensification (SCI)/ Alternative wetting and drying (AWD)** – innovative cropping practices such as SCI is yielding good results on the ground. It has been tested on rice, which is a major crop of India. SCI involves changes in the way soil, water and nutrients are managed. For rice, an increase in yield by 20 percent – 100 percent was observed and it led to a reduction of up to 90 percent seeds and nearly 50 percent water requirements. It achieves these benefits by reducing competition amongst crop, providing them sufficient space, the use of organic fertilizers and AWD instead of flood irrigation.

- **Access to energy** – rural regions in several states of India have sufficient water but insufficient access to energy, which limits access to water. The government is working on connecting every village with electric supply and solar powered pumps that can be used in such places to meet irrigation needs. In addition, immediate measures must be taken in areas where free access to energy has led to severe groundwater exploitation, to prevent further damage.

- **Regulation on cropping pattern by encouraging conventional crops** – recent water scarcity has been a result of unscientific choice of crops in various regions of the country. Whether it is Punjab growing rice or Maharashtra and Karnataka growing cotton and sugarcane. As agriculture uses more than 80 percent of the water share, it is important to bring efficiency in this sector. Even 10 percent increase in water-use efficiency in agriculture would be sufficient to meet increasing water demands elsewhere.

Industry: Towards 'water footprint' management

For any industrial unit, resource availability should be incorporated within the planning stages itself. A comprehensive understanding of resources, including seasonal fluctuations, should be carried out before setting up of industries. Impact assessment on local water resources, in the short and long-term scenarios, should also be critically evaluated. The current process of conducting an Environmental Impact Assessment requires a lot of improvement. Regulations should be in place that mandates industries to strive towards investment in water-efficient technologies. Along these lines, the latest notification issued by the MoEFCC in December 2015 mandates the existing thermal power plants (which are the major water consumers in the industrial sector) to limit their specific water consumption to 3.5 m^3/h per MW by December 2017. While the plants commissioned after January 2017 should have a maximum water consumption of 2.5 m^3/h per MW. These water use benchmarks can be instrumental in achieving high water-use efficiency in thermal power generation. However, mandates for technological solutions should be well researched and context specific. In this regard, a national level Bureau of Water Efficiency having a strong state-level presence could go a long way in encouraging water efficiency norms. Moreover, effluent management should come in the ambit of polluting industries and effluent reuse should be carried out wherever possible. Such resource sharing should also be facilitated

[81]Parikh, J. (2004). "Environmentally Sustainable Development in India". Available at http://scid.stanford.edu/events/India2004/JParikh.pdf

[82]Water Act (1974), the Water Cess Act (1977 and 1988), and the Environment (Protection) Act or EPA (1986)

[83]Murty, M.N. and Kumar, S.(2011)."Water Pollution in India; An Economic Appraisal". Available at https://www.idfc.com/pdf/report/2011/Chp-19-Water-Pollution-in-India-An-Economic-Appraisal.pdf

[84]Mehta, S., S. Mundle, and U. Sankar.(1994). "Controlling Pollution: Incentives and Regulation". Sage Publications, New Delhi.

[85]Murty, M.N., A.J. James, and Smita Misra. (1999)."Economics of Water Pollution: The Indian Experience". Oxford University Press, New Delhi.

in industrial clusters. Cluster level treatment of wastewater could be an alternative solution for small industries, which do not have the financial capability to treat wastewater on their own. For some industries, a zero liquid discharge policy could be game changing.

It is important that industrial policy is oriented towards 'water footprint' management. Efficient water use should be seen from the supply-chain point of view. Industries adopting best practices such as water stewardship etc. could be a part of a larger knowledge sharing platform wherein they can exchange technical know-how with industries, farmers and government institutions, to develop a successful working environment in other places. Besides technological knowledge sharing, industries can financially help farmers work towards efficient irrigation practices and thus contribute directly towards reducing the water footprint. Real-time monitoring of water use and effluent discharge should also be recorded. A uniform water assessment methodology and transparent water disclosure framework mandate could incentivize pro-active data disclosure.

Wastewater management: From burden to asset

Almost 80 percent of water supply flows back into the ecosystem as wastewater. While this can be a critical environmental and health hazard if not treated properly, its proper management can help water managers meet the city's water demand. 1.5 million children under 5 years die each year due to water-related diseases, 200 million-person days of work are lost each year and the country loses about INR 366 billion each year due to water-related diseases[81]. Pollution management of India's water bodies is not only socially desirable but also economically justified. As mentioned previously, India's current capacity to treat wastewater is estimated at 37 percent, or 23,277 million litres per day (MLD), against a daily sewage generation of approximately 61,948 MLD (CPCB report, 2016). Moreover, most sewage treatment plants do not function at maximum capacity and do not conform to the standards prescribed.

The laws that directly pertain to water pollution in India[82] have largely remained limited to controlling industrial water pollution and do not address pollution originating from household and agriculture activities. Apart from legislation-based command and control measures, the use of fiscal incentives has been limited.[83] These usually take the form of tax concessions for adopting pollution control equipment. There are some provisions for the use of levies, cess, fines and penalties for polluters, but their implementation and effectiveness needs strengthening (Kumar and Managi, 2009). Currently, effluent discharge tax or fees and tradable effluent discharge permits are the most popular incentive-based policy options for reducing industrial pollution.

The Ministry of Environment, Forest and Climate Change (MoEFCC) commissioned case studies showcased that there was a need for regulators to target industries with relatively high discharges of effluents and low costs of pollution abatement. For high-cost producers, the marginal abatement costs should serve as a basis for setting charges/taxes so that producers find it cheaper to abate than to pollute.[84] Researchers have recommended four options: (i) abatement charges with the government undertaking cleaning up, (ii) abatement charges with cleaning-up contracted out based on competitive bidding, (iii) a tax proportional to excess pollution on firms violating standards and subsidies for those going beyond the prescribed abatement standards, and (iv) a private permit trading system.

For pollution abatement by small-scale enterprises located in India's industrial estates, a collective action involving factories, affected parties, and the governments is an institutional option. [85] A Common Effluent Treatment Plant (CETP) can be adopted if necessary legislation is in place. A CETP for an industrial estate provides factories the benefits of savings in costs, and the reduction in damages to affected parties (local communities). This regulatory triangle will be completed with the involvement of government regulators as catalysts by providing information about environmental programmes and available cleaner technologies, and providing some financial incentives to local communities.

Municipalities can use user fees for wastewater treatment, subsidies for wastewater treatment facilities and subsidized pollution control equipment as policy instruments for reducing water pollution. The government can provide technical assistance and subsidized sanitation technologies to municipalities to encourage sustainable disposal of household sewage in areas which are not served by treatment plants. Finally, corrections in fertilizer and pesticide, and electricity pricing policies can be an instrument to check water pollution emanating from agriculture.

Experts have also pointed out the need to

[86] Hardach, S.(2015)."How the River Thames was brought back from the dead". British Broadcasting Corporation, 12 November

[87] Gray, R.(2010)."The clean up of River Thames". The Telegraph, 13 October

increase the number of monitoring stations in India and broaden the scope of monitoring from conventional compounds (such as Biological Oxygen Demand, total suspended solids, faecal coliform, and oil and grease), to non-conventional pollutants (such as ammonia, chlorine, and iron) that have hazardous health impacts. Monitoring responsibilities should be devolved to the states and further down to local bodies.

A positive case study, which highlights the potential and drastic turnaround of an ailing water body with concerted legislative and policy action is that of the Thames River in England. In 1957, the river, which had started to get increasingly polluted since that start of industrialization was declared biologically dead and unfit to sustain any life forms.[86] The Environment Agency enforced strict legislation that prevented industry from dumping polluted effluents into the river and its tributaries. Other key initiatives included the building up of mud banks and allowing reed beds to take hold. The transformation was evident even on the smaller rivers and streams that feed into the Thames. [87]

Urban: Circular "use, treat, and reuse" approach to water management

In cities, industries and commercial sectors pay higher tariffs for water but they don't have supply assurance. As reported by Fernandes and Krishna in their report, "Water shortages threaten coal company revenues", nearly 7 billion units (kWh) of coal power, with an estimated potential revenue of INR 24 billion were lost in the first five months of 2016 due to lack of water for cooling in thermal power plants. In addition to water supply augmentation, wastewater treatment offers new economic opportunities for energy and fertilizer recovery.

A shift from– a use and throw - linear" to a "use, treat, and reuse – circular" approach is needed to manage wastewater. That said, investment in wastewater treatment has associated risks as well. It is therefore important to understand the underlying social, political, technical and financial factors that will drive, facilitate, and sustain wastewater management interventions in India.

In urban areas, water resources are under significant pressure, due to complex water demand and consumption patterns within a small but highly-densely populated area. Currently, India is meeting the demands of most cities by transporting water over long distances. This is both inefficient and energy intensive. Therefore, finding a local level solution should be high priority. Currently, India has the capacity to treat approximately 23,277 (37 percent) million litres per day (MLD), against a daily sewage generation of approximately 61,948 MLD (CPCB, 2016). Most wastewater treatment plants do not even function at maximum capacity or conform to the quality standards prescribed.

CEEW in association with 2030-Water Resources Group completed an in-depth study on finding viable pathways for improved wastewater management in India. Eight factors that have been identified as the most critical for making an informed decision are: Drivers for initiating Wastewater management, Policies and regulations, Access to technology and finance, Scale of intervention, Management strategy and institutional framework, Public perception, Phases of deployment, Framework for participatory approach. These factors are not mutually exclusive and therefore studying just one factor could lead to the failure of the intervention. For example, water scarcity, which was found as the chief initiator for wastewater reuse practice across the globe, would need the support of policies and regulations as well as access to technology and finance to sustain the initiative.

An MS Excel-based techno-economic tool, which calculates the feasibility of water, energy and fertilizer recovery from wastewater, has also been developed. The tool helps in determining the potential tariff, based on choice of technology and level of treatment required, for the recycled wastewater at which it can be sold to recover treatment and supply costs. It also has the capability to conduct sensitivity analysis in order to understand how various technology options are sensitive to various parameters, such as land costs, power tariff etc., in determining the economics of the intervention.

The figure 15 outlines the case of a 50 MLD sewage treatment plant with Activated Sludge Process (most popular treatment method in India) with tertiary treatment.

The study establishes that direct benefits through recovered resources from wastewater could make an economically attractive case for practitioners to adopt circular economy pathways to manage wastewater. There are numerous indirect health and environmental benefits, which makes the case even stronger. This study could potentially guide utilities towards making treated wastewater reuse a viable option.

Rural: An integrated approach to water, sanitation and wastewater

In addition to water harvesting, water quality testing and infrastructure development for water supply would be necessary for providing clean, safe and affordable water to rural households. The choice of treatment technologies would be largely determined by the quality of raw water and the nature of demand. Some of the available water treatment technologies and methods are discussed below:

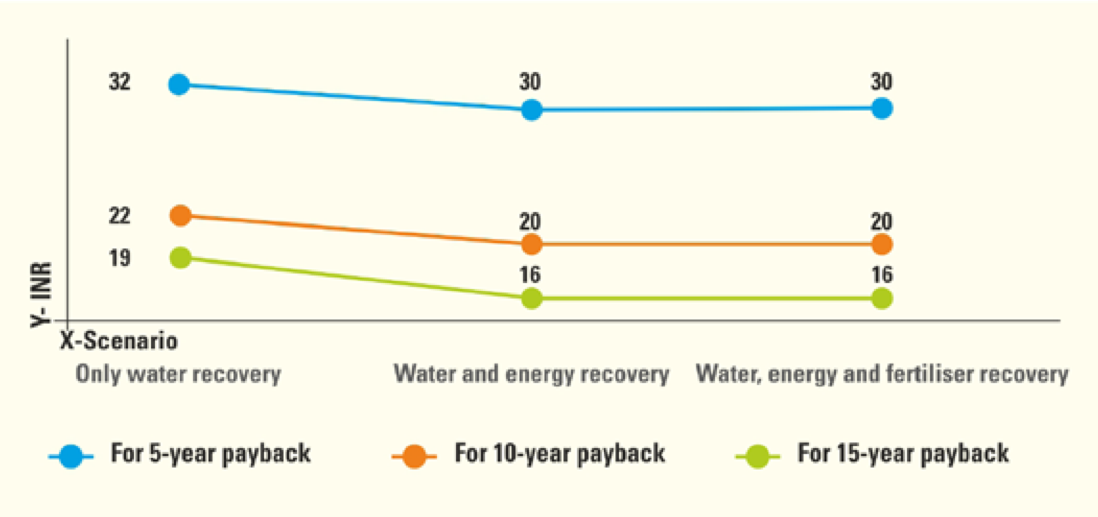
- **Slow sand filters (SSF)** – SSF is one of the most recommended methods of water treatment for rural areas. If designed properly, it purifies the water efficiently by reducing turbidity and bacterial contamination and it does not require highly skilled labour for operation and maintenance.
- **Chlorination** – disinfection using chlorine has been a common practice in various water supply systems. Being a strong oxidant, chlorine is used to remove taste and odour, as well as biological contamination. It can be used for the community water supply system as well as at the individual household level.
- **Solar Disinfection (SODIS)** – the SODIS method utilizes solar energy for water disinfection at the household level. A clean and transparent Polyethylene terephthalate (PET) plastic bottle (preferably below 2 litres) is filled with water and kept in direct sunlight for 6 hours during noon on sunny days and two days if the sky is more than 50 percent clouded. It has no chemical and external energy requirements thus making it an affordable choice. As reported, it removes 99.9 percent of microorganisms. The major limitations are that the raw water should not have turbidity more than 30 Nephelometric Turbidity Units (NTU) and there should be sufficient sunlight available.

Agriculture and domestic water needs are met by same/different water sources and runoff from such use pollutes these water sources. Sanitation-related water pollution is very high, therefore; an integrated solution is required for managing water, wastewater, sanitation and agriculture water. Treatment and reuse of wastewater would be essential to meet the increasing water demands and reduce water-related health diseases.

For the success of Swachh Bharat in rural India, it is essential to work towards analysing the status of toilets and mapping people's behaviour for understanding the local problems and not making broad countrywide generalisations.

A sound understanding of behaviour can be gauged through surveys conducted by agencies such as the Census department, National Sample Survey Organisation (NSSO), National Rural Health Mission (NRHM), Department of Water supply and Sanitation (DWSS) and, Sarva Siksha Abhiyan (SSA). Bringing about a change in people's behaviour and attitude towards sanitation requires more focussed and localised attention. A successful strategy of inducing shame, disgust and pride, used in Bangladesh may be applied. This would firstly require: a mapping of the village defecation areas, toilets and water and food sources, which can be done by NBA/DWSS workers in association with local NGOs, public personalities, local and national media. The District Sanitation Committee can also contract local NGOs for this purpose. Secondly,

Figure 15.
Water tariff for different payback periods and modes of revenue generation



Source: *CEEW*

[88] Ghosh, A., Sugam. R and Sharma, U.(2013)."Urban Water and Sanitation in India: Multi-stakeholder Dialogues for Systemic Solution". CEEW Report, November 2013.

[89] Burton, M. A., Grodon-Walker, S., Sen, R., Jalakam, A., and Ghosh, A.(2011)."National Water Resources Framework Study". New Delhi: CEEW

focused group discussions and community meetings can be conducted to promote audio-visual messages which talk about the demerits of open defecation. In addition, organising improved sanitation campaigns, advertisements through print and digital media, posters etc. and involving public personalities and local leaders for propagating the message of improved sanitation benefits would be useful.

Mechanisms such as awarding/recognising households with toilets as Nirmal households or propagating ideas such as no toilet no marriage may also be adopted. Lastly, in order to sustain the mission; it is imperative that the capacity of local workers is built. Providing training to local masons, vendor, operators of community toilets and locals can help achieve this. The training can be provided to local masons in groups of 20 to 30 for showing them ways to use local materials for construction of toilets and also demonstrating techniques to design proper toilets. Training/awareness campaigns can be conducted for creating new toilets and motivating existing local sanitary material vendors by educating them about the marketing of sanitation utilities. It is essential that operators of community toilets and sample households give trainings in cleaning and maintaining toilet hygiene.

The institutions involved in the execution of Swachh Bharat also need to be trained. United Nations Children's Fund (UNICEF) is one organisation, which can conduct trainings of district-level expert teams and Community-Led-Total-Sanitation (CLTS) facilitators. Nirmal Bharat Abhiyan (NBA) has already created a District level sanitation team which comprises of experts from different sectors who can act as trainers for block-level CLTS facilitators. The Administrative Staff College of India (ASCI), in association with UNICEF, has designed a course especially for District-level sanitation executives. It regularly offers training programmes for mid-level and senior level people working in the water and sanitation sector. Thus, the expert team could be sent to these training programmes for learning new technologies, developing management skills etc.

In India, as in many South Asian countries, lack of toilet facilities in schools is one of the major reasons why girls drop out of education. Every school should be mandated to build a separate toilet for girls. It is suggested that public spaces should be utilised for the construction of at least one community toilet complex per village. It should be provided with a dedicated operator preferably selected from one of the community toilet using households. Funds for constructing toilets at school and community level are already covered under SSA and NBA, respectively. A provision should also be made to ensure the regular cleaning of individual and community toilets, in order to maintain their hygiene status.

Most importantly, the existing sanitation team should do monitoring and evaluation. They can prepare a report of the type of toilets built at individual household and community levels but initial training to the sanitation team is required. It is also vital to keep a check on the use of toilets by villagers. Again, the Gram Panchayat (GP) sanitation team can send data to the district about household still defecating in the open. At the national level linking programmes such as NBA, SSA, MNREGA, DWSS, NRHM etc., which are working in isolation but for similar causes is important. While some work has been done to link MNREGA and NBA, a more holistic approach is required.

Better data for better water governance [88] [89]

Quality real-time data can significantly improve water management in the country. Developing an improved water database requires investments in various technologies ranging from flow measurement to installation of meters and digital water level recorders at a small-scale, to Supervisory Control and Data Acquisition (SCADA) system to use satellite data on a much larger-scale. It is therefore, important to estimate the losses due to unavailability of data against the costs of putting measurement devices and information systems in place.

An ideal hydrological information system in India should involve multiple agencies that collect, process and transmit water data to various government departments and users. The unit for data collection, processing and dissemination has been defined as the Data Processing Centre (DPC).

For the information system to function efficiently, the observed field data is submitted to the Sub-divisional/District/Unit DPC (SDDPC/dDPC/UDPC) at the end of each month of observation. Once data have been fed to the DPC, preliminary validation should be carried out within 10 days. The validated data should then be passed on to the Divisional/Regional DPC (DDPC/rDPC). Water quality samples must be sent regularly to designated water quality labs, who, at regular

[90] *Adapted from Chowdhary, H., Jain, S. K., Ogink, H. J. M. (2002)."Regional hydrology: bridging the gap between research and practice". Fourth International Conference on FRIEND (Flow Regimes from International Network Data), Cape Town, South Africa, 18-22 March pp. 35-42*

[91] *Chowdhary, H., Jain, S. K., Ogink, H. J. M. (2002)."Regional hydrology: bridging the gap between research and practice". Fourth International Conference on FRIEND (Flow Regimes from International Network Data), Cape Town, South Africa, 18-22 March pp. 35-42*

intervals, supply the data to the DDPC/rDPC. Given the larger area coverage under DDPC/rDPCs, data would be organised in basin-wise databases and within 15 days the secondary validation (spatial consistency checks) would be completed. The data would then be transferred to the respective state/regional DPC (SDPC/RDPC). The main activity at the SDPC/RDPC centres is to validate the hydrological data, fill in gaps, analyses and reporting. Inter-agency data validation exercises are scheduled twice a year: in February (for the data of the monsoon months) and August (for non-monsoon months). Next, the processed data should be transferred to the respective State/Regional Data Storage Centres (SDSC/RDSCs).

Central agencies are expected to have separate DSCs for each region. Each central agency will also have a National DSC (NDSC) for an overall perspective of the hydrological regime at the national level. All the SDSC/RDSCs store and administer the field (or raw) and processed (or authenticated) data and are expected to ensure smooth dissemination to users. DSCs would, in effect, function purely as hydrological data libraries equipped with a catalogue of stored data. A strict distinction between the DPCs and the DSCs is emphasised for ensuring sustainability and maintenance of finalised databases for all future reference and use. [91]

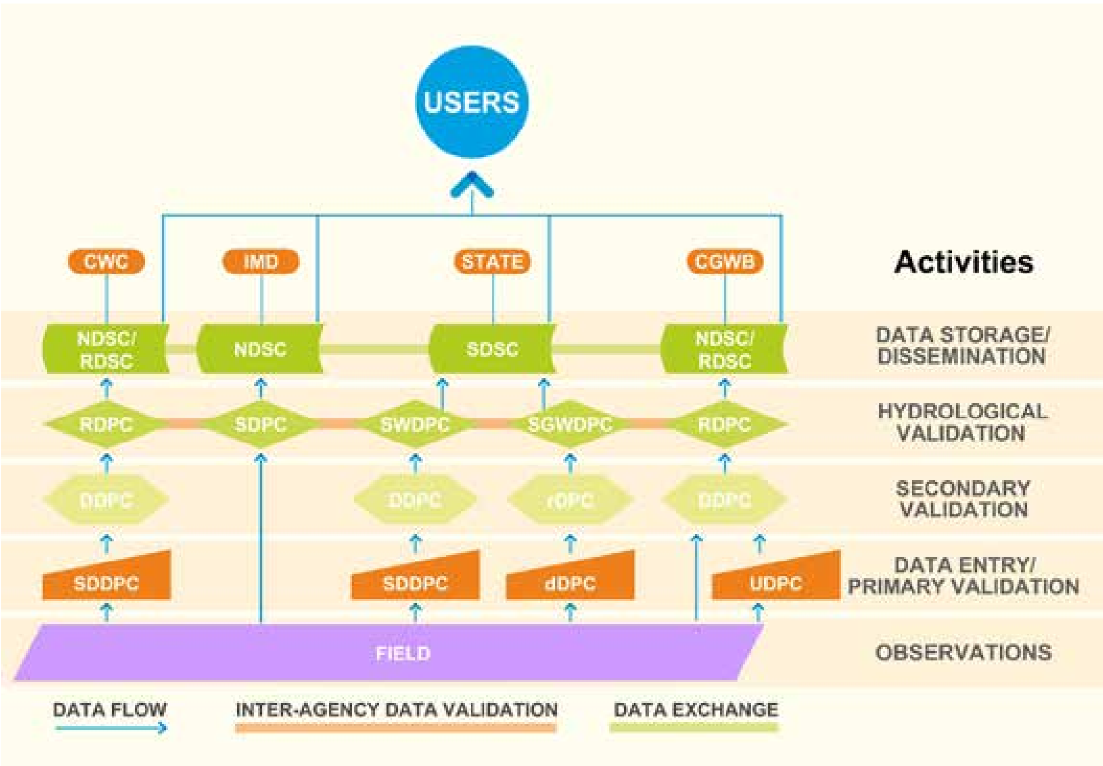
The development of a well integrated Hydrological Information System (HIS) would take time, in part because observation stations are not sufficient. But, more importantly, it is also necessary to understand the type of information commonly required by different users. Often there are gaps in transmission or unwillingness to share information with other agencies. Even final users of hydrological data should be bona fide users, vetted by controlling authorities.

Facilitate coordination among multiple institutions

The multiplicity of different departments and ministries entrusted with specific aspects of water management in India does not engender a holistic approach to the issue. As highlighted earlier, these institutions are struggling to keep pace with the country's changing water situation. Implementing national policies at the state and local level remains a challenge. Connecting river basin management with local management of water resources continues to be a gap in the current institutional framework. However, these gaps can be addressed through vertical coordination as well as through decentralization by an incentive structure.

Another challenge in the formulation and implementation of national-level water policies is the coordination required amongst ministries in the shared regulatory space, especially those

Figure 16.
Gaps in information flow in India's HIS [90]



CWC *- Central Water Commission*
IMD *- Indian Meteorological Department*
CGWB *- Central Ground Water Board*
NDSC *- National Data Storage Centre*
RDSC *- Regional Data Storage Centre*
SDSC *- State Data Storage Centre*
RDPC *- Regional Data Processing Centre*
SDPC *- State Data Processing Centre*
SWDPC *- State Water Data Processing Centre*
SGWDPC *- State Ground Water Data Processing Centre*
DDPC *- Divisional Data Processing Centre*
rDPC *- Regional Data Processing Centre*
SDDPC *- Sub-divisional Data Processing Centre*
dDPC *- District Data Processing Centre*
UDPC *- Unit Data Processing Centre*

[92] Prepared by DHV Consultants and DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG and JPS. (2003)."Design Manual for Hydrological Information System". Volume 1, Page Number 8

[93] Sing, N. (2011). India's Water Management Challenge, East Asia Forum. Retrived from http://www.eastasiaforum.org/2011/02/08/indias-water-management-challenge/ [Accessed 03 April, 2018]

[94] Administrative Conference of the United States. (2012). Improving Coordination of Related Agency Responsibilities. Retrieved from Administrative Conference of the United States: https://www.acus.gov/recommendation/improving-coordination-related-agency-responsibilities

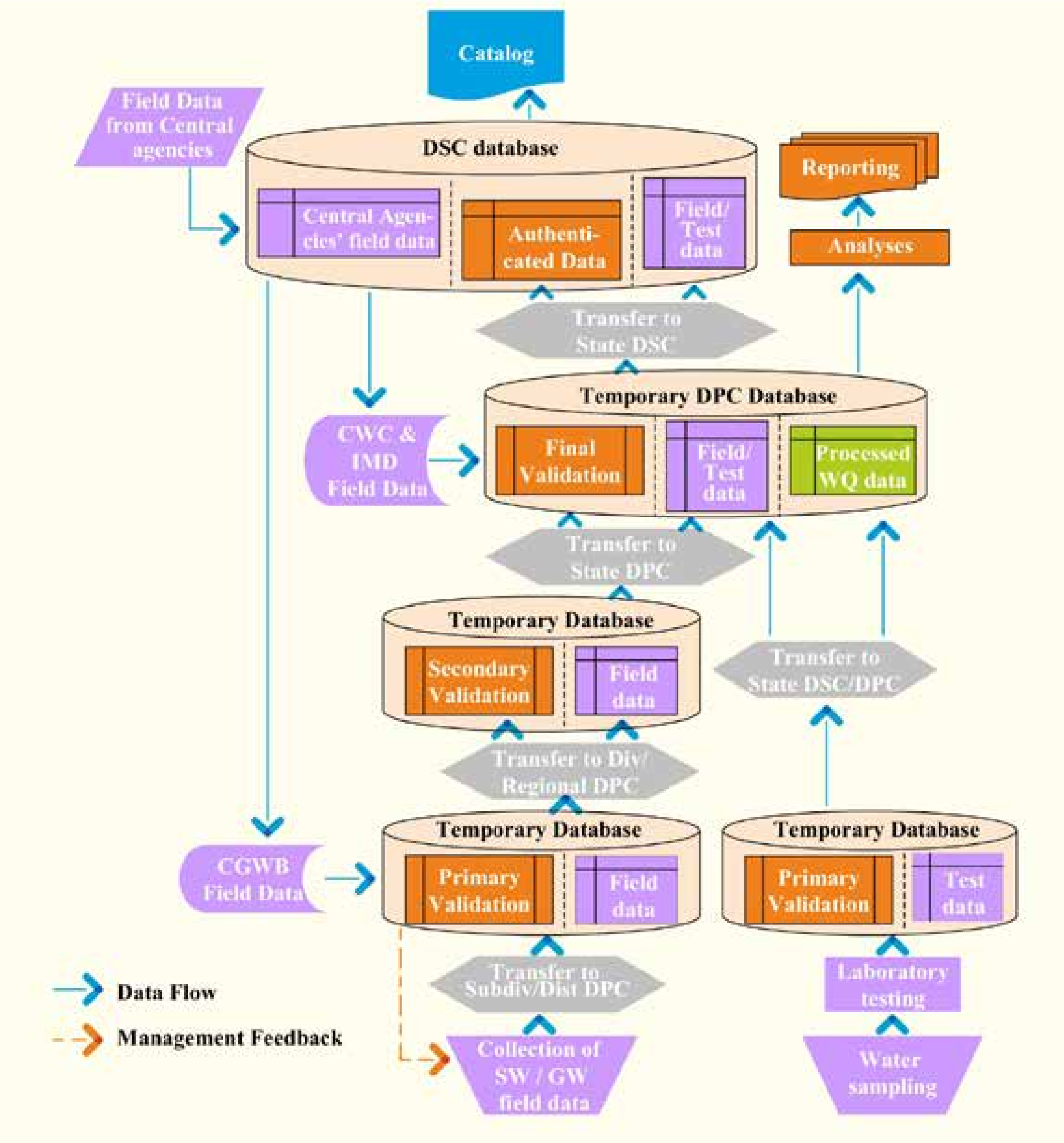
responsible for agriculture and water resources. The corresponding solutions lies in ensuring funds reach the correct administrative unit where they are most optimally utilised, greater capacity building for appropriate spending decisions and reducing spending distortions.[93]

It is imperative that federal agencies identify areas of shared or overlapping jurisdiction, and adopt policies and procedures to document ongoing coordination efforts. This policy formulation can be overseen by a nodal agency such as NITI Aayog, and could inter alia include mechanisms for: (i) resolution of disagreements over jurisdiction; (ii) sharing or dividing information generation responsibilities; (iii) redressal of potentially conflicting views on execution of shared responsibilities; (iv) minimizing duplications; and (v) development of joint standards, where appropriate.

The nodal agency should encourage coordinating agencies to set up inter-agency teams to produce and analyse data over the course of the decision-making process. These teams should meet early on before initial positions on issues are locked in, and consultations should be held in a continuing and integrated, rather than periodic and reactive way. [94]

The regulatory framework described above would be further strengthened by the drafting and passing of legislation that tasks the coordinating government bodies with implementation and coordination. Another option could be an online system, which would be a coordination and cooperation hub across ministries, connecting both the technical and high-level decision-makers with their counterparts in other coordinating ministries/departments. This system would accumulate all necessary and relevant documents, guidelines and procedures for the effective operation of government affairs both centrally and locally.

Figure 17.
Activities in data collection, processing and storage[92]



Box 6.
A case study on SCADA installation in Pimpri Chinchwad

In order to address the challenge of offering safe and reliable water supply, a recent concept in India is 24x7 water supply. The main purpose of this type of service is to regulate flow and pressure in the water supply system. Pimpri Chinchwad, near Pune, Maharashtra, undertook this journey in 2008 when the utility invested in a SCADA system comprising a range of field instrumentation including Krohne Flow Meters. According to the Municipal Corporation, the system helps with information on raw water lifted from the River Pavana, treated at the water treatment plants (WTPs), sent via the pipelines, and received at 85 elevated storage reservoirs (ESRs).

The system also helps in providing equitable water supply to the city. The corporation has set up benchmarks for the flow of water through the system. As part of this, the Corporation has installed flow meters at the raw water pumping stations at Ravet, the WTPs at Nigdi and at the main water pipelines and ESRs. If there is any deviation from the benchmarks, the official concerned is sent a message on his cell phone, after which he determines the reasons for the deviation and takes corrective action.

For these initiatives, the Pimpri Chinchwad Municipal Corporation (PCMC) received various awards under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) Programme. In 2011, the civic body received the first prize in the category of, 'Improvement in Water Supply and Wastewater Sector'.

Emboldened by this success, PCMC embarked on another successful pilot project to implement 24x7 water supply in a specified area. It has resulted in a reduction in water demand by eliminating the need to store water, which leads to subsequent wastage. The electricity bills of residents have reduced, as there is no need to pump water, thanks to pressure being maintained in the system. However, the leakages in the system had to be controlled first, for which an innovative helium-based technology was used.

With confidence levels high, the Corporation, aided by the fast track funding under JNNURM being extended by a year, is scaling up this concept to all the areas under its jurisdiction.

Source: *Neville Bhasin, Forbes Marshall*

At the State level, coordination amongst institutions is crucial for the successful implementation of water policies and programmes. Karnataka has a unique division called the Jala Samvardhane Yojana Sangha (JSYS), which looks after the formation and training of Water User Associations. It is a registered society established by the Government and serves as the nodal agency for Community Based Tank Management in the State. JSYS works for the minor irrigation sector to strengthen participatory systems in tanks and groundwater management. Its chair is the State Minister of Water Resources and it reports directly to an Executive Committee, chaired by the Additional Chief Secretary. Its multidisciplinary team operates out of nine District Project Units whose responsibility is to transfer the development and management of tank systems to the communities. It is completely multi-disciplinary in nature and involves multiple institutions from various ministries to work towards a common goal.

Transboundary water reforms

Transboundary water issues in South Asia need to be resolved in a manner that incorporates a basin-wide approach to the sharing of water, a departure from the status quo of bilateral treaties with vague clauses and redressal mechanisms. We can look at some examples from the international water governance framework to better inform us about the types of solutions that can be formulated to redress these issues.

The Nile Basin Initiative, set up in 1999, is an intergovernmental partnership of ten Nile basin countries, namely Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, The Sudan, Tanzania and Uganda. Eritrea participates as an observer. A goal of the Nile Basin Initiative has been to establish a "cooperative framework agreement" (CFA) to replace earlier bilateral treaties and to "formalize the transformation of the Nile Basin Initiative into a permanent Nile River Basin Commission."[95]

The Mekong River Commission (MRC) is an intergovernmental organisation that works directly with the governments of Cambodia, Lao PDR, Thailand and Viet Nam to jointly manage the shared water resources and the sustainable development of the Mekong River. It is one of the international organisations, working on transboundary water issues governed by a specific set of rules, developed to coordinate

[95] *International Water Governance. (n.d.). Nile River Basin Initiatives. International Water Governance.*

[96] Mekong River Commission. (2017)."About MRC. Retrieved from Mekong River Commission for Sustainable Development". Available: http://www.mrcmekong.org/about-mrc/

[97] UNECE.(2017)."Water Convention". Retrieved from UNECE: https://www.unece.org/env/water.htm

[98] The Helsinki Rules on the Uses of the Waters of International Rivers is an international guideline regulating how rivers and their connected ground-waters that cross-national boundaries may be used, adopted by the International Law Association (ILA) in Helsinki, Finland in August 1966. Despite its adoption by the ILA, there is no mechanism in place by which the rules can be enforced. Notwithstanding the guideline's lack of formal status, its work on rules governing international rivers was pioneering. It led to the creation of the United Nations' Convention on the Law of Non-Navigational Uses of International Watercourses. In 2004, it was superseded by the Berlin Rules on Water Resources. Adopted by the International Law Association at Helsinki, 20 August 1966. 52 I.L.A. 484 (1967)

[100] AISLUS.(1988)."Watershed Atlas of India, All India Soil and Land Use Survey".New Delhi.1988

[101] Mittra, S., Sugam, R., and Ghosh, A.(2014)."Collective Action for Water Security and Sustainability: Preliminary Investigations". New Delhi: CEEW

technical cooperation among its members. Since its establishment in 1995 by the signing of the Mekong Agreement, the MRC has adopted a series of procedures on water quality, data and information exchange and sharing, water use monitoring, among others, to provide a systematic and uniform process for the implementation of this accord. [96]

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) of the United Nations Economic Commission for Europe (UNECE), which came up in 1992, aims to protect and ensure the quantity, quality and sustainable use of transboundary water resources by facilitating cooperation. It provides an intergovernmental platform for the development and advancement of transboundary cooperation. It was initially negotiated as a regional instrument, it turned into a universally available legal framework for transboundary water cooperation. As of March 2016, countries outside the ECE region can accede to the Convention. [97]

The UN General Assembly adopted the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (UNCIW) in May, 1997. Since then it has had significant influence in the resolution of international disputes as well as the conclusion of new treaties and agreements relating to international watercourses. The UNCIW is widely accepted as a codification of customary international law. Various intergovernmental institutions have also contributed to the development of transboundary watercourses law. The International Law Association (ILA) adopted the Helsinki Rules[98] in 1966, which formed the critical mass of the UNCIW. The Helsinki Rules uses the single drainage basin approach, and is based on the principles of equitable utilization, no harm rule both for present and future use, and compensation for injury and dispute resolution through negotiation. Other elements which could be considered in the formulation of future instruments for transboundary water management by co-riparian countries are – mutual benefit, consultation before undertaking projects, prohibition of unilateral decisions, negotiating in good faith, prior rights, and protection of downstream interests.

A report by Chatham House[99] stated that, it will be nearly impossible to resolve differences on the transboundary front in South Asia until the domestic water security issues are resolved. The proposal to set up a single, permanent tribunal incorporating the existing eight tribunals on inter-state water disputes could be a possible solution to streamline the redressal mechanism. It should have a strong institutional framework, which is transparent to ensure buy-in from states. The framework and guidelines will also have to incorporate provisions and follow-up actions in the event of non-compliance by States.

In India, along with a nodal tribunal, which addresses all inter-state water disputes, the Centre has also proposed to set up an agency that will collect and process data on river waters. There is pressing need to have available authoritative water data that is acceptable to all parties in the dispute, and which allows the tribunal to set up a baseline for adjudication.

Applying water boundaries: Basin level planning

It is often suggested, based on scientific research that, a river is best managed at the basin level. Since water doesn't flow in accordance with administrative or political boundaries, the traditional way of trying to manage water resources based on administrative divisions has not proven successful. Rivers are a natural resource of flowing water, which makes their own way and support biodiversity and the ecosystem. They transcend political, economic and social boundaries creating their own hydro-ecological units. However, regions, states and countries that share river basins do not always follow through on the implications of this insight in their planning and management of water resources. As a result, inefficiencies and failures are visible. Therefore, it is necessary to investigate the fundamentals of river management and question the need to establish clear boundaries for water resource management.

In the Indian context, we define 'boundaries' as physical hydrological demarcations (derived from hydrological divisions recommended by the All India Soil and Land-use survey 1988[100] namely: water resources, basin, catchment, sub-catchment, watershed (macro and micro)). Each boundary is further described by its economic, socio-cultural and administrative components (which vary at different hydrological scales). [101]

The success of a river basin management plan ultimately depends on the collective involvement of the riparian states, which requires trust building. It is essential to demonstrate to all parties involved the benefits accrued by each when adopting a river basin management approach. A research study states that, without a reliable information base, society is unlikely to accept management decisions, as they would lack credibility. The study also suggests that, involving a wide range of stakeholders, including the local community, is an essential part of any management response (M. Eriksson, 2015). Another study done for Mongolia, defines the institutionalization of River Basin Management (RBM) as 'politics of scale' where a new governance scale is created in the process of political negotiations. The creation of a river basin authority (RBA) was found to be a crucial step towards overcoming the existing vacuum of administrative capacities for water management at the subnational level. Mongolia also has created river councils, which support river authorities in coordination and public participation. The study concluded that, the success of RBM depends on the clarification of monitoring and enforcement tasks. This can include detailed provisions on the financing of RBAs through water pricing and their implementation and most importantly, political commitment that endures the temporal power struggles.[102]

The Indian Government has taken steps in this direction with the launch of Namami Gange, which involves multiple states and institutions. Under the Namami Gange Programme, a holistic approach has been adopted to clean River Ganga. Various pollution control schemes categorised into core and non-core have been taken up to clean the river. Core schemes include interception and diversion of sewage discharging into the Ganga and creating treatment infrastructure to treat the intercepted sewage. Non-Core schemes include providing low-cost sanitation

Table 7.

Detailed explanation of "boundaries"

Boundaries/ Unit	Administrative Characteristics			Economic Characteristics	Socio-cultural characteristics
Water Resource	Numbers	Area (Avg. ha)	Administrative units	Sectors	Social Characteristics
River	6 Major Rivers	5,50,00,000	Regions (country)	Industry (Large, Small-Medium); Agriculture, Hydropower, Fisheries, Navigation, Domestic)	Income classes, Gender disparity, Religious groupings, literacy rate
Basin	35 Basins	95,00,000	Multiple States	Industry (Large, Small-Medium); Agriculture, Hydropower, Fisheries, Navigation, Domestic	Income classes, Gender divisions, Religious groupings, literacy rate
Sub-Basin	550 Sub-basin	7,00,000	Multiple districts	Industry (Medium, small), Agriculture, hydropower (medium, small), fisheries, domestic	Income classes, Gender disparity, Religious groupings, literacy rate, caste divisions, religious and cultural practices
Watershed					
Macro	3257	7000	Multiple sub-districts	Cottage industries, agriculture, small-micro hydels, sustenance fisheries, domestic	Income classes, Gender disparity, literacy rate, caste divisions, religious and cultural practices, vulnerable communities, livelihood impacts
Micro	3257	1000	Blocks, Villages, Tehsils	Cottage industries, agriculture, sustenance fisheries, domestic	Income classes, Gender disparity, literacy rate, caste divisions, religious and cultural practices, vulnerable communities, livelihood impacts

***Source:** Adopted from AISLUS 1988. Watershed Atlas of India, All India Soil and Land Use Survey, New Delhi.*

[102] Houdret, A., Dombrowsky, I. & Horlemann, L.(2014)."The institutionalization of River Basin Management as politics of scale – Insights from Mongolia". Journal of Hydrology, 519(C), pp. 2392-2404

at community and individual levels at identified locations, installation of crematoria (electric as well as wood-based improved crematoria), River Front Development (RFD) including bathing ghats, river surface cleaning, afforestation, protecting biodiversity and creating public awareness and participation. The sheer complexity of the management challenges can be understood by the fact that the river transverses 11 States which constitute 26 percent of the country's land mass and supports about 43 percent of its population. Inter-state coordination and data sharing is a must for the success of such initiatives. The recent court orders of allocating human rights to River Ganges and classifying it as a living entity might prove helpful in curbing pollution.

Chapter 4

Nexus Complexities

A sound understanding of the nexus of water resources with other sectors is essential for finding solutions to the challenges faced by it. The energy-water nexus is one such conundrum wherein water is present in all stages of electricity generation. Water is also central to food security and the agricultural sector, which is currently facing one of its biggest challenges in the face of climate change. When it comes to trade, India had the highest net virtual water exports in the world. China, in comparison is the eleventh largest. There also exists an intrinsic relationship of health with water. Both: the quality and quantity of water exposes individuals to preventable health risks. Even though access to water and sanitation are recognized as human rights, discrimination towards specific groups and individuals happens in numerous ways. Education can play an important role here; by creating a more informed and integrated understanding of the water sector.

An intertwined challenge: Energy and water

Water and energy systems are highly interdependent. While water is used in all phases of energy production and electricity generation; energy is required to extract, convey and deliver water of appropriate quality for a plethora of human uses such as irrigation, domestic use and industrial use, and then again to treat wastewater prior to their return to the environment. Impact on the availability of one affects the other and there is a strong nexus between these resources. Continued economic development will lead to increasing demands for water—for agriculture, electricity, industry, and households—putting pressure on local and national resources and will therefore expedite the need for developing long-term solutions.

Water for energy - Water is required for energy production from almost all fuel sources. As of 2010, 15 percent of the world's water withdrawals were estimated to be for energy production, of which 11 percent was consumptive in nature.[103] Majority of thermal power plants (TPPs), including coal, gas as well as nuclear power plants, consume freshwater from dam reservoirs, rivers and canals. Water withdrawal for thermo-electric power generation is the highest among all industries. Most of this water is used in the cooling processes. In India, 61 percent of the current installed capacity is coal-based. Large quantities of water are required in coal processing and handling, cooling purposes, and ash handling in thermal power plants, making them water guzzlers.

The power sector, which at present accounts for the bulk of all water use by India's energy sector, remains the major source of incremental water use. It accounts for 98 percent of additional withdrawals and 95 percent of additional consumption during the outlook period.[104] Moreover, the power generation sector comes low in the order of priority of water allocation as defined by the National Water Policy, 2012 and it will have to suffer if the water situation further deteriorates. As reported, approximately 7 billion units (kWh) of coal power, with an estimated potential revenue of INR 24 billion were lost in the first five months of 2016 due to lack of water for cooling.[105] This necessitates immediate action for conserving water by maximizing water-use efficiency of power plants and limiting the construction and use of the least efficient coal-fired power plants. This can be achieved by using super-critical technology, widely adopting dry cooling and/or highly efficient closed-loop cooling.

Energy for water – More than 60 percent of irrigation relies on groundwater, while only 24 percent of India's irrigated land is irrigated through surface canals. The steep rise in dependence of groundwater is due to an increase in the access to electricity, flat rate tariffs, energy subsidies and affordable pumps.[106] The major implication of this groundwater-energy nexus is the over-exploitation of groundwater in land-rich water-scarce Western India and also a wasteful use of energy. On the other hand, in water-rich states of Eastern India, groundwater development is constrained due to limited

[103] International Energy Agency.(2012)."World Energy Outlook". Paris: IEA

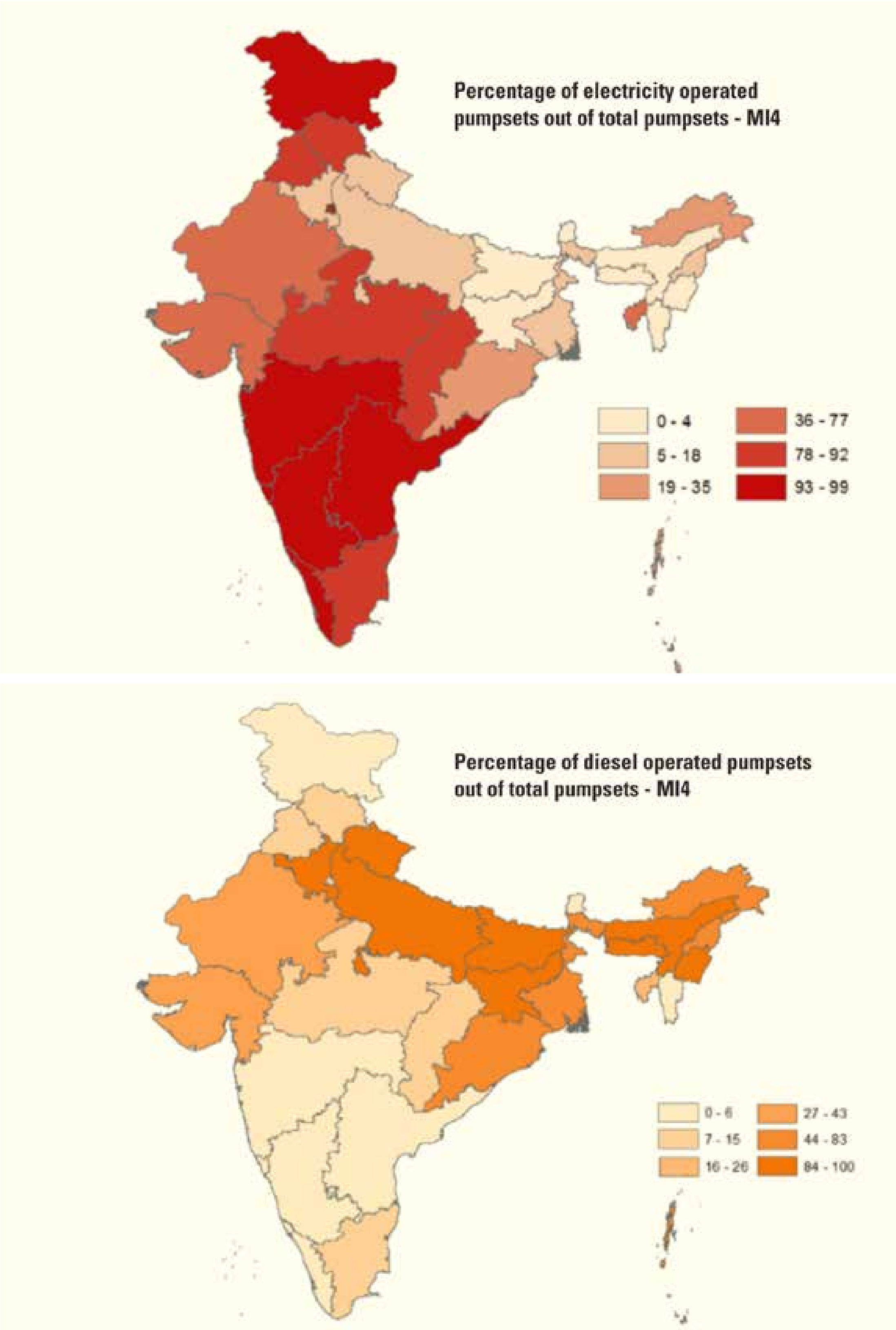
[104] Ibid.

[105] Fernandes, A., and Krishna, J, R.(2016)."Investor Briefing: Water shortages threaten coal company revenues". Greenpeace

[106] Mukherjee, A., Shah, T., and Giordano, M.(2012)."Managing energy-irrigation nexus in India: A typology of interventions". New Delhi: IWMI

Figure 18.

Distribution of electric and diesel pump sets across India – a clear Indication of the high penetration of electric pumps and water scarcity



Source: *Sugam and Choudhury (2014) – MI census IV analysis*

availability of arable land and an unaffordable and unreliable supply of electricity[107]. This nexus has led to far-reaching implications for all the three sectors involved – food, energy and groundwater. Food production has become more resilient to droughts due to widespread subsidized groundwater irrigation. On the other hand, as per the CGWB Groundwater Resource Estimates for 2011, groundwater abstraction exceeds recharge at several places. On the energy front, growing power subsidies became a financial burden to the state governments while removal of metering and introduction of highly subsidized tariff of electricity led to high-levels of power (and

[107] Bassi, N.(2015). "Irrigation and energy nexus: Solar pumps are not viable". Economic and Political Weekly, 63-66

groundwater) use per hectare.

Even in the domestic sector, expenditure on power across the water supply and sanitation sector utilities is higher than 50 percent of the operational costs. Due to low pressure and non-continuous supply– almost 30-50 percent of household level power is used for water pumping and storage.

Confronting climate change: Water and agriculture at risk

Given the importance of water to food security, agriculture and nutrition, climate change will become a central challenge in the coming years. While the precise impact of climate change on the environment and humans is yet to be completely measured, climate change is real, be it naturally occurring or human-induced. The findings of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), state that, human influence has been a major contributor to observed warming since the mid-20th century. The report also found that Asia as a whole experienced maximum weather and climate-related disasters in the world from 2000 to 2008. Moreover, Asia suffered the second highest proportion (approximately 30 percent) of total global economic losses due to climate-related disasters.

For India, a change in monsoon patterns will have huge implications on water resources and associated systems such as agriculture. This makes the country even more vulnerable as nearly half of the country's population rely on agriculture for livelihood and nearly two-thirds of the cultivated land is rain-fed.[109] Cases of crop failures, farmer suicides and a booming water tanker industry are found in several states, which clearly illustrates the negative impacts of climate change on water security, which poses a direct threat to India's food security as well.

Looking at some water-related statistics for India, it becomes clear why it is critical to start acting immediately. The total available water resources in India are around 4,000 BCM of which only 1,123 BCM i.e. 28 percent are utilizable.[110] Greater temporal and spatial variation in the monsoons will further decline utilizable water resources. Sectorwise, irrigation consumes more than 80 percent water with few states already extracting more groundwater than the amount that is naturally replenished.[111] Moreover, irrigation efficiency is low with an average irrigation efficiency of 50 percent and 70 percent for surface water and groundwater, respectively.[112] The demand from residential and industrial sector is ever increasing; and per capita water availability has decreased rapidly from 5,200 m^3 in 1951 to 1,588 m^3 in 2010.[113]

As predicted:

- There will be a downward trend in the number of wet days in a year. The impact of climate change will be seen in terms of increased sub-regional variations and more extreme rain events where the number of days it rains may further go down in future. In a country that gets rain for less than 100 hours in a year (a year has 8,760 hours), this would be disastrous.

Figure 19.
Extensive pumping to meet Bengaluru city's supply needs [108]

[108] Ramesh,N.(2016)."Bringing home the Cauvery". The Hindu. Available at http://www.thehindu.com/news/cities/bangalore/bringing-home-the-cauvery/article3422587.ece

[109] Central Water Commission. (2015)."Water and Related Statistics".New Delhi: CWC

[110] India WRIS.(2015, March 2)."India's Water Wealth". India-WRIS Wiki

[111] Central Ground Water Board.(2014)."Dynamic Ground Water Resources of India". Faridabad: CGWB

[112] Central Water Commission. (2014)." Guidelines for Improving Water-use Efficiency in Irrigation, Domestic and Industrial Sectors".New Delhi: CWC

[113] India WRIS.(2015, March 2)."India's Water Wealth". India-WRIS Wiki

- Sea level rise will lead to ingress of saline water and salination of groundwater and surface water in coastal areas. Saltwater intrusion caused by rising sea levels in low-lying agricultural plains could lead to food insecurity, further spread water-related diseases, and reduce freshwater supplies.

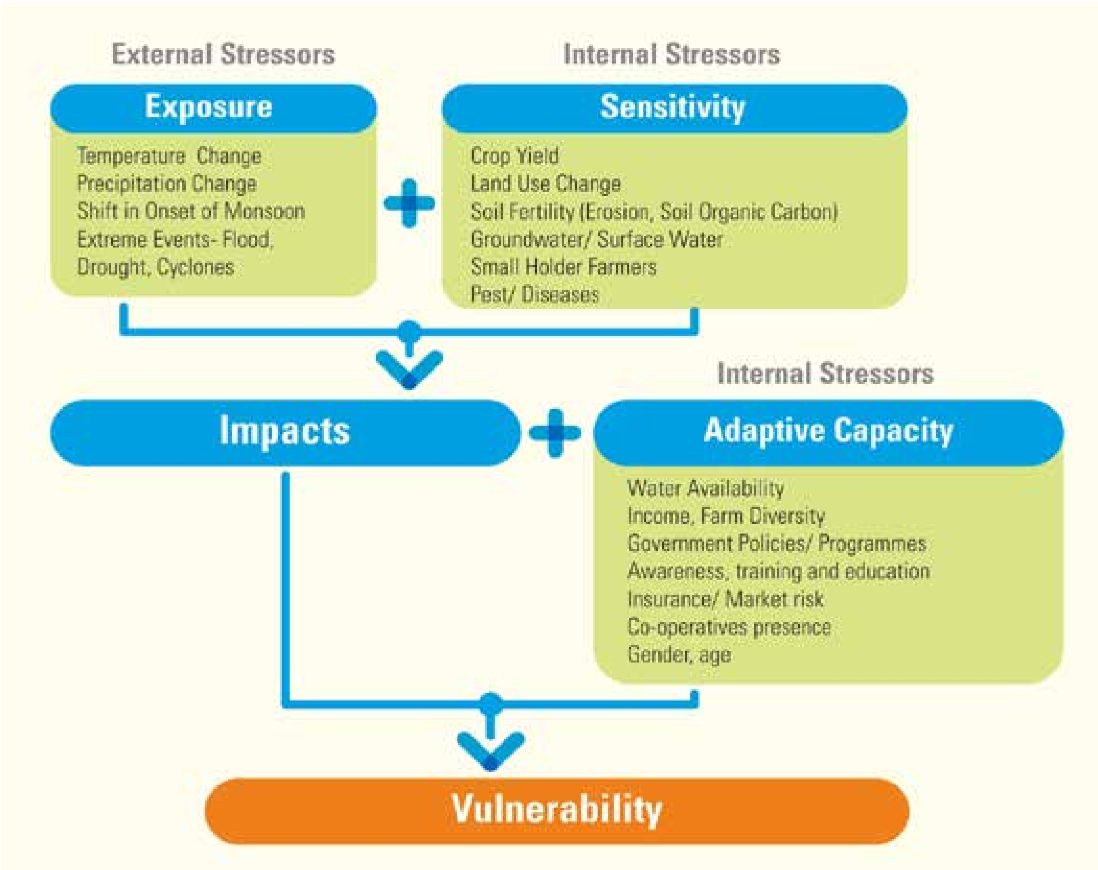
- With melting glaciers, flood risks will increase in the future. In the long-term, there can be no replacement for the water provided by glaciers, which could result in water shortages on an unparalleled scale. Floods and drought are thus projected to multiply because of climate change leading to huge crop loss and leaving large patches of arable land unfit for cultivation and hence, threatening food security.

It is estimated that the impact of climate change is significantly larger for the water sector and therefore newer strategies should be evolved to achieve a sustainable trajectory of growth and development with respect to water management in the country. The management of water resources, accompanied by upgrading the existing water infrastructure, is therefore among India's key challenges. Given the multiple issues that the water resource sector faces, it is necessary to re-think the approach to planning and implementing water projects. Since water has multiple uses, involving potential users from the start of a project is essential. This would not only help resolve conflicting demands, but also help maintain transparency. It is therefore necessary to have a comprehensive assessment of India's water sector, from an interdisciplinary perspective.

Future predictions include a worsening of the situation due to a disturbed hydrological cycle and regional climatic variability. The lack of water availability and poor management practices, have resulted in inadequate sanitation facilities, which is rapidly becoming the biggest environmental and social challenge in India. At the same time, open defecation leads to pollution of sub-soil water, establishes a two-way causation between lack of water and non-use of toilets. A recent study conducted by the Water and Sanitation Programme, a global partnership administered by the World Bank, estimates that inadequate sanitation causes India 'considerable economic losses', equivalent to 6.4 percent of India's GDP in 2006.[114]

[114] World Bank. (2010)."Inadequate sanitation costs India the Equivalent of 6.4 per cent of GDP. World Bank". Available at http://www.worldbank.org/en/news/press-release/2010/12/20/inadequate-sanitation-costs-india-the-equivalent-of-64-per-cent-of-gdp [Accessed 29 March, 2018]

Figure 20.
Agricultural vulnerability indicators



Source: *Sugam, Choudhury, and Hartl, (2016)* In the agriculture sector, practices such as System of Crop Intensification, Drip irrigation, Sprinkler irrigation and a change in cropping schedule and pattern can do wonders. However, making recommendations to farmers, without hearing them would be incorrect, since they are more familiar with ground realities and traditional agricultural practices. Therefore, neo-traditional agriculture practices could be the right way to address water security and climate change concerns.

In order to formulate an adaptation plan, it is critical to begin by understanding the vulnerability of a region. According to the IPCC (2007) definition, vulnerability in the context of climate change is, "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity"[115]. Exposure and sensitivity indicators describe the potential impact that climate change can have on a system. Thus, impact on the agricultural system is indicated by a combination of 'Exposure' and 'Sensitivity' indicators – see Box 4.3. Moreover, there is a third category, 'adaptive capacity' which according to the IPCC (2007) is the ability (or potential) of a system to adjust successfully to climate change (including climate variability and extremes).[116]

Vulnerability assessment is the most crucial step for coming up with a specific adaptation plan. Some essential policy reforms to make the agriculture system more resilient are:

- Reviving the traditional water bodies
- Agroforestry options for watershed management
- Selecting cropping pattern based on climate predictions
- Using wild varieties of crops which are resistant to extreme events
- Multiple cropping – as it gives buffer to farmer if one crop is lost
- Communication – implementing the right strategy to communicate about possible negative impacts of climate change
- Choosing resource efficient options such as micro-irrigation or system of rice irrigation
- Government programmes and plans should include the adaptation responses under different agro-climatic conditions
- Forming co-operatives at the village level increases resilience.
- Traditional cropping system should be studied in detail as they have sustained against extreme events for years

Save water through trade

While formulating national water plans, governments have typically taken a purely national perspective, without considering the global dimension of water demand patterns. Despite the significant volume of trade in water-intensive commodities, few governments have consciously considered options to save water through import of water-intensive products. By simply looking at water use within the confines of

[115] IPCC, IPCC Fourth Assessment Report: Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability.(2007)

[116] Sugam, R.K.,Choudhury, P. and Hartl,J.(2016)."Promoting Neo-Traditional Agriculture to Achieve Food and Livelihood Security, and Climate Change Adaptation". Policy Brief, July

[117] Mishra, S.,Choundhury, S. S., Swain, S., Ray, T.(2009)."Multiple cropping system for conservation and sustainable use in Jeypore Tract of Orissa", Asian Agri-History 13 (1): 39 – 51.

[118] Ibid.

[119] Centre for Science and Environment.(2012). "FAO recognition of traditional farming should keep GM away", CSE Newsletter. Available at http://www.cseindia.org/fao-recognition-of-traditional-farming-should-keep-gm-away-3683 [Accessed 29 March 2018]

[120] Sood, J.(2012) "UN heritage status for Odisha's Koraput farming system", Down to Earth, 04 January. Available at http://www.downtoearth.org.in/news/un-heritage-status-for-odishas-koraput-farming-system--35627 [Accessed 29 March 2018]

Box 7.

A case study on multiple cropping system of Jeypore Tract of Odisha

The Jeypore tract (undivided Koraput district), southernmost district of Odisha is famous for conserving genetic diversity of the Asian cultivated rice, managed by tribal farmers. Almost 60 to 80 percent of these farmers practice mixed cropping for their subsistence and only sell the surplus. [117]

- Different length crops are selected for maximising sunlight exposure
- Diverse topography has resulted in a wide range of ecosystems: upland (unbunded as well as bunded), medium land (irrigated and rainfed) or low land condition
- Plants are chosen based on morphological characters or cultural practices (aromatic and non-aromatic). [118]

The 'scared groove' system is an effective way to preserve genetic resources. It has helped in promoting protection of forest patches as well as biological diversity. [119] Recently, the FAO recognised the traditional agricultural practice under the Globally Important Agricultural Heritage Systems (GIAHS). Moreover, the MS Swaminathan Research Foundation has also taken up the documentation and conservation of traditional knowledge through community biodiversity registers.[120]

Source: *CEEW*

Box 8.

A case study on Parangipettai (Portonovo), Tamil Nadu [121]

The coastal agroecosystem of Parangipettai (Portonovo) in North Eastern coastal Tamil Nadu is a typical agri-silvicultural zone with an effective traditional farming knowledge culture. A wider range of indigenous methods like rainwater harvesting, soil and water conservation are in practice now employed to cultivate annual and perennial crops. These methods are eco-friendly, cost-effective and utilization of human knowledge to conserve the local environment, enhancing the use of locally available inputs and are used to uplift the economic growth of the rural people.

Crop production depends upon the input of locally available organic manure-derived through penning and crop residues. Management of traditional water resources is considered important in conservation and utilization of natural resources. Following are the traditional practices adopted:

- Soil conservation by using crop residue mulching, summer ploughing followed by leaf litter mulching, growing vegetative barriers, crop rotation and relay cropping
- Growing trees on field bunds
- Green Manuring
- Animal penning
- Farm Ponds
- Water management practices

Source: *CEEW*

national boundaries, governments will not be able to arrive at a comprehensive understanding of the sustainability of consumption of water resources.

A country that exports rice, for instance, is in effect also exporting the water needed to grow it. In 2014-15, India exported 37.2 lakh tons of basmati. To export this rice, the country used around 10 trillion litres of water. In other words, India virtually exported 10 trillion litres of water. At least one-fifth of this would have been surface/groundwater and not rainwater. In these times of global climate change, water is the one commodity where a trade surplus (i.e., exports higher than imports) is undesirable.[122]

India had the highest net virtual water exports of water in the world, as compared to China, which is the eleventh largest. China has higher virtual water imports from its trade in crop and animal products. But China ends up exporting more water than importing because of its overseas sales of industrial products. India, on the other hand, is a large virtual net export of water because of agricultural products.[123] While the nation aims to increase manufacturing exports, care should be taken to maximize water-use efficiency lest it ends up virtually exporting more water. However, it is important to remember that the total virtual water exports of India are only around 2 percent of the total available water resources in India.

Safe water, healthier life

Access to safe water for drinking, domestic use, food production and recreational purposes is a crucial aspect of public health. Inadequate water resources, both in terms of quality and quantity, expose individuals to preventable health risks. Globally, 844 million population lack basic drinking-water services, including 159 million people who are dependent on surface water. At least 2 billion people use a drinking-water source contaminated with faecal matter.[124]

Despite investments in water and sanitation infrastructure, many low-income communities in India and other developing countries do not have access to safe drinking water. At a global level, there is increasing effort to provide access to improved water services in order to avoid the health implications of not having the same. Although 2.1 billion people have gained access to improved water and sanitation since 1990, the issue still remains a challenge globally. Goal 6 of the Sustainable Development Goals recognises the importance of assuring clean water and sanitation to all. It is not just the quality of water directly consumed by individuals that matters; untreated water used for irrigation can significantly affect human health as well. According to a scientific study, the annual health cost per child in untreated wastewater-irrigated environments is around INR 4000/annum (~$60), which is 73 percent higher than the annual health cost per child in freshwater-irrigated areas.[125]

According to World Bank estimates, 21 percent of communicable diseases in India are water-related.[126] Diseases due to bacterial (typhoid, cholera), viral (jaundice) and protozoan (amoebic dysentery) infections spread primarily due to contaminated water sources.[127] Estimates suggest India loses INR 36,600 crore every year due to water-borne diseases.[128] In India, diarrhoea mainly

[121] R Rex Immanuel, V Imayavaramban, L Lyla Elizabeth, T Kannan and G Murugan.(2010)."Traditional farming knowledge on agroecosystem conservation in Northeast Coastal Tamil Nadu", Indian Journal of Traditional Knowledge, Vol. 9 (2), April 2010, pp 366-374

[122] Kishore, R.(2016)."India is the biggest virtual exporter of Water". Livemint. Available at https://www.livemint.com/Opinion/bPPHFHv19qBaA5qrPa6SuN/India-is-the-biggest-virtual-exporter-of-water.html [Accessed 02 April 2018]

[123] Mekonnen, M.M. and Hoekstra, A.Y.(2011). "National water footprint accounts: The green, blue and grey water footprint of production and consumption", Value of Water Research Report Series No. 50, UNESCO-IHE

[124] World Health Organisation. (March 2018)."Drinking Water: Factsheet". Retrieved from World Health Organisation: http://www.who.int/mediacentre/factsheets/fs391/en/

[125] Grangier, C., Qadir, M., and Singh, M.(2012)."Health Implications for Children in wastewater-irrigated peri-urban Aleppo, Syria". Water Quality, Exposure and Health, 4, 187-195.

[126] Water.org.(2017)."India's water and sanitation crisis". Retrieved from water.org: https://water.org/our-impact/india/ [Accessed 29 March 2018]

[127] TERI.(2017)."Health Impacts of Water Pollution". Retrieved from Edugreen: http://edugreen.teri.res.in/explore/water/health.htm [Accessed 29 March, 2018]

[128] *Centre for Science and Environment.(2015)."Body Burden 2015- State of India's Health"*

[129] *Lakshminarayanan, S. and Jayalakshmy, R.(2015)."Diarrheal diseases among Children in India: Current Scenario and Future Perspectives". Journal of Natural Science, Biology and Medicine, 6(1), p.24.*

[130] *Khurana, I., and Sen, R. (n.d.). Drinking Water Quality in Rural India: Issues And Approaches. Water Aid.*

[131] *UN WATER.(2018)."Human Rights to Water and Sanitation". Retrieved from UN Water: http://www.unwater.org/water-facts/human-rights/ [Accessed 29 March, 2018]*

[132] *UNECE and WHO. (2013)."The Equitable Access Scorecard: Supporting Policy Processes to Achieve the Human Right to Water and Sanitation"*

due to poor water quality is the third leading cause of childhood mortality and is responsible for 13 percent of all deaths/year under 5 years of age, killing an estimated 300,000 children in India each year.[129] Diarrhoea in children can be caused by numerous factors: mode of water transportation; poor handling of water in households; improper drainage of wastewater; refuse storage, collection and disposal; domestic water reservoir conditions; faeces disposal and, the presence of vectors. The situation worsens every monsoon with increased flooding and the mixing of sewage with drinking-water sources. Apart from diarrhoea, 66 million Indians are at risk due to excess fluoride and 10 million because of excess arsenic in groundwater. In all, 195,813 habitations in the country are affected by poor water quality.[130]

Water as a human right: 'Leave No One Behind'

Equitable access to water and sanitation, adequate in terms of quantity and quality, should be provided for all individuals, especially those who suffer from social exclusion and belong to disadvantaged groups. While water crises can be witnessed everywhere, it is most apparent amongst the marginalised groups. This can range from urban slum dwellers to remote rural communities, small farmers and flood-prone communities. The crisis particularly affects those marginalised by gender, caste, tribe or disability. Water for these groups is often a social exclusion issue and not just a water access one. Each of these groups has its own needs and faces different barriers to achieve equitable access. It is imperative that policy makers and office bearers identify these groups, review the status of their inclusion, and ensure that their needs are taken into account.[132]

Gender and water: Water has a woman's face

Women's role in water management is increasingly being acknowledged. The UN Commission on Sustainable Development has rightly affirmed that, "water has a woman's face". In most, if not all, Indian communities, women are primarily responsible for the management of water resources, sanitation and health. Over many generations, women have assimilated a wealth of knowledge about water resources, especially regarding location, quality and storage methods. However, this knowledge comes at a cost – women and girls, especially in rural India, bear a disproportionate burden of providing water, sanitation and hygiene for the household. This burden often impinges upon women's education, income-earning opportunities and socio-cultural and political involvement.

As per Census 2011, more than 22 percent of rural households must walk at least half a kilometre or more to fetch water, with the burden mostly being borne by women. Women and girls are often at risk of physical, mental and sexual violence when they travel long distances to fetch water. They are more vulnerable to water and sanitation related diseases when they are pregnant, while at the same time safe water and hygiene is key to preventing neonatal fatality. Girls are known to drop out of school due to their domestic responsibilities, and also due to the lack of available sanitation and menstrual hygiene facilities in schools. A proximate source of water has been associated with greater self-esteem, lesser harassment of women, and better school attendance of girls.

UNICEF and FAO's 2013 report, titled 'Water in India: Situation and Prospects' notes that no official uniform gender-disaggregated data is available for the drinking water sector. Due to this lack of data, there is insufficient evidence on the

> *Access to water and sanitation are recognized by the United Nations as human rights, reflecting the fundamental nature of these basics in every person's life. Lack of access to safe, sufficient and affordable water, sanitation and hygiene facilities has a devastating effect on the health, dignity and prosperity of billions of people, and has significant consequences for the realization of other human rights.*[131]
>
> *-UN Water*

133UN Water. (2015)."Eliminating Discrimination and Inequalities in Access to Water and Sanitation"

134Zwarteveen, M., Ahmed, S. and Gautam, S.(2012)."Diverting the Flow". New Delhi: Zubaan

135Van Koppen, B.(2001)."Towards a Gender and Water Index", s.l.: International Water Management Institute

relationship between gender and water. Gender disaggregated data on women's participation in Water User Associations, collected and analysed at the district and state levels, will help gain a better understanding of gender relations as well as women's participation in influencing desired outcomes of a project. This will hep assess the performance of projects aimed at addressing gender equity needs, in both: the irrigation and domestic water sectors.

A report prepared by the International Fund for Agricultural Development (IFAD) points out that, water for irrigation is inextricably linked to access and control over land. Therefore, gender-disaggregated data on access to land is essential for understanding the ownership pattern and relationship of these two critical resources, namely: land and water.

The Committee on Economic, Social and Cultural Rights adopted its General Comment No. 15, indicating that state should, "ensure that women are not excluded from decision-making processes concerning water resources and entitlements. The disproportionate burden women bear in the collection of water should be alleviated." However, all too often, decisions regarding the design and location of water facilities are made without the involvement of women. Efforts towards gender mainstreaming in water resource management have pushed for the integration of women in water supply schemes and the sharing of benefits among different stakeholders. However, less emphasis has been put on the integration of women in the design part of the schemes. While women's participation in programmes at the community level is a catchword in projects and policies of the state governments, there is little discussion on the issue of women professionals, or the lack thereof. 133

It has been found that projects/schemes in which women and men have an equal say have a better chance for success and are more sustainable because they address the needs of both. Women and men need access to information about technology, design and financing, as well as access to credit, land, legal institutions, and the ability to participate effectively in decision making. Affirmative action programmes for training women in technical and managerial careers in the water and sanitation sector could ensure that a minimum percentage of women participate in decision making for water schemes.

In addition, policymakers and project staff lack an understanding of gender issues. Thus, even if there is willingness amongst project staff, there is limited capacity to use relevant gender tools in water management.

The International Drinking Water Supply and Sanitation Decade (1981-90) recognised the role of women in water management. In 1992, the Dublin Principles gave further impetus to women at the management level.[134] In India, women, due to their close association with water management activities have a better understanding of its management strategies. Recently, there has been a shift from large-scale technocratic fixes to local approaches that called for people's participation in water management.

UNICEF-FAO's 2013 report highlights the linkages between improved access to irrigation and poverty reduction (ADB and IWMI, 2004). Women's participation in irrigation projects could be one of the means through which the dual objectives of efficiency in irrigation projects and improved social outcomes may be achieved. The report cites the example of Angul District in Odisha where 67 percent of Water User Associations comprised of women. These women initiated the Participatory Irrigation Management and also reaped its benefits.

Mere visibility in Water User Associations does not directly imply greater participation. While the introduction of quotas in Water User Associations has ensured women's representation in meetings, there exist glaring caste and economic-based inequalities within women's representation. Women's representation is often tokenistic and the benefits accrued to them are mostly in the form of self-help group (SHG) activities. It is also opined that with regard to Water User Associations, women's participation should not be limited to irrigation alone. This will not do justice to the generational knowledge they have on seeds and traditional crops.

In the Jambar village of Gujarat, women were trained by the Aga Khan Rural Support Programme to operate mechanised pump sets and organise themselves into management committees to decide on the water charges, supervise water distribution, collect water fees from the pump operator, and deposit the amount in the bank. Apart from the monetary benefits, this translated into greater decision-making power and visibility for women who were earlier neglected in community decision making.[135]

Similarly, State governments can also facilitate access to financing, on concessionary terms, for women's groups for installation and maintenance

[136] Johns Hannah. (2012)."Stigmatization of Dalits in Access to Water and Sanitation in India", National Campaign for Dalit Human Rights. Available at http://www.ncdhr.org.in/key-activities/Stigmatization%20of%20dalits%20in%20access%20to%20water%20-%20sanitation.pdf [Accessed 02 April, 2018]

of drinking water and sanitation facilities. They can also give recognition to women's role in agriculture, livestock and fisheries; and assist them in gaining access to water for productive uses, including women equal rights to land tenure.

Caste-based discriminations in access to water

Caste-based discriminations lead to human rights violations on access to water, making this a major social issue. The following numbers demonstrate the differences between Dalits and non-Dalits households (HHs) regarding drinking water. In India, more than 20 percent of Dalits are not allowed access to safe drinking water. Moreover, 48.4 percent of Dalit villages face denial of access to water sources. Only 10 percent of Dalit households have access to sanitation as compared to 27 percent for non-Dalit households. 27 percent Dalit households have water sources within premises as compared to 45.2 percent for the general population. 19.5 percent Dalit households have access to drinking water sources away from their premises whereas it stands at 14.45 percent for the general population. 32.3 percent of Dalit household have access to drinking water from tap as compared to 40.1 percent for the general populations.[136]

The Dalit community suffers from inaccessibility to infrastructure. Continuous deep-rooted and caste-based discrimination in services and entitlements in water provision can be witnessed. Usually, the wells have been situated in the dominant caste area. Dalit's habitations are thus left officially uncovered. As a result, the majority of Dalits depend on the goodwill of the upper-caste community members for access to water from public wells. Frequently, Dalits are disentitled and not allowed to use taps and wells located in the non-Dalit area.

In addition, the Dalit community faces violence against access to water on a daily basis. Due to the discrimination and untouchability, violence ensues as Dalit try to access water facilities such as public wells or hand pumps. Continuous and numerous case studies have reported violence against Dalit's in this regard. Especially, the population of Dalit women is the most affected by lack of water and sanitation facilities. Dalit women, among other things are responsible for bringing water for the household. Thus, they bear the brunt of the verbal and physical abuse from the dominant caste. Furthermore, they are exposed to constant threats while collecting water from public wells and taps.

Box 9.

A case study on the Self-Employed Women's Association's (SEWA) women's campaign on rehabilitation of water resources

The Self-Employed Women's Association's (SEWA) women, water and work campaign in Gujarat combined rehabilitation of piped water supply and traditional water sources with a microenterprise development program for women entrepreneurs. The three broad actions which were undertaken at the grassroots level by women as a part of this campaign were: (a) revival and upgrade of traditional sources of water, (b) roof rainwater harvesting and (c) SEWA's barefoot water technicians. Interventions of this nature can bring about social and economic empowerment and serve as an entry point for rural poverty alleviation programmes.

Source: *Panda, 2007*

Multiple deprivations in hilly, thickly forested areas

Even though lack of safe and adequate water is a pandemic issue across the country, tribal communities, who are the most excluded and

Table 8.

A comparison of drinking water sources available: Dalits and the general population

Drinking water sources	Dalits (% of HH)	Total (% of HH)
Drinking water sources within premises	27	45.2
Drinking water sources away from their premises	19.5	14.45
Drinking water from tap	32.2	40.1

Source: *Hannah Johns, 2012*

[137] Sunil.(2017)."Announcing the 1000 Springs Initiative: A Consortium for Clean Water in Tribal Areas of Central & Eastern India". Retrieved from Institute for Sustainable Development and Governance. http://isdg.in/blog/announcing-1000-springs-initiative-consortium-clean-water-tribal-areas-central-eastern-india/ [Accessed 02 April, 2018]

[138] 10.4 million male and 4.6 million female

[139] For Example, Government data suggests that only 3 percent of public buildings are accessible to people with disabilities. Sharma, N.(2018)."Only 3 per cent of Buildings Accessible for Disabled".The Economic Times. Available at https://economictimes.indiatimes.com/news/politics-and-nation/only-3-per-cent-of-buildings-accessible-for-disabled/articleshow/63104371.cms [Accessed 02 April, 2018]

[140] Heller, L.(2017). "End of Mission Statement by the Special Rapporteur on the Human Rights to Safe Drinking Water and Sanitation Mr. Léo Heller". United Nations Human Rights Office for The High Commissioner. Available at http://www.ohchr.org/EN/NewsEvents/Pages/DisplayNews.aspx?NewsID=22375& [Accessed 02 April, 2018]

marginalised group in the country, are the worst affected. According to Census 2011, more than 46 percent of the Scheduled Tribes HHs had access to unimproved water sources including un-covered well, spring, river/canal, tank/pond/lake, etc. or at best partial access to improved such as untreated tap water, covered well, tube well/borehole, etc. Compared to the national average at 46.6 percent, less than 20 percent of the Scheduled Tribes HHs have water resource within their premises. It shows that Scheduled Tribes households have the least (24.4 percent) availability of tap water, compared to other social groups. And even today, women and girls from more than one third (33.6 percent) of the Scheduled Tribes families walk more than 500 metres to access water. This is mainly due to the fact that the majority of tribal communities live in hilly and densely forested areas. Groundwater development potential through conventional means is limited in many hilly and thickly forested areas, due to geographical and hydrogeological constraints.

Rights to access water must be complemented with the provision of clean drinking water by the State to all citizens. Subsequently, strong legislation, which recognises access to water as a prioritised right is urgently required. As far as India is concerned, it should amend the SC/STs (Prevention of Atrocities ACT, 1989) to include discrimination and violence against Dalits regarding the right to drinking water.

People with disabilities and water: Multi-dimensional barriers to equitable access to water

According to Census 2011, India is home to 26.8 million people with disabilities, comprising of 2.21 percent of the total population. Of this, 18.6 million are male and 8.2 million are female. 15 million people with disabilities live in the rural areas[138]. In terms of social groups, 2.45 percent of people with disabilities are from the Scheduled Castes and 2.05 percent are from the Scheduled Tribes. Census data also shows that disability among Scheduled Castes is invariably higher across all age groups. While factoring this in, it is important to note that the percentage of the population living with a disability is likely to increase given the fact that the newly enacted Rights of Persons with Disabilities Act, 2016 expands the definition of disability from the previous 7 to 21 conditions. This will also have a significant impact on the number of people facing multiple barriers.

People with disabilities face systemic barriers while accessing services, including water, sanitation and hygiene. Observing the challenges faced in the overall accessibility of facilities for persons with disabilities[139], we can estimate the magnitude of challenges faced for ensuring equitable access to water. Additionally, the combination of disability with other social determinants such as gender, tribe, caste, residence, etc. further exacerbates the barriers faced by persons with disabilities, a fact recognised in the report of the Special Rapporteur on Human Right to Safe Drinking and Sanitation during his recent visit to India. It was described that people with disabilities extensively suffer from a lack of accessible sanitation facilities, but female disabled persons suffer more, and still more from the additional challenges in ensuring menstrual hygiene management.[140]

The government of India has taken several steps to address these barriers. The Swachh Bharat Mission has developed a Handbook on Accessible Household Sanitation for persons with

Box 10.

A case study on 'A Thousand Springs Initiative': Harnessing springs to address multiple deprivations in tribal areas

As the majority of Tribal live in hard to reach areas, Springs, which are a natural source of groundwater in the hilly region have the potential to address some of the gaps in access to water in tribal areas. While Himalayan states such as Sikkim, Uttarakhand etc. have been able to harness the potential of springs significantly, it remains largely overlooked and under-utilized in the Central and Eastern Indian tribal belt. In this context, Ministry of Tribal Affairs (MoTA) in partnership with United Nations Development Programme (UNDP) has decided to undertake 'A Thousand Springs Initiative' to address multiple development deprivations in hard to reach areas, by harnessing the potential of perennial springs across the Central and Eastern Indian tribal belt.

'A Thousand Spring Initiative' aims to work towards GIS-based mapping of springs across the Central and Eastern India tribal belt, and proposes integrated water development solutions around springs, ranging from protection, conservation and rejuvenation of springs for the long-term sustainability of the water infrastructure projects, to promoting safe sanitation and hygiene practices, improvement of food and nutritional security and enhancement of livelihood of tribal families.

Source: *Institute for Sustainable Development and Governance, 2017*[137]

[141] Sharma, A.(2017)."Build Unisex Toilets for the Disabled: PM Narendra Modi". The Economic Times. Available at https://economictimes.indiatimes.com/news/politics-and-nation/build-unisex-toilets-for-the-disabled-pm-narendra-modi/articleshow/60931363.cms [Accessed 02 April, 2018]

[142] UNESCO.(2015)."Advancing Water Education and Capacity-Building: Key for Water Security and Sustainable Development". Morocco: UNESCO.

[143] Ibid.

[144] Rejwan, A.(2011)."The State of Israel: National Water Efficiency Report". Water Authority.

disabilities. Recently, the Prime Minister made a call to build unisex, accessible toilets under Swachh Bharat Mission, to ensure that these facilities cater to people with disabilities and the elderly. However, implementation will require greater effort on the ground.[141] Additionally, addressing the multi-dimensional barriers created by the intersection of disability with other social determinants requires further attention.

Education as new potential to tackle water challenges

A comprehensive water education programme in the country has the potential to tackle the issues of governance, financing and technology in an integrated manner. Thus, it is important to envisage, develop and design a holistic water education package, which can change the behaviour of stakeholders to take care of the common goods (such as water) as well as to improve it. In doing so, water education must not be limited to a sectoral approach. It should combine sectors such as environment, engineering and economics and cover both multidisciplinary and interdisciplinary approaches. Therefore, investment in water education in terms of: identifying objects and target audience; institutions; financing and policy formulation are urgently required.

Water education can be categorised into three categories. Firstly, a comprehensive water education for decision-makers and water technicians right from utility managers and dam managers to valve operators is fundamental to dealing with the issues in the water sector. Currently, this remains largely overlooked. Better management of water resources requires a sound understanding of – the social, political, and environmental sectors. Water issues can only be understood better with interdisciplinary approaches. Most decision-makers and water technicians do not receive such comprehensive water education. Thus, if their knowledge of water is solely technical, or limited to their own fields, the response to the issues will not be exhaustive. Therefore, more holistic water education in this context would be beneficial to tackle water-related issues.[142]

Secondly, water education in school and other educational institutions needs to be addressed. Schools are excellent places to promote water education since they are well structured and can influence both, children and parents. With a sizable proportion of the population in India enrolled in schools and educational institutes, there is great potential to drive change in water sector. However, this would require a revision of the current curriculum. Water education is often very technical. Schools usually teach water in geography or natural sciences courses without offering comprehensive information in other disciplines. Such technical approaches may discourage children from pursuing an overall understanding of the sector.[143] Therefore, education imparted in school with regards to water issues needs to be revaluated.

Lately, water education for the public is also essential to achieve sustainability in water. A multi-media campaign is one of the most effective methods to reach out to the public. Since 2009, Israel has been conducting a similar campaign in response to their recent drought-prone conditions. It aims to warn the public of water scarcity, and to request them to use water more prudently. This campaign was conducted via various media platforms including television, radio, newspaper and the internet. The campaigns outcome exceeded all expectations, with a considerable amount of reduction (10 percent, 76MCM) in domestic consumption in 2009. Water consumption rate per capita was approximately 100 cubic meters per person per year before conducting the campaign. It has come down to around 90 cubic meters per person in 2009. Therefore, it is highly likely that this water education campaign for the public has been a huge success. [144]

Chapter 5

Water, at the Core of Achieving Sustainable Development Goals (SDGs)

In 2015, leaders of 193 Member States of the United Nations adopted "Transforming Our World: the 2030 Agenda for Sustainable Development" which came into effect on 1 January 2016 [146] . The 17 new SDGs and their corresponding 169 targets, which are part of the 2030 Agenda for Sustainable Development, build upon the experience of the Millennium Development Goals (MDGs) and aim to end poverty, hunger and inequality, take action on climate change and the environment, improve access to health and education, build strong institutions and partnerships, and more[147]. They are the result of an unprecedented consultative process that brought national governments and millions of citizens from across the globe together to negotiate and adopt the global path to sustainable development for the next 15 years. Critically, it also includes a stand-alone goal (Goal 6) to, 'Ensure availability and sustainable management of water and sanitation for all'.

[145]Guterres, A.(2017)."Our common goals". Retrieved from UNA-UK: here [Accessed 02 April, 2018]

[146]United Nations.(2015)." Transforming our world: the 2030 Agenda for Sustainable Development" Available here. [Accessed 20 April, 2018]

[147]United Nations Development Programme."Sustainable Development Goals". Available here. [Accessed 20 April, 2018]

SDG 6 is one of the most crosscutting goals of the SDGs. Clean water is critical to survival. Its absence has an impact on the health, food security and livelihoods of families across the world. Although our planet has sufficient fresh water to ensure regular and clean water supply for all, poor economic decisions and insufficient infrastructure can skew supply unfavourably. Drought afflicts some of the world's poorest countries, worsening hunger and malnutrition. Floods and other water-related disasters account for 70 percent of all deaths related to natural disasters. Every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation, and hygiene. It is estimated that by 2050, a quarter of the world's population is likely to live in countries affected by chronic or recurring shortages of water.

Global goals and national priorities of reliable energy, economic growth, resilient infrastructure, sustainable industrialisation, consumption and production and food security, are all inextricably linked to a sustainable supply of clean water.

Since 1990, two and a half billion people have gained access to improved drinking water sources, yet 663 million people still remain without it. Between 1990 and 2015, the proportion of the global population using an improved drinking water source increased from 76-91 percent, however, each day, nearly 1,000 children die due to preventable water and sanitation-related diseases.

At the core of the SDGs is the principle of universality, 'Leave No One Behind'. Access to water must be inclusive of all people, everywhere, and should be built through the participation of everyone, especially the most vulnerable and marginalised. As mentioned, particular groups of people including women, Scheduled Castes, Scheduled Tribes and people with disabilities often face discrimination while accessing safe water and adequate sanitation. The principle of 'Leave No One Behind' recognises access to water as one of the prioritised rights for all citizens across the globe, especially the marginalised.

> *The 2030 Agenda and its 17 Sustainable Development Goals (SDGs), adopted in 2015, provide a coherent, holistic framework for addressing these challenges and their interconnections. (…) They require member states to address the social, economic and environmental dimensions of sustainable development in a balanced manner. Their implementation must embody the principles of inclusiveness, integration and 'leaving no one behind.[145]*

- António Guterres, United Nations Secretary-General

[148]UN Water.(2016)."The Full Picture – A Holistic Water Goal". Retrieved from UN Water: http://www.unwater.org/full-picture-holistic-water-goal/ [Accessed 29 March, 2018]

[149] UN in India. (2018)."Sustainable Development Goals". Retrieved from UN in India: http://in.one.un.org/page/sustainable-development-goals/ [Accessed 29 March, 2018]

[150] DNA.(2016)."PM Modi Pitches for 'Save Water Abhiyan' During Upcoming Monsoon". Available at http://www.dnaindia.com/india/report-pm-modi-urges-for-save-water-abhiyan-during-upcoming-monsoon-2215271 [Accessed 29 March, 2018]

[151] UN in India.(2018)."SDG 6: Clean Water and Sanitation". Retrieved from UN in India: http://in.one.un.org/page/sustainable-development-goals/sdg-6/ [Accessed 29 March, 2018]

India strongly endorsed the General Assembly Resolution on the SDGs and affirmed India's commitment to Agenda 2030 and the SDGs. India's Prime Minister, Narendra Modi, speaking at the 70th Session of the UN General Assembly in 2015 stated that, "we live in an age of unprecedented prosperity, but also unspeakable deprivation around the world…(And) much of India's development agenda is mirrored in the Sustainable Development Goals". [149] The PM has strongly condemned the irresponsible use of water resources, saying that, "Even if one drop of water is wasted, it should pain us".[150] Improving sanitation is therefore a key priority of the government, which has introduced several flagship programmes including: the Swachh Bharat Abhiyan to clean India, the National Rural Drinking Water Programme, and Namami Gange, which aims to conserve and revive River Ganga.[151]

NITI Aayog has been entrusted with the role of coordinating the 'Transforming our world: the 2030 Agenda for Sustainable Development' in India. They have developed a comprehensive mapping of national schemes related to the SDGs and its targets, and have identified the lead and supporting ministries for each of the targets. For Goal 6, NITI Aayog has designated Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD and GR) as the nodal ministry. Furthermore, it has assigned the National Rural Drinking Water Programme, Swachh Bharat Abhiyan, Pradhan Mantri Krishi Sinchayee Yojana, National River Conservation Programme (NRCP) as centrally sponsored schemes for achieving clean water and sanitation for all. In addition, the Ministry of Statistics and Programme Implementation (MoSPI) has been leading discussions on developing national indicators for the SDGs to monitor and evaluate the progress.

SDG 6 has committed the international community to expand international cooperation and capacity building on water and sanitation related activities and programmes. It also seeks to support local communities in improving water and sanitation management.

Figure 21.
The water cycle in the Sustainable Development Goals.

Source: Un Water, 2016[148]

UN Water illustrates how Sustainable Development Goals cover the entire holistic water cycle in an integrated manner. Especially, Sustainable Development Goal 6 – Ensure availability and sustainability management of water and sanitation for all – brings together all the main aspects related to freshwater. The goal has eight targets that related to 6.1) safe drinking water, 6.2) adequate and equitable sanitation and hygiene, 6.3) water quality and wastewater, 6.4) water use efficiency, 6.5) integrated water resources management, 6.6) water-related ecosystems, 6.a) international cooperation and 6.b) local participation in water and sanitation management.

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UN Resident Coordinator's Office
55, Lodhi Estate, New Delhi
11003, India

UNITED NATIONS
संयुक्त राष्ट्र

unrco.in@one.un.org
@UnitedNationsIndia
@UNinIndia
in.one.un.org
91-11-46532333

CEEW
THE COUNCIL

Council on Energy, Environment and Water
Sanskrit Bhawan, A-10, Qutab Institutional Area
Aruna Asaf Ali Marg
New Delhi – 110067, India

info@ceew.in
@CEEWIndia
@CEEWIndia
ceew.in
91-11-40733300