NITI Aayog

सत्यमेव जयते

DEVELOPMENT MONITORING AND EVALUATION OFFICE

Water Resources

Sector Report

July 2021

Analysis by KPMG Advisory Services Pvt. Ltd.
Survey Partner: Hansa Research Pvt. Ltd.

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Preface

The Government of India (GoI) spends close to Rs. 14 lakh crores annually on development activities, through nearly 750 schemes implemented by Union Ministries. To improve the effectiveness and efficiency of public finance, and the quality of service-delivery to citizens, all schemes have been mandated to undergo third party evaluations, to provide an evidentiary foundation for scheme continuation from 2021-22 to 2025-26. In 2019, the Development Monitoring and Evaluation Office (DMEO), NITI Aayog was assigned the task of evaluating 28 Umbrella Centrally Sponsored Schemes (UCSS), which are schemes/programmes funded jointly by the Centre and the States and implemented by the States. This historic exercise, undertaken between April 2019 and February 2021, evaluated 125 Centrally Sponsored Schemes (CSS), under 10 Sectors, together covering close to 30% of the GoI's development expenditure, amounting to approximately Rs. 3 lakh crore (USD 43 billion) per annum.

In order to fulfil this mandate to the highest standard possible, to optimize both the robustness and the uptake of the evidence generated, DMEO adopted a nationally representative mixed methods evaluation methodology and a consultative review process for the reports. Through qualitative and quantitative analysis of secondary literature, analysis was done at three levels: the sector, the umbrella CSS and the scheme itself. The studies thus produced then underwent a review process involving consultations with NITI Aayog subject matter divisions, concerned Ministries and Departments, and external experts.

The present report is an outcome of this evaluation study and presents an analysis of the Water Resources, Environment and Forest Sector based on primary and secondary data collection. In this Report, we seek to cover the water resources sector in India, identifying the intended and actual contribution of GoI schemes to sector outcomes. This includes areas for more focused effort to achieve national priorities/SDGs. It also identifies opportunities for convergence of the schemes within the sector to other developmental programmes of the Central and the State Governments as well as with private sector, corporate social responsibility (CSR) efforts, international, multilateral and bilateral aid, etc.

We hope that this Report will further our understanding of the Water Resources, Environment and Forest Sector and help us move towards achieving the Sustainable Development Goals and the National Development Agenda, to promote the well-being of all sovereign citizens of India.

Acknowledgements

We would like to express our gratitude to Dr. Rajiv Kumar, Vice-Chairman NITI Aayog, and Shri Amitabh Kant, Chief Executive Officer, who have been the driving force, first in entrusting this important responsibility to the Development Monitoring and Evaluation Office (DMEO) and subsequently as mentors throughout the study, in providing all necessary support and guidance for the completion of the project. We also express our gratitude to the Ministry of Finance for recognizing the crucial need for evidence in the deliberations and decisions pertaining scheme budget allocations.

Our invaluable partners in this exercise have been the Department of Water Resources, River Development & Ganga Rejuvenation (D/o WR, RD & GR), Department of Agriculture, Cooperation and Farmer's Welfare (DAC&FW), Department of Land Resources (DoLR), and Ministry of Environment, Forest and Climate Change (MoEFCC) and all its officials, without whose cooperation this evaluation would not have been possible. We are grateful to them for giving us access to available data, for patiently sharing their expertise through Key Informant Interviews, and for providing their vital comments on the draft reports during various stages of the study. A detailed list of Key Informant Interviews can be found in the annexures to this report.

In our federal structure, equally important partners in this endeavour have been the State Governments of Assam, Andhra Pradesh, Bihar, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Manipur, Mizoram, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal and their Chief Secretaries. Officials across the State governments have extended their gracious cooperation to the study, for which we are deeply thankful.

Next, we must thank our external experts, Dr. Amarjit Singh, ex-Secretary (D/o WR, RD & GR), and Dr. Deepak Khare, Professor (Department of Water Resources Development and Management, IIT Roorkee) for helping refine and rationalize the report through their insightful comments, corrections and feedback. From the fundamentals of the sector to the latest developments, they helped ensure that the report was as comprehensive, cogent and technically robust as possible, within the short timeframes available.

M/s KPMG Advisory Services Private Ltd., the consultant firm, has done a remarkable job, particularly given the significant challenges of scale, time and resources presented by this project. Adding to the constraints, the global pandemic and the COVID-19 lockdown did not stop them from delivering top quality work. Particular appreciation is due to Mr. Sumouleendra Ghosh, Director, Mr. Manpreet Singh, Partner, and Mr. Anand Kulkarni, Technical Director and their team, Ankush Chakraborty, Deputy Team Leader, Sandip Keswani, Monitoring and Evaluation Expert, Gaurang Meher Diljun, Economist), Ranjan Roy, Water Resources Lead), Manpreet Singh (Environment, Forestry, Wildlife and Climate Change Lead), Shibabrata Chakraborty (Finance Specialist), Anandajit Goswami (Statistician), Ruchi Khurana (Gender and

Social Inclusion Specialist), Rumjhum Raychaudhuri (Safeguards Specialist), Kartik Chandra Sanati (Water Resources Management Specialist), Ashok Kumar Sahu (Aquatic Habitats Sector Specialist), Jignesh Thakkar (Tribal Welfare Specialist), Arghya Paul (Associate Director), Soutik Roy (Senior Consultant), Sushobhan Dutta (Senior Consultant), Pankaj Baksi (Senior Consultant), Poulomi Dhar (Senior Consultant), Sanhita Sharma (Consultant) from the KPMG support team and the field partners – IPSOS Team Tripti Sharma Team Lead, Sutapa Ray (Research Manager), Sayantika Palit (Research Executive) and Gangotri Dash (Research Executive).

At NITI Aayog, this exercise would not have gotten off the ground without the consistent support of the Procurement Management Committee and Bid Evaluation Committee, particularly Mr. Sonjoy Saha, Adviser (PPP/PAMD), Sh. Avinash Mishra, Adviser (Water & Land Resources), Sh. Jitendra Kumar, Adviser (Natural Resources & Environment), and Ms. Sanchita Shukla, Director, Internal Finance Division. Staff at the NITI Aayog Water & Land Resources vertical, particularly Sh. Mishra, Ms. Namrata Singh, Young Professional and Sh. Gopal Sharan, Scientist C, and NRE Adviser Sh. Jitendra Kumar have also been instrumental in seeing this project to fruition. The Internal Finance Division further merits special mention here for its extensive efforts.

DMEO team has been at the core of the evaluation studies - in this package specifically, Ms. Sumitra K, Monitoring and Evaluation Lead, Ms. Fatima Mumtaz, Young Professional and Sh. Kuldeep Pal, Economic Investigator worked on every last detail of this herculean endeavour, under the guidance of Deputy Director Generals Sh. Alok Mishra and Ms. Harkiran Sanjeevi. Across packages, Deputy Director General Sh. Ashutosh Jain also oversaw coordination, standardization and monitoring of the study design, analysis and implementation processes across packages. Across packages, Deputy Director General Mr. Ashutosh Jain also oversaw coordination, standardization and monitoring of the study design, analysis and implementation processes. They were supported by the Evaluations Core Team: Dr. Shweta Sharma, Mr. Anand Trivedi, Ms. Sanjana Manaktala, Ms. Vatsala Aggarwal, Mr. O.P. Thakur and Mr. Jayanta Patel. The DMEO administration and accounts officers, including Mr. D. Bandopadhyay, Mr. Munish Singhal, Mr. D.S. Sajwan, Mr. Manoj Kumar and others provided vital support on documentation, approvals, payments etc.

In accordance with the massive scope and scale of the exercise, this report owes its successful completion to the dedicated efforts of a wide variety of stakeholders.

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Sector Report – Water Resources

1.1 Introduction

A sectoral analysis of the water resources sector in India has been undertaken using an end-to-end value chain framework for the sector where areas of enquiry have been identified and analysed in respect of each element of the value chain. A summary of the value chain of the water resources sector and key issues in each component is shown in the figure below. Performance of the water resources sector as well as key issues in both supply and demand sides of the water resources value chain have been discussed in further detail.

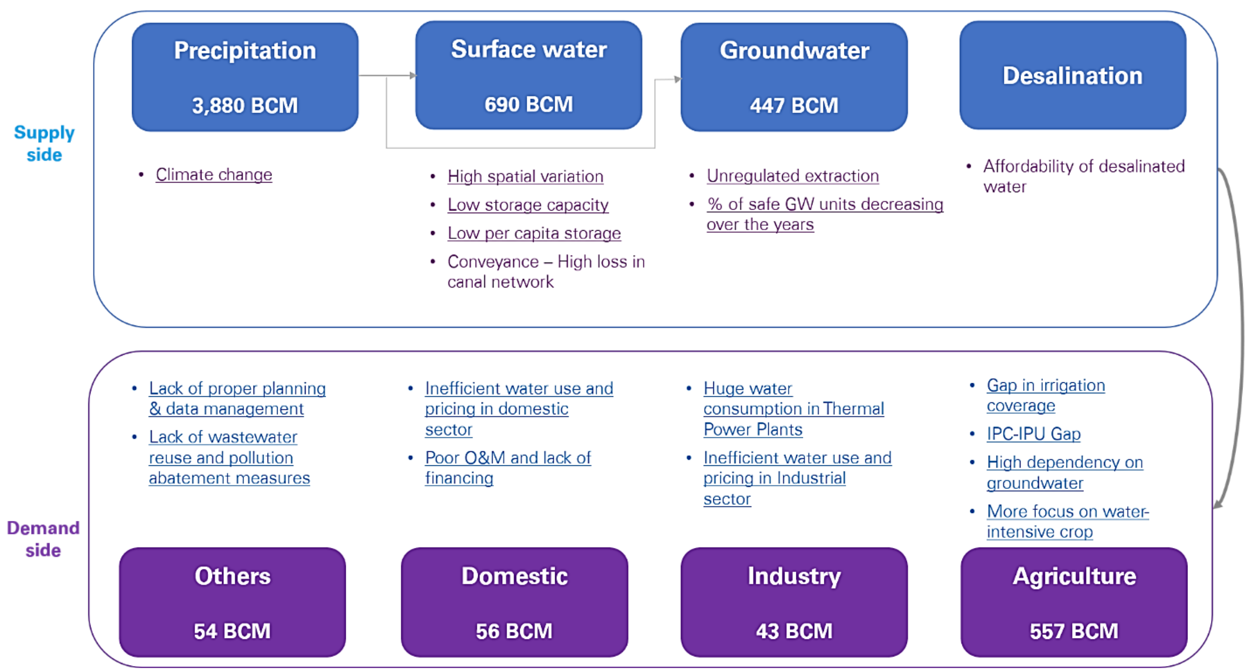

Figure 1: Water Resources sector- Value Chain with key issues

1.2 Background of the sector

1.2.1 Water resources in India - Supply Side

Water resource is an important national asset and is of foundational importance for sustenance of life, food security, and maintaining ecological balance. Over the past two decades, the demand for freshwater in India has increased significantly on account of growing population, rapid urbanization, industrial development and inefficient agricultural practices. The per capita availability of water in India has been on a decline – from 1,820 cubic metres in 2001 to 1,508 cubic metres in 2015[2]. Further, there is wide spatial variance in the availability of water – per capita availability in major Indian river basins varies widely from a mere 300 to about 2,000 cubic meter per person per year. Water pollution is another major cause for concern with 351 river stretches on 275 rivers across the country being polluted due to untreated discharge of both municipal and industrial wastewater over the years[1].

As per Falkenmark Water Stress Indicator, per capita availability of less than 1,700 cubic metres (m^3) indicates water stress, while per capita availability below 1,000 cubic metres (m^3) indicates water scarcity condition. India is currently classified as water-stressed as per this indicator. If water resources are not managed sustainably, there is an imminent possibility of India turning into a water scarce region with its attendant consequences such as food insecurity, among other things. The Falkenmark Water Stress Indicator for India projected till the year 2051 is shown below[2].

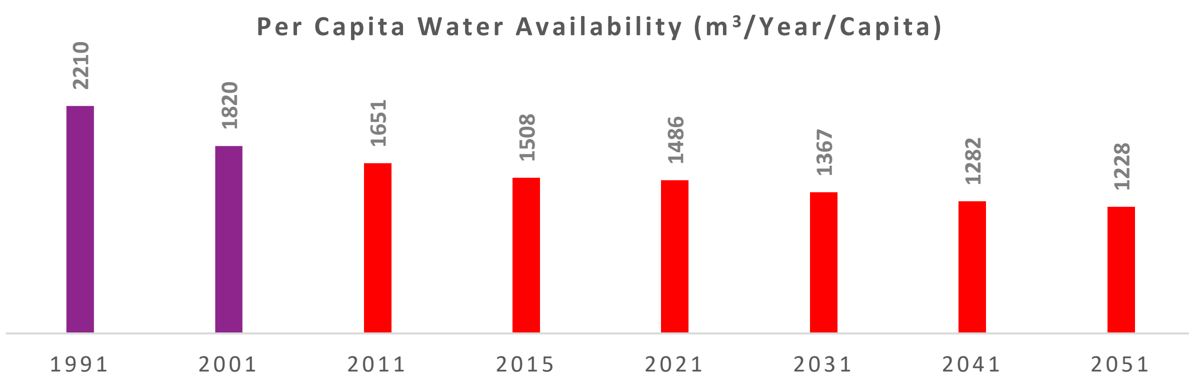

Figure 2: Per capita water availability (m^3/year/capita)

The reasons of overall water stress can be traced to issues related to both water supply and demand. A detailed analysis for each value chain component in the supply side is provided in the following sub-sections.

1.2.1.1 Precipitation

[1] Order issued by National Green Tribunal date 08th April 2019

[2] Reassessment of water availability in basins using space inputs, Central Water Commission, June 2019

Current Precipitation patterns in the country

India receives an annual precipitation of around 3,880 billion cubic metres (BCM)[2] and has an abundant system of rivers and snow-clad mountains. The forecast of water resources sector with such natural endowments ought to have been brighter. However, India is geographically diverse and there is a marked variation in rainfall across various parts of the country. Key observations and issues in this area have been described below.

Variations in Annual Rainfall Pattern

While the average annual rainfall is 119 cm; places near the Western Ghats and the sub-Himalayan areas in north-east India receive heavy rainfall of over 250 cm annually, whereas the areas of northern parts of Kashmir and western Rajasthan receive rainfall less than 40 cm. The following figure depicts the annual normal rainfall. [3]

[3] IMD Records of 50 years (1951-2000) of a network of 2412 stations all over the India.

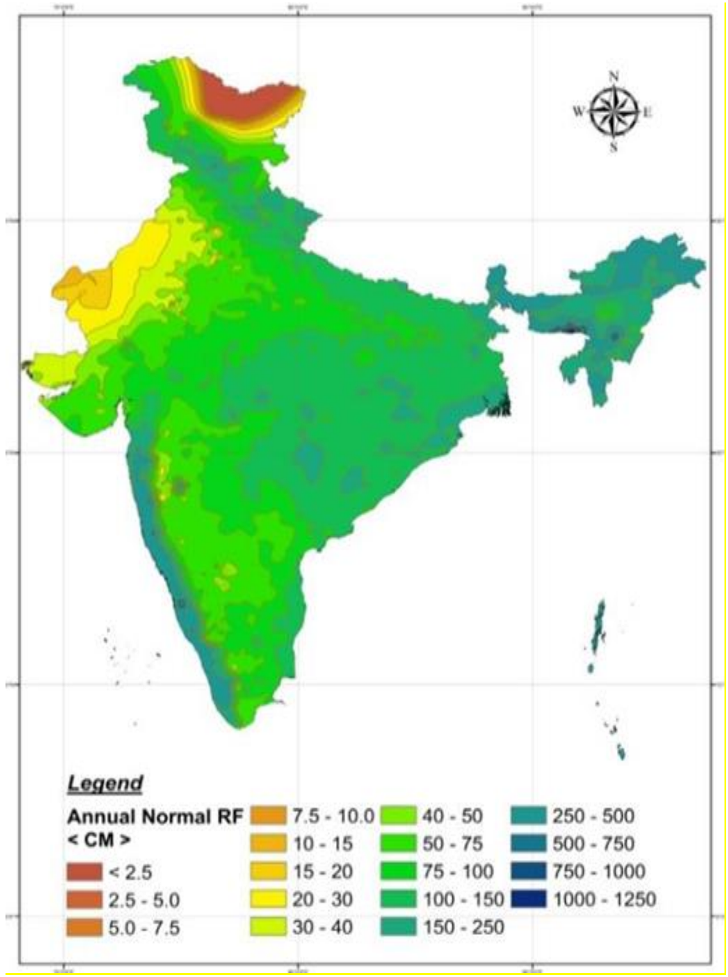

Figure 3: Annual Rainfall pattern over the country

About 70% of the annual rainfall is received during the monsoon from June to September. In recent times, every year there has been large variation in rainfall across the country resulting in phenomenon of widespread floods in a few regions as well as drought in a few others. Although the overall monsoon variations across the country have been in the range +6% to -14% (in the last five years) compared to average, in four of these five years around 30% of the sub-divisions[4] received rainfall of less than 20%. This means these deficits have been adjusted with much excess rains causing floods in a few other sub-divisions.

[4] There are 36 meteorological subdivisions of India.

Table 1: Sub-division wise rainfall variations (excess/deficit)[5]

Years	Sub-divisions with excess rains (+20% -+59%)	Sub-division with deficient rains (-20% - -59%)
2014	0	11
2015	4	12
2016	1	12
2017	3	7
2018	1	12

This fact is also evident from the following statistics of the deviation (%) in annual rainfall from the normal long-term average. It is observed that rains have been deficient in most years of the last two decades with only a few exceptions (i.e. 2005, 2010 and 2013)[6].

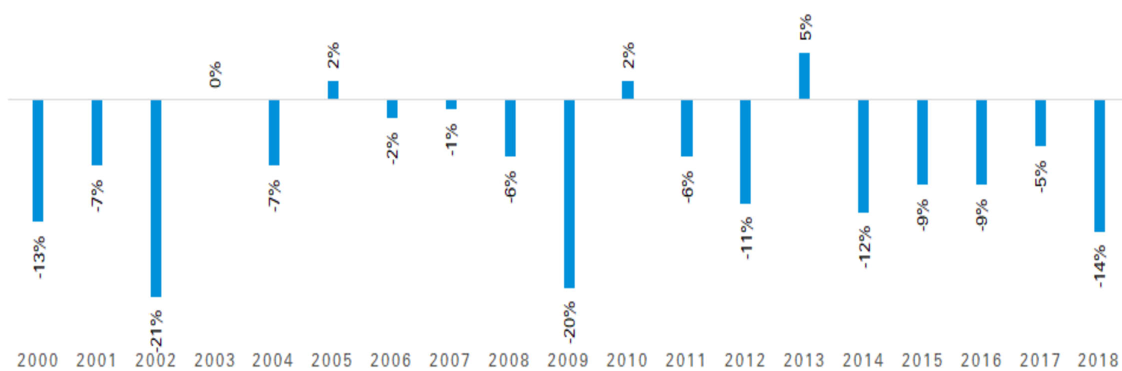

Figure 4: Departure in annual rainfall in % since 2000

Out of the total precipitation in India of 3,880 BCM, around 48.5% is lost to evapotranspiration, which leaves a balance of 1,999 BCM water in the country. Further, about 43% of the potential available water cannot be put to beneficial use due to topographical constraints and uneven distribution of water resources over space and time. This makes the utilizable water potential of the country around 1,122 BCM consisting of 690 BCM of surface water and 432 BCM of groundwater (Source for groundwater data: National Compilation on Dynamic Ground Water Resources of India, Central Ground Water Board, 2017) [2]. The figure below depicts the Water resources availability in India.

[5] Indian Meteorological Department-Customized Rainfall Information System

[6] EnviStats India 2018 - Supplement on Environmental Accounts, Ministry of Statistics and Programme Implementation, 2018 and Indian Meteorological Department-Customized Rainfall Information System

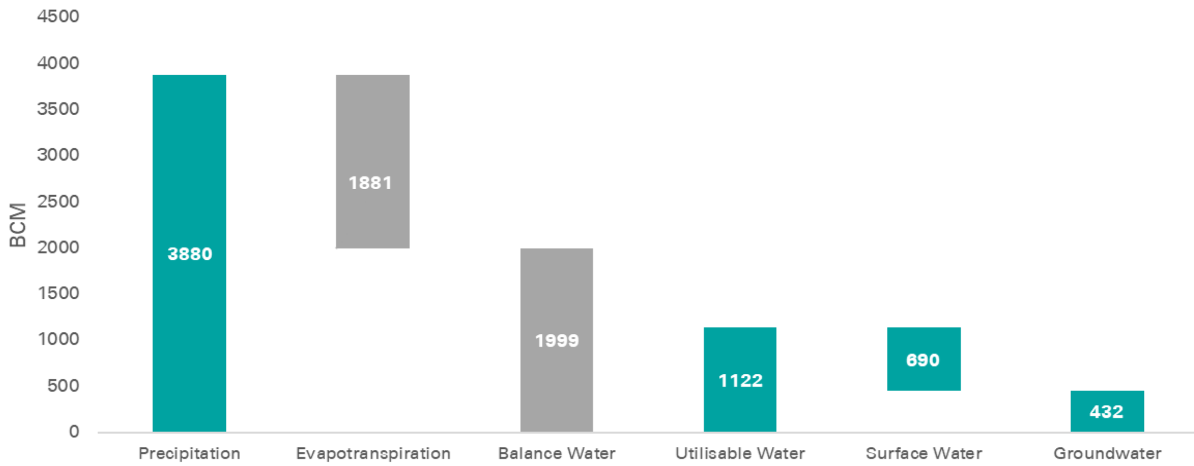

Figure 5: Water Resources Availability

This deficiency in annual rainfall in recent years is a cause for concern, since in India, monsoon rainfall is the main source of groundwater recharge, contributing about 58% of the total annual replenishable resource[7]. Even regional rainfall variations directly impact water availability. The annual replenishable groundwater resources is the sum of recharge during monsoon and non-monsoon seasons and these resources are used mainly for irrigation and domestic uses.

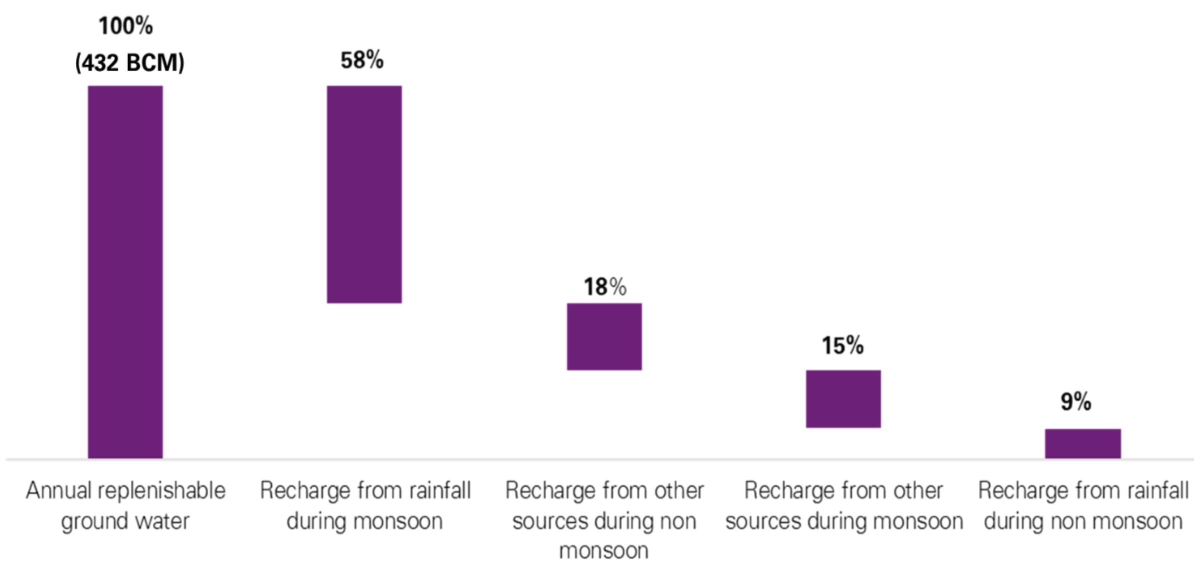

Figure 6: Sources of annual replenishable groundwater

[7] Dynamic Groundwater Resources of India, 2017 (Published on July 2019), Central Groundwater Board, Ministry of Water Resources and Reassessment of water availability in basins using space inputs, Central Water Commission, June 2019

It is evident from the above depiction that any deficiency in monsoon can significantly reduce annual replenishable groundwater.

Impact of Climate Change

Climate change in the form of changes in temperature and precipitation have come about as a result of global warming. This has impacted in the form of uneven rainfall distribution and water related disasters such as floods and droughts. Globally, average water stress[8] is 11%. India is among the 31 countries experiencing water stress in the range of 25-70%. It is forecasted that India will be among the worst affected countries with respect to change in net precipitation by 2050 vis-à-vis 2010. Net precipitation in significant parts of north, central and west India is expected to decrease by at least 0.5 mm per day while the rest of the country will witness a decrease between 0.1 to 0.5 mm per day[9].

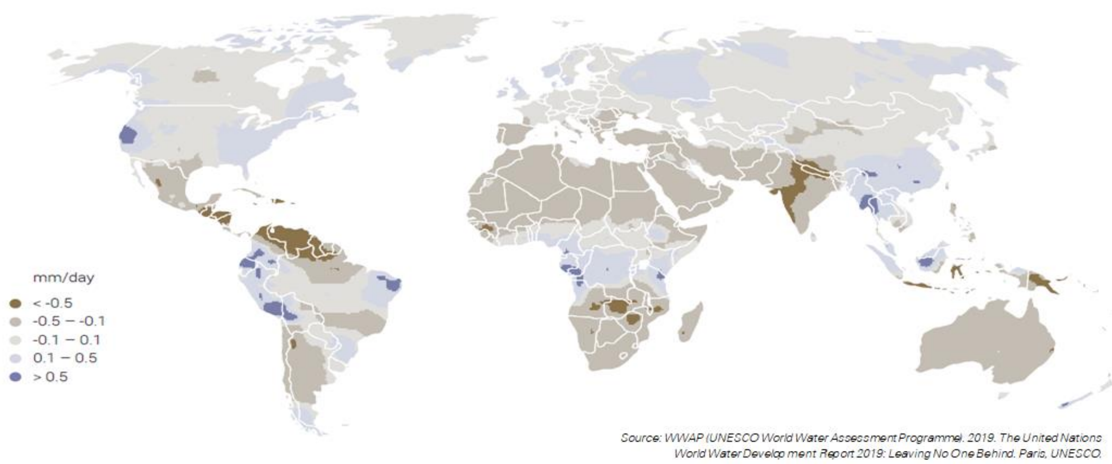

Figure 7: Change in net precipitation patterns

Growing water stress indicates increasing exploitation of water resources, with adverse impacts on resource sustainability, and a rising probability for conflicts among users. The overall water availability is discussed in respect of surface water and groundwater sources.

[8] Water stress for purpose of discussion in the above paragraph is defined as the ratio of total freshwater withdrawn annually by all major sectors, including environmental water requirements, to the total amount of renewable freshwater resources, expressed as a percentage. Source: UN (2018a, p. 72, based on data from AQUASTAT).
[9] Adapted from PBL Netherlands Environmental Assessment Agency (2018, p. 23)

1.2.1.2 Surface Water Resources

The analytical unit for the purpose of surface water analysis is a river basin. India can be broadly divided into 20 river basins. As indicated earlier, a reassessment of water resources potential has been carried out by Central Water Commission in a recent study "*Reassessment of Water Availability in India using Space Inputs*" dated June 2019 with support from National Remote Sensing Centre (NRSC). This study estimates the total water resource potential of India at 1,999 BCM with water availability being the highest in the Brahmaputra basin (527.28 BCM) followed by the Ganges basin (509.52 BCM).

This clearly shows that India is not a water deficient country. Lack of better planning and management of water resources have, however, led to several regions in the country experiencing water stress. Increase in population and associated economic activity in the future will lead to most river basins experiencing rising water stress.

Water Stress Characterization of River Basins

A river basin wise analysis of water stress is presented below by adapting the Falkenmark Water Stress Indicator and by using available population projections for 2025 and 2050.

Table 2: Categorization of river basins by water stress

Water availability (m^3/year/capita)	Category
>=1700 both in 2025 and 2050	Safe
>=1700 in 2025 but < 1700 in 2050	Moderately stressed
<1700 both in 2025 and 2050	Critically stressed
<1700 in 2025 and <1000 in 2050	Moderately scarce
<1000 in 2025 and <1000 in 2050	Critically scarce

Water Availability and Coverage of River Basins

The state-wise breakup of available resources vis-à-vis projected population depicts as many as 12 river basins in India will have critically or moderately water scarce scenario by 2050:

Table 3: River basin wise per capita Average Annual Water Availability (m^3)[10]

#	River Basin	Avg. annual Water Resources Potential (BCM)	Est. population (Mn)[11] 2025	Est. population (Mn)[11] 2050	Est. per capita annual water availability (m^3) 2025	Est. per capita annual water availability (m^3) 2050
1	Indus (up to Border)	45.53	69.2	81.41	658	559
2	Ganga-Brahmaputra-Meghna					
a	Ganga	509.52	593.04	697.69	859	730
b	Brahmaputra	527.28	48.06	56.54	10,971	9,326
c	Barak & Others	86.67	10.24	12.05	8,464	7,193
3	Godavari	117.74	89.18	104.92	1,320	1,122
4	Krishna	89.04	100.41	118.13	887	754
5	Cauvery	27.67	48.39	56.93	572	486
6	Subernarekha	15.05	15.52	18.26	970	824
7	Brahmani & Baitarani	35.35	16.18	19.04	2,185	1,857
8	Mahanadi	73.00	43.93	51.68	1,662	1,413
9	Pennar	11.02	16.02	18.85	688	585
10	Mahi	14.96	17.34	20.4	863	733
11	Sabarmati	12.96	17.34	20.4	747	635
12	Narmada	58.21	24.28	28.56	2,397	2,038
13	Tapi	26.24	24.44	28.75	1,074	913
14	West Flowing Rivers from Tapi to Tadri	118.35	42.61	50.13	2,778	2,361

[10] Reassessment of water availability in basins using space inputs- Central Water Commission- 2019 Study
[11] Report of the Standing Sub-Committee for assessment of availability and requirement of water for diverse uses in the country, 2000

#	River Basin	Avg. annual Water Resources Potential (BCM)	Est. population (Mn)[11] 2025	2050	Est. per capita annual water availability (m^3) 2025	2050
15	West Flowing Rivers from Tadri to Kanyakumari	119.06	53.84	63.34	2,211	1,880
16	East Flowing Rivers Between Mahanadi & Pennar	26.41	38.97	45.85	678	576
17	East Flowing Rivers Between Pennar And Kanyakumari	26.74	74.32	87.43	360	306
18	West Flowing Rivers of Kutch and Saurashtra including Luni	26.93	36.5	42.94	738	627
19	Area of Inland drainage in Rajasthan	Negligible	11.73	13.79	NA	NA
20	Minor River Draining into Myanmar (Burma) & Bangladesh	31.17	2.48	2.91	12,569	10,711

Water scarcity in these 12 basins may lead to around 11 states having critically water scarce scenario in future as per the above analysis. This is based on the area of coverage of the water basins in the respective states.

Table 4: State-wise riven basin coverage

State	River Basins covered[12]	Possible future scenario based on projected status of predominant basins[12]
Punjab	Indus	Critically Scarce
Rajasthan	Indus, Mahi, Sabarmati, West Flowing Rivers of Kutch and Saurashtra including Luni	Critically Scarce

[12] KPMG Analysis

State	River Basins covered[12]	Possible future scenario based on projected status of predominant basins[12]
Haryana	Indus, Ganga	Critically Scarce
Delhi	Ganga	Critically Scarce
Himachal Pradesh	Indus, Ganga	Moderately Scarce
Tamil Nadu	Cauvery, East Flowing Rivers Between Pennar And Kanyakumari, West Flowing Rivers from Tadri to Kanyakumari	Critically Scarce
Puducherry	East Flowing Rivers Between Pennar And Kanyakumari	Critically Scarce
Uttar Pradesh	Ganga	Critically Scarce
Karnataka	Godavari, Krishna, Cauvery, Pennar, East Flowing Rivers Between Mahanadi & Pennar, East Flowing Rivers Between Pennar And Kanyakumari, West Flowing Rivers from Tapi to Tadri	Critically Scarce
Gujarat	Mahi, Sabarmati, Narmada, Tapi, West Flowing Rivers of Kutch and Saurashtra including Luni, West Flowing Rivers from Tapi to Tadri	Moderately scarce
Uttarakhand	Ganga	Critically Scarce
Madhya Pradesh	Ganga, Godavari, Mahanadi, Tapi, Narmada	Critically stressed
Maharashtra	Godavari, Krishna, Mahanadi, Narmada, Tapi	Critically stressed
Kerala	Cauvery, West Flowing Rivers from Tadri to Kanyakumari	Moderately stressed
Bihar	Ganga	Critically Scarce

State	River Basins covered[12]	Possible future scenario based on projected status of predominant basins[12]
Chhattisgarh	Ganga, Godavari, Narmada, Brahmani & Baitarani	Critically Scarce
Andhra Pradesh	East Flowing Rivers Between Mahanadi & Pennar, East Flowing Rivers Between Pennar And Kanyakumari	Critically Scarce
Odisha	Mahanadi, Godavari, Subarnarekha, Brahmani & Baitarani, East Flowing Rivers Mahanadi & Pennar	Moderately Stressed
Goa	West Flowing Rivers from Tapi to Tadri	Safe
Jharkhand	Ganga, Mahanadi, Subarnarekha, Brahmani & Baitarani	Critically Scarce
Assam	Brahmaputra, Barak & Others	Safe
Tripura	Barak & Others, Minor River Draining into Myanmar (Burma) & Bangladesh	Safe
Meghalaya	Brahmaputra, Barak & Others	Safe
Nagaland	Brahmaputra, Barak & Others	Safe
Arunachal Pradesh	Brahmaputra	Safe
Sikkim	Brahmaputra	Safe
West Bengal	Brahmaputra, Ganga, Subarnarekha	Moderately scarce
Jammu & Kashmir	Indus	Moderately scarce
Manipur	Minor River Draining into Myanmar (Burma) & Bangladesh, Barak & Others	Safe
Mizoram	Minor River Draining into Myanmar (Burma) & Bangladesh, Barak & Others	Safe

Storage Capacities

At present, the storage capacity in basins with large water potential such as the Ganga, Brahmaputra, Indus, Godavari, Mahanadi, etc. is quite low. As of 2015, the storage capacity created is only 253.4 BCM under major and medium irrigation projects and an additional capacity of 51 BCM is likely to be created by the ongoing projects. Hence, 304.4 BCM will be available storage once the projects are completed which is not even 45% of the total available surface water resources potential in the country. The storage capacities in major basins vis-à-vis their respective water resources potential based on the previous estimate of 1,869 BCM of Average Annual Availability are shown herewith[6]:

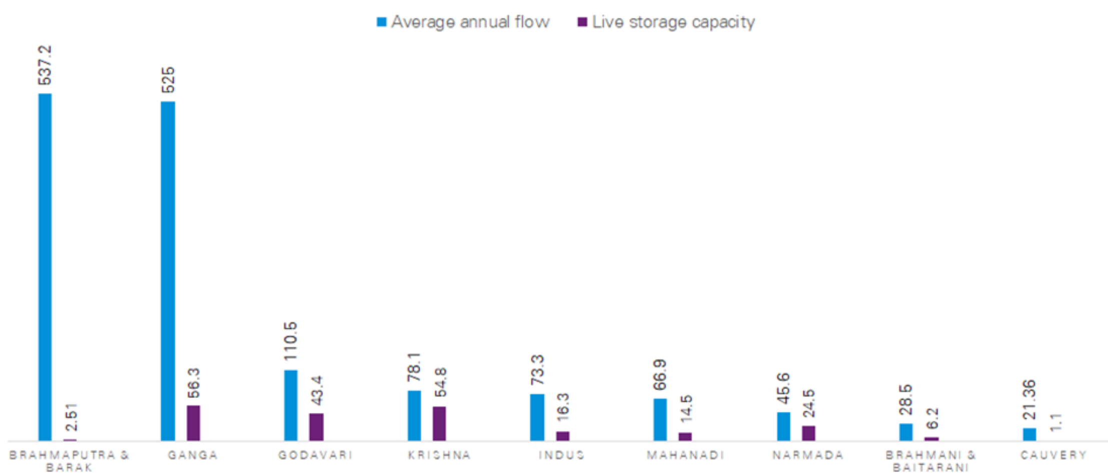

Figure 8: Storage capacities across major river basins in India (in BCM)

A comparison of water storage capacity of India against other countries is provided in the section below on "Benchmarking of Broad Sectoral Outcomes". However, it may be mentioned here that the storage capacity mentioned includes all major and medium irrigation projects while that from minor structures is not reflected in the above analysis.

1.2.1.3 Groundwater Resources

Groundwater is one resource which is replenishable and dynamic in nature. It is of utmost importance to periodically assess and monitor groundwater levels to understand availability and quality of water resources over time and across aquifers. The natural phenomena which impacts groundwater apart from rainfall include evapotranspiration, runoff, anthropogenic influences like withdrawal from the aquifer, recharge due to irrigation systems and other practices like water conservation.

Groundwater Levels in India

Central Groundwater Board (CGWB) monitors groundwater levels four times a year - in April/May, August, November and January through a network of 23,125 observation wells[13] across the country. In 2017, observations were carried out which depict the following with respect to the groundwater levels.

Table 5: Observations on groundwater levels throughout the year 2017

Depth (m) below GL	Pre-monsoon	August 2017	Post Monsoon	January 2018
0-2	Only 4%. A few states, such as Assam, Goa and Himachal Pradesh	27% falls under this range including small pockets of states of Assam, Chhattisgarh, Maharashtra, Bihar, Odisha, West Bengal and Uttar Pradesh, mostly in isolated areas	21% depicts this range including certain pockets in states of Assam, Odisha, Andhra Pradesh, Maharashtra, and Uttar Pradesh and isolated pockets in Jharkhand and Madhya Pradesh	10% falls under this range including pockets of states Assam, Odisha, Andhra Pradesh and Gujarat
2-5	24% depicts this range, mainly in the central and parts of eastern Indian states	32% falls under range, mainly in the states of Uttar Pradesh, Bihar, Odisha, Chhattisgarh and Assam	38% depicts this range, mainly in the states of Uttar Pradesh (eastern part), Bihar, Odisha, Chhattisgarh, Assam, Jharkhand, West Bengal, Andhra Pradesh, Telangana,	36% has shown this range, mainly in the areas of Sub-Himalayan area, north of river Ganges, northern and eastern parts of Uttar Pradesh, almost whole of Bihar, Andhra Pradesh, Odisha,

[13] As on March 31, 2017.

Depth (m) below GL	Pre-monsoon	August 2017	Post Monsoon	January 2018
			Karnataka and Maharashtra	Assam, coastal parts of Maharashtra
5-10	43% depicts this range, mainly in parts of peninsular India	24% falls under this range, mainly in the states of Andhra Pradesh, Maharashtra, Karnataka, Telangana, Tamil Nadu, Kerala, north western part of Uttar Pradesh and West Bengal	26% depicts this range, mainly parts of central and peninsular India	35% has shown this range, mainly parts of central India, peninsular India
10-20	23% falls under this range, including few parts of north-western and western states	11% depicts this range, including central part of West Bengal	11% has shown this range, including central part of West Bengal and central India	14% falls under this range, including peninsular part of country
20-40	5% has shown this range, including major parts of north-western and western states	3% depicts this range, including major parts of central and western India	3% has shown this range, including major parts of north-western states	4% falls under this range, including major parts of north-western states
>40	2% falls under this range, including parts Delhi, Chandigarh and Rajasthan	1% depicts this range, including in some parts of Delhi and Rajasthan	1% has shown this range, including in Haryana, and Delhi and almost major parts of Rajasthan	1% depicts this range, including in some parts of Haryana, and Delhi

Depth (m) below GL	Pre-monsoon	August 2017	Post Monsoon	January 2018
				and almost major parts of Rajasthan

It is quite evident that the sporadic rainfall patterns impact the groundwater level across various parts of the country. We observe that even in a few states where average rainfall is much below country average, certain areas witness shallow water level during monsoon on account of sporadic heavy rainfall. However, rainfall during monsoon acts as the main source of replenishment of groundwater, with substantial parts (more than 55%) of the country reporting groundwater depth of 0-10 mduring monsoon . However, states like Haryana, Rajasthan, Delhi show consistently higher depths of groundwater levels during entire year showcasing the obvious water scarcity in these states.

Variance in Groundwater level over years

Over the last couple of decades, there has been gradual depletion of groundwater levels in India primarily due to unregulated extraction of groundwater. The following figure depicts the consistent increase in depth of groundwater availability in India.

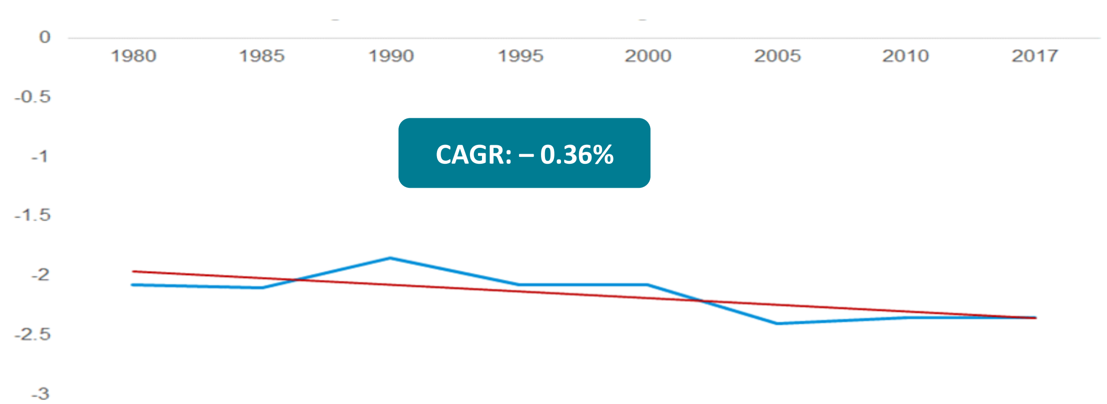

Figure 9: Average groundwater table levels in metres[14]

Since groundwater is a decentralized water source, the challenge lies in sustainable and equitable use of this common pool resource. Groundwater is highly exploited for irrigation wherein high levels of

[14] Central Groundwater Board data

extraction happens due to availability of heavily subsidized power (used to operate bore wells) and implicit preference for cultivation of water intensive crops such as paddy and wheat (because ofGovernment procurement for PDS). The same has been dealt in further detail in the section on agriculture sector water demand. The over-extraction of groundwater in some coastal areas has led to saline water intrusion, thereby, resulting in quality deterioration of freshwater aquifers. In case of private landowners, any amount of water can be extracted from groundwater sources and the individual rights to groundwater are indirectly granted through property rights. These factors have resulted in the reducing numbers of safe groundwater units over the years.

Table 6: Percentage of safe groundwater units decreasing over the years[15]

Categorization of blocks/ mandals/ talukas	2004	2009	2011	2013	2017
Safe	4,078 **(72%)**	4,277 **(74%)**	4,503 **(69%)**	4,519 **(70%)**	4,310 **(63%)**
Semi-critical	550	523	697	681	972
Critical	226	169	217	253	313
Over-exploited	839	802	1,071	1,034	1,186

Characterization of Groundwater Development

In addition to the variance in groundwater levels over years, it is also important to assess the current and future groundwater stress in the country. An indicator of the stress on groundwater is the stage of groundwater development, which is denoted by the percentage of utilization with respect to recharge and can be computed as follows:

Stage of development (%) = (existing gross draft for all uses ÷ net annual groundwater availability) x 100%

As per the Central Groundwater Board, the overall stage of groundwater development in the country is 62%. States of Delhi, Haryana, Punjab and Rajasthan report more than 100%, which implies that in these

[15] National Compilation on Dynamic Groundwater Resources of India, Central Groundwater Board, 2017

states the annual groundwater consumption is more than annual groundwater recharge. In states like Madhya Pradesh, Maharashtra, Gujarat and Himachal Pradesh the stage of groundwater development has increased and is gradually moving to a high utilization range of 50 -100%. Based on the stage of groundwater development and percentage of safe blocks/mandals/talukas available in each state, the states are categorized as follows:

Table 7: Categorization of groundwater development

Categorization	Stage of groundwater development	Colour
Safe	<=70%	
Semi-Critical	>70% & <= 90%	
Critical	>90% & <= 100%	
Over exploited	>100%	

The following table depicts the state-wise situation with respect to the stage of groundwater extraction along with the assessment of the over-exploited & critical blocks[7].

Table 8: State-wise stage of groundwater development

State	Category	Stage of GW extraction (%)	% of over-exploited & critical blocks
Punjab	Over-exploited	166%	80%
Rajasthan		140%	74%
Haryana		137%	63%
Delhi		120%	71%
Not Applicable	Critical	[90-100%]	NA
Himachal Pradesh	Semi-critical	86%	50%
Tamil Nadu		81%	46%
Puducherry		74%	25%
Uttar Pradesh		70%	17%
Karnataka	Safe	70%	30%
Telangana		66%	23%
Gujarat		64%	12%

State	Category	Stage of GW extraction (%)	% of over-exploited & critical blocks
Uttarakhand		57%	0%
Madhya Pradesh		55%	9%
Maharashtra		55%	6%
Kerala		51%	2%
Bihar		46%	6%
West Bengal		45%	NA
Chhattisgarh		44%	1%
Andhra Pradesh		44%	0%
Odisha		42%	0%
Goa		34%	0%
Jammu & Kashmir		29%	NA
Jharkhand		28%	2%
Assam		11%	0%
Tripura		8%	0%
Mizoram		4%	NA
Meghalaya		2%	0%
Manipur		1%	NA
Nagaland		1%	0%
Arunachal Pradesh		<1%	0%
Sikkim		<1%	0%

Of the 6,584 assessment units (viz. blocks/firkas/valleys/taluks/mandals/districts), as much as 32% are classified as over-exploited, critical or semi critical. The number of over-exploited and critical administrative units is significantly higher in Delhi, Haryana, Himachal Pradesh, Karnataka, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh.

Quality of Groundwater

The natural chemical content of groundwater is dependent on the depth of the soil and sub-surface geological formations with which groundwater remains in contact. In addition to the increase in exploitation of groundwater over the years, there have also been occurrences of quality related issues for groundwater. "Geogenic pollution" of groundwater, which refers to naturally occurring elevated concentration of certain elements in groundwater having negative health effects, is more prevalent in India. In India, geogenic contamination by fluoride and arsenic affecting several parts of the country is a major concern and remains a challenge for safe water supply in the contaminated areas. High concentrations of parameters like salinity, iron, manganese, uranium, radon and chromium, in groundwater, may also be of geogenic origin.

High concentration of fluoride in groundwater beyond the permissible limit of 1.5 mg/l poses health problems. In many districts of India, this permissible limit has been breached. Arsenic as a contaminant is significant in terms of its toxic nature and dangerous effects on the human body. As per BIS 2012 (IS 10500:2012), the acceptable limit of arsenic is 0.01 mg/l and the permissible limit in absence of alternate source is 0.05 mg/l. Large parts of the Ganga-Brahmaputra plains have breached the permissible limits of arsenic. Other types of groundwater pollutants include iron and nitrates. High concentration of iron (>1.0 mg/l) in groundwater has been observed in more than 1.1 lakh habitations in the country. Iron contamination has been reported from the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, J&K, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal and the UT of Andaman & Nicobar. High nitrate concentration in groundwater in India has been found in almost all hydrogeological formations and is indicative of high use of chemicals in agriculture[16].

The following figures show the arsenic and fluoride hotspots in India.[16]

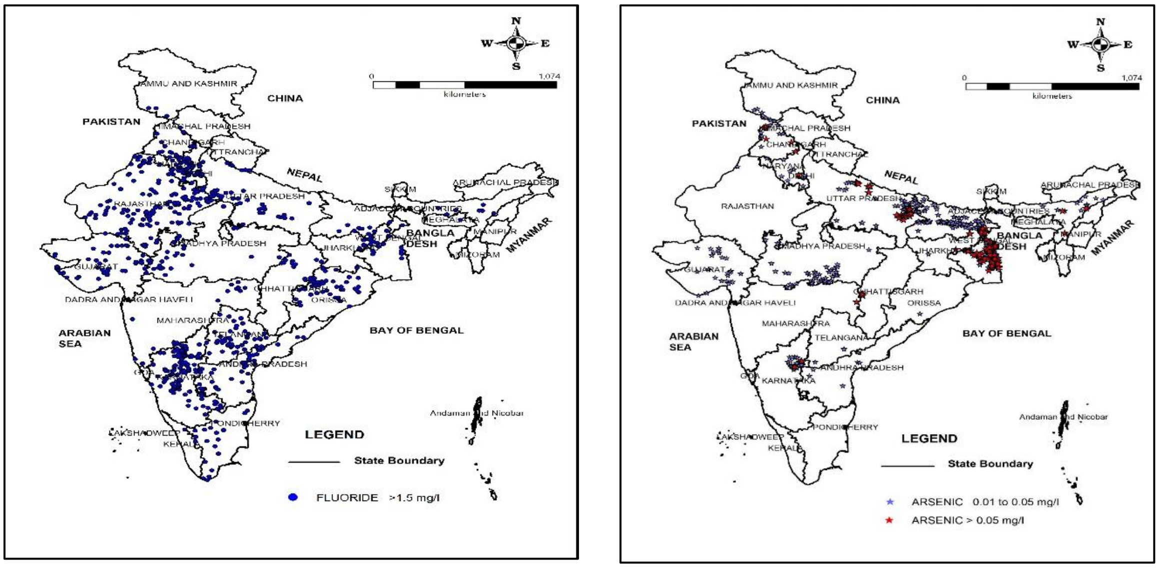

Figure 10: Arsenic and Fluorides hotspots in India

1.2.1.4 Desalination

Desalination is a major technology, which can potentially augment availability of water resources. Desalination is a process that removes salts and other impurities from water. While desalination technology (thermal) has been known to man for long, it has steadily gained in popularity and application as an alternative source of water for human consumption over the last three decades or so. This is because with ever increasing population and economic activity our demand for fresh water has increased while the growth in fresh water sources have not matched that growth.

Desalination has the potential to permanently bridge the ever-rising demand-supply gap of fresh water. Around 97% of the total water available on Earth is in the oceans and is saline; and, provides for a virtually unlimited stock of raw material for desalination. In addition to saline water from sea, brackish water found in river estuaries where sea and river waters meet, is also used for desalination. Desalinated water is consumed for industrial, domestic and agricultural purposes. Currently, the installed capacity of desalination plants across the world is around 86,572 MLD of which 44% is in the Middle East and North Africa. Currently, desalinated water is used by 1% of the global population on a daily basis. By 2025, around 14% of the world population is expected to start using desalinated water[17]. Desalination can be a

[16] http://cgwb.gov.in/wqoverview.html

[17] Article titled "Desalination industry enjoys growth spurt as scarcity starts to bit" published by Global Water Intel https://www.globalwaterintel.com/desalination-industry-enjoys-growth-spurt-scarcity-starts-bite/

suitable technology for coastal regions and port cities to meet their industrial and domestic water demand.

India too ranks reasonably high in the use of desalination, particularly for industrial use. At present, India has around 182 desalination plants located in different states. Gujarat has the maximum desalinated water generation capacity in the country with plants located at Kutch, Jamnagar and Metapur. Tamil Nadu is the country's second highest desalinated water producer with plants at Minjur and Nemmeli, each with a capacity of 100 MLD[18]. In fact, an additional capacity of 400 MLD is planned to be installed at the Nemmeli plant. In addition, a greenfield desalination plant with a capacity of 400 MLD is also being planned at Porur (Chennai).

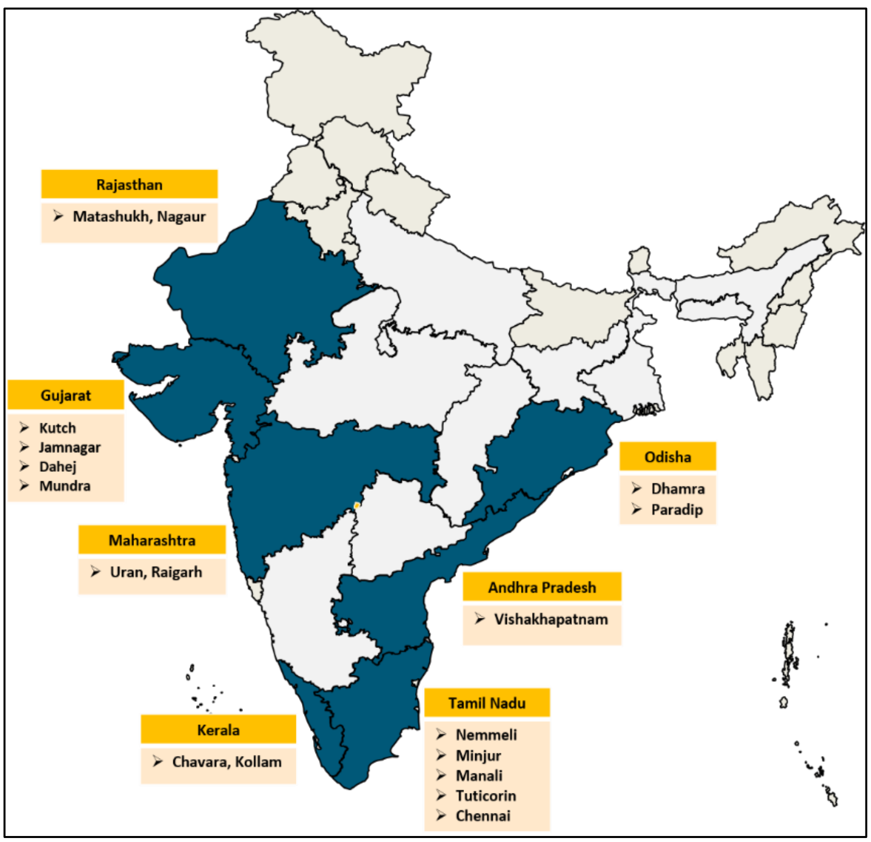

Figure 11: Desalinated Water Generation States in India

The challenge in the water desalination industry is the large gap between affordability and willingness to pay for water vis-à-vis the cost of desalination. Traditionally, in India, citizens pay very less or often nothing

[18] Report titled "Desalination- Easing India's Water woes" published by EPC World.

for water supply. Currently, the acceptable water tariff in India is estimated to be around Rs. 20-25 per kilolitre. In contrast, desalinated water costs four times this tariff at around Rs. 70-80 per kilolitre. However, this tariff includes annualised capex and O&M expenses. In fact, if capex is taken care of by programs like AMRUT, then a tariff for O&M cost recovery should be around Rs. 35-40, which is not too far from the average tariff prevailing in the country. The technological challenge at hand is to bring down the cost of desalinated water further down to the acceptable levels. With the emergence of newer energy efficient technologies and innovative solutions, desalination can be expected to become an economical alternative for meeting our water supply needs.

1.2.2 Utilization of Water Resources- Demand Side

The previous sub-section described the supply side of the water resources sector in terms of availability of water resources in India. However, to get an overall sector perspective, we will now discuss the demand side of the value chain which deals with the utilization of water resources in India.

1.2.2.1 Overview of Water Resources utilization

The key uses of water resources may be broadly clubbed under four major heads - irrigation, domestic, industrial and others (includes environmental requirements and evaporation losses). Among these, irrigation is by far the largest consumer of water resources. The latest available data related to estimated total water demand or withdrawal or utilisation is available for the year 2010. The figures from two key sources are presented below.

Table 9: Water resource utilisation in 2010 (in BCM)

Water demand by uses in 2010	Standing Sub-Committee of MoWR, RD & GR[20] Estimates	National Commission for Integrated Water Resources Development (NCIWRD) Estimates[19]
Irrigation	688	557
Domestic	56	43
Industrial	17	56
Others	52	54
Total	**813**	**710**

As evident from the table above a difference of 100 BCM exists between the two estimates. The sectoral split of water consumption as per NCIWRD estimates and its change from 2010 to 2050 is further shown in the figures below.[19]

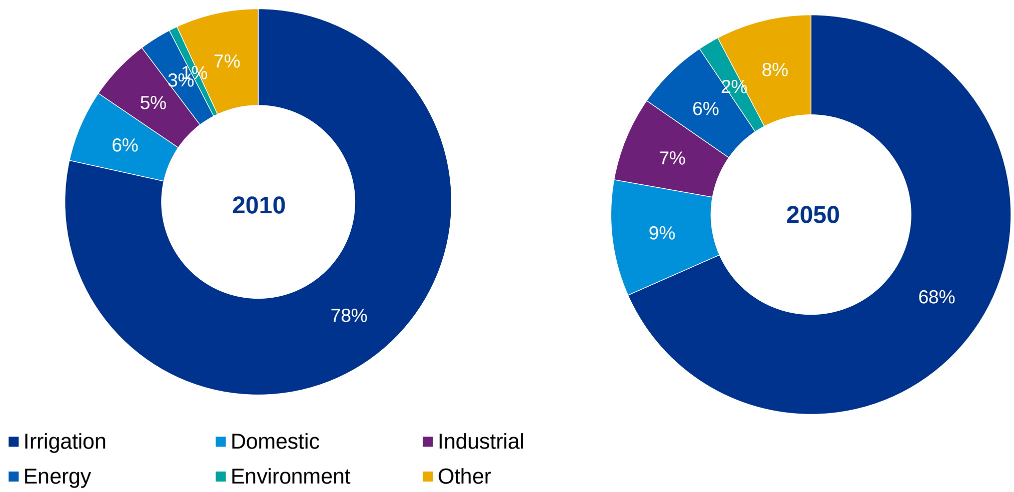

Figure 12: Changes in sectoral demand for water from 2010 to 2050

Further, water resources utilisation or future water demand estimation has been performed by multiple organisations. The National Commission for Integrated Water Resources Development (NCIWRD) has projected the demand for water for the various sectors, viz. Irrigation, Domestic, Industries, Power, Inland Navigation, Flood Control, Environment Afforestation, Environment Ecology and Evaporation Losses for the year 2025 and 2050. The demand for all the sectors were projected for both low and high demand scenarios. According to estimates, by the year 2050, the total demand of water is expected to be 973 BCM for low demand scenario and 1,180 BCM for high demand scenario. Moreover, the projected demand share is dominated by agriculture (68%) followed by domestic (9%) and industries (7%) by 2050. The detailed demand breakup is summarized in the table below[19].

Table 10: Future estimates of Water Requirement by uses (in BCM)

#	Use	Water Demand (BCM)			
		2025		2050	
		Low	High	Low	High
1.	Irrigation	561	611	628	807

[19] Report of the National Commission on Integrated Water Resources Development (NCIWRD) - 1999

#	Use	Water Demand (BCM)			
		2025		2050	
		Low	High	Low	High
2.	Domestic	55	62	90	111
3.	Industries	67	67	81	81
4.	Power	31	33	63	70
5.	Inland Navigation	10	10	15	15
6.	Flood Control	0	0	0	0
7.	Environment Afforestation	0	0	0	0
8.	Environment ecology	10	10	20	20
9.	Evaporation Losses	50	50	76	76
	Total	**784**	**843**	**973**	**1,180**

Water demand has also been estimated by multiple other authors or organisations over the period. These have been summarized below.

Table 11: Water Requirement or demand estimation by uses (in BCM)- Other sources

Projections as per Standing Sub-Committee of MoWR, RD & GR[20]		
Water demand by uses	2025	2050
Irrigation	910	1,072
Domestic	73	102
Industrial	23	63
Power	15	130
Others	72	80
Total	**1,093**	**1,447**

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

Projections as per Standing Sub-Committee of MoWR, RD & GR[20]		
Water demand by uses	**2025**	**2050**
Business as usual scenario- Water Demand projections- Paper on "India's Water Supply and Demand from 2025-2050", International Water Management Institute[21]		
Water demand by uses	**2025**	**2050**
Irrigation	675	637
Domestic	66	101
Industrial	92	161
Total	**833**	**899**
Business as usual scenario- Charting Our Water Future (McKinsey & WRG, 2009)[22]		
Water demand by uses	**2030**	
Irrigation	1,198	
Domestic	105	
Industrial	195	
Total	**1,498**	

As evident from the tables above, the major reason for the difference in total demand estimation is the varied projections of water consumption in the irrigation sector. Compared to the future demand estimates provided by the MoWR Standing Sub-Committee, the requirement estimated by NCIWRD is on a lower side since NCIWRD estimates were based on assumptions that the overall irrigation efficiency in the country will increase to 60% from the present level of 35 to 40%. Since the probability of increase in irrigation efficiency (in the future) is very high, the recommendations of NCIWRD has been accepted by the government.[20]

The total amount of water withdrawn per capita annually is a metric calculated by dividing the annual quantity of water withdrawn for agricultural, industrial and municipal purposes by the population. It includes water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water. It does not include in-stream uses, which are characterized by a very low net consumption rate, such as recreation, navigation,

[21] India's Water Supply and Demand from 2025-2050", International Water Management Institute

[22] Charting Our Water Future (McKinsey & WRG, 2009)

hydropower, inland capture fisheries, etc[23]. The estimated values of total water withdrawal per capita in India for year 2025 and 2050 are shown in the figure below[24].

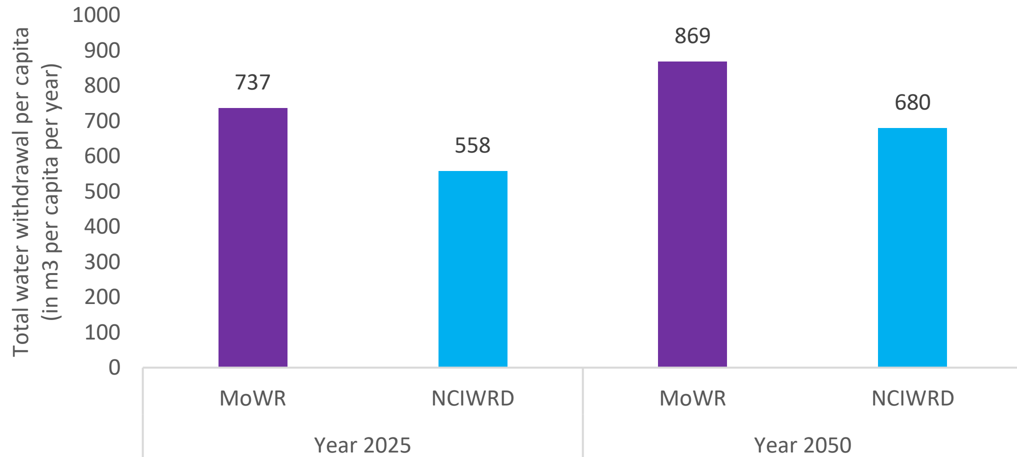

Figure 13: Projections of annual amount of water withdrawn per capita

As evident from the figure above, the projections show that the amount of water withdrawn per capita should be increasing with time in India. The figures for water withdrawn per capita as of 2011 stood at 629 m^3 per inhabitant per year based on MoWR estimates and 542 m^3 per inhabitant per year based on NCIWRD estimates.

1.2.2.2 Agriculture sector

Agriculture sector is the largest water consumer in India. Agricultural growth is necessary to support the food security of the growing population in India. Agriculture accounted for 23% of India's GDP and the sector employed 59% of the country's total workforce in 2016[26]. As per latest data available, agriculture (forestry and fishing) sector had 16% share in Gross Value Added at current prices during FY 2018-19[25]. Traditionally, India had been an agriculture dependent economy. However, as the Indian economy has diversified and grown since independence, agriculture's contribution to GDP has steadily declined steadily during the period of 1951 to 2011. Agriculture in India has achieved self-sufficiency in grain production.

[23] AQUASTAT database of the Food and Agricultural Organization of the United Nations
[24] The population projection has been done basis data available in Economic Survey 2018-19
[25] Agriculture Statistics at a glance, 2018, Ministry of Agriculture and Family Welfare, GoI

However, the production is, resource intensive, cereal centric and regionally biased. To make future agriculture growth sustainable, efficient use of water resources will be necessary.[26]

Irrigation, which is defined as the application of water to soil for supplying the moisture essential for plant growth, has a major impact on agriculture production and the wider economy. Irrigation plays a vital role in bringing more area under cultivation, increasing crop yields and stabilizing production. Depending on multiple factors like soil type, land topography, water availability, nearby sources of water, size of the area being irrigated, etc., various types of irrigation technologies/systems are implemented. Irrigation in India broadly includes well water irrigation system, reservoir water irrigation system, canal irrigation system and water from multipurpose river valley projects. These systems encompass a network of canals (major and minor), groundwater, wells, tanks, pool, basin, lake, dams, rainwater harvesting projects, etc. Further, irrigation involves diverse methodologies like flood irrigation, piped irrigation, manual irrigation, surface irrigation, drip and sprinkler irrigation among others.[27]

The overall irrigated area and land use statistics of India is summarised in the table below.

Table 12: Land use statistics (2014-15)

Land use	Area[25] (in Million hectares)
Geographical Area	328.73
Agricultural Land/ Cultivable land/ Culturable land/ Arable land	181.87
Cultivated Land	155.22
Net Area Sown	140.13
Total cropped Area	198.36
Area sown more than once	58.23
Net Irrigated Area	68.38

[26] India at a glance- FAO, United Nations
[27] FAO, United Nations; Review of Accelerated Benefits Programme, 2016-17

Land use	Area[25] (in Million hectares)
Gross Irrigated Area	**96.46**
Area Irrigated more than once	28.07

As evident from the table above, actual cultivated land comprised 85% of the total agricultural land/cultivable land/culturable land/arable land. Moreover, the net area sown, and the net irrigated area was 90% and 44% of the cultivated land respectively. Approximately, 49% of the agriculture land was sown from various irrigation sources whereas the remaining 51% was rainfed.

Irrigation sector water demand

Irrigation water demand from over approximately 100 million hectares (Gross Irrigated Area) makes it the major consumer of water resources in India. As described in the overview section above, water consumption for irrigation may reduce from 78% of the total water use to 68% of the total water consumption by 2050. As per the Mihir Shah Committee report (2016), historically, for the first two decades after independence, water required for Irrigation across the country was mainly supplied through large and medium irrigation dams constructed on our major river systems. However, over the last four decades it is groundwater that has been the main source of water. [28] The figure below summarises sources of water for irrigation in India and shows how groundwater (irrigation largely carried out through wells including dug wells, shallow tube wells and deep tube wells) has become the main source of irrigation at present. As shown in the figure below, groundwater today provides more than 63% of water for irrigation[29].

[28] Mihir Shah Committee Report, 2016
[29] Irrigation- Statistical Year Book India 2018

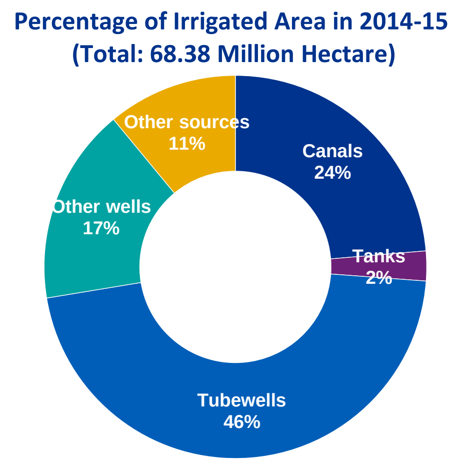

Figure 14: Area under irrigation by source

Irrigation sector water supply

Irrigation projects in India are classified based on culturable command area (CCA) of the project. A project having CCA of more than 10,000 hectares is termed as major irrigation project while a project having CCA between 2,000 and 10,000 hectares is called a medium irrigation project. A project/scheme having CCA up to 2,000 hectares is termed as minor irrigation scheme. The minor irrigation projects (schemes) are further divided into two categories viz. surface water schemes and groundwater schemes. Major and medium irrigation projects are generally surface water projects. The overall irrigation development status as on March 2012 is summarised in the figure below[30]. It depicts the Ultimate Irrigation Potential (UIP), Irrigation Potential Created (IPC) and Irrigation Potential Utilized (IPU). As evident from the figure below, the IPC in India comprises 56% from surface water sources and the remaining 44% from groundwater sources. Moreover, groundwater contributes more than 76% of the total irrigation potential created through minor irrigation projects. The created irrigation potential has also not been fully utilized and there exists a gap of around 23 million hectares (21%) between the IPC and IPU. The IPC-IPU gap has existed since 1974-75 as per the Mihir Shah Committee Report and measures are necessary to bring down this gap.

[30] UIP data based on Planning Commission (2009) Report of the Task Force on Irrigation; IPC and IPU data till the end of XI Plan (up to March 2012)

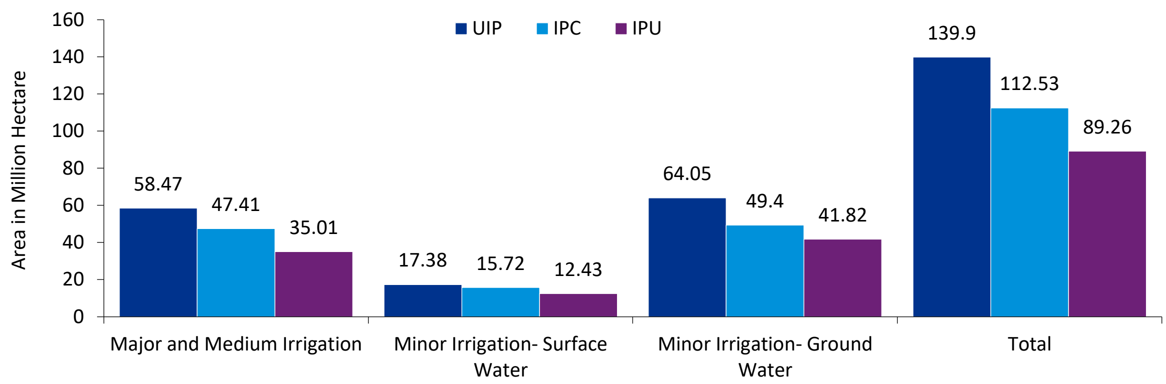

Figure 15: Irrigation water supply status

Comparison of Water Conveyance Efficiency

As discussed in the above section, Irrigation Potential Created in India comprises 56% from surface water sources and the remaining 44% is from groundwater sources. However, groundwater today actually provides more than 63% of water for irrigation. This signifies high dependence on groundwater for irrigation.

Conventional irrigation network incurs high losses as water travels from the point of extraction (in case of groundwater) or source of surface water supply to the point of water consumption at the farm. The network comprises multiple facilities/systems comprising reservoirs, diversion structures, canals, pump houses, piped supply systems, etc. in the irrigation water supply system- each with its own conveyance or storage efficiency. The typical efficiencies for various facilities or under different methods of application in the irrigation sector are summarised in the table below[31].

Table 13: Efficiency of various Irrigation system

Water usage method or system	Efficiency (%)
Water Conveyance System	
Conveyance through unlined canal for surface water	55-60
Conveyance through lined canal for surface water	70-75

[31] Guidelines for improving water use efficiency in Irrigation, Domestic and Industrial sectors, Central Water Commission

Water usage method or system	Efficiency (%)
Piped Distribution network[32]	90
Water application System	
Flood Irrigation	65
Furrow Irrigation	80
Sprinkler Irrigation	85
Drip Irrigation	90
Overall	
Surface Water System	30-65
Groundwater System	65-75

As evident from the table above, irrigation using groundwater system is more efficient compared to irrigation using surface water system. However, in addition to the above, the existing irrigation systems in India do not operate at the designed levels of efficiency mainly due to inefficient operation, poor/deferred maintenance and other factors. Overcoming these issues will result in significant water savings in the sector. As per a CWC report, approximately 146 BCM[31] savings is possible in the irrigation sector itself.

1.2.2.3 Industrial sector

The Industrial sector in India is the second largest consumer of water resources in the country. Further, energy sub-sector within the industrial sector is the largest industrial consumer of water. Industrial water demand has been increasing with the pace of industrial development. In addition to the energy sector, the growth in some of the other water intensive industries like iron & steel, paper, textile, etc. has been quite significant, putting further pressure on the available water resource. As per latest data available, industry (includes mining and quarrying, manufacturing, electricity and other utility services and construction) sector had 29.80% share in Gross Value Added at Current Prices during FY 2018-19[33]. As described in the overview section above, water consumption in the industrial sector may increase from 8% to 13% of the total water consumption by 2050. Growing population as well as rising standard of living may further increase the demand for industrial products, leading to an increase in future industrial water

[32] Guidelines for planning and design of Piped Irrigation Network, MoWR- July 2017

[33] Central Statistics Office (As per Press Release dated 28.02.2019)

requirement. At present, industrial sector in India consumes about 2 to 3.5 times more water per unit of production compared to similar plants operating in developed countries[34].

Shortage of water, in the form of insufficient or erratic water supply is already impacting, and will continue to impact, the industrial sector. This not only impacts the production processes of the industry but also its efficiency. The Small-to-Medium Enterprise (SME) and Micro, Small and Medium Enterprise (MSME) segment will be one of the worst affected due to the shortage and increased cost of water. The most severely affected industries are likely to include water-intensive sectors such as food & beverages, textiles, and paper and paper products. Amongst these, the textiles industry alone contributes 4% towards India's GDP, 14% to national industrial production, and accounts for 17% of the country's foreign exchange earnings[35].

Industrial sector water demand

Water requirements of major water intensive industries (other than power) in India is summarised in the table below[36].

Table 14: Water requirement of various industries (in Million m^3)

Category	2010	2025	2050
Iron & Steel	5,838	6,013	12,035
Smelters	24	32	44
Textiles & Jute	19,019	36,701	46,924
Leather Products	66	93	148
Inorganic Chemicals	1,600	3,346	615
Pharmaceuticals	209	276	429
Distillery	66	318	5,204
Paper & Pulp	207	10,240	19,490

34 Socio-economic impact of commercial exploitation of water by industries, Standing Committee Report, MoWR, 2018
35 Composite Water Management Index, 2019, Niti Aayog
36 National Water Mission under National Action Plan for Climate Change- Volume II, 2008

Three major water intensive industrial sectors – power, iron & steel, and textile have been discussed in this section. Power sector is the most water intensive industrial sector in India and is often estimated and mentioned separately during water demand estimation exercises. As per NCIWRD estimates cited in the overview section, as on 2010, power sector water demand is 34% of the total water demand for industrial sector. This will further go up to 46% (70 BCM) by 2050. Thermal power generation dominates energy production in India and is the major water consuming sub-sector. As on March 2019, all India installed capacity of thermal power plants was 226 GW which comprises 64% of the total installed capacity of power stations in India.[37] Approximately, 86% of India's electricity is generated from thermal power plants that rely significantly on water for cooling. Another 11% of electricity is generated from hydroelectric plants, which depend on water completely.[38] Due to unavailability of water, the operations of thermal power plants have been severely affected and the power plants may be forced to shut down or cut down generation in future. While generation from India's thermal utilities grew by 40% from 2011 to 2016, freshwater consumption in the thermal utilities sector increased by 43%, from 1.5 BCM in 2011 to 2.1 BCM in 2016. However, water consumption in the thermal power generation sector is estimated to stay below its 2016 level by 2027 if India's renewable energy goals are successfully achieved and the notified stringent water regulations are implemented. [39]

In addition to power sector, the iron & steel sector is another large consumer of India's water resources. Government has been monitoring the water consumption in the sector and has been focused on reducing the discharge water and implementation of innovative solutions to recycle and reuse water in the industry. The steel industry has also been planning to pursue strategies to reduce specific water consumption per tonne of steel produced. According to the National Steel Policy 2017, by 2030-31, the steel industry is annually estimated to require approximately 1.5 BCM of water[40].

Textile industry in India is another highly water intensive industry. Water is a key input for the industry as textile production involves large amount of water consumed in the supply chain as well as during direct operations. Moreover, the textile industry is largely dependent on the availability of raw material, such as cotton, which itself is a highly water-intensive crop. Study by the Centre for Science and Environment

[37] Central Electricity Authority report as on 31st March 2019
[38] Central Electricity Authority report, March 2019
[39] Luo, Tianyi, Deepak Krishnan, and Shreyan Sen. 2018. "Parched Power: Water Demands, Risks, and Opportunities for India's Power Sector." Working Paper. Washington, DC: World Resources Institute. (http://www.wri.org/publication/parched-power)
[40] National Steel Policy, 2017

(CSE) had revealed that the water consumption by the Indian textile industry alone was about 200-250 m^3 of water per tonne cotton cloth in comparison to the global best of less than 100 m^3 per tonne cotton cloth. In addition, it is known that the textile industry is mainly concentrated in a water-scarce region of India. Therefore, the long-term viability and sustainability of the Indian textile industry hinges heavily on sustainable water management practices[41].

Industrial sector water supply

Industrial demand for water is served by both groundwater (open wells, bore/ tube wells, etc.) and surface water (Rivers, streams, lakes, reservoirs, ponds, etc.). Choice of source of water for any industry often depends on the availability of adequate and regular supply of water as well as the cost of water, as per requirement of the specific industry. Groundwater has emerged as an important/preferred source to meet the water requirements of the industrial sector due to its availability and private ownership.[34]

The analysis of water supplied to the Industrial sector in India by source of water is presented in the figure below. As evident, surface water is the main source of water for the industries (41%) followed by groundwater (35%). Usage of municipal water (24%) is mainly limited to industries located in urban and peri-urban areas. In addition to the above, majority of industries use surface water in conjunction with groundwater to cater to its needs. Groundwater often augments the surface water requirement of an industry in instances when surface water availability is on a decline or is impacted by water pollution, which in turn may have an impact on the downstream industrial process.[42]

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[41] Water governance mapping report: Textile industry water use in India, Stockholm International Water Institute, 2016

[42] Water use in Indian Industry Survey, FICCI, 2011

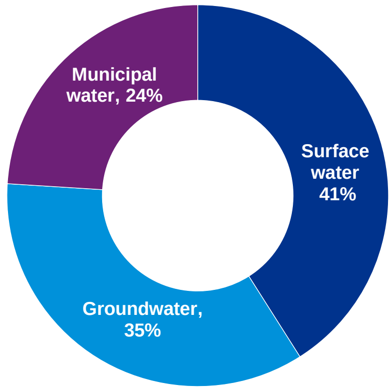

Figure 16: Source of water supplied to industrial sector

1.2.2.4 Domestic sector

The Domestic sector is the third largest (excluding environmental consumption) consumer of water resources in the country. As per estimates of NCIWRD, the percentage growth in water resources utilisation in the domestic sector is estimated to be the highest when compared to that in irrigation and industrial sector. From 2010 to 2050, the domestic sector demand is estimated to increase by 158%. Despite lower absolute demand of the sector (43 BCM as per NCIWRD), this is the most important water consuming sector.

Domestic water demand mainly comprises requirement of water for drinking as well as for other routine activities like, cooking, bathing, washing, flushing of toilet, gardening, etc. Moreover, domestic water demand includes water required for both – human beings and livestock. Domestic water demand is regulated primarily by the total number of people (or livestock) in an area and their daily water requirement. Moreover, water consumption in rural and urban areas is different due to the inherent lifestyle of the population. The National Water Policy (2012), allocates highest priority to ensuring safe water availability for drinking, followed by water allocated for other domestic uses (including needs of animals)[43].

Domestic sector water demand

[43] National Water Policy 2012, MoWR

As discussed above, drinking water is the primary component within domestic sector demand and is of utmost priority to the government. Consumption in domestic water currently is and is expected to be unequally distributed between the urban and rural population of India. While the urban population's consumption is at 195 litres per person per day (global average of 135 litres), the rural population of India consumes as low as 50 litres per person per day[44]. However, reports also suggest that actual quantity of water reaching the consumers is much lower due to high NRW losses in urban water supply networks across the country. The actual water available for the users is less than 100 lpcd in the various urban centres.[45]

As on 2014, no major city in India supplied 24x7 water to its entire urban population and only 35% of urban households in India had piped water in their dwelling as the primary source to support drinking water needs. The remaining rely on piped water to plot/yard, tube wells, and public taps, among other sources[35]. Increasing urbanisation coupled with rise in the consumption pattern among the urban population, would mean a new challenge for water resources[46].

About 77%[47] of rural households in India do not have individual piped water supply connections; however physical rural water coverage is estimated to be 79%[48]. Enormous progress has been achieved in the rural drinking water sector due to increase in budget with 39 million people gaining fully covered status each year. The Jal Jeevan Mission, announced in 2019, targets a Functional Household Tap Connection (FHTC) for every rural household in the country by 2024, supplying water at 55 lpcd on a regular basis and of prescribed quality (BIS: 10500 standard).

Domestic sector water supply

The main sources of water for the Domestic sector are groundwater (open wells, bore wells, tube wells, etc.) and surface water (rivers, streams, lakes, reservoirs, ponds, etc.). Although groundwater for domestic use comprised 9% of the total extracted groundwater in India, 50% of urban domestic water requirements and 85% of rural domestic water requirements are fulfilled by groundwater.[49]

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[44] Water for the Future- Challenges for India and its industries, 2012, Frost & Sullivan

[45] Centre for Science and Environment (2017), Water Efficiency and Conservation in Urban India, Reference link: Link

[46] UNICEF, FAO and SaciWATERs. 2013. Water in India: Situation and Prospects

[47] Format C36 - No. of Individual households with PWS Connections, IMIS Reports, e-JalShakti website, as accessed on 07th July, 2020

[48] Format 1 - Target & Achievement of Habitation, IMIS Reports, e-JalShakti website, as accessed on 07th July, 2020

[49] Overview of Ground Water in India, February 2016, PRS

1.2.2.5 Wastewater

Wastewater is defined as "used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff/stormwater, and any sewer inflow/infiltration".[50] Domestic wastewater may be tapped and treated for reuse. Approximately 80% of the water supplied for domestic use, comes out as wastewater. In majority of cases, wastewater is discharged untreated and it either sinks into the ground as a potential pollutant of groundwater or is discharged into the natural drainage system causing pollution in downstream areas. Sewage Treatment Plants should be used to treat sewage generated from residential, institutional, commercial and industrial establishments.[51]

Wastewater generation

During 2015, the estimated sewage generation in the country was 61,754 MLD (~23 BCM annually) as against the developed sewage treatment capacity of 22,963 MLD (~8 BCM annually). Low installed sewage treatment capacity has led to approximately 38,791 MLD of untreated sewage (62% of the total sewage) being discharged directly into the environment[52]. Out of the total municipal wastewater generation, the sewage generation in metropolitan cities, Class I cities and Class II towns account for 62% of the total sewage generated in the country. The treatment capacity developed in the cities is only about 31% of the total wastewater generated from the cities.[51]

Reports suggest approximately 60% of industrial wastewater generated (mostly from large industries) in India is treated[53].

Wastewater reuse for circular economy

As India's per capita water consumption grows rapidly, the quantum of the wastewater generated will also rise. Untreated wastewater is the prime contributor of surface and groundwater pollution in the country. The large volume of wastewater offers tremendous potential for urban local bodies (ULBs) to recycle water within the cities and minimize their dependency on bulk freshwater sources. While freshwater is required for human consumption, wastewater can be treated up to the desired quality

[50] Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Schertenleib, R. and Zurbrügg, C., 2014. Compendium of Sanitation Systems and Technologies. 2nd Revised Edition. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland

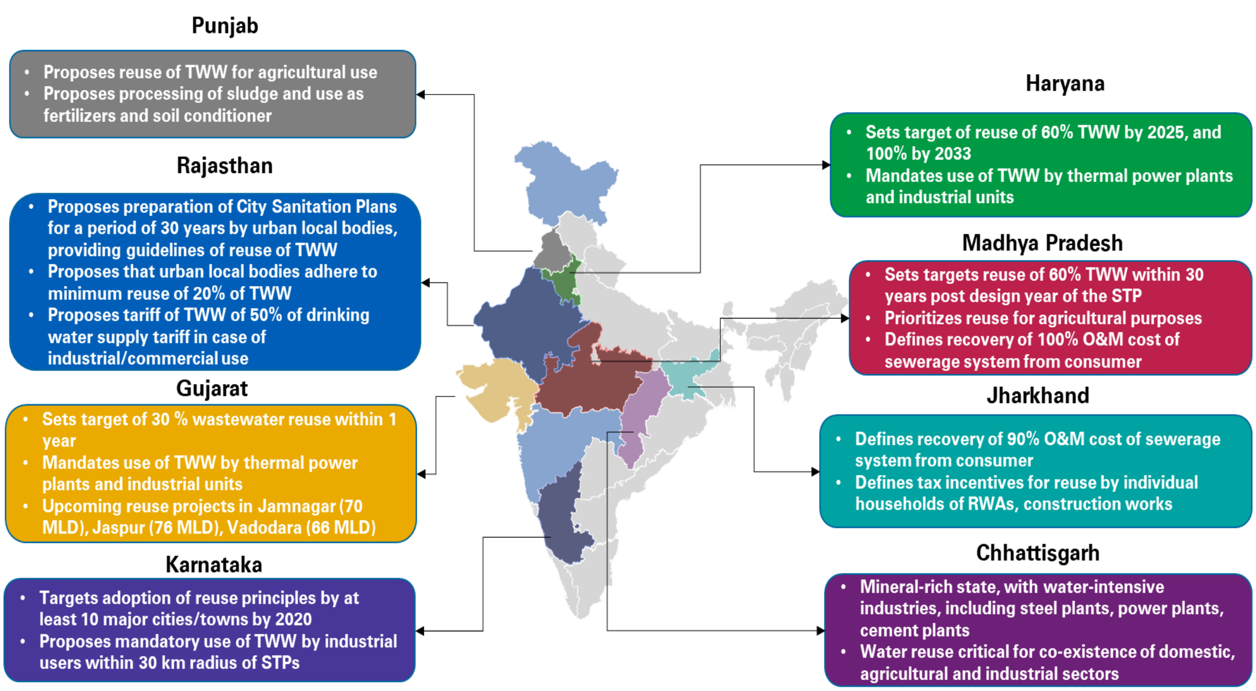
[51] Inventorization of Sewage Treatment Plants, March 2015, CPCB

[52] CPCB Bulletin, Volume-1, July 2016

[53] R Kaur, SP Wani, AK Singh and K Lal, Wastewater production, treatment and use in India.

required for its subsequent utilisation and can be safely reused for numerous purposes. Water recycling is generally interpreted as reutilising or reusing treated wastewater for beneficial purposes such as agricultural and landscaping irrigation, industrial processes, toilet flushing and several similar activities. Water recycling not only offers additional resource but also leads to financial savings. Wastewater treatment can also be tailored to meet the water quality requirements for a planned reuse. For instance, recycled water for landscape irrigation would require less treatment than recycled water used for cooling tower make-up. Currently, reuse of treated wastewater in the irrigation sector is mostly prevalent across the world with 32% of reuse application. However, the major challenge in using recycled water for agriculture is to shift from informal and unplanned use of partially or untreated wastewater to planned safe uses[54]. Additionally, as per orders from the Ministry of Power, from March 2020, all Thermal Power Plants have been mandated to use treated wastewater as per the provisions of the Tariff Policy 2016, provided there is an STP within 50 km radius of the power plant.

Numbers related to wastewater reuse in India are not available. However, many states in India have formulated wastewater treatment and reuse policy. The figure below summarises the wastewater reuse policy of various states in India. Once adopted on a massive scale, reuse of treated wastewater can certainly minimize our dependency on bulk freshwater resources.



[54] WWAP (United Nations World Water Assessment Programme). 2017. *The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource. Paris*, UNESCO

Figure 17: Summary of wastewater treatment and reuse policy across states in India

1.3 Performance of the sector

1.3.1 Analysis based on key enquiry areas

The study of the sector background in the preceding section has enabled in identification of multiple key enquiry areas related to the sector. In this section, we intend to undertake a deeper analysis of the performance of the sector with respect to enquiry areas identified through secondary literature and data collected through primary research (viz. key informant interviews with various stakeholders associated with the sector, focus group discussions and household surveys). The table below presents a summary of the evaluation objectives, specific areas of enquiry and findings from secondary literature as well as primary research.

Table 15: Performance of the sector with respect to key enquiry areas

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
Adequacy	Overall water storage capacity as well as water storage capacity per capita in dams	Secondary: • Storage capacity is low in large basins (Ganga, Brahmaputra, Indus, Godavari, Mahanadi) • Storage of 253 BCM under major and medium irrigation projects created with additional 51 BCM under works (2015) • Storage of less than 45% of total available surface water potential of 690 BCM Source- EnviStat India 2018, MOSPI
		Primary: <u>Increasing water storage in existing storage structures</u> • Siltation of reservoirs is a cause of reduction in water storage capacity. A national level stakeholder clarified that de-siltation of reservoirs is not taken up at the central level since this comes under the purview of states

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• The GoI is however looking at improving dam management through a World Bank supported program called Dam Rehabilitation and Improvement Programme (DRIP). The project aims at improving the safety and operational performance of existing dams through repair and rehabilitation of about 223 dam projects across seven states, namely, Jharkhand (DVC), Karnataka, Kerala, Madhya Pradesh, Odisha, Tamil Nadu, and Uttarakhand (UJVNL). The program was initiated in April 2012 and scheduled to complete in June 2020 at a cost of Rs, 3,466 Cr. [55] However, the existing project did not have any specific component to increase the storage capacity of the dams; instead it focussed on dam safety and O&M aspects. • Phase 2 and 3 of DRIP is proposed to be launched soon across 18 states at an estimated cost of Rs. 10,200 Cr., over a duration of 10 years. The key components should be (a) Rehabilitation and improvement of dams (b) Dam safety institutional strengthening (c) Revenue generation for sustainable O&M (d) Project Management[56] • As per CWC, currently in most states, budgets for dam O&M are part of the larger budget for irrigation and canal maintenance which is decided based on irrigated area. In practice, irrigation and canal maintenance tend to get greater priority, with the result that dam O&M is relatively neglected. Allocations for dam O&M need to be more in line with need-based assessments.[57] Moreover, an independent expert also pointed out, all state WRDs should have scheduled, pre-planned maintenance budget for dams.

[55] Website of DRIP
[56] DRIP Phase 2 and 3 project brochure
[57] Financial Management Manual- Dam Rehabilitation & Improvement Project, Central Water Commission

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Case Study: Efficient O&M by the Bhakra Beas Management Board (BBMB) The BBMB was formed in 1966 in the state of Punjab to undertake administration, maintenance and operation of Bhakra Nangal Project. As on date, the BBMB is responsible for administration, Operations & Maintenance of large dams- the Bhakra-Nangal Project, Beas Project Unit-I (Beas Sutlej Link Project) and Beas Project Unit- II (Pong Dam) in Northern India. BBMB generates its own revenue (mainly from power generation), and they have their own team and dedicated staff to perform the required O&M activities based on maintenance manual and a schedule of O&M activities. BBMB was awarded the most prestigious National Level Award for 'Bhakra Dam', as "Best Maintained Project (Functional for more than 50 years)". Source: BBMB website • Another common issue which the Expert pointed is that often multiple organizations are involved in operations of the dams on a river and they don't have enough coordination mechanism for operations & data sharing. This often is a major hurdle and the dam owners are not able to maximise storage utilisation of dams or reservoirs on the same river basin **Case Study: Resilient Kerala Program- World Bank** World Bank has sanctioned a loan of USD 90 Mn in 2019 to the Government of Kerala for the Resilient Kerala Program. The Program Development Objective

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		(PDO) is to enhance the State of Kerala's resilience against the impacts of natural disasters and climate change. An integrated river basin planning and management based on the River Basin Conservation and Management Act is being undertaken as part of the program. The major activities include (i) Developing and operating modern information and analytical systems to improve the quality and reliability of data and information, enhance real-time monitoring, and improve the scientific basis for informed decision making in the water sector; (ii) Integrating planning across all water-related sectors on a basin or sub-basin basis, including developing water allocation and use strategies; (iii) Strengthening systems for coordinated real-time water infrastructure (for example, dams and irrigation networks), including rolling out state-wide flood forecasting and early warning systems and improving the integrated operation of reservoirs in the State through updated cross-sectoral operation guidelines. Source: Program Document- Resilient Kerala Program- World Bank • In the state of Manipur, the height of one of the major dams has been increased by 1m to increase the overall storage capacity and results have been satisfactory. However, no desilting activities have been undertaken

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		<u>Construction of new storage structures</u> • A national level stakeholder suggested that the priority of the Central Government in recent years has been to focus on creation of smaller decentralised storage structures across the country. An Independent Expert supported the view of the government • Multiple national level stakeholders mentioned that construction of large dams have large environmental impact and high rehabilitation costs. Moreover, they take a significant amount of time for completion. For instance, planning of additional dams on Ganges and Yamuna may now pose significant environmental concerns since it is essential to maintain an optimal inflow to ensure river health (environmental flow). Moreover, in the absence of inflow, the groundwater availability also suffers **Case Study: Catch the Rain- NWM** National Water Mission (NWM) started the campaign “Catch The Rain” in March 2020 to nudge the states and the various stakeholders to create appropriate Rain Water Harvesting Structures suitable to the climatic conditions and sub-soil strata before monsoon. Under this campaign, implementation of check dams, water harvesting pits, rooftop RWHS etc; removal of encroachments and de-silting of tanks to increase their storage capacity; removal of obstructions in the channels which bring water to them from the catchment areas etc; repairs to step-wells and using defunct bore wells and unused wells to put water back

		to aquifers are being taken up with the active participation of people. The basic aim is to limit the water to flow out of the compound and improve soil moisture and groundwater table. In urban areas it will reduce water gushing onto roads, damaging them and will prevent urban flooding. All District Collectors, heads of institutions like IIMs, IITs, Central Universities, Private Universities, Chairmen of Railways, Airport Authority, PSUs; DGs of Central Armed Police Force, etc having large tracts of lands with them have been requested to take steps to "Catch the Rain". Source: NWM website • The stakeholder also mentioned that going forward, there is a need to measure the water storage capacity of smaller storage structures in addition to large irrigation projects. The 6th Minor Irrigation Census along with first Census of Water Bodies being conducted with Reference Year 2017-18 and scheduled to be released in FY 2020-21 is an important data point in this aspect. • Two national level stakeholders have mentioned that small barrages, check dams may continue to be developed (wherever feasible) since these involve less land acquisition and are more cost-effective ways of increasing the existing storage capacity. • The states of Bihar and Manipur have also mentioned that the focus is now on creating smaller decentralized storage structures. This is mainly since creation of large dams involve high rehabilitation costs, delays due to land acquisition issues and environmental concerns.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In the case of Himachal Pradesh it was mentioned, that since it is a hilly state, check dams and gully plugs may be used to capture rainfall water that otherwise runs off. Additional storage capacity needs to be created to store this water.
		Inference: • There are no specific schemes or initiatives targeted at increasing the storage capacity of dams. However, states are taking some initiatives like increasing dam height. Desilting, catchment area treatment, etc. are yet to be systematically adopted and has the effect of reclaiming lost storage capacity. • DRIP-Dam Rehabilitation and Improvement Programme (World Bank funded) has been implemented in select states and aims at rehabilitation and maintenance of select existing dams. Phase 2 and 3 of DRIP aims to bring more dams under its purview. • The focus is on creating small decentralised storage structures across the nation. This is mainly since creation of large dams involve high rehabilitation costs, suffer from delays due to land acquisition issues and environmental concerns. • Budgets for dam O&M are part of the larger budget for irrigation and canal maintenance. In practice, irrigation and canal maintenance tend to get greater priority, with the result that dam O&M is relatively neglected. • Small barrages, check dams may continue to be developed (wherever feasible) since these involve less land acquisition and are more cost-effective ways of increasing the existing storage capacity
Access	IPC-IPU Gap	Secondary: • IPC-IPU gap of 23 M ha (i.e. 21%)

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Faulty designs, unlined canals, lack of desilting, poor O&M of distribution channels and ineffective WUAs key factors • Shift in cropping pattern towards water intensive crops at upper end of command area another major factor. Source: UIP data based on Planning Commission (2009) Report of the Task Force on Irrigation; IPC and IPU data till the end of XI Plan (up to March 2012)
		Primary: <u>Measures to reduce the Gap</u> • The national level stakeholder shared that the AIBP and CADWM components of PMKSY with 99 priority projects are the focus projects of GoI. These intend to address the gaps between UIP-IPC and IPC-IPU respectively. The delay between construction of dam and main canal vis-à-vis field channels and developing the command area is a key reason for the IPC-IPU gap. Ensuring that the last mile connectivity of the canal network to farms is necessary to reduce this gap. • The completion of the PMKSY projects and focus on micro-irrigation by the GoI, will improve water use efficiency and help in reducing the IPC and IPU gap • An Independent Expert shared that often farmers (especially in head-end of a canal) switch to water-intensive crops once canal water is available. This leads to greater quantity of actual water requirement than the design requirement. As a result downstream farmer will not receive the designed water quantity and lead to increase in the IPC-IPU Gap

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In Manipur, to reduce the gap, piped irrigation network project is being piloted and micro-irrigation is being focussed upon. • However, post construction of canals in Manipur and Bihar, O&M funds are not available with the department to undertake regular maintenance activities. Due to the same, lining works for old canals have also been pending. This leads to seepage losses during conveyance which further increases the IPC-IPU gap. <u>Assessment related methodology</u> • Independent Experts shared that due to the inherent design and conveyance inefficiency of canal irrigation network, a significant quantity of groundwater recharge occurs in the command area. The present calculations of irrigation potential utilized does not take into consideration the additional water available for pumping due to seepage losses of the canal system. **Case Study: Sina Irrigation system Maharashtra-IWMI study** A study in Maharashtra by the International Water Management Institute to assesses the irrigation performance of Sina Irrigation project has demonstrated the following 1) The analysis based on satellite data shows the actual water influence zone (WIZ) of Sina

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		irrigation system is substantially larger than the designed canal command area. 2) Satellite-data based estimate of the ratio of IPU to IPC is considerably larger than the official estimate, primarily due to conjunctive use of groundwater. 3) The existing cropping patterns generate a substantially higher value of output than that based on the designed cropping patterns. It is evident from the above study that in the same irrigation command area after the introduction of canal, farmers started using the GW in the command area extensively. This is mainly due to the natural recharge of the groundwater from the return flow of the canal irrigation system. Source: Abstracts- 2nd International Conference on Sustainable Water Management, WRD, GoM • The state of Manipur shared that coordination and data management issues between departments often lead to mis-calculations related to IPC and IPU. It is therefore undertaking remote sensing studies and aerial surveys to measure and quantify the IPU on scientific basis. North East Water Resources Information Base – a geoportal funded by World Bank has been created for this purpose. The actual command area related data should now be available on a real-time basis.
		Inference:

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• The IPC-IPU gap can be reduced by focusing on last mile connectivity and completing the AIBP and CADWM projects • Innovative technologies like piped irrigation and micro-irrigation can help in reducing the gap further. The switching of head-end farmers to water -intensive crops also leads to IPC-IPU gap as tail-end farmers remain deprived of water (which was theoretical IPC of the project as per initial designs and planning) • Due to lack of O&M funds, lining activities and other maintenance activities remain incomplete causing water losses • Coordination and data gaps between departments at the state level leads to improper assessment of IPC and IPU; remote sensing and aerial survey activities can help in this aspect. • The present calculations of irrigation potential utilized does not take into consideration the water made available for additional pumping due to groundwater recharge from the seepage losses of the canal system.
Equity	Spatial variance in surface water availability and River interlinking	Secondary: • Avg. surface water potential – 1,999 BCM (at 75% dependability – 1,750 BCM) from 20 river basins • Avg. per capita surface water potential –1,537 cu. m. • High spatial variance – 7 river basins endowed with 49% of water resources but with only 14% of country's population

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Source: Reassessment of water availability in basins using space inputs- Central Water Commission- 2019 Study
		Primary: • National level stakeholder shared that river-interlinking projects to reduce the spatial variance is the focus of GoI. Accordingly, 38 links have been identified in peninsular and Himalayan rivers • DPRs and technical work have been completed for these river interlinking projects and there are four link projects that are ready to be implemented • For instance, the Ken-Betwa link is ready to be implemented. However, there are unresolved issues between the state governments of Madhya Pradesh and Uttar Pradesh. Perception issues and reservations over water sharing, have led to delays in implementation. Several rounds of negotiations are being undertaken to solve the issues. • Despite high level of technical preparedness, the political issues around the interlinking of river projects are leading to delays. • Water being a state subject, coordination among states is required. The central government has been acting as the mediator • For every interlinking project, detailed environmental impact assessments, social impact assessment in terms of rehabilitation requirement, are evaluated. There are multiple safeguards and range of clearances which are required. It takes about 4 to 5 years to get clearances for any one link. The Independent Expert

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		further added that comprehensive cost-benefit analysis (including socio-economic cost) must be undertaken prior to implementation of any ILP. • In Andhra Pradesh's Rayalaseema region (drought-prone area), after Godavari-Krishna River interlinking, groundwater levels have improved significantly, and water availability has increased to a great extent.
		Inference: • Managing the coordination between states and the political processes around interlinking of rivers has been challenging. This has further led to delays in implementation, • Detailed technical and environment impact studies are being undertaken for each link. Detailed cost benefit analysis (including socio-economic cost) may also be undertaken for such projects. • Multiple environmental and social clearances are being taken; this leads to delay in implementation
Sustainability	Extraction of groundwater and its regulation	Secondary: • Extraction in 37% of GW assessment units exceeded safe limits (2017); in 2013, this was 31% • High levels of extraction is due to availability of heavily subsidized power, impetus to paddy and wheat from PDS • While a decentralized water source, challenge lies in sustainable & equitable use of common pool resource • Percentage of safe GW units has been decreasing over the years

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Source: National Compilation on Dynamic Ground Water Resources of India, Central Ground Water Board, 2017 Source: Central Ground Water Board
		Primary: <u>Over-extraction of GW related:</u> • In the state of Himachal Pradesh, over-extraction of GW has been in selective blocks where private bore wells have been installed to cater to the industrial clusters and high-density population (due to tourism). In addition, growing of water-intensive crops like paddy with GW (especially in valley areas), has led to over extraction in some pockets. • In Karnataka, free electricity to farmers, subsidy on bore well connections, non-availability of reliable surface water source in certain pockets- have led to over extraction of GW. Especially for rainfed areas, insufficient and irregular rainfall has led to increasing reliance on GW. • In Andhra Pradesh, increase in agricultural land, cropping intensity, monsoon failures, reduction in surface water availability, inequitable distribution of surface water (especially for tail end farmers) and easy availability of GW are the key reasons for over extraction of Groundwater • In Uttar Pradesh due to subsidised electricity and poor regulations, GW extraction for irrigation has been high. • In Punjab, despite good network of canals, GW extraction has taken place since it is a very dense agricultural area. In addition, the traditional cropping

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		pattern includes paddy and wheat, which require significant quantity of water **Case Study- Participatory watershed management at Ralegan Siddhi in Ahmednagar, Maharashtra** Ralegan Siddhi village is in a drought-prone and resource poor area with annual rainfall ranging between 50-700 mm. In 1975, the GWL in the village was poor (upto 65 feet) and most of the wells used to dry up during summer and the drinking water had to be fetched from the neighbouring village. The key reason for the same was poor rainfall and high rate of surface run off, due to high degree of slope and lack of vegetative cover. Scarcity of water was a key distress which limited the prospects of agriculture in the village. Post 1975, under the leadership of Mr. Anna Hazare, a popular figure in the area, the village promoted and implemented participatory watershed management initiatives.. Key initiatives undertaken were rainwater harvesting and management of the four village watersheds. Every drop of rain was trapped by developing a drainage system, trenches, check dams, drainage plugs, percolation tank, etc. and by developing and designing micro-watershed specific schemes. These initiatives recharged the groundwater and now adequate water is available throughout the year at 21 feet depth. Improved GWL and water availability improved the

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		agricultural produce and socio-economic status of the farmers and the village. Impact of the project: • Irrigation potential increased from 0.5 % in 1975 to 70 % in 1985. • Agriculture production increased by four times. Overall socio-economic status of the village has improved- now there is an intermediate college, post office, bank, cooperative societies, solar street lights, low-cost latrines, bio-gas plants, training centre for watershed management etc. in the village. Source: A successful case of participatory watershed management at Ralegan Siddhi Village in district Ahmednagar, Maharashtra, India- as published on FAO website Regulation of GW: • The national level stakeholder mentioned that regulation of groundwater is being undertaken by either Central Ground Water Authority or by the state groundwater authority (wherever it has been formed). However, the main aspect of the regulation is primarily controlling the industrial water use. Regulation of Irrigation and domestic use is not the focus, because of various socio-economic and political reasons. Moreover, the monitoring agencies do not have adequate manpower to monitor compliance.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Only 17 states in India have a dedicated groundwater department/directorate/agency and in other states the same is being handled by other departments like PWD, Irrigation, WRD, etc. • In addition, the National Level stakeholder mentioned that in this regard an order was released by NGT on 20th July 2020 which has put curbs on over-exploitation of groundwater. In this order, NGT has focused on industrial exploitation and has asked CGWA being a statutory regulator for the country, to exercise overriding power in the form of statutory regulatory orders. The order also mentions that no general permission for withdrawal of groundwater should be provided, (particularly to any commercial entity) without environmental impact assessment of such activity. Moreover, the order also mentions that any permission should be for specified times and for the specified quantity of water and not in perpetuity.[58] • In Himachal Pradesh, the groundwater related regulations have been notified by the state government. The CGWB is providing technical inputs required including GWL monitoring. • In Karnataka, the state GW authorities regulate GW as per the Karnataka GW Act 2011. They issue NOCs for usage of GW based on the priorities. Drinking Water gets the highest priority followed by Irrigation and then Industries. Moreover, the critical/semi-

[58] NGT Order dated 20 July 2020- Shailesh Singh versus Hotel Holiday Regency, Moradabad & Ors.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		critical/safe status of the block is also looked at. However, the enforcement was weak and after issuance of NOC, monitoring (compliance) is poor due to lack of institutional capacity. Later, as per National Water Policy 2012, decentralised and participatory approach was undertaken- where selective powers have been given to District Collectors and district level committees. • In Andhra Pradesh, The Andhra Pradesh Water, Land and Trees Act, 2002 is used to regulate GW extraction. • In Maharashtra, as per the Maharashtra Groundwater (Development and Management) Rules, 2018, it is mandatory to establish watershed committees at district level and at tehsil level. Farmers need to obtain permissions from the committee before digging the wells • The national level stakeholder further shared that a new Model groundwater bill is being prepared by the MoJS and it will incorporate certain observations, which have been given by the NGT related to the over-extraction of GW • The Model Ground Water Bill 2016, which focuses on further decentralised regulation of groundwater and enforcement by local GPs, has not been adopted by Karnataka. • The Central Ground Water Authority maintains an online portal (NOCAP) where application for issuance

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		of NOC for GW abstraction can be made online. The same is in use in Karnataka and Punjab.
		Inference: • Over extraction of water by the irrigation sector across the states of Karnataka, Himachal Pradesh, Uttar Pradesh, Punjab and Andhra Pradesh is mainly due to free/subsidised electricity available to farmers, subsidy on bore well connections, non-availability of reliable surface water source, prevalence of cultivation of water-intensive crops, monsoon failures, reduction in SW capacity, unequal distribution of SW (especially for tail end farmers) and easy availability of GW. Other reasons for over extraction of GW include its easy accessibility and availability in many geographical regions, cheap and easy availability of bore well drilling and construction technology as well as absence of GW regulations. • Although the state groundwater authorities have GW abstraction related regulations and acts, the enforcement and adequate monitoring of the same remains a challenge. Only 17 states in India have a dedicated groundwater department/directorate/agency. • CGWA regulations on industries may also be further imroved. The quality of data and impact analysis studies (required to obtain NOC by industries) conducted by third part agencies, need to be further improved.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• The Model Ground Water Bill 2016, which focuses on further decentralised regulation of groundwater and enforcement by local GPs has not been adopted by majority states. A new Model groundwater bill is being prepared by the MoJS incorporating certain observations which have been given by the NGT related to the over-extraction of GW.
Equity	Efficiency of canal network	Secondary: • Canal-based irrigation prone to high losses to evaporation, seepage • Over-extraction by head-end farmers through canal breach, unauthorized pumping • Around 4-5% of command area needs to be acquired for project – leads to project delays Source: Guidelines for improving water use efficiency in Irrigation, Domestic and Industrial sectors, Central Water Commission
		Primary: • The national level stakeholder shared that the GoI is currently encouraging all states to go for piped irrigation networks. This is mainly to avoid the inefficiency related to the canal network and high land acquisition costs. Odisha, Maharashtra, Karnataka, Telangana, Manipur have been implementing such projects. Independent experts supported this view and added that piped irrigation will help in better accountability and monitoring and control of water supply (if SCADA and automatic valves are installed).

		Case Study- Telangana Piped Irrigation Network A sub-surface piped irrigation network to irrigate over 800 mn sq. m. (2 lakh acres) is being implemented in Nizamabad and Jagtial districts in Telangana. The project is being implemented as a part of the Kaleshwaram Lift Irrigation Project (Package 21). The estimated capital cost of the project is Rs. 2,400 Cr. The project implementing agency, the Irrigation and CAD Department, Government of Telangana has engaged a contractor, selected through a competitive tender process, to provide its services under Design-Build-Operate-Transfer (DBOT) mode and undertake O&M for a period of 15 years. The contract was awarded in April 2018 and implementation of the same is under progress. The project has been designed to reduce losses and improve water conveyance efficiency and leverage technology to allow remote monitoring and control of water supply across their networks through SCADA based Outlet Management system. Technology will allow the project operators to monitor consumption, manage demand and match supply to demand to reduce waste and contribute to additional water savings. Remote monitoring and control of the networks reduces the number of personnel required to manage the networks and thereby reduce O&M cost. Source: KPMG Analysis

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• The GoI also extends necessary support to increase efficiency of canals and provides financial support for re-lining, gate maintenance and better management of select old canals on a case to case basis and there is no specific scheme dedicated to this. • For instance, in 2018 the centre provided financial assistance for re-lining of Sirhind and Rajasthan feeder canal (in Punjab) over five years till 2022-23. They were issues related to water logging and huge seepage losses • The centre has also been encouraging states to laterally assess their canal networks • In Manipur, piped irrigation network project is being piloted and micro-irrigation is being focussed upon. • However, post construction of canals in Manipur and Bihar, O&M funds are not available with the department to undertake regular maintenance activities. Due to the same, lining works for old canals have also been pending. This leads to losses and decrease in efficiency of the canals in the states • In Punjab, due to low efficiency of the canal network, water is not able to reach the tail ends of canal. Therefore, the state is focusing on increasing efficiency using underground pipeline network and micro-irrigation.
		Inference: • Canal-based irrigation is prone to high losses due to evaporation and seepage

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• The central government is assisting the states and promoting the implementation of piped irrigation networks and micro-irrigation systems to improve the irrigation efficiency. • The GoI is also assisting in re-lining and better management of select old canals on a case to case basis. However, there is no specific scheme dedicated to this. • Post construction of canals in Manipur and Bihar, O&M funds are not available with the department to undertake regular maintenance activities. Due to the same, lining works for old canals have also been pending. • Punjab is focusing on increasing efficiency using underground pipeline network and micro-irrigation.
Access	Irrigation coverage status	Secondary: • Ultimate Irrigation Potential is approx. 140 M ha whereas only 68 M ha (i.e. 49%) is net irrigated area • Land productivity remains low in rainfed areas compared to 2 - 3x in canal and 3 – 5x in well irrigated areas • Need to close gap in irrigation coverage to improve food production Source: Agriculture Statistics at a glance, 2018, Ministry of Agriculture and Family Welfare, GoI
		Primary: Irrigation coverage

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In the state of Andhra Pradesh, difference in spatial availability of surface water is one of the key reasons for inadequate irrigation coverage. The state government is undertaking large lift irrigation projects to bring irrigation access to water deficient regions in the state. • Moreover, in AP, the rainfall pattern is not beneficial- very high rainfall concentrated over fewer days does not benefit the crops. Additionally, during very heavy rains- runoff is more and percolation to GW aquifer is less. Therefore, there is not much of an increase in GW levels. The state government is focussing on water conservation and creating small storage structures under PMKSY/MGNREGA to increase irrigation coverage. • In Bihar, floods during monsoon often lead to crop damage especially in North Bihar; whereas in South Bihar is often affected by droughts. The state government is planning the Ganga Water Lift Project to solve this. Although the initial focus of the project is on drinking water, the same is expected to be extended to the irrigation sector in the future. • In Punjab, the irrigation coverage is high due to availability of SW and GW sources. Certain hilly areas do not have access to irrigation due to the terrain. The state government has implemented lift irrigation projects in these regions. However, O&M costs of such projects are high; farmers may not be able to bear the Electricity charges in the long term

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In Jharkhand, small existing ponds in villages are being desilted and thereafter rainwater harvesting is being promoted to improve irrigation coverage. • In Uttar Pradesh, creation of more command area is required to increase the irrigation coverage. <u>Cropping Intensity</u> • In Manipur, assured irrigation has started recently and now the agriculture department is motivating farmers to take two crops • In Andhra Pradesh, surface water in canals are released in the month of August, one month after the start of monsoon. During the Rabi season, farmers are mostly dependent on GW since SW is not available reliably. • In Punjab, most of the farmers cultivate 2 crops in a year and aim to cultivate 3 crops going forward <u>Household Survey insights</u> Household Survey conducted across 11 states revealed 34% of the farmers still undertake mono-cropping.
		Inference: • Due to unavailability of assured surface water sources, under-developed command area of canals and depleting GW levels, the irrigation coverage needs improvement in the states of Bihar, Uttar Pradesh and Andhra Pradesh • The cropping intensity is also expected to increase after assured irrigation is available in Manipur

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Development of decentralised storage structures, desilting of ponds and rainwater harvesting structures are being undertaken to increase irrigation coverage in Jharkhand
Sustainability	Dependence on groundwater for irrigation	Secondary: • As per the Mihir Shah Committee the first two decades after independence, water required for irrigation was mainly supplied through large and medium irrigation dams. In last four decades groundwater (mainly irrigation through wells), has become the main source of irrigation • Groundwater today provides more than 63% of water for irrigation • Heavy subsidies for agriculture power consumption encouraged wasteful use Source: Irrigation- Statistical Year Book India 2018
		Primary: • The National level stakeholder highlighted that electricity cost subsidy provided by majority states to farmers is the main reason for overdependence on draftgroundwater. • In Himachal Pradesh, farmers depend on GW for irrigation since it is an assured source of supply, power for bore wells is available at a subsidised rate and GW is available in the field itself. The Independent Experts also highlighted this as the major reason for dependence on GW for irrigation. In addition, the

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		experts felt economic aspirations have led to farmers making investments in their farms and that has led to more installation and use of diesel pumps or electric pumps for irrigation. • In Karnataka, free electricity, subsidy on bore wells and non-availability of assured SW has led to preference of GW by farmers. Moreover, in some cases, it has been observed that power subsidy has led to over pumping and over irrigation. Also, sometimes there are no switches and the pumps keep on running as long as power is there; this leads to wastage of GW. IEC and capacity building activities are being undertaken for the farmers to avoid such issues. • In Andhra Pradesh, approximately 80% of the GW is being used for agriculture. Implementation of AIBP and CAD projects as well as focus on micro-irrigation is helping in reducing the dependence on GW. Moreover, lift irrigation projects are being undertaken to bring assured SW supply to the dry areas of the state. AP also faces SW shortage in low monsoon seasons due to the presence of dams in the Krishna Basin (upstream in Karnataka) • In Andhra Pradesh, under the NTR Jala Siri scheme solar powered bore wells have been installed to pump GW and use for irrigation. • Punjab is also attempting lift irrigation projects in hilly areas of the state • In Maharashtra, lack of access to surface water has resulted in the over extraction of groundwater.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Tendency to grow sugarcane (due to the presence of multiple sugar cooperatives) and assured price (MSP) have further aggravated the situation. The farmers also lack awareness in this subject. **Case Study- "Pani Bachao Paisa Kamao" scheme- Punjab** "Pani Bachao Paise Kamao" scheme has been launched by Government of Punjab with an aim to motivate farmers to improve efficiency in the use of groundwater for agriculture by providing them monetary incentives. The State Government had launched the Pilot for the scheme in June 2018 on 6 Agriculture feeders in Fatehgarh Sahib, Jalandhar and Hoshiarpur Districts. After the initial success during the pilot phase, the same was extended to 250 additional feeders in June 2019. The scheme is being implemented by the Punjab State Power Corporation Limited (PSPCL) and Agriculture Department and supported by The World Bank and J-PAL. The provisions of the scheme are such that farmers would be given a fixed electricity entitlement (kWh) for every month of the year which would vary by season (paddy and non-paddy) and would depend on sanctioned load of the consumer. The energy entitlement would be based on average consumption of the previous year. Any consumption measured from individual metres lower than the fixed settlement will

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		be reimbursed at the rate of Rs. 4 per kWh, while excess consumption above the fixed entitlement will attract no charge from the farmers. No bills will be issued, and the farmers will be intimated through SMS about their saving bimonthly and electricity consumption fortnightly and the amount (of saving) will be transferred directly to the consumer's bank account. Source: PSPCL website FGD insights • From the various Focus Group Discussions held with the farmers, the following points emerged related to the groundwater usage for irrigation: ○ In areas where SW source or assured irrigation facilities are available, farmers have reduced dependence on GW. However, they often use GW conjunctively especially during low rainfall days/ Rabi season/ days in which SW is not available, to maintain better crop productivity ○ In some areas of Assam, where the socio-economic status of the farmers is low, farmers are largely dependent on rainfall or SW (if available), as they do not have personal bore wells. ○ In difficult terrains (select districts of MP, AP, TN and Assam), where GW abstraction using bore well is not feasible, farmers have no dependency on GW. Instead they rely on SW sources (if available) and rainfall for irrigation.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		○ Dependence on GW (from bore well/dug wells) as a source of water for MI systems, was observed in the various states adopting micro-irrigation (like Karnataka, Uttar Pradesh, Andhra Pradesh, etc)
		Inference: • Free/subsidised electricity, subsidy on bore wells and non-availability of assured SW has led to greater dependence on GW by farmers • Power subsidy has led to over extraction and over irrigation and wastage of GW • Implementation of AIBP and CAD projects as well as focus on micro-irrigation and Lift Irrigation projects is helping in reducing the dependence on GW. • In addition, economic aspirations have led to farmers making investments in their farms and that has led to more installation and use of diesel pumps or electric pumps for irrigation
Sustainability	Cropping pattern and crop diversification	Secondary: • Preference of farmers to cultivate water intensive crops such as paddy even in areas of water stress • Rice, wheat and sugarcane consume almost 80% of freshwater available for irrigation leading to inequity in irrigation water availability for other crops • Large scale procurement of rice and wheat by the public distribution system at assured minimum support prices ensures demand for such water intensive crops

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Source: Agriculture Statistics 2018, Stress category based on CGWB data
		Primary: <u>Crop diversification</u> • A national level stakeholder pointed out that MSPs for a variety of crops exist. However, not all food grains / crops are procured for distribution through PDS. In contrast, cultivation of crops that have assured MSPs and supported by PDS procurement is high. • The NWM has started a campaign called "Sahi Fasal" which is nudging the states to look at water efficient crops or diversification of crops and asking/requesting the farmers to cultivate alternate crops which consume less water • In Andhra Pradesh, it has been observed that market of the new crops and buy back arrangement of the new crop under diversification by the government are the key factors affecting crop diversification plans. Often it has been observed that lack of buy back makes farmers sceptical and unwilling in adopting crop diversification. The same logic of inadequate market linkages being the main hurdle for crop diversification on a large scale, and was corroborated by multiple Independent Experts • To address these issues, online agriculture trading platform has been implemented- e-NAM platform (GoI initiative); also in Andhra Pradesh, e-Rythu application has been created to connect- buyers, farmers and

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		agents in the agricultural value chain. These market mechanisms provide assured prices to the farmers for a large variety of crops **Case Study- Ramthal Drip Irrigation Project** Ramthal Drip Irrigation project in Bagalkote district in Karnataka is the largest drip irrigation project in Asia. With commencement of water supply in 2017, the project currently caters to 24,000 ha comprising 15,000 farmers across 30 villages. The project was executed by private players and their scope also includes O&M for a period of five years along with the responsibility of creating WUAs. The project involves bulk water supply through fully automated drip irrigation systems. Farmers are provided water in their respective farmlands through installed cylinders, which have provisions for mixing the required fertilizers and pesticides. The project is expected to alleviate the water scarcity related issues of farmers in Ramthal Marola region. It is envisaged that installation of drip irrigation equipment shall result in improved water-use efficiency, reduction in pesticide and fertilizer usages and increase in crop yields. The project is further benefitted by the initiative of Government of Karnataka's (GoK) Agriculture, Horticulture and Water Resources departments in establishing market linkages by signing MoUs with 14 private sector agri-companies for offtake of

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		agricultural produce. To facilitate the scaling of this drip irrigation technology, Drip-to-Market Agro Corridor (DMAC) has also been established for promoting market-based mechanisms. Source: Multiple news articles related to the project and KPMG Analysis **Case Study- Market linkage support by FieldFresh Foods, Punjab** Field Fresh Foods Private Limited made its entry into horticulture in September 2004 in Punjab. A 300-acre Agri Centre of Excellence (ACE) government-leased model farm was established at Ludhiana to develop it as an R&D farm. The agency currently works with over 5,000 farmers and provides them the required technology support and offtake supply chain to grow baby corn, sweet corn and a variety of herbs and chillies using drip irrigation technique. The firm also has a joint venture between Bharti Enterprises & Del Monte Pacific Limited and exports fresh and processed vegetables like Baby Corn, Sweet Corn, Chillies etc to UK and western Europe. Source: KIIs with stakeholders in Punjab and website of FieldFresh

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In Punjab, it was observed that farmers are sticking to the traditional crops mainly due to the assured prices and procurement. Procurement of crops by private traders often suffers from price fluctuations. However, attempts are being made to grow maize instead of paddy. The presence of food processing industry has further supported this. • Crop diversification attempts are also being undertaken by the states of Jharkhand (maize instead of paddy), Assam (maize, pulses, mustard instead of paddy), Karnataka (pulses, pigeon peas instead of sugarcane), Maharashtra (various horticulture crops), Tamil Nadu (groundnut) and Telangana (soya bean, groundnut and Bengal gram) • In the state of Telangana, the state government is attempting to introduce the "Crop colony concept". Under this initiative, the state government has studied per capita consumption of all major agricultural produce in each district of the state and identified the crops for which surplus production exists currently. Based on the demand-supply gap, market demand, price of the crops, and other factors, the Agriculture Department advises the farmers (using various channels including social media), to grow specific remunerative crops only, prior to the start of the Kharif and Rabi season. The aim is to grow crops based on demand-supply gap of crops. The implementation of the concept is being done in coordination with Rythu

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Samanvaya Samithis (Farmers' Coordination Committee). **Case Study- "Mera Pani Meri Virasat" scheme, Haryana** The department of Agriculture, Govt of Haryana started the "Mera Pani Meri Virasat" scheme from FY19-20 to promote crop diversification in the state. Under this scheme, farmers who cultivate alternate crops like maize, bajra, cotton, pulses, vegetables, etc. (instead of paddy), in more than 50% of the land parcel available with them, are eligible to receive subsidy at Rs. 7,000 per acre. The government has also assured procurement of the produce at reasonable price. The government is also providing crop insurance as part of the scheme. The required irrigation equipment is also being supplied by the government at subsidised rates. Source: Mera Pani Meri Virasat web portal <u>Reduce water consumption of water-intensive crops</u> • To reduce the water consumption for paddy cultivation, Punjab has experimented with direct seeding technology. It consumes around 20-30% less water than the traditional methods. Trials have given good results and the yield remains almost same (within a range of +/- 5-10%) • However, in direct seeding of paddy, farmers need to use appropriate machines which plant the seedling directly into soil. The state is moving towards this

Key Evaluation sectoral objective	Area of enquiry	Findings from the research

		technology especially due to labour shortage. This is easier for larger farmers to adopt.
		• Punjab has also conducted trials for micro-irrigation of paddy. However, it is cost intensive and does not increase the yield
		
		FGD insights
		• From the various Focus Group Discussions held with the farmers, the following points emerged related to crop diversification:
		  ○ In areas where SW source or assured irrigation facilities are available, farmers have a general tendency to shift to water-intensive cropping pattern
		  ○ In areas where MI has been adopted (such as states like Karnataka, Uttar Pradesh, Andhra Pradesh, etc), farmers have started to grow various fruits and vegetables. In addition, traditional crops like sugarcane and wheat are also being cultivated using MI techniques.
		
		Household Survey insights
		• Household Survey conducted across 11 states revealed 49% of the farmers stick to water intensive crops due to the profitability factor.
		• Moreover, 51% of the farmers were growing paddy as a primary crop across 11 states
		• Among the mono-cropping farmers, 72% were willing to change the cropping pattern

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Among those not willing to change the cropping pattern, profitability was the main reason cited for the same.
		Inference: • In order to promote crop diversification, in addition to declaring an MSP, it is important to ensure that procurement of such crops happen and adequate market linkages are established for offtake of these alternate crops. • Alternatively, assured price needs to be ascertained for the alternate crops by adopting online agriculture trading platform like- e-NAM platform (GoI initiative). Moreover, e-Rythu application in AP has been created to connect- buyers, farmers and agents in the agricultural value chain. These assure fair prices to the farmers for a large variety of crops • Most states have tried to adopt crop diversification techniques. However, stronger market linkages and procurement supply chain can further strengthen such initiatives • To reduce the water consumption in paddy, direct seeding of paddy has been tried. It consumes around 20-30% less water than the traditional methods. Trials have given good results and the yield remains almost same (+/-5 to10%)
Water Security		Secondary:

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• The ratio of water consumption and area cultivated is an important metrics as it signifies the water use efficiency in the agricultural sector • India is one of the highest water consuming countries Source: World Resources Institute (AQUEDUCT) database
	Agriculture water use efficiency	Primary: • A national level stakeholder mentioned that dedicated “Micro-irrigation fund” has been set up (Rs. 5,000 Cr. Corpus -NABARD) by the MoA&FW, GoI under PMKSY. Some of the states have come forward to take up various innovative projects with these funds related to micro-irrigation and water-use efficiency improvement. • The NWM is also assisting the state government and the various stakeholders to increase water-use efficiency. • In Punjab, power supply to the agriculture sector is being provided free of cost. This is the major impediment to increasing the adoption of micro-irrigation **Case Study- Gujarat Solar Irrigation Cooperative to promote water use efficiency** The Dhundi Solar Pump Irrigators' Cooperative Enterprise (SPICE) provides the proof of concept for promoting Solar Power as a Remunerative Crop (SPaRC). Supported by International Water Management Institute (IWMI), the model has tried to

		provide a solution to western India's groundwater woes as well as curtailing the carbon footprint of agriculture in India and aims at creating a risk-free source of cash income for India's farmers. The SPICE, which began operating in May 2016, is the world's first solar irrigation cooperative formed in Dhundi village in Gujarat's Kheda district, about 90 km from Ahmedabad. Through this initiative, the farmers not only made a switch from diesel to solar pumps but also adopted net metering–selling excess power to the local electricity utility. Members now have an incentive to save power and curtail their groundwater use (thereby promoting water use efficiency), as any leftover power is sold to the Madhya Gujarat Vij Company Limited (MGVCL @ Rs. 4.63/kWh under 25-year power purchase agreement), the local power utility, thereby creating a parallel revenue stream. Source: "Solar Power as a remunerative Crop" by Tushar Shah et al. and various news articles **Case Study- Solar powered MI project- Punjab** The Solar Powered Community Lift Micro-irrigation Project (SCMIP) was conceptualised in Punjab, India by the Department of Soil and Water Conservation (DSWC), Government of Punjab. The project, situated in the district of Hoshiarpur, irrigates 6.64 mn sq. m (1,641 acres) of farmland located on the foothills of Shivalik mountain range and adjacent to the Kandi canal, the source of water for the project. The project was completed and O&M commenced in August 2017.

		The key project components comprise: i) pumping of water from Kandi canal to the command area using solar energy, ii) water distribution network, iii) on-farm micro-irrigation equipment and iv) SCADA powered automation. The project was implemented by a contractor selected through a competitive tender process. The scope of the contractor includes construction of the project and operations and maintenance for a period of seven years. In order to reduce the cost of operations and to make the project financially sustainable, the entire project is designed to exclusively rely on solar energy. Source: KII with stakeholders in Punjab and KPMG Analysis • In paddy growing areas; Punjab is going for underground pipelines to increase agricultural water use efficiency. Direct seeding of paddy using machinery is also being practiced as it consumes 20-30% less water • In Jharkhand, PDMC under PMKSY is being popularised for adoption among farmers • In Andhra Pradesh, surface water release and flows using SCADA control system has led to efficiency gains • Across the states of Manipur, Bihar, Assam, Tamil Nadu, Telangana, Maharashtra, increased adoption of micro-irrigation among the farmers, has been reported • The Independent Expert mentioned that we need not focus resources on adoption of micro-irrigation in the

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Gangetic basin, which has robust canal network and shallow aquifers.
		Inference: • Free power supply to agriculture sector is a major impediment for farmers to adopt micro-irrigation. • In paddy growing areas: underground piped irrigation network and direct seeding of paddy using machines may increase agricultural water use efficiency. • Large scale adoption of PDMC (MI) and use of SCADA system leads to an increase in agricultural water use efficiency. • The authorities may prioritise resources and not focus on adoption of micro-irrigation in the Gangetic basin, which has robust canal network and shallow aquifers. However, even in Gangetic basin, periodic assessment of the aquifers using suitable technology may be undertaken before deciding on the adoption of MI.
Water Security	Agriculture Sector Contribution	Secondary: • India is one of the highest water-stressed country with 18% of the GDP from agriculture and 52% of the country area under cultivation • With increase in area under cultivation/ value of produce/ cropping intensity India can further increase contribution to GDP from the sector • However, to avoid facing severe scarcity in the future; India must focus on water use efficiency in Irrigation

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Source: Food and Agricultural Organization- AQUASTAT database; World Resources Institute (AQUEDUCT) database for Water Stress scores
		Primary: • No additional insights gained during primary research on this enquiry area
		Inference: • India needs to ramp up the land productivity by growing high value crops, increasing water use efficiency, area under cultivation and cropping intensity
Sustainability	Water consumption in Thermal Power Plants	Secondary: • Power sector water demand is 34% of the total water consumption for industrial sector • Thermal power plants rely on water for cooling • Plants failing to adhere water consumption regulations as per MoEF&CC • There is less focus on reducing water footprint since water costs constitute a miniscule portion of the overall variable costs of a thermal plant Source: CERC Reports, WRI Working Paper
		Primary: • The Ministry of Power, GoI has made it mandatory for all the thermal power plants which are lying within 50 km of any sewage treatment plant, to take the treated wastewater from the treatment plant • In Maharashtra, the regulatory authority (MWRRA) has set standard water usage norms by the thermal power

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		plants in terms of their power generation (water consumption per MW power generation). The water allocation to power plants are done in accordance to these norms. Any additional water consumption by the thermal power plants attracts penal charges. These norms are revised every 3 years
		Inference: • Water consumption in Thermal Power plants across the country needs to be monitored and regulated in line with Maharashtra.
Sustainability	Efficiency in water use and pricing in Industrial sector	Secondary: • Water consumption in industrial sector may increase from 8% to 13% by 2050 • Inefficient use of water and water pricing in the industrial sector • Lack of effective regulations and coordination between regulatory bodies of centre and states • Lack of incentives provided to industry for efficient water use • Low tariffs for industrial consumption Source: NCIWRD data, National Steel Policy 2017; Water governance mapping report: Textile industry water use in India, Stockholm International Water Institute, 2016
		Primary: • NWM is promoting Water audit for industries. In association with TERI, benchmarking studies for optimum water usage and water audit are being

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		undertaken for various industries such as paper and pulp, leather and tannery. • In Maharashtra, the regulatory authority (MWRRA) has set standard water usage norms for every industry type/category. in terms of their volume of water per unit output. The water allocation to each industry is done in accordance to these norms. Any additional water consumption by the industries attracts penal charges. These norms are revised every 3 years. Volumetric pricing has been adopted for all industries
		Inference: • Inefficient use of water and water pricing in the industrial sector • Lack of effective regulations and coordination between regulatory bodies of centre and states • Water consumption in all industries across the country need to be monitored and regulated in line with Maharashtra
Sustainability	Efficiency in water use and pricing in domestic sector	Secondary: • Inefficient use of water and water pricing in the domestic sector • Changing lifestyles will further increase consumption of domestic water. • Poor water pricing has led to inefficient utilization of water resources • More than 40% of water produced in Indian cities does not earn any revenue (NRW losses) • Arbitrary tariff setting in most ULBs across India

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• From 2010 to 2050, the domestic sector demand is estimated to increase by 158%. Source: NCIWRD and Water for the Future- Challenges for India and its industries, 2012
		Primary: • In Karnataka, currently water tariff in ULBs is levied as per GO of 2011 and it should be revised every 3 years to take care of the increment in electricity and other costs. However collection efficiency is poor. • In some of the ULBs in the state of Karnataka, bulk water meter and domestic water meters have been installed (approx. 45%-50%); however, still lot of work on metering needs to be done • In some ULBs up to 40% NRW losses have been observed. • As per 74th Constitution Amendment, after construction, the Karnataka Urban Water Supply and Drainage Board hands over the assets to ULBs for maintenance. Only as per Government mandate, in 10 out of 230 ULBs, the authority is also maintaining the schemes on pilot basis. • In HP, high wastage of water in commercial uses (tourism, hotels) is there. Telescopic water tariff has been implemented in Shimla. Metering has been undertaken in multiple cities/urban centres across the state. • In Maharashtra, the water regulatory authority fixes bulk tariff for drawing surface water from rivers/dams

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		by the RLBs/ULBs for domestic sector. The responsibilities of retail tariff setting are vested with the RLBs/ULBs • In Odisha and Rajasthan, the main reasons for inefficient consumption are lack of awareness in public, old distribution system and associated NRW losses. In Rajasthan, under AMRUT replacement of non-functional water meters and IEC activities are being undertaken. **Case Study- Drink from Tap Mission, Odisha** In October 2019, to provide quality drinking water to every urban household in the state, the Housing and Urban Development Department, Govt of Odisha has initiated a program on "drink from tap mission". UNICEF will provide technical cooperation to the government of Odisha for implementation of the program which aims at providing piped quality drinking water supply to each household on a 24-hour basis, to 1.20 lakh people (in Phase 1). The program envisages to adopt community-based water management system at ward-level, involving Women Self-help Groups, which will ensure the household connection for every household, meter reading, billing, collection of water tariff, complaint management and field quality testing by using standard tools.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Source: Various news articles and KII with stakeholder in Odisha • The Independent Expert shared non-metered connections and low tariff (non-volumetric) are the major issues related to water use efficiency in the domestic (urban) sector. Transparency in meter reading and maintenance of meters should also be undertaken to ensure sustainability.
		Inference: • Currently water tariff in ULBs in Karnataka is levied as per State Government Orders. The same is required to be revised every 3 years to take care of the increase in electricity and other costs. However, collection of tariff is not adequate. • Adequate metering, volumetric tariff setting and awareness generation among consumers need to be undertaken
Sustainability	O&M and financing	Secondary: • Estimated NRW is between 40-70% of the water distributed in Urban areas • As of 2014, no major city in India supplied 24x7 water to its entire urban population • Urban water O&M cost recovery through tariff is not more than 30-40% • 35% of urban households in India have piped water Source: Urban Water Supply and Sanitation, The World Bank

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Primary: O&M related- Domestic Water: • In some ULBs in Karnataka up to 40% NRW losses have been observed • In Karnataka, only in 3 ULBs, 24x7 water supply has been established on a demo basis. • As per 74th Constitution Amendment; after construction, the authority hands over the assets to ULBs for operations and maintenance. • The capability of the ULBs (especially ULBs within 50,000 population range) in undertaking O&M needs to be ramped up • Due to poor O&M, after 4-5 years the benefits are not fully realised and the projects deteriorates • In HP, despite tariff collection, lack in O&M funds exists since tariff is not adequate to meet the high O&M costs (high power bills due to terrain) • In Rajasthan, the authority is working on the strategy to reduce NRW losses. Study is going on by forming DMA under pilot project in some areas. **Case Study- Water Corporation of Odisha (WATCO)** WATCO is a wholly-owned, not-for-profit Company of the Government of Odisha, established in 2015 to provide water supply and sewerage services in the cities of Bhubaneswar, Jatni and Khordha on behalf of the respective municipal bodies. The corporation manages the overall water production, treatment, and distribution and sewerage

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		collection, treatment and disposal activities. It also levies and collects tariff from the consumers. WATCO is currently providing services in 3 cities in Odisha, however it is planning to expand its services to the entire state very soon. Source: WATCO website <u>O&M related- Irrigation:</u> • The national level stakeholder mentioned majority of the states focus on creation of new infrastructure and neglect O&M. They propose ERM (Extension/renovation/modernization) projects and propose the same to be funded by PMKSY. ERM projects are accorded priority since these can be completed quickly with minimum funds. The same view was supported by an Independent Expert • In AP, O&M of canals for lining in 19 medium irrigation projects and one major irrigation project is being undertaken with JICA funding. Under Nagarjuna Sagar project, lining is being done with financial assistance from World Bank • In Maharashtra, WRD has been able to recover the entire O&M costs in FY 18-19 due to the various tariff provisions of MWRRA <u>Financing- Domestic water</u> • In Karnataka, cost recovery is very poor- since the collection of tariff is inadequate. Additionally, no one

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		is willing to implement and levy tariff and the issue is highly politicised • ULBs currently sighs away from their responsibility especially when it comes to collection of tariff required for funding the O&M of the water supply schemes. They ask the authority or the contractor to collect from the state government. Therefore, the state government currently deducts the electricity cost from GoI's Finance commission funds. • Urban Water Supply PPP has been tried but without significant success as financial feasibility is poor. **Case Study- PPP in Bulk Water Supply, Odisha** The Public Health Engineering Organisation (Urban), Govt of Odisha has engaged a private player and various stakeholders to implement a bulk water supply project in Bhubaneshwar at a cost of Rs. 188 Cr. in public-private partnership mode. The project started commercial operations from September 2017 and currently supplies water to the Indian Institute of Technology (IIT), National Institute of Science Education and Research (NISER) and various industrial establishments, including Infocity-II in Bhubaneshwar. This project has benefited a population of more than two lakh with uninterrupted supply of clean drinking water at an affordable rate. The project, financed under the Viability Gap Funding of the central

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		government, has been provided with Rs. 50 Cr. to be shared jointly by the Centre and the state government. Source: Various newspaper reports <u>Financing- Irrigation</u> • The Independent Experts shared that strong and active WUAs can collect irrigation service fee. However, it is imperative that the canals are transferred to WUAs in good conditions. It is however challenging since groundwater abstraction is free in most of the states
		Inference: • The O&M of the urban water supply schemes has been inadequate mainly due to the lack of capacity, the unwillingness to levy tariffs and inadequate collection of tariff (where tariff is levied) • High NRW and poor service levels further worsens the situation • The state government subsidises the O&M costs to cover for poor collection efficiency • O&M for irrigation projects is also a challenge due to low ISF collection and subsidised GW. The state governments are also focused more on asset creation rather than O&M
Overall nature and responsiveness	Planning and data management in the sector	Secondary: • Lack of holistic planning and management, MIS and poor / dated data on sector

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
of Water sector planning		• Siloed approach to water management – ground and surface water departments are separate • Lack of capacity in water sector institutions • Lack of regulation, private sector participation and innovative financing mechanism
		Primary: • National level stakeholders shared that the National Hydrology Project is the flagship program of GoI which is aimed at pooling and maintaining real-time and updated data related to the sector. The same view was confirmed by the Independent experts. Experts additionally commented that utilization of the data for the analysis and research is lacking. • In addition, the National Water Information Centre (NWIC) has been set up recently and is being strengthened. The idea is to bring in all states as stakeholders. • The NWM has been trying to promote State specific action plans for water budgeting. • The Government of Punjab has recently engaged a leading private sector company to prepare a comprehensive water sector plan for the state. It should cover all aspects including improving water use efficiency, water supply, water demand, and measures to increase efficiency in agriculture, industrial, domestic sectors • In Punjab, as on date accurate data of water consumption in various sectors is not available.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Authentic data about the volume of water consumed by industrial sector, or domestic sector is also not available because metered water supply is only in urban area. • In AP, the GW department has been renamed as Groundwater and Water Audit department and they plan to undertake comprehensive water audit activities • In Maharashtra, multiple water resources related departments have been mandated to maintain and submit data in specific standardised formats by MWRRA • For wastewater related data in the Ganga basin, in addition to the manual stations, special cell for ganga monitoring under CPCB has been set up. Online Continuous Emission & Effluent Monitoring Systems (OCEMS) is being set up under NMCG and integration of data from the SCADA system of new STPs is being attempted **Case Study- Maharashtra: Hydro-Economic Analysis by WRG 2030** The complexity of the interaction between water resource management and economic indicators can be demonstrated through integrated mathematical (hydro-economic) models. The use of hydro-economic models in water management helps in defining the physical behaviour of the system, with a realistic representation of surface water and groundwater

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		resources, including their interaction, and estimating the spatial and temporal variability of their availability. In 2015, WRG 2030 conducted a hydro-economic analysis to prepare a comprehensive planning by analysis of opportunities to improve Water Use in Agriculture Sector for Maharashtra. The hydro-economic analysis report captures various key elements related to the sector including diagnosis of water challenge in Maharashtra's agriculture, understanding agriculture growth in Maharashtra, and identifies the challenges and opportunities for agricultural growth in rainfed areas. A detailed Water Balance and Water Demand Forecasting was undertaken as part of this exercise. Such detailed studies help in comprehensive planning for the sector. Source: 2030 WRG – Hydro-economic Analysis for Maharashtra – Agriculture sector
		Inference: • The National Hydrology Project is the flagship program of GoI which is aimed at pooling and maintaining real-time and updated data related to the sector • Accurate and updated data, especially related to the demand side for Irrigation, Domestic and Industrial sectors are not available • Attempts are being made to pool data under the NWIC and NMCG projects (for wastewater)

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Secondary: • Inadequate capacity of STPs generating approximately 38,791 MLD of untreated sewage • Lack of ETP facilities causing 40% of industrial wastewater to be untreated • 317 polluted river stretches on 293 rivers and tributaries have been identified by CPCB Sources: CPCB Bulletin, Volume-1, July 2016; Kaur et al., Wastewater production, treatment and use in India; India Water Portal (https://www.indiawaterportal.org/articles/80-indias-surface-water-polluted); Restoration of Polluted River Stretches, CPCB, 2017

Quality	Wastewater reuse & pollution abatement measures	Primary:
		• A national level stakeholder shared that NMCG has been the flagship program in this sector.
		• Another national level stakeholder commented that NMCG has been able to bring in both financial and technical innovations to reduce the wastewater infrastructure gap in the Ganga basin. Some of these are as mentioned below
		    ○ Assured financial commitment (pre-NMCG annual budget Rs. 200-400 Cr; currently Rs. 1,600-2,200 Cr annual budget
		    ○ HAM model- concept of long-term operations and maintenance introduced with delayed capex annuity payment
		    ○ NMCG- technology neutral tenders
		    ○ One city one operator model

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		○ Installation of OCEMS – (Online Continuous Effluent Monitoring systems) for polluting industries ○ Focus on pollution abatement plus *Aviral Dhara, Nirmal Dhara*, bio-diversity – lot of public outreach activities undertaken ○ To avoid mixing of effluent from industries, which is a major challenge for operating STPs- NMCG conducted inventory of all industries and undertook CETP projects ○ Policies – In recent times NMCG is trying to improve usage of treated wastewater – e.g. in Mathura project – 20 MLD treated wastewater is being purchased by Indian Oil. Moreover, in Haridwar STP, canals are being built to carry treated wastewater to agricultural fields **Case Study- Kanpur CETP set up by NMCG for tannery** Kanpur's tanneries are perceived to be the primary source of industrial pollution in the Ganga. To solve the pollution issue, National Mission for Clean Ganga (NMCG) is undertaking projects worth approx. Rs. 4,000 Cr. which includes a 20 MLD Common Effluent Treatment Plant (CETP) for tannery cluster at Jajmau in Kanpur, Uttar Pradesh. This 3-phase project at an estimated cost of Rs. 629 Cr. includes pre-treatment unit in 380 individual tannery units, a 20 CETP with physical, biological and tertiary treatment and installation of Zero Liquid Discharge

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		(ZLD)-based pilot plant of 200 KLD capacity among other components. The central share of this project is Rs. 472 Cr. This is a major step forward in arresting the pollution in Ganga emanating from the crucial industrial town of Kanpur. The project will be executed by a Special Purpose Vehicle (SPV) – Jajmau Tannery Effluent Treatment Association. Source: PIB release dated 22 February 2018 • In Maharashtra, the state government has planned to treat 100% of domestic and industrial water and reuse at least 30-40% by 2022 **Case Study- Wastewater reuse in Israel** The constraints of water scarcity, combined with a fast-growing population and the decision to stop over-exploitation of the aquifers, has made it imperative for Israel to engage in a massive program of reuse of treated wastewater. Gradually, reclaimed wastewater has become a major source of water for farmers, supplying more than 40 percent of the country's needs for irrigation and more than 87 percent (approx. 500 MCM) of wastewater being reused. Favourable pricing policies have been put in place to give farmers a strong incentive to use treated reclaimed wastewater for irrigation instead of freshwater. Wastewater is priced at US$0.3 per cubic

meter for unrestricted irrigation and US$ 0.25 per cubic for restricted irrigation, less than half the tariff for freshwater for agriculture which stands at $0.66 per cubic meter. As an additional incentive for farmers to use reclaimed wastewater, they were also initially offered to convert their allocation of fresh water to reclaimed water using a ratio of 1 : 1.2 (20 percent higher allocated water volume).

Source: Marin, Philippe, Shimon Tal, Joshua Yeres, and Klas Ringskog. 2017. Water Management in Israel: Key Innovations and Lessons Learned for Water-Scarce Countries. World Bank, Washington, DC.

- In Karnataka, an attempt is being made to reuse wastewater in 4 ULBs. Focus is on treatment of wastewater and attempt to supply treated wastewater for reuse in industries
- In Punjab, STPs are being developed all across the state. Currently from around 100 sewage treatment plants around 2000 million litres per day of treated wastewater is available. However major part of this treated wastewater is not being reused
- Currently Punjab is using around 300 MLD (implemented using state funds) of treated water in agriculture. Under this project, underground pipes have been installed in the areas adjoining the sewage treatment plants and that water is supplied to agriculture sector
- The same need to be scaled up because Punjab has a silver lining due to vast urbanization, adequate amount of water supply to households, piped water

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		availability in almost every rural household in Punjab. For organised use, an action plan has been formed in the state and the same includes existing plus proposed STPs
		Inference: • NMCG has been the flagship program in this sector. Numerous technological and financial innovations have been implemented by the Mission. Reuse component is also being included in some recent projects, wherever feasible. • Certain states like Punjab and Maharashtra are aiming to undertake reuse of treated wastewater on a larger scale • Karnataka is also trying to supply treated wastewater to the industrial sector.
Sustainability	Climate Change	Secondary: • Change in temperature and precipitation due to global warming • Uneven rainfall distribution, intense & localized rainfall • Water related disasters like flood, drought Source: WWAP (UNESCO World Water Assessment Programme), 2019. The United Nations World Water Development Reports 2019: Leaving No One Behind. Paris, UNESCO
		Primary: • Independent experts mentioned the following related to climate change impact on the sector: ○ Climate change will lead to India requiring even more storage capacity as even if the total rainfall

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		remains same, erratic rainfall patterns (decrease in number of rainfall days) should require more storage since surplus days should be lower and the amount of surplus each day should be high ○ Multiple studies in India have been undertaken related to climate change and several schemes related to the same are being administered by MOEF&CC related to issues such as impact on river basins due to climate (both the volume and the flow) **Case Study- Ohio River Basin climate change study** In USA, the Huntington Engineer District in cooperation with the Pittsburgh, Louisville and Nashville districts, and the Great Lakes and Ohio River Division, prepared an adaptation pilot study to address the effects of climate change within the Ohio River Basin, in 2017. The Ohio River Basin Climate Change Pilot Report investigated potential climate change impacts to basin infrastructure. Infrastructure components include federal facilities operated for reduction of flood damages, navigation, local protection, water supply and hydroelectric power production. The study also investigated the potential impacts on terrestrial and aquatic ecosystems that are influenced by operation of these infrastructure components. The study provides downscaled climate modelling information for the entire basin with forecasts of

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		future precipitation and temperature changes, as well as forecasts of future streamflow. These forecasts, according to the report, are presented through three 30-year time periods between 2011 and 2099. Strategies to overcome potential impacts of climate change on the river basin are proposed in the study Source: The Waterways Journal ○ Wastewater reuse is potent solution to counter climate change since supply of wastewater is assured throughout the year
		Inference: • Climate change may lead to uneven rainfall distribution, intense & localized rainfall • Frequency of water related disasters like flood, drought is likely to increase • Climate change will lead to India requiring even more storage capacity due to erratic rainfall patterns • Wastewater reuse is potent solution to counter climate change since supply of wastewater is assured throughout the year
Sustainability	Micro level information on all depleted aquifers	Secondary: Lack of micro level information on all depleted aquifers. Currently only broad macro level information is available which is not suitable for making plans for artificial recharging of all depleted aquifers
		Primary:

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Himachal Pradesh, being a hilly state, the number of monitoring wells are not enough to gather detailed information on depleted aquifers. • The National Project on Aquifer Management (NAQUIM), is a flagship program of the CGWB, was initiated as a part of the Ground Water Management and Regulation scheme to delineate and characterize the aquifers to develop plans for groundwater management across India. As per data received from CGWB, out of the total 24.8 lakh km^2 area identified for aquifer mapping under the scheme, an area of 13 lakh km^2 (52%) has been covered up to March 2020. As a part of this programme, region specific groundwater management plans have been prepared, which suggest appropriate demand and supply side management interventions to improve sustainability of groundwater resources. However, NAQUIM is undertaking mapping at 1:50000 scale and may not provide village level aquifer level data • In Karnataka, Atal Bhujal Yojana is being implemented which has a mapping component. For selected GPs (almost 1,200 GPs) micro level water security is being planned. • In Karnataka, artificial recharge is also currently done at GP level by convergence with MGNREGA- however more scientific project preparation is needed • In Andhra Pradesh, 6 hourly data from 1,254 piezometers are being measured, recorded and reported through APWRIMS website. However, there

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		is scope for further analysis using the available data. The funds for O&M of the APWRIMS infrastructure including field equipment is currently being arranged through World Bank NHP. • Under National Hydrology Project of the GoI, real-time GWL monitoring is being implemented through telemetry system • The national level stakeholder commented that the various Groundwater recharge structures being created across the country (under MGNREGA and other schemes), are currently being undertaken by multiple state government departments or local administration. These structures are often created without any coordination, proper planning or technical knowledge. Guidelines of CGWB need to be compulsorily followed for the effectiveness of recharge structures. Moreover, O&M of these structures have also been lacking. The independent experts supported these views and added that recharge structures should not hamper the downstream water availability **Case Study- Groundwater Recharge planning and implementation in Madhya Pradesh** The aquifer mapping program undertaken by CGWB, has been beneficially utilised by the state government of Madhya Pradesh to plan and implement various GW

		recharge initiatives across the state. Select such cases provided below: • Based on the recommendations of NAQUIM, state govt. has finalized Water conservation/ Artificial Recharge sites in 9 blocks in districts of Chattarpur (3), Tikamgarh (3), Panna (1), Damoh (1) and Sagar (1) • 18 successful wells were constructed and handed over to the State Govt for water supply based on NAQUIM studies in parts of Bundelkhand region • Madhya Pradesh State Employment Guarantee Council is implementing water conservation and artificial recharge interventions as per NAQUIM studies reports for Ujjain District. Source: CGWB • However Independent experts commented that in addition to improving the quantity we need to improve the quality, reliability and availability of data related to depleted aquifers. It is also important that we analyse the data and prepare actionable recommendations based on the data. **Case Study- Groundwater Management in Palla Well Field of Delhi Using Numerical Modelling Technique** The Palla well field of Delhi is a model of sustainable groundwater development and management practices. A battery of ninety tube wells extract

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		around 25-30 MGD (41-49 million m^3/day) of groundwater to augment drinking water needs of Delhi. The groundwater management policy for groundwater abstraction from the well field is based on a numerical modelling study. Source: CGWB • In Punjab, a master plan for implementation of artificial recharge structures was prepared in 2013.
		Inference: • The NAQUIM and NHP are flagship programs aimed at aquifer mapping and real-time GWL monitoring • The Atal Bhujal Yojana is being implemented in seven states across India also has an aquifer mapping component • APWRIMS capture 6 hourly data from 1,254 piezometers in Andhra Pradesh • In addition to improving the quantity we need to improve the quality, reliability and availability of data related to depleted aquifers. It is also important that we analyse the data and prepare actionable recommendations based on the data. • The implementation of GW recharge structures needs to be improved and O&M of the structures must be mandated.
Quality	Groundwater quality	Secondary: • In addition to the increase in exploitation of groundwater over the years, there have also been

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		occurrences of quality related issues for groundwater. Large parts of the Ganga-Brahmaputra plains have breached the permissible limits of arsenic. High concentration of Iron (>1.0 mg/l) in groundwater has been observed in more than 1.1 lakh habitations in the country. In addition, several Arsenic and fluoride hotspots have emerged across India. Source: Central Ground Water Board
		Primary: • The national level stakeholder shared that in some coastal areas, over extraction has led to ingress of saline water. Moreover, in some states in the Ganga basin (10-15 km on either side of Ganga) like in states UP, Bihar, WB- arsenic contamination has been observed in some blocks. **Case Study- Use of deeper aquifers in arsenic affected areas for community water supply** In India, the problem of arsenic contamination of groundwater from the state of West Bengal, initially reported during the 1980's is widely known. Subsequently, the contamination was also reported from several other areas. The largest contiguous belt of high arsenic in groundwater in India is reported from the shallow alluvial aquifers in the Ganga Plain. In this part arsenic contamination has been reported from nearly 66 Districts in 6 States (West Bengal, Uttar

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Pradesh, Bihar, Jharkhand, Haryana and Delhi). The problem is compounded by the fact that the drinking water supply in these densely populated areas is dependent on shallow aquifers, which are found to be contaminated. In detailed investigations undertaken by CGWB under the NAQUIM, it has been found that wherever the deeper aquifers are separated from the shallow aquifers through a clay barrier, these are safe from arsenic contamination. A suitable well design has been developed by CGWB for tapping the deeper aquifers for arsenic safe water supply. The wells are constructed by tapping the arsenic safe deeper aquifer zones and separating the tapped deeper aquifer zones in the wells from the overlying contaminated shallow aquifers through cement sealing technology. The States of Uttar Pradesh and West Bengal are replicating the well design proposed by CGWB for construction of arsenic safe wells for public water supply. Source: CGWB • In the industrial clusters in Himachal Pradesh, GW pollution is mainly due to ineffective handling effluents by the industries • In Karnataka, over exploitation of GW and no natural/artificial recharge has led to quality degradation with time in some blocks. The quality of

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		groundwater is envisaged to be controlled by preventing industrial pollution, wastewater treatment, rainwater harvesting and artificial recharge • In Andhra Pradesh, industrial pollution has led to quality issues in some pockets. In coastal areas, below 500-600 ft saline ingress is observed • In some parts of south-west Punjab, salinity problems have been observed.
		Inference: • The quality of groundwater can be improved by preventing industrial pollution and undertaking wastewater treatment, rainwater harvesting and artificial recharge. • Salinity problems in coastal areas (due to over-extraction) and arsenic problems in gangetic plains exist but some of problems can be alleviated by adoption of suitable innovative measures like specially designed wells.
Water Security	Using recycled water for agriculture	Secondary: • Reuse of treated wastewater in the irrigation sector is mostly prevalent across the world with 32% of reuse application. However, the major challenge in using recycled water for agriculture is to shift from informal and unplanned use of partially or untreated wastewater to planned safe uses Source: WWAP (United Nations World Water Assessment Programme). 2017. The United Nations World Water

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Development Report 2017. Wastewater: The Untapped Resource. Paris, UNESCO
		Primary: • In Andhra Pradesh, not much has been done especially since wastewater collection in rural areas is not prevalent • In Uttar Pradesh, STPs have been installed as a part of NMCG. However, for reuse of treated wastewater, awareness should be generated at the community level • A national level stakeholder shared that NMCG has been the flagship program in this sector. . In recent times NMCG is trying to improve use of treated wastewater in agriculture – e.g. in Haridwar STP, canals are being built to carry treated wastewater to agricultural fields • The independent experts pointed out that, reuse in peri-urban areas and areas near STPs may be easier from implementation perspective. However initial pricing is required to be low to encourage adoption. Moreover, treated wastewater can act as an assured source of supply for the farmers. • Currently Punjab is using around 300 MLD (implemented using state funds) of treated water in agriculture. In the intervention underground pipes have been installed in the areas adjoining the sewage treatment plants and that water is supplied to agriculture sector

		Case Study- Reuse of wastewater in Punjab The state government of Punjab is using treated wastewater in agriculture. The treated water from the STPs goes directly to the farmland via underground pipelines, from which farmers can irrigate their agricultural land. Currently the STPs are located in Mukerian (4MLD), Talwara (4MLD), and Sham Chaurasi (3 MLD). In addition, in Shahpur a 30 MLD STP is being constructed (under AMRUT) and its treated wastewater is being used for agriculture. Farmers are happy to use the treated wastewater because earlier they were using the untreated water. Treated wastewater is more nutritious than the groundwater and they are getting good yield. The treated wastewater quality is examined through the labs every quarter. This water is rich in nutrients and consumption of fertilisers has also decreased. Source: KII with Punjab stakeholder • In Maharashtra, wastewater reuse for agriculture has been attempted from 3 STPs in Solapur • However, planned reuse of treated wastewater in agriculture has not been attempted in large scale in Assam, Jharkhand, Rajasthan, Tamil Nadu, Manipur, and Telangana Household Survey insights • Household Survey conducted across 11 states revealed 70% of the farmers are willing to use recycled

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		wastewater in case the government mandates the same. • Among farmers not willing to use treated wastewater for agriculture, fear of losing crops was cited as the main reason for the same.
		Inference: • NMCG has been the flagship program in this sector. In recent times, NMCG is trying to initiate/incentivize use of treated wastewater in agriculture. • Certain states like Punjab and Maharashtra are aiming to undertake reuse of treated wastewater in agricultural sector on a larger scale • Huge potential of wastewater reuse exists in Uttar Pradesh due to the NMCG projects • Reuse in peri-urban areas and areas near STPs may be easier to be implemented. However initial pricing is required to be low to encourage adoption. Treated wastewater can act as an assured source of supply for the farmers.
Overall nature and responsiveness of Water sector planning	Coordination between the various central government level organisations and the state government departments	Secondary: Water is a state subject as per the Constitution of India. Therefore, the institutional structure and departments at state level for implementation of water resources sector related planning, are key to ensure efficient planning and implementation in the area. Greater coordination between the various central government level organisations and the state government departments is required going forward.
		Primary:

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• A national level stakeholder has mentioned that water being a state subject, coordination among states is required. The central government has been acting as the mediator in implementing various river interlinking projects • In Andhra Pradesh, stakeholder suggested that role of rural development department should be reduced in water sector related activities. The Irrigation and Agriculture department can take up these activities. Implementation of SCADA in select projects has led to better coordination between irrigation and agriculture departments • For better coordination, fortnightly meetings may be undertaken. Currently there exist coordination issues • In Karnataka, multiple agencies and department undertake water conservation and artificial recharge initiatives. This may lead to duplication of effort. • Two different departments operate in Manipur - WR and CADA. Coordination issues exist between Water Resources, CADA, Agriculture and Horticulture departments • In Punjab, stakeholder mentioned that irrigation being the pivot of agriculture, there is need for much more coordination between water resources department and agriculture department. • In Uttar Pradesh, coordination among state departments is good, however the stakeholder mentioned that liaison with Central Government can be further improved • In Maharashtra, government had formed river basin organizations and 5 such organisations (or corporations)

		exist. These Multi-disciplinary organizations consisting of agriculture, groundwater, surface water and all other related departments working together. However, the integration expected in the river basin organizations did not materialise. **Case Study- Tennessee Valley Authority – a River Basin Organisation** The Tennessee Valley Authority (TVA) is a federally owned corporation in the United States created in the year 1933 to provide navigation, flood control, and land management for the Tennessee river system as well as undertake electricity generation, fertilizer manufacturing, environmental and economic development of the Tennessee Valley region. TVA was envisioned not only as a provider, but also as a regional economic development agency that would use federal experts and rural electrification to help modernize the rural region's economy and society. Since 1933, TVA has worked to make life better for the people of the Tennessee Valley region, which spans 80,000 square miles across parts of seven states in the Southeast USA. Source: TVA website **Case Study- Damodar Valley Corporation – a River Basin Organisation in India** The Damodar Valley Corporation (DVC), established in the year 1948, came into existence as the first multi-purpose river valley project of independent India. As on date, DVC functions as a river basin authority, of

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		the Damodar valley area spanning across the states of West Bengal and Jharkhand. DVC undertakes the following key activities with the ultimate objective of socio-economic development of the Damodar Valley area: • Power supply including hydro-power generation in the area • Flood control activities • Irrigation and water supply related activities • Soil conservation in the valley Source: DVC website
		Inference: • Overall, most states stated that greater coordination between irrigation and agriculture department is required • Water being a state subject, in case of inter-state river disputes and river interlinking projects, better coordination is necessary
Sustainability	Gap between demand and supply of water	Secondary: • A WRG 2030 study states India may be facing a supply deficit of 50% vis-à-vis actual demand by 2030, driven by rapid growth in agricultural, municipal and domestic sector demand • India should face the worst scarcity in terms of percentage of demand when compared to the other countries • 6% loss in the country's GDP anticipated by 2050 due to water scarcity (CWMI, 2018) Source: 2030 WRG

Key Evaluation sectoral objective	Area of enquiry	Findings from the research

		Primary:
		• National level stakeholders and independent experts suggested the following to decrease the demand supply gap
		  ○ Improved GW management
		  ○ Better regulatory system
		  ○ Improve water use efficiency in agriculture
		  ○ Strengthening micro-irrigation
		  ○ Working on crop diversification
		  ○ Reuse of treated wastewater in agriculture/industry
		  ○ Recharge and conservation of water
		  ○ River rejuvenation
		  ○ Design, management and O&M of irrigation infrastructure keeping in view various climate change aspects
		• The stakeholder from Punjab also agreed that the gap between demand and supply of water needs to be addressed by the following:
		  ○ Reduce area under water intensive crops like paddy
		  ○ Promoting micro-irrigation of alternate crops like cotton and horticulture
		  ○ Reuse of treated wastewater

		Inference: • The gap between demand and supply of water needs to be reduced through interventions related to both supply and demand side of water

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Secondary: • India is one of the world's largest groundwater users, accounting for more than 25% of the global total. As per the estimates of the Central Groundwater Board, share of bore well irrigation went up from just 1% (1960-1961) to 60% (2006-2007).
Gaps in broad sectoral outcomes	Efficient groundwater management and technologies	Primary: • Stakeholder from Himachal Pradesh suggested that better technology and more scientific instruments are required to improve groundwater management • In Andhra Pradesh, 6 hourly data from 1,254 piezometers are being measured and recorded in the APWRIMS website. In addition, geo-tagging of approx. 14 lakh bore wells spread across the state has been achieved. The department further plans to perform yield test and aquifer performance tests based on available field data **Case Study- APWRIMS- Water information system of Andhra Pradesh** Andhra Pradesh Water Resources Information and Management System (APWRIMS), is a comprehensive water information system, developed by the Water Resources Department, Government of Andhra Pradesh. APWRIMS not only includes real-time information on reservoir water storages of Major and Medium Projects, but also storages in minor projects, minor tanks, water conservation structures (check dams, percolation tanks). Additionally, APWRIMS also

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		provides data related to groundwater from 1,254 piezometers (6-hourly data) and soil moisture. Under this project, geo-tagging of approx. 14 lakh bore wells spread across the state has also been achieved. The information related to the various aspects of the water sector is collected in real-time from diverse information sources including on ground measurements, satellite-based assessments from Satellites/ models/ IMD/ ISRO/ WRD, among other sources. The WRD, GoAP was also awarded the first prize in the NWM 2019 awards (Category- Comprehensive Water Data Base in Public Domain) for APWRIMS. Source: APWRIMS website and KIIs with stakeholders in Andhra Pradesh • Under National Hydrology Project of the GoI, real-time GWL monitoring is being implemented through telemetry system
		Inference: • Real-time data for GWL monitoring using advanced telemetry is required for efficient management of groundwater resources.
Gaps in broad sectoral outcomes	Wastewater reuse policy	Secondary: Wastewater reuse policy mandating the use of treated wastewater especially for industrial sector is required for all states

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Primary: • NMCG is working with GIZ to develop a framework for treated wastewater reuse • Wastewater reuse policy exists for the states of Karnataka, Jharkhand and Punjab- implementation needs to be further strengthened • HP is planning to introduce wastewater reuse policy
		Inference: Wastewater reuse policy exists in a few states and the implementation of the reuse initiatives needs to be strengthened. More states need to adopt wastewater reuse policy.
Gaps in broad sectoral outcomes	Need for water regulator for all states and /or central	Secondary: The national water policy 2012 talks about setting up a water regulator to manage various issues around water. Considering the enormous challenges in water sector, lack of a water regulatory authority is hampering the growth of this sector. With multiple disputes around water resources, supplies etc., there is an urgent need of a regulator to create proper legislation, regulations for private sector participation and innovative financing mechanism
		Primary: • National level stakeholder and Independent Experts suggested that there is scope and need for a regulator to issue such as competing uses of water and allocating water resources across drinking, industrial and irrigation sectors • Karnataka suggested that a state level regulator is required to levy tariff • Independent water regulator is required to look into various issues like tariff setting, water quota allocation, equitable distribution, dispute resolution, water use efficiency promotion, etc. The regulator being third party

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		(neither part of government nor from other stakeholders) can perform effectively without bias. **Case Study- Maharashtra Water Resources Regulatory Authority (MWRRA)** The Maharashtra Water Resources Regulatory Authority formed in the year 2005 is the first independent water regulatory body in India. The Established under the MWRRA Act, the authority establishes a regulatory mechanism for overseeing the relationship between the service provider and water user entities as well as among the various water user entities, in terms of determination, enforcement and dispute resolution of entitlements and fixing of water charges, in the state of Maharashtra. The regulator regulates activities across the water sector in Maharashtra- starting from supply side- surface water and groundwater as well as the demand side- industrial sector, domestic sector, agricultural sector and commercial sector. MWRRA also regulates wastewater treatment and wastewater reuse related activities. Challenge: MWRRA currently does not have any field agencies to monitor the implementation of the various initiatives and check compliance of the same. Source: MWRRA website; KII with stakeholder
		Inference:

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Independent Water regulator is necessary to address issues such as competing uses of water and allocating water across drinking, industrial and irrigation sectors
Gaps in broad sectoral outcomes	Capacity building of the organisations/utilities creating and managing Water Resources infrastructure and providing service	Secondary: Lack of capacity of the departments / utilities managing water resources and the service delivery is leading to poor water management. There is a serious need of involving the community (end beneficiary) in the process of management of these infrastructures for optimum use. Similarly, the capacity available in the private also should be tapped for bringing in efficiency in the management systems.
		Primary: • The national level stakeholder mentioned that Krishi Vikas Kendras situated across the country impart training to the farmers and the government officials at the state/district level • Independent Expert shared that knowledge or capacity needs to be built in areas related to climate modelling, hydrological modelling and similar advanced aspects • In Bihar, more capacity building activities are required for micro-irrigation and crop diversification aspects. WALMI is currently providing trainings in Bihar • In Karnataka, capacity building to undertake O&M of water supply and sewerage assets of ULBs is necessary • In Manipur, capacity building in latest technologies and new instruments being installed as a part of NHP is required • In Punjab, local awareness generation programs are regularly held by Punjab Agricultural University • In HP, engineers in the PHE or other engineering departments need capacity building in social skills.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Case Study- Odisha – AMRUT Orientation Program The Government of Odisha in association with MoHUA (GoI) organises structured capacity building at regular intervals, for the various Municipal functionaries across the state who oversee implementation of the various AMRUT projects in the state. The various agencies who have provided required capacity building activities for AMRUT (both technical and managerial) are: 1) Centre for Science and Environment, New Delhi 2) Indian Institute for Human Settlements, Bangalore 3) All India Institute Of Local Self Government, Mumbai 4) National Institute of Urban Affairs (NIUA), New Delhi 5) World Bank (under Capacity Building for Urban Development- CBUD) Source: KII with Odisha stakeholder
		Inference: Capacity building of departments, ULBs and organizations involved in management of water resources is essential in areas such as soft skills, new technologies, micro-irrigation and crop diversification.
Convergence	Scheme convergence	Secondary: • The major objective of PMKSY has been to achieve convergence of investments in irrigation sector. However, seeing the irrigation sector in isolation has

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		led to duplication of efforts. There are several central government ministries in addition to MoJS like MoA&FW, MoHUA, MoRD, etc implementing programs related to water sector. Source: Refer to Fig 22,23 and 24 of Inception report for further details
		Primary: • The national level stakeholder mentioned that the GoI is striving to achieve greater convergence among schemes. Creation of new small storage structures and water bodies in convergence with MGNREGA is being attempted • Greater convergence is being attempted between Jal Jeevan Mission and Atal Bhujal Yojana • Greater convergence is being attempted with MNRE for solar interventions in the sector • The NWM is trying to promote and implement "Catch the Rain" initiative (decentralised rainwater harvesting structures) in convergence with MGNREGA • In Punjab, Uttar Pradesh and Andhra Pradesh, convergence is being tried with MGNREGA **Case Study- NMCG Convergence** The National Mission for Clean Ganga (NMCG), is trying to converge various available fund sources to

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		achieve its objective of clean Ganga. Some key initiatives are: 1) Programme for promotion of afforestation in convergence with MoEF&CC (with CAMPA funds) to attend to the issue related to agricultural runoff and pollution 2) Program for Organic farming all along ganga river in convergence with Ministry of Agriculture and Farmer Welfare. Under the initiative, there are plans to undertake organic riverbed farming in 5-7 km belt along the river Ganga. Source: KII with stakeholder
		Inference: • There is increasing focus on convergence both at National and state levels. Creation of new small storage structures and water bodies in convergence with MGNREGA is being attempted. Other areas are use of solar power and agriculture, which are also being tried.
Gaps in broad sectoral outcomes	Staffing levels	Secondary: • Present staffing levels are ten times that of international norms, and most public funds are now spent feeding the administrative machinery, not maintaining the stock of infrastructure or providing services. Source: India's Water Economy: Bracing for a Turbulent Future – WBG

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Primary: • In Bihar, there was no regular recruitment after 1994. So the WRD department is under staffed • In Karnataka, the stakeholder mentioned that in terms of permanent staff, the authority was under staffed • In Manipur, the stakeholder informed that staff numbers at lower levels were less • A national level stakeholder shared that CWC and its regional offices are understaffed • Another national level stakeholder mentioned that state groundwater departments are understaffed and have a very skeletal structure. AP state GWD stakeholder confirmed the same. • HP stakeholder shared that field staff were less in number. **Case Study- Telangana agriculture staffing** The Department of Agriculture, Government of Telangana had envisaged to increase the staff strength in its department including extension and district offices. Therefore, from 2017 onwards, for every 5,000 farmers, one agricultural extension officer was recruited. For instance, the state has 77 agricultural extension officers working in one district (Narayanpet) and around 1,800-2,000 farmers come under each officer's jurisdiction. Earlier one officer used to cater to around 40,000 farmers. Due to fresh recruitments, that gap

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		has been reduced and the farmers are benefiting as the department is able to provide better service. Source: KII with stakeholder
		Inference: • Most states mentioned that they are under-staffed during the primary survey. This is in contrary to the findings from the secondary research.
Gaps in broad sectoral outcomes	Financing in the sector	Secondary: • Staffing levels are ten times international norms, and most public funds are now spent feeding the administrative machinery, not maintaining the stock of infrastructure or providing services. On the "supply side" there are ultimately only two sources of financing – tax revenues and user charges • Poor management and maintenance of water supply projects leading the system to be termed to have the implicit philosophy of Build-Neglect-Rebuild Source: India's Water Economy: Bracing for a Turbulent Future – WBG
		Primary: • The National level stakeholder informed that due to no revenue collection and low payment by WUAs, PPPs in the sector has not been possible

		Case Study- PPP- Guerdane Irrigation Project, Morocco To confront the growing environmental damage and help farmers achieve sustainable growth, IFC assisted Moroccan officials in 2004 to design the world's first irrigation public-private partnership (PPP). IFC structured a project introducing drip irrigation that brought nearly $40 million in private investment into the region and created hundreds of local jobs. Key features of the project are mentioned below: • Design-Build-Operate based on a 30-year concession contract • Government subsidy provided in form of 25% initial investment and soft loans to the tune of $25 million (total estimated cost was $105 million); balance was borne by the private contractor • To minimize revenue risks, users needed to pay an upfront subscription fees plus a variable component; revenue deficit due to water shortages (the project being in a drought prone area) to be shared between the parties with private concessionaire's loss capped to 15% while users need to partly bear the loss through increase in water charges • Concessionaire agreement was signed in 2006 and the project achieved a 100 percent connection rate by 2009

		Source: Public-Private Partnership Impact Stories- Morocco: Guerdane Irrigation- IFC • Independent Expert shared that for dams revenue generation from tourism is a possibility • In Bihar, Revenue collection has not been adequate due to less manpower and farmers often don't come to the office to pay since it is far away and they will incur costs. • In Bihar, under Participatory Irrigation Management (PIM); the department is handing over certain canals to the empanelled agencies after construction for O&M only. They are mandated to collect the required revenue. 30% of the fees is to be shared with Govt and the remaining 70% is to be used for O&M. However, collection has been inadequate and the contractor has defaulted in payments • In Karnataka, urban water supply related schemes have received capex funding from various Central government and state government schemes like AMRUT. The O&M funds are however to be met only from tariff which has been inadequate. Therefore, currently electricity bills are directly paid by the Government after deducting from Finance Commission grants • In AP, rural water supply schemes are receiving capex funds primarily from the State Government and select IFIs (in addition to JJM where Central funding is being provided to provide HH connections to all rural HHs across all states). For O&M GP/ZP funds (Finance Commission grants) are utilised

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In case of NMCG- CSR funding and Clean Ganga Fund are being used in addition to Central Govt fund. • In Manipur, WUAs have been formed, however collection remains poor. There is lack of O&M funds
		Inference: • Funds for O&M of assets created both in Irrigation and Drinking water have been an issue • Poor collection is an issue • PPPs in irrigation has not been attempted in a significant way
Gaps in broad sectoral outcomes	Project Management issues and slow project execution	Secondary: • Project Management issues and Slow project execution are teething issues Source: Report of the working group, MoWR • Currently majority of the irrigation projects in the country face issues related to time and cost overruns. The major and medium irrigation projects in India suffered from cost overrun to the extent of Rs. 1.20 Lakh Cr. In addition, approximately 105 projects faced time overrun issues with the duration of time overrun ranging up to 18 years Source: Report of the Comptroller and Auditor General of India on AIBP, 2018
		Primary: • Karnataka and HP stakeholders mentioned that projects are delayed mainly due to government

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		approval and land acquisition issues. The independent expert supported these reasons • In HP natural calamities and long winter seasons also lead to delays • In Odisha, implementation delays occur partly on account of inadequate quality of DPR and initial cost estimates • Manipur stakeholder informed that land acquisition, rehabilitation and environment clearance issues delay projects
		Inference: • Land acquisition and rehabilitation leads to delay in water sector related projects
Gaps in broad sectoral outcomes	Enforceable water entitlements	Secondary: • Lack of stringent governance on water use inefficiency, unregulated groundwater extraction, negligence of traditional and low-cost water bodies. Inadequate legal and financial checks to ensure groundwater resources are developed only in safe and semi-critical areas Source: Water Resources Development in India: Critical Issues and Strategic Options
		Primary: • In Karnataka and Himachal Pradesh, State GW authorities have regulations to monitor and control withdrawal of GW. • However enforcement has not been very good primarily due to capacity issues

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• In Maharashtra, user wise Water entitlements, have been decided by MWRRA. However, MWRRA does not have adequate staff to make sure enforcement is done. They are planning to have enforcement commissioners in the future to attend to this. **Case Study- Water entitlement and trading in Murray Darling Basin, Australia** The Murray–Darling Basin Authority operates the River Murray on behalf of New South Wales, Victoria and South Australia. Under the Murray–Darling Basin Agreement, the Murray–Darling Basin Authority determines the amount of water available to each state each year. The various state governments work with the Authority to provide an allocation of water to their entitlement holders. To access water in the River Murray, an entitlement holder places a water order directly with their state water agency. Water in the Murray–Darling Basin can be bought and sold. This water is traded on markets – within catchments, between catchments (where possible) or along river systems. This form of trading allows water users to buy and sell water in response to their individual needs (mainly surface water and some groundwater). Water trading (from the entitlement) helps Murray–Darling Basin farmers to make more productive use of water and contributes to sustainable water

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		management. Water trading in the Basin is worth about $2 billion annually. Source: Website of Murray–Darling Basin Authority
		Inference: • State GW authorities have regulations to monitor and control withdrawal of GW. However, enforcement has not been very good primarily due to capacity issues • MWRRA has allocated water entitlements to the various category of users, however the enforcement of the same requires improvement.
Sustainability	Urban Water Consumption	Secondary: • The urban population consumption is at 195 litres per person per day (global average of 135 litres) Source: Water for the Future- Challenges for India and its industries, 2012, Frost & Sullivan
		Primary: • In Karnataka, studies have revealed approximately 110 lpcd water is supplied 24x7 in a specific ULB. The quantity increases by 15% during summers. The NRW losses ranged from 15% to 40% in some of the ULBs. The lpcd calculations were done at the supply end and therefore includes NRW losses • In HP, currently 135 lpcd water is supplied in the urban areas. However, this includes NRW losses. The authority has tried to reduce wastage by billing all public taps. In addition, meters are installed at all consumption points (including bulk water meters). The

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		department gets to know the leakages in the main line due to this. So, leakage detection in the primary grid is being done. However leakage detection in distribution network is yet to be undertaken • In Rajasthan urban water supply goes up to 275 lpcd • In Odisha, urban water supply is around 275 lpcd and includes high NRW losses
		Inference: • High NRW losses inflate the per capita consumption by urban water users. Consumer-end metering would indicate actual consumption.
Sustainability	O&M and lack of financing- rural water supply	Secondary: • Estimated NRW is between 40-70% of the water distributed. About 82% of rural households in India do not have individual piped water supply; however physical rural water coverage is estimated to be 81%. Government of India has recently launched Jal Jeevan Mission (JJM) which targets to provide piped water supply connections to 100% of the households by 2024 Source: Urban Water Supply and Sanitation, The World Bank
		Primary: • In AP, O&M of rural water supply schemes are primarily done using Finance commission funds (received by GPs/ZPs). Improvement in metering and tariff collection can further augment the existing O&M funding sources

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Currently in AP, metering is being done only in a few pilot projects • For O&M financing- NABARD and in some cases CSR funds are being utilised. In most cases GP/ZP funds (Finance Commission) funds are being used **Case Study- Efficient rural water supply O&M in Maharashtra** Maharashtra Water Supply and Sewerage Board (MWSSB) was established as per MWSSB Act 1976 for rapid development and proper regularization of water supply and sewerage services in the state. MWSSB was subsequently named as Maharashtra Jeevan Pradhikaran (MJP) in 1997. The authority is responsible for implementing the rural water supply schemes and undertakes O&M of multiple rural water schemes. It hands over some rural water schemes to GPs but many schemes are being managed by them. The authority also collects tariff from the users in case it undertakes the O&M itself. In case O&M is undertaken by the GP/ZP, they collect the appropriate tariff charge from the GP/ZP, who in turn recovers it from the consumers. Source: MJP website and KII with stakeholder
		Inference: • The JJM will aim to provide household connection to all rural households by 2024

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Sustainable O&M of RWS schemes is currently a major issue
Overall nature and responsiveness of Water sector planning	Groundwater Level Monitoring	Secondary: • Currently, CGWB monitors groundwater levels four times a year through a network of 23,125 observation wells as on 31.03.2017, which are spread throughout the country. Moreover, the CGWB undertakes detailed groundwater assessment studies across 6,881 assessment units (Blocks/Mandals/Talukas/Firkas) in the country (2017) Source: Dynamic Ground Water Resources of India, 2017 (Published on July 2019), Central Ground Water Board, Ministry of Water Resources and Reassessment of water availability in basins using space inputs, Central Water Commission, June 2019
		Primary: • As per data received from CGWB, as on March 2020, CGWB has a total of 22,730 monitoring wells throughout India which includes 16,375 Dug Wells and 6,355 Piezometers for monitoring GWL. The national level stakeholder mentioned that in addition to the above, approx. 50,000+ monitoring wells have been installed by various state level monitoring agencies. The density of monitoring wells may be further improved. However, it depends upon the aim of monitoring

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Both the states of Himachal Pradesh and Karnataka have suggested that number of monitoring points need to be increased • Automatic GWL recorders based on telemetry are required • In hilly areas, separate study needs to be done to determine the adequate number of piezometers • In Punjab, both manual and automatic monitoring systems for recording GWL are in place. Participatory monitoring is also undertaken. NHP is further strengthening the monitoring ecosystem **Case Study- National Hydrology project for innovative GWL monitoring** In order to strengthen the monitoring program, under National Hydrology Project (a World Bank aided project), all the State agencies and central agency (CGWB) are installing DWLRs (Automatic Digital Water Level Recorder) and data is being acquired through telemetry. In CGWB, bids have already been floated for 3,400 DWLRs with telemetry for acquiring data through telemetry two times a day (0600 Hrs & 1800 Hrs) and bids for 60 DWLRs with water quality probes are to be floated. Similarly, in other States, the bidding processes are in various stages and in total about

Key Evaluation sectoral objective	Area of enquiry	Findings from the research

		6,000 DWLRs are proposed to be procured by various States under NHP.
		
		The water level monitored by DWLRs would be transmitted to various data centers of State and CGWB and thereafter transmitted to Water Resources Information System (WIMS), a common database being maintained by NPMU and thereafter sent to India- Water Resources Information System (India-WRIS) for data dissemination. The manual data collection will continue till the automatic measurement is strengthened with higher requisite numbers to make the monitoring more robust.
		
		Source: CGWB
		
		• In Karnataka- State GWB and CGWB together have monitoring stations. However, based on analysis, additional 50 stations are required
		• In Karnataka technology used for GWL monitoring are
		  ○ Manual monitoring by officials
		  ○ Participatory monitoring involving SHGs and volunteers who have been trained to monitor-GP etc- based on nominal payment; the same is being recorded locally and shared by phone, postcard etc. Numbers are being ramped up
		  ○ Automatic recording using telemetry- there are a few, more is being procured; given the higher cost, there is a need to optimize.

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		Inference: • The number of GWL monitoring wells need to be increased based on the terrain and specific requirements • Automatic GWL recorders may be installed and optimised
Overall nature and responsiveness of Water sector planning	Conjunctive use of surface and groundwater	Secondary: • Conjunctive use of surface and groundwater consists of harmoniously combining the use of both sources of water in order to minimize the undesirable physical, environmental and economic effects of each solution and to optimize the water demand/supply balance. Usually conjunctive use of surface and groundwater is considered within a river basin management programme Source: FAO
		Primary: • National level stakeholder suggested that conjunctive use of SW and GW is happening. However due to different implementing agencies, unification for better planning is required • In Punjab, conjunctive use of SW and GW is undertaken in areas where there is the issue of soil salinity
		Inference:

Key Evaluation sectoral objective	Area of enquiry	Findings from the research
		• Conjunctive use of SW and GW may be strengthened, better coordination between agencies and unification for better planning is required
Overall nature and responsiveness of Water sector planning	Water for environmental needs	Secondary: • Environmental water requirement was 5 BCM is 2010 and estimated to increase to 10 BCM in 2025 and 20 BCM in 2050 Source: NCIWRD estimates
		Primary: • No additional insights on this enquiry area
		Inference: • There is need to provide for environmental water requirement

1.3.2 Benchmarking of Broad Sectoral Outcomes

This section has been used to benchmark the broad sectoral outcomes with focus on Irrigation sub-sector. Key observations from each benchmarking exercise have also been summarized.

Water storage capacity

Total water storage capacity of all dams in the country is an important indicator as stored water serves as a buffer stock for water during scarcity periods. Stored water takes care of seasonal, geographical and annual variation in availability of water resources in the country since unavailability of adequate storage of substantial quantity of water, especially during monsoon season, remains unused and flows into sea. As illustrated in the figure below[23], India's total dam storage capacity of 253 BCM is considerably less when compared to other countries. Further per capita water storage is also low in India. This makes it possible to store small quantity of water from the seasonal rainfall.[59]

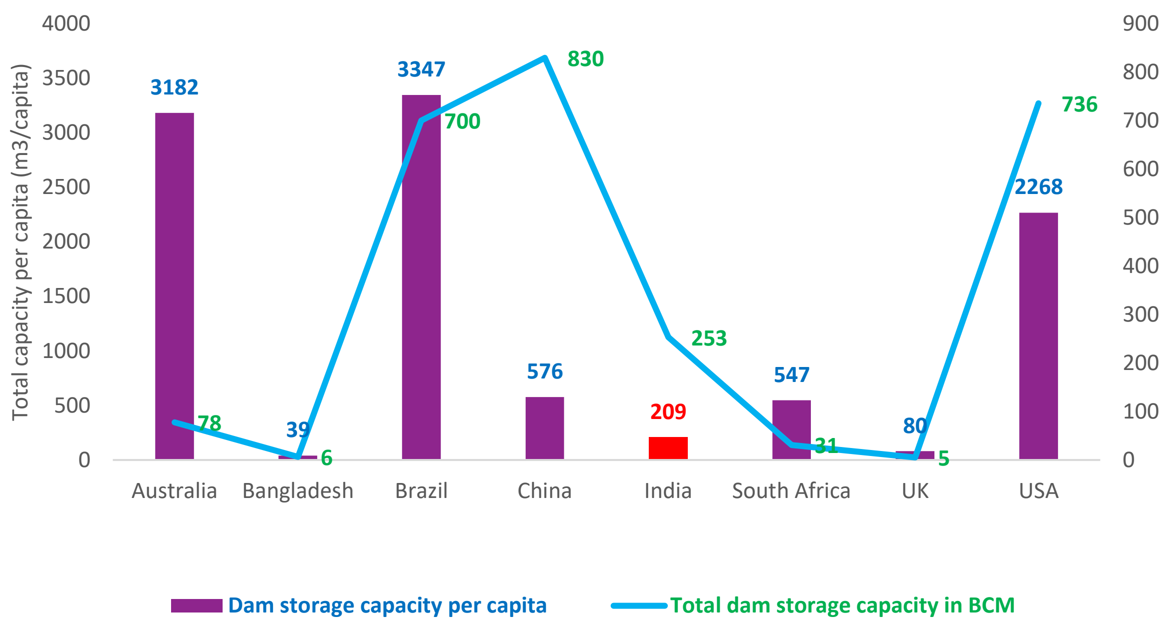


Figure 18: Water storage capacity comparison

Water resource utilization

Comparison of India with other major countries in the world in terms of the total water withdrawal per capita and GDP per capita (in current USD per capita) is provided in the figure below. It is evident from the figure below, that India is among the low performing countries when it comes to efficient water resource utilisation per unit GDP. For example, while USA's GDP per capita is approximately 35 times that of India's, its annual water withdrawal per capita is approximately only two times that of India. In fact, countries such as UK, Australia, and China have GDP per capita higher than that of India but similar or lower capita water withdrawal[60]. India therefore has made its economic activities highly water intensive.

[59] Press Release from MoWR, 2012
[60] AQUASTAT database of the Food and Agricultural Organisation of the United Nations

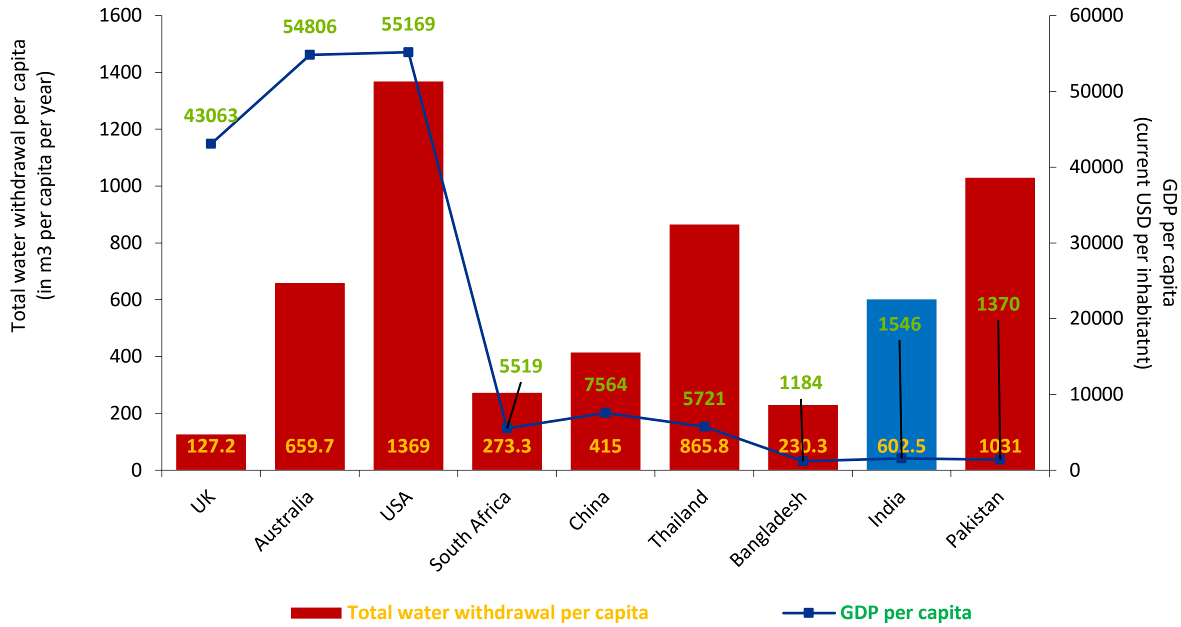


Figure 19: Country comparison on total water withdrawal per capita

Demand supply gap

Various estimates related to the demand supply gap of water resources in India in the future are available. The absolute numbers vary based on the models considered during water demand or supply estimation. However, the increasing gap between demand and supply of water is an established fact, not only for India but also for other countries. The figure below compares the demand supply gap for four countries. The model calculated the gap between projected 2030 demand and existing supply based on commonly accepted projections of economic and population growth. As estimated by the author, India may be facing an aggregate gap of 50% of the actual demand by 2030, mainly driven by rapid growth in agricultural, municipal & domestic sector demand. India faces a large gap between current supply and projected. Climate change effects can further worsen the situation for India. The gap as projected by the author, shows that India should face the worst scarcity in terms of percentage of demand when compared to the other countries[22].

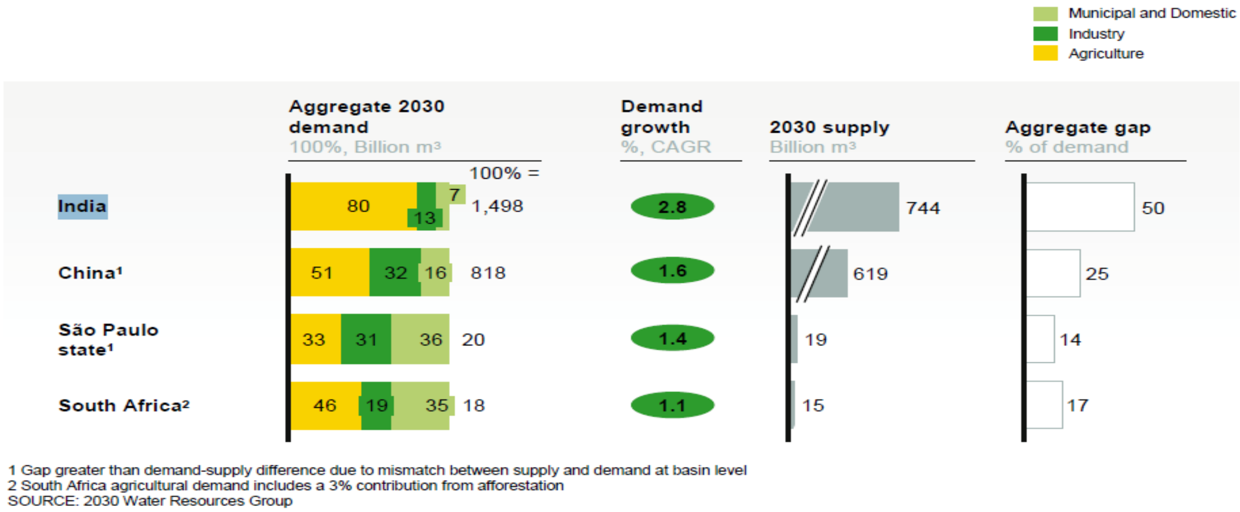


Figure 20: Demand supply gap of water resources

Agriculture sector contribution to GDP

The World Resources Institute has modelled water stress for various countries and assigned water stress scores (out of 5) to all the countries[61]. India is one of the most stressed country in terms of water availability with 18% of the GDP from agriculture and 52% of the country area under cultivation[23]. With increase in area under cultivation or value of produce or cropping intensity, India can further increase contribution to GDP from the sector. However, to avoid facing severe scarcity in the future; India must focus on water use efficiency in irrigation sector.

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[61] World Resources Institute (AQUEDUCT) database

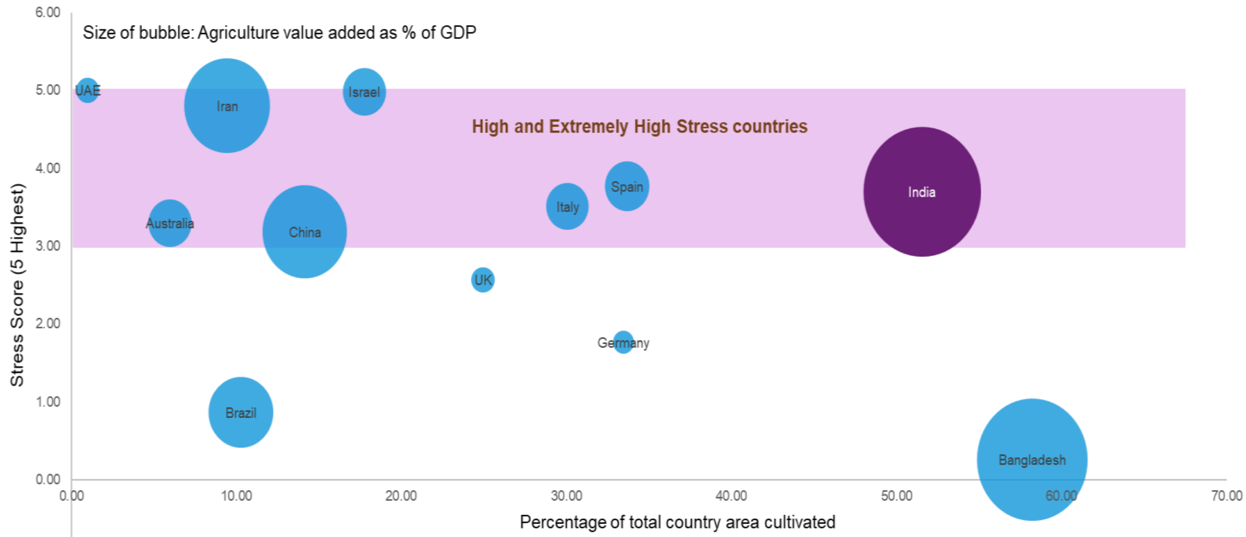

Figure 21: Agriculture sector contribution to GDP

Agriculture sector Water Use Efficiency

As per Food and Agricultural Organisation of the United Nations, the total water consumption in the agricultural sector is defined as the "*Annual quantity of self-supplied water withdrawn for irrigation, livestock and aquaculture purposes. It can include water from primary renewable and secondary freshwater resources, as well as water from over-abstraction of renewable groundwater or withdrawal from fossil groundwater, direct use of agricultural drainage water, direct use of (treated) wastewater, and desalinated water*". The total cultivated land is defined as the "*The sum of the arable land area and the area under permanent crop*". The ratio of water consumption and area cultivated is an important metrics as it signifies the water use efficiency in the agricultural sector. As evident in the figure below, India is one of the highest water consuming countries[23].

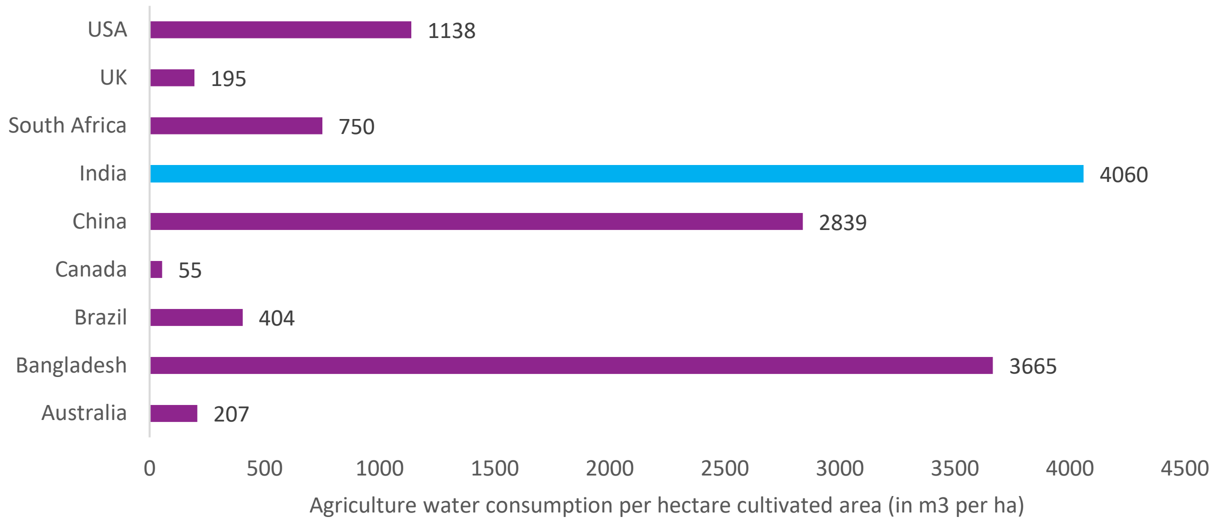

Figure 22: Comparison of water use efficiency in the agriculture sector

1.3.3 Water Security Assessment

The rapid growth and urbanization of India is unique as well as dynamic. It is currently holding the centre stage with respect to economic and population growth. However, with this growth comes increasing demands of natural resources consumption including water. This places finite water resources into an even more perilous situation. The most daunting challenge will be to increase food production in the next two decades for the growing population, while also providing water for users and at the same time meeting industrial and energy demands. The impacts of climate change as well as increasing climate variability and water-related disasters also culminate in a more challenging horizon than we have experienced in the past.

The Asian Water Development Outlook (AWDO) provides a framework along with suitable indicators to understand the current water security in a country by sub-dividing it into Household, Economic, Urban and Environmental water security. It thus captures the issues related to overall demand and supply sides of the water cycle through this assessment.

Many definitions of water security exist and most have a certain sector bias. The following definitions are the most comprehensive and most referenced as per the AWDO study:

> “The reliable availability of an acceptable quantity and quality of water for production, livelihoods and health, coupled with an acceptable level of risk to society of unpredictable water-related impacts.”

> “The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic
>
> development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.”

As per the AWDO 2013 study, the following shared vision of water security was formulated:

> Societies can enjoy water security when they successfully manage their water resources and services to
>
> - *satisfy household water and sanitation needs in all communities;*
> - *support productive economies in agriculture, industry, and energy;*
> - *develop vibrant, liveable cities and towns;*
> - *restore healthy rivers and ecosystems*

From this shared vision different dimensions under the Household, Economic, Urban and Environmental water security have been examined with respect to their current status, issues and government interventions.

1.3.3.1 Household Water Security

The foundation of water security happens at the household level. Providing the entire population with reliable, safe water, and sanitation services should be the top priority of any country. From the perspective of poverty eradication and economic development, household water security is an essential foundation.

Accordingly, the key indicators of Household Water Security are:

- Access to piped water
- Access to improved sanitation

On both these fronts, India has been making progress, however with varying degree of outcomes and successes. Let us look at the current situation in the country and upcoming government initiatives.

Table 16: Summary of current status, issues and current government initiatives- Household

Current Status	Key issues	Current government initiatives
▪ In rural India only 18% of households are provided with piped water supply connections[62]	▪ In rural areas issues are manifold; few key issues include: ○ Limited co-ordination between the water resources department and the rural drinking water supply department during planning of water supply schemes ○ Lack of capacity of Panchayati Raj Institutions for management for asset ownership and long-term maintenance ○ Lack of innovative financing structures attracting private sector involvement in development and long-term O&M of the assets	▪ National Rural Development Programme was focused towards providing piped water supply connections to rural households. This programme is likely to be subsumed by Jal Jeevan Mission which targets to provide piped water supply connections to 100% of the households by 2024
▪ 100% of households had access to toilets[63] ▪ 96.5% of the people with access to toilets used them	▪ Possible slip backs due to lack of maintenance or falling back to old habits ▪ Ensuring availability of water in rural areas is critical in sustaining the usage of toilets	Swachh Bharat's future focus areas include ▪ Sustained usage of Individual Household Latrines (IHHL) ▪ Sanitation coverage of public spaces (through

[62] National Rural Drinking Water Programme database accessed on 7 November 2019

[63] Swachh Bharat Mission-Gramin Dashboard, Department of Drinking Water and Sanitation, Ministry of Jal Shakti, Government of India, accessed October 11, 2019, https://sbm.gov.in/sbmdashboard/IHHL.aspx

Current Status	Key issues	Current government initiatives
▪ 90.7% of villages which were previously declared and verified as ODF were confirmed to be ODF. The remaining villages had sanitation coverage of about 93% ▪ 97.5% households did not report to have visible garbage or litter within the premises	▪ Solid and Liquid Waste Management – The scheme's focus on emptying and transportation, and treatment and disposal, and SLWM was relatively limited. ○ 63.3% of villages in India practice Solid & Liquid Waste Management (SLWM) which was far below the figures for ODF outcomes.	public and community toilets) ▪ Enhanced focus on Solid and Liquid waste management (SLWM)

1.3.3.2 Economic Water Security

Water can be treated as one of main fuel which powers any economy. The use of water in all sectors like Agriculture, Industry and Domestic is critical in enabling value addition to our GDP.

The use of water in these sectors should no longer be seen in isolation from each other. Debate about the water–food–energy nexus has begun to raise general awareness about the critical interface among water uses to support the various economic activities.

Accordingly, the key indicators of Economic Water Security are:

- Agricultural Water Productivity
- Energy and Industrial Water Productivity

Table 17: Summary of status, issues and current government initiatives- Economic

Current Status	Key issues	Current government initiatives
▪ Water productivity of main water guzzling crops like rice, wheat & sugarcane.[64] ○ Rice- Irrigation Water Productivity- 0.22-0.48 kg/m3 ○ Wheat- Irrigation Water Productivity- 0.84 kg/m3 ○ Sugarcane- Irrigation Water Productivity- 4.38 kg/m3	▪ Rice, wheat and sugarcane consume almost 80% of freshwater available for irrigation leading to inequity in irrigation water availability for other crops ▪ In addition to this inequity, it is worth noting that these water guzzler crops are concentrated in some of the most water scarce regions of the country like Punjab and Haryana which is leading to massive depletion of groundwater in these states ○ The irrigation water productivity of rice, wheat and sugarcane with their corresponding land productivity across major states, are nonaligned with respect to cropping patterns and available water resource	▪ With schemes like "Per Drop More Crop", and related policies the government is looking towards ○ Shifting towards production of less water guzzling crops like pulses, oil seeds ○ Improving water use efficiency through encouraging micro-irrigation, sprinklers, drip irrigation ○ Increasing usage of solar power in irrigation

[64] NABARD- WATER PRODUCTIVITY MAPPIN of MAJOR INDIAN CROPS Bharat R. Sharma, Ashok Gulati, Gayathri Mohan, Stuti Manchanda, Indro Ray, and Upali Amarasinghe

Current Status	Key issues	Current government initiatives
▪ Current specific water consumption in power sector is 5-7 m^3/MWh as per NITI Aayog estimates[65]	▪ More than 80% of the water consumption in industries is on account of thermal power plants ▪ Thermal Power Plant are failing to adhere to the regulations of the limits of water consumption as set by the Ministry of Environment, Forest & Climate Change (MoEF&CC) ○ There is less focus on reducing water footprint since water costs constitute a miniscule portion of the overall variable costs of a thermal power plant	▪ MoEF&CC has regulated the water consumption limit of thermal power plant to be 3.5 m3/MWh- However despite this regulation, multiple power plants are failing to adhere to these norms ▪ The government has mandated the power plants which are within 50 Kms radius of a Sewage Treatment Plant (STP) to use treated wastewater from those STPs ▪ Current focus on increasing the share of renewable energy deployment will reduce dependencies on Thermal Power Plants and in turn lead to water savings
Apart from Power, two most water consuming industries are Iron & Steel and Textiles. The specific water consumption figures are:	▪ Lack of effective regulations and coordination between regulatory bodies of centre and states ▪ Lack of incentives provided to industry for efficient water use	▪ Ministry of Environment Forest &Climate Change (MOEF&CC) has set a regulation for Zero Liquid Discharge (ZLD) four industrial sectors (textile

[65] Study on Assessment of Water Foot Prints of India's Long-Term Energy Scenarios by TERI sponsored by Niti Aayog

Current Status	Key issues	Current government initiatives
▪ Ratio of water to textile production is 200-250 m^3 of water per tonne cotton cloth ▪ 3.5 m^3/tonne for Iron & Steel	▪ Low water tariffs even for industrial consumption	(wet processing), distilleries, pulp and paper and tanneries) ▪ Multiple states like Gujarat, Chhattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Haryana, Punjab and Rajasthan have come up with policies which mandates industries within a certain range of a STP to use treated wastewater to reduce the burden on freshwater sources

India's water productivity in all major segments of the economy (agriculture, industry and domestic) is poor. This is primarily on the account of the lack of appreciation towards the value of water.

It needs to be deliberated on how an adequate price should be attached to water for it to get the value it deserves. Also, it needs to be debated on how to make the economic value of water appreciated by all segments of consumers. Water costs although constitute a minor item in O&M for industries, a water scarce situation can lead to a complete shutdown.

1.3.3.3 Urban Water Security

In India, over the next few decades increasing population will start to migrate to cities as it slowly transforms from its agrarian rural societies to urban centres. Many cities will become important drivers of the economy soon in years to come.

The urban water security indicators measure the creation of better water management and services to support vibrant and liveable water-sensitive cities.

Accordingly, the key indicators of Urban Water Security are:

- Access to water supply
- Non-revenue water
- Water consumption per capita
- Percentage of wastewater treatment
- Percentage of sewerage network facilities

Table 18: Summary of status, issues and current government initiatives- Urban

Current Status	Key issues	Current government initiatives
▪ 54% of urban households have access to tap water within households[66] ▪ Municipal water consumption per capita- 125 lpcd[67] ▪ NRW losses in cities ranges between 30-50%[68]	▪ In Urban areas, the urban local bodies suffer from financial distress, lack of capacity, poor cost recovery of existing assets, high Non-Revenue Water (NRW) losses ▪ Inadequate pricing of water in many cities leading financial distress of the utilities as well as the projects	▪ Ministry of Housing & Urban Affairs (MoHUA) has set targets of minimum water consumption of 135 lpcd, to reduce NRW losses to a level of 20% and provide 100% metering ▪ Programmes like Smart Cities Mission, AMRUT, HRIDAY are focused towards improvement in urban water supply schemes especially focusing on 24 X 7 water supply, reduction of NRW

[66] https://www.wateraidindia.in/sites/g/files/jkxoof336/files/state-of-urban-water-supply.pdf accessed on 7 November 2019
[67] White Paper for 2012 Environment and Energy Conclave by The Bengal Chamber of Commerce and Industry (BCCI) 31st August - 1st September 2012
[68] Water in India-Situation & Prospects by UNICEF

Current Status	Key issues	Current government initiatives
	▪ Lack of adequate metering infrastructure	losses, creation of metering infrastructure ▪ Focus on innovative PPP models
▪ 51% of the domestic wastewater generated remains untreated[69] ▪ 74% of India's urban population is not connected to a sewerage network	▪ Lack of sewerage network makes many of the installed STPs non-operational since there was lack of proper planning during the development stage ▪ Lack of ULB capacity in carrying out O&M of STPs renders failure of the same ▪ Outdated technologies of existing STPs which needs renovation to adhere to the current water quality norms	▪ The government through National River Conservation Plan, National Mission for Clean Ganga programme is trying to: o Delink the sewerage network with the development of STPs through developing Interception & Diversion Structures which will carry the sewage to the STPs o Adopting innovative business models like Hybrid Annuity Model (HAM) through which makes the private sector responsible for O& M of the assets ▪ Programmes such as AMRUT will continue to be focused towards o Development of sewerage network

[69] Composite Water Management Index, NITI Aayog, 2018

Current Status	Key issues	Current government initiatives
		○ Development of Faecal Solid Waste Management in cities currently without sewerage networks ○ Development of decentralized models of STPs

India's urban population is expected to reach 600 million by 2030. This will lead to increase in demand supply gap and will lead city administration to focus on recycle, reuse in addition to improving efficiencies of water supply, reduction of losses and attaching a deserved value to water.

1.3.3.4 Environmental Water Security

With its economic growth as priority, often environment and precious natural resources take a back seat. However, India being at the cusp of its economic growth is focused on sustainable development and inclusive growth. The water cycle is such that it ends up in the rivers after usage on all fronts of the economy. Hence without proper treatment prior to its disposal it can impact the river health which is again a source of our water consumption.

Accordingly, the key indicator of Environmental Water Security is:

- River Pollution
- Surface Water Quality

Table 19: Summary of current status, issues and current government initiatives- Environmental

Current Status	Key issues	Current government initiatives
▪ 317 polluted river stretches on 293 rivers and tributaries have been identified by CPCB	▪ Outdated technologies of existing STPs which needs renovation to adhere to the current water quality norms	▪ Government is following river basin approach in developing the current infrastructure through programmes such as

Current Status	Key issues	Current government initiatives
▪ About 70% of surface water resource in India are polluted. ▪ According to WHO Water quality data from CPCB shows that organic and bacterial contamination are becoming increasingly critical in water bodies leading to gradual degradation of water quality. Biological Oxygen Demand (BOD) for most of the rivers of India are increasing and exceeding the standards	▪ Dumping of Industrial pollutants in addition to inadequately treated sewage leading to increase in river pollution ▪ Lack of online monitoring system in the industrial units leading to violations of regulations by the industries ▪ Inadequate capacities of Effluent Treatment Plants (ETPs)	National Mission for Clean Ganga with a focus to clean the river and maintain the flow ▪ Recent NGT guidelines recommends stringer water quality parameters for disposal into the surface water sources ▪ Other rives like Godavari, Cauvery is considering following the same approach as that of NMCG ▪ Directions issued for ZLD in respect of distillery units and specific plan is under implementation with respect to Pulp& Paper Sector, Textile Sector and Sugar Sector

It will be important to create an ideation of moving away from the linear water economy to a circular economy that focuses on restoration and regeneration of a natural resource like water. Focus towards this will automatically lead to lowering of environmental pollution and at the same time will lead to creation of additional economic value through the recycling of possible polluting water.

Climate Change and its impact on Water Security issues

Climate Change in the form of global warming leads to changes in temperature and precipitation which has serious impacts on hydrological processes and regional water resources of India. It impacts the supply and demand of water as well as its quality, especially in arid and semi-arid areas.

Rising temperature contributes to glacial melts which results in its retreat and in turn impacts the water availability in Himalayan rivers including the entire Gangetic belt, thus threatening the water supplies on which hundreds of millions of people depend. In the last few decades, nearly 67% of the Himalayan glaciers have retreated due to global warming.

Another profound impact of climate change in the increase in the frequency of heavy precipitation events. Increase in precipitation intensity within a short period leads to increasing flood events per year over the last decade. It is predicted extreme rainfall events are very likely in three major river basins viz. Krishna, Godavari and Ganga by 2100 with dry season becoming drier and wet wetter. Over the last five decades there has been increasing events of natural disasters in the country which is testimony to the fact that climate change is a reality and it can have profound impact to our country's economy.

India[70] has faced 649 disasters in last 100 years out of which 302 were caused by flood with an average of 3 floods per year. This accounted approximately 47% of total disasters took place in India in last 100 years. The average annual flood damage during the period 1996-2005 was Rs. 4,745 Cr. as compared to Rs. 1,805 Cr., the corresponding average for the previous 53 years which shows the trend of increasing events of floods in the recent years.

As per the assessments carried out by *INCCA: Indian Network For Climate Change Assessment in 2010*[71]*,* which deliberated on the possible impacts of climate on Indian Water Resources in 2030, the following were the key observations:

- Due to increase in precipitation, the water yield in the Himalayan region, mainly covered by river Indus, is likely to increase by 5%–20% in most of the areas, with some areas of Jammu and Kashmir and Uttarakhand showing an increase of up to 50% with respect to the 1970s

[70] https://www.adriindia.org/adri/india_water_facts
[71] Reference Link

- The Western Ghats region exhibit wide variability in water yield in the 2030s. The northern portion of the Western Ghats shows a decrease in the water yield, ranging from 10%– 50% in the 2030s with respect to the 1970s
- North-Eastern region except for Mizoram, Tripura, Manipur and Assam shows an increase in the evapotranspiration in the 2030s. As a result, a reduction in water yield by up to 20% is projected for Arunachal Pradesh. The increase in the water yield in Assam and Manipur is projected to increase by 40%
- The reduction in water yield in coastal areas of West Bengal & Orissa in the 2030s is as less as 40%. However, in the southern parts of Andhra Pradesh and northern parts of Tamil Nadu, the water yield is projected to rise by 10%–40%
- Moderate to extreme drought severity has been pronounced for the Himalayan region where the increase is more than 20% in many areas despite the overall increase in precipitation.
- Flooding may vary from 10% to over 30% of the existing magnitudes in most of the regions. This will have a very severe implication for existing infrastructures such as dams, bridges, roads, etc., in the areas and will require appropriate adaptation measures to be taken up

Summing up it is quite evident that climate change considerations will need to be a part of mainstream water resources planning in this country. Few possible actions could involve:

- Spatial development of existing models to allow greater precision in climate change predictions.
- Agricultural policy will require more flexible food policies that can anticipate the selection of crops for the planting season.
- Forest policy will need to account for erosion mitigation measures in areas where precipitation is predicted to be high.
- Wastewater treatment and sewerage planning will need to address overflow and capacity issues related to intense precipitation
- Development of water-intensive industries will need to take account of siting issues related to changes in precipitation

1.3.4 Government interventions in the sector

1.3.4.1 Overall nature and responsiveness of water resources planning in the country

The water resources planning has been receiving increased policy attention over the past few years. In this decade the Indian government has been taking several key steps to revitalise water resources planning in the country. The major initiatives related to the water resources are highlighted in the figure below.

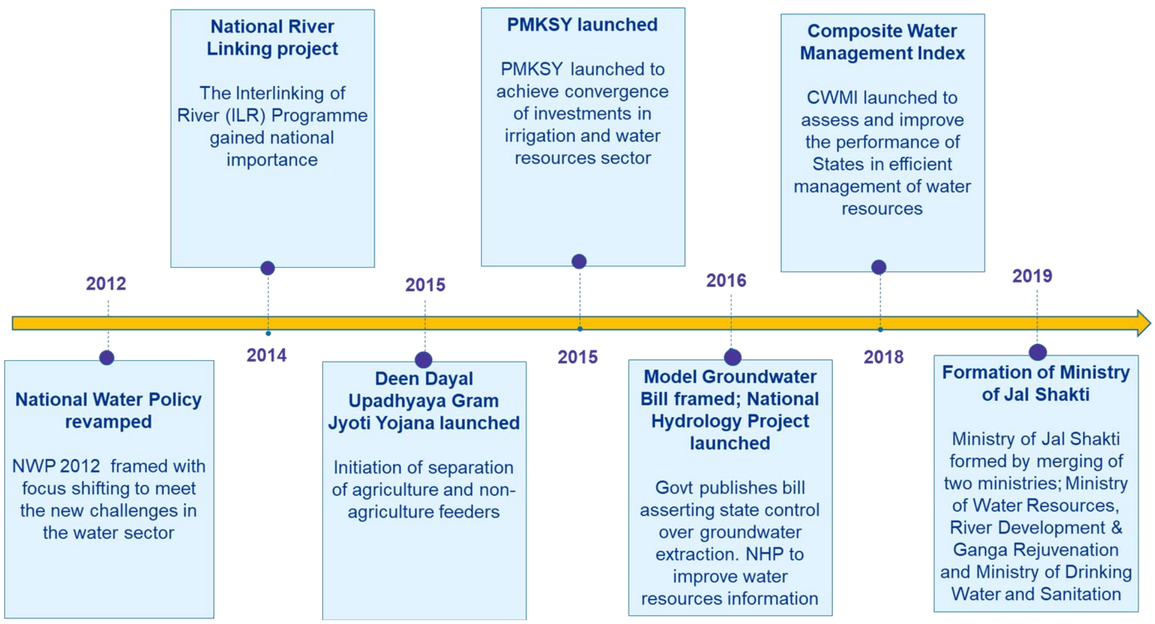

Figure 23: Planning in the water resources sector

In the present scenario, water resources planning is of utmost importance. At institutional level, the major water resources sector related planning in the country is undertaken at both the central government as well as state government level. Since water is a state subject, planning at state level is equally (if not more) important. The key central government departments or organisations and their responsibilities with respect to planning for the water resources sector are mentioned below.

Central Water Commission- The Central Water Commission is a technical organization in the field of Water Resources development and planning in India. It is currently functioning as an attached office of the Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India. Key responsibilities of the commission include initiating, coordinating and furthering in consultation of the State Governments concerned, schemes for control, conservation and utilization of water resources in areas related to Flood Control, Irrigation, Navigation, Drinking Water Supply and Hydro Power Development[72].

Department of Water Resources, River development and Ganga rejuvenation- Earlier a ministry, the Department of Water Resources, River development and Ganga rejuvenation has currently been merged with MoDWS under the Ministry of Jal Shakti. The department is responsible for laying down policy guidelines and programmes for the development and regulation of country's water resources. Its key function is overall planning, policy formulation, coordination and guidance in the water resources sector.[73]

Central Groundwater Board- The Central Groundwater Board is the key nodal agency responsible for groundwater related planning. It is a subordinate office under the Ministry of Jal Shakti responsible for sustainable development and management of groundwater resources of the country. Its key mandate is to develop, monitor and implement national level policies for the scientific and sustainable development as well as management of India's groundwater resources.[74]

In addition to the above-mentioned central government agencies, designated departments at state level are responsible for water resources planning at state level. The water resource planning departments for few select states are mentioned below.

Table 20: State level water resources planning

State Name	Name of Organization	Brief role related to planning of water resources in the state
Andhra Pradesh	Water Resources Department	Hydrological assessment of availability of water in the river basins including water allocation to the Irrigation and other purposes, Planning & design of Irrigation systems
Arunachal Pradesh	Water Resources Department	Nodal Department for Water resources Management. Survey and Investigation of Major Water resources in the State and planning for its utilization

[72] Website of the Central Water Commission
[73] Website of the Ministry of Water Resources, GoI
[74] Website of the Central Groundwater Board

State Name	Name of Organization	Brief role related to planning of water resources in the state
Bihar	Water Resources Department	Creation of irrigation potential and utilization of created potential through construction, maintenance and regulation of major and medium irrigation schemes
Gujarat	Narmada and Water Resources, Water Supply and Kalpsar Department	Effective planning of utilization of available water resources in accordance with state water policy.
Karnataka	Water Resources Department	Harnesses Surface Water for Irrigation and Drinking Water Purposes
Madhya Pradesh	Water Resources Department	Responsible for creation and maintenance of irrigation potential through construction of water resources projects.
Maharashtra	Water Resources Department and Rural Development & Water Conservation Department	Survey, planning & design, construction & management of major, medium and minor projects
Punjab	Water Resources Department	Develop, plan, conserve, utilize and manage both surface and groundwater resource
Rajasthan	Water Resources Department	Construction of major, medium and minor irrigation projects, operations and maintenance of existing tanks, canals and other irrigation structures
Uttar Pradesh	Irrigation & Water Resources Department	Development and construction of dams, canals and wells; ensure adequate irrigation facility; execution of flood prevention works

1.3.4.2 Major central government schemes in the water resources sector

Water resources is a vast sector composed of multiple vital sub-components. The key sub-sectors or sub-components within the larger sector are- Groundwater, Surface Water, Reservoirs, Micro-irrigation Tanks, Water consumption and wastewater. Various central government ministries are responsible for implementation of multiple schemes under each sub-sector or component as listed above. A brief overview of major central government schemes in the water resources sector is shown in the figure below. The list is indicative in nature and not exhaustive.

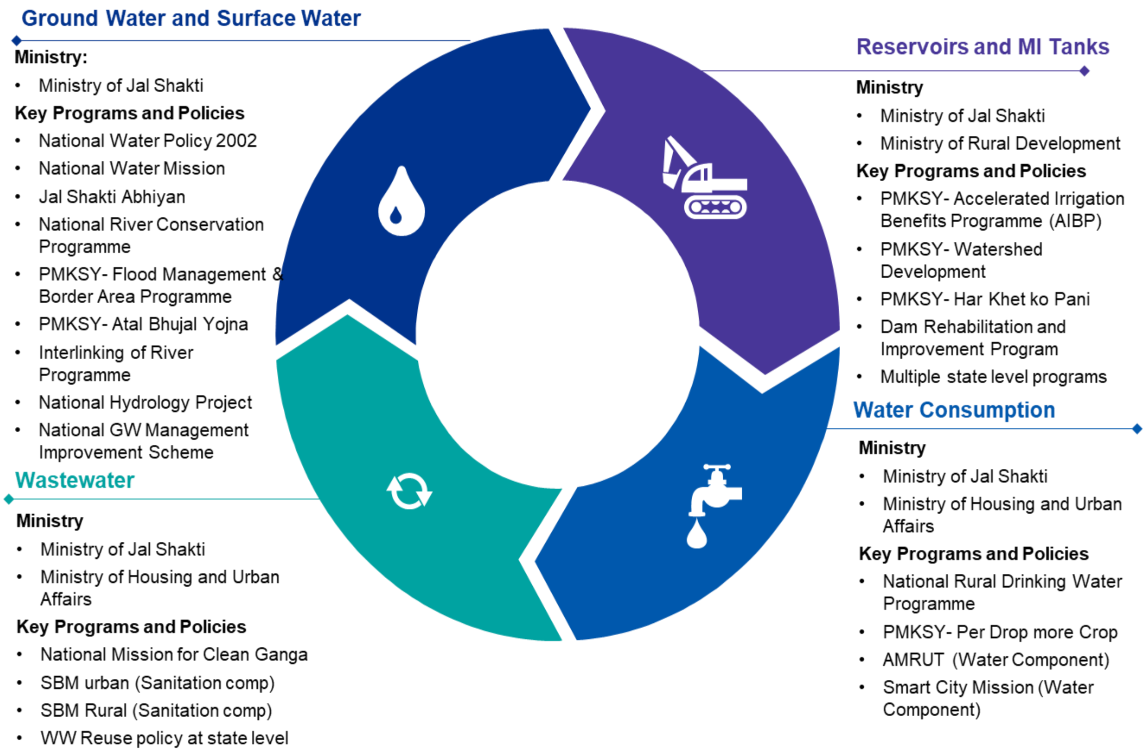

Figure 24: Major government schemes

As shown in the figure above, there are multiple central government ministries related to various sub-components of the water resources sub sector. Ministry of Jal Shakti is the major ministry within the central government and is responsible for laying down policy guidelines and planning as well as implementing programmes for the development and regulation of country's water resources.

1.3.4.3 Externalities and relation to other sectors

The Sustainable Development Goals (SDGs) have been pledged to be implemented by all United Nations Member states in 2015 as a universal call to action to end poverty. The SDGs once implemented should protect the planet and ensure that all people enjoy peace and prosperity by 2030. Total 17 SDGs are integrated and improvement in one area is bound to impact outcomes in others[75]. A deep dive into the multiple SDGs including the sub goals within each SDG is useful in discovering externalities for the water resources sector. Among the 17 SDGs, the 6th SDG pertains to Clean Water and Sanitation and is directly related to water resources sector. However, as explained in the figure below, multiple goals within other SDGs are dependent or related to the water resources sector.

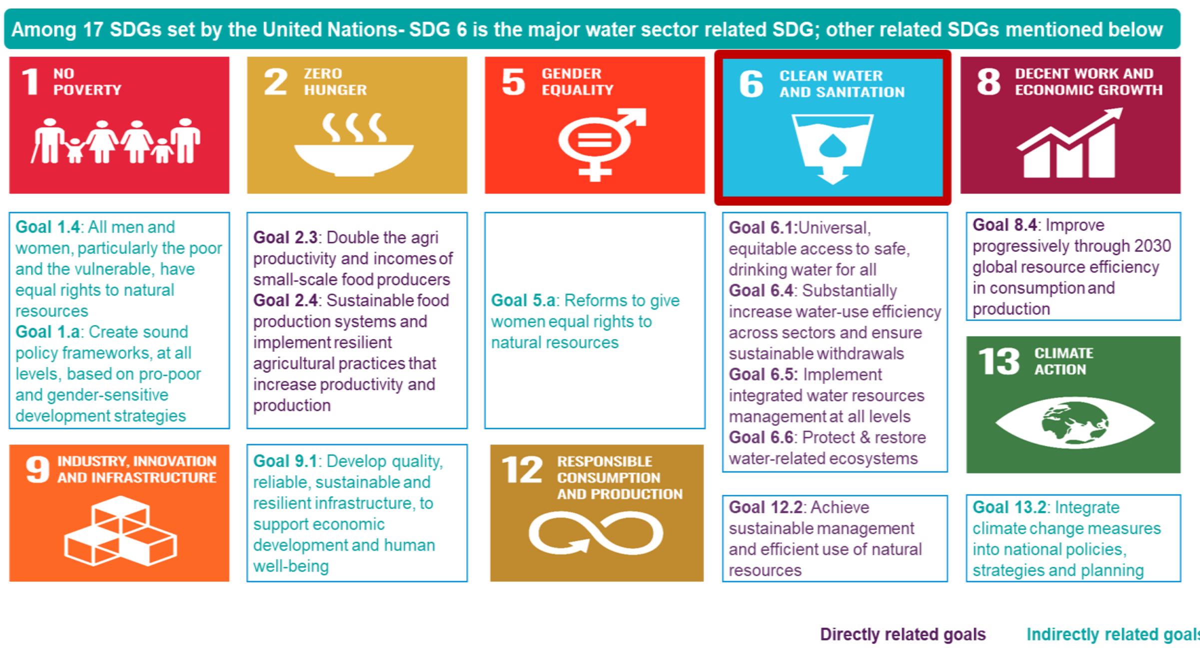

Figure 25: SDGs related to water resources sector

As mentioned in the figure above, directly and indirectly related thematic areas with the water resources sector, makes it an important focus area for development. The related ministries in India implementing programs in the identified related sectors have been further derived in the figure below. Key programs with respect to each ministry which can directly impact the water resources sector are mentioned below.

[75] United Nations Development Programme, Sustainable Development Goals web page

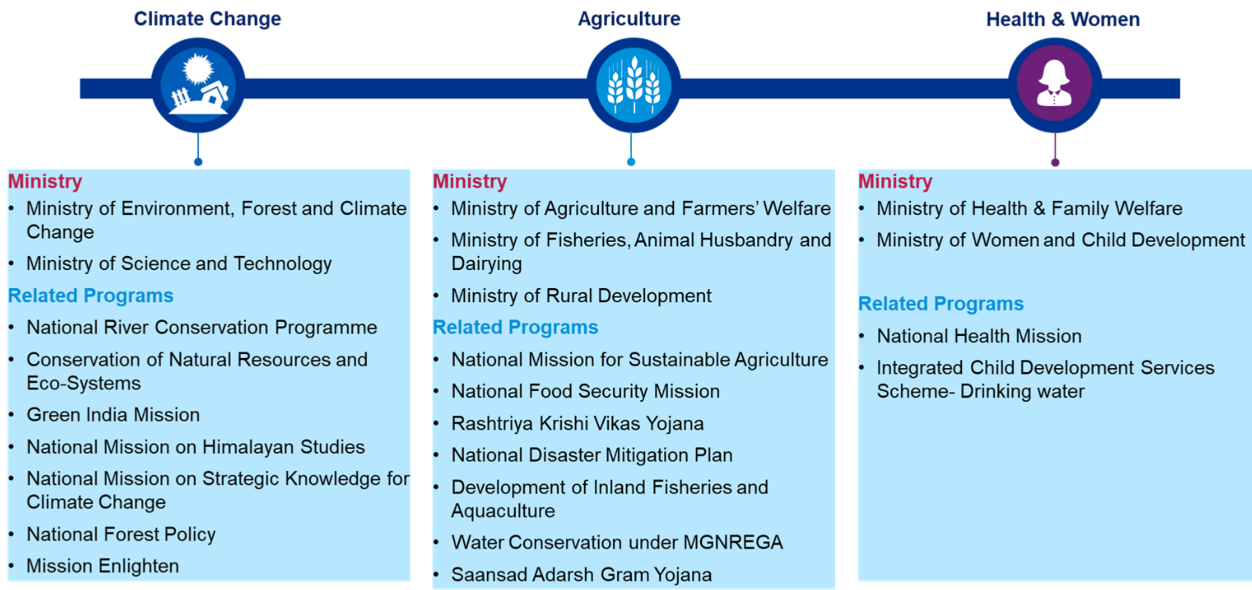

Figure 26: Related ministries and key related programs

The related programs listed above are not only linked with the water resources sector, but also share certain commonalities with the Pradhan Mantri Krishi Sinchayee Yojana.

1.4 Issues and challenges

Table 21: Water resources Sector – issues and challenges

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
Supply Side					
WR-F1	**Water Storage Capacity**	• Low total water storage capacity as well as water storage capacity per capita in dams is one of the key issues. This leads to inadequate buffer stock during periods of droughts, summer months and seasonal, geographical and annual variation as well as high run-off of surface water into sea in the absence of adequate storage			
WR-F2	**Spatial Variance in SW**	• High spatial variance in surface water availability leads to unequal distribution and availability of surface water			

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
WR-F3	**Unregulated extraction of GW**	• Unregulated extraction of groundwater has led to decrease in percentage safe groundwater units over the years			
WR-F4	**GWL monitoring**	• Over dependence on groundwater for various uses has led to over extraction of groundwater. Currently, the Central Groundwater Board (CGWB) monitors groundwater levels four times a year through a network of 22,730 observation wells as on March 2020, which are spread throughout the country. In addition, the states have 50,000+monitoring wells. Moreover, the CGWB undertakes detailed groundwater assessment studies across 6,881 assessment units (Blocks/ Mandals/ Talukas/ Firkas) in the country (2017)[7]. Although the number of observation wells as well as the number of assessment units has increased over years, groundwater level monitoring needs to be further ramped up for a country given the country's size.			
WR-F5	**Micro level information of depleted aquifers**	• There is a lack of micro level information on all depleted aquifers. Currently only broad macro level information is available which is not suitable for making plans for artificial recharging of depleted aquifers. The analysis of data to plan GW recharge initiatives and formulate other actionable recommendations, is lacking			
Demand Side- Irrigation					
WR-F6	**IPC IPU Gap**	• There is a large gap between IPC and IPU leads to low utilization of expensive irrigation assets			

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		(viz. major and medium irrigation projects) and impedes irrigation coverage. There are several reasons for the large gap between IPC and IPU such as non-completion of command area works, high water loss during conveyance through open canal networks, switching to water-intensive cropping pattern on project completion (esp. head end farmers), faulty designs, unlined canals, lack of desilting, poor O&M of distribution channels and ineffective WUAs. Closing the gap can substantially improve irrigation coverage at low incremental cost			
WR-F7	**Irrigation Coverage**	• India's Ultimate Irrigation Potential is estimated at approximately 140 million hectares as evident from Land-use statistics. However, with only 68 Million Hectare of net irrigated area and 97 million hectares of Gross Irrigated Area[76]; there is an urgent need to close this gap and bring more cropped area under assured irrigation as well as increase the cropping intensity and thereby increase agriculture productivity and production			
WR-F8	**Water Demand increase**	• India's population is estimated to be 1.5 billion by 2041[77], one of the largest in the world. Feeding such a large population will require increase in food production and therefore in water demand. With growing affluence, the demand for food is expected to increase by twice the population growth. Even if we assume that specific water consumption for			

[76] Source: Agriculture Statistics at a glance, 2018, Ministry of Agriculture and Family Welfare, GoI
[77] Economic Survey 2018-19, Chapter 7

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		crops in India will decrease in the future, the absolute water quantity will still increase by 2% every year. The challenge will be to meet this demand through existing water resources			
WR-F9	**Irrigation Efficiency**	• Indian irrigation suffers from low water use efficiencies. To increase the irrigation coverage, more irrigation infrastructure will need to be created. But with poor water use efficiency, this new infrastructure will lead to more water losses. The other issue with poor water use efficiency is that farmers at the tail-end of the canal network receive much less (or no water) compared to farmers at the head. This leads to inequity with tail-end farmers forced to cultivate dry crops that are less remunerative than crops grown by farmers upstream			
WR-F10	**Cropping pattern**	• Farmers prefer to cultivate water intensive crops such as paddy even in areas of water stress. Gains from improvements in water use efficiency is lost to increased cropping of water intensive crops. Large scale procurement of rice and wheat for distribution through public distribution system at subsidized rates encourage market for such water intensive crops.			
WR-F11	**GW Irrigation**	• Unregulated and over extraction of groundwater is leading to severe water crisis with groundwater catering to more than 63% of water required for irrigation. Heavy subsidies for agriculture power consumption has encouraged wasteful use of both water and power. Farmers have been encouraged to			

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		extract water from deep aquifers leading to rapid depletion of groundwater			
Demand Side- Industrial					
WR-F12	**Water demand**	• India's population is estimated to be one of the largest in the world 40 years from now. Industrial water demand will also be increasing with the pace of industrial development. Despite evolving water-efficient industrial processes, the challenge would be to meet this demand through existing water resources. Water deficiency in the country can hinder industrial output and other economic activity in the future and lead to subdued economic growth			
WR-F13	**Efficient use and pricing**	• Water is used by many industries as an input, like all other inputs during the process of production. Therefore, the demand for water is directly linked with the demand for the final products. Moreover, the efficiency of water usage in multiple sectors is quite low compared to global standards. On the contrary, the price of water that any industry pays for water consumption also controls the demand for it to a considerable level. Poor water pricing is one of the major reasons for inefficient utilisation of water resources by the industrial sector[78]. Differential pricing between freshwater and treated municipal wastewater for reuse may also be explored on a larger scale to promote use of treated			

[78] Industrial Water Demand in India- IDFC

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		wastewater and reduce demand for freshwater			
WR-F14	**GW policy**	• Usage of groundwater as a source of water resources in the industrial sector may lead to severe water crisis in the future. Unabated extraction of groundwater may lead to inefficient water resources utilisation in the industrial sector and encourage wasteful use			
WR-F15	**Energy production**	86% of India's electricity is generated from thermal power plants that rely significantly on water for cooling. As power generated from thermal power plants continues to remain major source of energy for all industrial and commercial activities, exposure to high water stress may hamper India's energy production and economic activity[39]. Wastewater reuse in the sector may be further explored to combat the scarcity.			
WR-F16	**Impact on Banking sector**	Water scarcity may pose significant impact on the Indian economy through the banking sector as the portfolio of banks is exposed to the Industrial sector, which may be facing operational risks (production as well as regulatory risks) due to water scarcity[35].			
Demand Side- Domestic					
WR-F17	**Water Demand**	India's population is estimated to be one of the largest in the world 40 years from now. Domestic water demand will also be increasing with the increase in population, changing lifestyle and urbanisation. Supply of			

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		adequate (or 24x7) safe treated drinking water at household level (using piped water supply) to the increasing population of India is therefore a challenge.			
WR-F18	**Water quality**	• In addition to the increase in exploitation of groundwater over the years, there have also been occurrences of quality related issues for groundwater. Therefore, quality of water for domestic use must be monitored strictly.			
WR-F19	**Efficient use and pricing**	• There exists a difference in the amount of water consumed by rural and urban population in India. Changing lifestyles will further increase consumption of domestic water. Poor water pricing may lead to inefficient utilisation of water resources. Differential pricing between freshwater and treated municipal wastewater for reuse may be explored for domestic sector to promote reuse of treated wastewater for non-potable domestic purposes.			
WR-F20	**Water Scarcity**	• The urban population across the various urban hubs in India is expected to increase to 600 million in the year 2030 and 877 million by the year 2050[79]. With the increase in population, pressure on water resources will substantially increase. Water supply infrastructure in the major urban centres of the country should be facing this stress as these were never designed to cater to such large population sizes and may			

[79] United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		not be well equipped to handle such demand. As of 2014, none of the major cities in India have been able to supply 24x7 water to its entire urban population[35].			
WR-F21	**O&M and NRW**	Water supply system especially in urban areas, suffer high non-revenue water due to leakages, unauthorized connections, billing and collection inefficiencies. Estimated NRW is between 40-70% of the water distributed and leads to loss of water resources. High NRW is due to system inefficiencies as most urban water supply operations survive on large operating subsidies and capital grants and O&M cost recovery through tariff is not more than 30-40%.[80] Further since capital investments on drinking water supply networks are expensive, reducing leakages will reduce or delay the need for new investments as the saved water can be used to improve coverage.			
Wastewater					
WR-F22	**WW treatment capacity**	• Inadequate capacity of STPs has led to discharge of 62% of the total sewage generated (38,791 MLD) directly into the environment • Lack of ETP facilities in the industrial sector leads to discharge of 40% of industrial wastewater in untreated form			

[80] Urban Water Supply and Sanitation, The World Bank

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		• Release of untreated wastewater into the environment has led to pollution of 80% of surface water resources in India and 317 polluted river stretches			
WR-F23	**Use of recycled water for agriculture**	• Currently, reuse of treated wastewater in the irrigation sector is mostly prevalent across the world with 32% of reuse application. However, in India, planned reuse of wastewater is still to take off.			
Broad sectoral outcomes					
WR-F24	**Agricultural Water Use efficiency**	• The ratio of water consumption and area cultivated is an important metrics as it signifies the water use efficiency in the agricultural sector. India is one of the highest water consuming countries with an approximate agriculture water consumption of 4,060 m^3 per hectare of cultivated area			
WR-F25	**Water regulator**	• The national water policy 2012 talks about setting up a water regulator to manage various issues around water. Considering the enormous challenges in water sector, lack of a water regulatory authority is hampering the growth of this sector. With multiple disputes around water sources, supplies etc., there is an urgent need of water regulators to create proper legislation, and regulations			

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
WR-F26	**Capacity Building**	• Lack of capacity building of the various agencies managing water resources infrastructure and the service delivery is leading to poor water resources management.			
WR-F27	**Convergence**	• Multiple central government ministries have been implementing programs related to water sector with scope to reduce duplication in effort and fund utilization. Greater convergence across scheme is necessary			
WR-F28	**Staffing levels**	• Staffing levels are ten times international norms, and most public funds are now spent feeding the administrative machinery, not maintaining the stock of infrastructure or providing services.			
WR-F29	**Financing**	• There is an ever-increasing funding gap in the sector due to poor tariff collection and absence of alternative financing mechanisms			
WR-F30	**Project Management**	• Currently majority of the irrigation projects in the country face issues related to time and cost overruns. The major and medium irrigation projects in India suffered from cost overrun to the extent of Rs. 1.20 Lakh Cr. In addition, approximately 105 projects faced time			

Sl.no	Area	Issues & Challenges	Secondary	KII	HH/ FGD
		overrun issues with the duration of time overrun ranging up to 18 years			
Overall nature and responsiveness of Water sector					
WR-F31	**Planning and Data Management**	• Water is a state subject as per the Constitution of India. Therefore, the institutional structure and departments at state level for implementation of water resources sector related planning are key to ensuring efficient planning and implementation in the area. Due to the involvement of multiple agencies both at national and state levels, there is poor data collection, management and sharing.			
WR-F32	**Coordination between agencies**	• Water is a state subject as per constitution of India. Greater coordination between the various central government level organisations and the state government departments is required going forward.			
WR-F33	**Conjunctive use of SW and GW**	• Further promotion and awareness related to conjunctive use of surface water and groundwater is required			
WR-F34	**Water sharing treaties and disputes**	• The water sharing treaties and disputes among states have led to delays in implementation of river interlinking projects			

Issue relevance legend

	Supported		Partially supported		Not supported		Not applicable

1.5 Recommendations and solutions

The recommendations and solutions and their mapping to the issues/findings mentioned in the above sub-section, are summarised in the table below.

Table 22: Water resources sector – recommendations and solutions

Sl.no	Recommendations	Finding
Supply Side		
WR-R1	**Increase overall water storage capacity** Increasing the overall water storage capacity across the country is very vital to ensure water security. The following approach may be adopted: • Focus on creating additional decentralised storage structures across the country. Construction of such decentralised storage structures may be taken up on large scale and such structures created at village levels can also be implemented with minimum land acquisition costs if the beneficiaries are educated and their support is sought for the same. The same can also be planned in barren or waste land in or near the villages. Local GP Pradhans may be taken into confidence and small to medium size water storage structures can be created across the country. Existing village ponds may also be rejuvenated, desilted and/or expanded as part of this initiative. Water from these storage structures may be supplied to the nearby agricultural fields during rainfall deficient periods. Design and procurement process for implementation of such lined storage structures may be standardised for easy adoption and implementation across the country. Financing of such initiatives can be done in convergence with MGNREGA schemes. • A large-scale initiative on de-siltation of all existing major and medium irrigation reservoirs may be initiated. Such de-siltation will increase the actual existing capacity of the reservoirs across the country. Before commencing desilting, environmental impact assessment studies may be carried out so that water turbidity and erosion of the reservoir banks are avoided. Further, the silt recovered from these bodies (after separation of sand) may be provided to farmers/WUAs in the nearby areas for improving fertility of their agricultural fields. Processing of desilted soil would provide a huge quantity of sand which can further be used for construction works. The inclusion of de-siltation component in the upcoming DRIP Phase 2 and Phase 3 projects may be explored.	WR-F1

Sl.no	Recommendations	Finding
	Similar large-scale de-siltation initiatives have been taken up by the Government of Maharashtra in the year 2017. • Alternatively, dredging of accumulated silt may also be attempted for very large dams. Extensive catchment area treatment should also be undertaken for all reservoirs to avoid silt deposition • A feasibility study to increase the existing height of the reservoirs of all existing major and medium irrigation projects in India may be taken up in a systematic manner. If feasible the height of the reservoirs may be increased based on recommendations by the technical panel. Through such initiatives, the storage capacity of reservoirs can be increased without incurring large investments. Similar attempts have been successful in Manipur where the state has increased the height of an existing dam by 1m to increase the storage capacity of the reservoir. • Since the focus should remain on small decentralised storage structures, in future we may have to measure the water storage capacity of dams plus other small storage structures on a regular basis. The storage capacity of Major and Medium irrigation projects is monitored by the CWC. However, a robust census of Minor Irrigation and other such small storage structures created across the country needs to be parallelly strengthened. The 6th Minor Irrigation Census along with first Census of Water Bodies is being conducted with Reference Year 2017-18 and scheduled to be published in FY 2020-21, may provide essential data in this aspect. • O&M of large dams across the country should also be focused upon. Currently, majority of the dams do not have a separate operations and maintenance budget. Moreover, state WRDs don't have scheduled and pre-planned maintenance budget. A dedicated budget for operations and maintenance of the dams to address the existing O&M issues, is required. • Going forward, Integrated operations and monitoring system of dams may be introduced, Such systems can help optimize water storage capacity of dams on the same river and will help the dam operators	

Sl.no	Recommendations	Finding
	maximize storage, especially during the monsoon season through integrated operations. • In addition to the above initiatives, using select groundwater storage aquifers for storage of water may also be explored. With increased knowledge on aquifers and improved recharge techniques, Mega-scale Artificial Recharge Schemes may be implemented after conducting detailed feasibility study for the same. Such schemes can create large underground storage in suitable geological areas, without acquiring land as well as with no threat of loss due to evaporation (as in surface water reservoirs).	

WR-R2	**Reduce spatial variance in surface water**
	• The GoI has been planning and undertaking multiple river interlinking projects to reduce the spatial variance in surface water. However, the on-ground implementation has been rather slow. The following aspects may be explored to implement these projects on a faster pace:
	  ○ Prioritize intra-state river inter-linking projects as these may be quick wins due to less political interventions
	  ○ River Interlinking projects may be further promoted, and their environmental sustainability may be publicised (through workshops, seminar or webinars) for better acceptability among the various stakeholders
	  ○ Better coordination among states is required to implement such river interlinking projects as very often multiple states may be involved in a single inter-linking project. To empower a central agency, which often acts as a mediator in such disputes, either the Central Government (Ministry of Jal Shakti) may be empowered or a Central Regulatory Authority may be formed to act as a referee in such cases. However, for implementing this, such water treaties/interstate disputes, may have to be brought under the concurrent list.
	  ○ Alternatively, for better coordination among the participating states, river basin authorities – may be created as special bodies with representatives from all participating States. Such authorities should be made responsible
		WR-F2
		WR-F34

Sl.no	Recommendations	Finding
	for implementing the water linking project under suitable guidance from the MoJS. The above recommendation should also help in better management of water sharing treaties and disputes among states. • In addition to river inter-linking projects, Lift Irrigation (LI) projects can also be promoted for reducing the spatial variance in surface water availability. For implementing this, technical and financial feasibility studies may be undertaken before implementing LI schemes. Alternative innovative financing options like PPPs (Hybrid Annuity Model) may be explored. Moreover, use of solar power as a source can also be promoted in convergence with the various GoI schemes in the renewable energy sector like the Jawaharlal Nehru National Solar Mission (JNNSM). Large LI projects are being constructed in certain states. Key projects are the Kaleshwaram LI project in Telangana and the Polavaram LI project in Andhra Pradesh.	
WR-R3	**Reduce unregulated extraction of groundwater** • The Groundwater (Sustainable Management) Bill, 2017 drafted by the MoJS, GoI has been a welcome step towards decentralised groundwater regulation enforcement and may assist in regulation of unregulated extraction of GW. States should be encouraged to adopt the salient features of the Bill, after suitable customization to suit local conditions, institutional, legal, governance as well as aquifer related differences. Decentralised monitoring and enforcement of GW related regulations are key to the success of GW acts. Public participation and awareness campaigns may be conducted in large scale, and participatory enforcement through WUAs and similar grassroot level organisations may also be explored. Latest NGT guidelines should also be accommodated to reduce unregulated extraction of GW. • In the long term, remote and real-time telemetry-based water sensors may be installed across states for accurate and updated data. Rain gauges may also be installed for accurate data on rainfall. Modelling and analysis of real-time GWL and rainfall data may be conducted to track extraction of GW. The state of Andhra Pradesh is attempting the same, with the help of piezometers located	WR-F3

Sl.no	Recommendations	Finding
	across the state. The APWRIMS portal provides updated information related to crucial aspects of GW. • Implement real-time telemetry-based meters for GWL measurement to monitor GW extraction through bore wells • Additional analysis using satellite data (such as NASA's Gravity Recovery and Climate Experiment) of groundwater level changes may also be undertaken at regular intervals to measure seasonal changes in groundwater levels. Such analysis shall help in understanding the multi-tier aquifers of the Indo-Gangetic plains.	
WR-R4	**Upgrade Groundwater level monitoring** • As highlighted in the above recommendation, in the long term, remote and real-time telemetry-based water sensors may be installed across states for accurate and updated data on GW level. The implementation of the same can be converged with the National Hydrology Project on a larger scale. The data can also be used to prioritise investments in GW recharge structures and other GW conservation initiatives. • As an alternative in the medium term, participatory GWL Monitoring may be undertaken. For implementing such initiatives, SHGs and volunteers may be involved who may be formally trained by CGWB or Stater Ground Water Board officials, to monitor GWL at GP level. Once the GWL is found out at the local level, the same may be shared with the State level GW authorities by phone or through an application on a regular basis. Utilisation of WUAs may also be done for this purpose. Similar initiatives are being undertaken in Karnataka where select SHGs and volunteers have been trained to record GWL at GP level based on nominal payment. The same is being shared by phone, postcard, etc.	WR-F4
WR-R5	**Micro level information of depleted aquifers** National Aquifer Mapping programme (NAQUIM) is being implemented across the country which involves mapping of aquifers to some extent. Moreover, Atal Bhujal Yojana also has an aquifer mapping component. However, the same can be undertaken in further detail going forward. In addition to this, the data generated	WR-F5

Sl.no	Recommendations	Finding
	from the aquifer level mapping needs to be used for actionable insights generation. A few such probable initiatives are: • Water budgeting at GP level may be carried out by using micro level (at least GP) information. Such water budgeting document can be used to prepare a GP-wise water security plan, especially for those GPs which fall in the unsafe category. • GP level rainwater and GWL recording can be used to understand the extent of natural recharge of the aquifers and therefore plan for artificial GW recharge initiatives by prioritising investments • Attempts may be made to digitize GWL data and integration of data from all GWL recorders (under the NHP or NWIC) and use advanced mathematical techniques like artificial algorithms to check the quality of the data sets. Thereafter, the existing data may be used for analysis and planning of GW recharge initiatives. Collaborations and MoUs may be executed with various national level institutes like IITs, NITs, IISc and International institutes like Delft Institute (Netherlands) to undertake research on the GWL data collected, and formulation of recommendations based on the findings for implementation by the stakeholders.	
Demand Side- Irrigation		
WR-R6	**Reduction of IPC IPU Gap** • Standard guidelines and methodology should be developed for assessing the IPC and IPU of the various irrigation projects across India. This will enable to correctly ascertain the true potential of the irrigation systems and to promote more transparency in reporting by various organizations. Details related to the same are provided in the recommendations for AIBP scheme. • For monitoring IPU more effectively, remote sensing may be used for real-time data on cropping. A similar initiative has been taken up by the state of Manipur where remote sensing studies and aerial surveys are being undertaken to measure and quantify the IPU on scientific basis. North East Water Resources	WR-F6

Sl.no	Recommendations	Finding
	Information Base – a geoportal funded by World Bank has been created for this purpose. • Further, completion of distributary networks, field channels, lining of canals and adequate O&M of the existing canals need to be undertaken to reduce the IPC-IPU gap. The MoJS may plan for incentivising the states in the form of additional subsidy/central funds, based on reduction of IPC-IPU gap. However, standardised methodology (based on remote sensing) for measuring IPU needs to be developed and agreed prior to such initiatives.	
WR-R7	**Increase Irrigation Coverage for better crop productivity** • The existing Irrigation Census may be further strengthened by introducing community participation initiatives and technology to collect this data. WUAs may also be involved for getting more authentic data on actual irrigation coverage. Details related to the same are provided in the recommendations under Irrigation Census scheme. • Creation of additional small and decentralised storage structures under PMKSY/MGNREGA schemes will lead to more land area being brought under assured irrigation • Rainwater harvesting at village level may be further encouraged for increasing the coverage of irrigation. Convergence with the recently launched Jal Shakti Abhiyan (JSA) may be explored to create an intensive water conservation campaign built on citizen participation across the country. • Artificial GW recharge initiatives in select water scarce zones based on recommendations suggested earlier will also increase the access to assured irrigation • In addition, based on the recommendations suggested earlier, River Interlinking projects and Lift Irrigation projects will also increase irrigation coverage. • In areas where groundwater is in abundance and surface water availability is unreliable, farmers sometimes do not have money to invest in pumps to extract groundwater. Erratic electricity supply or high price of diesel further affects the usage of groundwater for agriculture in such regions. A suitable service delivery model may be explored in such areas where a mobile solar pump may be rented	WR-F7

Sl.no	Recommendations	Finding
	to farmers (at fixed hourly rates). Claro Energy has implemented a similar service delivery model in Bihar where a portable trolley-mounted solar pump is offered on a fixed hourly rent to small farmers within a local area.	
WR-R8	**Reduce dependency on GW for irrigation** Input subsidy to farmers in the form of free/subsidised power for irrigation and subsidy on bore wells may be removed to minimise over extraction of groundwater for irrigation. The following options may be explored, alternatively: • Regulating the supply of electricity supplied for groundwater pumping and limiting it to a few hours • Fixing ceilings for water or power used per hectare and thereafter providing cash incentives to farmers in the form of DBT corresponding to the quota allocated to the farmer based on his land ownership. The same can be converged with PM-KISAN scheme • Provide power subsidy in the form of DBT only to targeted farmers; for instance, subsidy may be provided to farmers practicing micro-irrigation or to farmers cultivating water efficient crops (in convergence with PM-KISAN scheme). • Measure the quantum of power and water for each connection; this may have an impact on the farmers psychology who in turn may reduce water abstraction and wastage	WR-F11
WR-R9	**Increase Irrigation Efficiency** • Incentivize introduction of piped irrigation networks (PIN) for new irrigation projects or for all ongoing branch, distribution and minor canals should lead to increase in irrigation efficiency. However, detailed feasibility study (including cost benefit analysis covering social and environmental costs and benefits) may be undertaken before implementing PIN projects. Some facts on PIN are as follows: o Recent successful implementation of PIN projects in various states like Maharashtra, Odisha, Gujarat and Rajasthan o Countries like Israel have migrated from open water canals to piped supplies and drip irrigation; currently Israel has the world's highest crop	WR-F8 WR-F9

Sl.no	Recommendations	Finding
	yield/ m^3 of water consumed. Successful case studies in China showed 30% savings in water delivered (equivalent to 15% of the total irrigated area) and 25% in labour input using PIN in place of canal-based irrigation. o However, it may be noted that PIN is needed to be fitted with proper de-silting arrangements, including de-silting chambers and flushing arrangement, where irrigation water contains large quantity of sediments particularly in case the source of water is any of the Himalayan rivers. o Adequate provisions should be made for electricity connections through DISCOMS/solar power for operation of the pumps. Use of solar power as a source can also be promoted in convergence with the various GoI schemes in the renewable energy sector like the Jawaharlal Nehru National Solar Mission (JNNSM) o Further details related to PIN are mentioned in the recommendations for AIBP scheme. • Lining of old canals based on detailed condition assessment studies may also be taken up on a large scale to increase the irrigation efficiency. A detailed feasibility study including cost benefit analysis to determine impact of reduction of seepage on groundwater level, may be conducted before undertaking such projects. The same may be taken up in convergence with AIBP component (at least lining of the main canals); the funding modalities for the same needs to be finalized.	
WR-R10	**Crop Diversification** Crop diversification initiatives of the government may be further strengthened by adopting the following: • In the long term, alternative and less water intensive crops (like ragi, jowar, bajra) may be promoted over traditional water intensive crops like paddy and wheat. Nutritional security may be promoted among the population and thus crop diversification may be achieved through change in mindset and food habits.	WR-F10

	The same can be undertaken in convergence with existing schemes like Poshan Abhiyaan • Promotion and strengthening of E- platforms may be undertaken for wider awareness and acceptance among the farmer community. Specific IEC and Capacity building activities may be undertaken with WUAs to promote online agriculture trading platform like the e-NAM platform (GoI initiative). Increase in popularisation and adoption of such platforms will further bolster crop diversification as it will attract more buyers, farmers and agents and provide an assured market and price for a variety of crops through the portal. Similar initiative taken by the Government of Andhra Pradesh is the e-Rythu application. The initiative is designed to digitise agriculture marketplace by connecting buyers, farmers and agents in the agricultural value chain. This assures fair prices to the farmers for a large variety of crops and the application is easy to use and can be accessed from feature phones. • The Government can also promote crop diversification by introducing MSP for less water intensive crops and undertake actual procurement of such crops. • Additionally, strong market integration for offtake of agricultural produce and remunerative crop price must be ensured to promote MI adoption and avoid slip backs. Implementing agencies may sign MoUs with NGOs, private players and other similar marketing/food processing supply chains to promote such initiatives. • Crop diversification may also be promoted by adopting the concept of crop colonies as part of the regulated farming. Agriculture experts may be consulted to design and plan the specific crops to be grown in a particular state in a given area based on various factors like forecasted rainfall and water availability during the season, soil conditions, demand of the produce, etc. The state of Telangana is planning to introduce this crop colony concept. • Alternatively, in addition to individual farmer-based beneficiary model, basin-centric approach for widespread implementation of MI initiatives with a specific area may be undertaken in a time bound manner. Karnataka's Ramthal MI project is one such example. • Additionally, by using water quota as a tool, crop planning, water budgeting and crop rotation policy may be implemented at WUA level. A specific water quantity	

Sl.no	Recommendations	Finding
	may be allocated at WUA level and the individual crop planning responsibility (like cash crop rotation among farmers) may be left to the WUA for deciding on. Agriculture department may provide necessary capacity building and support to WUAs. Similar initiatives have been successful in Maharashtra on a small scale where WUAs are deciding who will take normal crop and who will take the crash crop during any given year. Crop rotation is being practiced to promote crop diversification among the members of the WUA.	
Demand Side- Industrial		
WR-R11	**Reduce Water consumption in Thermal Power Plants and other water intensive industries** • Thermal power plants are one of the major consumers of water in the industrial sector. It is necessary that India moves on to produce power from sources which have lesser water footprint. Diversifying to solar and wind power, will not only enable India to save on its precious water resources, but also reduce pollution and combat climate change. As per the Paris Accord on Climate Change, India has promised installation of 175 GW of renewable energy capacity by 2022. This includes 100 GW from solar power projects, 60 GW from wind power, 10 GW from bio-power and 5 GW from small hydro power projects[81] • To further promote water use efficiency among industries and optimise water consumption in the water sector, fixed water allocation (quotas) for each industrial sector may be explored. Tradable water use permits in the industrial sector may further improve water use efficiency.	WR-F12 WR-F13 WR-F14 WR-F15 WR-F16
WR-R12	**Increase efficiency in water use and pricing in Industrial sector** • It has become extremely essential to promote water efficient processes across all industries, especially in the major water intensive industries such as, power, textile, iron & steel. These industrial sectors may be incentivised further to innovate and use water efficient processes, thereby reducing the pressure on water resources. In addition, appropriate tariff for the industrial consumers may	WR-F12 WR-F13 WR-F14 WR-F15 WR-F16

[81] Press Information issued by Ministry of New and Renewable Energy, GoI, December 2018

Sl.no	Recommendations	Finding
	be levied. Reuse of treated wastewater may also be promoted in the industrial sector; especially in regions of water scarcity. In Karnataka, the urban water supply authority is currently supplying treated wastewater to the industrial clusters (mining and sponge iron industries) in the water scarce areas.	
Demand Side- Domestic		
WR-R13	**Increase efficiency in water use and pricing in Domestic sector** • It has become extremely essential to encourage water savings and thereby prevent wasteful consumption of water resources. Metering of water supply and appropriate tariff rates will encourage water conservation. Intermediate tariff (until meters are installed) may be set based on Built Up Area (BUA) of the property. The same may be collected as a part of Property Tax. However, ring fencing of water revenues collected by ULBs or Authorities should be made mandatory to ensure financial sustainability of the various water supply schemes. Moreover, ULBs may be mandated to have sub-budgets for specific components like water supply, distribution, sanitation, etc.	WR-F17 WR-F19 WR-F20 WR-F21
WR-R14	**Enhance O&M and Financing of drinking water schemes** • To achieve O&M efficiency- O&M of common infrastructure of the water supply scheme may be handed over to a private or professional agency. However, inside ULB area, ULBs themselves need to take responsibility for O&M of distribution network and other assets. A dedicated water supply cell with dedicated manpower may be allocated for this purpose. • Water Audit for ULBs may be made mandatory. Such audit reports should also be put on the public domain. Similar initiatives have been implemented in Nagpur. The audit report includes key water supply related parameters like quantity of water withdrawal, water treated, water supplied, wastage and losses, cost recovery from users, etc., and is available in the public domain. Such data can be expected to motivate the people to put pressure on the authority to reduce the loss to make it more	WR-F17 WR-F19 WR-F21

Sl.no	Recommendations	Finding
	efficient. Additionally, collection efficiency may also increase due to such initiatives. • Extensive capacity building activities may be undertaken for ULB officials to enable them to undertake efficient O&M of assets • To enhance the financial sustainability of drinking water schemes, metering and tariff collection are extremely essential. The recommendations mentioned above may be implemented	
WR-R15	**Water quality** • Water quality of drinking water supply projects may be maintained by proper O&M and monitoring. Additionally, water quality tests may be undertaken at regular intervals and as per CPHEEO guidelines to ensure adherence to drinking water quality standards • In addition, ETP for industries must be made mandatory and PCBs should monitor any pollution sources to maintain the water quality	WR-F18
Wastewater		
WR-R16	**Wastewater reuse & pollution abatement measures** • State level action plan may be prepared to identify STP requirements. The mapping of the same should be done with the possible demand centers in the state (industrial clusters, agricultural zones, etc.). Projects in nearby demand centers and in water scarce areas may be taken up on priority. Financial feasibility of such projects will also be high due to possible revenue sources. • In line with NMCG, similar missions for creation of STPs in other states and for important rivers like Mahanadi, Godavari, Krishna, Kaveri, etc. may be undertaken. PPP (HAM model) similar to NMCG projects may be adopted for financing of such projects. • Wastewater treatment for rural and peri-urban areas may also be planned, going forward as JJM is being implemented which will bring household drinking water	WR-F18 WR-F22

Sl.no	Recommendations	Finding
	supply to rural areas. Modular and decentralized wastewater treatment plants may be explored for such rural and peri-urban areas • Reuse of wastewater in Agriculture and/or Industrial sector is currently being included as a component in the new NRCP projects. However, options for wastewater reuse in agriculture and industrial sector as a revenue generation mechanism may be explored for the previously commissioned projects under NRCP. This will also help boost the financial sustainability of those projects. The same may also be extended to the implemented NMCG projects, wherever possible. • For quicker adoption, areas where there is scarcity of water may be taken up on priority • Wastewater reuse policy should be framed by all state governments • Wastewater reuse roadmap may be prepared and extended to industrial and domestic sectors, gradually mandating reuse targets for industries as well as for large cities (starting with large commercial SEZs and housing complexes)	
WR-R17	**Formalise and increase use of recycled water for agriculture** • Further formalization and promotion of use of recycled water for agriculture may be undertaken in a large scale. Initially, water scarce areas may be the focus. Capacity building and IEC activities are required for farmers to educate them about the use of recycled wastewater and these should be undertaken.	WR-F23
Broad Sectoral outcomes		
WR-R18	**Improve Agriculture Water Use Efficiency** • To improve agriculture water use efficiency, micro-irrigation needs to be adopted at an even larger scale. Further details related to adoption and improvement of micro-irrigation are mentioned in the recommendations for PDMC scheme. • Broadly, micro-irrigation guidelines need to be crop specific and also tailored to the climatic or soil conditions. Such initiatives will allow the farmers to get better subsidy and also maintain better land productivity • Additionally, to increase micro-irrigation adoption, subsidised power is a major impediment. Therefore, blanket subsidy on power may be avoided.	WR-F24

Sl.no	Recommendations	Finding
WR-R19	**Bridge increasing gap between demand and supply of water** Supply Side- Key interventions in the supply side are: • Improved Groundwater Management through community participation • Better regulatory system • Assured SW supply through LI, River interlinking and PDN projects • Reuse of treated wastewater in agricultural sector • GW recharge and water conservation promotion • River rejuvenation Demand Side- Key Interventions in the demand side are: • Improving water use efficiency in agriculture by strengthening micro-irrigation • Reducing conveyance losses in canals • Working on crop diversification • Implementing climate smart agriculture (CSA) and the climate smart water management practices. CSA aims to tackle three primary objectives- (1) Sustainably increasing agricultural productivity and incomes (2) Adapting and building resilience to climate change; and (3) Reducing and/or removing greenhouse gas emissions, where possible. Climate smart water management practices involve safeguarding of critical water resources for sustainable use through adaptive measures for effective water management, particularly in drought-prone regions. An integrated approach needs to be implemented in agricultural water management through adoption of innovative practices such as rainwater harvesting, micro-irrigation and resource conservation farming to increase water-use efficiency in agriculture.	WR-F8 WR-F12 WR-F20 WR-F24
WR-R20	**Efficient groundwater management and technologies** • In addition to the earlier mentioned GW related initiatives, crowd sourcing GW related data may be attempted. For instance, it may be made mandatory by state GW authorities, to disclose GW related data when a user receives a NOC from the authority for extracting groundwater. The detailed level by level drilling data of soil strata should be shared with the authority. Such information regarding depth of individual strata will be beneficial to create a profile of the area. Moreover, information on GWL in the area can also be shared. Such information may be digitized and used judiciously for planning GW recharge	WR-F3 WR-F11

<table>
<tr><th>Sl.no</th><th>Recommendations</th><th>Finding</th></tr>
<tr><td></td><td>related initiatives. However, in addition to GWL, monitoring of flow regime dynamics and GW quality shall also be taken up on regular basis.</td><td></td></tr>
<tr><td>WR-R21</td><td>Water regulator
• Like the transformation in Telecom and Power sector has been achieved with a regulator in place, there should be a state level regulatory authority for water. The authority should monitor the progress of goals set in the state water policy and regulate the quantity of water for different category for users- agricultural, industrial and domestic. The regulator will also be an independent body which will be authorised to arbitrate on water related disputes. Such regulatory authority may also take up the mandate for streamlining and improving the data collected and maintained by various stakeholders. A careful attention should also be given to the organisation structure of the Authority, by drawing members from all all sectors of economy and water value chain, such as industrial users, domestic users, agricultural users, groundwater and surface water management authorities, legal and financial experts while constituting the Authority.
• Various incentives may be provided by the GoI to the states to form an independent water regulator (similar to Maharashtra Water Resources Regulatory Authority. Specific measures may be:
○ Providing more subsidy on certain schemes (e.g. micro-irrigation / PDMC) to states where independent regulatory authority has been formed. Such a move can initiate people's movement and create pressure on the state governments
○ Another option could be to provide a one-time grant to the states whereby initiation fund may be provided for setting up an independent water regulatory authority in the state. Specific guidelines and suggested organisation structure may also be suggested by the Central government for adoption by the states.</td><td>WR-F25</td></tr>
<tr><td>WR-R22</td><td>Capacity building of organizations
• Renowned organizations working in the irrigation and agricultural sectors like Water and Land Management Institute (WALMI) and Punjab Agricultural</td><td>WR-F26</td></tr>
</table>

Sl.no	Recommendations	Finding
	University (PAU) may be empaneled for providing capacity building on latest technologies • The key topics which may be focused upon initially are Micro-irrigation, National Hydrology Project monitoring, Piped Distribution Network, reuse of treated wastewater and other such novel initiatives. In addition, certain special skillsets/capabilities may be developed among selected state officials in advanced areas related to climate modelling, hydrological modelling, etc.	
WR-R23	**Scheme convergence** • The primary schemes with which attempts may be made to achieve convergence are MGNREGA, IWMP, SBM(G), MPLAD, MLALAD, DMDF • A cross-sectoral task force may be formed especially involving irrigation, agriculture, horticulture and rural development departments to facilitate scheme convergence	WR-F27
WR-R24	**Staffing levels** • A thorough organisational and institutional study needs to be conducted to identify the gaps in staffing. Organisation restructuring, reskilling and job role review may be undertaken based on this comprehensive assessment. In case of inadequate staff strength, or poor ratio of field to office staff, recruitment or departmental transfer initiatives need to be undertaken	WR-F28
WR-R25	**Financing in the sector**	WR-F29

Sl.no	Recommendations	Finding
	To improve revenue collection in the irrigation sector, the following initiatives are suggested: • Mandatory formation of WUAs (or strengthening where it exists) • Stronger outreach, including training and capacity building of the WUAs may be focused upon • Strengthening of the Irrigation Act • Assured service levels to customers / beneficiaries • Online collection or local payment collection of irrigation fees through agents or WUAs • Linking of disbursal and approval of agricultural loans and other government support to payment of irrigation fees • In case of Micro-irrigation projects – PPP initiatives may be explored where capex is borne by Private sector. During O&M period, the irrigation service fee is collected through WUA. Such targeted programs may be carried out in water scarcity areas • Alternative financing mechanisms like Outcome financing and Impact financing may be explored for financing of water sector related projects. In these innovative financing mechanisms (mostly used to fund social sector projects), investors provide up-front capital to service providers, with the potential for a return if selected outcomes are achieved. Such innovative funding mechanisms have enabled successful achievement of outcomes across a variety of sectors like improved learning outcomes among primary school-aged girls in rural India, family reunification of children in out-of-home care in Australia, and sustained employment among vulnerable youth in Colombia, etc.	
WR-R26	**Improve Project Management** • Develop a national contractor management tool/ software- Since most large irrigation projects involve engagement of a host of contractors over a long period of time, an online contractor management tool should be developed by	WR-F30

<table>
<tr><th>Sl.no</th><th>Recommendations</th><th>Finding</th></tr>
<tr><td></td><td>the Central government and source code should be shared to each of the states to avoid individual state investments in such tools.
• Systematic progress tracking of contractors will help to identify critical paths and ensure timely actions and escalations are undertaken.</td><td></td></tr>
<tr><td colspan="3">Overall nature and responsiveness of Water sector</td></tr>
<tr><td>WR-R27</td><td>Improve Planning and data management in the sector
Creation of reliable and dedicated data sources for the Water Resources sector focusing on supply as well as demand side (irrigation, industrial - consumption by sector, domestic and wastewater) is of utmost necessity. For this, the following may be adopted:
• Since water is a state subject, data is collected and maintained by various state government agencies operating in the sector. Pooling and collection of existing data related to the water resources sector through state WRD (like APWRIMS). This should include both water supply and use related data.
• In line with the National Hydrology Project which aims to improve Supply side data availability, demand side data may also be collected from the various responsible agencies by designing a similar scheme going forward. Moreover, when coverage of metering and monitoring infrastructure becomes more widespread, decentralized data collection from all demand centers (irrigation, domestic and industrial) may be attempted. Involvement and support from various associations like WUAs, civil societies, industry associations, etc. may be sought for this.
Planning in the water resources sector may also be improved by adopting the following:
• A separate scheme may be undertaken dedicated to water resource planning at state level. Such exhaustive exercise is required to be conducted individually for all states. A comprehensive sector plan covering all facets of the sector- water supply and demand for irrigation, industrial and domestic sector, water use efficiency, etc. is required to be undertaken. A deeper and exhaustive study through a well-designed scheme will strengthen the state sector planning. The existing State Specific Action Plan which primarily focuses on climate change</td><td>WR-F31</td></tr>
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Sl.no	Recommendations	Finding
	and water conservation initiatives, may be subsumed and merged with the proposed initiative. Such initiatives will also address data gaps pertaining to the sector Similar initiatives have been taken by the Government of Punjab which has recently engaged a leading private sector company to prepare a comprehensive water sector plan for the state. It should cover all aspects including improving water use efficiency, water supply, water demand, and measures to increase efficiency in agriculture, industrial and` domestic sectors. • In Irrigation department at state level, three wings may be created based on the distinct skillsets required for the exhaustive list of activities conducted by the department. (1) Construction and Design Wing- The same to continue to focus on technical designs, asset creation and other technical activities; (2) Operations wing- The same may focus on O&M of existing assets, and other softer aspects like Community mobilization, and (3) Commercial Wing - focusing on commercial aspects like service fee collection, etc. These separate wings may operate under a common Engineer in Chief and Secretary. A fixed percentage of the capital expenses budget for the department should be allocated for O&M • Water entitlement for all category of users - domestic (bulk), industrial and irrigation may be fixed to promote water use efficiency. Regulatory authorities should be mandated to implement such initiatives. • In drinking water supply, for better planning, implementation and efficient O&M it is suggested that due to the inherent difference skillset required for undertaking these activities, bulk water production and transmission may be undertaken by a single entity (preferably Water Supply Authorities in case of Urban areas and ZPs in case of rural areas), whereas drinking water distribution related activities are conducted by a separate entity (preferably ULBs in case of Urban areas and GPs via VWSCs in case of rural areas).	
WR-R28	**Improve coordination between various agencies** • Design of irrigation sector related schemes and implementation of the same would require better cooperation between the Jal Shakti ministry, Agricultural Ministry and the Irrigation, Agriculture, Horticulture, Rural development and Groundwater authorities or departments at the state level. To promote this, task	WR-F32

Sl.no	Recommendations	Finding
	force or similar coordination mechanisms may be formalized both at State as well as District levels between the above-mentioned departments or agencies. The state of Gujarat has attempted such initiatives while implementing micro-irrigation programs. They have undertaken micro-irrigation programs in mission mode wherein they have created a task force and engaged experts from agriculture, water resources and rural development departments, to promote better coordination and planning. Alternatively, to improve the coordination especially between state groundwater departments/directorates and Irrigation department, a "Sustainability wing" may be created within the larger WRD to look after sustainability of groundwater resources. This wing should be filled up by domain specialists selected by the state groundwater departments/directorates/CGWB, as appropriate. Such an initiative would improve the coordination between the groundwater department and the irrigation department.	
WR-R29	**Promote conjunctive use of surface water and groundwater** • The departments at State levels are separate - GW being monitored and maintained by State GW authorities and surface water by WRD or Irrigation department in most cases. Therefore, for better coordination and planning on conjunctive use of SW and GW, the same task force as mentioned in the above recommendation may be used. • Alternatively, the Sustainability Wing as mentioned in the above recommendation may also be used to promote conjunctive use.	WR-F33

Development Monitoring and Evaluation Office

NITI Bhawan, Sansad Marg, New Delhi-110001

contact-dmeo@gov.in I https://dmeo.gov.in/

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