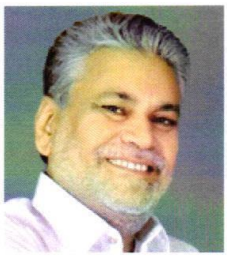
Plugging India's agri-water gap: Sustainable and innovative approaches

February 2020

pwc

FICCI
Federation of Indian Chambers of Commerce and Industry

परशोत्तम रूपाला
PARSHOTTAM RUPALA



सत्यमेव जयते

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Minister of State For
Agriculture & Farmers Welfare
Government of India
D.O. No.....169....MOS(A&FW)/VIP/2019-20/

Message

As we embark on a new era of agriculture with enormous pressure to produce more food with shrinking water and other natural resources, there is urgent need to address the issue of conserving and judiciously use the available water resources with help of technology. With advanced technologies, additional area can be irrigated with same amount of water compared to conventional method of irrigation. Therefore, providing complete technical back up support to farmers and develop models that can be later replicated on larger scale is imperative.

Pradhan Mantri Krishi Sinchai Yojana is an important policy push that needs to be strengthened and streamlined. Therefore, involvement of multiple stakeholders in such initiatives is inevitable and hence a systemic approach has to be evolved. PMKSY aims at improving on-farm water use efficiency to reduce wastage of water and enhance adoption of water saving technologies.

I am certain that efforts of FICCI and PwC in putting together this knowledge report with detailed analysis of facts will be helpful in crafting suitable policies by the Government. My heartiest congratulations on this timely and wholesome initiative and best wishes for meaningful dialogue across the board.

(Parshottam Rupala)

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13th February, 2020.

MESSAGE

Government of India is committed to accord high priority to water conservation and its management. To this effect Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) has been formulated with the vision of extending the coverage of irrigation 'Har Khet Ko Pani' and improving water use efficiency 'Per Drop More Crop' in a focused manner with end to end solution. Out of about 141 million hectare of net area sown of the country, only 65 million hectare is currently covered under irrigation. The approaches of past simply cannot meet the set objectives of this programme. Technical challenges will arise at every stage of the value chain. Therefore, every stakeholder has a critical role to play and this requires intensification and integration of efforts across the board.

Agriculture consumes nearly 90% of the fresh water in India. The water use efficiency in Agriculture is extremely poor. A promising approach to increase water use efficiency is to promote water saving systems in water intensive crops like paddy and sugarcane. There is a need for massive campaign to change farmers attitude as well as develop integrated approach to achieve higher productivity in these crops with lesser amounts of irrigation water.

I congratulate FICCI and PwC for this timely initiative. I hope this Report will provide important inputs for policy interventions in the sector.

(U.P.Singh)

जल संरक्षण - जीवन संरक्षण
Conserve Water - Save Life

Message from FICCI



Agriculture is the biggest user of water. Nationally, groundwater contributes up to 62% of water used for irrigation[1]. Alarming rates of ground water depletion deserves urgent attention. Rice, wheat, cotton and sugarcane are the four major crops in India which occupy 46% of gross cropped area (GCA) but take up 65% of the gross irrigated area (GIA)[2]**.** This signifies the need for sustainable cropping pattern, which is in line with water usage.

It has been projected that population and income growth will boost water demand in future to not only meet food production, but also to support living standards**.** The water availability for agricultural uses has already reached a critical level. The next step is to move up on the water usage, conservancy and recirculation by advanced precision agriculture, which will direct the water to the precise seed bed, thereby reducing the quantity of water even up to 30% of current needs[3]. More importantly, water will be directed only to crops rather than unwanted areas like weeds. Most of the soil is left undisturbed, thereby reducing losses due to evaporation and preserve soil quality. Improved water use technologies for farmers – such as micro-irrigation systems – can improve fertiliser and power use efficiency by 28% and 30% respectively[4], and this can be directly translated into considerable water savings. This saved water will further help in bringing more area under cultivation.

The challenge in future will be to ensure efficient as well as productive utilisation of available water, through a collaborative participation of all concerned stakeholders. Therefore, an integrated agriculture water policy at the national level is essential to address major concern areas in the context of agricultural water use. This knowledge report consolidates relevant facts and analysis on the aspects of water usage in the agriculture sector. I am certain the report will be of interest to policymakers, industry players and academia.

TR Kesavan

Chairman, FICCI National Agriculture Committee and Group President, TAFE Ltd.

1 National Compilation on Dynamic Groundwater Resources in India, 2019, Central Ground Water Board

2 Pocket Book of Agricultural Statistics, 2018, Ministry of Agriculture and Farmers' Welfare

3 Precision Agriculture Technologies Positively Contributing to GHG Emissions Mitigation, Farm Productivity and Economics

4 https://pmksy.gov.in/microirrigation/Archive/August2015.pdf

Message from PwC



India's share of the global population is 18%, while it has access to only 4% of global water resources.[5] Nearly 90% of freshwater withdrawn in India is used for agricultural purposes. Post the Green Revolution and the adoption of water-intensive agriculture production systems in the 1960s, the area under rice and wheat cultivation in India has expanded rapidly.[6] The country's rice production has increased from 20.58 million tonnes in the 1950s to 112.75 million tonnes in 2018, an increase of nearly 547%.[7] While we achieved self-sufficiency in food production, the increase in productivity has significantly strained our water resources.

The growing population, increased urbanisation and impetus to raise domestic and industrial consumption have further pushed us towards becoming a water-scarce nation. India is one of the 17 countries that has reached a water-stress situation, and more than one-third of its population lives in water-distressed areas.[8]

In general, there is a critical need to review how we utilise every drop of water. Particularly in agriculture, there is a need to focus on increasing productivity per litre of water rather than productivity per hectare. The change in agricultural practices like choice of crop and use of technology to improve efficiency are some of the immediate imperatives for Indian agriculture, apart from considering long-term measures such as traditional approaches of conserving water and efficient use of available resources. This report proposes strategies and measures for ensuring efficiency and availability of water in agriculture. They involve adopting some of the best practices drawn from national and international use cases which are acceptable and suitable to both farmers and other stakeholders.

Ashok Varma

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PwC India

5 https://www.worldbank.org/en/news/feature/2019/12/09/solving-water-management-crisis-india

6 http://edugreen.teri.res.in/explore/bio/green.htm

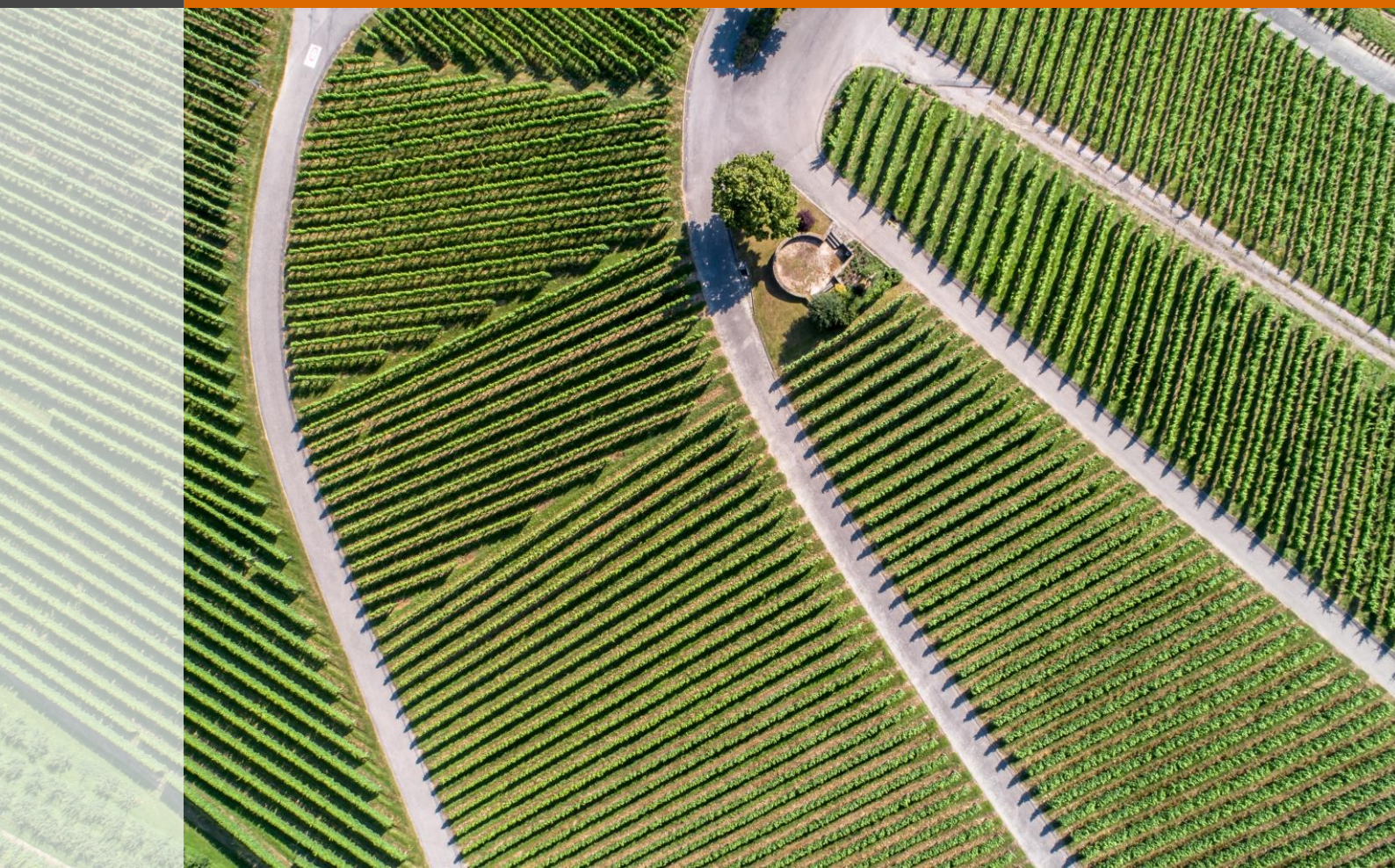
7 https://www.indiastat.com/agriculture-data/2/cost-of-cultivation-production/32320/rice-paddy/570057/stats.aspx

8 https://www.wri.org/blog/2019/08/17-countries-home-one-quarter-world-population-face-extremely-high-water-stress

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1. Executive summary



Water is a scarce resource and a fundamental requirement for the existence of life on the earth. The US has the world's largest freshwater reserves at 45%, followed by Asia (27%) and Europe (15%). Almost 70% of all freshwater withdrawal in the world is used for agriculture. In India, **90% of all freshwater withdrawal is used by the agriculture sector** alone, followed by consumption for municipal (7.4%) and industrial (2.2%) purposes.

Agriculture contributes around 17 %[9] to the country's GDP and engages almost 55% of the population. Having an average annual rainfall of 1170 mm,[10] India is endowed with surface water availability of almost 4000km/year.[3] Monsoons, and especially the south-west monsoon, account for more than **70%[11] annual rainfall and are spread over a four-month** period. National annual precipitation varies from 100 mm in Rajasthan to 11,000 mm in Cherrapunji. River basins are another important water source and nationally, the Ganga river basin has the largest catchment area. The Ganga, together with the Brahmaputra and Meghna, makes up the largest basin area in the country, occupying 34%of the total area.[12]

Global warming and climate change have become crucial issues. As countries compete for accelerated holistic development, meeting the United Nations' Sustainable Development Goals (SDGs) has been a critical challenge. The per capita availability of water is dipping while the global population keeps rising, resulting in increased water demand due to rapid urbanisation, industrialisation and economic development. The rate of groundwater extraction in India is so severe that its **water table is depleting at a rate of 0.3 m per year.[13]** Rice, wheat, cotton and sugarcane are the four major crops grown in India which occupy 46% of the gross cropped area (GCA) but take up 65% of the gross irrigated area (GIA).[14] These four crops together consume up to 70% of all the water that is used in agriculture. Indian agriculture requires alternative and contingent crop planning, crop diversification, drought proofing and promotion of direct-seeded rice (DSR) technology for water productivity.

Keeping water scarcity in mind, the NITI Aayog has developed an index called the Composite Water Management Index (CWMI). The Government of India (GoI) has been proactive about water management and has formed the Ministry of Jal Shakti to consolidate interrelated functions pertaining to water management. The ministry should prioritise the strengthening of programmes such as the Command Area Development Programme (CADP) and the Accelerated Irrigation Benefits Programme (AIBP) to promote decentralised water management and drive the adoption of sustainable water management practices. All irrigation projects may be designed for improvement of water productivity by laying underground pipeline networks (UGPLs) from the source of water to farm outlets, with a pressurised irrigation network (PIN), coupled with completely automated micro-irrigation facilities. This may help in ensuring convergence of irrigation technology for achieving water productivity and water security.

Despite being a water-stressed country, India's virtual water trade in the form of embedded water or invisible water in foodgrain is very high. It is estimated that Indian agriculture uses two to four times more water for producing one unit of food crop when compared to China and Brazil.[15] Promotion of precision irrigation systems (PISs) like micro-irrigation technology over flood irrigation could lead to 36–68% water savings and improve the crop yield efficiency by 27–88%.[16]

Initiatives taken by the Central and the state governments and various industries to work towards judicious water management have seen considerable success. A few corporate organisations have been proactively contributing as a part of their corporate social responsibility (CSR) to encourage project-driven initiatives.

9 Press Information Bureau, Government of India, Ministry of Finance

10 Part I Irrigation: Achievements and Challenges, Apoorva Oza

11 Annual report 2016–17, Department of Agriculture, Cooperation and Farmers' Welfare, GoI

12 Spatial variation in water supply and demand across river basins of India, 2005, International Water Management Institute

13 The Hindu Business Line, 14 January 2019

14 Pocket Book of Agricultural Statistics, 2018, Ministry of Agriculture and Farmers' Welfare

15 https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf

16 Part I Irrigation: Achievements and Challenges, Apoorva Oza

Encouraging public-private partnership (PPP) for better creation and utilisation of irrigation infrastructure seems a feasible solution for developing countries. Largely, the public sector has been driving the development of water resources, irrigation management and bringing in reforms. To attract private investment, we may have to develop innovative funding models such as viability gap funding, incentives for execution, or a mix of both. Participatory irrigation management (PIM) through the formation of water user associations (WUAs), where irrigation system users are involved at all the levels of irrigation management could be a feasible solution. Promoting irrigation as a service (IaaS) could be another solution, which could result in reducing the financial burden on farmers, saving electricity and resulting in more efficient utilisation of water. Involvement of farmers' collectives, WUAs and farmer producer organisations (FPOs) undertaking operation, management and maintenance (OMM) functions of irrigation systems increases reliability and water productivity.

Therefore, it is fundamental that sustainable waterways are created for meeting future demands by promoting PPP in irrigation infrastructure management by institutionalising and strengthening a water agency/authority. The agency may be entrusted with developing equitable access to irrigation infrastructure for farmers by enabling an environment for IaaS in the country. Watershed management in conjunction with precision technologies and PIM are other avenues which could be explored by industry partners, NGOs and FPOs. **The current situation demands innovation in financing irrigation infrastructure for prudent economics and judicious water usage.**

Water scarcity in the agriculture sector also calls for a national integrated agriculture water policy to ensure the current and future water demands by investing in sustainable approaches. The states need to reinvigorate their policies and sustainability should be the focus while planning or promoting policy interventions for water management in the agriculture sector. The policies should promote water-smart technology and water-smart cropping patterns with the introduction of precision technology in irrigation. They should also reflect the value of water, water budgeting, water pricing, increasing water use efficiency and water rights, drought-proofing strategies and crop diversification plans for regulating use of water. Natural wetlands, ponds, river basins and mangroves need to be conserved for accelerating groundwater recharge to create a positive water balance.

This report suggests sustainable approaches for efficient water management in agriculture and identifies policies and practices which could be adopted to ensure judicious water use. It proposes meeting increases in current and future water demands through sustainable management of water in the agriculture sector.



2. Understanding the water scarcity situation



Water is vital for survival of life on Earth. Similar to clean air, it is a basic need for sustenance of life. With growing population, food demand and industrialisation, water is a more crucial resource today than it was in the past. As the demand for water increases for production of more food and energy, there is a need to study its resources and availability in order to effectively manage its consumption across the world. The undervaluation and over utilisation of water has resulted in severe global water woes. This section analyses current and future water demand across the globe and explores challenges and opportunities for sustainable water management.

2.1. Global woes around water

Global water conflicts are rising due to opposing interests of water users. A study by the European Commission, Joint Research Centre has highlighted five most vulnerable hotspots on the globe where hydro-political issues will result in instability and unrest. This includes the Nile, the Ganges-Brahmaputra, the Indus, the Tigris-Euphrates and the Colorado rivers.[17]

2.1.1. Global water availability

More than 70% of the earth's surface is covered with water. However, 97.5% of all the available water on the earth is saline and not fit for consumption. Only 2.5% of all water is freshwater, most of which is trapped in glaciers, icecaps and permanent snow. The extractable freshwater available for human consumption is 10,623,120 billion cubic metre (bcm), which is only 0.8% of all the water available on earth. The natural sources of extractable freshwater are rivers, lakes and groundwater. While 70% of fresh water is unextractable and lies in glaciers, icecaps, permanent snow, soil moisture, ground ice and permafrost, swamps, atmosphere and biological beings, only 30% remains available for meeting consumption and usage demands of humans.[18] Globally, when continents are compared in terms of water availability, the Americas emerges as the largest shareholder of world's freshwater deposits with 45%, followed by Asia (27%) and Europe (15%).[19]

2.1.2. Global water scarcity

Ideally, water availability should remain more or less the same as the Earth keeps replenishing its water reserves via the water cycle – from evapotranspiration to precipitation. But it becomes a scarce resource when the consumption exceeds the availability at a given point in time and/or available freshwater resources get polluted. Water scarcity may also mean scarcity in access due to inefficient water supply management and lack of water-related infrastructure. Global freshwater withdrawals have doubled in the past five decades; the reason being resource-intensive consumption patterns due to population growth, rising per capita incomes and resultant affordability.[20]

Total freshwater withdrawals are the sum of withdrawals for agriculture, industry and municipal uses. **Agriculture has the largest share in global water usage – 70% of all freshwater withdrawal is used for agriculture. In India, 90% of all freshwater withdrawal is consumed by the agriculture sector alone.** This usage pattern made Indian agriculture the largest consumer of freshwater in 2010 with 582 bcm, followed by China (385 bcm).[21]

Water scarcity is a global issue. In its Global Risks Report, 2019, the World Economic Forum (WEF) cited water crisis as the fourth-biggest risk in terms of impact on the global society.[22] Nearly two-thirds of the global population lives under conditions of water scarcity for at least one month every year and nearly half of those people live in India and China. If the current trend of water consumption continues without any efficient water management interventions, more than five billion people around the world could face water shortages for basic needs by 2050.[23]

17 https://www.weforum.org/agenda/2018/10/where-the-water-wars-of-the-future-will-be-fought

18 United States Bureau of Reclamation, 2019

19 The State of the World's Land and Water Resources for food and agriculture, Food and Agriculture Organization (FAO), 2001

20 FAO AQUASTAT 2014

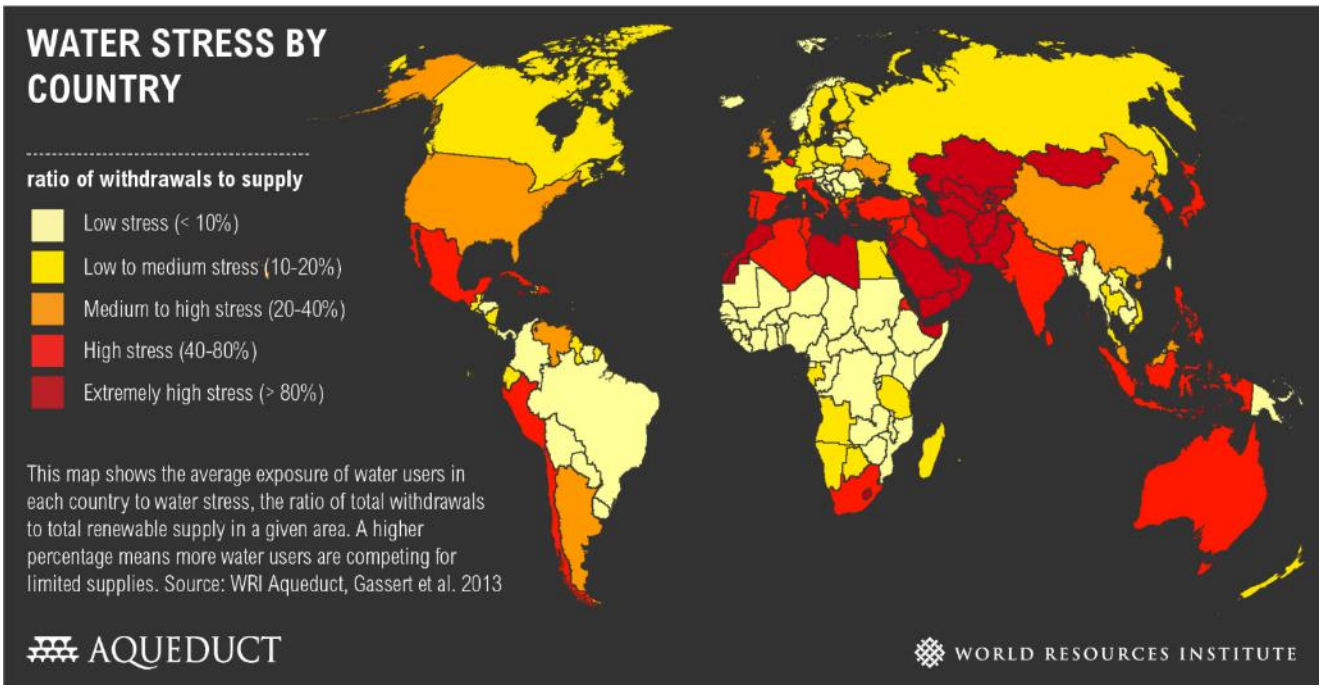
21 https://data.worldbank.org/indicator/ER.H2O.FWAG.ZS

22 The Global Risks Report, 2019, World Economic Forum. (http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf)

23 World Water Development Report, 2018, United Nations (https://unesdoc.unesco.org/ark:/48223/pf0000261424)

Cities worldwide are rapidly running out of freshwater. In recent times, cities are approaching 'day zero,' a reference for the day when they will run out of their utilisable freshwater resources. For example, Cape Town in South Africa was about to face this situation in 2018.[24] There is large variance in levels of water withdrawal across the world. This depends on a range of factors, including latitude, climate and the importance of a country's agricultural or industrial sector. An image depicting the global water stress levels has been shown below:

Water stress level by countries, 2013



Source: The World Resources Institute

The image above shows that water stress is more prevalent in the eastern part of the world than it is in the western part, and most of the Middle-Eastern countries face high to extremely high water stress. This implies that these water-stressed countries withdraw over 80% more water that they have in their reserves. Water scarcity in India is comparable to Australia, Southeast Asian countries, South Africa and Mexico.

In order to maintain constant, sustainable level of water resources within a country, the rate of water withdrawal should always be less than the rate of freshwater replenishment. The internal water resources within a country are also referred to as renewable internal freshwater flows which normally include the internal river flows and the extractable groundwater. The extraction rate of renewable internal freshwater flows is thus an important indicator of water security or scarcity for a country. When the rate of water withdrawal begins to exceed the rate of replenishment of renewable internal freshwater flows, the water resources of a country begin to decline. An indicative example has been provided below for BRICS (Brazil, Russia, India, China and South Africa) nations:

A comparison of BRICS nations in terms of their respective renewable internal freshwater resources and stages of withdrawal[25]

Country	Renewable internal freshwater resources (in bcm)	Percentage of withdrawal
Brazil	5,661	1%
Russia	4,312	1%
India	**1,446**	**45%**
China	2,813	21%
South Africa	45	35%

Source: World Bank

[24] Stephen Leahy, From Not Enough to Too Much, the World's Water Crisis Explained, 22nd March 2018, National Geographic (https://www.nationalgeographic.com/news/2018/03/world-water-day-water-crisis-explained/)

[25] data.worldbank.org, 2014

The availability of internal freshwater resources is an important indicator of how a country is faring in terms of fulfilling the demand of water, and whether a country is water secure or water scarce.

The global population is estimated to reach 9.1 billion by 2050 and 70% of it will live in urban areas,[26] resulting in an increased demand for food. Water is a crucial element in food production. The rising global demand for food and drinking water, the industrial demand for water, coupled with the implications of climate change will further put pressure on the already scarce resource that is water. A common scientific consensus is that climate change will result in extreme weather conditions. The dry regions will become drier and wet regions will become wetter, implying increased incidences of floods and droughts. This may result in loss of agricultural production and reduction in agricultural area. It is thus also important to understand the global actions on mitigating climate change and ensuring water security for future.

2.1.3. Global action on ensuring water security: SDG and UNFCCC highlights

Aware of the global water and climate situation, countries adopted the 2030 Agenda for Sustainable Development in the year 2015, consisting of 17 Sustainable Development Goals (SDGs) to holistically combat water and climate risks, among others. All the SDGs are interlinked with each other and the progress on one goal ensures support for another. **The SDG number 6, while specifically focusing on "ensuring availability and sustainable management of water and sanitation for all," also helps in attainment of the remaining 16 SDGs.[27]** Realisation of this goal is essential for achieving global water security. Giving equal priority to the climate component, countries also entered into the United Nations Framework Convention on Climate Change (UNFCCC) treaty in Paris in 2016. Under this agreement, the participating nations have pledged to address the need to limit the rise of global mean temperature to well below 2°C by end of this century and adapt to the impacts of climate change by building on climate-resilient measures.[28]

India, being a party to the UNFCCC, updates biannually on fulfilment of the Convention's obligations. The Convention enjoins upon all parties, from both developed and developing economies to furnish information, in the form of a national communication regarding implementation of the Convention. Abiding by the decision taken during the Conference of Parties to the UNFCCC in its 16th session, India submits biennial update reports on national greenhouse gas inventories and information on actions taken and support needed and received.

2.2. Water outlook and distress in India

India is a highly water-stressed country, with renewable internal freshwater withdrawals at 45%. It is also the largest extractor of freshwater in the world and nearly 90% of the extracted freshwater is used in the agriculture sector alone. Also, groundwater contributes up to 62% of all the water used for irrigation in India.[29] The rate of groundwater extraction is so severe in India that the country's water table is depleting at a rate of 0.3 metre per year.[30] A comparison of pre-monsoon water level (depth to below ground level) in 2018 with that of the decadal mean pre-monsoon (2008–2017) revealed that water level in at least 50% wells across India is plummeting.[31]

The water extraction behaviour has also impacted the per capita freshwater availability, resulting in its steady decline in the past five decades. A brief analysis of past data reveals that population growth and decline in per capita freshwater availability are inversely proportional. Today, only one-third of per capita water is available as compared to the amount available five decades ago. Urbanisation has further aggravated the problem by putting undue pressure on natural ecosystems that are already turning fragile by unchecked water withdrawals.

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26 How to Feed the World in 2050, The Food and Agriculture Organization of United Nations (FAO), 2009. Retrieved from http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

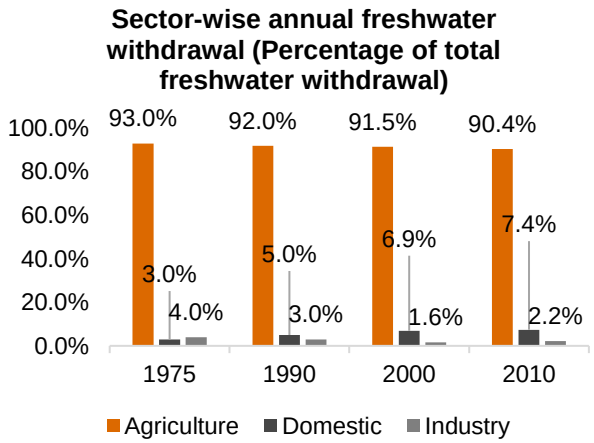
27 Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/?menu=1300) and PwC analysis

28 United Nations Climate Change. Retrieved from https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change

29 National Compilation on Dynamic Groundwater Resources in India, 2019, Central Ground Water Board

30 https://www.thehindubusinessline.com/opinion/its-time-to-tax-groundwater-use/article25994382.ece

31 Composite Water Management Index, 2019, NITI Aayog. Retrieved from http://social.niti.gov.in/uploads/sample/water_index_report2.pdf



Source: World Bank

As the largest consumer of all freshwater extracted in India, the agriculture sector will bear the brunt of the looming water scarcity most harshly. As India's population is expected to increase to 1.66 billion by 2050[32] and per capita income is estimated to increase by 5.5% per annum,[33] the increasing population and purchasing power will lead to increased food demand (more than 250 million tonnes) by 2050.[34] While the per capita consumption of cereals will decrease by 9%, 47% and 60% respectively for rice, coarse cereals and maize, the per capita consumption of sugar, fruits and vegetables will increase by 32%, 65% and 78% respectively.[35] The surge in demand for these water-intensive crops will increase the current agricultural consumption of water. This estimate is in line with German economic Ernst Engel's law, which explains that increasing income brings a decline in the relative importance of food consumption, a wider spread of spending patterns and a demand for higher-quality goods.

2.3. Analysing water distress in the agriculture sector

Agriculture is the predominant source of livelihood in India as 58% of the country's population depends on it[36]. Owing to India's diverse geography and climatic conditions, a variety of crops are grown in the country's 15 agro-climatic zones. Crops are cultivated either in irrigated or rainfed conditions. In case of irrigated crop production, it is noteworthy that 90% of India's freshwater extraction is consumed by the agricultural sector alone. There are high variations in water requirement of different crops. For example, while rice is suited for cultivation in irrigated conditions, coarse cereals such as bajra can be comfortably grown in rainfed conditions. Such variations indicate the need of studying the availability of water sources within the country.

2.3.1. Sector-wise water usage trends

A comparative study of water usage trends in agriculture, domestic and industrial sectors

Globally, water consumption patterns are measured by gathering water consumption data from agriculture, domestic (also referred as municipal/household) and industrial sectors. In India, agriculture accounts for more than 90% of annual freshwater withdrawals in the country. The consumption trend, however, is gradually decreasing – from 93% in 1975 to 90% in 2010.[37]

A similar trend can be observed in China, where agricultural water consumption has declined from 88% in 1980 to 64% in 2015.[38] The other sectors, i.e. domestic and industrial, account for only 2% and 7% of the total water consumed in India. While the consumption trend in the domestic sector is gradually increasing – from just 3% in 1975 to more than double in 2010, the trend in the industrial sector has declined – from 4% in 1975 to its half in 2010.[39] In China, water consumption trends for both domestic and industrial purposes have increased.

32 Ibid. (http://social.niti.gov.in/uploads/sample/water_index_report2.pdf)

33 Ibid. (http://social.niti.gov.in/uploads/sample/water_index_report2.pdf)

34 Ibid. (http://social.niti.gov.in/uploads/sample/water_index_report2.pdf)

35 Composite Water Management Index, 2019, NITI Aayog. Retrieved from http://social.niti.gov.in/uploads/sample/water_index_report2.pdf

36 https://www.ibef.org/industry/agriculture-india.aspx

37 data.worldbank.org, 2014. Retrieved from https://data.worldbank.org/indicator/ER.H2O.FWAG.ZS

38 data.worldbank.org, 2014. Retrieved from https://data.worldbank.org/indicator/ER.H2O.FWAG.ZS

39 data.worldbank.org, 2014

2.3.2. Source-wise water availability and its usage in agriculture

Source-wise water usage in agricultural production systems

There are two sources of renewable internal freshwater resources in India – surface water and groundwater. Rivers are the major source of surface water. The surface water availability in India's rivers is 1,869 bcm, out of which only 37% (690 bcm) is utilisable as the remaining volume eventually drains off into the oceans. In addition, the replenishable groundwater resources amount to 432 bcm, of which 393 bcm is utilisable/extractable. The total utilisable freshwater resources in India amount to 1,083 bcm.[40] Even though the available surface water resources are more than groundwater resources, there is more reliance on groundwater resources for fulfilling agricultural demands. Nearly 62% of India's irrigation needs are met by groundwater, thus putting more pressure on its replenishment rate. The reason for higher contribution of groundwater in irrigation can be attributed to its all-time availability and easy extraction, supplemented by subsidised electricity costs, compared to cost-intensive extraction of surface water from rivers, canals, lakes or ponds. Surface water sources may also be second priority for farmers as their availability is highly dependent on monsoons. Thus, groundwater is an assured source of irrigation round the year while surface water tends to be seasonal in nature and for an individual farmer, portability of surface water is cost-intensive.

Even though India receives ample rainfall annually, there are variations observed in its spatial distribution, varying from 100 mm in Rajasthan to 2,500[41] mm in Assam. Temporally, the country receives an average rainfall of 4,000 bcm annually, nearly 80% of which is received in the four months of June to September. As a result, the rivers carry more than 75% of their annual flows during this period, which often leads to them exceeding their capacity and reach danger levels. The remaining eight months account for only 30% of the annual flows, which is further reduced by rising temperatures during summer. There is also wide variation in geographical distribution of rainfall – ranging from 296 mm in the Indus river basin to 1,800 mm in the Meghna river basin.

2.3.3. Region-wise water availability – a geographical analysis

There is also significant variation observed in volume of water flow in different river basins across the country. The table below gives a clear picture of total renewable internal water flows of river basins in India, which vary widely – from just about 4 bcm in the Sabarmati river basin in western India to as much as 586 bcm in the Brahmaputra basin in the eastern region.[42] It is important to note that only two river basins, i.e. Ganga and Brahmaputra, account for nearly 60% of the total internal river flow in India**.**

Situational analysis of water availability in India's river basins for agricultural water use

Category of river basins	Name	Catchment area (in '000 sq. km)	TRWR[a] (in bcm)	Per capita availability (m^3/year)	Irrigation intensity (in percentage)	States with catchment areas (at least 10% of the area)
Basins of the easterly flowing rivers	Ganga	861	525	1,418	135	Bihar, Haryana, Himachal Pradesh, Madhya Pradesh, Rajasthan, West Bengal, Uttar Pradesh
	Godavari	313	110.5	1,441	120	Andhra Pradesh, Madhya Pradesh, Maharashtra, Orissa
	Krishna	259	78.1	1,133	127	Andhra Pradesh, Maharashtra, Karnataka
	Brahmaputra	194	585.6	17,661	108	Arunachal Pradesh, Assam, Meghalaya, Nagaland, Sikkim, West Bengal
	Mahanadi	142	66.9	2,463	112	Madhya Pradesh, Odisha

40 National Compilation on Dynamic Groundwater Resources in India, 2019, Central Ground Water Board

41 Central Ground Water Board, 2014

42 National Compilation on Dynamic Groundwater Resources in India, 2019, Central Ground Water Board

Category of river basins	Name	Catchment area (in '000 sq. km)	TRWR[a] (in bcm)	Per capita availability (m^3/year)	Irrigation intensity (in percentage)	States with catchment areas (at least 10% of the area)
	EFR2[c]	100	16.5	423	127	Tamil Nadu
	EFR1[b]	87	22.5	1,169	127	Andhra Pradesh, Odisha
	Cauvery	81	21.4	656	127	Karnataka, Tamil Nadu
	Pennar	55	6.3	440	129	Andhra Pradesh
	Brahmani and Baitarani	52	28.5	1,703	121	Odisha
	Meghna	42	48.4	4,830	117	Manipur, Meghalaya, Mizoram, Nagaland, Tripura
Basins of the westerly flowing rivers	WFR2[e]	378	200.9	3,871	126	Goa, Karnataka, Kerala, Maharashtra
	Indus	321	73.3	1,501	177	Punjab, Jammu and Kashmir, Himachal Pradesh, Haryana
	Narmada	99	45.6	2,542	106	Madhya Pradesh
	Tapi	65	14.9	831	120	Maharashtra
	WFR1[d]	56	15.1	257	122	Gujarat, Rajasthan
	Sabarmati	22	3.8	631	122	Gujarat

[a] **TRWR**: Total renewable water resources (sum of utilisable and non-utilisable renewable water resources)

[b] **EFR1**: Easterly flowing rivers – group 1: The easterly flowing small- and medium-sized rivers between the Mahanadi and the Pennar basins.

[c] **EFR2**: Easterly flowing rivers – group 2: The easterly flowing small- and medium-sized rivers between the Pennar basin and the Kanyakumari.

[d] **WFR1**: Westerly flowing rivers – group 1: The westerly flowing rivers in the Kutch and Saurashtra regions in the state of Gujarat, and the Luni river.

[e] **WFR2**: Westerly flowing rivers – group 2: The westerly flowing rivers south of the Tapi basin.

Legend for colour codes: According to the Falkenmark indicator/water stress index:

Water scarcity: Per capita water availability <1000 m^3 per year

Water stress: Per capita water availability <1700 m^3 per year

Source: Central Ground Water Board and PwC analysis

Share in percentage	States and union territories
≤50%	Dadra and Nagar Haveli, Kerala, Goa, Jammu and Kashmir, Delhi, Tripura, Arunachal Pradesh, Nagaland, Manipur, Andaman and Nicobar, Mizoram, Chandigarh, Lakshadweep
>50% and ≤90%	Uttar Pradesh, Tamil Nadu, Rajasthan, Andhra Pradesh, Telangana, Chhattisgarh, Bihar, Odisha, Uttarakhand, Meghalaya, Puducherry, Assam, Himachal Pradesh, Jharkhand
>90%	Punjab, Haryana, Gujarat, Maharashtra, Karnataka, Madhya Pradesh, West Bengal

Source: Central Ground Water Board and PwC analysis

The states where groundwater is most exploited for agriculture are mainly located in the north-western, central and southern regions of the country, with the exception of West Bengal which is located in the eastern region. In terms of groundwater extraction, north-western states such as Punjab, Haryana and Rajasthan fall within the over-exploited category.

Increase in water consumption below the threshold recharge levels may contribute to further depletion and create hydrological imbalance. Going by the current trend in population and water use patterns of both China and India, the countries will need all their surplus resources to meet their water demands in the next 20 years. Groundwater overdraft, a condition in which the rates of extraction from an aquifer exceed the rates of recharge by water percolating from above, occurs in almost every region of the world. It is evident that freshwater reserves are stressed globally. Water withdrawal trends suggest that agriculture production systems are withdrawing groundwater at a much faster rate, resulting in groundwater sources not getting enough time to replenish themselves.



3. Reasons for water distress in the Indian agriculture sector



In the previous sections, we have discussed the state of freshwater availability in India by source, region and sector. Agriculture in is the largest water-consuming sector in India but the overall irrigation efficiency is low. It is thus important to study agricultural water usage patterns across river basins, compare water-intensive/non-intensive cropping patterns with the respective suitability of region-basis water availability, the economics of agricultural water and the role of climate change in agricultural water usage in India.

3.1. River basins and watersheds – a critical situational analysis

A river basin refers to the drainage area of a river and its tributaries. It is also known as watershed or catchment area. A river basin or a watershed supplies water by surface or sub-surface flows to a given drainage system and subsequently discharges off into an ocean. From a few to millions of hectares, watersheds vary widely in size. While watersheds mostly include surface drainage, they do not ignore the contribution by groundwater through the aquifers present in that catchment area. Thus, a river basin or a watershed is the sum of all the land and waterbodies which drain into a stream/watercourse.[43] River basins are the fundamental hosts to a variety of closely-knit socioecological systems and thus, to human civilisation. The various components in a catchment area such as land, vegetation, fauna and human beings are linked together by a common adhesive – water.

The renewable internal water resources of India are usually categorised into 19 major river basins, with smaller basins clustered on basis of their direction of flow and geographical location (refer to the table below). With 8.6 lakh square kilometres, the Ganga river basin has the largest catchment area, and together with the Brahmaputra and the Meghna, it makes up for the largest watershed area in the country, occupying 34% of the total area.[44] The table below shows India's river basin wise catchment areas, total renewable water resources, per capita water availability and irrigation intensity, along with the states that share at least 10% of their geographical area with the respective basins.

Touching Rajasthan and Haryana in the west – states with arid climate, the Ganga flows towards the east through Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal – states with a predominantly monsoon climate. There are also variations observed in the catchment area and river flows, as it is clear from the table above that with less than a quarter of the Ganga's catchment area, the Brahmaputra has more TRWR than the Ganga. However, it is interesting to note that even when the Brahmaputra has the highest volume of water availability, only 8% of it is utilisable due to geographical restrictions.[45]

A comparison of per capita water availability among the river basins displays the real picture of water stress in different regions in India. According to Falkenmark's water stress index, per capita water availability in seven river basins is less than 1,000 m^3 and thus, these river basins are already water scarce. Most of these water-scarce river basins are spread over the western and the southern parts of the country. Speaking of population pressure on river basins, it is noteworthy that the Ganga river basin is home to 40% of the country's population. In comparison, the Brahmaputra houses only 4% of the population while having 30% of the TRWR. Speaking of irrigation intensity, the Indus river basin has the highest pressure on its TRWR with 177% irrigation intensity in the region. This is mainly driven by water-intensive cropping patterns in Punjab, followed by Haryana and the misalignment of crop choices with water availability contributes toward the water supply-demand gap.

It is thus equally important to study the cropping patterns across the states/river basins and establish whether they are suited to the water resources availability of the respective region.

[43] Central Water Commission, 2015

[44] Spatial variation in water supply and demand across river basins of India, 2005, International Water Management Institute

[45] Spatial variation in water supply and demand across river basins of India, 2005, International Water Management Institute

3.2. Overdependence on water-thirsty cropping patterns

India displays contrasting features in agriculture. 90% of the annual freshwater withdrawals in the country is consumed by the agriculture sector alone, but only 49% of the GCA is irrigated.[46] More than half of India's cultivated area is rainfed. This can be attributed to either large spatial variations in water availability leading to high cost of access to water for agricultural purposes, or disproportionate allocation of water to major crops that are grown in the country. While lack of physical access to irrigation water in difficult geographies may still be justified given the time and money required to be spent on making water accessible and affordable for farmers, the disproportionate allocation of irrigation water to different crops in the same region is a matter of concern. Often, this skewed allocation of irrigation water is due to better marketing opportunities and infrastructure available for only a specific set of crops.

Rice, wheat, cotton and sugarcane are the four major crops in India which occupy 46% of GCA but take up 65% of the GIA.[47] These four crops together require up to 70% of all water that is used in agriculture, with rice alone guzzling more than half of what all these four crops require together. This shows that there is significant inequity in availability of irrigation water for other crops. The other major crops such as maize, pulses and oilseeds are mostly grown in rainfed conditions.

It is quite contrasting that Punjab and Maharashtra – the respective leading states in rice and sugarcane production – have 100% irrigated areas under these crops despite these states already facing a major water crisis.[48] also It is important to note that the annual groundwater extraction rate in Punjab is 166%, and thus the state is putting immense pressure on its groundwater resource. Haryana and Rajasthan are other states which are following a similar trend of groundwater exploitation where the volume extracted significantly exceeds the limits.

State-wise irrigation water productivity of paddy vis-à-vis percentage of area irrigated under the crop

States	Irrigation water productivity – paddy (kg/lakh litre)	Percentage of irrigated area out of total paddy area
Bihar	56	63%
Assam	51	11%
West Bengal	42	47%
Tamil Nadu	39	93%
Andhra Pradesh	33	97%
Chhattisgarh	31	35%
Odisha	30	33%
Uttar Pradesh	27	83%
Punjab	19	100%

Source: Indian Council for Research on International Economic Relations (ICRIER) and the National Bank for Agriculture and Rural Development (NABARD)

The table above shows that the situation in Punjab is quite a matter of concern – where almost 100% of the area under paddy is irrigated but the irrigation water productivity (IWP)[49] is the lowest among other major rice producing states. The IWP of rice is higher in eastern states that are also less water-stressed than states like Punjab and Haryana, where neither water is abundant, nor the arid climate is favourable for rice cultivation.[50] Whereas the eastern states like Assam and Bihar have hydro-ecology better suited for water-intensive crops such as rice.

46 Pocket Book of Agricultural Statistics, 2018, Ministry of Agriculture and Farmers' Welfare. Retrieved from https://eands.dacnet.nic.in/PDF/Pocket%20Book%202018.pdf and PwC analysis

47 Pocket Book of Agricultural Statistics, 2018, Ministry of Agriculture and Farmers' Welfare

48 Towards Sustainable, Productive and Profitable Agriculture: Case of Rice and Sugarcane, 2018, Indian Council for Research on International Economic Relations (ICRIER)

49 Irrigation Water Productivity (IWP) estimates crop yield obtained per unit of irrigation water applied.

50 Water Productivity Mapping of Major Indian Crops, 2018, Indian Council for Research on International Economic Relations (ICRIER) and National Bank for Agriculture and Rural Development (NABARD)

Indicators of water uptake by four major water-intensive crops[51]

Crop	GCA (in million hectares)	GIA (in million hectares)	Total consumptive water use (TCWU) (in bcm)	Average IWP (kg/m^3)
Rice	43.3	26.0	206.2	0.4
Wheat	30.2	28.5	82.7	0.8
Sugarcane	4.9	4.5	57.4	4.4
Cotton	11.9	4.0	51.1	-

Source: ICRIER and NABARD

Similarly, in the case of sugarcane, Uttar Pradesh (10.2 kg/m^3) and Bihar (12.4 kg/m^3) have much higher IWP than the states of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu (ranging from 3.5–4.5 kg/m^3). This shows a mismatch between the IWP and the cropping pattern of sugarcane in water-stressed states in India, which needs to be corrected through improving the water-use efficiency of irrigation water in water-stressed states and promotion of sugar cooperatives/industry in water-abundant states.

In the case of wheat, although it is a water-intensive crop, the cropping pattern is more or less in line with IWP of major wheat-growing states. For example, Punjab and Haryana have high IWP (1.2 and 1 kg/m^3 respectively), as well as land productivity (4.6 and 4.4 tonnes/hectare respectively) as compared to Madhya Pradesh, Maharashtra and Gujarat, which have hot and dry weather conditions and suffer from dwindling water resources.

The above-mentioned examples of the four most water-intensive crops grown in India indicate the need of efficient water resource management in agriculture. It is thus important to delve deep into understanding the agri-water economics in the present context of hydrology.

3.3. Hydrology and the agri-water economics

Depending on the season, availability and access to water, agriculture is largely either irrigated or rainfed. Irrigation can either be a natural process using precipitation during monsoons or can be an artificial one, in which water is supplied via canals/tanks and extracted through diesel-operated pump sets. The application of irrigation water to a crop is closely related with its yield, and that is why irrigation, along with proper doses of fertilisers, is crucial for enhanced yields from crop production. However, excessive irrigation can also lead to decreased crop yields. Excessive irrigation may either be a result of the perceived free nature of water as an input as compared to other agri inputs such as seeds, fertilisers and agro-chemicals, or the inability to control water supply from canals/tanks/reservoirs. It is therefore important to understand water rights and entitlements in the context of both surface and groundwater extraction.

Water rights and entitlements

The nature of water as an ‘economic good’ is complex when compared to other goods. While water is a private good when used on a farm, it is considered as public good when left in situ such as in rivers and lakes. Further, the consumption of water is largely at a private/individual level. For example, a farmer uses water for agriculture, an urban/rural resident uses it for domestic purposes and a papermill owner uses it for paper manufacturing, but its ownership and delivery is usually owned by the government. In case of groundwater, the water rights are tied with the riparian land rights vested with the landowners, which allow them to extract groundwater unchecked, without any metering (except for the electricity used to extract groundwater) and monitoring mechanism. This carries negative implications on the distribution as well as sustainability of groundwater resources within the country. Water pricing is therefore crucial in putting a check on injudicious water use in agriculture.

[51] Pocket Book of Agricultural Statistics, 2018, Ministry of Agriculture & Farmers’ Welfare

Water pricing

Water pricing refers to the price to be paid by a user to access water. Globally, there are two main types of pricing mechanisms – flat rate or fixed charge based on land area and volumetric supply charge based on fluctuating/actual water requirement in a given point in time. Fair water pricing can be achieved by establishing clear access rights, setting a cap on water allocations (which can depend on region, crop water requirement, cropped area, etc.) and other scientific measures. It is equally important to take the economics of adoption into consideration. For example, if farmers perceive these measures as beneficial, only then they are more likely to adopt them.

The efforts towards bringing in clear water rights and transparent water pricing for equitable distribution of water are incomplete if the global and local effects of climate change are not taken into consideration. The adverse effects of climate change are more evident today time as water-related disasters such as floods and droughts are on the rise. Thus, it is crucial to understand and be aware of the effects of climate change on the availability of water, especially for Indian agriculture.

3.4. Climate change and virtual water trade in agriculture

Water scarcity, coupled with the implications of climate change, results in displacement of human settlements and mass migration of wildlife. India's unique geography is highly vulnerable to impacts of climate change. Rise in mean temperatures may lead to increased incidences of natural disasters, especially water-related ones such as floods and droughts. This will impact agricultural production systems in India, that are already facing the risk of limited land supply for food production due to increasing population and the resultant need for increased housing. Enhancing water-use efficiency in agriculture becomes even more crucial to achieve sustainable availability of water in future.

An initial indication of water-use efficiency in India can be drawn from studying the country's virtual water trade. Estimates suggest that India exported around 25 bcm of water embedded in its agricultural products in 2010, which equals to food demand for nearly 13 million people.[52] The country was a net importer of embedded (i.e. virtual) water during the pre-liberalisation era, but with increasing food exports, especially rice, which consumes more than 200 bcm of water for production, India has become a net exporter of virtual water. While the ratio of export to import of virtual water is only 0.1 for China, it is 4 for India.[53] Water used in agriculture and exports from India need to be efficiently managed, and a shift is required towards practising low-carbon, climate-resilient agriculture.

3.5. Challenges in scaling water use management in agriculture

The main challenges in sustainable water use management in agriculture are the automatic ownership on water resources through land ownership, encouraging unchecked groundwater withdrawals for crop production, general practice of inefficient irrigation methods (such as flood irrigation) by farmers, and production of water-intensive crops in water-stressed regions. In addition, where check dams are constructed, the downstream catchment area is often flooded during monsoons due to opening of flood gates, leading to economic loss. This also results in inefficient floodwater management due to lack of appropriately located storage structures.

[52] Water and Agriculture in India, 2017, OAV – German Asia-Pacific Business Association. Retrieved from https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf

[53] Water and Agriculture in India, 2017, OAV – German Asia-Pacific Business Association

Despite several measures undertaken by the Central and state governments to enhance water use efficiency, the challenges in scaling often make it difficult for such projects to be executed. These challenges in scaling can be categorised into the following three segments:[54]

Sl.	Challenges	Underlying issues in the challenge
1	**Financial issues**	• Lack of access to capital: Farmers are unable to access financial resources to pay for the necessary upfront costs of a lever. • Requirement of high upfront capital: Even when capital is accessible, the upfront costs are high. • High transaction costs: The transaction costs of accessing capital are high.
2	**Structural and organisational capacity**	• Limited management capacity: The existing capacity of public and private stakeholders is not sufficient to carry out the projects undertaken to improve efficient use of water in agriculture. • Unclear lines of authority: The responsibility to implement a measure lies across multiple agencies without a clear line of authority.
3	**Social and behavioural**	• Lack of awareness: There exists a lack of awareness on how a specific measure can be beneficial for farmers. • Water has low mindshare for farmers: Improving water efficiency is not a priority in farmers' decision-making process. • Difficult to measure consumption: It is difficult to measure water consumption at farm level.

Source: Water Resources Group

There is a growing need to strategise on enhancing both the availability and efficiency of water use in agriculture. Researchers and policymakers need to collaborate, discuss and align policies with modern, more resilient technologies for charting out a water-secure future for India.



[54] Charting Our Water Future: Economic frameworks to inform decision-making, 2009, 2030 Water Resources Group

4. Identifying best practices and policy frameworks



4.1. Government of India's (GoI) schemes and vision towards improving water efficiency and availability

Water in India is considered to be a freely available public good and holding property titles gives the owner the right to exploit the community groundwater for private and agricultural use. Also, the overdependence on groundwater has resulted in a decline in its reserves. The Central Ground Water Board has categorised 16.2 % of the total assessment units, i.e. blocks, mandals and talukas, numbering 6,607, as overutilised.[55]

To identify best practices related to water management, the GoI formed the Ministry of Jal Shakti in 2019 and merged all the linked functions under the Ministry of Water Resources and the Ministry of Drinking Water and Sanitation. The GoI had launched various schemes to improve water resource management in past and renewed them periodically as per the changing requirements at local, state and national levels. Some of the major initiatives, programmes and schemes structured and promoted centrally by the GoI for ensuring water sustainability in irrigation are mentioned below.

- **National Water Policy (NWP):[56]** First launched in September 1987 and updated subsequently in 2002 and 2012.
- **National Water Mission:**[57] The GoI had established the National Water Mission as one of the eight national missions under the National Action Plan on Climate Change (NAPCC). The Union Cabinet approved (on 6 April 2011) the comprehensive mission document for the National Water Mission (NWM).
- **Jal Jeevan Mission:**[58] In order to provide a functional household tap connection (FHTC) to every rural household, i.e. Har Ghar Nal Se Jal (HGNSJ) by 2024, the existing National Rural Drinking Water (NRDW) Programme has been restructured into the Jal Jeevan Mission (JJM) by the GoI. The scheme aims to provide a tap connection to every household with 55 litres per capita per day as a service delivery benchmark.
- **Jal Shakti Abhiyan:**[59] With an aim to create awareness about water conservation and water security, the campaign was launched on 1 July 2019 and continued till the end of September 2019.
- **Micro irrigation fund:**[60] The GoI, along with the National Bank for Agriculture and Rural Development (NABARD), has created a fund which has been approved with an initial funding of INR 5,000 crore (INR 2,000 crore for 2018–2019 and INR 3,000 crore for 2019–2020), with an aim to promote public and private investments in the micro-irrigation space and mobilise resources for expanding its coverage.
- **Composite water management index:**[61] To oversee water use efficiency and effective resource management at the state level, the ministry of Jal Shakti has developed the Composite Water Management Index (CWMI) in collaboration with NITI Aayog.
- **Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):[62]** The programme was launched in July 2015 with prime objectives of convergence of investment in irrigation at the field level, expanding total irrigated land under cultivation, improving water use efficiency and adopting precision irrigation technologies.

55 http://cgwb.gov.in/GW-Assessment/GWRA-2017-National-Compilation.pdf
56 http://mowr.gov.in/policies-guideline/policies/national-water-policy
57 http://nwm.gov.in/?q=about-us
58 https://jalshakti-ddws.gov.in/sites/default/files/JJM_note.pdf
59 https://jalshakti-ddws.gov.in/
60 https://pmksy.gov.in/microirrigation/Archive/Guideline_MIF03082018.pdf
61 http://social.niti.gov.in/uploads/sample/water_index_report2.pdf
62 https://pmksy.gov.in/AboutPMKSY.aspx

The schemes and policies undertaken by the GoI are some of the major commendable efforts in the agri-water space to increase the overall irrigated area. One important scheme launched in 2015 is the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). This scheme provides for an established framework to increase efficiency and reach of water used in irrigation. Some of the micro-level propositions of PMKSY like Jal Sanchay and Jal Sinchan focus on creating assured irrigation sources and bringing in a protectionist approach through rainwater harvesting.

The programme architecture of PMKSY follows a decentralised planning strategy where state-level planning and projectised execution approach allows individual states to formulate customised irrigation development plans for them based on their specific district irrigation plans (DIPs) and state irrigation plans (SIPs)

The above efforts seem to work with similar approaches towards normal and chronic water-stressed areas, which brings the need for specialised solutions under the PMKSY scheme for chronically water-stressed areas where normal measures and present strategies are inutile. Linking of chronic water-stressed areas with normal water/water-abundant areas can be one such specialised approach. Such areas are an ideal place for calculated interventions of watershed development along with livelihood support activities, i.e. convergence with the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). Furthermore, the NWP, 2012, has emphasised on the importance of participatory irrigation management (PIM) systems and water user associations (WUAs) in execution of large-/small-scale irrigation projects where active involvement of people increases the project's success rate. The priorities under the NWP are:

- completion of underway irrigation projects over commencement of new projects through strengthening of related programmes such as the Command Area Development Programme (CADP) and the Accelerated Irrigation Benefits Programme (AIBP)
- institutional restructuring of local water institutions which play a critical role in water management
- strengthening of PIM programmes and WUAs.

In India, the complex legal, constitutional and social issues involved in creating suitable institutional strategies for effective water resource management make the process slow and challenging. Some states like Andhra Pradesh (south-eastern coast of India), Madhya Pradesh (central India) and Maharashtra (western India) have implemented suitable reforms and policies in irrigation management and substantially improved their agri-water situation. These states have also worked towards strengthening water institutions and governance structures by adopting ideal regulations to promote PIM.

4.2. State interventions/ policies/schemes in the agri-water space

In addition to initiatives undertaken by the GoI, many states have recognised the threat of water scarcity in their region. To promote decentralised water management and drive the adoption of sustainable water management practices, the states have designed PIM programmes. This chapter highlights some of the prominent programmes undertaken by states. Other states could potentially replicate these programmes to tackle the issues of water scarcity.



State	Name of the initiative	Interventions	Achievements/Outcomes
Telangana	Mission Kakatiya (launched in 2014)[63]	The mission aims to restore minor irrigation water resources and infrastructure like ponds and tanks. It focuses on community-based irrigation management in a decentralised manner. The mission adopted a comprehensive programme for restoration of tanks and water sources to effectively utilise 265 thousand cubic metre (tmc) of water allocated for minor irrigation sectors under the Godavari and the Krishna river basins.	• The intervention bridged the 63% ayacut (area served by an irrigation project) gap and also helped in the stabilisation of ayacut under minor irrigation. • Over 22,500 tanks had been restored till March 2018, as per reports. The mission led to an increase in the gross area irrigated under tank ayacut by 51.5% compared to the base year (2014).
Rajasthan	Mukhya Mantri Jal Swavlamban Abhiyan (launched in 2016)[64]	The programme aims to make villages self-sufficient in water usage through a participatory water management approach. Use of advanced technologies such as drones to identify water bodies for restoration is one unique feature of the programme. The gram sabhas in villages are responsible for budgeting of water resources for different uses and providing greater power to the community members in decision-making.	• 7,742 villages in Rajasthan benefited from 2.3 lakh water conservation activities in the first phase. • 1.35 lakh water conservation structures were created in 4,213 villages in the second phase. • Benefited more than 88 lakh people and 93 lakh heads of livestock, covering an area of more than 33.50 lakh hectares. • After the first phase, water supply through tankers reduced by 56%.
Rajasthan	Narmada Canal Project (from 1989–2017)[65]	The Narmada Canal Project was the first project where irrigation with sprinkler and drips was made mandatory. Establishment of integrated irrigation system that comprises canal systems, micro-irrigation facilities and a network that handles the problems of salinity, soil moisture, drainage, etc. Some key features of the project were: • mandatory use of sprinkler/drip irrigation technology • PIM with formation of 2,236 WUAs for effective water management • judicious usage of bio-drainage in command area and tree plantation along the 1,570 km length of the canal.	• Culturable command area (CCA) increased from 1.35 lakh hectares to 2.46 lakh hectares though the quantity of water used remained the same. This was done by adopting micro-irrigation techniques such as drip and sprinkler system in the entire project. Key outcomes of the project are: • irrigation intervention enabled extension of benefit from 89 villages to 233. • food production increased from worth INR 534 crore to INR 1,480 crore, i.e. by INR 946 crore (277%), in 2013–14. • in the modified project, 20% of the area was dedicated to growing kharif crop.

63 https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf. Section, 1 Page 6 and http://missionkakatiya.cgg.gov.in/

64 http://mowr.gov.in/sites/default/files/BP_State.pdf S12

65 http://nwm.gov.in/sites/default/files/waterwiki/14.pdf

State	Name of the initiative	Interventions	Achievements/Outcomes
Andhra Pradesh	Neeru Chettu (launched in 2015)[66]	The Neeru Chettu programme was launched to make the state **drought-proof** and reduce economic inequalities through better water conversation and management practices. Repair, renovation and maintenance of irrigation assets are the key objectives under the programme and the state government prioritised to complete such activities before monsoon.	• The state has repaired about 7,000 farm ponds and over 22,000 check dams under the programme. • Additionally, 102 lift irrigation schemes have been commissioned or revived by the state. • Efforts under the Neeru Chettu programme have enabled irrigation access to nearly 2,10,000 acres of land in the state.
Maharashtra	Participatory Irrigation Management: Waghad (launched in 2011)[67]	Key objectives of the programme are: • to promote conjunctive use of surface and ground water • enforcement of water use entitlement (WUE), monitored and regulated by the Water Resources Regulatory Authority of Maharashtra • steps taken up to achieve equitable distribution of the resources using the tail to head principle • farmers contributing INR 50 lakh for rehabilitation costs and 15% of the cost for building an office.	• Higher water use efficiency and water productivity with water-saving of up to 27%. • Additionally, the drip irrigation coverage increased from 25% to 40% from 2011–2017. • **100% recovery of water charges.** • Total area benefited by the project was around 10,000 hectares and overall irrigation area increased from 7,885 hectares to 9,354 hectares. • Waghad witnessed a rise in average annual income from INR 60,000 to INR 292,139 from 2014–2017.
Gujarat	Micro-irrigation Scheme under the Gujarat Green Revolution Company (GGRC) (launched in 2005)[68]	With an objective to revolutionise agriculture in Gujarat, the state government had incorporated a special purpose vehicle (SPV) named the Gujrat Green Revolution Company for promotion and implementation of micro-irrigation in Gujarat. The initiative embarked upon the Jal Sanchay Abhiyan which is a drive for water storage. Micro-irrigation is an integral part of the programme. The GGRC initiative also took care to provide electricity connections on priority basis to approximately 116,146 farmers who adopted micro-irrigation on their agricultural lands.	• A total number of 18.51 lakh farmers[69] have adopted micro-irrigation systems in a total area of 11.45 lakh hectares. • GGRC's work in the Banaskantha district was recognised by the Pradhan Mantri Krishi Sinchayee Yojana and GCRC was awarded the Prime Minister's Award for Excellence in Public Administration. • Gujarat has achieved double digit growth in the agriculture sector and the state is a pioneer of second green revolution in the country.

66 http://mowr.gov.in/sites/default/files/BP_State.pdf S2, 4.

67 https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf. Case 5, 13–14.

68 https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf. Case 6, 16.

69 https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf. Case 6, 16.

State	Name of the initiative	Interventions	Achievements/Outcomes
Gujarat	Bhungroo [70]	It is a rainwater harvesting and management system recognised and awarded by the World Bank. • Steps such as installation of one unit with sub-surface storage at three levels between 25 to 110 feet with a total capacity of 2 crore litres was implemented. • Piezometers were installed to monitor for water levels on a day-to-day basis.	• Artificial recharging of aquifers by adding rainwater to underground water reservoirs enables the communities to continue farming for more than half of the year. • The massive underground reservoir can hold as much as 40 million litres of rainwater. It harvests water for about 10 days per year and can supply water for as long as seven months.
Madhya Pradesh	Kapil Dhara Yojana (launched in 2011)[71]	It is developed under the MGNREGS to provide irrigation facilities on private land owned by small and marginal farmers, through the construction of dug wells, farm ponds, check dams, etc. The programme focuses on providing financial support to landholders without access to irrigation facilities and prioritises marginalised communities to maximise impact.	• The programme has contributed to improved productivity, intensity, and diversity of crop production in the region and generated livelihood sources.
Bihar	Jal Jeevan Hariyali Programme (launched in 2019)[72]	It is a programme launched as a part of the Bihar Agriculture Road Map 2017–22. As a subcomponent, water conservation is one of the prime objectives of the Jal Jeevan Hariyali programme. The proposed interventions of the programme are: • identification and renovation of ponds and other traditional modes of water conservation like **aahar** and **pyne** • conducting aerial survey using satellite mapping and drone technology to identify waterbodies.	• To revive 4.238 lakh hectares of irrigational capacity lost earlier, by March 2022. • To increase the existing irrigation capacity of 26.69 lakh hectares to 36.313 lakh hectares, by March 2022. • To provide protection from floods to an area of 15.35 lakh hectares by constructing 1,731 km of new embankments between the years 2017–22. • To make lining of canals, make new channels or restore the old canals as required, in order to ensure that the water reaches the last point of the canal.

70 https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf.Case 8, 19.

71 http://mowr.gov.in/sites/default/files/BP_State.pdf.Section 5, 10.

72 http://www.jaljeevanhariyali.bih.nic.in/JalJeevanHaryali/Default.aspx, https://www.bvm.bihar.gov.in/content/684/mission; http://wrd.bih.nic.in/

State	Name of the initiative	Interventions	Achievements/Outcomes
Telangana	System of Water for Agriculture Rejuvenation (SWAR)[73]	Invented by the Centre for Environment Concerns (CEC), Hyderabad. It involves storing of water in overhead tanks and sending it through a small diameter pipe to a customised, locally made clay pot that is buried near the root area. The pot contains micro-tubes that transmit water through a sand pouch, to prevent the roots from invading the pipes and the pot.	• The government has placed orders for implementation of the system across an area of 400 acres in Anantapur, Kurnool and Chittoor. • For cultivation of vegetables and fruits, where close planting is done, it was discovered that one-eighth of water suffices, compared to drip irrigation. • SWAR received the Global Champion Innovation Prize for Water and Forestry at the 2015 Paris International Agricultural Show.[74]
Odisha	Orissa Water Resource Consolidation Project (OWRCP) [75]	It is a PIM programme backed by the Pani Panchayats Act (2002). PIM was introduced in Odisha in 1995 on a pilot basis under the Orissa Water Resources Consolidation Project (OWRCP), which was extended to all the commands of major, medium, minor and lift irrigation projects.	• 30,033 pani panchayats have been programmed, out of which 28,105 have been formed by conducting elections. • Mayurbhanj district recorded 36% more cultivation due to PIM through pani panchayats. • Regular on and off campus training programmes held.

4.3. Drought proofing strategies

India's has witnessed some disastrous droughts throughout history. The droughts of 1877 and 1899 resulted in 38 lakh and 12 lakh deaths respectively, as reported by the famine commissions appointed during British rule in India.[76] The twentieth and the twenty-first centuries also witnessed droughts and though huge loss of life was avoided, the economic toll on the country was significant. Therefore, it is imperative to implement drought proofing strategies for creating a socioeconomic balance in the country.

4.3.1. Impact of droughts on the agriculture production system

In India, the seasonal and spatial variability in rainfall makes 68% of the total country area prone to drought in varying degrees. 35% of the area which receives **rainfall between 750 mm and 1,125 mm is considered as drought prone,** i.e. the states of Andhra Pradesh, Telangana, Tamil Nadu, Punjab, Haryana, eastern Uttar Pradesh, parts of Karnataka, Maharashtra, Rajasthan Madhya Pradesh, Bihar and West Bengal. **33% of the area receiving less than 750 mm is chronically drought prone,** i.e. Gujarat, parts of Rajasthan, Madhya Pradesh and Maharashtra.[77]

Concerns of drought have grown more in recent years due to erratic rainfall patterns becoming more frequent over the last few decades due to climate change, thereby increasing the likelihood of short-term crop failures and long-term production shortages. Smallholders and agricultural labourers who are poor and have very few assets and limited access to credit and insurance are the worst affected. It is crucial for local bodies, the Central and the state governments and water resource management institutions to monitor drought conditions and work on mitigation strategies.

[73] https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf. Case 7, 17.
[74] https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf. Case 7, 17.
[75] https://niti.gov.in/writereaddata/files/document_publication/BestPractices-in-Water-Management.pdf.Case 9, 21.
[76] http://egyankosh.ac.in/bitstream/123456789/25200/1/Unit-6.pdf
[77] http://mowr.gov.in/brief-drought

4.3.2. Different types of drought – creating socioeconomic imbalances

Drought is unavoidable in India. It is a frequent natural weather condition and we face mild to severe drought-like situations at one or different parts of the country, at the same or different points of time. Therefore, it is necessary to understand the different types of droughts that could create socioeconomic imbalances. As a widely accepted weather condition, drought can be technically explained as a duration of time when an area or region experiences below normal rainfall, resulting in low soil moisture, fall in groundwater, diminished stream flow, crop damage and general water shortage. Researchers have more formal definitions of types of drought. Droughts can be commonly classified into four major categories based on their severity.[78]



Meteorological drought

A situation when normal rainfall decreases significantly (>25%).



Hydrological drought

When a metrological drought is prolonged, resulting in marked depletion of surface and groundwater and leading to drying of reservoirs



Soil moisture/agricultural drought

When the soil moisture is inadequate for supporting healthy crop growth, resulting in crop stress and wilting



Socioeconomic/ecological drought

When the drought results in declining food reserves, leading to famine, poverty and environmental degradation

Unlike many other natural weather conditions or disasters, it is difficult to identify the starting point of a drought and it may take weeks or months to determine that a drought has started. Similarly, the end point is also difficult to identify and hence a drought may last for weeks, months or even years.

4.3.3. Drought proofing measures

In order to bring drought resilience to agriculture in India, sufficient drought proofing measures ought to be incorporated in water resource management, with an integrated approach at national, state and local levels. Looking at the nationwide rise in droughts, it is time that the government focuses on drought mitigation measures rather than drought management. Mitigation in the context of a drought refers to activities which can be undertaken prior to or at the initial stage of a drought to help reduce its overall effects. Going forward with these mitigation actions is not only a crucial step towards adaptation to climate change but can also restore ecological balance and result in developmental benefits for people at large. Few such important measures and strategies are discussed in this section.

A. Contingency crop planning

Contingency crop planning offers different options to cultivate different crops which can be resilient against drought conditions. This contingency plan for alternative cropping includes selection of adequate crops or varieties, optional strategies, mid-season rectifications and identifying the crop saving measures. This contingency plan for crops should be:

- ready prior to starting of rabi and kharif crop seasons, as per the suitability of the agro-climatic region
- revisited within 2–3 years in order to reap the benefits of new varieties of crops and to get advantage of improved technologies in agriculture production
- promoters of crop diversification, intercropping (main crop with drought-resilient crop), weeding, mulching and micro-irrigation techniques.

In order to make the crop contingency plan more efficient, the information pertaining to spatial and temporal distribution of rainfall across the country in both kharif and rabi seasons should be taken into account, as the uncertainty in climatic behaviours of a region has a direct effect on its crop contingency plan. Exhaustive mass media campaigns should be carried out by the state governments for creating awareness amongst the farmers about the contingency cropping plan. WUAs and self-help groups (SHGs) can be utilised for propagating this type of planning, mid-season rectifications and crop saving techniques. A tentative contingency cropping plan is tabled below.

[78] https://www.nationalgeographic.org/encyclopedia/drought/

Crops that are affected by rainfall deficit[79]	Alternate crops
Paddy	Pulses, gram, fodder and oilseeds
Maize	Oilseeds and pulses
Cotton	Soybean and pulses
Sugarcane	Fodder and Pulses

Source: NITI Aayog

B. Rainwater harvesting and conservation methods

One of the most effective measures for conserving and recharging groundwater is rainwater harvesting. This also prevents the loss of freshwater in the forms of surface runoff and seepage. This is a traditional method of stocking excess precipitation, collecting runoff in catchment areas and directing them towards human settlements for consumption. This is broadly categorised into two methods, namely:

- **Modern artificial methods:** These include watershed-based methods (integrated techniques for groundwater recharge, viz. tanks, anicuts, dams, artificial recharge and percolation) to harvest and conserve water in order to revive the high-capacity aquifers facing depletion. A few important methods which are a part of modern artificial methods are:
    - Contour bunding, contour trenching, contour cultivation, bench terracing graded bunding, gully plugging are some of the water conservation farming methods typically suggested for hilly terrains to impound runoff water and conserve runoff water as soil moisture. This includes construction of bunds with narrow base or creating trenches (in an intermittent manner) across the slope of land and develop small earthen bunds on the downstream side.
    - *Nala* bunding, check dams, farm ponds, percolation tanks/spreading basins are created in areas with relatively high rainfall. These practices comprise establishing masonry-based embankments throughout the *nala* or the stream with due arrangements created for surplus, navigable canals at appropriate intervals. Such structures result in capturing the maximum runoff water with arrangements placed at appropriate intervals to drain excess water. This appropriation technique enables water infiltration into the deeper soil and facilitates cultivating land under the *nala*'s bed.
    - The most appropriate artificial structure for encouraging groundwater recharge is a sub-surface barrier. The said structure is safe from flood occurrences as it is constructed beneath the riverbed. Construction of two sub-surface embankments (measuring 100 metres in length) at an interval of 300 metres between upstream and downstream water supply sources can result in holding and infiltration of sufficient water to cater to a village with a population 500. Even injection wells could be promoted in a land-scarce area as their structures are similar to tube wells, aiming at enhancing the storage of groundwater in aquifers through pressure-based pumping of treated surface water. In comparison to these artificial recharge methods, injection wells cost more and depend on specialised tube well construction facilitated by operations and maintenance (O&M) in order to avoid blockages in recharge.
    - Micro-irrigation systems made up of drips and sprinklers provide for a scientific water management system that could be used for irrigation. This has proven to reduce water consumption and enhancing the water use efficiency (WUE) of the region.
- **Traditional methods**: In India, traditional structures and techniques for water harvesting have been present for years. Varying ecological areas have different water conservation and harvesting structures, the rejuvenation of which can be something state governments can work towards, through specialised schemes. Some such traditional and prominent structures are the dug well recharge system, village ponds/tanks, *khadin* and other structures known by different names across the country.

[79] http://nicra-icar.in/nicrarevised/images/statewiseplans/Contingency%20crop%20bk_27-7-2012%20Full%20Book%20Proof%2028-7-2012-High-1.pdf

C. Long-term approaches

Besides the above measures, long-term drought proofing measures and strategies are required. The long-term strategies would be beneficial to mitigate potential risks efficiently. Some such long-term strategies are:

- **Afforestation**: Afforestation in areas vulnerable to droughts is an effective measure for creating drought resilience. Barren lands with no trees face adverse soil erosion and require vegetation coverage to subdue the effects of droughts. Such areas suffer from huge surface runoff, because of which not even subsistence or marginal agriculture is practised in the adjacent locations. To resolve this problem, trees can be planted in vulnerable areas such as hill slopes and catchment areas. Vegetation development in such areas can prove quite advantageous with benefits such as avoiding soil erosion, reducing runoff, adjusting the drainage (including underground), enhancing water holding capacity – leading to enhanced soil productivity.

    - **Drought mitigation through community participation**: Community participation is an integral component of drought mitigation programmes. Government policies and programmes should encourage management of water resources through community participation as localised management of water and rainwater harvesting are key to achieving drought proofing. Therefore, WUAs, SHGs, FPOs, and other such community-based institutions can be vital in water management at micro levels.

    - **Climate variability and adaptation:** Annually, the climate of a specific area varies from one point in time to another. Due to the ubiquitous occurrence of climate change, India's agriculture is bound to be affected. Variability in climate changes affects the hydrological cycle, resulting in different parts of the country facing severe droughts or intense floods. The effect will extend to livelihood activities linked to the cultivation practices. Adaptation consists of developing, improving and implementing techniques aimed at restraining, managing or benefiting from the climatic occurrences. Some of the examples of adaptation are intercropping, fodder cultivation, home stead gardens, short-term cropping, fish cultivation and rainwater harvesting through pond construction. Such livelihood-linked practices can be an integral part of drought management programmes due to their ability to enhance farmers' adaptability.

    - **Crop insurance:** Agricultural insurance can help in reducing the adverse financial burden incurred by farmers due to droughts. Even though India's experience with agricultural insurance schemes has not been conducive, multiple initiatives have been taken by the Central and the state governments to enhance insurance coverage and reach.



4.4. Successful best practices, CSR initiatives – learnings worth emulation

There are multiple best practices at the community, government and private levels. This section looks at some of the best practices and learnings so that their success could result in stakeholders considering the adoption of such methods.

4.4.1. Practices for water resource management in agriculture

- **International best practices**: Some of the best international practices that are sustainable and could be customised for our country are tabulated below.

Some examples of PPP irrigation system management

Project	PPP model	Details	Risk management	Takeaways
El Guerdane project (Morocco)	Design-build-operate (DBO)	• Construction of a 300-km irrigation network. Manages irrigation network to channel water from the dam and distribute it to farmers in Guerdane. Existing infrastructure to be handover to government after 30 years. • Exclusivity to channel and distribute irrigation water in the perimeter	• The construction (time and costs) and the collection risks were transferred to the concessionaire. • The government was responsible for ensuring water security. • Demand/payment risk was mitigated by carrying out an initial subscription campaign whereby farmers paid an initial fee covering the average cost of on-farm connection. • Water shortage risk allocated among the private partner (up to a consequential revenue loss capped at 15%), the farmers (via the application of a tariff surcharge in case of drought leading to a shortage of water, capped at 10% of the tariff), and the government (sustaining the risk of more significant water shortage through a financial compensation to the private partner).	• Selection criteria based on lowest water tariff. • Water tariff maintained equivalent to current pumping costs, making them affordable to farmers. • The tariff quoted was lower than Guerdane farmers paid for irrigated groundwater supplies.

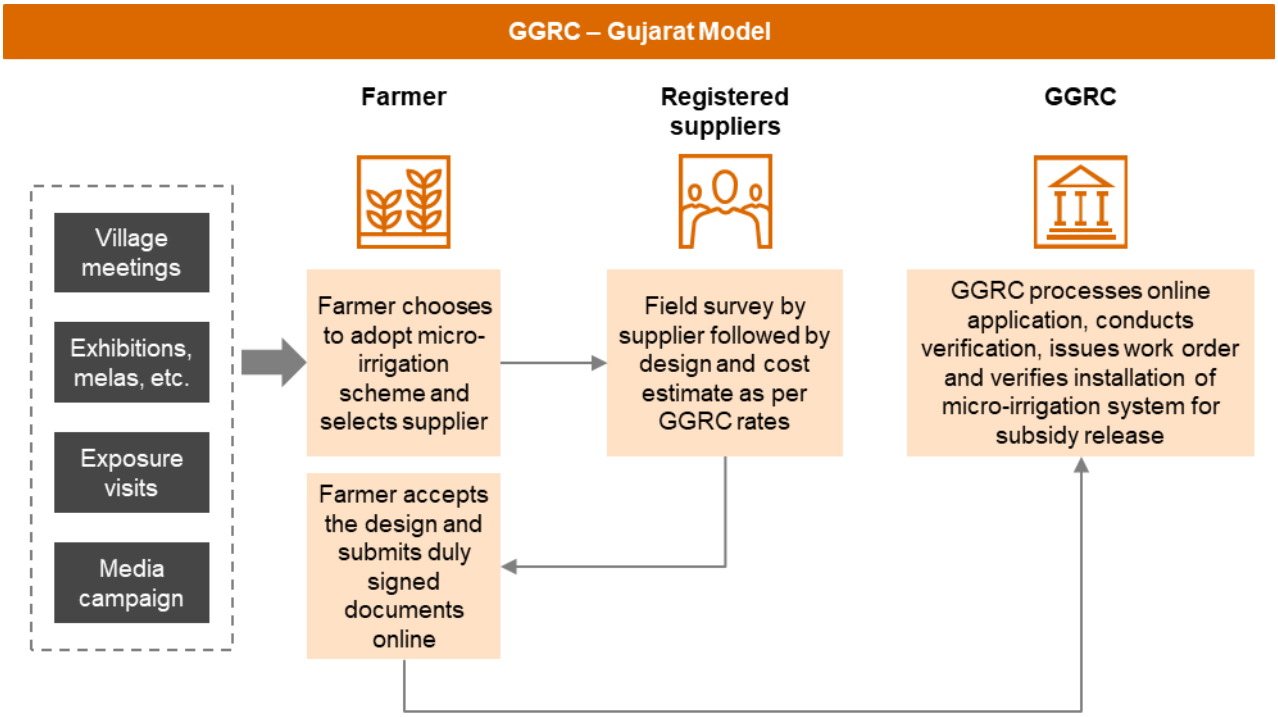
Project	PPP model	Details	Risk management	Takeaways
Megech-Seraba Irrigation Scheme (Ethiopia)	O&M funded by the International Development Association (IDA)	• The project provides water to over 6,000 landholdings over a 4,040-hectare irrigated area in Megech, Ribb River, and Anger Valley regions. • Apart from O&M of the irrigation network, private partner's functions: - incorporate oversight/commentary by the private operator on the network's construction program - construction supervision responsibility on the private operator - building capacity and training the farmers and public officials.	• Project entirely funded by the government, through a World Bank International Development Association (IDA) credit of USD 30 million. • Farmers charged an irrigation service fee for the full cost of O&M of the irrigation system – including energy costs – thereby contributing to making the system financially sustainable. • Remunerate the private operator on a key performance indicator basis, but without placing demand risk on the operator.	• Management contractor to provide customer relations services, including advice on water management issues, farm irrigation, and related agricultural issues • High-quality O&M services and long-term sustainability of the investment
Chiansi Irrigation Scheme (Zambia)	Build-operate-transfer	• Provision of irrigation services to 600 smallholder farmers and some commercial farmers on up to 2,500 hectares of undeveloped land • Not-for-profit, special purpose infrastructure service company responsible for building, operating and financing the irrigation assets. Board of company includes representatives of the local farmers and providers of the investment capital.	• USD 15 million of patient capital by development partners to fund the one-off start-up costs to make it a much more viable proposition from a commercial perspective. • Smallholder farmers (no payment for the access to irrigation facilities) to form landholder cooperatives, with 20 years' lease agreement with FarmCo(s) – formed under ownership of the commercial farmers and smallholder cooperatives. • FarmCo(s) pay service charges to the service provider for the irrigation facilities.	• Smallholders get access to farming equipment and some technical assistance along with irrigated water • Use of patient capital cover the high upfront costs and some of the costs of the very long-life assets • After 25 years, full control of the organisation will be transferred to local farmers who will own it along with the government.

Source: World Bank

- **Best practices in the country**: Some of the best practices in India that are worth adopting, based on their success, are detailed below. Source: World Bank

Case 1: Gujarat Green Revolution Company Limited[80]

Adopting an integrated approach towards different schemes and sub-schemes offering micro-irrigation systems, the Government of Gujarat constituted GGRC, an SPV which promotes drip and sprinkler irrigation systems in the state. One of the objectives of forming this SPV was to eradicate confusion amongst farmers against the varying subsidy assistance norms implemented by multiple government departments. Through this initiative, the government also wanted to put an end to the delays in subsidy disbursals and integrate all available funds under a single entity so that they could be utilised efficiently, and the benefits extended to a greater number of farmers. With this step, authority and responsibility for implementation of the Social Sector Scheme-MI was handed over to a corporate body and GGRC had relatively more autonomy in its functioning and decision-making. This is the country's first public-private partnership (PPP) model in implementing a socioeconomic scheme.



[80] https://macrofinance.nipfp.org.in/PDF/10_Sugoor_Micro_Irrigation_in_Gujarat.pdf

Case 2: WUA: Participatory irrigation management

Waghad project, Maharashtra

This is an innovative and well-managed project by a WUA. This project was implemented in 19 villages and 715 water use groups which use water from the Waghad Dam participated. This project covers around 10,000 hectares of land and benefits around 15,000 farmers. It has been noticed that due to this project, the annual income of farmers has gone up from INR 27,000 to INR 1.75 lakh per hectare.[81]

Adoption of a pay and use model in which farmers pay water charges of INR 50–70 per hour in the rabi season.

Farmers create a water budget and engage in crop planning every year on the basis of water availability.

Irrigation as a service (IaaS), Bihar[82]

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), a German development agency, in its efforts to implement diverse service-delivery models, has supported a community-based pay-as-you-go model in Bihar's Vaishali district in collaboration with the Vaishali Area Small Farmers' Association (VASFA). As a part of this model, diesel pumps have been replaced by solar pumps for irrigation in two sites. The operator of the pump is selected from the farmers' group and one member is selected as the group leader who is responsible for collecting the due charges from the farmers for irrigation services. The service charge to be collected is also decided by the group and the collected money is partly used to pay the salary of the operator and partly for the asset's O&M. Based on mutual consent, the group leader decides on the scheduled provision of irrigation to be allocated to each farmer. Once the irrigation requirements of the member farmers are met, the same is shared with non-member farmers as well, though they are required to pay slightly higher service charges.



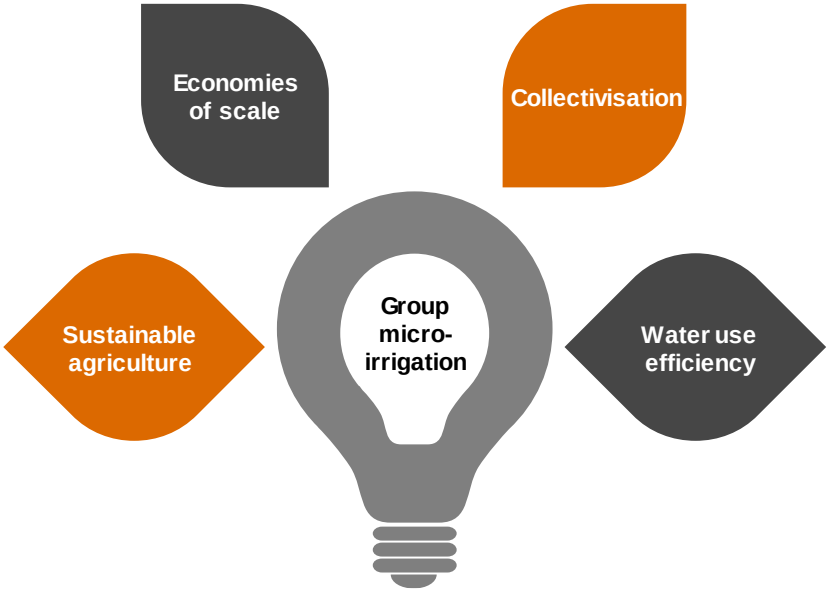
81 https://www.indiawaterportal.org/sites/indiawaterportal.org/files/waghad_report.pdf

82 How to develop with private sector participation, Word Bank and PPIAF, 2016; PPIAF Support to Private Sector Participation in the Irrigation Sector in Ethiopia 2012; PwC analysis.

Case 3: Group micro-irrigation model: Maharashtra and Telangana

In this unique model, farmers use micro-irrigation facilities as a service in groups. These groups set their own rules for operations and collective decisions. The uniqueness of this model is that the micro-irrigation infrastructure becomes affordable to poor and marginal farmers without them investing and owning individual bore holes. They are encouraged to use water judiciously to take an active part in irrigation management.

Group micro-irrigation (GMI) – in-built principles



GMI model promoted by Trust

- One of the trusts has supported the group micro-irrigation (GMI) model in villages of Maharashtra and Telangana with irrigation sources such as bore wells, dug wells, ponds and farm ponds.
- GMI focuses on the principle of water being used as a common good and not a private one, which can bring down the overexploitation of water resources.
- GMI includes crop planning according to soil type, water-use efficiency, good agricultural practice (GAP), and water availability, etc.
- There were two main purposes of bringing together farmers together – firstly, judicious use of water and secondly, to see if benefits could be generated using economies of scale.
- One such group of farmers is the Jalsamruddhi Shetkari Bachat Gath (Farmers' Self-Help Group for Prosperity through Water) from Tigalkheda of Jalna district, Maharashtra. This SHG uses drip irrigation with defined rules for operations and taking collective decisions on who takes what crop in which season. These farmers have been educated about the advantages of doing away with competition for water and becoming a more cooperative unit.

4.4.2. CSR initiatives in water management

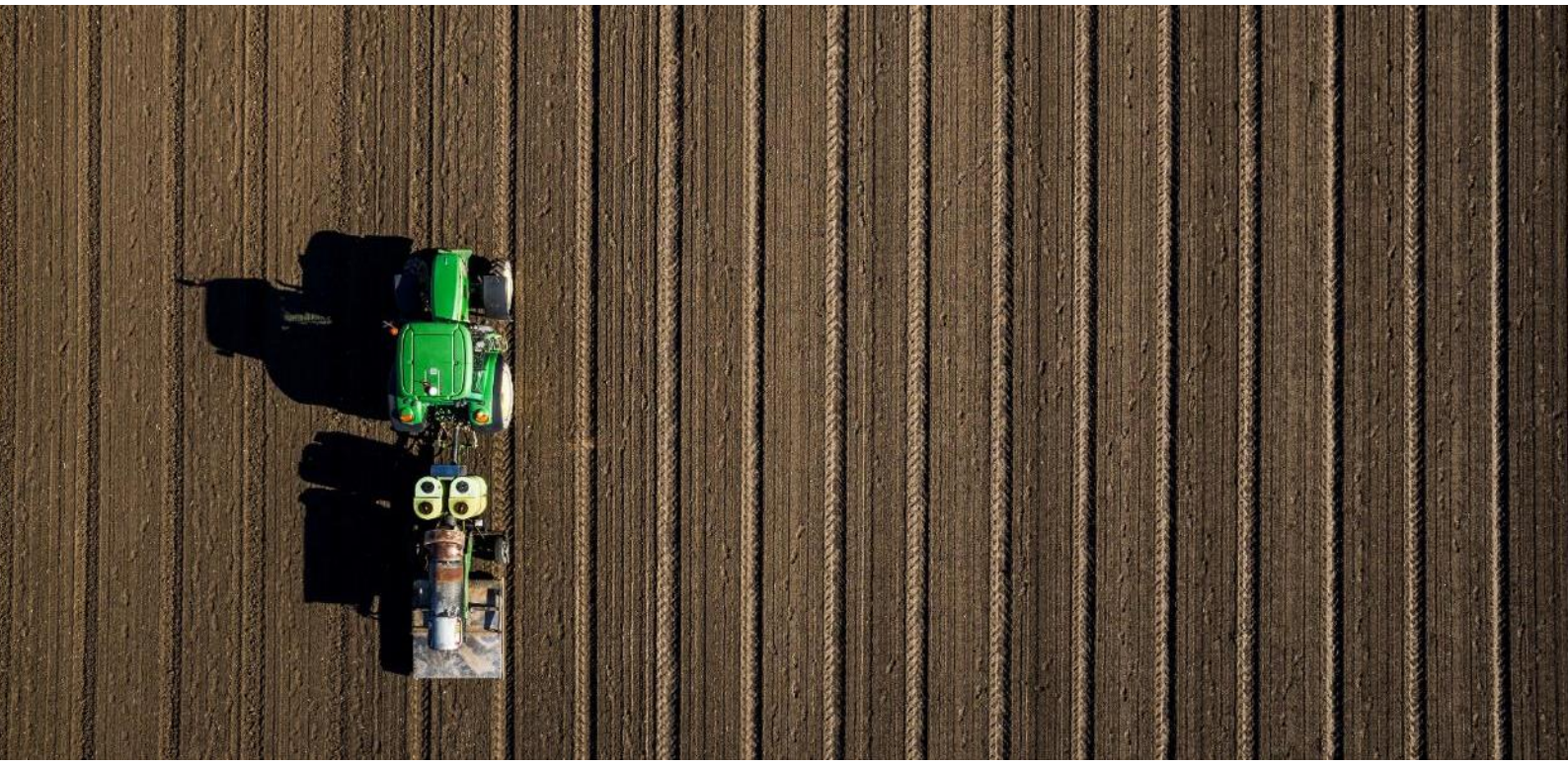
Corporate social responsibility (CSR) is a well-established practice for national and international companies. However, with the enactment of the Companies Act, 2013, and subsequent amendments, CSR has become a mandate for the boards of Indian companies. Companies with a net worth of INR 500 crore or more, or a turnover of INR 1,000 crore or more, or a net profit of INR 5 crore or above have been brought within the ambit of the Companies Act, 2013, and are required to spend 2% of their average profits on CSR activities. As a result of this law, it is estimated that a fund of INR 20,000 crore can be pooled for CSR activities with contributions from about 6,000 companies. Many corporates have been contributing proactively out of a sense of social responsibility in the form of donations, charity, relief works, etc. Though the overall participation of the private sector in the irrigation and agriculture sector is limited due to heavy fund requirements for agriculture projects, the government may promote partnerships with corporates and social organisations to support some of the critical projects and address challenges such as water sector which have a direct social and economic impact on people as well as on environmental sustainability. Some of the key avenues for CSR partnerships in the agri-water space are listed below:

1	water use efficiency improvement programmes
2	participatory irrigation management promotion programmes
3	awareness creation programmes for farmers on conservation of water and minimising wastage
4	Increasing adoption of water-saving irrigation techniques by farmers
5	development of information and communication technology (ICT) for irrigation management
6	extension, renovation and modernisation (ERM) programmes for existing old irrigation infrastructure.

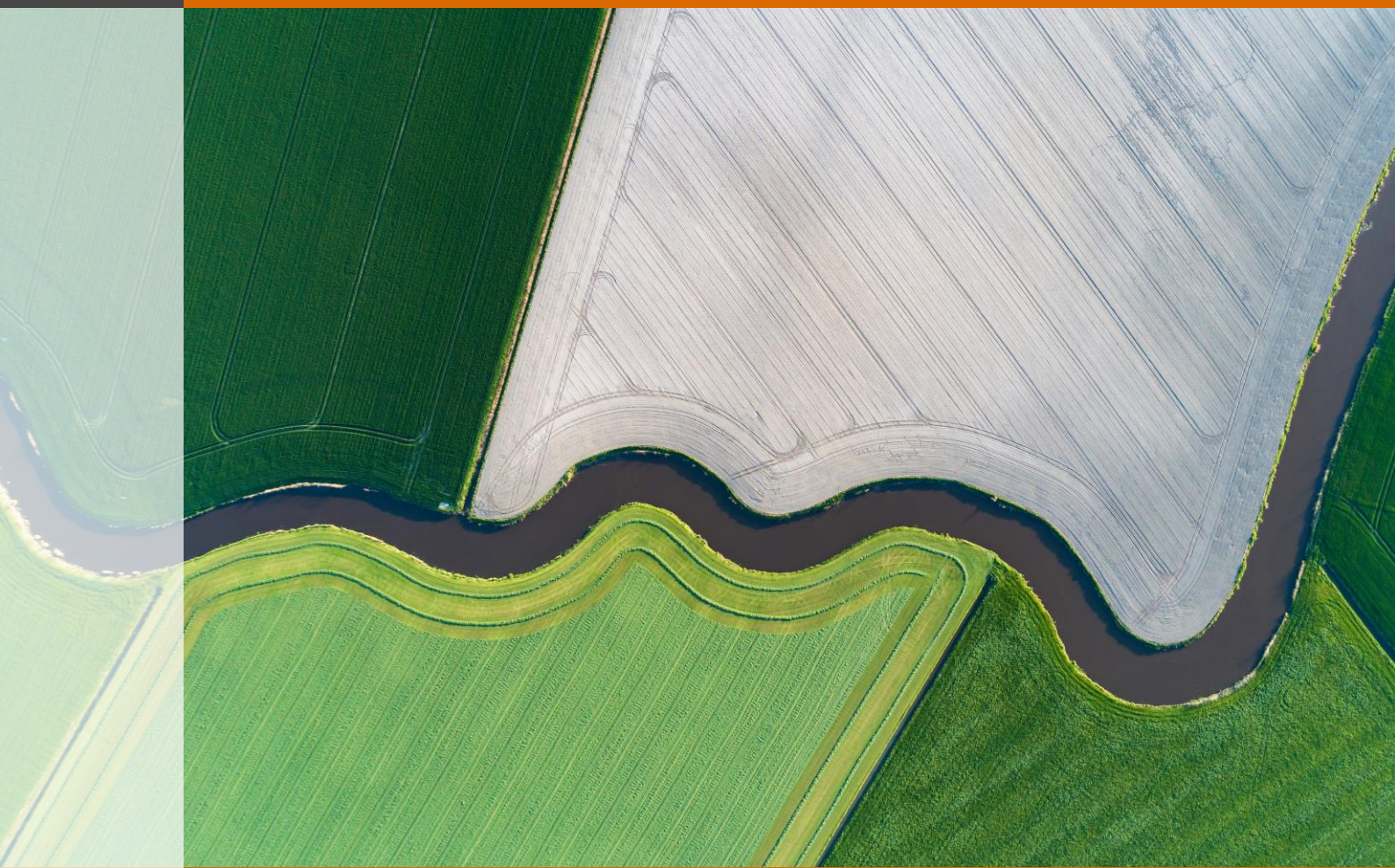
Other than the areas mentioned above, organisations/companies may also decide to work on interventions based on the geographical and territorial requirements. Some of the initiatives taken by Indian companies as CSR activities in the irrigation sector are listed below.

Lead organisation	Initiative	Impact
A private bank – total assistance of INR 92.78 crore to farmers across India	• Assistance to farmers in soil and water conservation, water management, construction, renovation and maintenance of water harvesting in partnership with Village Development Committees • Rejuvenation of existing structures like ponds, wells, and constructed check dams	• Across India • Soil and water conservation work on 550 acres of land • Benefited over 140 farmer families • 65 acres of land brought under irrigation for the first time • 45 acres brought under assured irrigation
A public sector bank –total funding of INR 19.36 crore for soil and water testing programme	• Soil and water testing services in Maharashtra	• Analysed 7,418 soil and water samples in 2015–16 • Various activities have benefited 2,363 farmers

Lead organisation	Initiative	Impact
Leading tractor and farm equipment manufacturer – total funding of INR 5.47 crore for a farmers' programme	The programme includes: • soil testing • advisory services • drip irrigation • community farming • seed culture farming • infrastructure development and capacity building	• The programme benefited 49,635 farmers of • Raigad in Maharashtra, • Sagar and Tikamgarh in Madhya Pradesh • Ajmer and Alwar in Rajasthan
Leading tractor and farm equipment manufacturer – total funding of INR 1 crore for farmers' wellness project	• Aimed to educate farmers on new technologies • Helped farmers to solve the drought-related issues by implementing drip irrigation to ensure an economical use of water • Use of biodynamic techniques which improve soil water retention capacity and groundwater levels	• Benefited 345 farmers from different villages of Vidarbha (Wardha, Amravati and Akola districts)



5. Sustainable waterways for future demands



Sustainability should the main focus while planning or promoting practices, policies, interventions in the area of water management in the agriculture sector. For this, a coherent strategy covering all aspects related to the utilisation of water for farming and allied activities is needed. This section presents a unified strategy which includes promoting the right technologies, encouraging PPP in the creation and management of water resources, ensuring economical use of water and an integrated policy framework. This strategy can act as a catalyst for better water management.

5.1. Promoting 'water smart' technology

5.1.1. Introducing water smart cropping patterns

Since three of the major water-consuming crops, namely **rice, wheat and sugarcane**, take up almost 80% of the irrigation water, it is important to rectify cropping patterns with respect to water availability and endowment across states. It is critical to re-orient farmers from **water-guzzling crops such as rice, sugarcane and cotton to water-efficient crops** with an eye on self-sufficiency and future water demands.[83]

It is equally important to promote better agronomical practices (aimed at reducing water consumption) like direct seeded rice (DSR), modern mulching methods, and new seed varieties which consume less water, and to develop an ecosystem that promotes other crops on the residual water.

5.1.2. Modernisation of canal command area through promotion of integrated irrigation systems

Keeping in mind the irrigation water scarcity, all irrigation projects (major/medium and minor) should be designed with 'water productivity' as the main criterion. This calls for leveraging of technology to enhance productivity. One such approach may be promoting improved resource management with **pressurised irrigation networks (PINS)** and last-mile connectivity with **micro irrigation**. All future projects under AIBP may be designed by creating a distribution network with **underground pipeline network (UGPL) pipes** up to the farm outlet from the source, creating a secondary storage structure at the farm outlet and 'on-farm' water application with **micro-irrigation systems and automation techniques.**

5.1.3. Promoting precision technologies in irrigation

Precision irrigation systems (**PISs**) can contribute towards increasing water use and economic efficiency both by appropriately matching irrigation to inputs in specific sections of a field and either bringing down the cost of inputs or enhancing the yield with the same inputs. Instead of uniform irrigation, which is followed in traditional management approaches, a PIS has a systematic approach and adopts 'differential irrigation' based on the spatial and temporal variations in the field. An ideal PIS utilises innovative irrigation methods and technology application along with sophisticated modelling, sensing and control technology to achieve the best possible performance. It typically combines automation, informatics, application technology (with spatial and temporal variation abilities) and real-time control.

The targets under SDGs (6.4 and 6.5) are achievable with the broad actionable strategies recommended for modernisation of canal command areas through the adoption of **integrated irrigation system networks with micro-irrigation.**

[83] Water Productivity Mapping of Major Indian Crops. (2018). Retrieved from https://www.nabard.org/auth/writereaddata/tender/18061811 28Water Productivity Mapping of Major Indian Crops, Web Version (Low Resolution PDF).pdf

5.1.4. Approaches to introduce a precision irrigation system

Precision irrigation can be considered as a management approach established under the precision agriculture cycle. It may be useful not only for water-deficient zones but also for areas which have an abundant supply of water. This approach involves four essential steps; these steps and the benefits and various sensing models of precision agriculture have been elaborated below:

Step 1	**Data acquisition:** Technology capable of measuring a range of soil-crop-atmosphere factors such as soil-based and weather-based monitoring in real time and at sub-metre levels, resulting in precise or real-time control of the irrigation system.
Step 2	This step includes collecting data and construing and evaluating it at suitable scales and frequencies. Further, multidimensional factors such as system limitations and integration of crop responses are necessary for optimising irrigation management.
Step 3	Enabling control: A vital component is being able to shift inputs and regulate irrigation at suitable temporal and spatial levels. This can be achieved by altering the application rate or time.
Step 4	**Ingraining evaluation:** Evaluation is a crucial process in precision irrigation. Measuring the performance of an irrigation system from the agricultural, technical and economic perspectives is a critical step as the results can be useful for enhancing the performance of the precision irrigation system's subsequent cycle.

Potential economic benefit: Reduction in input cost and maximising the returns by enhancing the crop yield. Impact of variable rate irrigation on water savings in individual years ranged from **0–50%,** and savings over several years averaged from **8–20%,** depending on the previous irrigation management. Variable rate irrigation could save **10–15%** of the water used in conventional irrigation practices.[84]

Sensing models utilised for a PIS: Weather-based sensing, plant-based sensing, thermal sensing, soil-water sensing and other sensing applications (rainfall, salinity), etc.

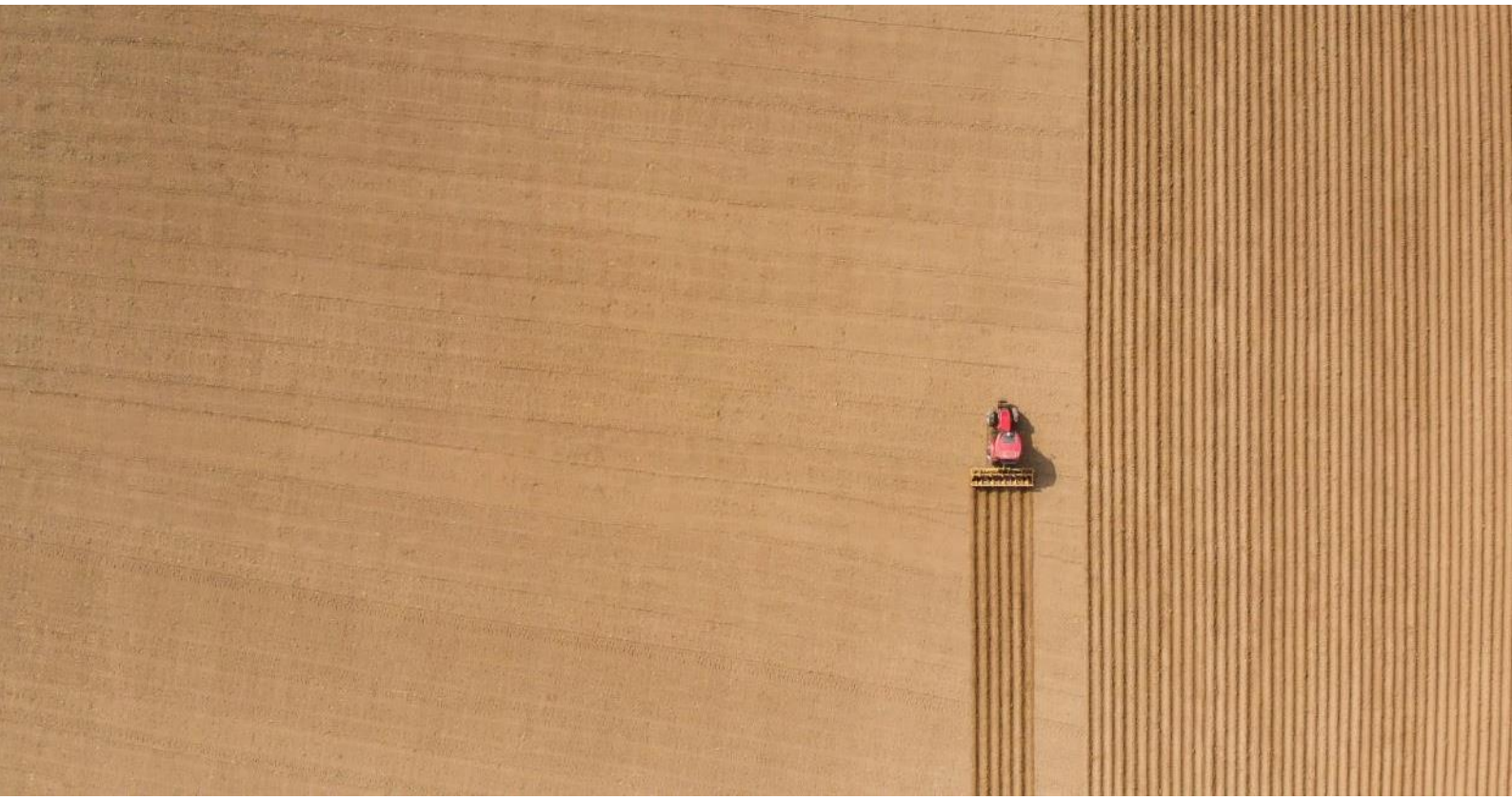
The right mix of the above steps, approaches and models can be used to introduce PISs in water-deficient as well as abundant areas.

Leveraging PISs in water-deficient areas	**Drip irrigation technology:** Water is delivered directly to the roots of a plant. This technology reduces the evaporation which occurs in a spray-based water system and has enabled farmers to cut down groundwater overdraft and helped in recharging many aquifers. Its advanced precision technology has a manual and automatic control mechanism to efficiently utilise the available water resources. This technology can result in 80% more water savings than traditional irrigations methods.
	Variable rate technology (VRT): It allows fertilisers, chemicals, irrigation water and other farm inputs to be applied at different rates across a field, without manually changing the rate settings on equipment over a farming area. Different locations of a field can have different irrigation requirements as soil, present nutrients, terrain and growth of a certain crop differ from one location to another.
	GPS technology for irrigation: GPS is an integral part of precision farming and is also contributing to irrigation. GPS facilitates the demarcation of geographic locations of irrigation management zones, variable rate irrigation (VRI) and interpretation of soil moisture data as well. It can help in avoiding excessive watering based on precise identification of irrigation needs within a field.

[84] N. G. Shah and Ipsita Das. (2012). Precision Irrigation: Sensor network-based irrigation, problems, perspectives and challenges of agricultural water management, Dr. Manish Kumar (Ed.)

	Digital irrigation scheduling: Smart irrigation management only deals with how water reaches the field but also at what time, how frequently and in what quantity. In order to avoid under- or excessive irrigation of crops, farmers depend on weather forecasts and soil moisture, based on which they alter the irrigation cycle.
	Nanotechnology in agriculture: Biodegradable nano hydrogel can absorb and release water and nutrients in cycles, leading to more efficient use of water. The technology could be especially useful in dry areas. Seeds that have undergone treatment with nanoparticles have shown increased drought resistance.[85]
	Spray/sprinkler irrigation system and sensor-based irrigation: Nowadays, in order to make irrigation more precise, farmers are adopting centralised command and control solutions by using smart farming software. The software predicts and prepares irrigation schedules based on soil and weather data in order to optimise crop irrigation with a high level of water use efficiency by combining the best hardware and software available.
Leveraging PISs in water-abundant areas	**Predicting unwanted water pooling or ponding:** Ponding or unwanted water pools have always been a concern for farmers as these result in oxygen deprivation and stress for crops. Moreover, they can result in soil erosion and nutrient loss. The latest AI-based technology can forecast which locations are prone to ponding. Data available from the GPS-based tracking system can be analysed trough specialised algorithms and, in turn, identify the exact areas of a field which are more susceptible to floods. With this data, a farmer can take a decision to reduce irrigation in identified areas or develop better drainage by planting seeds deeper.

In order to ensure the functionality of a PIS, its viability has to be defined at both the conceptual and practical stages. At the conceptual stage, the ideal spatial levels across multiple crops and application methods can be determined through simulation.



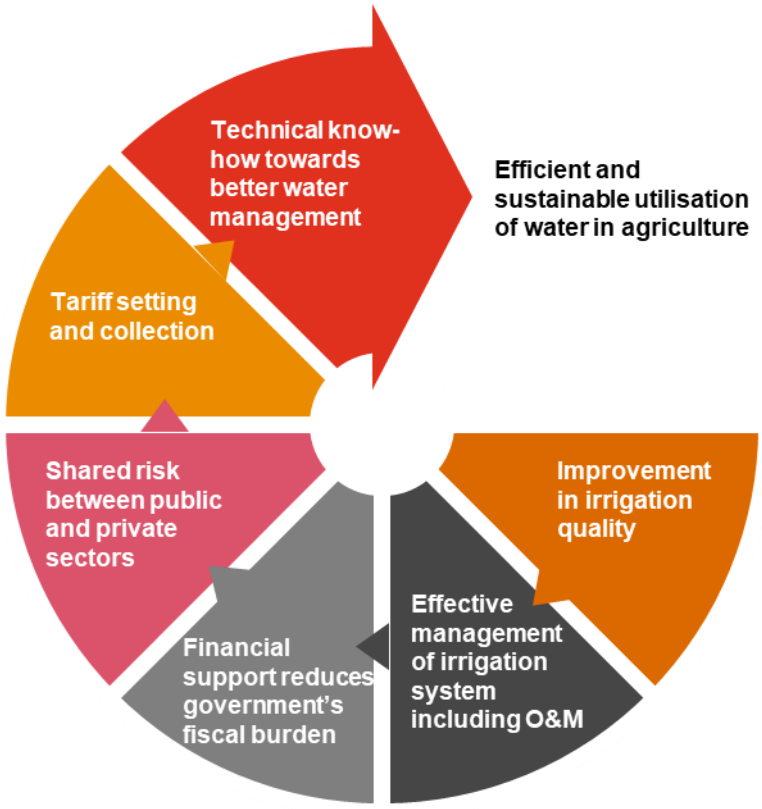
[85] Martínez-Vilalta J, Piñol J. Drought-induced mortality and hydraulic architecture in pine populations of the NE Iberian Peninsula. Forest Ecology and Management. 2002; 161, 247–256

5.2. Encouraging PPP for better creation and utilisation of irrigation infrastructure

The public sector has largely been responsible for the development of water resources, irrigation management and bringing in reforms in this sector. As per a World Bank study, only 25–30%[86] of the water diverted from large canal systems reaches the crops requiring it. Government institutions are supposed to fund irrigation projects and manage them by providing free or subsidised water supply to farmers. However, due to the changing scenario, the government needs to make its approach more efficient and leverage the expertise of the private sector and the farming community as partners in irrigation projects.

5.2.1. Rationale for PPP in irrigation

As irrigation schemes are 'common pool resources' and intended for the 'public good', it is not possible to have 100% private funding.



However, PPPs with sharing of responsibility and risks can offer good incentives for enhanced private investments in this sector. The private sector can invest in the irrigation management sector through agreements based on equal benefits in terms of resource utilisation, latest technology, improved strategy and implementation of projects, and enhanced operational-cum-delivery efficiency. PPP undoubtedly also increases the pace of implementation, brings down the life-cycle cost (low maintenance and risk designs and constructions, leading to long-term cost savings) and optimises risk. However, it may not be a valuable proposition for the private players to invest in large irrigation infrastructure by private and hence, to attract private investment, innovative funding models such as viability gap funding, incentives for execution or a mix of both will have to be developed. Probable PPP options are discussed below.

[86] How to develop Sustainable Irrigation Projects with Private sector participation, World Bank Group. Public-Private Infrastructure Development Facility, 2015

PPP arrangements in irrigation system

	Type of arrangement	Description of arrangement	Expected risk factor for the private sector	Length of contract (in years)	Capital investment	Ownership of asset
PPP on a broad interpretation	**Management contract**	Operations management (complete/ partly)	Low/medium	1–5	Public	Public
	Lease/ affermage contract	Operations management with renewals	Medium	10–15	Public	Public
Fundamental PPP arrangements	**Build-own-transfer (BOT), build-own-operate (BOO), Design-build-operate (DBO)**	Investment and operations of a particular section of infrastructure service	High	Varies	Private	Public/private
	Concession	Financing, operations and execution of specific investments	High	2530	Private	Public/private
	Service contract	Infrastructure maintenance services	Low	1–3	Public	Public
	Divestiture/privatisation	Complete handover of public infrastructure to private sector	Complete	Indefinite	Private	Private

Source: PwC analysis

5.2.2. PPP in irrigation infrastructure creation

In the past few years, the PPP model has proved to be quite effective for infrastructure development in the country, including roadways airports, seaports and power, resulting in various success stories. However, this model has yet to be implemented in the construction of water resources for irrigation purposes (e.g. dams).

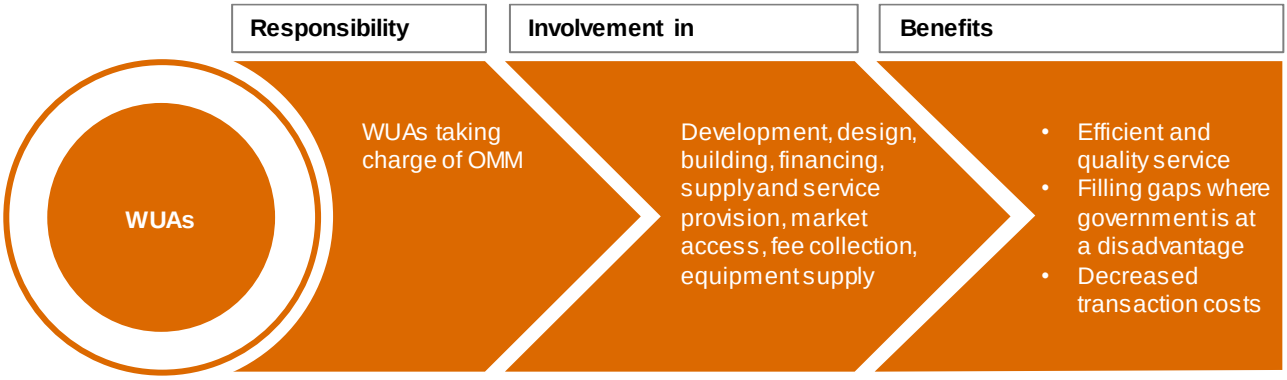
Therefore, this sector presents a great opportunity where the PPP approach would help not only in bridging the financing gap in large-scale projects (mostly multi-purpose water infrastructure projects) but also ensuring timely completion while taking into account public interest as well as the environment.

5.2.3. PPP in irrigation infrastructure management

In the Indian context, multiple financial and operational risks make funding of agriculture irrigation projects a challenge. In many developing countries, recovery of operation and maintenance (O&M) cost, let alone investment returns, has been extremely difficult because of farmers' being unable to comprehend the need of payment for irrigation services, inability to make payments, ineffective collection of water charges by public bodies and reluctance of governments to raise tariffs to cover expenses. In view of these challenges, the private sector would enter this sector only if it is confident about recovering its investments. The lower the certainty, the lower will be their interest and the higher the requirement for subsidised or public sector resources.

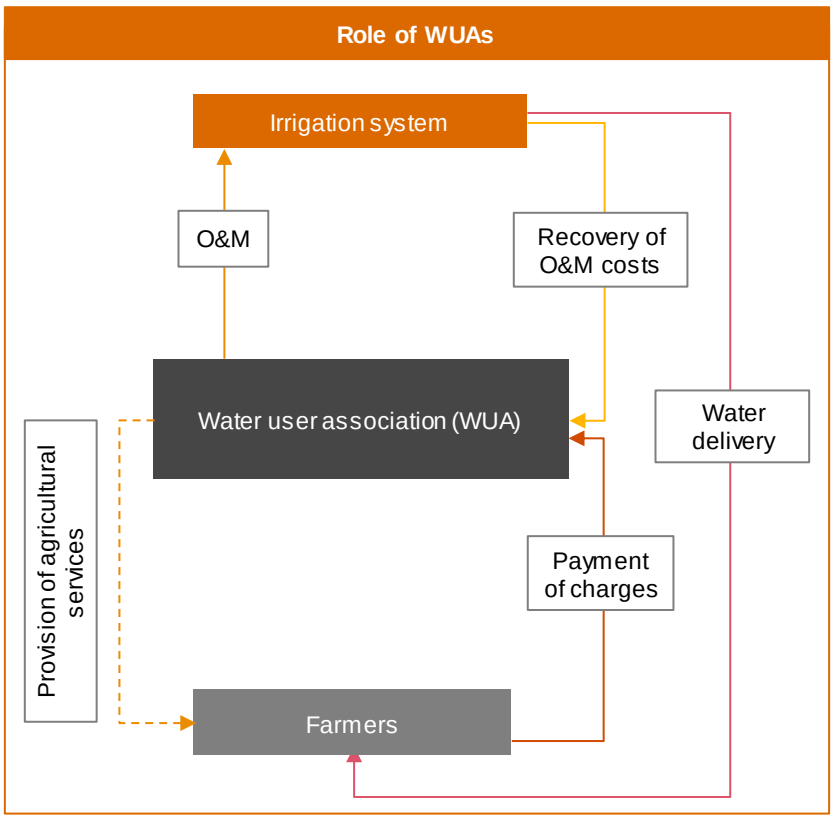
5.2.4. Promoting participatory irrigation management (PIM)

PIM, through the formation of water user associations (WUAs) comprising irrigation system users involved at all the stages of irrigation management, has been recognised as one of the feasible solutions to achievement sustainability in this sector. It helps in resolving common problems with publicly managed irrigation-related schemes, specifically unsatisfactory maintenance of physical systems, insufficient use of irrigated area, high financial cost, low productivity, and poor irrigation facilities. Further, third-party participation brings sustainability. Presently, 15 Indian states have formulated legislation to support PIM and enable the formation of WUAs. The remaining states should fast-track the process of formulating PIM acts.[87]



Source: PwC analysis

WUAs can become partners in setting up PPP contracts with private operators which become responsible for delivering irrigation services. Cost recovery is possible as under competitive market conditions, the private operator provides the most cost-effective solutions for O&M of the agriculture irrigation system.



Source: PwC analysis

[87] http://wua.aquiferindia.org/Introduction.aspx

5.2.5. Irrigation as a service (IaaS)

The irrigation sector has witnessed more and more large-scale irrigation schemes. The rising cost of these schemes farmers and increasing energy subsidies to farmers are leading to extreme stress on the energy sector as well. Donor agencies, entrepreneurs, the private sector and community-based organisations (CBOs) are trying to find a solution to the issues of small and marginal farmers, namely dependency on rainfall and expensive diesel pumping sets. One such model is making irrigation available as a service, which can lower the financial burden on farmers, save electricity and result in more efficient and sustainable utilisation of water in irrigation.

5.2.6. Community-based service delivery model

A community-based model in irrigation management is defined by the sharing of an irrigation asset among a group of farmers depending on the irrigation requirements (traditional or-micro irrigation) of individual group members. One of the conditions for the formation of such a collective is that the land of farmers sharing the infrastructure/service should be either located adjacent to or a part of a catchment area to which the service can be delivered. For example, in the case of a solar pump, it is a common practice to select a pump operator is from the farmers' groups. The operator keeps a record of pump usage by group members and a service charge is levied depending on the volume of water delivered to farmers. This can be effective model for promoting enterprises and self-employment for rural people and achieve efficient and equitable irrigation as well. This can lead to the formation of village-level entrepreneurs (**VLEs**).

PPP in irrigation can be a new revolution in the sector and transform the whole water requirement, management and regulation system in agriculture. For efficient rolling out of PPP models, it's also imperative to generate government support in terms of enabling policies and institutions to promote and catalyse investments in the sector. Some of the prerequisites for promoting PPP in irrigation management are shown below:

1	**Favourable governance environment**	Coherent policies cutting across multiple departments and an institutional watchdog for promoting PPP
2	**Innovative and supportive financing tools:**	VGF, **patient capital or** charging for the use of land at irrigation project sites or leasing irrigation project assets
3	**Involvement of farmers' collectives:**	WUAs and FPOs can undertake operation, maintenance and management (OMM) functions of irrigation systems, increasing reliability and productivity; they can also act as markets for agriculture produce and provide IaaS.

5.3. Promoting a conducive policy framework in irrigation

Policies guide the decisions made and action taken towards 'water'. India has witnessed the formulation and adoption of three water policies, namely the National Water Policy (NWP), 1987, the reviewed version of the NWP which was adopted in 2002 and lastly, the revised version which was adopted as the National Water Policy, 2012. As per the Indian Constitution, water is a state subject listed as Entry 17 of List II. As per the provisions of Entry 56 of List I, the Union Government may intervene only in the case of inter-state river waters.

5.3.1. Developing a national agency (or authority) for promoting private participation in the irrigation system

In order to promote PPP interventions in irrigation infrastructure or management, the government may create an institute to enable transparency and enforcement of PPPs. The institute would be responsible for the provision and maintenance of the irrigation infrastructure network and bringing it up to global standards. It would help to meet users' expectations in a timely and cost-effective manner within the strategic policy framework set by the government, and thus promote farmers' economic well-being and quality of life.

The institute would ensure that all contract awards and procurements conform to the best industry practices with regard to transparency of process, adoption of bid criteria to ensure healthy competition in the award of contracts, implementation of projects as per the best quality requirements, and maintenance of the highway system to ensure user comfort and convenience. It might also endeavour to provide the status of infrastructure projects to irrigation systems, which would mean better government support, financing options and subsidy prospects for PPP-based irrigation infrastructure creation.

The institute may also play a leading role in the promotion of irrigation management through village-level entrepreneurship, community-based organisations (FPOs, SHGs, etc.), thus providing small and marginal farmers access to irrigation facilities at affordable prices and creating employment at the rural level.

5.3.2. Developing the National Integrated Agriculture Water Policy (NIAWP)

Efforts have been made to orient the NWP towards envisaging 'water' as an economic good along with emphasising its usage efficiency and conservation while promoting a participatory approach to the same. However, in practice, the focus of improving efficiency and water conservation is skewed towards the domestic and industrial sector rather than agriculture, which accounts for maximum freshwater consumption across the nation. Therefore, an Integrated Agriculture Water Policy at the national level is essential to address the major concern areas in the context of agricultural water use, such as water law, water rights, water pricing, water allocation, user participation, subsidy policy, and asset and management transfer of infrastructure (i.e. Irrigation Management Transfer [IMT]). Taking the NIAWP further, policy implementation would require water laws and regulations.

National

Water is a national concern as the resource is not bounded by political or administrative boundaries. For its sustenance in future, national laws, rules and regulations are vital.

Agriculture

Agriculture accounts for 90% usage of freshwater withdrawals. 62% of irrigation needs are met by groundwater. Agriculture through the usage of chemicals and fertilisers contributes the most towards groundwater pollution.

Integrated

Rather than just being a concern for the Water Ministry or related departments, water is a concern for agriculture, irrigation, animal husbandry and fisheries, rural development, etc. Therefore, an integrated approach is a must.

NIAWP – tentative objective, impact and thrust areas

The broad objectives of the proposed NIAWP and intended are summarised below:

Objectives	Intended impact
To adopt a river basin approach for all planning and management purposes	Eliminate river water disputes across states
To develop an integrated strategy for agriculture water resource creation and utilisation at the national level	Equitable access to water and its sustainable usage
To establish agriculture water as an economic good and promote its conservation	Efficient and effective water usage in the agriculture sector
To undertake better agriculture water information management	Efficient management of available resources, enabling better preparedness and planning
To promote innovative technologies, stakeholder partnerships and participatory management in agriculture water	Creation of well-structured and sustainable models in agriculture water management
Thrust areas: Water framework law, water economics, irrigation system creation and management, participatory irrigation management, promotion of efficient technologies, climate change and its impacts, etc.	

Going ahead, a National Water Act on the lines of that of countries such as Israel, South America and Australia may be envisaged to ensure adherence to the provisions by the different administrative bodies.

5.3.3. Efficient implementation and convergence of schemes

With the plethora of developmental schemes available in the irrigation sector, run by multiple government departments, it is necessary to bring in coherence and efficiency.

In order to ensure effective water management at the state level, the Ministry of Jal Shakti, in collaboration with NITI Aayog, has developed an index called the **Composite Water Management Index (CWMI)**. It is the first robust collection of country-wide water data and has been hailed as a major step towards creating a culture of data-based decision making on water in India. The continuous monitoring and evaluation of the index will be important for understanding the impact of these schemes and initiatives. **Convergence of the various irrigation schemes would be a very crucial step to achieve their objectives. An illustrative plan for convergence is presented below:**

Sr. No.	Scheme	Department	Objective of the scheme
1.	PMSKY – 'Har Khet Ko Paani'	Ministry of Agriculture & Farmer Welfare	New water sources through minor irrigation (both surface and ground water) Creating and rejuvenating traditional water storage systems
2.	PMKSY – 'Per Drop More Crop'		Promoting efficient water conveyance and precision water application devices like drips, sprinklers, pivots, rain-guns in the farm (Jal Sinchan)[88]
3.	PMKSY – Accelerated Irrigation Benefit Programme (AIBP)		Faster completion of ongoing major and medium irrigation

[88] https://pmksy.gov.in/AboutPMKSY.aspx

Sr. No.	Scheme	Department	Objective of the scheme
4.	PMKSY – Watershed Development		Developing in-situ water conservation to ensure soil moisture and effective run-off management
5.	Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM-KUSUM)	Ministry of New and Renewable Energy	Provide a reliable solar power source for irrigation and de-dieselise the farm sector

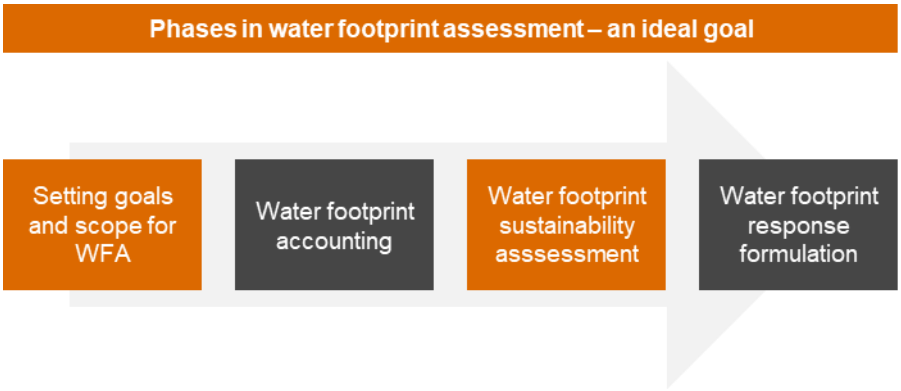
Sr. No.	Scheme	Department	Objective of the scheme
Way ahead and tentative convergence plan: The government may plan to make Jal Sinchan components of PMKSY an integral part of PMKSY – Watershed or explore their utilisation in KUSUM to promote efficient utilisation of water. Such inter-scheme convergence will help to develop an impact area for schemes and the water use efficiency (WUE) will enhance multifold by cross-leveraging the scheme benefits. PMKSY – (Per Drop More Crop) can be dovetailed with PMKSY – 'Har Khet Ko Paani'). These two schemes can be operated by the same nodal agency in the state.			

5.4. Monitoring and promoting judicious water usage: 'Measure the treasure'

It is very important to practise water accounting and audit measures in irrigation water management to promote prudent usage and measure utilisation and distribution.

5.4.1. Water accounting, footprint accounting and water auditing

As per the Food and Agriculture Organization (FAO), 'water accounting is 'the systematic acquisition, analysis and communication of information relating to stocks, flows and fluxes of water (from sources to sinks) in natural, disturbed or heavily engineered environments'.[89] It is mainly used to assess the efficiency and productivity of the various water uses or users and to assessing the potential risks of enhancing water efficiency or productivity (e.g. if one person gains from water productivity, it might result in someone else being denied access to water).



Source: PwC analysis

It is also important to introduce a sense of 'water footprint accounting'.[90] This involves measuring how much water is consumed in order to produce any of the goods and services we use. The amount of water consumption can be measured for a single activity (e.g. growing rice, manufacturing a product such as a pair of jeans or fuel, or usage by an entire company). To make water footprint accounting more applicable, it should be ensured that packaged goods being sold may be labelled with a measure of water footprint so that the consumers are aware of how much water footprint is created due to their consumption. Further, water accounting should be linked to energy, ecological and carbon footprints, including life-cycle assessment and input-output models.

89 Water accounting and auditing A sourcebook, 2017, FAO, http://www.fao.org/3/a-i5923e.pdf

90 https://waterfootprint.org/media/downloads/Report47-WaterFootprintCrops-Vol1.pdf

Water auditing involves placing water accounting findings in the relevant context, say governance, service delivery, the political domain, and public as well as private expenditure. It focuses on understanding and evaluation of water supply, management and delivery as services in a broader framework. Water auditing is a systematic and scientific examination of the water accounts of projects. It provides a rational, scientific framework that categorises all water used in the system.

Comprehensive studies and general guidelines on water auditing have already been developed by the FAO, and in 2017, India's Ministry of Water Resources has drafted guidelines in collaboration with the Directorate of Evaluation and Water Utilization.[91] States and other civic bodies are required to adhere to these guidelines to enhance India's water use efficiency.

5.4.2. Promoting fiscal and economic water instruments to ensure efficiency

Economic instruments can help manage demand for water and enhance economic activity while protecting the environment and fulfilling water-related policy objectives. Their main function is to encourage economic agents to change their behaviour, so they can contribute to water resource management, conservation and protection. These instruments can also serve as tools to generate revenue, which may be used to finance water management or provide water-related services. Moreover, they can have a significant impact on water resource status. An indicative list of these instruments is listed below:

Sr. no.	Economic instruments	Proposed objectives of the instrument
1.	Right irrigation pricing	• Reduce imperfect water and power pricing through subsidies (which make them almost free) along with assured procurement policies (for rice and sugarcane) and inputs • Restrict skewed pricing – surface irrigation system is unable to recover even 20% of O&M expenses of canal networks, and that too without taking into account of capital costs, which are deemed sunk forever
2.	Irrigation water usage efficiency incentives	• To promote high WUE in irrigation, either a flat-rate incentive (rate per m^3) or two-part incentive (rates per ha and per m^3) could be devised • A precursor to the same would be high-end methods for water accounting and auditing in agriculture
3.	Water tax for surface and underground bodies	• Where water is abstracted in excess of set quarterly or annual water use limits, a tax or penalty may be applied
4.	Water pollution charge	• Discourage discharge of pollutants, other substances and microorganisms into surface water bodies, underground water bodies or catchment areas • Such activities should be subjected to a charge/fine for keeping a check on water resource contamination • Ascertain Maximum allowable emission limits (MAEL) and temporary agreed emission limits (TAEL) to regularise control with variable fees
5.	Introducing housing and utilities tariffs	• Tariff regulations on water supply, sanitation and wastewater treatment by the government for regulating public water utilities

[91] http://www.cwc.gov.in/water-planning-and-projects-wing

Water pricing refers to the price (financial payment) to be paid by a user to access water. Globally, there are two main types of pricing mechanisms – (1) flat rate or fixed charge based on land area and (2) volumetric supply charge based on fluctuating/actual water requirement at a given point in time. **Fair water pricing** can be achieved by establishing clear access rights, setting a cap on water allocations (which can depend on region, crop water requirement, cropped area, etc.) and other scientific measures. It is equally important to take the economics of adoption into consideration. For example, farmers are more likely to adopt these measures only if they perceive them as beneficial.

Economic instruments in the water sector may be used as a tool for future water resource management. Developing on national good practice on water management, economic instruments such as abstraction and pollution charges, water incentives, and user charges have a critical role to play in water resources management. But it is critical to measure the treasure before introducing such instruments, and incentives are more likely to work than penalties in such ecosystems.



6. Conclusion



It is understood that even with modest economic growth, the increasing global population will demand 50% more food compared to the 2013 agriculture output.[92] In order to meet this food, feed and fodder production and demand, we need to ensure that sustainable water management practices, backed by a plan and a conducive policy environment, are present to promote **water productivity and water security** in the country.

For decision-makers to control and regulate water usage, it is necessary to know the quantum of groundwater withdrawn and being recharged, annually. There is a need to integrate data from all the water withdrawal points by fixing water meters and integrating them with a unified software solution for enabling a **robust policy framework** and **institutional structure** in the country.

Important schemes such as the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), with components comprising micro-irrigation, accelerated irrigation benefit and water to every field have made considerable strides to drought proof Indian agriculture and usher water use efficiency. However, considerable efforts in promoting NGOs, WUAs, start-ups, agtech companies in water for scaling technology, and **accelerating innovation in water conservation** is further required to sustain the current and future water demand in the country. The government may consider promoting the irrigation industry to capitalise on water use efficiency by bringing it under the **infrastructure** category.

When it comes to adopting water resource management, we need to have a **long-term and futuristic approach,** keeping climatology and cropping pattern in mind. The country should focus on better demand management by adapting **smart and climate-resilient agricultural practices** for water-deficient and water-abundant regions. Efforts are required to make water-abundant regions focus on judicious usage of water and encourage the cultivation of water-efficient crops and regulated irrigation in farms located in such areas. Water-stressed areas need to focus on the formula of **per drop, more crop** and increase cropping intensity and productivity.

In order to bring efficiency in irrigation, PPP opportunities need to be promoted. **Managing water as an economic good** is the best way to ensure water efficiency and sustainability. The government needs to create avenues for private organisations, waterpreneurs and WUAs for participatory irrigation management. Policies formulated by the government should ensure returns and repayment on investment by creating a **sustainable ecosystem for hydro-economic models**.



[92] Agriculture 4.0: the future of farming technology

Notes

About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

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About PwC's Agriculture and Natural Resources team

PwC India has a dedicated team and highly experienced team working in the agriculture and natural resources sector which provides advisory services related to agriculture and agribusiness management, long-term transformational project implementation, food processing, agricultural credit, agri policy, impact assessment, performance improvement, commodity trading, integrated resource management, farm inputs and agri infrastructure. The group consists of graduates and postgraduates in agriculture, agribusiness management and natural resources with extensive experience in various aspects of agriculture, including advisory in the agriculture and food domain, supply chain management, public private partnerships, policy advocacy, agri economics, agri retail, agri marketing, farm inputs and banking.

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Editorial support

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Acknowledgements

We would like to acknowledge inputs received from the people whose names are listed below.

1. T R Kesavan, TAFE Ltd
2. Kaushal Jaiswal, Rivulis Irrigation India Pvt Ltd
3. Vishal Bhardwaj, Dalmia Bharat Foundation
4. Pravesh Sharma, Kamatan Farm Tech Pvt Ltd
5. Jyoti Vij, FICCI
6. Ajai Kumar, Corteva Agriscience
7. Sanjay Sacheti, Olam Agro India Pvt Ltd
8. Dr. Ombeer Tygai, UPL Ltd
9. Dr. Sangita Ladha, Jain Irrigation Systems Ltd
10. Vedika Kapoor, Corteva Agriscience
11. Romit Sen, Sustainable Communities India Pvt Ltd
12. Karanjit Sarkar, DCM Shriram Ltd
13. Gajendra Verma, Irrigation Association of India
14. Rishu Garg, WOTR

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GG/February 2020 – M&C 4901