Sattva Knowledge Institute SKI perspective

# WORSENING WATER STRESS IN AGRICULTURE: IS THERE A GLIMMER OF HOPE?

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# Acknowledgements


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# Executive Summary

India has 18% of the world's population and 4% of the water resources, making the dynamic heavily skewed. Agriculture accounts for a whopping **89% of the water use** in India, compared to 69% at the global level. Compared to other leading agricultural producers like Brazil, the USA, and China, India takes **2-3 times the quantity of water** to produce the same amount of crops. The increasing demand due to the growing population, coupled with declining supply owing to climate change, overexploited groundwater, salinisation, etc., makes it imperative to focus on optimal models of water use in the agriculture sector.

One of the key reasons for the inefficient usage of water in agriculture is the **wear and tear on existing irrigation infrastructure**. More than 70% of the country's dams were constructed before 1990, and they are more than 30 years old. The storage capacity of tanks has dropped to as low as 30% in recent years due to neglect and disrepair. Apart from this, another core issue is that major conventional crops grown in India consume almost 80% of the freshwater available for irrigation. **Preference for water-guzzling crops** can also be accrued to favourable market factors and outdated policies, which leads to significant overexploitation of water resources.

Furthermore, due to poor affordability, low economic viability, and a lack of surplus capital for farmers, there is **poor adoption of micro-irrigation and precision technologies**, which have the potential to reduce the cost of irrigation by 50%, save water by 45% and improve yield by 114% compared to conventional flood irrigation.

This perspective focuses on solutions that can address these challenges and help in **improving efficiency during water use in agriculture** through interventions such as the adoption of improved farming practices aimed at water conservation and efficient utilisation of resources, promoting successful models of adoption of micro-irrigation and precision irrigation technologies, development and promotion of high yielding and water-efficient seed varieties and modernization of existing irrigation technologies to tap underutilised potential and optimise the resulting impact. To ensure the effectiveness of the solutions, the interventions would need to be designed and implemented in an integrated manner with enablers aimed at promoting **awareness, research, market support, capacity building, financing, deployment**, and **policy**.

This is where **funders working at the nexus of water and agriculture** can play a pivotal role in driving Indian agriculture towards a water-efficient future. They can accelerate water-efficient techniques in Indian agriculture by investing in research, offering incentives, supporting awareness programmes, and collaborating with NGOs.

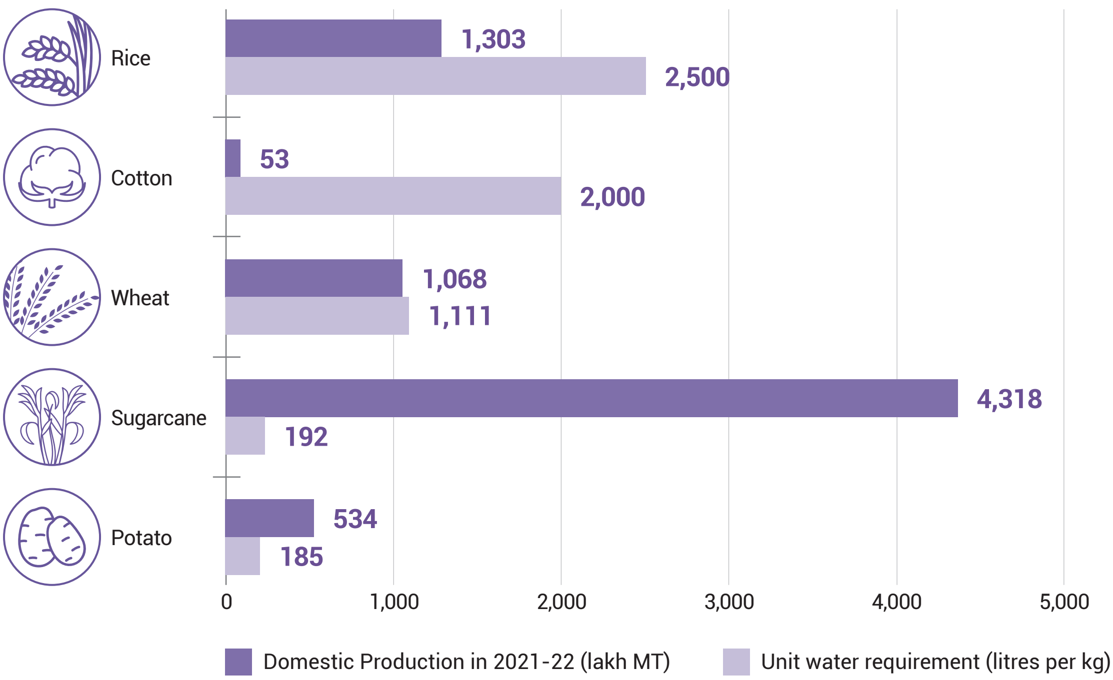
# Depleting Water Availability - A Key Concern in Indian Agriculture

## The Critical Role of Water in Agriculture

The World Economic Forum estimates that by 2050, global food production would need to **increase by 60%** to meet the demand (Murray 2015). Projected levels for 2050 indicated by the The National Commission for Integrated Water Resources Development (NCIWRD) estimate that nearly 68% of the total water available will be utilised for irrigation purposes highlighting a **significant demand for water** in the agriculture sector. On the supply side, **climate change effects** like droughts, salinisation in coastal areas, and erratic rainfall are adversely impacting the quantity and quality of freshwater.

The high water dependence of crops like paddy, cotton, and wheat makes them highly vulnerable to the risk of water stress. This will have **severe implications on farmers' livelihoods and the country's food security**, since rice and wheat are the staple foods in India (Refer to *Figure 1*). With access to only 4% of the total freshwater supply in the world for 18% of the world's population, India's **water demand far outweighs the supply**. Agriculture accounts for 69% of the water use globally, but a whopping 89% of the water use in India. The country's water footprint for agricultural production far exceeds that of other leading agricultural producers like China, Brazil, and the USA, and **India uses 2-3 times more water per unit** of major food crops (NWM 2020).

**Figure 1: Water Usage in Crop Production**




Source: NABARD, ICRIER

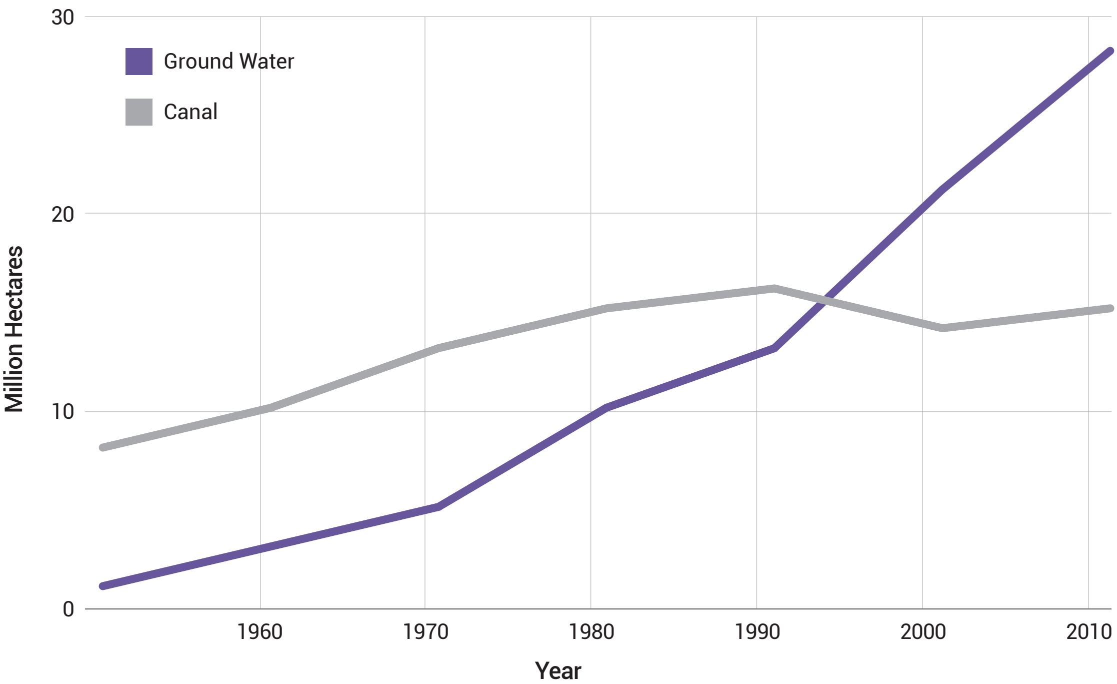
**Agri-allied livelihood activities** like dairy, livestock, poultry, and piggery also require access to fresh water daily for drinking, feed cultivation, and cleaning. The total Livestock population in India today is estimated to be 535.78 million (Department of Animal Husbandry and Dairying 2019). With a daily water requirement of 18-30 litres per head per day, an estimated 4,887 billion litres of water were required annually for rearing cattle, buffaloes, sheep, and goats with a population of around 479 million in the last decade (Phansalkar).

## However, trends in availability of water highlight overexploitation and critical status of rainfed areas of India.

In 2020, India accounted for the largest annual total water withdrawals, at 761 billion cubic metres per year. It was followed by China, which withdrew around 600 billion cubic metres that year. Water levels in most major reservoirs in the United States that supply water to millions of people have dropped to historic lows as a result of the megadrought in the West (Statista 2023).

**Rain and the Himalayan glaciers** are the main sources of **freshwater in India** for rivers, lakes and underground aquifers. However, over the years, **groundwater has become the dominant source of irrigation**, supplying water to two-thirds of the irrigated area in India, resulting in excessive use and exploitation of groundwater.

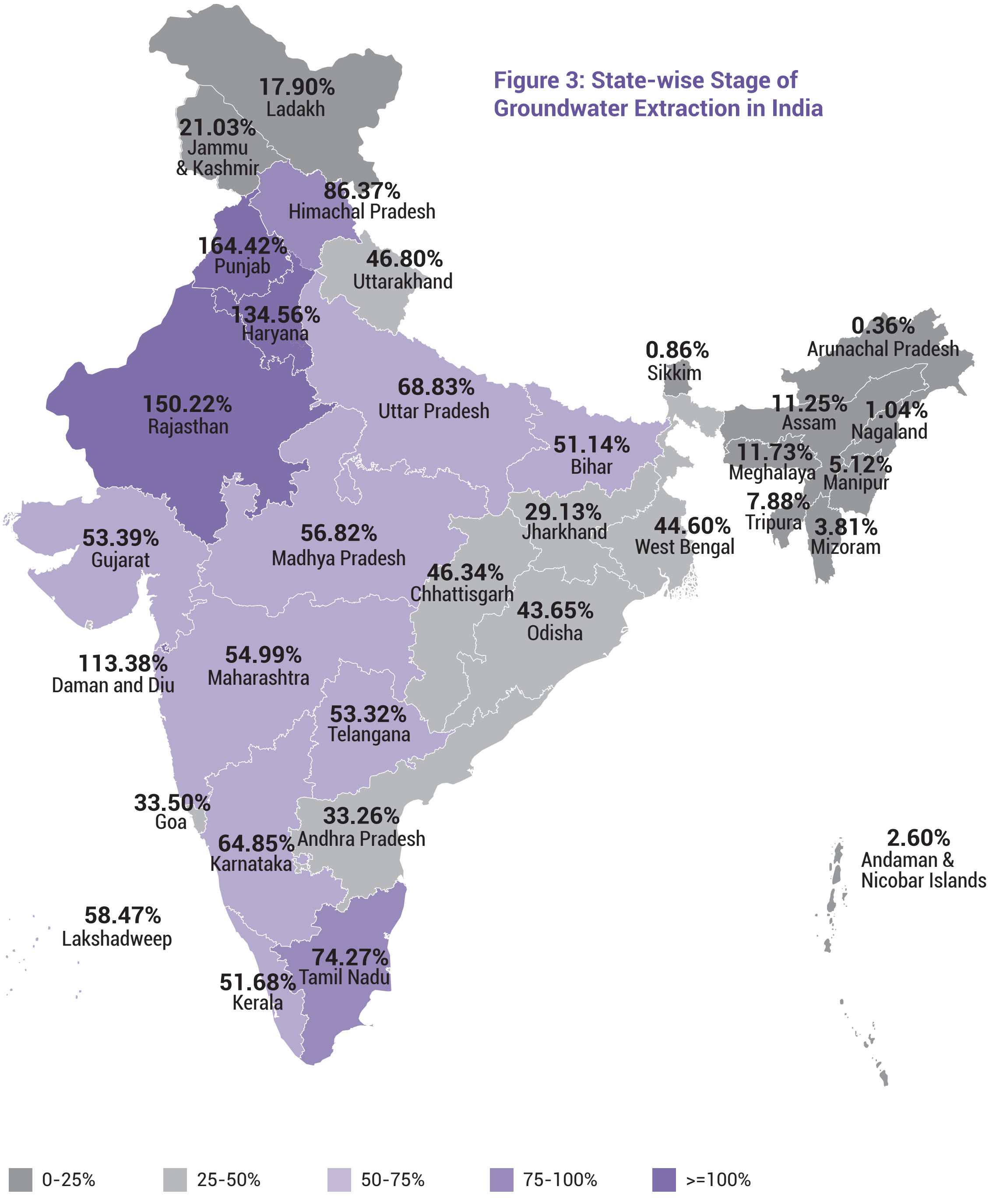
**Figure 2: Trends of Usage of Groundwater and Canal Irrigation in India**




Source: Rainfed Atlas (Agcensus 1996 to 2011)

In India, the groundwater situation is **overexploited** in 14% of the blocks, and the situation is **critical or semi-critical** in 16% of the blocks (CGWB 2022). The situation is more acute in the rice-producing states of **Punjab and Haryana**, where the groundwater is overexploited in 76% and 62% of the blocks, respectively.

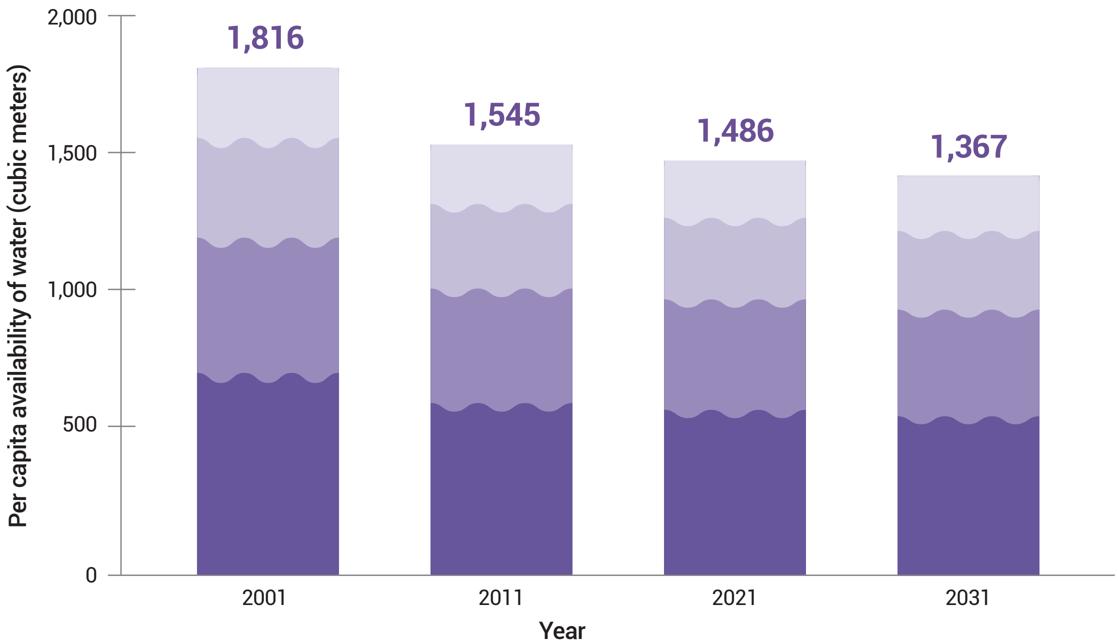
**Figure 3: State-wise Stage of Groundwater Extraction in India**




Source: IDI, Sattva

As per estimates by the Ministry of Jal Shakti, the **per capita availability of water** is projected to **decline to 1,367 cubic metres** by 2031.

**Figure 4: Per Capita Availability of Water in India**




Source: Ministry of Jal Shakti, 2020

Agricultural areas where less than 40% of the sown area is irrigated are defined as rainfed. It can be observed that large parts of western, central, southern, eastern, north-eastern, and Himalayan states have low irrigation penetration. Among these, the western, central, and south-central regions are low rainfall zones as well. Thus, utilising the available water resources efficiently to maximise agricultural productivity and income becomes much more important in rainfed areas.

Timely availability of sufficient quantities of water is critical to production and productivity in agriculture. Hence, it is imperative to focus on efficient management and usage of water.

# Key Factors Responsible for Unsustainable and Inefficient Use of Water in Agriculture

Some of the key factors responsible for the inefficient use of water in agriculture are:

### Poor maintenance and management of large-scale irrigation infrastructure

Studies by the Central Water Commission (CWC) have shown that the overall water use efficiency of major and medium irrigation projects in India is only about 36% (CWC 2020-21).

More than 70% of the country's dams were constructed before 1990, making them over thirty years old (CWC). Outdated infrastructure and poor maintenance of dams and canals, coupled with a lack of effective management and distribution, lead to leakages, evaporation, and inefficient usage of water.

## Crop preferences and farming practices

Rice, wheat, and sugarcane are together cultivated over 85 million ha, and account for 43% of India's gross cropped area. These crops consume almost 80% of the freshwater available for irrigation (NABARD; ICRIER) and are causing water stress in key production clusters. Sugarcane cultivation has severely affected groundwater levels in Maharashtra, while paddy cultivation has resulted in perennial waterlogging of fields and massive depletion of groundwater levels in Punjab and Haryana.

Various studies have established that crop productivity has a direct correlation with irrigation coverage. However, most farmers are either unaware of, or do not follow the recommended irrigation practices in terms of the quantity of water required for crops, and believe that more water would result in better yields. An analysis of the irrigation practices of 90 sugarcane farmers in Satara district in Maharashtra, jointly undertaken by Sattva and Cultyvate, revealed that 74% of the farmers used their pumps indiscriminately without measuring or monitoring the volume of water used. 70% of the surveyed sample was engaged in flood irrigation. Only 25% of the farmers were aware of precision technologies, and only 31% practised some form of water conservation.

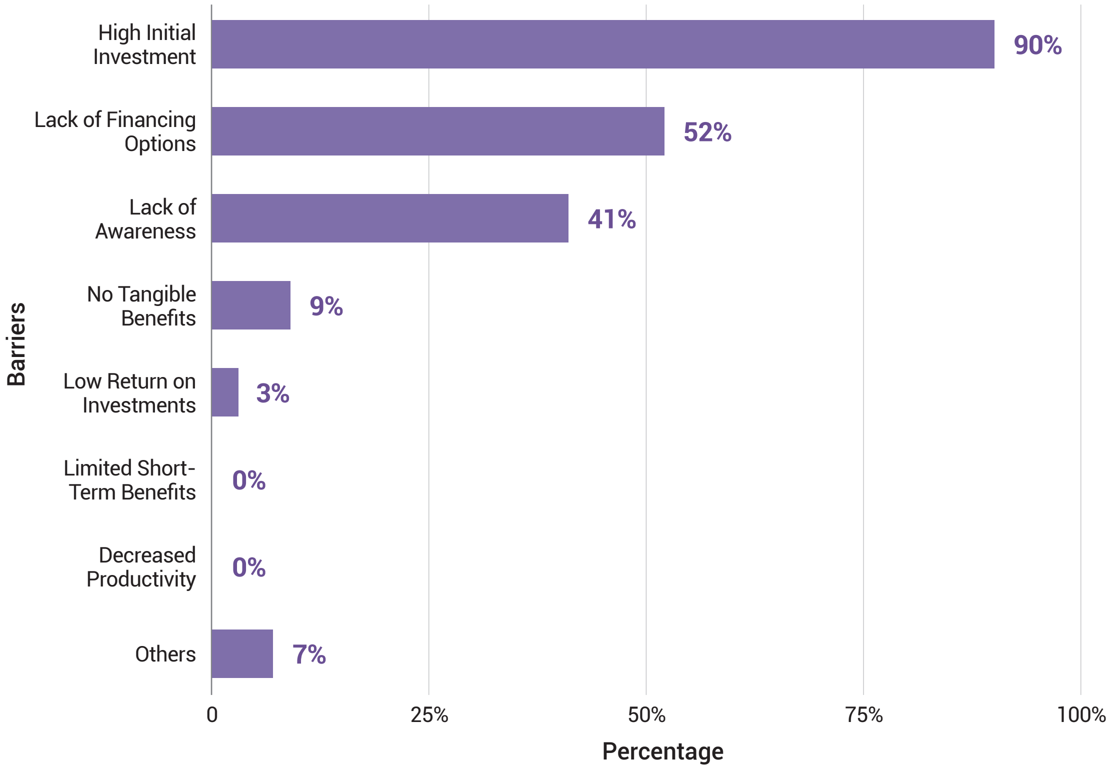
## Poor adoption of micro-irrigation and precision technologies

Crops like paddy (rice), potato, and sugarcane are usually subjected to flood or furrow irrigation, which can result in up to 50% water loss through evaporation (CWC 2020-21). Farmers who implemented micro-irrigation technology in their wheat crops observed a 15% reduction in water usage compared to those using flood irrigation. Additionally, the adoption of this technology resulted in a significant 21% improvement in crop yield (Chand et al. 2020).

Still, while micro-irrigation can minimise the loss, the adoption of micro-irrigation and precision irrigation technologies is low among smallholder and subsistence farmers. As per ICAR analysis, 11.8% of the country's gross irrigated area, which is equivalent to 96.75 million hectares, is being utilised for micro-irrigation purposes. This also varies significantly across states (Chand et al. 2020). This is also low as compared to global players like the USA, where micro-irrigation systems comprise a significant portion, ranging from 58% to 65%, of the irrigation systems used (Stubbs 2016).

The reasons for the low adoption of micro-irrigation and precision technologies are poor affordability, low economic viability, and a lack of surplus capital. The viability is further reduced for farmers who own fragmented parcels of land in different parts of the village.

**Figure 5: Key Barriers in Adopting Progressive Irrigation Technologies by Indian Farmers**




Source: Sattva and Cultyvate 2022

Automated drip irrigation systems cost approximately ₹1 lakh per acre (Cultyvate). The Government has incentivised the adoption of drip irrigation through subsidies. Under the current subsidy scheme, small and marginal beneficiary farmers installing micro-irrigation systems receive a 55% subsidy on the total cost, while other beneficiary farmers get a 45% subsidy. The subsidy is shared by the Centre and State Governments in a 60:40 ratio for most states, and a 90:10 ratio for the North Eastern and Himalayan states (Chand et al. 2020). However, these are usually back-ended, i.e., the farmer has to buy the equipment up-front, and the subsidies are transferred to the farmer later, as per the disbursement schedule. Among the surveyed sugarcane farmers in the Satara district of Maharashtra, only 24% of farmers availed of subsidies, and 50% of them faced delays in disbursement. Poor awareness and limited access to capital for up-front purchases, coupled with delayed subsidies, are key barriers that prevent smallholder farmers from adopting progressive irrigation technologies. Moreover, existing subsidies only cover the cost of micro-irrigation equipment, but not that of automation equipment like sensors, and controllers, making it unaffordable and unviable for small farmers.

## Outdated and farmer-appeasement policies that favour water-guzzling crops

Input subsidies, electricity subsidies, price policies, public procurement, and other support schemes of the Central and State Governments favour crops like paddy, wheat, and sugarcane. Most of these policies were framed to ensure food security in the late 1960s, when India was going through a severe food crisis.

The skewed incentive structures for rice and sugarcane in states like Punjab, Haryana, Maharashtra, Telangana, Karnataka, Tamil Nadu, and Andhra Pradesh limit the use of irrigation water for other crops. The assured MSP (Minimum Support Price) for rice, and a well-developed public procurement infrastructure in Punjab and Haryana, coupled with subsidies on electricity, water and fertilisers, encourage farmers to grow rice, despite rice not being the staple food in the region.

In the case of sugarcane, apart from power and fertiliser subsidies and procurement by sugar factories at Government-determined FRP (Fair and Remunerative Price), in May 2022, the Maharashtra Government also announced a transportation subsidy of ₹5 per MT per km, and an additional price incentive of ₹200 per MT to compensate farmers for delays in procurement and crushing. While these welfare measures safeguard smallholder farmers against poor economies of scale, they also end up encouraging more farmers to take up water-inefficient crops in water-stressed zones.

# Towards a Water-Efficient Future: Highlighting Successful Replicable Models with Potential

To solve the above-mentioned challenges, water-efficient technologies and models play a crucial role in conserving resources and promoting sustainable water management practices.

**Figure 6: Key Existing Interventions Addressing Water-Efficiency in Agriculture**

| Main Area of Focus to Enable Water Efficiency | Existing Prominent Techniques and Interventions | Enablers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Water-Efficient Farming Practices** | • System of crop intensification for rice, etc.<br>• Promotion of water-efficient farming practices like mulching, alternative wetting and drying, etc.<br>• Linking farmer incentives to water-efficient practices | Research | Policy | Awareness | Capacity Building | Financing & Convergence | Deployment | Market Support |
| **Micro-Irrigation and Precision Technologies** | • Promotion of micro-irrigation like drip and sprinklers<br>• Promotion of precision and smart irrigation technologies like sensors and controllers to optimize drip and sprinkler usage | Research | Policy | Awareness | Capacity Building | Financing & Convergence | Deployment | |
| **Promotion of Climate Smart, Water Efficient Crops** | • Promotion of high-yielding, drought tolerant and water-efficient crop varieties like millets along with improved package of practices | Research | Policy | Awareness | Capacity Building | Financing & Convergence | Deployment | Market Support |
| **Modernisation of Existing Technology** | • Using Solar Irrigation Infrastructure<br>• Upgrading Existing Tank Irrigation Systems<br>• Construction, rejuvenation and maintenance of water storage structures at village level, etc. | | Policy | Awareness | Capacity Building | Financing & Convergence | Deployment | |

Research | Policy | Awareness | Capacity Building | Financing & Convergence | Deployment | Market Support

*Note: Refer to Annexure for different water-use efficiency metrics used to understand the efficiency of various interventions*

**Table 1: Technologies, Interventions and Actors Addressing Water-Efficiency in Agriculture**

| Existing Prominent Technologies | Details of Interventions | Organisations |
|---|---|---|
| Water Efficient Farming Techniques like System of Rice Intensification | Techniques like System of Rice Intensification (SRI) cultivation, methods like Alternate Wetting and Drying | MANUVIKASA, TATA TRUSTS, VNV Advisory, BAIF, Pradan |
| Micro-irrigation and Precision Technologies | Drip irrigation, sprinkler and precision irrigation, water conveying systems, percolation and mini percolation tanks | GVT Global Vikas Trust, WOTR, Kothari Group, Sujay, Ambuja Cement Foundation, Netafim, AKRSP, Jain Irrigation Systems Ltd., Naam Foundation, Bhavani Drip Ecoflo Irrigation |
| Promotion of High-yielding, Drought-tolerant, and Water-efficient Crop and Seed Varieties | Climate-smart, drought-tolerant seed varieties and water- efficient crops | IRRI, ICRISAT, CIMMYT, ICAR |
| Modernisation of Existing Technology | Solar irrigation systems, modernisation of existing irrigation tanks, rejuvenation of farm ponds and tanks | DHAN Foundation, syngenta Global, Agri EXPO, GVS, aeg foundation, Aroehan, WeAreWater Foundation, Nexus Green Everything Solar |

To achieve the targeted goals, corporate funders and international and domestic foundations can direct their investments towards replicating successful interventions. These replicable interventions, described below, have shown a significant degree of success in improving the imbalances created due to inefficient water usage in agriculture.

It is to be noted that these solutions are set within specific contexts and would also require a thorough needs assessment while being replicated in another location or context.

## Water-efficient farming techniques like the System of Rice Intensification

Farming practices like mulching, SRI (System of Rice Intensification), zero-tillage, raised-bed planting, alternative wetting and drying and dry direct seeding of rice, among others, promote water usage efficiency and conservation. SRI techniques have resulted in water savings of 40%, improved productivity by 46%, and reduced the cost of cultivation by 23% over traditional inundation methods (Narayanamoorthy & Jothi 2019). However, these practices require capacity building, demonstration, and handholding support to reach their full potential.

Replacing a conventional cropping system requires interventions across the entire value chain - across inputs, production, extension, post-harvest management, marketing, and financing - and the capacities of all the relevant stakeholders must be upgraded to ensure effective implementation.

## SUCCESS STORY
## System of Crop Intensification (SRI)

### Organisations
TATA Trusts, NGOs like PRADAN

### Technique
It involves a package of techniques like Alternate Wetting and Drying (AWD), and the methodology is based on four main, interacting principles:

- Establishing plants early and quickly to favour healthy and vigorous root and vegetative plant growth.
- Maintaining low plant density to allow optimal development of each plant and to minimise competition between plants for nutrients, water, and sunlight.
- Enriching soils with organic matter to improve nutrient and water holding capacity, increase microbial life in the soil, and provide a good substrate for roots to grow and develop.
- Reducing and controlling the application of water, providing only as much water as necessary for optimal plant development and to favour aerobic soil conditions.

### Situation
The traditional practice of continuous flooding of the rice field produces a significant amount of greenhouse gas (GHG), specifically methane ($CH_4$). With SRI, soil moisture is kept at an optimum level, thus reducing methane emissions from rice production. Opting for organic fertilisers over synthetic nitrogen fertilisers, which emit the GHG nitrous oxide ($N_2O$), also reduces the GHG contribution from rice production.

### Intervention
Since 2008, the Trusts have been leading the way with the System of Rice Intensification (SRI) project. Targeting small and marginal farmers in select districts across multiple states, this initiative, implemented in collaboration with NGOs, has made a significant impact. By improving cropping patterns, enhancing yields, and promoting sustainable practices like reduced water and chemical inputs, the SRI project has benefited over 1,70,000 farmers in 3,500 villages across 104 districts.

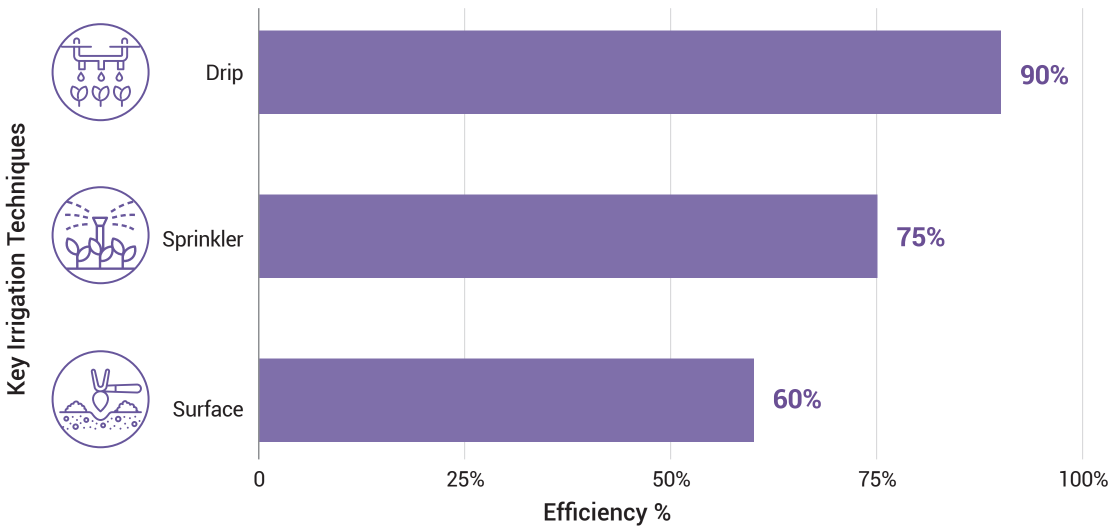
### Impact
Using the SRI methodology, yields are increased by 20-50% or more while reducing input requirement: seed by 90%, irrigation water by 30-50%, chemical fertiliser by 20-100%, and usually the need for pesticides.

## Micro-irrigation and Precision Technologies

Micro-irrigation technologies like drip and sprinkler irrigation not only help in saving water but also in reducing fertiliser usage, labour expenses, and other input costs and enhancing farmers' income. With this technology, additional areas can be irrigated with the same amount of water as conventional methods of irrigation. Additionally, water-deficient, cultivable wasteland and undulating land areas can be potentially brought under cultivation.

Field application efficiency in drip irrigation is 90%, while that of sprinkler and surface irrigation (furrow, border, basin, flood, etc.) is 75% and 60% respectively (FAO). Surface moisture evaporation is the least in drip irrigation, and there is no conveyance loss in drip and sprinkler irrigation since the water flows through closed pipes, unlike surface irrigation.

**Figure 7: Field Application Efficiency of Key Irrigation Techniques**




Source: FAO

Precision and automated irrigation systems using sensors and smart controllers to control and operate irrigation valves can further optimise water use based on the prevailing atmospheric and soil characteristics. In the case of sugarcane, a survey of 90 farmers in Satara concluded that drip irrigation with precision or automation had the highest productivity at 71.4 MT per acre, while flood irrigation yielded 54.4 MT per acre. In the case of cultivating cotton, drip irrigation reduces the cost of irrigation by 50%, saves water by 45%, and improves yield by 114% compared to flood irrigation.

Apart from the agronomic and economic factors, awareness, demand, supply, distribution, and after-sales service are the other key determinants for the adoption of micro-irrigation (CMA, IIMA).

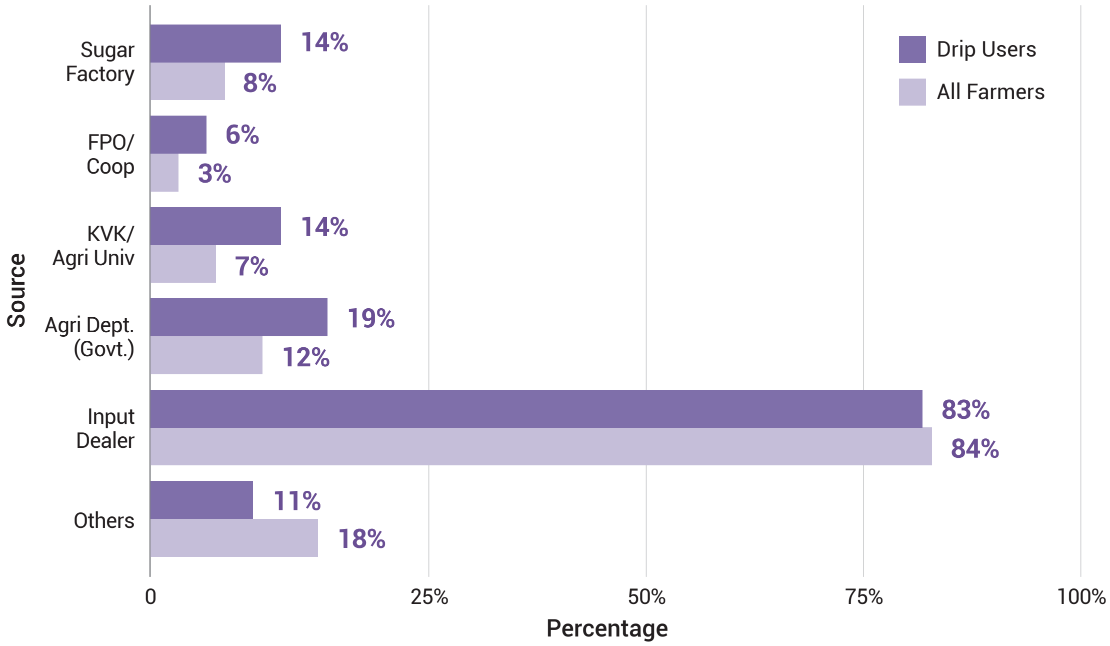
The study of sugarcane farmers in Maharashtra revealed that input dealers were the most effective partners for awareness creation and distribution of precision irrigation solutions.

There is potential to leverage grassroots NGOs, FPOs, and cooperatives to improve awareness around the benefits of micro-irrigation and precision irrigation technologies.

### Global Vikas Trust
### Establishing the Efficacy of Bridge Loans for Innovative Irrigation Technologies

Global Vikas Trust, an NGO working among farmers in Parli taluka in the drought-prone Beed district in Maharashtra, was able to facilitate bridge loans for horticulture farmers interested in adopting drip irrigation systems and thereby reduce the pressure of high up-front payments.

**Figure 8: Preferred Sources of Advice and Information regarding Irrigation**




Source: Sattva and Cultyvate 2022

## SUCCESS STORY
## Drip Pool Programme

**Organisations**
C&A Foundation, Aga Khan Rural Support Programme - India (AKRSP-I)

**Technique**
Drip irrigation delivers water directly to the root zone of plants through a network of tubes or emitters. Water drips slowly and steadily near the base of each plant, providing targeted irrigation. A pressure-compensating dripper will deliver the same amount of water to each plant regardless of changes in pressure throughout the drip irrigation

system. A non-pressure compensating dripper will not compensate for the pressure change, and thus not all plants will receive the same amount of water.

**Situation**

Since the drip system is a costly technology. This system is mostly encouraged for non-closed growing crops. e.g., vegetables, cereals, etc. Government subsidies cover approximately half of the installation costs, with the remaining amount being the responsibility of the farmers themselves. However, small and marginal farmers, who make up nearly 80% of India's farmers, do not have the financial resources to pay for this.

**Intervention**

AKRSP-I, along with the C&A Foundation, has developed a community financing model to provide interest-free loans to farmers. The fund is managed by Farmer Producer Companies (FPCs) with support from AKRSP-I. The organisations also simultaneously train and build the capacity of farmers to make financial decisions and attain empowerment.

**Impact**

An important lesson from this intervention is that if financial products are customised to small and marginal farmers in specific regions, the repayment rate of loans is 98-99%. Moreover, water-related impacts have been very positive too. Traditionally, a crop like cotton consumes 6,000-7,000 litres of water, but with drip systems, the consumption falls to 1,100-1,200 litres – an 80-90% drop. With this innovative method, participants have reported a notable 6% reduction in seed costs and an impressive 24% increase in productivity, compared to their counterparts who do not use drip irrigation.

## Promotion of High-Yielding, Drought-Tolerant, and Water-Efficient Crop and Seed Varieties

While the use of genetically modified and hybrid seed varieties may be contested due to the risk of increasing farmer dependence on agri-input companies, their use in water-stressed regions can potentially reduce the water footprint of crops. Short-duration and dwarf varieties of crops mature earlier and hence require fewer irrigation cycles, compared to conventional or traditional long-duration varieties. Some seed varieties may reduce direct water use but may also have a higher indirect water footprint through increased fertiliser application. Hence, the promotion of improved seed varieties must take into account the cost-benefit and sustainability concerns in the region, and their use should be limited to highly water-stressed areas.

The traditional variety of irrigated rice demonstrates remarkably low water-use efficiency, utilising a staggering 3,000-5,000 litres of water to produce just 1 kg of rice. In lieu of the traditional variety, Aerobic Rice is a variety that has adapted to aerobic soil conditions and responds effectively to inputs. Unlike traditional rice, it thrives in non-puddled and non-saturated soils, maintaining a water content of 70-100% of its water-holding capacity throughout the entire growing season. Aerobic rice can save as much as 50% of irrigation water in comparison with lowland rice (Lal et al. 2014).

Moreover, promoting water-efficient crops like millets will revolutionise the future of agriculture, given that millet cultivation requires fewer resources, making it a farmer-friendly and eco-friendly crop. Millets, such as pearl millet (bajra), finger millet (ragi), foxtail millet (kangni), and little millet (kutki) are well-known for their exceptional drought tolerance and water efficiency. The most prominent millet category grown in India, sorghum (jowar) is a staple in many parts of the country and exhibits excellent drought tolerance. It can be grown in regions with limited rainfall or under rainfed conditions, reducing the dependence on irrigation. Another example is pearl millet which requires just 350 mm compared to other crops like wheat, maize, and sugarcane, which demand 500% more water (Ullah et al. 2017). Other crops like pulses, specifically chickpeas (chana), pigeon peas (tur and arhar), and mung beans (moong), exhibit a relatively higher tolerance to water scarcity. They have the ability to fix atmospheric nitrogen and can be cultivated with limited irrigation, making them water-efficient choices.

Integrated strategies must be in place to promote alternative crops in areas where the groundwater situation is critical and overexploited. With farmers in Punjab and Haryana majorly cultivating rice and wheat over the past five decades, there has been considerable erosion of traditional knowledge around the cultivation practices of alternate crops like maize, bajra, etc. Hence, capacity-building programmes on packages of practices for alternate crops that are remunerative and have a lower water footprint need to be scaled up in collaboration with grassroots NGOs, Krishi Vigyan Kendras, and agricultural universities.

The Government, corporates and philanthropic agencies should continue funding research institutions under CGIAR, ICRISAT and ICAR, along with regional agricultural universities, research stations and KVKs, to develop climate-resilient and low-water footprint seed and/or crop varieties and a package of practices for water-guzzling crops like paddy, cotton, wheat, and sugarcane, that are suitable for the key agro-ecological zones in the country.

### Power of Progressive Policies in Promoting Alternate Crops

**The 'Mera Paani, Meri Virasat' Scheme**

To tackle the issue of water stress, the Government of Haryana has rolled out a few progressive policies to substitute paddy cultivation with other crops. The 'Mera Pani Meri Virasat' scheme, launched in May 2020, focuses on crop diversification, market support for alternate crops, and subsidies on farm machinery (Mongabay 2022). Under the programme, the Government incentivises farmers with ₹7,000 per acre to substitute paddy with maize, bajra, pulses, vegetables, or even leave it fallow. Farmers become eligible for the scheme if they ensure crop diversification on at least 50% of their land. Under the scheme, maize and pulses would be procured from farmers at MSP. Taking cues from Haryana, the Punjab Government has also launched a similar programme.

Other policy interventions include conditional incentives to promote good practices such as providing new electricity connections only to farmers who use micro-irrigation, or restricting the eligibility of subsidies to farmers who have farm ponds or use solar power.

While the Haryana Government has taken a bold approach to instituting conditional subsidies and promoting alternate crops, there have been some constraints in their implementation. New programmes and approaches require the existing implementing and extension agencies to change or update their approaches and systems to facilitate the new cropping ecosystem.

## Success Story
## Improving Outcomes Through Water-Saving or Drought-Tolerant Rice Varieties

### Organisations

International Rice Research Institute with support from community and government organisations.

### Technique

The promotion of alternate seed varieties in place of conventional water-guzzling varieties of rice can have a significant impact on reducing water usage through agriculture. The International Rice Research Institute (IRRI) has made significant strides in developing drought-tolerant and water saving rice varieties. These resilient strains, such as Sahbhagi dhan in India, Sahod ulan in the Philippines, and the Sookha dhan varieties in Nepal, are now being embraced by farmers.

### Situation

Drought stands as one of the most pervasive and detrimental environmental stresses, impacting a staggering 23 million hectares of rainfed rice in this region alone. While rice cultivation traditionally aligns with the rainy season, the marked irregularity and intensity of rainfall in India frequently expose rice crops to severe moisture stress. As a result, the ability of rice crops to withstand drought becomes crucial in tropical rice-growing regions. Addressing this challenge holds immense significance for the sustainability and resilience of rice farming practices. Moreover, rice is a water-guzzling crop, and by the end of 2025, 15 million hectares of irrigated rice is estimated to suffer from 'physical water scarcity' in South and Southeast Asia (NRRI Technology Bulletin 2016).

### Intervention

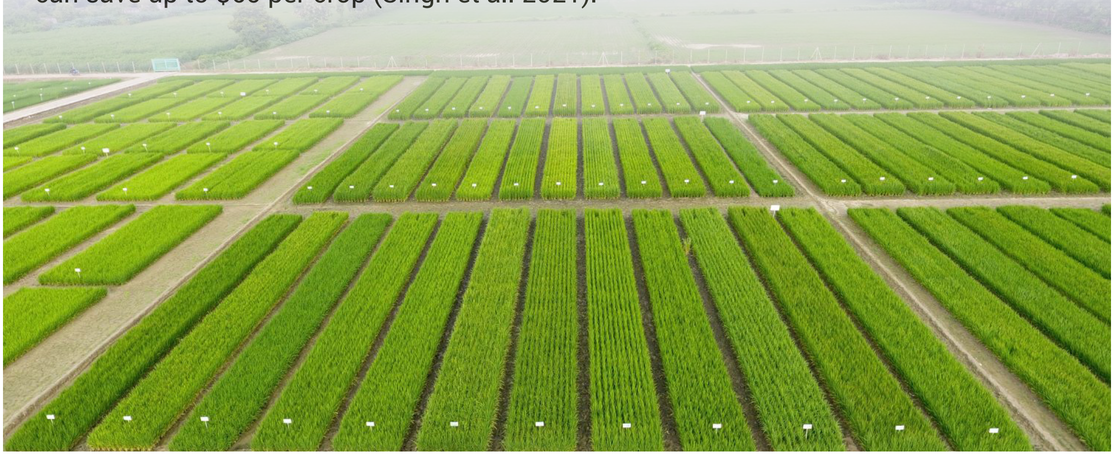
IRRI projects prioritise supporting rice farmers in adapting to the impacts of climate change. Drawing on the vast genetic diversity of the Rice Genebank - the repository of their researched rice varieties – they breed resilient rice strains capable of withstanding unforeseen climate shocks and thriving in marginal environments. Moreover, extensive areas of land in Asia and Africa are currently unproductive for rice farming due to their high salt content. IRRI has also worked on the integration of the Saltol gene into popular rice varieties across Asian countries, which has proven successful. There are other varieties that are resilient to heat, cold and submergence.

IRRI has successfully developed and released 17 high-yielding drought-tolerant rice varieties, which include Sahod Ulan and Katihan (Philippines), Hardinath and Sookha Dhan (Nepal), Sahbhagi Dhan (India), BRRI Dhan (Bangladesh), Inpago LIPI Go 1/2 (Indonesia), M'ZIVA (Mozambique), and UPIA3 (Nigeria) (Singh et al. 2021). Also, upland and aerobic rice varieties like the IR64 have well-known characteristics, can grow in non-flooded conditions and have shown good yield potential with reduced water usage.

### Impact

Field trials have shown that these drought-tolerant varieties consistently outperform their susceptible counterparts, providing an average yield advantage of 0.8-1.2 tonnes per hectare under drought conditions. Recent research has also shown that traditional flooded rice cultivation underpinned by paddy or lowland rice requires approximately 5,000 litres of water to produce one kilogram of rice. In contrast, by transitioning to aerobic rice cultivation, which is a water-saving rice variety that involves growing rice in non-flooded conditions, water usage can be significantly reduced to approximately 3,000-3,500 litres per kilogram of rice. Water productivity (defined as grams of grains produced per kg of water input) was reported to be approximately 60-70% higher as compared to traditional rice varieties.

Moreover, in terms of other positive impact parameters, IRRI has developed and released several drought-tolerant rice varieties like Sahbhagi dhan and DRR dhan 42, 43 and 44 in India, field trials for which suggest that their average yield advantage over drought-susceptible ones is 1.0-1.5 tonnes per hectare under drought conditions. Moreover, due to its early maturity (105 days) and low irrigation requirements, farmers can save up to $60 per crop (Singh et al. 2021).



## Modernisation of Existing Technology

The modernisation of irrigation technology can play a significant role in enhancing water efficiency in agriculture. For example, implementing solar-powered irrigation systems can reduce dependence on conventional energy sources and promote sustainable water use. Solar pumps utilise renewable energy to extract water from sources such as wells, rivers, or canals. This shift to solar energy decreases operational costs, making irrigation more affordable for farmers. By enabling reliable and cost-effective water supply, solar irrigation systems enhance water efficiency and promote environmentally friendly farming practices (Hartung & Pluschke 2018). However, it is important to note that in some cases, in regions that use groundwater for irrigation, solar pump adoption has led to an increase in the average farmer's water consumption. So, necessary measures need to be considered to mitigate those risks (Gupta 2019).

The other viable option of modernising 60% of the tank-irrigated areas in the country can be done through tank modernisation techniques (Palanisami 2022). The productivity and efficiency of tanks have been affected due to years of disrepair, neglect, and a lack of proactive management. There has been a 30% reduction in the storage capacity of tanks throughout India. With water demands increasing and putting stress on groundwater development and canal irrigation, rehabilitating tanks and their capacity is an important area for investment (Palanisami 2022).

In terms of maintaining and upgrading existing infrastructure, tank modernisation including various measures such as catchment treatment, foreshore plantations, establishing dead storage for community and livestock needs, enhancing supply channels and tank infrastructure, implementing on-farm development initiatives, promoting effective crop and water management, and facilitating the provision of community wells wherever appropriate, can lead to better systems. Rehabilitation efforts should prioritise the equitable distribution of water based on crop requirements and the adoption of crop and water management practices through on-farm development.

### SUCCESS STORY
### Vayalagam Tankfed Agriculture Development Programme by DHAN Vayalgam Foundation

#### Organisations

DHAN Vayalagam Tank Foundation (DVTF) executed this project with support from the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), state governments, individual donors, corporate philanthropies and other funding agencies.

#### Technique

The rehabilitation and modernisation of tank irrigation refers to the process of restoring and upgrading existing tank-based irrigation systems to improve their functionality, efficiency, and sustainability. This involves repairing, renovating, and refurbishing the infrastructure of the tanks, including channels, gates, outlets, and other components. Additionally, modernisation entails integrating advanced technologies and management practices to enhance water storage, distribution, and usage. The aim is to optimise the performance of the irrigation systems, ensure effective water management, and maximise agricultural productivity in the respective areas. Because tanks are distributed across the landscape, they provide an avenue to capture more water.

### Situation

With approximately 0.25 million tanks scattered throughout the country, their irrigated area was 1.67 million hectares in 2018, a decline from 3.3 million hectares in 1953. The southern states contribute nearly 60% of the total tank-irrigated area in the country. However, over the years the utility of tanks has been significantly impacted due to lowering productivity and efficiency. Challenges such as encroachment, improper land use in the upstream areas, and siltation have led to a substantial 30% reduction in tank storage capacity across most regions, resulting in poor tank irrigation performance. In light of limitations in expanding canal irrigation and groundwater development, irrigation tanks have now resurfaced as a prime example of providing extensive protective irrigation in the semi-arid tropics.

### Intervention

By providing access to water, crop production technology, and institutional governance, the main goal of maintaining tank-fed agriculture was to support tiny, marginal, and poor agricultural communities. The initiative, which started in the late 1990s and continued until 2021, merged microfinance, insurance, extension (via Plant Clinics), and tank-based watersheds. The main organisation, the Vayalagam (tank association), is promoted in small communities and around fresh water sources like tanks, village ponds, community wells, and similar sources. These Vayalagams are integrated at the level of the cascade or watershed, followed by the level of the block as Federations, in order to provide better water sharing on a hydrologic basis.

### Impact

By the end of March 2021, 3,511 Vayalagams and 36 federations, spread throughout more than 17 river basins, had been promoted. It has touched over 2,550 villages in six states and even led to the creation of 3 million cubic metres of additional water storage through ₹175.33 million worth of renovation works. Moreover, this technique has been reported to have rehabilitated more than 450 water bodies, accounting for ₹35 crores. Rehabilitating irrigation tanks to their original storage capacity significantly increases water availability for cropping. Moreover, in other tank rehabilitation-related projects, interventions by DHAN have been able to double the crop production while growing paddy as the first and second crop in Virudhunagar district of Tamil Nadu (DHAN Foundation 2018).

### Notable Mention: BAIF's Work in Water

BAIF, operating across 12 states, is dedicated to generating sustainable livelihoods and employment opportunities. With a workforce of 6,000 employees, they focus on conserving local seeds with inherent value, promoting agrobiodiversity conservation. Farmers have also joined in this effort.

One of the key agronomic practices employed by BAIF in rainfed regions is the System of Rice Intensification (SRI) coupled with effective fertiliser management. This approach has led to enhanced productivity per unit of input consumption. BAIF's efforts span across 3.72 lakh hectares of land, benefiting around 2.84 lakh individuals across various regions in India. Notable water efficiency models include Karnataka's Network of Farm Ponds, Gujarat's Landscape Development, conjunctive water use in Maharashtra, and demand-side management strategies to curtail groundwater consumption in irrigation. In Vidarbha district, the `Prosoil project implemented drip and sprinkler systems for over 1,000 tribal families. Diverse irrigation systems, such as diversion-based in Nellore, gravity-based in Uttarakhand, and a smart irrigation system using sensors in Ranchi District, showcase BAIF's innovative approach to sustainable water management.

## Way Forward: Funders Can Play a Pivotal Role

In conclusion, improving the efficiency of water-use dynamics in Indian agriculture requires focused and coordinated efforts, long-term commitment and the active participation of relevant stakeholders. Funders working at the intersection of water and agriculture have an important role to play in pivoting water-related interventions to the right focus areas, depending on the geographical context of water-use statistics accrued to farming activities across India. Funders can be pivotal in driving the adoption of water-efficient techniques in Indian agriculture through strategic actions.

By investing in research and development, providing financial incentives and subsidies, supporting capacity-building and awareness programmes, and establishing demonstration farms, they can encourage farmers to embrace water-saving technologies. Collaborating with NGOs and agricultural institutions, promoting market linkages, and advocating for favourable policies are also essential. Monitoring and evaluation ensure effectiveness and continuous improvement. These efforts collectively contribute to sustainable water use, heightened agricultural productivity, and resilience in the face of water scarcity, fostering a more water-efficient agriculture sector in India.

# Annexure 1

## Water Use Efficiency Metrics

Water use efficiency metrics play a crucial role in water management and agricultural practices. They help identify opportunities for improvement, optimise water use, and promote sustainable water use practices. By understanding these different types of water use efficiency, farmers, policymakers, and water managers can make informed decisions to enhance water productivity and reduce water waste. From this perspective, we have tried to understand water-related interventions in agriculture from all three lenses. It is important to highlight that all these efficiency metrics are used interchangeably based on context throughout the perspective.

### Output-Based Water Use Efficiency

Output-based water use efficiency measures the effectiveness of water concerning the output or yield achieved. It is calculated by dividing the total quantity of output (e.g., crop yield, industrial production) by the total amount of water used in the field to achieve that output. This metric assesses how well water resources are utilised to generate a specific product or result.

### Crop-Based Water Use Efficiency

Crop-based water use efficiency is a specific measure used in agricultural contexts. It evaluates the efficiency of water use for a particular crop. In simple terms, it is calculated by dividing the yield of a specific crop (e.g. kilograms of rice, bushels of wheat) by the evapotranspiration (amount of water that is lost to evaporation) rate of the crop plus water used for metabolic purposes. Crop-based water use efficiency provides insights into how effectively water is utilised to produce a specific crop.

### Irrigation Efficiency

Irrigation efficiency measures how well water is delivered and utilised in the irrigation process. It is the ratio of the amount of water beneficially used by the crops to the total water applied during irrigation. In other words, it quantifies the percentage of water that reaches the plant roots and is used for crop growth, as opposed to being lost through evaporation, runoff, or deep percolation. Efficient irrigation systems, such as drip and sprinkler irrigation, are designed to minimise losses and maximise water use for plant growth.

# Annexure 2

## Glossary

1. **Per capita availability of water** - The per capita water availability is estimated by dividing the annual average water availability by the population.
2. **Per capita withdrawal of water** - It is the quantity of freshwater taken from groundwater or surface water sources (such as lakes or rivers) for use in agricultural, industrial, or domestic purposes divided by the population.
3. **Zero-tillage** - Zero-tillage is also known as No-Tillage. It is a minimum tillage practice in which the crop is sown directly into the soil that has not been tilled since the harvest of the previous crop.
4. **Raised-bed planting** - Raised-bed planting is a form of planting in which the soil is raised above ground level and usually enclosed in some way.
5. **Alternative wetting and drying** - Alternate wetting and drying (AWD) is a management practice in irrigated lowland rice that saves water and reduces greenhouse gas (GHG) emissions while maintaining yields.
6. **Dry direct seeding** - Dry direct seeding, an ancient method of rice establishment, is based on sowing dry rice seeds directly in the main field without saturated and puddled soils.
7. **Field Application Efficiency** - Field application efficiency (Ea) is the ratio between water directly available to the crop and that received at the field inlet. It represents the efficiency of water application in the field.
8. **Bridge Loan** - It is a short-term financing option used by companies to cover costs or fund a project before income or financing is expected.
9. **Catchment area treatment** - The catchment area treatment involves understanding the erosion characteristics of the terrain and identifying or suggesting remedial measures to reduce the erosion rate. For this reason, the catchment area is responsible for directly draining rivers, streams, tributaries, etc.
10. **Foreshore plantations** - It refers to the establishment of vegetation or plantings along the foreshore, which is the area of land that lies between the low tide and high tide marks on a shoreline.
11. **Dead storage** - The volume of water held below the minimum pool level is called dead storage. It is provided to cater for the sediment deposition by the impounding sediment laid in the water.

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