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Co-optimizing solutions in water and agriculture

Lessons from India for water security

Photo Credits: UPL Limited, Trials with “Zeba”

Knowledge contributions received from WBCSD member companies

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WBCSD is a global, CEO-led organization of over 200 leading businesses working together to accelerate the transition to a sustainable world. We help make our member companies more successful and sustainable by focusing on the maximum positive impact for shareholders, the environment and societies.

Every business needs water-smart agriculture

Around the world, water deficiency is a critical factor that limits growth and development. India ranks high on water stress. Over 330 million Indians were affected by drought conditions in April-May 2016.

For businesses, managing water has become a priority to ensure resilience, operational continuity and growth. Strategizing to counter water stress, especially for those engaged in agricultural production, manufacturing, mining or energy production, has become an imperative. This also holds true for companies where their workforce, supply chain or markets will be affected by disruption of water supply. It also includes those companies whose social license to operate depends on protecting and enhancing the welfare of vulnerable communities.

Strengthening water efficiency in agriculture, a lesson learned from India, is key for improving the availability and quality of all users, including industry. If agricultural water efficiency is not addressed smartly, other water management practices will not suffice.

As businesses, we recognize that water is the key common denominator underlying the challenges faced by India's food system. We also recognize that we have a significant role to play in developing solutions to mitigate these challenges.

This study outlines interventions on water efficiency and their impacts on productivity and other co-benefits. The study contends that implementation of "smart" solutions is a need as well as an opportunity. Finally, it outlines different avenues for the application of these solutions, and suggests means of collaboration for businesses, policy-makers and other stakeholders.

Jai Shroff
CEO, UPL Limited

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foreword

foreword

Water-smart agriculture brings solutions to the water-energy-food nexus

WBCSD produced a report in 2014 on "Co-optimizing solutions: Water and energy for food, feed and fiber." The objective of this report was to identify a broad spectrum of business solutions to the "nexus" between the inter-connected challenges and solutions involving climate and energy, water, food and land-use systems.

Estimates are that in the next three decades, the global food system will need 40-50% more water than today. Municipal and industrial demand for water will increase by 50-70% during this period, while demand for water in the energy sector will increase by 85%[1]. In India, the stresses to the ecosystem caused by this demand are already acutely felt.

In 2014 WBCSD produced a report on "Co-optimizing solutions: Water and energy for food, feed and fiber." The objective of this report was to identify a broad spectrum of business solutions

to the inter-connected challenges and solutions involving climate and energy, water, food and land-use systems.

The 2014 report identifies how the most appropriate and scalable solutions can be implemented, with multiple benefits on yields, energy, water, climate change, resource use and other factors. Many of these benefits translate into direct financial opportunities and present a sound case for business action. In fact, there are a lot of advantages in co-optimization. If water is used more efficiently to grow crops, then less energy is needed to pump water for irrigation.

This paper builds on the findings of the 2014 report by placing a key emphasis on water and agriculture. It aims to learn from the experience of WBCSD members operating in India, and provides a narrative on a range of solutions across multiple parameters.

Water scarcity is a challenge in many geographies including South East Asia, Sub-Saharan Africa, Latin America and the United States of America (USA). In these regions, water efficient measures used in agriculture play a significant role in conserving and enhancing water availability and quality, increasing productivity and reducing emissions.

We hope the findings of this India-based study will support business to business collaboration in India, and are relevant for learning and implementing these practices in other geographies too.

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Introduction

India faces high water stress. The country is amongst those with the most fragile water resources across the world[2]. The serious impact of this stress was evident in early 2016, when 300 million Indians faced severe water shortages following two consecutive seasons of weak monsoons. Farm production fell and industrial production was significantly hit[3].

Estimates suggest that nearly 90% of available water in India is consumed by the agricultural sector. Agriculture holds the key for unlocking sound water management in the country if inefficiencies in water usage are identified and adequately addressed.

Water scarcity has a direct impact on all businesses operating in the agricultural value chain. Further, inefficiencies in agricultural water use impose significant operational risks on any business that relies on shared water resources for operations.

Businesses also have the opportunity to offer services, products and innovation that address the water challenge and create sustainable livelihoods for farmers.

Farming as a share of India's GDP has fallen dramatically, while remaining the largest employer by far. The increasing demand for food represents a sizeable market waiting to be served. The annual demand for food-grains in India will rise to 333 million tons by 2050, up from 250 million tons today. Further, commercially dominant segments such as dairy, horticulture and inland fisheries, which drive India's growth in international markets, can be significant in improving agriculture' share in India's economy.

However, agriculture in India operates on over-stretched resources of land and water. The judicious use of resources is required to improve agricultural production and trade practices.

Figure 1: Share of agriculture and allied sector in employment and GDP of India[4]

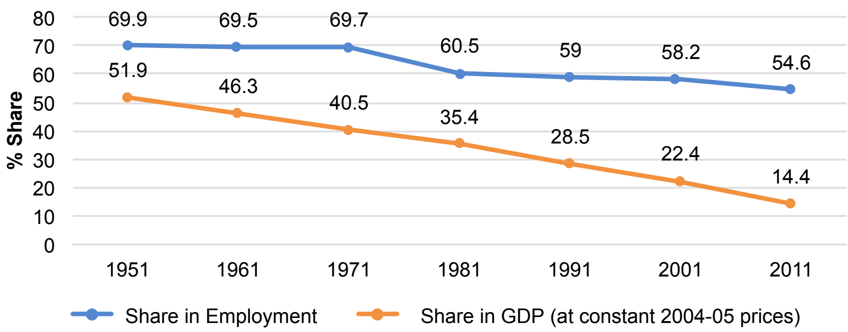


Table 1 Issues associated with the agricultural sector in India

Production

Issue	K	I	D	P
Technology development and application	✓	✓		
Low productivity (yield)	✓	✓		
Inappropriate use of inputs (water, fertilizers, energy)	✓	✓		
Depleting input/resource quality	✓			✓
Smallholder land sizes				✓
Agriculture-related GHG emissions	✓	✓		✓
Skewed production (towards cereals – rice and wheat)	✓			✓
Lack of productive non-agricultural activities like livestock-rearing and off-farm allied activities		✓	✓	
Lack of efficient storage and agro-processing facilities		✓	✓	
Lack of extension services, market-reach				
Climate-change adaptation and resilience	✓			✓
Food safety and health				✓
Price volatility				✓
Middlemen in agricultural supply chains	✓	✓	✓	
Low farmer incomes and poverty				✓
Inefficient credit and lending systems				✓
Ineffective reach and delivery of Insurance				✓
Gender inequalities in agriculture	✓			✓
Food loss and waste in production and processing	✓	✓		

Table 1 Provides a list of issues associated with the agricultural sector in India. It organizes these issues into four broad categories

- **K** Knowledge
- **I** Infrastructure
- **D** Delivery and support services
- **P** Policies

These categories are based on an understanding of the key controls for addressing these issues.

Consumption

Issue	K	I	D	P
Food loss and waste in retail and consumption	✓			✓
Consumer preferences and demands	✓			
Under-nutrition and obesity	✓		✓	✓

Against this background, the study describes "smart" agricultural solutions being implemented by businesses in India in order to address some of the issues mentioned above.

The study is an attempt to customize WBCSD's global work on "*Co-optimizing solutions: Water and energy for food, feed and fiber*"[5] in the Indian context. Its principle aim is to highlight solutions being deployed by Indian businesses, and set out their relevance and impact.

The study organizes the examples from India into 10 comprehensive solution areas, capturing ways to address the challenges faced by the agriculture sector. It highlights their applicability in the Indian context, while presenting the opportunities for business under each solution.

This study recognizes the nexus approach[6] i.e., the concept that there is an inter-connection between water, energy, food and climate change. A proper understanding of this is essential to develop solutions and address the identified challenges in a mutually beneficial manner.

Co-optimizing solutions

Table 2 provides an overview of the segments into which the solutions have been organized[7]

1 Smart varieties	• Increased maximum potential yield • Pest smart • Resource smart • Tissue culture
2 Smart crop management	• Efficient fertilizer use • Smart pesticides • Fertigation • Integrated pest management
3 Mixed farming systems	• Multiple cropping • Agro-forestry
4 Better blue water management	• Water-use and water-conveyance efficiency • Water-saving rice systems
5 Better green water management	• Conservation agriculture • Super-absorbent chemicals • Integrated watershed management and rainwater harvesting

Table 2 provides an overview of the segments into which the solutions have been organized (continued)

6 Efficient farm operations and mechanization	• Energy-efficient farm equipment
7 Bridging the yield gap	• Best management practices • System of crop intensification • Farmers' inclusion in innovation systems
8 Efficient fertilizer production	• Energy efficiency and greenhouse gas emissions reduction
9 Making use of trade	• Trade based on water productivity
10 Reducing food loss and waste	• Improving post-harvest storage • Improving market linkages

Table 3 (next page) Overview of solutions, geographical spread and impacts

This paper attempts to identify opportunities to scale up and collaboratively implement some of these solutions. The solutions are in the form of technologies, practices or approaches. Often, these are implemented in combination with other technologies/practices. However, their success largely depends on local conditions.

Solution	Case examples from businesses in India; Data recorded from interventions by these companies	Effects on			Other Benefits
		Yield	Farmer Incomes	Water-use efficiency	
Smart varieties – high yielding	**Monsanto India's Dekalb** • Available in 16 high-yielding varieties • Introduced in 18 Indian maize-growing states	**32% higher**	**Limited data**	**Limited data**	Hardiness in case of rainfall fluctuations recorded for particular varieties
Smart varieties – insect resistant	**Monsanto India's Bt Cotton** • Available in 2 generations with trade name Bollgard I and Bollgard II • Introduced in 9 Indian cotton-growing states	**50% higher**	**375% higher**	**Limited data**	• Yield improvements recorded from reducing losses due to insect Bollworm • significant returns noted on the quality of life of farmers
Tissue culture and grafting	**Jain Irrigation** • JV-12 variety for white onions; grown by over 5,000 farmers in Maharashtra and Madhya, Pradesh • High-yielding varieties for banana, pomegranate and strawberry; grown by over 20,000 farmers • Grafted plants- high-yielding varieties developed for mango (Ultra HighDensity Plantation), citrus, guava, sapota and gooseberry	**50-200% higher**	**150-300% higher**	**90% higher**	• Superior product quality • Early fruiting allows for early harvesting, thus achieving multiple cropping cycles over the same period as compared to conventional practice

Solution	Case examples from businesses in India; Data recorded from interventions by these companies	Effects on			Other Benefits
		Yield	Farmer Incomes	Water-use efficiency	
Sustainable cotton cultivation – a cotton value chain initiative	**Ambuja Cements** • Set of practices that include integrated pest management, conservation and minimum tillage, and water management- good management of storage and delivery systems • Implemented in partnership with Better Cotton Initiative in five Indian states	**50% higher**	**14% higher**	**10-22% higher**	Significant reduction in the use of fertilizers **(33%) and chemical pesticides (60%) -** significant improvement in soil health
Fertigation products	**Yara India** • Traded as Yara Mila Complex and Yara Liva Nitrabor • Mainly on fruits and vegetable crops	**Limited data**	**Limited data**	**Limited data**	• Targeted improvements on yields and farmer incomes, reduction in use of chemical fertilizers • Demonstrated on large farm-sizes
	Jain Irrigation • Automated fertigation – traded as Nutricare • Manual Fertigation – Fertigation Tank, Venturi and Injector pumps	**50-200% higher** (when used with micro-irrigation systems)	**150-300% higher** (when used with micro-irrigation systems)	**Up to 90% higher** (when used with micro-irrigation systems)	**Saving in fertilizer use by 30-40%**

Solution	Case examples from businesses in India; Data recorded from interventions by these companies	Effects on: Yield	Effects on: Farmer Incomes	Effects on: Water-use efficiency	Other Benefits
Integrated watershed manage-ment	**ITC Limited** • Is an approach for water stewardship to achieve water security for all stakeholders • Implemented in 12 Indian states, covering 7.85 lakh acres of land	**Yield improved by 16%, 10% and 11% higher** than baselines in wheat, paddy (rice) and maize respec-tively	**Farm incomes improved in a range of 18 to 46%** against baselines across crops and geogra-phies	**46% higher area brought under irrigation; 18% to 73% improvement in groundwater levels**	Significant improvements in soil health and reduction of fertilizer use
	SABMiller India • Implemented as an approach in all manufacturing locations of the company • Specific noted example of Neemrana, Rajasthan; implemented on crops- pearl millet, cotton, wheat etc.				
	Jain Irrigation • Implemented on Girna river and its microwatershed in Maharashtra • Soil conservation and drainage and construction of rainwater harvesting structures			Total conservation capacity of 1,800 million L per annum; and total rainwater harvesting capacity of 1,500 million L per annum	Significant run-off generated within the watershed; moderate to good possibility of groundwater recharge
Agroforestry	**ITC Limited** • A program involving cultivation of trees and field crops together to support small and marginal farmers • Implemented in Andhra Pradesh, Telangana and Karnataka covering over 83,000 acres of land	**44% higher**	**71% higher**	**Limited data**	Food, fuel, fodder and wood security for all stakeholders

Solution	Case examples from businesses in India; Data recorded from interventions by these companies	Effects on			Other Benefits
		Yield	Farmer Incomes	Water-use efficiency	
Drip Irrigation – a micro-irrigation solution	**Jain Irrigation** • Implemented as manufacturers and service providers of drip and other micro-irrigation solutions. Coverage: Four million smallholder families adopted drip to date **Ambuja Cements** • Implemented as facilitators for drip uptake as part of their CSR commitments on Water and Agriculture. Focus on provision of finance and training for drip uptake. Presence in nine Indian states with very good coverage in Gujarat **Monsanto India** • Monsanto as facilitators for drip uptake among their contracted farmer community. Ensure finance and training. Coverage: 2300 acres in four Indian states	50 - 360% higher	20-30% higher	60-70% higher	50% reduction in energy use 50% reduction in fertilizer use High savings in labor cost
Direct seeding, and drip fertigation – in rice	**PepsiCo** • Implemented direct seeding in four Indian states - Punjab, Rajasthan, Karnataka, Tamil Nadu	Limited data	Higher by INR 1500 per acre	30% higher	Significant (75%) reduction in greenhouse gas emissions
	Jain Irrigation • Implemented drip fertigation in rice	22.5% higher	20% higher	60% higher	100% reduction in greenhouse gas emissions due to maintenance of aerobic conditions in soil

Solution	Case examples from businesses in India; Data recorded from interventions by these companies	Effects on			Other Benefits
		Yield	Farmer Incomes	Water-use efficiency	
Bio-degradable super absorbent	**UPL Limited** • Starch-based super absorbent to improve field capacity; improve uptake of moisture and nutrients • Field trials in four priority markets in India • Crops: onions, potatoes, pomegranate, mustard, groundnut, cotton	**10 - 12% higher**	**10-12% higher** additional income from improved size and grade of commodity	**75%** reduction (in controlled trials)	Significant soil health improvement- improves soil porosity, prevents soil erosion, improves soil organic content Significant reduction in fertilizer application

Photo credits: Monsanto, promotion of Drip Irrigation in contracted farms

Solution	**Case examples from businesses in India;** Data recorded from interventions by these companies	Effects on			Other Benefits
		Yield	Farmer Incomes	Water-use efficiency	
Efficient water manage-ment practices implemented as a set - drip irrigation, furrow irrigation, gated pipes, land levelling, trash mulching	**Olam India** • Project Madhushree in Madhya Pradesh (Case 1) and Maharashtra (Case 2) • Implemented on sugarcane **ITC Limited** • Implemented in eight states covering 1.3 lakh acres • Zero tillage on wheat, broad-bed furrow in soya and direct seeding and mechanized transplant in paddy	**Case 1: 23% higher** **Case 2: 44% higher** **21% higher in soya; 13% higher in paddy**	**Case 1: 23%** **Case 2: 48%** **1.3 times higher in wheat; 39% higher in**	**25- 35 % higher (Case 1 and 2)** **Number of irrigtions reduced from 9 to 7**	Significant supplement to small-holder income Significant improvement in soil moisture retention and resistance to climate variability
Conserva-tion tillage	**Monsanto India** • Implemented as a practice allowing crop residue on field before planting next crop • Project Nalanda from Bihar- covered 9 districts in South Bihar	**5.2% higher**	**45%**	**35%**	Significant saving in labor cost Often implemented in conjunction with other good practices
Greenhouse technology	**Jain Irrigation** • Cultivation of vegetables and flowers under protected conditions – controlled temperature, humidity, light intensity; use of special soil media, irrigation, fertigation and other agronomic practices	**Up to 1,000% higher**	**Significantly higher**	**50% higher**	• Significant (30%) higher fertilizer use efficiency • Constant supply of high quality produce

Solution	Case examples from businesses in India; Data recorded from interventions by these companies	Effects on			Other Benefits
		Yield	Farmer Incomes	Water-use efficiency	
Solar pumps	**Grundfos pumps** • Use of solar technology to pump, lift and supply water to crops through pipes/drip • Implemented in Karnataka and Tamil Nadu for irrigation	**20% higher**	Significant saving; payback period for technology - 1.5 years	Improved due to the use of piped/drip systems	• Significant reduction in energy use, and labor cost • Improved fertilizer use efficiency
Sustainable Sugarcane Initiative (SSI) and System of Rice Intensification (SRI)	**Nestlé India** • Implemented as a set of identified practices for cultivation of sugarcane and rice; includes appropriate raising and planting of seedlings and saplings, protective irrigation and organic methods of plant nutrition and protection • As trial in Karnataka's KabGni river basin	**20-50% higher**	**45-62% depending on location**	**40-70%**	Significant improvement in soil health from avoidance of chemical fertilizers

Each of these solutions are further discussed in detail, along with solutions implemented by businesses in India. Companies are leading the way in implementing the solutions, as demonstrated by case studies from Ambuja Cements, Grundfos Pumps, ITC Limited, Jain Irrigation, Olam, Monsanto, Nestlé, PepsiCo, Rabobank, SABMiller, UPL Limited and Yara International.

"A lesson learned from India is the importance of strengthening water efficiency in agriculture. This is key to improving the availability and quality of water for all users"

Jai Shroff, CEO, UPL Limited

Solution area 1

Smart varieties

Smart varieties are new crop varieties with beneficial properties. These are obtained by conventional breeding, i.e., crossing closely or distantly-related varieties to produce new lines with the desired characteristics. This is also achieved through genetic crop engineering, i.e., incorporating the specific exogenous genes from other organisms or plant species into a certain crop.

Smart varieties require optimization of soil nutritional quality that comes from specific inputs and farm practices. As new varieties are introduced into the field, farmers receive training and access to better inputs.

Three potential areas for development of smart varieties are:

- High-yielding varieties
- Insect-resistant varieties, and those resistant to non-optimal growth conditions (drought, salinity)
- Herbicide-tolerant varieties

Photo credits: Jain Irrigation, Tissue Culture Laboratory at Jalgaon, Maharashtra

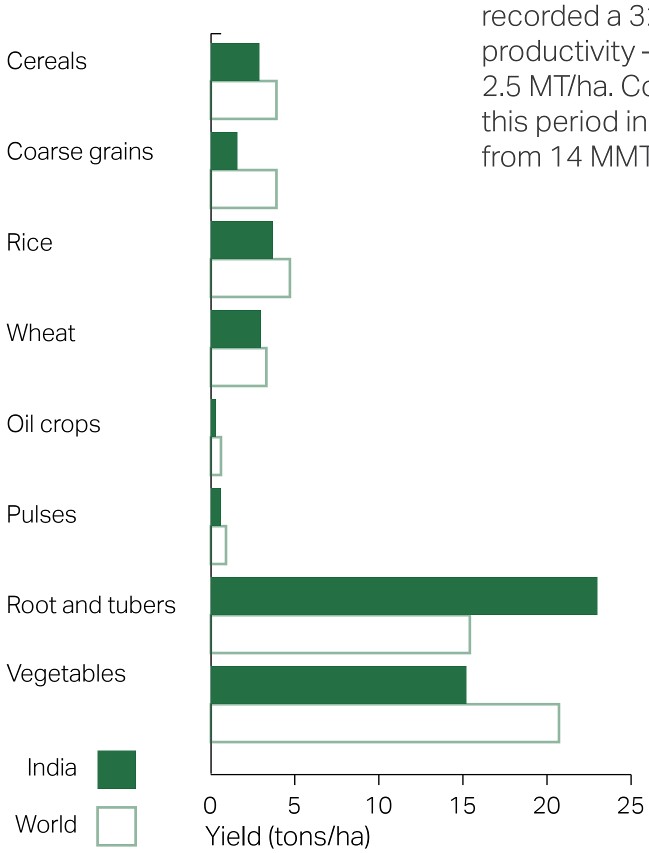
In light of the increasing demand for food, smart varieties provide effective solutions to address the food security challenge in India. A general view is that 90% of increasing food demand will be met by improvement in crop yields and by increasing cropping intensity.

While the cropping intensity is limited by availability of water and by opportunities for land extensification, improvements in crop yields are pivotal to meet the targeted demand for food[9]. Smart crop varieties that improve crop yields or reduce crop losses ensure that most of the resources are used, thereby reducing further demand.

Smart varieties can play a transformative role in the case of pulses, for which self-sufficiency is key for meeting the nutritional needs of India's rising population.

Figure 2 Major crops and their yields in India vs global averages[8]

The gaps underline the potential of Smart Varieties in improving crop yields in India.



Monsanto India, a provider of technology-based seed and crop-protection solutions, produces Dekalb, India's largest selling smart corn variety, which is currently grown across 18 states[10].

Dekalb is available in 17 high-yielding hybrids that suit India's diverse agronomic and climatic conditions. Each of these hybrids are developed in India and tested extensively through Monsanto's partnership with state agricultural universities and leading agricultural institutions. The Dekalb varieties are a leading contributor to the corn revolution in India. During the decade between 2004 and 2013, Dekalb recorded a 32% increase in corn productivity – from 1.9 MT/ha to 2.5 MT/ha. Corn production during this period increased by 64% – from 14 MMT to 23 MMT.

The cotton revolution that made India the second-largest producer and exporter of cotton has been a result of the introduction of hybrid cotton varieties called Bt Cotton[11]. Monsanto developed this variety of cotton in partnership with MAHYCO (Maharashtra Hybrid Seed Company Limited). As part of this, a series of field trials were carried out in different agro-climatic zones and the variety was introduced commercially in 2002, following approval from the government.

Bt Cotton contains the patented Bt gene which offers protection against all major species of insect Bollworms that had previously been responsible for heavy losses in cotton crops.

Besides insect protection, Bt also offers higher yields, significant reduction in input cost and ease of farming.

Since its introduction[12], Bt demonstrated successive improvement in productivity of cotton, farmer incomes and their standards of living. Results demonstrated an improvement of an average 50% in cotton yields, 375% in farmer incomes and 9.25% increase in production area across the nine cotton-growing states in India. There was a rapid uptake of Bt among farmers, which increased India's cotton production tremendously.

The second generation of Bt technology was introduced later, with encouraging returns to cotton yields and farmer incomes.

Solution area 2

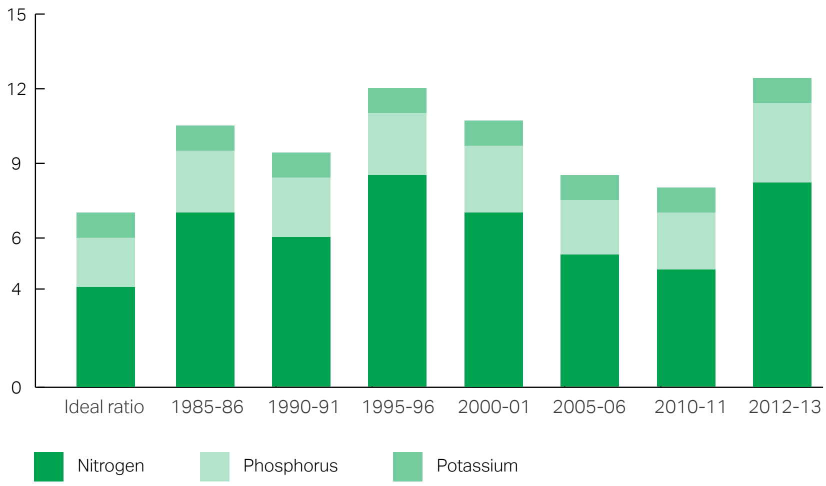
Smart crop management

Smart crop management implies improved management of external farm inputs, including fertilizers and pesticides, in order to correct the deficiencies of nutrients in soil and to avoid crop losses due to pest and disease attacks. It involves controlling the type, quantity and timing of the application of these chemicals (fertilizers and pesticides) so as to ensure that while productivity is improved, the soil's capacity to retain nutrients and support optimal plant growth is not compromised.


Photo credits: Ambuja Cement, interventions with Better Cotton Initiative

Figure 3: Consumption ratios of primary nutrients –

Nitrogen (N), Phosphorus (P) and Potassium (K), in India since 1985. Food production relies heavily on the use of these primary nutrients. Against the ideal N:P:K ratio of 4:2:1, the ratio in Indian soils has been skewed due to the imbalanced use of fertilizers. Smart crop management can help address some of the issues associated with the skewed nutrient ratio.

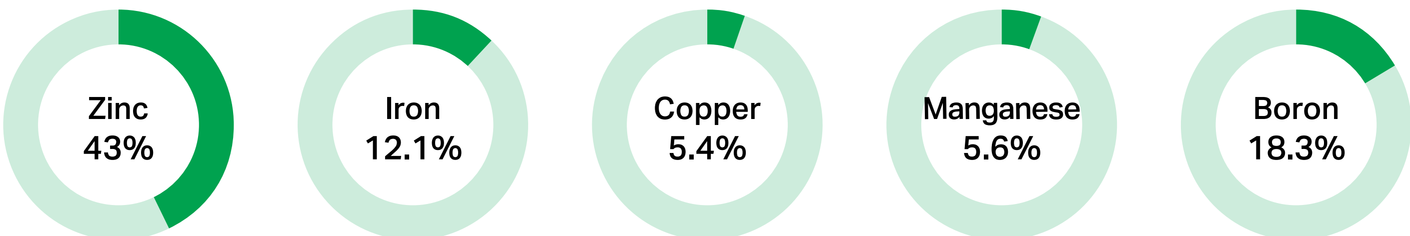


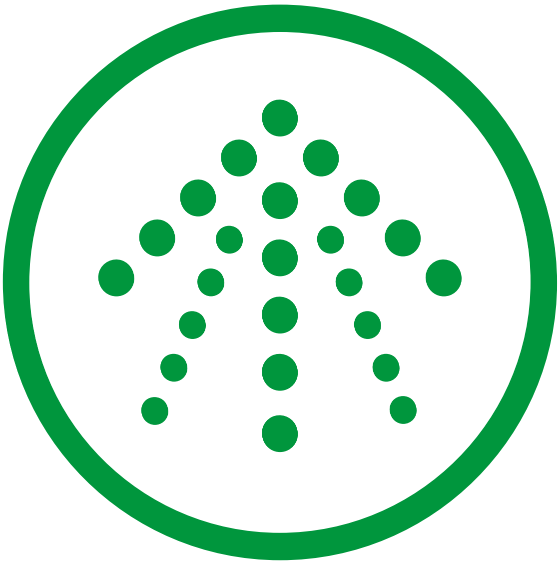
Plant nutrients and water are complementary inputs. A plant's response to water availability depends on the balanced availability of nutrients. Plants with balanced nutrient levels better withstand water stress. In fact, fertigation, which is the technique of applying fertilizers through irrigation water, has proved effective in more precise and uniform application of these chemicals.

Soil crop management brings substantial gains in crop yields due to the improvement in soil health and an overall balanced uptake of inputs. It also reduces pollution from leaching of these chemicals, besides saving energy and greenhouse gas emissions from their production.

Figure 4: Critical micro-nutrient deficiency in Indian soils[13].

Judicious application of fertilizers ensures that nutrient deficiencies in the soils are adequately addressed and the capacity of soil to support plant growth in the long run is not compromised.





Yara is a global company and the world's largest supplier of nitrogenous fertilizers. It focuses on the delivery of optimal crop nutrition products for farmers, with the aim of improving farm productivity and product quality. Apples have been a key focus for Yara both in India and at the global level. The company's interaction with Indian farmers revealed that fertilizer application was highly skewed in favor of nitrogen use. This led to the deficiency of critical growth elements such as phosphates, potash and other micro-nutrients in soil. Water scarcity during the critical fruit development period of April to June further reduced the effectiveness of fertigation. An average productivity of 2-2.5 tons/ hectare of apples was observed, which is far lower than some of the developed countries such as Italy, producing as much as 40 tons per hectare. In response to the observed issues, Yara designed the Crop Nutrition program for apples - the YaraMila Complex and YaraLiva Nitrabor. These formulations dissolve in low moisture, ensuring that the crop gets sufficient nutrition even in dry conditions. A foliar application of the product is made available for use during the drought years. The Crop Nutrition program has helped improve the yields and the quality of apples and is fetching the farmers substantial returns on their produce.

Fertilizer and water-use efficiency together offer huge gains in terms of improving crop productivity and relieving strain on resources, while reducing the input costs for farmers. UPL's "Zeba," a starch-based super absorbent chemical, improves water-use efficiency of crops. In parallel, it also ensures that soil nutrients are made available to the plant in the right amounts. Significant improvement in the yields (10.5% yield improvement for onions, for example) has been recorded in field trials with reduced application of fertilizers and water. A test plot showed a yield improvement of 11.4%, with a fertilizer dose reduction by 50%, promising a good potential for reducing input cost for farmers.

Integrated Pest Management (IPM) offers a range of options including cultural, biological, mechanical and chemical tools and practices for prevention and control of pests. These are for cultural, biological, mechanical and chemical tools and practices. This is opposed to the application of chemical pesticides only for control of pests and diseases in crops. IPM offers great potential in reducing the use of harmful chemical pesticides as well as input costs for farmers. Ambuja Cements has promoted the adoption of IPM practices as part of their intervention with cotton farmers and in partnership with the Better Cotton Initiative in five Indian locations. Cotton is attractive to a range of pests such as Bollworm and sucking pests; diseases such as parawilt are also common. Against the use of synthetic pesticides, a range of techniques are available to allow long-term prevention and damage of pests. This includes the use of bio-control agents, pheromones and hormones, cultural and mechanical techniques, as well as cultivar selection, among others.

Ambuja Foundation has made investments into capacity building of farmers on these lines with the help of "Extension Volunteers" to achieve positive returns on cotton crops. The use of fertilizers was reduced by 33%, while the use of chemical pesticides was reduced by 60%. The use of some toxic chemicals such as monocrotophos, imidacloprid and dimethioate was reduced by 9%, 22% and 21%, respectively, at their locations of intervention. This created a huge difference in the input cost for farmers, and along with measures for soil-health management and water management, translated into tremendous improvement in yields and economic returns.

Photo credits: Ambuja Cement, interventions with Better Cotton Initiative

Solution area 3

Mixed farming systems

Mixed farming involves multiple cropping, (diversification of crops either in time or space). It also involves intercropping with cereals or legumes which have the capacity to enrich soil through nitrogen fixation and agro-forestry - the practice in which trees are managed together with crop production systems to offer significant advantages over monocultures.

Intercropping improves soil fertility and water use efficiency, thus reducing the use of external inputs and increasing yields. Agro-forestry supports a variety of complementary products. It is an important means to increase smallholder incomes. In the light of constraints in land and water availability, mixed farming offers a solution to food security challenges.

Photo credits: ITC Limited, Integrated Watershed Management

ITC Limited, one of India's leading multi-business conglomerates, has been working on an Integrated Watershed Management approach, in partnership with the rural communities in the 12 states where the company has its operations. Several partner communities in these areas are vulnerable and face seasonal uncertainties for irrigation-water availability.

Following a watershed-level evaluation in each location, an extensive program has been established in public-private partnership mode and through participation from the village communities. The program includes multiple interventions suited to the local geography. These include: revival of traditional harvesting structures, multiple cropping and crop diversification for soil and water resources development, among others.

Several benefits are realized by farming communities in these areas based on the crop and geography involved. In Sehore, Madhya Pradesh, for example, 80% of the farmers began practicing double cropping and the area under crop increased by 24%. Significant benefits on yield and income improvements were realized.

An example of watershed-based assessment and intervention is that of SABMiller, the beer company in Neemrana, Rajasthan. The company began a detailed assessment of the watershed in 2010 by conducting water balances, assessing the aquifer characteristics, profiling the soil and assessing the land-use. This led to a clear and comprehensive plan for overall improvement of the watershed. This was achieved by working with the local farming community to improve farming practices and the development of water harvesting structures suited to the aquifer type. Since then, SABMiller has been working to provide training and support to farmers, helping them switch to smart cropping practices like crop rotations and multiple cropping for improving soil health and returns, the cultivation of extended Kharif crops and the use of drip irrigation.

The interventions conducted in partnership with the Confederation of Indian Industry, ACWADAM and the government of Rajasthan, are yielding good returns to farmers. Since 2010, improvements in productivity in the range of 24-38% have been realized by farmers for different crops like pearl millet, cotton, cluster bean, etc. A significantly high reduction in groundwater use has also been recorded.

ITC's operations in certain locations are based in districts with large tracts of land that are unsuitable for agriculture. This leads to low productivity and poor returns from traditional cash crops. Here, marginalized smallholders constitute the majority of the population. The company promoted pulp-wood plantations in districts neighboring its paper mills with species such as eucalyptus, subabul, casuarina and bamboo.

ITC's model of tree-based mixed farming commenced with multi-location trials in 1992, followed by the Farm Forestry component in 1998-99. It fine-tuned the model before taking it to economically weaker households through Social Forestry in 2001-02. This provided those households with the means to turn their underperforming lands into a sustainable livelihood opportunity and an income-generating asset. Households were mobilized in partnership with local NGOs to form community-based wood-producers' associations. ITC provided long-term and interest-free loans, a package of extension services, training in financial management, as well as a buy-back guarantee at prevailing market prices.

Even though the program successfully promoted over 1.75 lakh acres as block plantations over the years, it still faced the issue of competition with field crops. Consequently, ITC re-devised its model and launched the Agro-Forestry program in 2010-11. This enabled pulpwood species and agricultural crops to be grown together throughout the 4-year maturation cycle. Using a paired row design with wider spacing, the model was standardized, in collaboration with research organizations. ITC's Agro-Forestry program today covers over 83,000 acres of land in the three states of intervention - Telangana, Karnataka and Andhra Pradesh.

The benefits realized under the model are:

- Diversification of farm lands and improvement in soil health.
- Relieving pressure from natural forests for wood supply.
- Wood and food security for the country, and stable and better incomes for farmers.
- Once planted, the same set of trees are harvested for a total of four times, giving returns to farmers for 16 years.


Photo credits: ITC Limited, Agro-Forestry program

Solution area 4

Blue water management

Blue water management refers to the improved management of fresh water used in agriculture. This can be either surface water or groundwater. Since the agriculture sector consumes almost 90% of the available freshwater in India, improving water use efficiency in irrigation offers a concrete solution to India's water scarcity challenge.

There is huge scope for improvement in water use efficiency in India as it has a much higher water footprint for major crops, compared to most developed countries. The water footprint for wheat, rice and cotton in India on an average are 1,654 L/kg, 2,850 L/kg, and 8,694 L/kg, respectively. On the other hand, the corresponding global averages are 1,334 L/kg, 2,291 L/kg, and 8,242 L/kg, respectively[14].

Improved blue water management produces positive outcomes in the form of improved yields and produce-quality. It improves fertilizer and pesticide-use efficiency too, reducing the input cost for farmers. And as groundwater is the main source of irrigation water in India, and is closely linked to energy use (for pumping), blue water efficiency delivers benefits on both water and energy use.

Figure 5: **Map of categorization of groundwater blocks in India.**

The blocks are categorized by Central Ground Water Board (Government of India) based on the rates of groundwater consumption versus annual recharge, and the observed long-term trends in water level decline. 30% of the blocks show significantly high rates of groundwater consumption and water level decline in the long term.
Source: www.indiawatertool.in

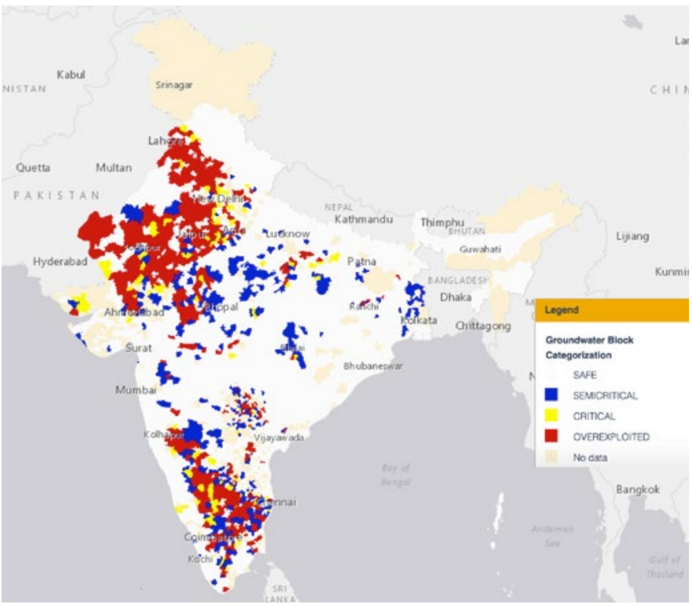
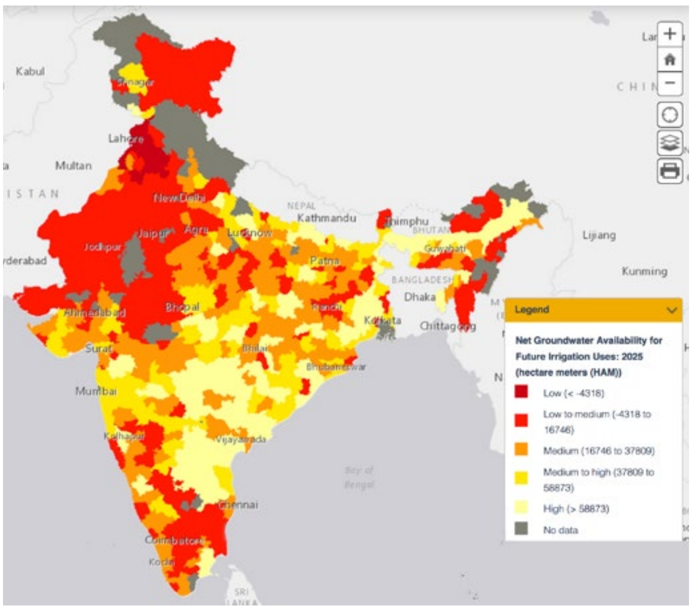


Figure 6: **Map of net availability of groundwater for future irrigation use (2025).**

Several districts in the country show no net availability of water for irrigation use in future. Source: www.indiawatertool.in



The irrigation method used conventionally in India, called the "furrow," or "flood irrigation" system, uses terrain for supplying water. The sand bunds or weirs regulate the amount of water that reaches individual rows of crops. A modern, more efficient technology of drip irrigation allows water to drip directly to the root-zone of crops, using a well-engineered system of pipes and valves. Drip has proved phenomenal, leading to a 60-70% improvement in water use efficiency and a 50-360% improvement in yield and farm productivity depending on the crop. It also leads to a significant improvement in farmer incomes due to reduced input and labor cost.

Jain Irrigation System Limited, the manufacturer and complete solution provider for drip and micro irrigation systems in India, impacted the lives of more than 4 million smallholder farmers in different parts of the country. Currently in partnership with the government of Karnataka for a large irrigation project, Jain Irrigation is working as a provider for Integrated Irrigation Solutions (IIS) for improving the efficiency of water pumping, purification and conveyance of water, involving the use of solar technology for pumping, and the use of modern piping systems for conveyance.

Ambuja Cements Foundation has made drip irrigation a part of its social commitments in the agriculture and livelihoods space. Its efforts include facilitating access to finance for smallholder farmers, as well as training them to improve the uptake of drip. Currently present in nine states of India, Ambuja Cements Foundation has created significant impact through the uptake of drip irrigation in Gujarat, in partnership with the Gujarat Green Revolution Company.

Monsanto India, the seed company, contracts up to 30,000 seed-growing farmers annually to produce high quality corn, cotton and vegetable seeds. The company is convinced that drip has the potential to improve the sustainability of Indian farming. And hence, it invests in improving the uptake of drip irrigation among its contracted farmers. By improving farmer access to funds, training them and connecting them to reliable drip vendors, the Monsanto supply chain production and research teams have remarkably converted 2,300 acres of agricultural land to drip in the 4 states of Andhra Pradesh, Telangana, Maharashtra and Karnataka.

India, with 44 million hectares of land under rice cultivation, is one of the world's largest rice producers. Around 21% of the global rice production in 2013-14 was contributed by India. Of the total area sown under rice, about 50% is irrigated, drawing water from India's precious reserves. Traditional growing involves seeding rice in nurseries, and then transplanting the seedlings into 10 centimeters of standing water. This system is labor and water intensive. In addition, the presence of biomass immersed in water over a longer period leads to 4.5 million tons of methane emitted yearly from India's paddies. In direct seeding, dry seeds of rice are sown onto the dry or wetted soil, avoiding puddling, transplanting and standing water.

Since 2004, **PepsiCo** has successfully supported direct-seeded rice in a number of initiatives with farmers in India, covering 4,000 hectares. PepsiCo also introduced a special tractor, coupled with a direct seeding machine, that can be adjusted according to seed variety, planting depth and plant-to-plant spacing. Its key benefits are in the form of 30% saving of water use, up to 75% reduction in methane emissions and significantly reduced labor costs. Several research institutes, including the Indian Agriculture Research Institute (IARI) and the International Rice Research Institute (IRRI), have vetted the results. Punjab Agriculture University included direct seeding in their package of practices and recommendations based on their own findings, as well as PepsiCo's results[15].

Solution area 5

Green water management

Green water management refers to the improved management of soil moisture by improving the water availability in the root zone of plants, and maximizing the plant water uptake capacity. Simple physical interventions, such as field bunds or terraces and agronomic practices, such as mulching and reduced tillage, achieve soil moisture management.

Green water management is critical to improving agricultural production efficiencies in India since a large part of the agriculture (67%) is rain-fed. Soil moisture is an effective buffer that supports crop growth in times of drought and low rainfall. Improvement in soil health, resulting from better green water management, contributes to the resilience of farming communities to climate change.

The management of soil moisture significantly improves crop yields and farmer returns from reduced inputs, and delivers better produce quality.


Photo credits: Olam, Project Madhushree

India is the largest producer of sugarcane in the world after Brazil. More than 50 million farmers are engaged in cultivating sugarcane over 4 million hectares of land. Sugarcane is a water guzzler – it consumes 1,500 to 3,000 liters of water per kg of sugar produced - and in the light of the increasing variability in rainfall that India is experiencing due to climate change, the sugar value chain is affected due to erratic production. Olam India, under its project "Madhushree" and in partnership with International Finance Corporation and NGO Solidaridad, worked on the sustainability of the sugar supply chain in the catchments of two of their sugar mills – Barwani in Madhya Pradesh and Rajgoli in Maharashtra. Most farmers in these intervention areas are either smallholder or medium landholding farmers. Olam's intervention strategically promoted the efficient, cost-effective, and locally applicable water use techniques for irrigation, including furrow irrigation, the use of gated pipes, land-levelling, trash mulching and drip irrigation.

Regular training sessions for farmers through demo farms and champion-progressive farmers helped promote these techniques. The water-use efficiency techniques proved transformative in improving yields, and saving the water used for sugarcane farming in the two areas. During the period 2012-2015, these measures resulted in a yield improvement of 23%, income enhancement of farmers by 23% and avoided water use of 25 billion liters in Barwani alone. In Rajgoli, the yield improvements were recorded at 44%, income enhancements at 48% and avoided water use at 18 billion liters. The income improvement of farmers was also a result of the intercropping that farmers were encouraged to do, which fetched them US$ 600-700 per hectare, in addition to their income from sugarcane cultivation. A direct benefit to Olam resulted from their two sugar-manufacturing locations achieving 100% capacity utilization, record production in volumes and sugar productivity.

Because of the high-water consumption during sugar production and processing, businesses operating in the sugar value chain face significant operational risks. In areas where sugarcane is grown, the water withdrawal to water availability ratio is more that 50%. In the western and southern parts of India, the ratio is almost 90%. Unsustainable sugar production leads to water depletion in the region, and poses significant risk to businesses.

Rabobank and WWF-India have collaborated to intervene in the sustainability of sugarcane production by reducing the risk faced by businesses because of the high-water footprint of the product. The partnership is creating a knowledge tool – the Decision Support Tool (DST) – for managing water sustainably in the critical water depleted sugarcane growing areas. The DST considers the geology, the quantification of water resources and its dynamics on a temporal scale, scenarios of climatic factors and water use patterns. The tool will be used by the sugar industry to avert future risk because of water depletion, thereby impacting the raw material availability for sugar production.


Photo credits: Zenit, Bhakra Main Canal in Punjab state

Land productivity is closely governed by field capacity, which is the amount of moisture a field retains once excess water has drained away. This also ultimately decides the yield. Based on this concept, UPL has developed an environmentally friendly starch-based super-absorbent product called “Zeba.” This holds water and slowly releases it to plants, improving the field capacity. “Zeba” is starch-based, can be conveniently mixed with fertilizers, and absorbs more than 400 times its weight of water. When applied during planting, it slowly releases water over the growing season. A healthy micro-environment is created in the soil, and plants receive the right amount of moisture and nutrients during the growing period. Since the product is made out of starch, it degrades in soil just like other plant residues. “Zeba” has been launched by UPL in several global markets, including India. Awareness programs and field demonstrations are underway. Trials have shown significant improvements in the yield of crops (10.5% improvement in the yield of onions), along with a significant improvement in the size and grade of produce. “Zeba” promises good financial returns to farmers from improved quality of the produce that can fetch a better price in the market, and a reduced input cost from the reduced irrigation and fertilization requirements.

Monsanto’s project Nalanda was started in South Bihar in 2011, when there was no history of corn cultivation in the region. There was also no awareness of the potential of simple conservation practices to transform their living. On the other hand, farmers in 21 districts of North Bihar had an experience in raising corn, and demonstrated productivity rates higher than the all-India average in the same set of agro-climatic conditions.

Monsanto India introduced three different hybrid varieties of corn Dekalb – DKC9081, Pinnacle and 900M GOLD - in nine districts of South Bihar, and trained farmers to grow the crop under the conservation tillage practice, and perform direct seeding using the locally invented “Bhoka” tool. The results were encouraging. A 35% saving in irrigation requirement resulted from conservation tillage practices, while an overall 26% saving was realized in labor cost. Monsanto recorded a yield improvement of 5.2% at five locations in South Bihar. The saving in input cost and the improvement in yield raised the net income of farmers by 45% over the period of 2011-2013.

Solution area 6

Efficient farm operations and mechanization

Agricultural mechanization helps achieve timeliness in farm operations, bringing precision in input placement. It also helps improve the efficiency of utilization of expensive inputs, improving productivity and profitability.

The level of farm mechanization in India is around 30% - which is low compared to other countries. This is mainly because of the higher availability of farm labor and smaller land-holdings. The present increase in power in Indian agriculture comes from the deployment of tractors for tillage and sowing, and from the deployment of pump-sets for drawing groundwater for irrigation, making water available to farms with no access.


Photo credits: istock photo

Mechanization comes with higher energy use. Increasing mechanization should be carried out while improving efficiency in energy use.

Much of the irrigated agriculture in India is dependent on groundwater. 19 million electricity connections in the country and seven million diesel pump sets are estimated to power irrigation pump-sets in India. As a consequence, 30% to 50% of the total electricity consumption in certain Indian states happens in the irrigation sector. Grundfos India, a leading company in advanced pumping solutions, developed solar pumping and water lifting equipment that use solar photovoltaics to make available water at the point of use. With a conjunctive use of drip irrigation, the system has the potential to bring significant co-benefits from water and energy use efficiency. A major limiting factor in the wide uptake of this technology has been the high cost and requirement for specific technical support. However, despite the limitations, several Indian states have learnt the use of solar technology for their agricultural pumping requirements. These states are: Karnataka, Tamil Nadu, Rajasthan, Maharashtra, and Madhya Pradesh. At the field level, Grundfos has demonstrated a payback period of 1.5 years for the integrated technology and savings of up to INR 7 lakh per annum from fuel and manpower.

Solution area 7

Bridging yield gaps

This solution area involves implementing management practices and inputs in accord with best practice, thereby improving yields. The yield gap in this case refers to the difference between actual yields realized in farmer fields and the yields attained in-farm under optimum conditions.

Yield gaps are often higher in rain-fed systems relative to irrigated systems, and can be addressed by enabling an access of farmers to better inputs and knowledge improving their awareness for effective use.

Table 7: The average yield gaps observed in research on major crops in India[16]

Crop	Yield Gap (kg/ha)	Condition for gap recording	Geographical variations
Rice	Higher than 1670	Rain-fed conditions; all-India average	Smaller in West Bengal; highest in Uttar Pradesh
Cotton	1120	Rain-fed conditions; state-average yield considered	High in Gujarat, Maharashtra; Modest in Andhra Pradesh; relatively low in Karnataka and Madhya Pradesh
Mustard	860	Rain-fed conditions; state-average yield considered	High in Uttar Pradesh and West Bengal
Wheat	Nil or small (80-800)	Irrigated conditions	Karnataka, West Bengal and Madhya Pradesh record gaps

Every crop grown in a certain agro-climatic condition and on a certain soil type has a set of recommended practices to achieve its optimum growth and best yield. Furthermore, for processed and packaged food items, an additional set of recommendations ensures that the product meets food safety and quality standards. Jain Irrigation has developed a set of standards called the Jain G.A.P. (Jain Good Agricultural Practice) that provide a recommended set of practices for sustainable farming and food safety. A customization of the Global G.A.P, Jain G.A.P, has been developed as an entry-level standard and certification process for small and marginal farmers. The Jain G.A.P standard helps farmers achieve the best attainable yields for specific crops. It also helps the company meet the buyer's concerns for food safety, farm-level practices and traceability. Jain Irrigation has implemented Jain G.A.P. among their contracted farmer base in India, especially for onions, mangos and bananas. Standards on pomegranate are under development. As of March 2017, almost 6,000 farmer suppliers of onions, mangos and bananas were certified on Jain G.A.P.

Crop-specific ecologically sustainable cropping systems, such as System of Rice Intensification (SRI) and Sustainable Sugarcane Initiative (SSI), are focused on the improvement of yields of specific crops by soil, water and nutrient management. The SRI and SSI approaches involve a set of recommended cultural practices involving controlled planting, irrigation and manuring. These approaches have demonstrated substantial improvements in crop productivity, while reducing the overall water use for these otherwise water-intensive crops. Nestlé India, as part of its water stewardship efforts, is currently implementing pilot projects for SRI and SRI in the catchment area of Kabini River basin in Karnataka. It has so far recorded encouraging results on key parameters such as crop yields, farmer incomes and water use efficiency. An increase of up to 57% in rice yields per acre, and up to 50% improvement in water use efficiency, has been recorded. Due to a reduction in the input cost of farmers, and good returns realized from improved yields, the net income of farmers increased by 62% relative to the conventional practice of rice cultivation. Soil health was enriched due to improved microbial activity, which holds the promise of benefiting farmers year-on-year. For sugarcane, the yield improvements stood at 28%, the water-use efficiency improved considerably, and farmer incomes improved by 45% due to the recommended practice of providing irrigation ay set intervals. Further, as SSI supports inter-cropping with crops like wheat, potato and cow pea, it ensures additional income for farmers while reducing weed growth.

Photo credits: Nestle, interventions with System of Rice Intensification

In India, a majority of agricultural produce comes from small farmers. Sometimes these farmers are excluded from innovation systems and lack access to relevant information to effectively plan and manage production. In many instances, farmers are also poorly linked to markets, institutions and service providers. All these factors may hold farmers back from being more productive, while securing their livelihoods. ITC conceived the revolutionary concept of e-Choupal by setting up internet kiosks. These make a host of services related to the know-how, best practices, timely and relevant weather information and transparent discovery of prices available to farmers. As of today, ITC reaches out to 4 million farmers in the country through this initiative. The kiosks are managed by trained farmers, who help the agricultural community access information in the local language.

The initiative is a strong example of a development model that delivers large-scale societal value by co-creating rural markets with local communities. It addresses the challenges faced by farmers, such as fragmented farms, weak infrastructure and involvement of numerous intermediaries. It enhances the value to all participants in the value chain. With a judicious blend of click and mortar capabilities, the initiative has triggered a virtuous cycle of higher productivity, higher incomes, enhanced capacity for farmer risk management, larger investments and higher quality and productivity.

Solution area 8

Efficient fertilizer production

India is the world's third largest producer and the second largest consumer of fertilizers. Although India has a wide variety of soils, Indian soils are naturally deficient in certain key plant nutrients, such as phosphate, nitrogen, zinc, sulphur and potassium. To cover for these essential micronutrients, the application of fertilizers is essential.


Photo credits: istock photos

The fertilizer industry has been instrumental in making India self-sufficient in food and agricultural production. The production and consumption of fertilizers is expected to increase further as the country produces more to feed its growing population. Fertilizer production in general, is heavy on energy use. Its energy input is in the form of coal, naphtha, fuel oil and/or natural gas. In the Indian economy, fertilizer production represents one of the most energy-intensive sectors. Given the limited domestic reserves of natural gas, it is a constant challenge for the government to balance the needs of the fertilizer industry and that of other sectors depending on natural gas. The improvement of energy efficiency in fertilizer production promises significant returns to the Indian economy.

Under the fertilizer subsidy policy, the Government of India provides fertilizers to farmers at affordable prices to ensure sustained agriculture growth. This subsidy regime involves the government compensating the manufacturers of fertilizers for the difference between the government's regulated fixed Maximum Retail Price (MRP) of the fertilizer product and the manufacturer's production cost. About 80% of the production cost comes from energy use, varying dramatically between manufacturers. The survival of the fertilizer industry in India depends on energy efficiency. An improvement in efficiency holds the promise of reducing the burden of subsidies on the government exchequer.

The overhauling of production plants and upgradation of technology improves the energy efficiency of fertilizer production. Further, natural-gas fired facilities for fertilizer production are far more efficient than coal-fired facilities[17].

The production and use of fertilizers also contributes significantly to the emission of green-house gases. Emissions from the production and use of synthetic Nitrogen fertilizers represent 6% of India's total anthropogenic emissions. This is comparable to the cement industry, and to the whole road transport system in India. There is a potential to reduce the share of emissions from this sector to 2% through improved efficiency in fertilizer production, and a judicious use of fertilizers[18].

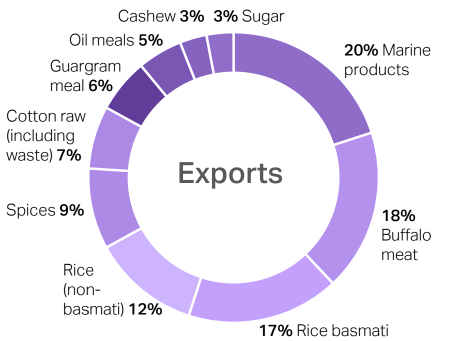
Solution area 9

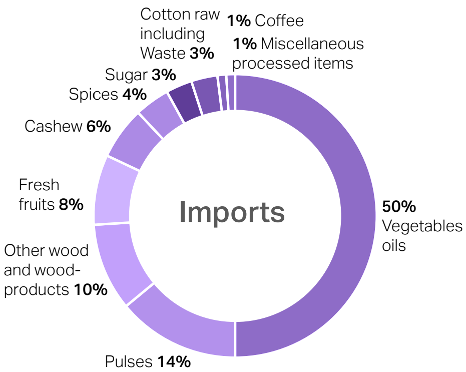
Making use of trade

Since 1991, India has transformed itself from one of the most closed economies of the world to a relatively open one. Trade as a percentage of GDP reached nearly 50% in recent years. In terms of agricultural products, India has remained a consistent net exporter in the last 25 years. Its share in global agricultural exports increased from 0.8 in 1990 to 2.5 in 2014.

Photo credits: WBCSD, of Jain Irrigation Banana harvesting

Figure 7: Percentage share of top commodities from agriculture and allied sectors in India's imports and exports[19]. India exports mainly water intensive products like meat, rice, cotton, sugar[20] and records among the highest water footprint for crop production[21], the situation brings negative impact in terms of trade of virtual water.





Since the trade of agricultural products is closely linked to the trade of water (virtual water i.e., the amount of fresh water consumed or polluted for producing the product, measured over its entire production chain, is also traded), there is scope to balance international trade in a way that does not elevate water stress. Possible solutions include crop diversification and gradual shifts to less water-intensive crops in states. For example Punjab, which exports most of its production of cereal crops, shows alarming rates of water withdrawal for irrigation.

In the case of internal trade of agricultural products – i.e. from one state to another within India - it is understood that access to local markets, and local demand for a certain commodity, play a key role in trading decisions. Virtual water is often not considered in such decision-making. In theory, trade could improve Indian (and global) water productivity by shifting production from areas with low water productivity and higher water stress to areas with high productivity and low stress. Agrarian stress in certain states of the country (like Maharashtra) can be relieved by encouraging the production of pulses and oilseeds, and limiting the production of water guzzling crops.

Solution area 10

Reducing food loss and waste

An estimated 32% of food produced globally, about 1.3 billion tons, is lost or wasted along the food chain every year. A United Nations report estimates that India wastes about 40% of the food produced every year, which has a net worth of approximately US$ 8.5 billion.

Photo credits: gettyimages

Fruit and vegetables present the most losses, followed by cereals, roots and tubers. In contrast to the developed countries where most waste (18-24%) happens at the retail and consumer end, most of the loss of food in developing countries like India (25-35%) occurs early in the food chain – at the harvesting, storage and processing end. The post-harvest management of food provides a huge potential for achieving sustainability in the agriculture sector. Addressing this loss can decrease the overall demand for food, thereby relieving the pressure on water, land and energy. Additionally, this reduces greenhouse gases associated with production of wasted food, and waste rot.

Food loss in India is mostly related to deficient infrastructure, lack of facilities for harvesting, and the absence of cold storage and efficient transport systems. Smallholders, who produce only a small surplus, often face weak links with the markets, leading to a loss of produce. It is estimated that cold-storage facilities are available for only 10% of perishable food products in India, and about 21 million tons of wheat grain in the country rot due to inadequate storage and poor management.

Storage losses are high in potatoes, which are harvested in bulk and are high on starch content. Under ambient conditions, potatoes sprout, turn green and their sugar content increases. Potatoes with a higher sugar content are less marketable, and often lead to a direct loss of the product. Therefore, potatoes strictly require maintenance in cold storage (at <2 deg. C) and under appropriate conditions of relative humidity. UPL Limited, a leading agriculture solution providing company, manufactures a wide portfolio of products in the post-harvest category. Decco, which is UPL's wholly owned subsidiary in India, manufactures "Oorja," a unique anti-sprouting chemical used to fumigate potatoes in storage. "Oorja" allows potatoes to be stored at temperatures of 10°C, saving energy involved in refrigeration, and allowing storage over longer periods. Decco's product named "Decco Shield" is used widely by handlers and processors of fruits and vegetables to delay ripening and improve the shelf life of these products in storage.

Integrating farmers into product supply chains is an effective way of reducing post-harvest losses in agricultural produce. Ambuja Cements, as part of its intervention with farmers in Charawa, Rajasthan, has been working to link farmers with institutional buyers (super-markets) for vegetables. Under their project with Better Cotton Initiative, they also work to link farmers to approved ginners, that is - people who operate cotton gin machines. This enables a fair sale and ensures that farmers can avoid losses due to an uncertainty in market linkage. The Better Cotton Initiative in Maharashtra provided training to farmers in Kodinar, Guakarat about how to avoid water spays on harvested cotton. This training helped avoid additional product losses.

Photo credits: Jain Irrigation, implementation of vertical farming

Conclusions and recommendations

In India, water scarcity is a national issue, that affects both rural and urban populations, while impinging on agriculture, industry and the ecosystems that support life and biodiversity. Agriculture consumes most of the available water in India, and is often given the highest priority for water allocation. If water-use efficiencies are improved, agriculture can be more profitable and more water will be available to other users – domestic, municipal and industrial.

The solutions described in this report have the potential to help farming:

- Become more precise, less wasteful and lower emitting, with less impact on the food and land system through efficient irrigation, mixed farming and a reduction in food loss and waste.
- Become more stress and climate-resilient while maintaining productivity through smart-crop varieties, maintenance of soil moisture, mixed farming systems and smart crop management.
- Become more effective in the use of input resources to get the best value by bridging the yield gaps, smart-crop management and crop-specific sustainable cropping systems.
- Protect and restore ecological and societal capital, for example, by recharging water through integrated watershed management, and generating higher farmer incomes through agroforestry.

Each solution described in this report delivers value to business and to the farming community, paving the way for a more resilient future. In some cases, these solutions are implemented as a result of a strong collaboration between businesses and farming communities. There is an understanding that "de-risking agriculture" brings returns to businesses in the agriculture value chain. This includes businesses that share water resources with agriculture, or those seeking to improve the well-being and resilience of communities depending on agriculture for their livelihoods.

The solutions indicate that, when applied in the appropriate context and with robust management, investments in water efficiency lead to significant co-benefits. These benefits are for farmers, for productivity, for communities and for the companies involved. There was a consensus among companies who took part in this study that **if farmers do well, businesses do well.** All recommendations for improving water-use efficiency that emerge from this work should be viewed in light of improvement in farmer livelihoods.

The study aims to highlight the potential for water-efficient technologies, practices and solutions to be scaled-up and co-implemented. Businesses have a large role to play in realizing this potential by:

- Using their organizational skills and community networks to strengthen supply systems, and deliver value to communities by deploying the identified solutions.
- Tracking performance, measuring impact and communicating the benefits of interventions.
- Applying their capacity to innovate towards higher water and energy productivity and ensuring sustainable harvests.
- Strategically anticipating future challenges and opportunities, by developing and investing in long-term agro-solutions.

As businesses implement these solutions, they advance the Indian Government's agenda of "water-to-every-farm" and "per-drop-more-crop." The identified solutions are a step forward in achieving the Sustainable Development Goals, directly contributing to SDG1 (No Poverty), SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), and SDG 15 (Life On Land). They support the Government in achieving India's Nationally Determined Contribution (NDC): enhancing water-use efficiency by 20%, provision of 100,000 solar pumps for farmers, and creating carbon sinks equivalent to 2.5-3 billion tons of carbon-di-oxide, through additional forest and tree cover by 2030.

This report demonstrates the relevance and potential of the smart business solutions in India. It should be used as:

1. A reference for the potential that business solutions hold and their scope to creating impact in the water and agriculture space in India. Several solutions have received endorsement from national and local research institutes. The approaches to implementing these have been standardized in a few cases.
2. An important first step to catalyzing partnerships and promoting collaborations to scale up the identified solutions.
3. An input into the co-development of guidance by businesses and authorities for technical and regulatory information, related to implementation and permitting of smart solutions.

The following enablers have been identified for these solutions:

1. Availability of funds

Several of these solutions are cost-intensive and their scale-up largely depends on the availability of funds. In the Indian context, Corporate Social Responsibility funds can be strategically invested and appropriately channeled, with the aim of delivering maximum value to the communities, while advancing business goals.

2. Government

Sound and supportive government policies can ensure that:

a. Proper and fair pricing of food drives investment in sustainable agriculture;

b. Clear and fair land ownership rights are defined and smallholder rights are protected;

c. Financial incentives support wider adoption of these solutions;

d. Innovation is encouraged and more relevance is given to science and technology in informing and guiding regulations and actions;

e. Business contributions in the space are recognized and supported;

f. Businesses are encouraged to improve data quality and availability of hydrology and agricultural productivity.

3. Training and on-site support

Providing farmers with training and support is critical to ensure successful implementation. Its role in scale-up as has been demonstrated in most of the case studies provided in this report.

4. Partnerships

Partnerships can support knowledge transfer, access to funds and bring in complementarity of solutions. The examples in this study involve partnerships that are business-to-community, business-to-NGO and business-to-government. In the process of producing this study, additional business-to-business partnerships have been created.

This set of enablers complement the scale-up of solutions which deliver the co-benefits to farmers and businesses. The solutions not only reduce the stress on water resources, they also assist in increasing yields and creating better quality products for India's growing population.

Photo credits: Jain Irrigation, implementation of Aeroponics

Endnotes

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India Water Tool

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