Principal Sponsor

HSBC

FICCI

FICCI – HSBC

Knowledge Initiative

Sustainable Agriculture

Water Management



Principal Sponsor

HSBC

FICCI

FICCI – HSBC

Knowledge Initiative

Sustainable Agriculture

Water Management



© Federation of Indian Chambers of Commerce and Industry

FICCI
Federation House
Tansen Marg
New Delhi - 110001
Website - www.ficci.com

This report is a product of FICCI Water Mission's interaction with the members of the Agriculture Committee, and case studies submitted to the Mission.

Though utmost care has been taken to present accurate information, FICCI and HSBC makes no representation towards the completeness or correctness of the information contained herein. This document is for informational purposes only. Further, all information contained in the document are subject to change without notice.

This publication is not intended to be a substitute for professional, legal or technical advice. FICCI and HSBC does not accept any liability whatsoever for any direct or consequential loss arising for any use of this document or its contents.

Rights and permissions

The material in this publication is copyrighted. Reproduction / transmission of all or any part of this work without permission may be a violation of the applicable law. FICCI encourages you to seek permission before producing portions of this work. Inquiries in this regard can be addressed to FICCI Water Mission, FICCI Federation House, Tansen Marg, New Delhi -110001. Ph: +91-11-23738760-70 (ext - 252/488).

Contents

1. Foreword 01

2. Message 03

3. Background Paper

I. Irrigation in India 07

II. Status of Irrigation 10

III. Micro Irrigation 15

IV. Water Demand for Agriculture 19

V. Emerging Issues 21

VI. Water Conservation and Efficiency in Agriculture 23

4. Case Studies

I. Coca-Cola India and Hindustan Coca-Cola Beverages Pvt. Ltd. 28

II. ITC Limited 33

III. Pepsico India Holdings Pvt Ltd. 37

IV. Columbia Water Centre, Columbia University 43

V. Columbia Water Centre, Columbia University 45

VI. Jain Irrigation Systems Limited 48

VII. Monsanto India 49

VIII. Mahyco Monsanto Biotech India Limited (MMB India) 52



Acknowledgements

The report has been prepared by the FICCI Water Mission Secretariat – Romit Sen with contribution from Amit Verma. We acknowledge the contribution of the companies who sent their case studies. We also thank HSBC for their support in developing the report.



Foreword



Agriculture remains the mainstay of Indian economy; contributing 14 per cent of Gross Domestic Product (GDP) and with its allied sectors like forestry and fisheries employing 50 per cent of the country's workforce. India's demand for food grains will be at 240 million tonnes by the end of the XII Five Year Plan (2012-2017). Enhanced agricultural production will mean increased use of water for irrigation. At present the sector receives the largest share of freshwater in the country (around 90 per cent[i]).

Projections on water demand for agriculture by the standing sub-committee of Ministry of Water Resources (MoWR), Govt. of India indicate a three time rise in water demand - from 688 Billion Cubic Metres (BCM) in 2010 to 910 and 1072 BCM in 2025 and 2050 respectively. Similar projections have also been made in a study by the Water Resources Group which estimates that water demand for agriculture will rise from 656 Billion Cubic Meters (BCM) in 2005 to 979 BCM in 2020 and 1,195 BCM in 2030[ii].

In India, some of the major challenges in agriculture water management relates to aging infrastructure and low water efficiency. Climatic changes will impact water availability and will pose a threat in times to come. Attaining efficiency in irrigation, developing ways to minimize losses and use of technology that uses less water to produce more per unit of land will be critical is meeting the increasing food demand simultaneously reducing the impact on environment.

Businesses across the world are fast realising the need to reduce agriculture water footprint. There is also a growing understanding in looking at the water use in the entire supply chain of a product. This becomes significant considering that the demand for agricultural products with high water footprint is projected to rise with increased disposable income and urbanisation.

The report on Sustainable Agriculture Water Management is therefore important in highlighting some of the best practices adopted by the industry in minimizing freshwater intake and enhancing food production. An important aspect of the case studies presented is the importance given to engaging with farmers in capacity building, sensitizing and adoption of technology.

Naina Lal Kidwai
President, FICCI
Country Head HSBC India and Director HSBC Asia Pacific

---

[i] *India Assessment Report-Water Supply and Sanitation, 2002, Planning Commission, GoI*

[ii] *Charting our Water Future; 2009, Water Resources Group*



Message



India has a large and diverse agricultural sector. The country has made immense progress towards food security, with a substantial increase in per capita availability of food grains. Growing population will require greater production but this has to be employed with sustainable practices for ensuring the long-term available availability of natural resources.

Water is an important input for agriculture. The sector receives the maximum share of freshwater in the country. Increase in production will necessitate greater allocation of water for sustaining agricultural growth. Over the past few decades, there has been a decline in freshwater water availability. This coupled with the growing demand for water across sectors including agriculture will require water use efficiency to be brought in our agricultural practices.

FICCI Water Mission has identified water conservation and efficiency as an important area of work. Member industries of the Mission across different sectoral committees have undertaken water conservation measures in their organisations. While the scale and nature of work may vary amongst different companies, it is true that Indian companies are seriously taking steps to reduce their water footprint. This applies for the companies engaged in food production with member companies are working with farmers, local communities and NGOs to bring down the water usage in agriculture.

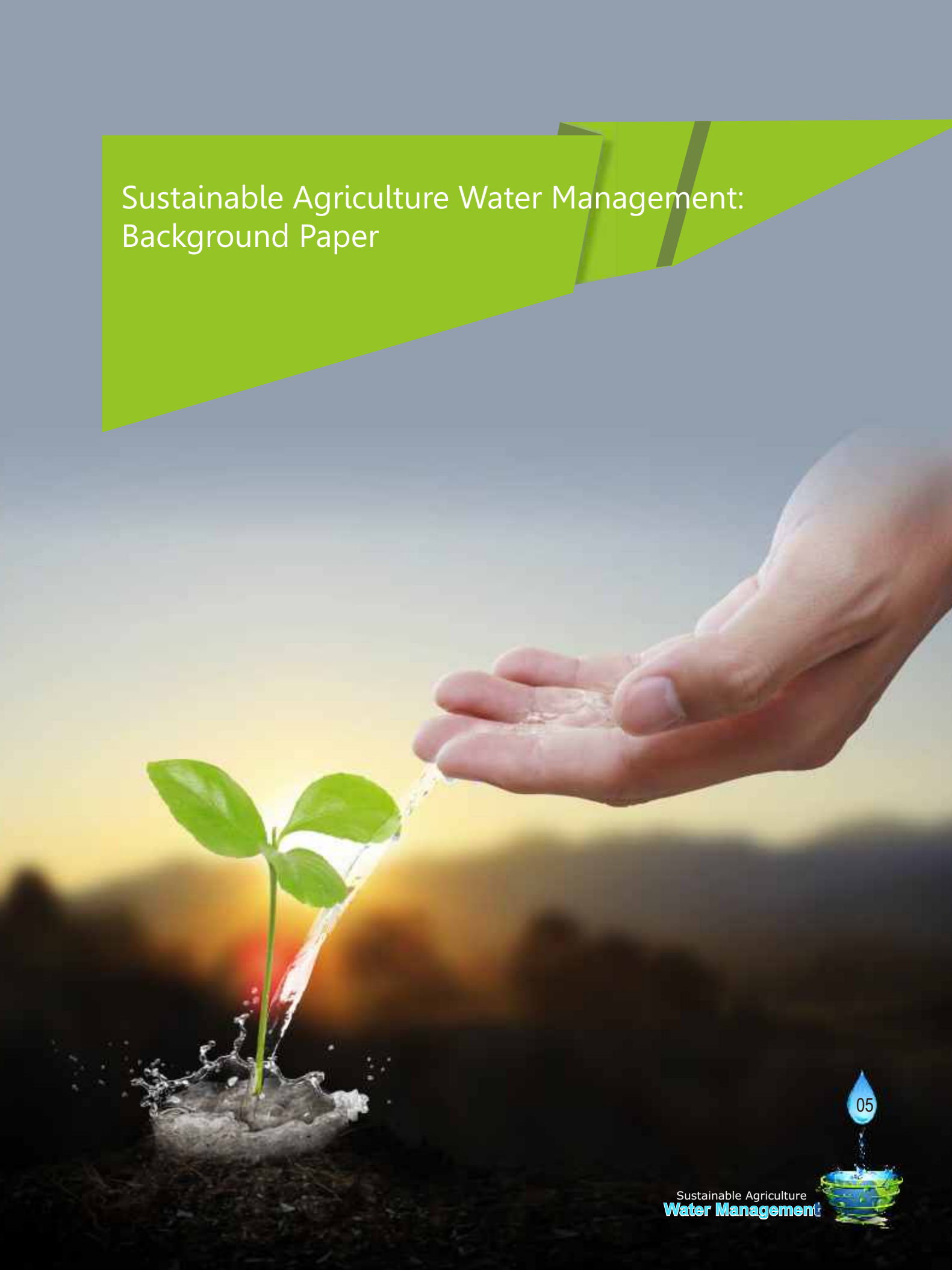
The publication 'Sustainable Agriculture Water Management is an attempt to highlight some of the efforts of Indian companies in the area of irrigation efficiency. The case studies documented in the publication depict a variety of measures various companies have undertaken. These range from direct seeding of paddy, use of drip and sprinkler irrigation, rainwater harvesting and watershed management. The development of low cost technologies and its use for better irrigation scheduling is an important area of work which is receiving major attention.

I hope that the publication will serve as a valuable resource and would enable sharing of best practices within the agriculture sector.

Dr. Arbind Prasad
Director General
Federation of Indian Chambers of Commerce & Industry (FICCI)


04

Sustainable Agriculture Water Management: Background Paper





Irrigation in India

Agriculture remains central to the Indian economy and therefore, receives the greatest share of the annual water allocation. Around 90 per cent of utilizable water given to this sector, mainly in form of irrigation. Water for agriculture has mainly been through major and minor irrigation projects. India's irrigation infrastructure is expanding by 1.8 M ha of irrigation potential with a public outlay of ₹7,000 crore per annum[1]. Current annual expansion is one-third less than the maximum growth achieved in the past. The problems are due to poor implementation and the long gestation period of irrigation projects which results in spill over leading to the delay amongst others. Another aspect linked to the use of water is the low agricultural water productivity which is sometimes due to the aging infrastructure and inadequate maintenance thereby adding to the demand-supply gap.

Irrigation in India has moved from the initial collection of rainwater in ponds and diversion of excess water through channels adopted during the 18th century to the canal based irrigation system developed during the British Rule to medium and large storage based irrigation systems developed post independence. Table 1 gives an outline of the development of irrigation system in the country.

Table 1: Development of irrigation system in India

Time period	Highlights of the irrigation system
Ancient times	❖ Irrigation was mainly in form of small ponds used by individual farmers. ❖ In peninsular India, irrigation system developed around numerous irrigation tanks while in northern India there were small canals in the upper valleys of rivers.
Medieval times	❖ This period saw the development of the canal system of irrigation, first initiated by the Tughlak rulers. ❖ In south India irrigation through canals and tanks were developed by the Vijayanagar Empire



[1] *http://www.ncap.res.in/upload_files/policy_brief/pb15/pb15.htm*

Time period	Highlights of the irrigation system
British rule	❖ The British rulers further developed the canal and well irrigation system in the country. Some large and extensive works like Upper Ganga Canal, the Upper Bari Doab Canal and the Krishna and Godavari Delta Systems were developed during the British rule. ❖ Following the famines of 1897-98 and 1899-1900, the government set the first irrigation commission in 1901, especially to report on irrigation as a means of protection against famines. ❖ Setting up of river basin commissions to oversee water resources development. ❖ As a result of recommendations of first irrigation commission total irrigated area by public and private works increased to 16 Mha in 1921. During 1910 to 1950 growth rate of irrigation was estimated at 2.0 per cent per annum for government canal irrigation, 0.54 per cent per annum for well irrigation and 0.98 per cent per annum in respect of irrigation from all sources.
Post Independence (1950-1974)	❖ The First Five Year Plan saw the launch of major multipurpose irrigation programmes like the Bhakra-Nangal, Hirakud and Nagarjunasagar. ❖ Simultaneous launch of minor irrigation schemes based on groundwater.
Post Independence (1974-1995)	❖ Command Area Development Programme (CADP) was launched as a Centrally Sponsored Scheme with the objective of reducing the lag between potential created and optimum utilization of available land and water. ❖ Emphasis was on completion on the 60 projects conceived under CADP. ❖ The first minor irrigation census initiated with 1986-87 as reference year. ❖ Second minor irrigation census initiated with reference year 1993-94.

Time period	Highlights of the irrigation system
Post Independence (1996-2004)	❖ Accelerated Irrigation Benefit Programme (AIBP) was launched in 1996 for speedy completion of irrigation projects. ❖ User's participation in major and medium irrigation schemes received greater attention. ❖ Greater focus on repairs and improvements in minor irrigation projects, as a part of integrated micro-development. ❖ Move towards including sprinkler and drip irrigation programmes and the conjunctive use of surface and ground water gained momentum. ❖ Third minor irrigation census initiated with reference year 2000-2001.
Post Independence (2004 onwards)	❖ Irrigation development becomes part of the Bharat Nirman programme. Target of creating an irrigation potential of 42 lakh hectare. ❖ Plan for restoring and utilizing irrigation potential of 10 lakh hectare through implementation of extension, renovation and modernization of schemes along with command area development and water management practices. ❖ Focus on modernisation of irrigation schemes through greater community participation. ❖ Launch of National Mission on Micro Irrigation.

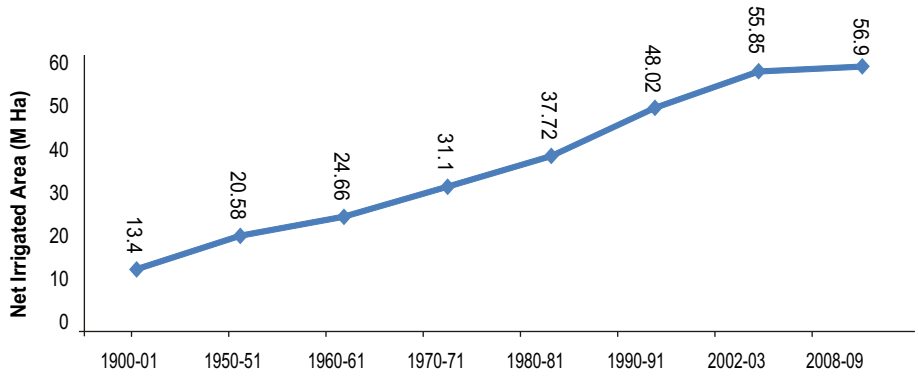
Data Source: Ministry of Water Resource; Planning Commission, Government of India

Status of Irrigation

Irrigation is one of the major drivers for agriculture. Both global and national trends depict a phenomenal rise in irrigated area. Globally, irrigated crop yields are about 2.7 times higher than that of rain-fed farming[2]. At a global level , irrigated area increased from 8 million hectares (M Ha) in 1800 to 40 MHa in 1900[3]; 225 M Ha in 1995 and to 304 M Ha in 2008[4].

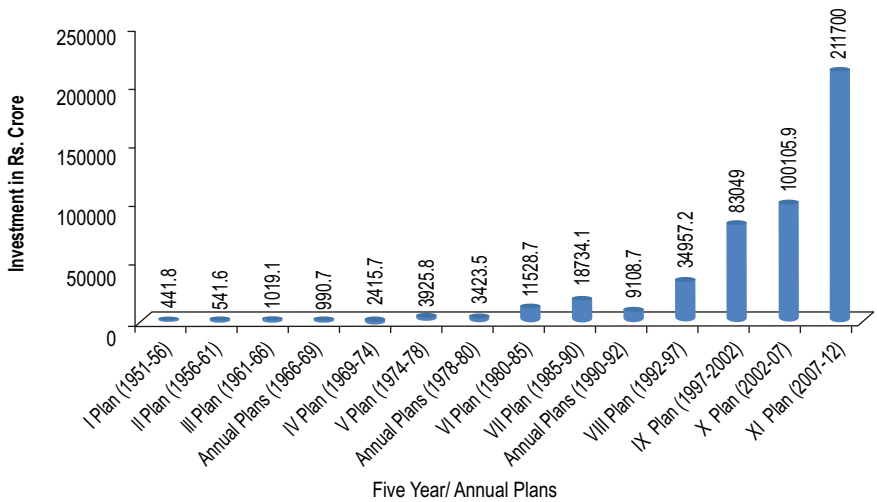
In India, the net irrigated area saw an increase from a meagre 13.4 M Ha in 1900 to 56.9 M ha during the period 1900 – 2009 (See Figure 1). The corresponding investment in the irrigation sector increased from ₹441.8 crores in the first plan (1951-56) to ₹211,700 crore (projected) in the XI Five-Year Plan (See Figure 2).

Figure 1: Increase in Net Irrigated Area in India



Data Source: Assessment of Irrigation in India, 2009, SANDRP

Figure 2: Investment in the irrigation sector



Data Source: Report of the Working Group on Major and Medium Irrigation and Command Area Development for the XII Plan, Planning Commission, 2012, GoI

[2] *Managing Water Under Uncertainty and Risks, 2012, UN World Water Development Report*
[3] *Thakkar Himanshu, Assessment of Irrigation in India, 1999, South Asia Networks on Dams, Rivers and People*
[4] *Managing Water Under Uncertainty and Risks, 2012, UN World Water Development Report*

Ever since the launch of Five-Year (FY) Plans, the irrigation potential of the country has increased from 26.26 M Ha in the end of first FY Plan to 102.09 M Ha at the end of X FY Plan. There has been an additional increase of 4.47 M Ha during the period 2007-2010. Of the total irrigation potential created till 2010 which amounts to 106.56 M Ha, 81 per cent (87.50 M Ha) has been utilised. Table 2 below summarises the progress in the development of irrigation potential created (IPC) and irrigation potential utilised (IPU) since the implementation of the FY Plans.

Table 2: Irrigation potential created and utilised

	Irrigation Potential Created (M Ha)					Irrigation Potential Utilised (M Ha)				
Five Year Plan/ Annual Plan	Major & Medium Irrigation Schemes surface water	Minor Irrigation Schemes based on ground water	Minor Irrigation Schemes based on	Total Irrigation potential created	Cumulative irrigation potential created	Major & Medium Irrigation Schemes surface water	Minor Irrigation Schemes based on ground water	Minor Irrigation Schemes based on	Total Irrigation potential utilised	Cumulative irrigation potential utilised
Upto 1951 (Pre-plan)					22.6					22.6
I Plan (1951-56)	2.5	0.03	1.13	3.66	26.26	1.28	0.03	1.13	2.44	25.04
II Plan (1956-1961)	2.13	0.02	0.67	2.82	29.08	2.07	0.02	0.67	2.76	27.8
III Plan (1961-1966)	2.24	0.03	2.22	4.49	33.57	2.12	0.03	2.22	4.37	32.17
Annual Plans 1966-1969)	1.53	0.02	1.98	3.53	37.1	1.58	0.02	1.98	3.58	35.75
IV Plan (1969-1974)	2.6	0.50	4.0	7.1	44.2	1.64	0.5	4	6.14	41.89
V Plan (1974-1978)	4.02	0.50	3.33	7.85	52.05	2.7	0.5	3.3	6.5	48.39
Annual Plans (1978-1980)	1.89	0.50	2.20	4.59	56.64	1.48	0.5	2.2	4.18	52.57
VI Plan (1980-1985)	1.09	1.70	5.82	8.61	65.25	0.93	1.01	4.24	6.18	58.75
VII Plan (1985-1990)	2.22	1.29	7.80	11.31	76.56	1.9	0.96	6.91	9.77	68.52
Annual Plans (1990-1992)	0.82	0.47	3.27	4.56	81.12	0.85	0.32	3.1	4.27	72.79
VIII Plan (1992-1997)	2.21	1.05	1.91	5.17	86.29	2.13	0.78	1.45	4.36	77.15
IX Plan (1997-2002)	4.1	1.09	2.50	7.69	93.98	2.57	0.37	0.85	3.79	80.94
X Plan (2002-2007)	4.59	0.71	2.81	8.11	102.09	2.73	0.56	2.26	5.55	86.49
X I Plan (till 2010)	2.78	NA	1.69	4.47	106.56	1.02			1.01	**87.50**

Data Source: Report of the Working Group On Major & Medium Irrigation and Command Area Development for XII Five Year Plan(2012-2017) and Final Report Of Minor Irrigation and Watershed Management for XII Five Year Plan (2012-2017), Planning Commission, GoI

An interesting trend observed is the increased use of groundwater for developing irrigation schemes especially during the third to eight FY Plan. Groundwater accounts for 45 per cent of the total irrigation potential developed so far in the country (WG Report Minor Irrigation) with the overall the share of groundwater in irrigation amounting to 70 per cent. The share of major and medium irrigation systems in the total irrigation potential created has declined marginally between 1951 and 2002. Figure 3 (a) and 3 (b) enumerates the changing share of different sources in irrigation potential created and utilised in India.

Figure 3 (a) - Changing share of surface/ groundwater sources in irrigation potential created

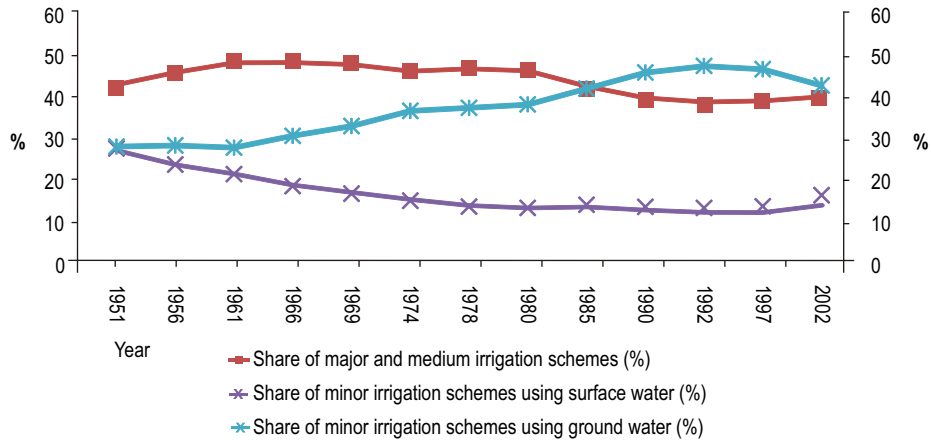
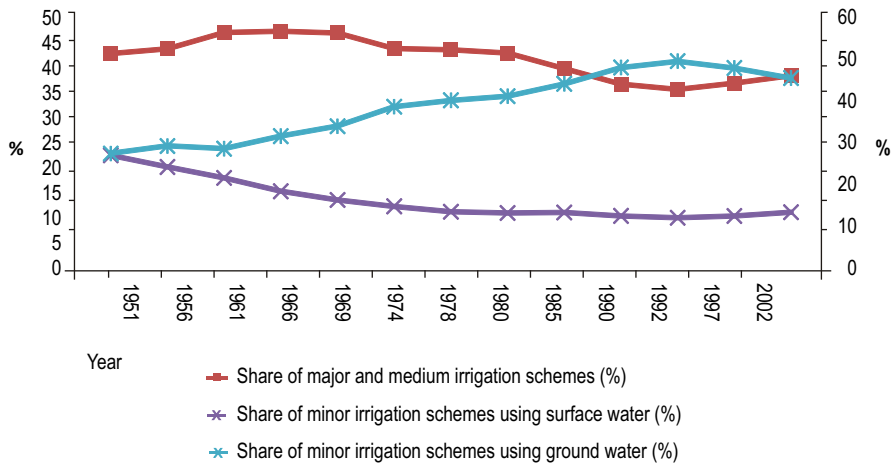


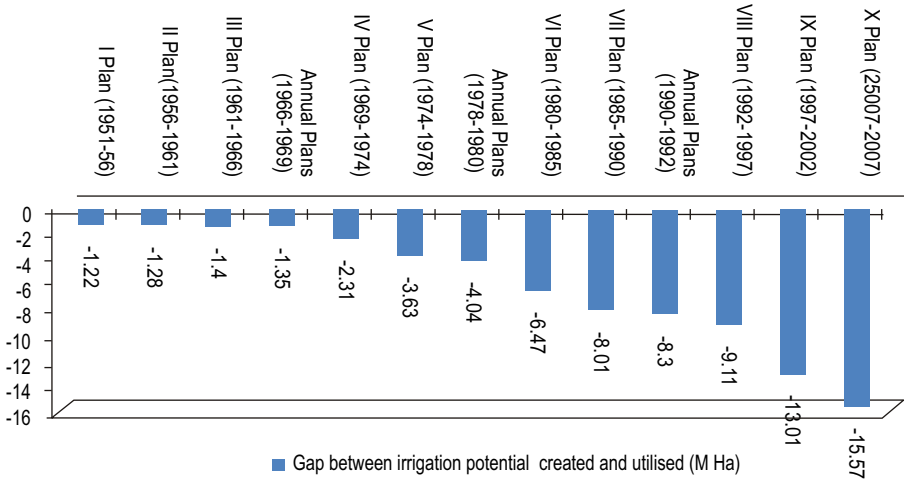
Figure 3 (b) - Changing share of surface/ groundwater sources in irrigation potential utilised



Data source: Studying Gap between Irrigation Potential Created and Utilized in India, 2008, IIM Ahmedabad

While there has been increase in the irrigation area, an area of concern has been the increasing gap between irrigation potential created and utilised. The gap which was -1.22 MHa during the first FY plan increased to -15.57 M Ha at the end of the tenth FY plan (See Figure 4).

Figure 4: Gap in irrigation potential created and utilised



Data source: Data analysis from MoWR

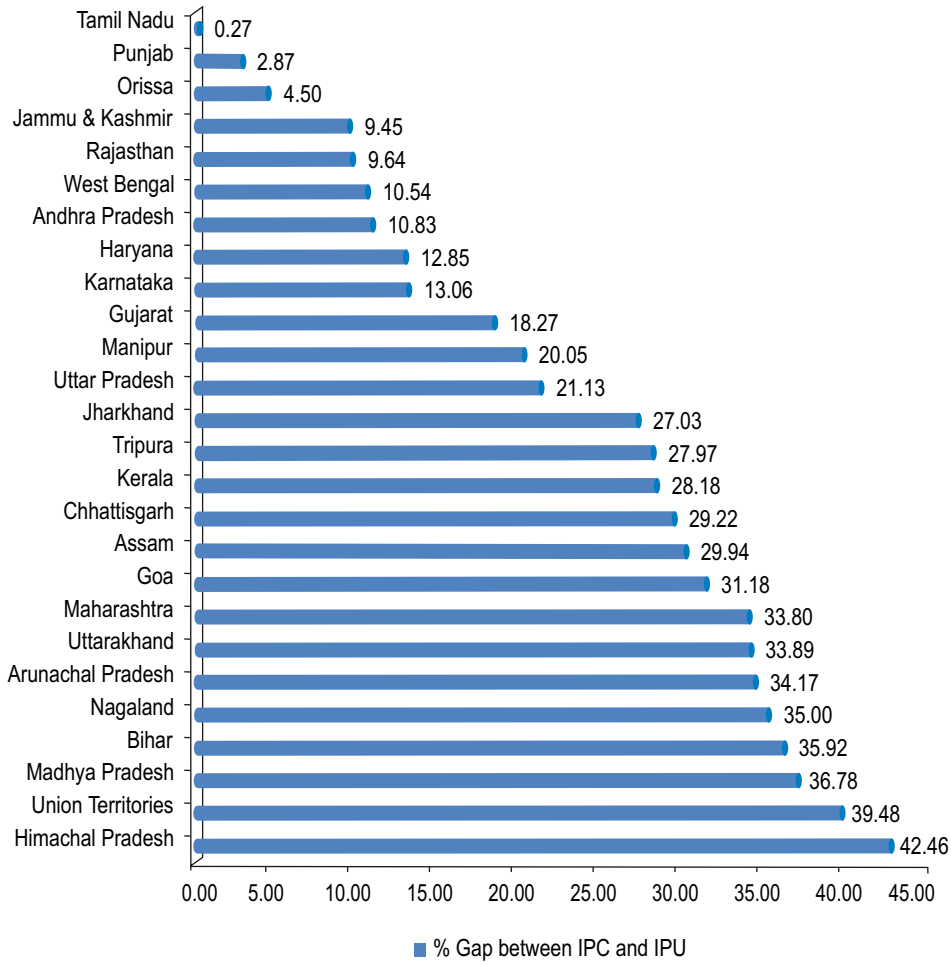
An analysis of the percentage gap between irrigation potential created (IPC) and irrigation potential utilised (IPU) across different states indicate a wide variation across states. The percentage gap for Tamil Nadu is the lowest with 0.27 per cent while that of Himachal Pradesh is the highest (42.46 per cent) (See Table 3 and Figure 5).

Table 3: Categorisation of states

% gap between IPC and IPU	States
0-10	Tamil Nadu, Punjab, Orissa, J&K, Rajasthan
>10 - < 20	West Bengal, Andhra Pradesh, Haryana, Karnataka, Gujarat
>21 - <30	Manipur, Uttar Pradesh, Jharkhand, Tripura, Kerala, Chhattisgarh, Assam
>31 - <40	Goa, Maharashtra, Uttarakhand, Arunachal Pradesh, Nagaland, Bihar, Madhya Pradesh, Union territories
Greater than 41	Himachal Pradesh

Data Source: Analysis from the data available with Ministry of Water Resources, GoI (till the end of X Five Year plan)

Figure 5: State wise % gap between IPC and IPU



Data Source: Analysis from the data available with Ministry of Water Resources, GoI (till the end of X Five Year plan)

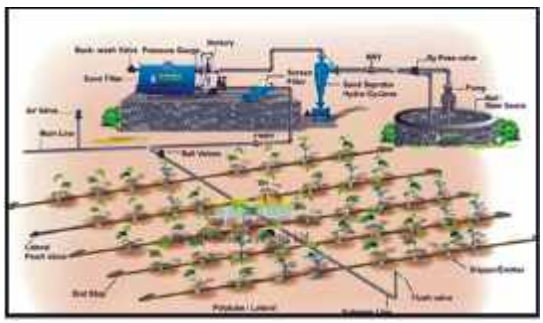
Several reasons are attributed to for not realising the complete irrigation potential created. Some of these are due to changes in rainfall patterns; absence of adequate storage structures and depletion of groundwater sources while others range from changes in cropping patterns, political decisions governing irrigation policies.

Micro Irrigation

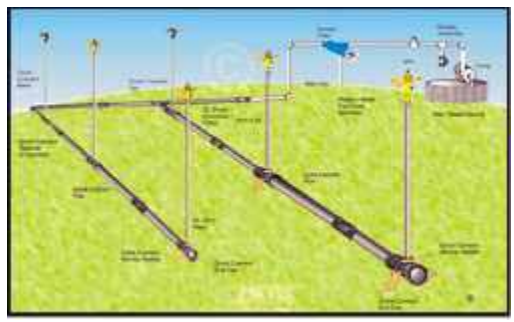
Despite having the largest irrigated area in the world, the coverage of irrigation in India is about 40 per cent of the gross cropped area. One of the main reasons for this low coverage is the predominant use of flood irrigation where water use efficiency is very low. Available estimates indicate that water use efficiency under flood irrigation is only about 35 to 40 percent because of high distribution losses[5].

Micro irrigation (MI) which is the most efficient method of irrigation was introduced in India in 1987. Micro irrigation can be in form of drip/sprinkler irrigation method and is the most successful demand management strategy to reduce water consumption in agriculture. Unlike flood irrigation, water in MI is supplied at a required quantity and interval required interval and quantity using pipe network, emitters and nozzles.

In drip irrigation water is directly supplied to the root zone of the crop through a network of pipes with the help of emitters, whereas in sprinkler irrigation method water sprinkles similar to rainfall is released into the air through nozzles which subsequently break into small water drops and fall on the field surface.



Drip irrigation system



Sprinkler irrigation system

Source: Jain Irrigation

While the primary objective of micro irrigation system is reduction in the amount of water used in agricultural production, research indicate that micro irrigation also results in productivity gains (in the range of 20-90 per cent); reduces the growth of weeds, controls soil erosion and is less labour intensive. There is an impact on energy savings as well which is reduced due to less power utilized in lifting water from wells. Evidence shows that up to 40 - 80 per cent of water can be saved and water use efficiency can be enhanced up to 100 per cent in a properly designed and managed MI system compared to 30-40 per cent under conventional practice[6].

[5] *Potential for Drip and Sprinkler Irrigation in India; Narayanamoorthy. A*

[6] *Spread and Economics of Micro-irrigation in India: Evidence from Nine States: K Palanisami, Kadiri Mohan, K R Kakumanu, S Raman, Economic and Political Weekly, June 25, 2011 VOL XLVI NOS 26 & 27*

There has been a tremendous growth in the area under micro irrigation during the last 15 years. At present, around 3.9 million ha area is under micro irrigation which is broken down further into 1.42 million ha under drip irrigation and 2.44 million ha under sprinkler irrigation. The potential for the expansion of MI in the country is immense with a projection of 42.23 million ha as the potential area which can be brought under MI[7]. Table 4 depicts the actual area under drip and sprinkler irrigation across different states in India.

Table 4: Area under micro irrigation

State	Area under drip irrigation in '000 ha	Area under sprinkler irrigation in '000 ha	Total area under MI in '000 ha
Andhra Pradesh	363.07	200.95	564.02
Bihar	0.16	0.21	0.37
Chhattisgarh	3.65	59.27	62.92
Goa	0.76	0.33	1.09
Gujarat	169.69	136.28	305.97
Haryana	7.14	518.37	525.50
Himachal Pradesh	0.12	0.58	0.70
Jharkhand	0.13	0.37	0.50
Karnataka	177.33	228.62	405.95
Kerala	14.12	2.52	16.64
Madhya Pradesh	20.43	117.69	138.12
Maharashtra	482.34	214.67	697.02
Nagaland	0.00	3.96	3.96
Orissa	3.63	23.47	27.10
Punjab	11.73	10.51	22.24
Rajasthan	17.00	706.81	723.81
Tamil Nadu	131.34	27.19	158.52
Uttar Pradesh	10.68	10.59	21.26
West Bengal	0.15	150.03	150.18
Other States	15.00	30.00	45.00
Total	**1428.46**	**2442.41**	**3870.86**

Data Source: Spread and Economics of Micro-irrigation in India: Evidence from Nine States: K Palanisami, Kadiri Mohan, K R Kakumanu, S Raman, Economic and Political Weekly, June 25, 2011 VOL XLVI NOS 26 & 27

[7] *Spread and Economics of Micro-irrigation in India: Evidence from Nine States: K Palanisami, Kadiri Mohan, K R Kakumanu, S Raman, Economic and Political Weekly, June 25, 2011 VOL XLVI NOS 26 & 27*

High costs involved in the adoption pose the biggest challenge in the spread of MI technology in the country. This led to state governments like Andhra Pradesh and Karnataka develop schemes for promotion of MI with support of the manufacturers. The Government of India also launched a centrally sponsored scheme (CSS) on MI which came into effect in 2005-06. Table 5 illustrates the subsidy scheme for drip and sprinkler irrigation across different states in India.

Table 5: Subsidy scheme across states

State	Subsidy % for drip irrigation	Subsidy % for sprinkler irrigation	Major crops under MI
Andhra Pradesh	70	70	Chilies, Mango, Orange, Groundnut
Bihar	90	90	Sugarcane, Banana, Coconut, Maize
Chhattisgarh	70	70	Sweet Orange, Vegetables
Goa	50	50	Vegetables
Gujarat	50	50	Cotton, Vegetables, Groundnut
Haryana	90	50	Orchard crops
Himachal Pradesh	80	80	Orchard crops
Jharkhand	50	50	Vegetables
Karnataka	75	75	Grapes, Vegetables, Groundnut
Kerala	50	50	Coconut, Areca Nut, Pepper
Madhya Pradesh	70	70	Sweet Orange, Banana, Vegetables
Maharashtra	50	50	Grapes, Banana, Sugarcane, Cotton
Orissa	70	70	Vegetables, Cashew, Mango, Banana
Punjab	75	75	Vegetables, Orchard crops
Rajasthan	70	60	Groundnut, Maize
Tamil Nadu	65	50	Sugarcane, Banana, Coconut, Maize, Groundnut
Uttar Pradesh	50	100	Vegetables, Mango, Sugarcane
Uttarakhand	50	50	Potato, Groundnut, Orchard crops
West Bengal	50	50	Banana, Maize, Mango

Data Source: Spread and Economics of Micro-irrigation in India: Evidence from Nine States: K Palanisami, Kadiri Mohan, K R Kakumanu, S Raman, Economic and Political Weekly, June 25, 2011 VOL XLVI NOS 26 & 27

The rate of adoption of MI has been slow as compared to the potential of the technology. The subsidy mechanisms and vary across the states and barring few states like Maharashtra, Andhra Pradesh, Karnataka, Gujarat and Tamil Nadu, MI is yet to catch up as a preferred choice. The poor adoption can be attributed to factors like high cost, complexity of the technology and other socio-economic issues such as a lack of access to credit facilities, fragmented land holdings, localized crop pattern, etc. Technical knowledge about MI; accessibility through easy credit facilities and institutional support systems are essential for the adoption and spread of MI technology.

National Mission on Micro Irrigation

Government of India launched a Centrally Sponsored Scheme (CSS) on micro irrigation during the financial year 2005-06. This was up-scaled as National Mission on Micro Irrigation (NMMI) in 2010 to boost convergence of micro irrigation activities under major government programmes such as National Food Security Mission (NFSM), Integrated Scheme of Oilseeds, Pulses, Oil palm & Maize (ISOPOM), Rashtriya Krishi Vikas Yojna (RKVY) Technology Mission on Cotton (TMC) etc. for increasing water use efficiency, crop productivity and farmers income.

NMMI has three components namely - area coverage under micro irrigation; transfer of technology through demonstrations and human resource development through training awareness programmes, exhibitions, publications and quality control. The mission was set up with the following objectives -

- Increase the area under micro irrigation through improved technologies,
- Enhance water use efficiency in the country,
- Increase the productivity of crops and farmers income,
- Establish convergence and synergy among on-going government programmes,
- Promote, develop and disseminate micro irrigation technology for agriculture/ horticulture development with modern scientific knowledge, and
- Create employment opportunities for skilled and unskilled person's especially unemployed youth.

Under the provisions of the NMMI, the centre provides a subsidy of 40 per cent; the state provides 10 per cent (this does not prevent the state from providing additional subsidy) and the remaining amount is borne by the beneficiary either from his/ her own resources or loan from financial institutions. In case of small and marginal farmers, the centre provides an additional subsidy of 10 per cent. The assistance to farmers is limited to a maximum of 5 ha per beneficiary and Panchayati Raj Institutions (PRIs) are involved in identification of priority areas and promoting the scheme.

Assistance is also provided for irrigations systems for protected cultivation including greenhouses; polyhouses and implementation of advanced technology like fertigation with fertilizer tank, venture systems, sand filters, media filters and other different type of filters and valves required for the MI system.

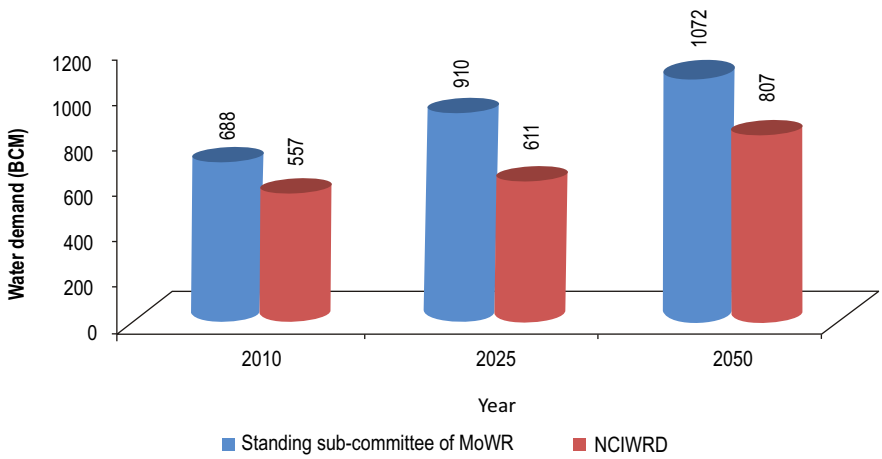
Source: Operational guidelines, NMMI, Department of Agriculture and Cooperation, GoI, 2010.

Water Demand for Agriculture

The share of irrigation in the overall allocation of water resources has been maximum. Projections on water demand of the irrigation sector by the standing sub-committee of Ministry of Water Resources (MoWR), Govt. of India and the National Commission on Integrated Water Resources Development (NCIWRD) indicate manifold rise in water demand (See Figure 6).



Figure 6: Water demand for irrigation



Data source: Report of the Working Group for Water Resources for XI Five Year Plan, GoI

A study by the Water Resources Group has predicted that in 2030, the gap between demand and availability in India will be 50 per cent, with the demand touching 1,498 billion m^3 and availability at mere 744 billion $metre^3$. It also states a 58 per cent rise in demand from 2005 baseline in 2030, with demand almost doubling for the three sectors of agriculture, domestic and industry. The report cautions that the impact of the water crisis will be severe in the water rich basins and measures for water security will have to factor impacts of climate change into any planning for future. In case of agriculture, water demand is projected to rise from 656 Billion Cubic Meters (BCM) in 2005 to 979 BCM in 2020 and 1,195 BCM in 2030[8].

[8] *Charting our Water Future; 2009, Water Resources Group*

A study by the Water Resources Group has predicted that in 2030, the gap between demand and availability in India will be 50 per cent, with the demand touching 1,498 billion m^3 and availability at mere 744 billion metre[3]. It also states a 58 per cent rise in demand from 2005 baseline in 2030, with demand almost doubling for the three sectors of agriculture, domestic and industry. The report cautions that the impact of the water crisis will be severe in the water rich basins and measures for water security will have to factor impacts of climate change into any planning for future. In case of agriculture, water demand is projected to rise from 656 Billion Cubic Meters (BCM) in 2005 to 979 BCM in 2020 and 1,195 BCM in 2030[9].

Growing population will necessitate higher food production which in turn would require higher volumes of water for irrigation. Irrigation in addition to enhancing food production provides stability to production against variable weather. Some estimates suggest that irrigated agriculture with less than one third of gross cropped area produces more than 75 per cent of total food grains production and 95 per cent of non-food grain production[6].

Irrigation is the major driving force for realizing increased agriculture production from the available land. Therefore it is pertinent for providing irrigation facilities at a faster rate with a focus on improving irrigation efficiency. Growth in the agriculture sector, with its forward and backward linkages, works like an engine to drive the economic growth of the country as a whole. Increase in agricultural output has the potential to enhance growth in the manufacturing and tertiary sector as well in addition to providing employment to a large section of the population. It is thus imperative that ways and means of attaining water use efficiency in irrigation is looked at for enhancing our food production and protecting our water resources.

[9]Water Analysis, Innovations, and Systems Program, Water Sector Assessment Report, 2011, USAID

Emerging Issues

The challenge in agriculture water management is complex with a wide range of factors contributing to resource availability, allocation, use and efficiency. A clear understanding of the issues outlined below coupled with an adaptation plan will enable us to develop a water efficient model of agriculture.

- ***Gap between irrigation potential created and utilized:*** The widening gap between irrigation potential created and utilized presents the greatest challenge for ensuring efficiency in agriculture water management. There causes for these range from changes in the climatic patters (including less rainfall leading to inadequate physical access to water) to a mix of infrastructural, institutional and environmental causes.

- ***Dependence on groundwater:*** In the past 30 years the dependence on groundwater for irrigation has increased tremendously with 60 per of the net irrigated area meeting its requirements from groundwater sources mainly in form of tube-wells (40 per cent). It is estimated that there are around 19 million wells in the country, of which 16 million are in use that draws 231 BCM of water[10]. This has been at the expense of decline in irrigation by canals and tanks. What is significant is that since 1996-97 (when AIBP was initiated) the net irrigated area through canals has actually undergone an absolute decline, rather than achieving an accelerated growth despite the fact that funding has increased 1,520 times from ₹500 crore to ₹7,598 crores[11]. The impact of the over-withdrawal has been felt on the overall availability of groundwater with the number of over exploited blocks in the country having risen from 231 in 1994 to 839 in 2005[12]. Measures to augment irrigation would have to include mechanisms for recharge (in case of groundwater based systems) and greater emphasis on surface water based methods for irrigation.

- ***Institutional weaknesses:*** The absence or ineffectiveness of institutions at the village level (Water User Associations) poses a hindrance in realizing the full irrigation potential. Problems of the WUAs even arise due to the inadequate powers assigned to them and the inability to mainstream them into the village governance system. The capacities (technical and managerial) of departments responsible for implementation and maintenance of irrigation projects are of importance in the overall performance of irrigation schemes. It also has a bearing on the time and costs overrun for projects. The involvement of WUAs and Panchayati Raj Institutions (PRIs) in planning, construction and maintenance of irrigation projects will have to be strengthened through trainings.

---

[10] *Report of the expert group: Groundwater Management and Ownership, 2007, Planning Commission, GoI*

[11] *Mid Term Assessment of the XI Five Year Plan, 2009, Planning Commission, GoI*

[12] *Dynamic Ground Water Resources of India, 2006, Central Ground Water Board*

- ***Financial inefficiencies:*** Often, irrigation charges do not cover operating and maintenance costs leading to progressive neglect and reduced efficiency of systems created. Estimates till 1994-95 indicate that revenues earned from pricing water covered barely 15 per cent of working expenses and only 5 per cent of total costs thus increasing the losses to ₹7,000 crores[13]. Pricing water for irrigation is a tricky issue which is avoided in the political interest. Irrigation should be valued as an essential input into agriculture and mechanisms for pricing and cost recovery should be developed.

- ***Water use efficiency:*** The consumptive use factor of irrigation is relatively low (ranging from 12 to 59 per cent across basins) creates scope for demand management in agricultural production[14]. This can happen both at the basin and national level taking into consideration climatic and geographical factors but driven by efficiency in water application. It may warrant innovations in technology, pricing, institutional strengthening cropping patterns amongst others.

[13] *Mid Term Assessment of the XI Five Year Plan, 2009, Planning Commission, GoI*

[14] *Amarasinghe, U.A.; Rathinasamy Maria Saleth; Promoting Irrigation Demand Management in India: Policy Options and Institutional Requirements. Research Report; International Water Management Institute.*

Water Conservation and Efficiency in Agriculture

The increasing population would have a direct bearing on the agriculture sector with the need to feed the increasing number of people and also contribute to the Indian economy. Irrigation is the major input for agriculture and would require a mix of reforms to help it keep pace with the future challenges.

Reducing the dependence on groundwater for irrigation should be the top most priority for attaining sustainable water use in agriculture. The decline in surface and canal irrigation over the past few decades have been due to the over-extraction of groundwater sources. Measures for augmenting water supply through agricultural rainwater harvesting should be accorded high importance. Using ***Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) funds*** for construction of water courses, channels and drainage structures in fields, revival of water harvesting structures, repair and maintenance of minor tanks and canals and de-silting should be taken up. There are examples of convergence of NREGS funds for agricultural water harvesting in the states of Madhya Pradesh, Andhra Pradesh which can be looked into. Local measures like these would also reduce the vulnerability of farmers to climatic changes and operational problems of irrigation schemes.

Irrigation charges in the country do not cover operating and maintenance costs, which leads to neglect and reduced efficiency of systems created. The revenues collected from pricing irrigation water remotely cover the working expenses and total costs resulting in huge losses. As is the case with drinking water pricing water for irrigation is also avoided owing to the political sensitivity. But water should be valued as an essential input into agriculture and mechanisms for ***pricing and cost recovery should be developed.***

There has been an inability to realise the full irrigation potential due to the absence or ineffectiveness of institutions at the village level like the Water User Associations. Problems of the WUAs even arise due to the inadequate powers assigned to them and the inability to mainstream them into the village governance system. With only 20 per cent of the total command area having WUAs there remains a scope to strengthen these across the country. In addition to giving WUAs a legitimacy within the PRI, they would need ***measures that give them authority, funds, functions and functionaries.***

In a changed scenario where the policy focus of various government programmes are on decentralised management of resources it is important that ***the profile of irrigation department officials is broadened.*** Irrigation department has so far been seen as a department of only engineers provide technical inputs and designing structures. It is worthwhile considering the inclusion of social workers and anthropologists who would

understand social dynamics of farmer stakeholders for better governance, delivery and maintenance of irrigation programmes.

Improvements in the irrigation sector have resulted in an overall increase of the irrigated area in the country by four times in the period 1957-1997. However, there still remains a huge gap between irrigation potential created and utilised. The Command Area Development Authority Set up for undertaking a variety of improvement measures to improve irrigation efficiency has had its share of success and failures. With irrigation taking up bulk of the water resources, measures for ***on farm water conservation using technological improvements*** like sprinklers, laser levellers, needs to be promoted on a large scale. These initiatives would have to be linked with supportive financial measures for adoption by farmers.

Planning for irrigation scheduling is to be made robust through ***developing decision support systems for agriculture which take into account real time weather forecasts and predictions.*** These will help in better management of water resources and reduce incidences of crop failure owing to climatic changes. The approach for XII plan will have to look at encouraging experiments on these lines and pilot them across various states.

The misuse of water in agriculture is also contributed by faulty crop planning. Encouraging better crop planning measures will be a key determinant in regulating water usage. These measures could include regulations on the time of sowing of crops as has been done in Punjab through a legislative measure namely The Punjab Preservation of Sub Soil Water Act, 2009 which prohibits sowing paddy nursery before May 10 and transplanting paddy before June 10. ***Legislative measures such as these have to be adopted at a basin level,*** by other states to regulate the use of water and prevent over-exploitation of a common pool resource.

Other measures which can be undertaken include selecting efficient crops and cropping systems matching the length of the growing season and promoting off-season ploughing to conserve moisture. Table 6 illustrates some of the measures which can be employed for water conservation and improving irrigation efficiency.

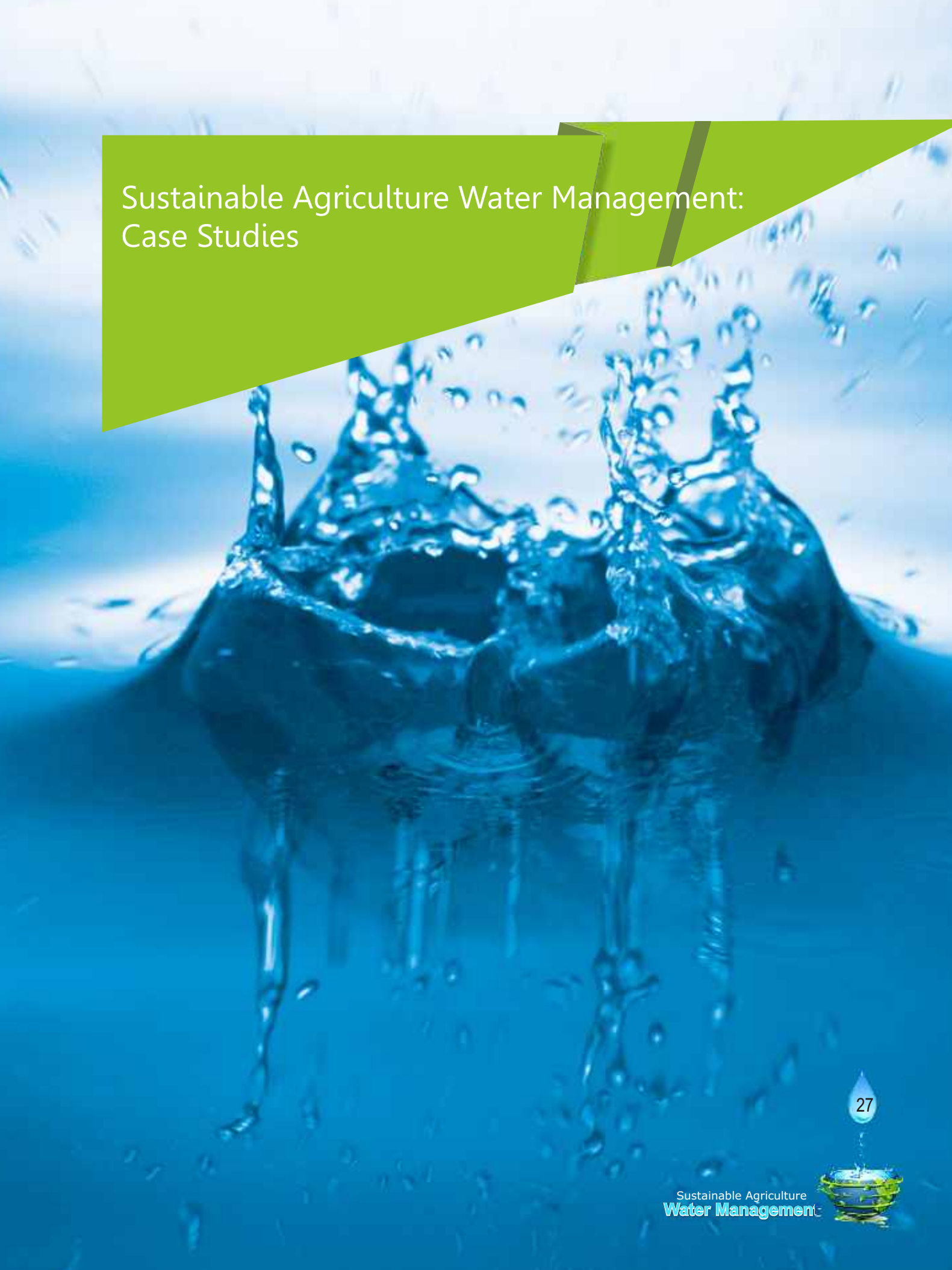
Table 6: Measures for agriculture water management

Measure	Description	Measure	Description
Agricultural rain water harvesting with fertigation	Boost productivity of currently rain-fed crops by applying water during dry spells; requires construction of small reservoirs for rainwater collection.	Drip irrigation	Applying water through low-pressure tubing requires less water than flooding
Canal lining	Line on-farm canals with cement/ plastic to reduce seepage.	Irrigation scheduling	Prevent farmers from over-irrigating; linked to controls/ subsidies for groundwater pumping.
Drainage construction	Construction of adequate drainage structures will increase yield and reduce need for irrigation and enable cultivation of land during monsoon.	Sprinkler irrigation	Increase yield and irrigation efficiency (e.g., through reduced evaporation).
Genetic crop development	Continued development and adoption of varieties that enable farmers to attain higher yields; includes both conventional breeding and genetic engineering.	Soil techniques/ no-till agriculture (irrigated)	Techniques to reduce tillage; laser land leveling to reduce runoff and better drain lands.
Improved fertilizer balance	Apply optimal mineral balance to improve mineral absorption and sufficiently supply micro-nutrients.	System of rice intensification (SRI)	Improve rice planting, irrigation and production practices.
Integrated plant stress management	Efforts to improve yield by resistance to abiotic (climate) and biotic (pests, disease) stresses. Combine impact of improved practices (such as integrated pest management) and innovative crop protection.	Improved germplasm	Increase average yield potential by dissemination of existing, higher yielding seed varieties that are best adapted to the specific, regional conditions.

Data source: Charting our Water Future; 2009, Water Resources Group



Sustainable Agriculture Water Management: Case Studies



Case Study 1: Coca-Cola India and Hindustan Coca-Cola Beverages Pvt. Ltd.

Region: Kaladera village located in Jaipur district of Rajasthan

Intervention type: Public Private Community Partnership (PPCP) for sustainable water management using drip irrigation

Genesis

The economy of Rajasthan's is mainly agriculture and livestock based. About 65 per cent of the population lives in rural areas and is dependent on farming. Kaladera falls under Chomu and Govindgarh Blocks which are known as the 'Vegetable Basket' of the state. Vegetable cultivation puts increased pressure on groundwater due to the predominant use of traditional flood irrigation techniques.

The region faces water scarcity which is heightened during the summer months. Water is intrinsically linked with development of the people and society at large. Coca-Cola India and its bottling unit-Hindustan Coca-Cola Beverages (HCCB) has initiated the concept of Public-Private-Community Partnership (PPCP) to promote drip irrigation for water use efficiency. This is an attempt to work with the largest water user groups in the region, the farmers to promote sustainable water management practices in agriculture.

The Model

The PPCP model involves working with different stakeholders namely, local farmers (community), Department of Horticulture, Government of Rajasthan (provides financial subsidy), Krishi Vigyan Kendra, Takerda (Knowledge Partner) and Coca-Cola India and Hindustan Coca-Cola Beverages Pvt. Ltd. (Funding Partners). This collaborative partnership has provided a sound foundation for an effective and long-term partnership. The objectives of this partnership programme were:

- To facilitate setting up of long term, economically sustainable infrastructure benefiting local communities, and
- To bring down the overall usage of water in agriculture to reduce the dependence and help conserve groundwater.

The drip irrigation initiative was undertaken for efficient use of water for vegetable cultivation in the region. The objective was to enhance the economic gains to the farmers and at the same time use less water for production. The partnership model functioned in the following manner (See Figure 1).

Figure 1: Partnership Model -PPCP Project

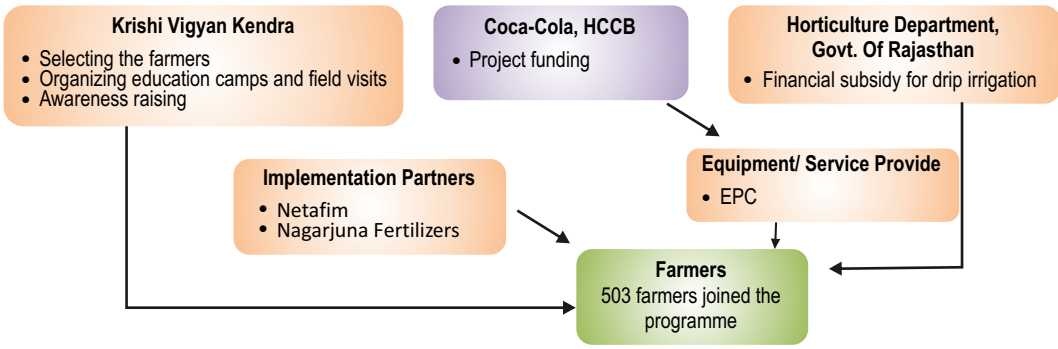
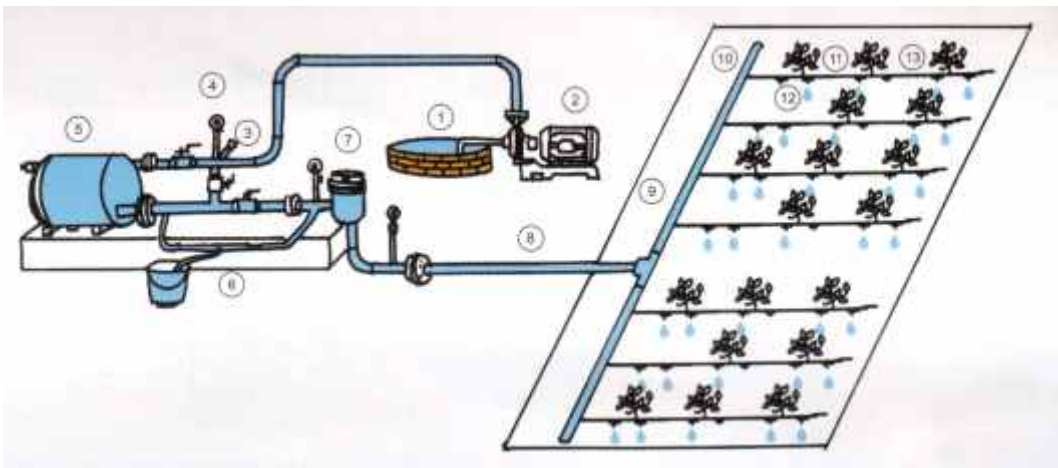


Figure 2: Application of drip irrigation



1. Water Source	2. Pump	3. Bypass Assembly
4. Pressure Gauge	5. Sand Filter	6. Venturi Assembly
7. Screen Filter	8. Main Line	9. Sub-main
10. Sub-main Flush Valve	11. Lateral	12. Drippers
13. Lateral End Plugs		

Impacts and Outcomes

The partnership rolled out in 2008 with 27 projects covering 13.5 hectares of land. By end of 2011, 400 projects have been executed covering 205 hectares of agricultural land under drip irrigation. The programme now has 503 farmers under its ambit who are earning higher economic returns.

Regular assessments of the intervention across the past few years have indicated improvements in water and electricity savings and economic return to farmers through higher production.

- *Water saving:* Implementation of drip irrigation system has led to savings of approx. 1200 cubic meter of water for a cropping cycle of 110 days/hectare. In most cases, farmers grow at least two crops (mostly vegetables) using drip irrigation. An overall calculation of the total water savings (for 500 farmers) in indicated below (See Box: 1)

Box 1: Water savings

No. of farmers implementing drip irrigation = **500**

Land with each farmer = 0.5 hectare

Total area under drip irrigation = 0.5*500 = 250 hectares = **600** acres (1 hectare = 2.4 acre)

Water savings per acre = 1,200 cubic metre/annum

Water savings for 600 acres = 1,200*600 = **720,000 cubic meter/annum**

- *Savings on electricity, fertilizer and pesticide expenses:* The estimated average savings on account of electricity, fertilizers and pesticides is ₹ 2000/hectare/year.
- *Economic benefit:* Adoption of drip irrigation has led to a shift in cropping pattern from mono-cropping to inter-cropping, thereby improving quality and quantity of yield. This has resulted in better price realization for the farmers. Depending on the crop, economic benefit accruing to the farmers ranges between 20-80 per cent (See Table 1).

Table 1: Economic gains*

Crop	Total Yield Under Flood Irrigation (Quintal)	Total Yield Under Drip Irrigation (Quintal)	Total Increase in Yield (Quintal)	% Increase in Yield under Drip Irrigation
Barley	58	75	17	29.31
Bottle guard	207	300	93	44.93
Brinjal	62	111	49	79.03
Cabbage	1,146	1,725	579	50.52
Cauliflower	1,685	2,336	651	38.64
Chilly	7,156.5	10,744	3587.5	50.13
Garlic	50	70	20	40
Guar	40	60	20	50
Kakdi	867.5	1,170.5	303	34.93
Muskmelon	560	920	360	64.29
Onion	18,885	27,380	8,495	44.98
Raddish	990	1710	720	72.73
Tomato	18,508	29,075	10,567	57.09
Watermelon	5,160	7,424	2264	43.88

** Figures shown above are for an area of 0.5 hectare*

Voices from the community



Shri. Chhitarmal
Vill: Kachauliya
Year of Installation: 2010

".....There are various benefits of the drip set-through the drip technology water directly reaches the root of the plant as a result there is a saving of 30-45% in water usage. It has become easier for us to give right dose of fertilizer and pesticides to the plant, which leads to an approx. savings of 40-50% in terms of expenditure on fertilizer and pesticides. With the usage of drip technology, we are able to bring more area under irrigation....."



Shri. Jagdish Prasad Sharma
Vill: Pokhar ka waas
Year of Installation: 2008

".....I have been using the drip technology since 2008. There are several benefits of the system especially in vegetable cultivation. There has been an increase of nearly 20-30% in the produce and the quality of the product is good. After adoption of the technology, there has been decline in electricity consumption by 10-15% for irrigation purpose. There is decline in usage of weedicides as the growth of weeds is controlled by application of right dosage. There is also saving in terms of labor and time ....."

Testimonials from Implementation Partners

Netafim

Netafim has installed approximately 180-190 drip irrigation during 2008-11. Benefits incurred through drip irrigation are:

- 65 -70 per cent saving of water
- 20 -30 per cent increase in yield and of better quality
- Reduction in electricity bill
- Less use of manual labour
- Reduction in usage of manure

Nagarjuna fertilizers

Nagarjuna fertilizers have installed approximately 180-190 drip irrigation during 2008-11. Benefits incurred through drip irrigation are:

- Water savings up to 70 per cent
- Irrigation efficiency up to 90 per cent
- Irrigating undulated land is possible using drip irrigation
- Minimizes mortality of plants and ensures uniform growth
- Early maturity, good quality of produce and increase yield
- Less growth of weeds, hence reduced manual labour
- Saving on fertilizer, pesticide and fungicide expense
- Inter-culture and irrigation is possible simultaneously

EPC

EPC has installed approximately 40 drip irrigation during 2008-11. Benefits incurred through drip irrigation are:

- 40 -50 per cent saving of water
- 20 - 35 per cent increase in yield
- 40 - 45 per cent reduction in labour costs
- 20 - 30 per cent reduction in electricity bill
- 20 - 30 per cent incremental economic benefit to farmers.
- Possibility of growing multiple crops

The drip irrigation project has been a successful example of PPCP based on the strength of values which all partners cherish. Commitment to sustainability, transparency, appropriate structure of governance, feedback mechanism has paved the way for larger partnership. Impact Assessment and the lessons learnt have not only strengthened the partnership but have also provided a new direction for the future. There are plans to further expand the drip irrigation in the current and subsequent years.

Case Study 2: ITC Ltd.

Region: 8 States across India - Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh

Intervention type: Implementing soil and moisture conservation measures, building, reviving and maintaining water-harvesting structures to reverse land degradation, extend critical irrigation and raise agricultural productivity.

Genesis

India is on the edge of a serious water crisis with more than one third of the districts reeling under severe water-stress and 99 districts officially deemed drought-prone. The conservation and management of India's depleting water and other natural resources is therefore very important. More so because it directly impacts the livelihood security of over 70 per cent of its population and 58 per cent of its workforce who are dependent on agriculture and related activities for their livelihood. Largely consisting of resource-strapped small/marginal farmers, these agricultural communities are almost invariably engaged in rain-fed agriculture, and therefore most vulnerable to the adverse impacts of seasonality and environmental degradation. Almost entirely dependent on common property resources, including water, they are among the most disadvantaged sections of rural communities. Rain-fed agriculture covers approximately 80 million hectares of the 141 million hectares of net sown area, and is largely practiced by marginal smallholders in regions where the natural resource base is already fragile and under increasing stress.

- Though India's precipitation is good by global standards, rainfall patterns are erratic. Despite the huge potential for harvesting rainwater, public or private investment in water-harvesting and its use for irrigation has been grossly inadequate. Only 10 per cent of annual precipitation is harvested and the remainder lost as run-off.
- India is the largest user of groundwater in the world, with an estimated usage of 230 cubic km every year - more than a quarter of the global level. Groundwater sources meet almost the entire rural water demand, account for more than 45 per cent of total irrigation, and are the only water source during droughts, which have intensified and become increasingly unpredictable. Indiscriminate sinking of bore-wells and poor conservation practices have led to drastic reductions in water-table levels, further reducing irrigation potential.
- An estimated 147 million hectares across the country suffer from various forms of land degradation due to water and wind erosion, a consequence of inappropriate land management practices.

- The adverse effects of climate change are already evident in erratic rainfall and drought patterns which are predicted to intensify. Rain-fed agriculture is likely to be most impacted - as it is practiced in degraded, fragile lands by economically backward communities whose adaptive capacities are severely limited.
- Over the years, the National Water Policy has provided a framework for coordinated water resource development activities, but it is yet to be supported by legislation. Public investment in agriculture has declined over the past 2 decades - a gap that has not been adequately filled by private investment.

These factors have led to stagnating agricultural productivity and growth - further exacerbated by population pressure, increasingly fragmented landholdings, limited alternative off-farm employment options, poor infrastructure and inadequate marketing channels.

The Model

ITC's watershed programme promotes development and local management of water resources by facilitating village-based participation in planning and executing watershed projects. Adopting a bottom-up participatory approach, with disadvantaged sections as the primary target, ITC works with NGOs as implementation partners to mobilise them to form Water User Groups (WUGs). These groups are trained to carry out the entire spectrum of activities from planning to implementation and maintenance. The focus is on implementing soil and moisture conservation measures and building, reviving and maintaining water-harvesting structures to reverse land degradation, extend critical irrigation and raise agricultural productivity.

Groups are also trained to formulate regulations and fix water user charges. These go towards creating a fund used to maintain existing structures, build new ones and tap government schemes. ITC's ultimate aim is to federate these groups into mandal and district level organizations. The goal is to enable them to be active participants in the development process. The model is highly replicable as traditional methods are used in conjunction with modern techniques to build location-specific, low-cost water-harvesting structures, relying on simple technology and locally available materials. Emphasis is laid upon community contribution, both financial and in terms of labour, and the creation of a Maintenance Fund from user charges. This generates high levels of ownership crucial to long-term sustainability. As a community financial resource, the fund expands a community's choice and decision-making ability. There is an emphasis on undertaking civil works on structures as also in carrying out additional farming activities as a result of increased water availability. This ensures generation of employment within villages, benefiting marginal/landless farmers - a key factor in reducing seasonal out-migration.

Physical measures are only one aspect of a mosaic of solutions, the core objective being building sustainable livelihoods. The majority of ITC's watershed projects are located in areas where it has an agri-business presence and where ITC's e-Choupal initiative operates. This supports backward and forward linkages and enables beneficiaries the advantage of being able to access e-Choupal services, including an efficient agri-commodity procurement channel. The creation of a more stable agricultural regime secures the long-term competitiveness of both farmers and ITC, which also gains by being able to source better quality products.

ITC's Improved Agriculture Practices and Livestock Development programmes are integrated with its Watershed Development programme, to optimise usage of water resources created. Apart from water saving technologies and efficient irrigation devices, farm extension services help to promote crop diversification, best practices, organic composting and other measures to raise productivity and quality. A large percentage of rural households, both landed and landless are cattle owners. ITC's Livestock Development programme assists cattle owners to raise milk yields through breed improvement supported by comprehensive animal husbandry services. This enables cattle owners to convert a latent asset into a productive one.

Impacts

ITC's integrated watershed development programme provides soil and moisture conservation to over 90,000 hectares of water stressed areas. The company has created over 3,600 rain water harvesting structures both at the company premises and through external watershed development projects in socially relevant areas.

As on 31 March 2012, the total rainwater harvesting potential created by the company is over two times the total net water consumed by its operations. It is a matter of great pride that ITC continues to be a 'Water Positive Corporation' for a decade now.

Water Balance at ITC	2009-10	2010-11	2011-12
Fresh water intake	29.96	29.36	29.02
Treated effluents discharged	23.41	22.21	22.80
Net water consumption	6.55	7.15	6.22
Total RWH potential*	20.60	19.89	21.05
created (till date)			

Units in Million KL, except percentage.

**Besides the actual rainfall, the amount of rainwater harvested in a year is also determined by the rainfall pattern.*

Initiated in 2001, by 2011-12 ITC's Watershed Development programme covered 8 states across the country. The total watershed area covered was over **90,000 hectares** benefiting nearly **90,000 households**. There were **756 functioning Water User Groups** who had a cumulative Maintenance Fund of ₹**47.57 lakhs**. Civil work on structures generated 2.6 million person-days of employment, particularly benefiting the landless.

Projects under this programme, have made the most significant contribution in ITC maintaining and enhancing its water positive footprint for 10 consecutive years. As the first corporate to partner State Governments and NABARD in watershed projects, ITC's PPPs had a target of 1.22 lakh hectares under 5-year across 5 states by the close 2010-11.

ITC's Improved Agriculture Practices, which commenced in 2003, is operational in 8 states by the close of 2011-12. Similarly its Livestock Development programme, initiated in 2004 is active in 5 states by the close of 2011-12.

Case Study 3: Pepsico India Holdings Pvt Ltd.

Region: Punjab, Maharashtra

Intervention type: Water use efficiency in irrigation through direct seeding of rice and drip irrigation initiatives in potato cultivation

Genesis

Water for agriculture takes up the major share of freshwater allocation in the country. A study by Maplecroft ranks India at 34 amongst 168 countries in respect of water stress index due to widespread use of irrigation for agriculture, combined with increasing domestic and industrial water demand. India's usable supply of water by 2030 could fall short of projected demand by as much as 50 per cent, according to a recent study by the Council on Energy, Environment and Water, a New Delhi-based think tank

It is difficult to address this issue unless per acre water use efficiency in agriculture is improved. PepsiCo realized this in early 2000 and started work on two major water intensive crops, paddy and potato. Paddy consumes about 50 per cent of total water used in agriculture and in potato crop also water saving is substantial.

Traditional Paddy Cultivation

India's water efficiency in paddy cultivation is 4 KL / kg, against the international average of 3 KL / Kg. This low water efficiency is because of the traditional method, which involves three high water consuming operations like nursery raising, puddling (process of soil compacting of the field to make the water stand rather than seep into the soil) and transplanting after which the field is flooded with 4 -6 inches of water for two initial months of crop raising (See Figure 1). Due to presence of organic matter in water over a prolonged period, paddy cultivation is the largest contributor to Methane emission at 4 million tons which is equivalent to 90 million tons of CO_2 annually in the country.

Figure 1: Traditional paddy cultivation



Transplanting



Puddling

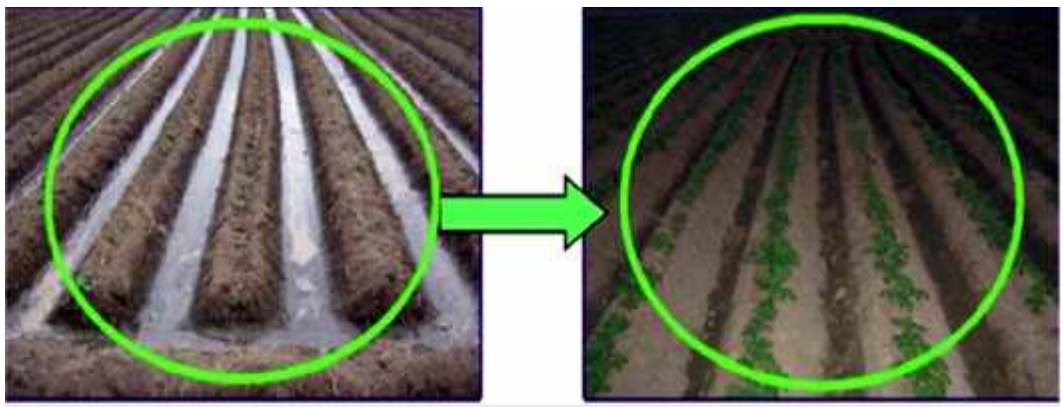


Flooding

Potato Cultivation

Traditionally potato is grown on ridges of 26-28 inches with free flowing water which leads to suffocation of crop when water is flooded. The negative effects of flood cultivation are low yields, more water consumption, uneven size of the tuber and inability to grow potato on marginal lands (See Figure 2).

Figure 2: Conventional potato cultivation

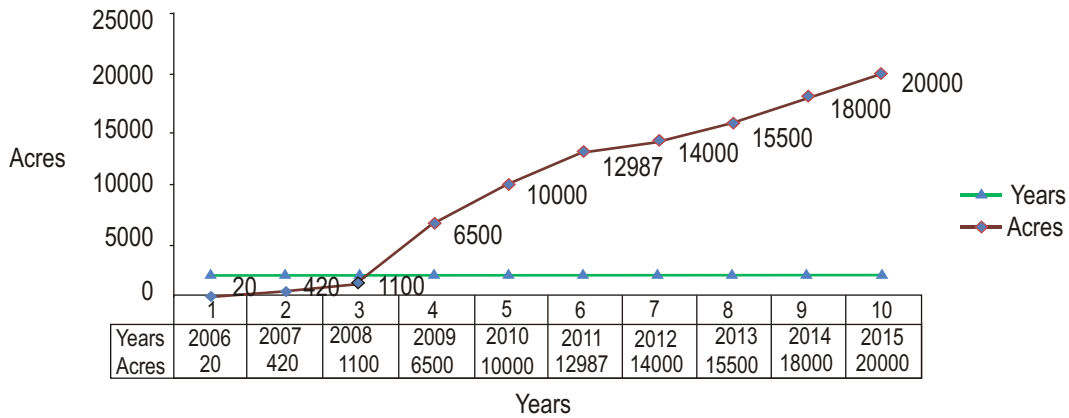


The Model

PepsiCo Direct Seeding of Rice (DSR) Model

After a successful demonstration of direct seeding at PepsiCo's R&D fields in Punjab during 2004 and 2005, this technology was taken to farmers' fields. Large scale DSR cultivation was first carried out by PepsiCo during 2008, and since then acreages have been increasing every year (See Figure 3).

Figure 3: Increase in area under DSR



	1	2	3	4	5	6	7	8	9	10
Years	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Acres	20	420	1100	6500	10000	12987	14000	15500	18000	20000

The critical success factors for direct seeding are:

- Proper seed germination, plant population and its geometry,
- Nutrition and management of micronutrient deficiency,
- Management and control of weeds.

Direct Seeding Machine: PepsiCo has developed a tractor driven direct seeding machine locally with a specific seed-metering device used for sowing the rice seeds.

In direct seeding, depth of sowing is very important as it affects the seed germination efficiency. In order to have good germination, the machine has been designed to sow the seeds at a depth of 1-1.5 inches. The direct seeder developed by PepsiCo has a unique seed-metering device which ensures planting of the seeds 8-9 inches apart (4 - 5 seeds falling at this distance) and also maintains a row to row distance of 9 inches. This machine ensures about 30-32 plants / sq meter. PepsiCo has bought many direct seeding machines giving free access to the farmer to carry out direct seeding in their fields (See Figure 4).

Figure 4: Direct seeding of paddy using seeding machine



Seed priming

Seed priming is soaking and treatment of seeds before actual seeding through the machine. This is a very important operation which helps to improve germination and control of seed borne diseases. The seed is soaked in solution having fungicide and antibiotics for 15-20 hours. The seed thus treated is dried for 1-2 hours in shade so that it can be dispensed efficiently from the machine.

Role of DSR to manage micronutrients deficiencies

Since direct seeding follows aerobic cultivation of rice, it usually results in certain micronutrient deficiencies, namely Zinc (Zn), Iron (Fe), Sulphur (Su) and Phosphorus (P) among macronutrients. These deficiencies are corrected by application of Chelated Zinc and Ferrous fertilizers. To meet this demand and to avoid nutritional deficiencies, the following fertilization schedule has been followed -

Time of Fertilization	Fertilizer (in Kgs / acre)				
	Urea	DAP	MOP	Librel Zinc	Librel Fe
At the time of sowing	15	25	20	0.5	0.5
20 days after sowing	15-20	0	0	0	0
35 days after sowing	10-15	0	0	0	0

Weed management and control

Management of weeds with pre and post emergence herbicides plays a critical role for success of direct seeding technology. Application of pre-emergence herbicide is important as it reduces the competition between germinating rice and weeds by stopping the growth of weeds for first few days, hence improving rice seed germination (See Figure 5).

Figure 5: Absence of weeds in paddy cultivation



15 Days Old Crop



30 Days Old Crop



40 Days Old Crop



70 Days Old Crop

PepsiCo provides technical support throughout the cultivation process by trained field extension staff, free access to direct seeding machines developed / procured by PepsiCo, free seeds in the initial stages to encourage the farmers to try out the innovative paddy cultivation process. DSR has become extremely popular with the farmers and during 2011 PepsiCo carried out direct seeding over 12,987 acres across states like Punjab, Haryana, Tamil Nadu and Karnataka having different agro-climatic and soil conditions and with various varieties of rice. By 2015 PepsiCo proposes to carry out DSR over 20,000 acres which will result in water saving of 13.5 million KL.

Advantage of DSR

- 30 per cent reduction in water consumption (confirmed by multiple year studies carried out in collaboration with IRRI);
- ₹ 1,500 / acre reduction in cost of cultivation;
- Savings on electricity to the tune of 200 units per acre;
- Savings of 10 man days per acre; and
- 75 per cent reduction in Methane emission.

If 25 per cent paddy cultivation is converted using DSR, the water saved will be equivalent to 25 billion KL - the total water consumed by Indian industry. In addition, the farmers will save ₹ 41.25 billion and methane emission will reduce by 0.75 million tons.

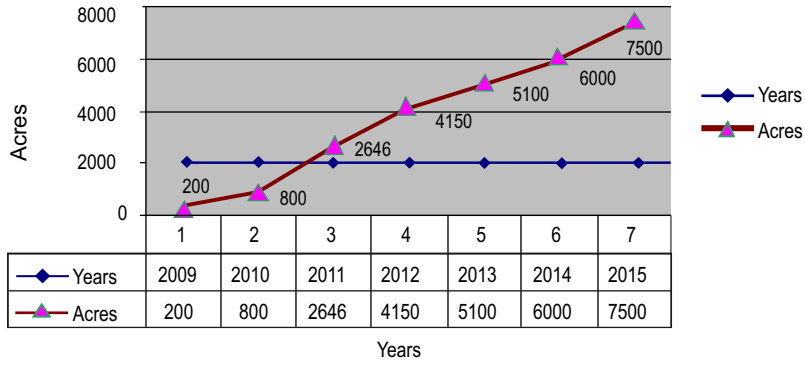
Drip irrigation model for potato

Potato cultivation using drip irrigation ensures optimum use of water. It results in 40-50 per cent of water saving in addition to improvements in yields and uniformity in tuber size. PepsiCo worked with the farmers by contacting drip irrigation companies and tying up with bank for loans and also coordinating with state agriculture departments in providing subsidies to farmers on drip. In state like Maharashtra, PepsiCo efforts helped the farmers to convert unproductive land to productive land and hence impacted farmer's livelihood.

PepsiCo demonstrated the cultivation of potato under drip on barren land in Maharashtra where no crop was grown. After successful demonstration the program has been scaled up to 1,900 acres in 2011 which resulted in net saving of 0.9 billion litres of water. Before this intervention, the farmers were growing low profits crops like Jowar and family members were doing low grade jobs in cities.

This initiative not only saved water but also improved the crop yield by 30 per cent which resulted in doubling the farmers income. PepsiCo converted 2,000 farmers in Maharashtra on drip irrigation and facilitated them to avail subsidy available on drip through state agriculture department. The future outlook on drip in potato is as follows (See Figure 6):

Figure 6: Progress of drip irrigation



	1	2	3	4	5	6	7
Years	2009	2010	2011	2012	2013	2014	2015
Acres	200	800	2646	4150	5100	6000	7500

Years

Earlier, most of the farmers were keeping their land fallow in Kharif Season because of paucity of water for irrigation. Now with drip irrigation they cultivate potatoes for PepsiCo and also getting benefits of drip in Rabi season with cash crop cultivation like onion. With the support of PepsiCo initiatives, farmers in Satara district have converted their barren land into arable for the last three years and their income has doubled.

Impacts

A. DSR Cultivation: In DSR, the yields are at par with transplanted rice and even better yields can be taken provided proper management of weeds is taken care in the fields. With at par yields and low cost of cultivation, the net income to the farmers increases by 15 per cent compared to traditional method of cultivation keeping quality at par.

B. Drip irrigation cultivation: The increase in yield for potato was to the tune of 20-40 per cent. The drip irrigation technology is supporting farmers to increase their net income by 20 per cent. With drip irrigation the quality of potatoes are extremely good in terms of shape and size of tubers

c. Water use efficiency: PepsiCo successfully saved 11.2 billion liters of water through Direct Seeding initiatives and 0.9 billion liters through scaling up of drip initiatives in potato cultivation in 2011 resulting in addressing the transformation of lives of 5,000 farmers by supporting their livelihood which not only raised their income levels through better yields and good quality produce but also reduced the cost of cultivation.

Case Study 4: Columbia Water Centre, Columbia University

Region: Punjab

Intervention type: Developing low cost tensiometer and better irrigation scheduling.

Genesis

In the 1960s and 70s, the arrival of the Green Revolution appeared to put an end to a long history of recurrent famine in India through improved seed varieties, extensive use of fertilizers and pesticides and, perhaps most importantly, a dramatic increase in pumped irrigation from underground aquifers.

But while the growth in irrigation allowed India to provide more food for its population, it also led to severe overexploitation of groundwater resources. Continued depletion of groundwater at current rates poses a critical threat to the sustainability of water resources for all uses, including safe drinking water and irrigated agriculture itself.

The problem of irrigated agriculture and depletion of groundwater is particularly acute in Punjab, the "food bowl" of the nation. Punjab region of Northern India was historically considered to be one of the most fertile on earth, producing wheat, cotton, sugarcane and vegetables. In recent years, however, rice production has become increasingly important, as Punjab was targeted as a primary source for government grain reserves. Rice traditionally requires 1.8M of water application per season, far in excess of the average annual rainfall in Punjab.

The Model

Columbia Water Center has partnered with Punjab Agricultural University (PAU) to design and pilot several water-saving strategies for farmers, including tensiometers, direct seeding of rice and contract farming.

- *Developing low cost tensiometer:* The tensiometer project provided hundreds of rice farmers with an inexpensive soil-measuring device to help them irrigate more efficiently. In contrast to more expensive previous tensiometer designs, the simplified, specially calibrated tensiometer (See Figure 1) from PAU costs only $7 [₹ 364 (1 US $ = ₹ 52)approx], making it affordable for many farmers and greatly increasing the possibility of widespread adoption.

Figure 1: Low cost tensiometer



- *Irrigation scheduling and shift to water efficient crops:* To develop the water saving potential of contract farming, the team worked with Del Monte/ Field Fresh to design an optimal irrigation schedule for baby corn production. In addition, the team is testing the potential of contract farming to create incentives for farmers to shift production from rice to more water efficient vegetable crops.

In 2011, the project has expanded to more than 5,000 farmers through farmer cooperatives as a test of an adoption strategy.

Impacts

- In its first year, the project's 525 farmers cut water use by an average of 22 per cent per acre.
- If just 40 per cent of the area under rice cultivation in Punjab were to adopt tensiometer use, it would save an estimated 3 million dollars in energy per year, and 22 billion cubic meters of water.
- If 60 percent of Punjab's farmers were to adopt this inexpensive technology, groundwater depletion could be significantly reversed. This is what the project is targeting now.

This project is carried out in partnership with the PepsiCo Foundation as part of the 'Improving Rural Water and Livelihood Outcomes' initiative, which addresses water scarcity and income generation in Brazil, India, Mali and China.

Case Study 5: Columbia Water Centre, Columbia University

Region: Gujarat

Intervention type: Strategies for stabilizing groundwater and improving farmer livelihoods.

Genesis

The growing scarcity of water in many parts of the world has serious implications for lives and livelihoods of those dependent on it-particularly in semi-arid and irrigated agricultural areas such as that of North Gujarat, where high demand for irrigation threatens to deplete groundwater supplies and has created unsustainable growth in energy consumption for pumping.

Energy use per hectare in North Gujarat is more than three times the Indian national average and water tables have declined over 80 metres in the last 30 years. Further decline in water tables could lead to irreversible salinization and even higher energy use for extracting groundwater. Since it can take many years to recharge aquifers, this is a critical situation.

Livelihoods are also negatively affected; many farmers are no longer able to generate net incomes that exceed the cost of subsidized electricity supplied to them. In other words, the net economic impact of their farming is negative to the state.

The water-use problem warrants a range of solutions that include (a) restructuring of the supply chain, (b) demand-side management, (c) shifting cropping patterns, and (d) the creation of incentives for capital investment in devices that improve water-use efficiency.

Two main approaches that could improve the situation include:

- Incentivize reduced energy and water use while maintaining farmer income as well as revenue neutrality of the State.
- Plant and market crops that use less water while delivering reliable and superior income to farmers.

The Model

The Columbia Water Centre Gujarat project promotes a variety of measures to help farmers save water and energy, including:

- Irrigation efficiency improvement including reducing irrigation depths and adopting innovative devices such as tensiometers-low cost, farmer-customized soil moisture measurement devices-that can help farmers schedule irrigation for greater efficiency. In addition, by adopting micro irrigation systems such as drip and sprinkler irrigation, farmers can cut water use by 30 - 50 per cent without impacting crop yields.
- Crop diversification towards less water intensive crops. The project team is currently pilot testing baby corn, a short duration, fodder-rich crop, as one of several less water intensive crop options.
- Farm mechanization such as laser leveling can reduce water use by 15 per cent.

While doing so the project aims to achieve the following key outcomes:

- Understanding and analyzing Water/Energy/ Food/Livelihood Nexus in North Gujarat.
- Critical analysis of the causes of groundwater depletion and increasing energy use.
- Design and implementation of incentive-driven water/energy savings reform strategy that enhances farmer incomes through adoption of resource saving measures.

Project innovations

- Development and demonstration of an approach to stabilize farmer income through resource sustainability.
- Development of agricultural supply-chain decision support tools for crop selection, contract farming, agro-processing, and marketing that leads to water savings and higher incomes.

Project outreach and extension work: To increase adoption of various water/energy saving measures by the farmers in the study area, Columbia Water Center has undertaken an extensive outreach campaign (See Figure 1). Activities include:

- Organizing farmer level interactive meetings and workshops to create awareness.
- Preparation of crop specific information material (such as brochures, pamphlets, posters) on water energy savings techniques.

Figure 1: Training workshops with farmers and information booklets





The Centre works closely with the Government of Gujarat, particularly with the Department of Energy and Petrochemicals and Uttar Gujarat Vij Company Ltd. (UGVCL) along with its academic partner, Sadarkrushinagar Dantiwada Agricultural University.

Impacts

The project has helped achieve the following impacts in the short span of its operation:

- Development of new systems to stabilize, increase and improve income, livelihood opportunities, and water availability to farmers in Gujarat.
- Simultaneously improved reliability of water and electricity supplies to hundreds of poor farmers, reduction in electrical utility costs, increased revenue and reduced groundwater consumption.
- More efficient agricultural water use through crop diversification and other innovations enabled by improved partnerships between corporations, government, and farmers.

This project is carried out in partnership with the PepsiCo Foundation as part of the 'Improving Rural Water and Livelihood Outcomes' initiative, which addresses water scarcity and income generation in Brazil, India, Mali and China.

Case Study 6: Jain Irrigation Systems Ltd.

Region: Across India

Intervention type: Public awareness through demonstration farms, contract farming

Genesis

Of the total 142 million hectares of cultivated land in India, only 60 million hectares is under irrigation cover while the remaining 82 million ha is still rain fed. Dependence on monsoons not only puts Indian agriculture in an unfavorable light but is also an unscientific production practice that yields in sub-optimal results. Among other things, irrigation is one of the most crucial factors that if done efficiently would greatly enhance the productivity of crops.

The Model

Jain Irrigation Company established Jain High-tech Agriculture Training Institute, (JHAI) for imparting practical training for farmers, students, Government department officers and NGO's from India and overseas on topics ranging from management of watershed, wasteland, water resources and irrigation, fertigation and modern methods of crop cultivation. The Institute also has a research laboratory with latest facilities for research in microbiology, molecular biology, and gene transfer etc.

Besides JHAI, the company also has team of experts, predominantly in engineering and agronomy that spread awareness in various parts of the country. Through these experts, the company maintains contact with and provides crop-growing methodology to their user farmers. During the past few years, Central government of India and several state governments started providing price subsidy assistance to farmers shifting to drip irrigation.

Impacts

India currently has 1.7 million hectares of land under drip irrigation, of which nearly 65% is done via drip lines installed by Jain Irrigation. The grapes in Nasik, Bananas in Jalgaon, Pomegranate in Sholapur, Maharashtra are almost 100 per cent drip irrigated crops. Similarly, Sugarcane in Tamil Nadu, Citrus in Andhra Pradesh, Vegetables in Andhra Pradesh and Tamil Nadu are slowly moving into full drip irrigation cover. Jain Irrigation technologies are also slowly propagating to Northern and North-eastern States of India.

Case Study 7: Monsanto India

Region: Across India

Intervention type: Implementation of drip irrigation in Monsanto hybrid seed production and R&D seed breeding farms.

Genesis

Monsanto hybrid seed production and R&D Seed breeding farms primarily comprised of conventional watering / irrigation system. The conventional irrigation system is also known as a "flow-through" system, because water is usually supplied in a series from the top most to the bottom most basin and is regulated by weirs or sand bunds. These involve pumping of water from the open dug wells or bore wells (tube wells) on to the open land for natural gradient flow. With conventional irrigating systems, water may be lost through surface runoffs, low system uniformity and high rate of evaporation or wasted on non-growth areas. Further, conventional irrigation is energy intensive.

The Model

With a view to control water consumption, Monsanto introduced drip irrigation, a micro irrigation (MI) method.



Drip irrigation is a method of applying slow, steady, and precise amounts of water and nutrients to specific areas of crop, trees, vines, ground covers, potted plants, or shrubs. In drip irrigation, unlike conventional watering system, the required quantity of water is supplied at required intervals using a network of pipes, emitters and nozzles.

At a slow application rate, water seeps into the soil and moves laterally by capillary action beneath the soil's surface. An adequate section of the root zone of the plant is maintained with moisture close to soil capacity, providing a soil-to-water-to-plant relationship which is conductive to better plant growth. Thus, smaller quantities of water are used to the utmost efficiency. Drip irrigation application uniformity is very high, usually over 90 per cent.

Drip irrigation system is controlled manually or by the use of an automatic timer, and is also used to apply fertilizers directly to the roots of plants (if required). Further, as drip irrigation is along the root zone of the plant the time required for operating the pump is much lesser as compared to the conventional irrigating system; thus gaining the positivity of energy efficiency. On an average conventional irrigating systems are operated 7 hours a day versus the drip irrigation operational time of approximately 1 hour. This is very important considering the fact that in rural India, the reliability of electricity supply is very poor with intermittent supply.

This has resulted in tremendous reduction in water consumption at Monsanto R&D seed breeding sites including:

- Reduction in conveyance and distribution losses;
- Enhanced plant growth and yield;
- Most suitable to poor soils;
- Control of weeds;
- Economy in cultural practices and easy operations;
- Possibility of using saline water;
- Improves efficiency of fertilizer;
- Flexibility in operation;
- No land preparation; and
- Minimum diseases and pest problems.

Community engagements: Several local farmers near Monsanto hybrid seed production farms and R&D breeding stations have adapted to drip irrigation on observing the impact of the Monsanto India program. The local farmers who have installed drip irrigation in their agricultural lands and are enjoying improved income by increasing crop yield and quality at the same time improving agricultural input efficiency like water, energy, labor and fertilizers.

Impacts

Yield increase - Drip irrigation helps in saving space in the field by avoiding open channels and as a result allowing for available cultivation area to be increased by an average of 15-20 per cent. Thus it helps in increased crop yield per acre also besides conservation of energy and water.

Quality assurance - Improved quality (by improving the plant vigor) by delivering water and nutrients directly to the plant roots and avoiding unnecessary wetting of plant leaves.

Water use efficiency - Monsanto has installed drip irrigation systems in 2,285 acres of agricultural land including corn, cotton and vegetables hybrid seed production farms and breeding stations. This has resulted in approximate reduction in water consumption of 84 per cent [reduced water consumption from 4,978,285 KLD (m^3/day) to 817,029 KLD (m^3/day)].

Case Study 8: Mahyco Monsanto Biotech India Limited (MMB India)

Region: Across India

Intervention type: Implementation of drip irrigation in Monsanto hybrid seed production and R&D seed breeding farms

Genesis

By adoption of Bollgard and Bollgard II Bt insect protected cotton technologies, farmers have realized higher yield and reduced spray for bollworm control. To address the impact of technology on water utilization and water use efficiency, if any, studies were conducted in State Agricultural Universities.



The Model

MMB India sponsored research studies at three State Agricultural universities namely, Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu; University of Agricultural Sciences (UAS), Dharwad, Karnataka; Navsari Agricultural University, (NAU) Navsari, Gujarat - to evaluate the water requirement and water use efficiency of Bollgard II Bt cotton hybrid seeds in comparison with conventional cotton hybrid in relation to Seed Cotton Yield.

Impacts

Yield Increase:

- **NAU, Gujarat:** 65 per cent higher increased yield in Bollgard II when compared to conventional cotton.
- **TNAU, Tamil Nadu:** Bt cotton gave 25 per cent higher yield compared to conventional cotton at given standards of irrigation and fertilizer application
- **UAS, Karnataka:** Higher yield in Bollgard II when compared to conventional cotton

Water use efficiency

- **NAU, Gujarat:** Higher water use efficiency (1.128 kg/ha-mm) in Bollgard II when compared to conventional cotton (0.683 kg/ha-mm)
- **TNAU, Tamil Nadu:** Water use efficiency in Bt cotton was higher (4.87 kg/ha-mm) when compared to non Bt cotton (3.82 kg/ha-mm) when compared with similar levels of irrigation and fertilization
- **UAS, Karnataka:** Higher water use efficiency recorded in Bollgard II when compared to conventional cotton

FICCI Water Mission

Access to safe water is one of the essential elements for sustainable development and poverty reduction. However, the past few decades has seen an increase in demand amongst various water using sectors putting enormous stress on the natural resource.

FICCI constituted a 'Water Mission' to promote and provide thought leadership in the area of water efficiency. It aims to facilitate the sharing and dissemination of best practices across industry sectors in order to encourage corporate and industry players to imbibe a culture of water conservation within their organizations.

The Mission is working to create awareness on the existing situation pertaining to water scarcity, quality and generate a discourse on sustainable use of water amongst various users. With growing and extensive depletion and pollution of our water resources, our current work is being restructured to bring this issue back in focus to provide a sense of urgency to the debate of water management.

The objectives of the Mission's work are:

- To formulate suggestions for changes in policy framework in India for better water resource allocation, conservation and management;
- To promote fresh water conservation strategies across the irrigation, industry and domestic sectors;
- To document and disseminate best practices across various sectors and create a forum to facilitate exchange of information and experiences in the country;
- To promote new innovative technologies of water saving and management like rainwater harvesting, watershed management, desalination, water auditing and accounting across water intensive sectors through projects, workshops, conferences and training programmes.

Queries to FICCI may be directed to: ----------

Mr. Romit Sen
Senior Assistant Director
FICCI Water Mission

Federation of Indian Chambers of Commerce and Industry
Federation House, Tansen Marg
New Delhi - 110001
Ph: +91-11-23738252
Fax: +91-11-23765333
Email: romit.sen@ficci.com