Final Report

An Analysis of Resource Conservation Technology: A Case of Micro-Irrigation System (Drip Irrigation)

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Foreword

It gives me great pleasure to present to you an important work of the Centre for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad (IIMA). The Centre has been actively engaged in research on management of the agriculture, food, agribusiness and rural sectors of the Indian economy since its inception in 1971. The Centre also regularly undertakes research studies for the Ministry of Agriculture as well as other agencies, on policy and institutional issues related to the development, technology, resources, inputs, production, procurement, processing, and marketing in the sectors.

This book explores the experiences in adoption of drip irrigation and the impact of the technology on the conservation of the water resource and benefits to farmers. This book is a departure from the usual supply-side perspective which is often presented, and provides a demand-side perspective. It seeks to overcome the limitations of irrigation engineering oriented research which does not take into account the need, aspiration and experience of the users. It combines and compares the observations across four states of India, in two different zones, and covers pockets with varied cropping. The book shows that farmers are motivated to adopt drip irrigation primarily to cope with the scarcity in at least one of three factors of production, namely water, power and labour. They also adopt the technology in pursuit of a rapid growth in incomes which can be achieved through it. Drip irrigation appears to give very good results on each of these counts, and therefore it is seen as a very useful technology by the farmers.

Drip irrigation reduces the water need per unit of land resulting in and gives a significant saving of water. The survey results show that farmers use the 'saved' water for a variety of purposes including cultivation of new crops, giving more irrigation to other existing crops, expanding the area under cultivation / irrigation, and also non-agricultural use. Though rare, some farmers also do sharing and / or selling of water. The study clearly establishes the benefit of the technology for conservation of water and extending its use.

The book explores the adoption process beyond technology use to mastering the management of drip-irrigated agriculture and roles of stakeholders in this. The book shows that the adoption is based on a process extending from hearing about the technology, to acquiring knowledge of drip irrigation and implementing. The phases include the steps of purchasing the equipment, installation, getting subsidy approval & disbursement (which are very important given the high cost), and obtaining aftersales, technical and agronomic services. This post-adoption phase is important in getting the maximum benefit from the system. While the initial phases are substantially influenced by friends, family and local networks, the subsequent phase is dominated by the actions of drip dealer / company salespersons, and the final phase is determined by others such as the drip after-sales service staff and NGOs. The book also establishes that subsidy related experiences vary across farmers and there are major concerns of equity and equality in subsidy allocation and procedures on the ground.

The findings show the positive impact of drip irrigation on soil quality, and on improving the capacity of agriculture to cope with power, labour and water scarcity. Findings indicate for a wealth maximizing impact on various kinds of farmers, it is very important to provide support to the farmers after the sales. The book presents suggestions / policy recommendations on bringing the best benefits of drip irrigation to the farmers and providing an environment friendly technology. These include promotion of clusters within a district, partnering with

various stakeholders across different phases and objectives of drip irrigation adoption. We hope the book will be found useful by researchers, policy makers, planners and practitioners.

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AIBP –Accelerated Irrigation Benefit Programme
AP – Andhra Pradesh
APMC – Agricultural Produce and Marketing Committee
APMIC – Andhra Pradesh Micro Irrigation Corporation
APMIP – Andhra Pradesh Micro Irrigation Project
BCM – billion cubic metres
CICR – Central Institute for Cotton Research
DAP – District Agricultural Plan
DAP – Diammonium Phosphate
DCPC – Department of Chemicals and Petrochemicals
DI – Drip Irrigation
DoA – Department of Agriculture
DoH – Department of Horticulture
ECM – Executive Committee on Micro Irrigation
ET – Evapotranspiration
FAO – Food and Agricultural Organization
GGRCL – Gujarat Green Revolution Company Limited
GoI – Government of India
GNFC – Gujarat Narmada Valley Fertilizers and Chemicals Limited
GSWMA – Gujarat State Watershed Management Agency
HDPE – High Density Poly Ethylene
HMNH – Horticulture Mission for North Eastern and Himalayan States
ICAR – Indian Council for Agricultural Research
ICID – International Commission on Irrigation and Drainage
IDE – International Development Enterprises
IFFCO – Indian Farmers Fertilizer Cooperative Limited
INCID – Indian National Committee on Irrigation and Drainage
IPC – Irrigation Potential Created
IPCL – Indian Petrochemicals Corporation Limited
IPU – Irrigation Potential Utilized
ISOPOM – Integrated Scheme of Oil – seeds, Pulses, Oil – Palm and Maize
IWMI – International Water Management Institute
KRIBHCO – Krishak Bharti Cooperative Limited
LDPE – Low Density Poly Ethylene

LLDPE – Low Linear Density Poly Ethylene

MI – Micro Irrigation

MoA – Ministry of Agriculture

NABARD – National Bank for Agriculture and Rural Development

NABCONS – NABARD Consultancy Services

NADP – National Agriculture Development Plan

NCPA – National Committee on use of Plastics in Agriculture

NCPAH – National Committee on Plasticulture Applications in Horticulture

NDC – National Development Council

NER – North Eastern Region

NGO – Non Governmental Organization

NHM – National Horticulture Mission

NMMI – National Mission on Micro Irrigation

OBC – Other Backward Classes

OHDS – Orissa Horticultural Development Society

PFDC – Precision Farming Development Centres

PDC – Plasticulture Development Centres / Product Development Centres

RIDF – Rural Infrastructure Development Fund

RKVY – Rashtriya Krishi Vikas Yojana

SAP – State Agricultural Plan

SC – Scheduled Castes

SIMI – Smallholder Irrigation market Initiative

ST – Scheduled Tribes

SPC – State Planning Commission

TM – Technology Mission

TN – Tamil Nadu

TNAU – Tamil Nadu Agricultural University

TANHODA – Tamil Nadu Horticulture Development Agency

UNEP – United Nations Environment Program

USA – United States of America

USSR – Union of Soviet Socialist Republics

WWDR – World Water Development Report

Chapter 1

Introduction

1.1 Introduction

There is a global crisis about water and its management. The crisis is significantly about availability of water for use and its highly uneven spatial distribution. Enhancing water availability, making it amenable for use and managing the distribution are challenges of a tall order due to the dynamic nature of the resource and its varied usage.

The situation of water availability has changed drastically over the last 4-5 decades. Measures to increase water supply such as completion of storage dams, interlinking of rivers, desalination of sea-water and artificial recharge of groundwater and rainwater harvesting are costly and long term steps (Sipes, 2010). The marginal gains from traditional, civil and engineering oriented solutions have increasingly become costlier and more difficult to achieve.

Agriculture accounts for a majority of global freshwater withdrawals and almost all in some fast-growing economies (WWDR, 2012). At the global level more than two thirds of the blue water withdrawals are for irrigation. Irrigated agriculture represents almost a fifth of the total cultivated land but contributes more than one third of the total food produced worldwide (FAO, 2012) and therefore it is of critical importance to sustenance of the human race.

The last 20-40 years have witnessed massive increases in groundwater irrigation in arid regions and areas that have extended dry seasons and/or regular droughts. As a result of this the demand for ground water has been rising all over the world and India is no exception. In India the area irrigated with groundwater has increased 500% since 1960. As of 2009, annual ground water withdrawal for irrigation has been estimated as 221 billion cubic metres (BCM).

The overall irrigation efficiency in India is often found to be quite low compared to global standards due to the use of conventional flood irrigation technique, practiced in large parts of India.

Micro – irrigation (MI) techniques, including drip and sprinkler irrigation, were introduced as water saving technologies (Narayanamoorthy, 2003). They were expected to make a contribution to conservation of the water resource in India. (Phansalkar and Verma, 2008). A

minimalist expectation was to save water out of the quantum used in Irrigation and it was expected to promote sustainable water use (INCID, 1994 and Narayanamoorthy, 2001).

Micro-Irrigation has made its mark as an agri-input that enhances productivity and enables cash crop and in some cases export oriented cultivation using very little water by enabling better nutrient management. Various field experiments have shown this technique to increase farm level water use efficiency up to 80 - 90% depending on the crop and soil type (INCID, 1994; Sivanappan, 1994)

Drip Irrigation is one of the most efficient methods of irrigation (Keller and Blisner, 1990). It is viewed as a promising technology for its ability to support farmers in raising incomes and reducing poverty (IWMI Water Policy Briefing, 2006). A number of benefits have been ascribed to the use of micro-irrigation. In addition to saving of water these include increased yield and productivity of certain crops (especially spaced crops), labour cost savings, electricity savings, lesser pumping hours and hence easier irrigation, better crop growth and also better soil health. Strong evidence exists claiming economic benefits from the adoption of micro-irrigation. However there exists little or sparse evidence of socio-economic benefits from the adoption of micro-irrigation. There are mentions of positive nutritional impact on adopting households as well but these are few and far apart.

In spite of these advantages, the spread of micro – irrigation has been restricted to only a few pockets across India. The government has launched various schemes to promote micro – irrigation in the country. It set up the National Committee on use of Plastics in Agriculture (NCPA) which took up various schemes for the promotion of use of plastics, and in particular micro – irrigation systems. In agriculture, NABARD has been financing micro – irrigation systems since 1985.Maharashtra was the first state to introduce subsidies in 1986 – 87. Subsidies ever since have been a regular and dominant phenomenon in the efforts to spread the use of drip irrigation.

There is a new debate concerning the impact of micro-irrigation systems at various levels of water use for consideration of ’water-saving” and also on the status of the resource (water resource) itself from the basin perspective (Phansalkar and Verma, 2008).

Molle and Tural (2004) argue that ‘water-saving’ is notional and point out that while a farmer may save water for growing a given crop on a given plot in a given season however it may not necessarily result in water savings even at the farm level as the farmer is likely to use the ‘saved’ water in a nearby plot to grow another crop. As a result there might be increase in crop output but no net water saving may result.

There may also be a case wherein a farmer may save water on his farm but other famers draw out and use water from the aquifer resulting in no savings. Some researchers and practitioners therefore believe that the commercialization of agriculture and increasing area under irrigation and / or intensifying agriculture with the aid of micro-irrigation might lead to unsustainability of agriculture in the long run enabling use of even the marginal water quantities and sources rather than their conservation. Such complicated issues are resulting in a debate on the impact of micro-irrigation on agriculture and water resources.

Understanding the impact of adoption of micro-irrigation is crucial for different states of India like Gujarat, Andhra Pradesh and Rajasthan giving a massive push to promote micro-irrigation for water resource conservation. The Andhra Pradesh Micro-Irrigation Project (APMIP) claims to have brought 1.66 lakh ha. area under micro-irrigation during 2.5 years (Punetha and Reddy, 2006). At the same time there are pockets like Jalgaon and Nashik in Maharashtra, Narsinghpur and Maikaal in Madhya Pradesh where the market forces are leading to high adoption rates. In some pockets high adoption rates are observed even in the absence of government subsidies. (IWMI 2006)

There is a need to understand the impact of micro-irrigation technology vis-a-vis resource conservation and other claimed benefits.

1.2 Review of Literature

1.2.1 The Global Water Management Crisis and Micro-Irrigation

According to the UN estimates, the aggregate volume of water on earth is approximately 1400 M-km^3. The volume of freshwater resources is a trivial ~35 M-km^3, or about 2.5 percent of the total volume. Of these freshwater resources, about M-km^3 or 70 percent is in the form of ice and permanent snow cover in mountainous, the Antarctic and Arctic regions. Another 22.6 per cent is present as ground water. The rest is available in lakes, rivers, atmosphere, moisture, soil and vegetation. Groundwater (shallow and deep groundwater basins up to 2 000 metres, soil moisture, swamp water and permafrost) constitutes about 97 percent of all the freshwater potentially available for human use. (UNEP, 2012).

The crisis of water management arises because most of the water is not available for use and is characterized by highly uneven spatial distribution. Accordingly, the importance of water has been recognised and greater emphasis is being laid on its economic use and better management. The utilisation of water for most of the users i.e. human, animal or plant involves movement of water. The water resources have two facets. The dynamic resource,

measured as flow is more relevant for most of developmental needs. The static or fixed nature of the reserve, involving the quantity of water, the length of area of the water bodies is also relevant for some activities like pisciculture, navigation etc. (Ministry of Water Resources, GoI, 2013).

Asia and North & Central America have the biggest masses of arable land at 32% and 21% respectively of the total land mass on earth. Asia has only 21% of the geographical area on earth (excluding erstwhile countries of USSR). The irrigated area was only 18.5% of arable land in 1984 and is still a little over one fifth of the arable land. In 1994, 64% of the global irrigated area was in Asia up from 63% in 1989. This represents a huge in equality in availability of arable land and demand for irrigation water.

37 per cent of arable land of Asia was irrigated in 1994. Among Asian countries, India has the largest arable landmass close to 39 per cent of Asia's total. Only United States of America has more arable land than India (Source: WWDR, 2012). Irrigated agriculture represents 20% of the total cultivated land but contributes ~40% of the total food produced worldwide (Source: FAO, 2012). Water for irrigation and food production constitutes one of the greatest pressures on freshwater resources. Agriculture accounts for up to 90 percent in some fast-growing economies (Source: WWDR, 2012). Future global agricultural water consumption (including both rainfed and irrigated agriculture) is expected to increase by 19 percent (8,515 km^3 per year) by 2050 (Source: WWDR, 2012). If water is not managed properly then this could manifest a holocaust.

The critical status of Ground Water Resources all over the world and especially in the arid and semi – arid regions has been analysed by some experts (See Wallace and Batchelor, 1997; Shah et. al, 2000; Florke and Eisner, 2011). Groundwater is one of the primary resources used by industries for production, households for domestic purposes and farmers for irrigation. The domestic and industrial usage of groundwater has increased manifold and irrigated agriculture is increasingly important to sustain the food requirements of a growing population the world over. The groundwater irrigated agriculture boom has also brought major socioeconomic benefits to many rural communities in Asia, Middle East & North Africa and Latin America – with numerous economies dependent on groundwater (GW-MATE, 2010). Globally, the area equipped for irrigation is currently about 301 million ha of which 38% are equipped for irrigation with groundwater. Total consumptive groundwater use for irrigation is estimated as 545 km^3/yr, or 43% of the total consumptive irrigation water use of 1277 km^3/yr. The countries with the largest extent of areas equipped for irrigation with groundwater are India (39 million ha), China (19 million ha) and the USA (17 million ha). (D¨oll, 2009; FAO, 2010; Shiklomanov et al., 2000).

Table 1.1: Sectorial water requirements in India (in billion cubic metres)

Water Requirements for Different Uses in India (BCM) (1997-1998, 2010, 2025 and 2050)										
Uses	**Year 1997-98**	**Year - 2010**			**Year - 2025**			**Year - 2050**		
		Low	**High**	**%**	**Low**	**High**	**%**	**Low**	**High**	**%**
Surface Water :										
Irrigation	318	330	339	48	325	366	43	375	463	39
Domestic	17	23	24	3	30	36	5	48	65	6
Industries	21	26	26	4	47	47	6	57	57	5
Power	7	14	15	2	25	26	3	50	56	5
Inland Navigation		7	7	1	10	10	1	15	15	1
Flood Control		-	-	0	-	-	0	-	-	0
Environment (1)Afforestation		-	-	0	-	-	0	-	-	0
Environment (2)Ecology		5	5	1	10	10	1	20	20	2
Evaporation Losses	36	42	42	6	50	50	6	76	76	6
Total :	**399**	**447**	**458**	**65**	**497**	**545**	**65**	**641**	**752**	**64**
Ground Water :										
Irrigation	206	213	218	31	236	245	29	253	344	29
Domestic & Municipal	13	19	19	2	25	26	3	42	46	4
Industries	9	11	11	1	20	20	2	24	24	2
Power	2	4	4	1	6	7	1	13	14	1
Total :	**230**	**247**	**252**	**35**	**287**	**298**	**35**	**332**	**428**	**36**
Total Water Use :										
Irrigation	524	543	557	78	561	611	72	628	817	68
Domestic	30	42	43	6	55	62	7	90	111	9
Industries	30	37	37	5	67	67	8	81	81	7
Power	9	18	19	3	31	33	4	63	70	6
Inland Navigation	0	7	7	1	10	10	1	15	15	1
Flood Control	0	0	0	0	0	0	0	0	0	0
Environment (1)Afforestation	0	0	0	0	0	0	0	0	0	0
Environment (2)Ecology	0	5	5	1	10	10	1	20	20	2
Evaporation Losses	36	42	42	6	50	50	6	76	76	7
Total :	**629**	**694**	**710**	**100**	**784**	**843**	**100**	**973**	**1180**	**100**

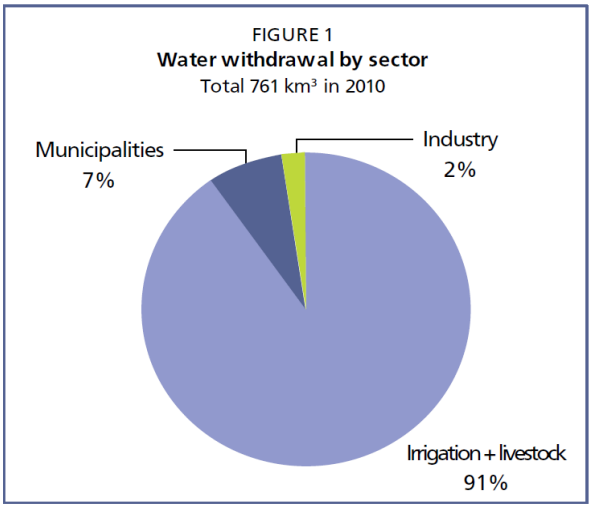
(Source: Central Water Commission)

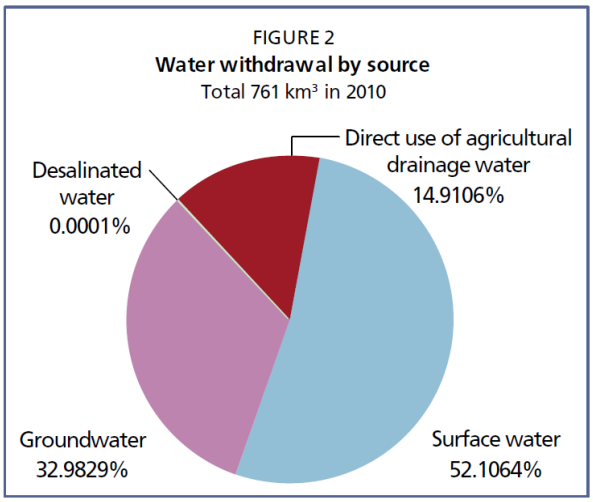
1.2.2 Water Management and Irrigation in India

Agriculture, Domestic households, industries, and thermal power production are the major consumers of water in India (see Table 1.1). A sub – committee constituted by the Ministry of

Water Resources in the year 2000 had different number and observed that demand for water is projected to rise to 1093 billion cubic metres (BCM) by 2025 and 1447 BCM by 2050. With the given constraint of total utilisable water resources of 1123 BCM [Report for National Mission for Sustainable Habitat, 2010], is evident that steps are needed to improve irrigation and urban water use efficiency. This needs to be stressed further as measures to increase water supply such as completion of storage dams, interlinking of rivers etc. are costly and need long durations for results to show(Sipes, 2010).

Another estimate given in figure 1 shows that 91% of the water withdrawal in the country in 2010 is for irrigation and livestock purposes. This is a gloomier picture compared to CWC estimates given in table 1.1.





Source: AquaStat Country Profile - India, 2013)

Analysing water withdrawal by sources it is observed that one third of the water withdrawal in the country was from groundwater sources as shown in Figure 2. This is a cause for alarm as deep groundwater if exploited from a greater depth cannot be recharged by rainfall and therefore cannot be called a renewable resource unlike most surface water flows.

Today, groundwater supports approximately 60 percent of irrigated agriculture and more than 80 percent of rural and urban water supplies in India (World Bank 2010). The share of ground water as a source of irrigation potential created has increased significantly during the last 50 years. As per ground water resource assessment carried out jointly by Central Ground Water Board and State Ground Water Organizations, in 2009, annual ground water withdrawal for irrigation has been estimated as 221 billion cubic meters (bcm) while that for domestic and industrial uses as 22bcm. (Table 1.2)

State wise details of ground water extraction are given in table 1.2. It clearly shows Uttar Pradesh, Punjab, Madhya Pradesh, Maharashtra, Tamil Nadu, Rajasthan, Andhra Pradesh, Gujarat, and Haryana are the major groundwater extractors for irrigation. The water withdrawal for industrial and domestic uses is highest in Uttar Pradesh but is still only a fraction of withdrawal for agriculture in most agriculturally important states.

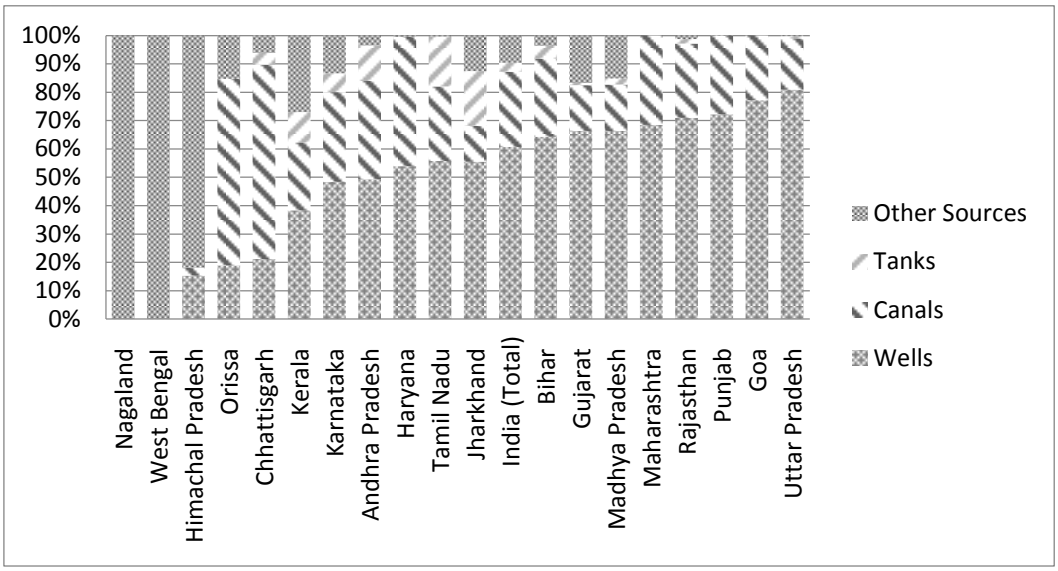
Table 1.2: State wise water withdrawals for various purposes in India (bcm/yr.) (2009)

Sr. No.	States/Union Territories	Annual Ground Water withdrawal (bcm/yr)		
		Irrigation	Domestic / industrial uses	Total
	States			
1	Andhra Pradesh	12.61	1.54	14.15
2	Arunachal Pradesh	0.002	0.001	0.003
3	Assam	5.333	0.69	6.026
4	Bihar	9.79	1.56	11.36
5	Chhattisgarh	3.08	0.52	3.60
6	Delhi	0.14	0.26	0.40
7	Goa	0.014	0.030	0.044
8	Gujarat	11.93	1.05	12.99
9	Haryana	11.71	0.72	12.43
10	Himachal Pradesh	0.23	0.08	0.31
11	Jammu & Kashmir	0.15	0.58	0.73
12	Jharkhand	1.17	0.44	1.61
13	Karnataka	9.01	1.00	10.01
14	Kerala	1.30	1.50	2.81
15	Madhya Pradesh	16.66	1.33	17.99
16	Maharashtra	15.91	1.04	16.95
17	Manipur	0.0033	0.0007	0.0040
18	Meghalaya	0.0015	0.0002	0.0017
19	Mizoram	0.000	0.0004	0.0004
20	Nagaland	-	0.008	0.008
21	Orissa	3.47	0.89	4.36
22	Punjab	33.97	0.69	34.66
23	Rajasthan	12.86	1.65	14.52
24	Sikkim	0.003	0.007	0.010
25	Tamil Nadu	14.71	1.85	16.56
26	Tripura	0.09	0.07	0.16
27	Uttar Pradesh	46.00	3.49	49.48
28	Uttarakhand	1.01	0.03	1.05
29	West Bengal	10.11	0.79	10.91
30	Union Territories	0.13	0.05	0.18
Total States		**221.29**	**21.83**	**243.14**
Grand Total		**221.42**	**21.89**	**243.32**

(Source: http://pib.nic.in/newsite/erelease.aspx?relid=83055**)**

The Figure 3 shows the state wise variation of area under different sources of irrigation. Groundwater (wells and tube wells) supports up to 80% of agriculture in Uttar Pradesh. Other states that rely on groundwater to a large extent are Maharashtra, Rajasthan, Punjab and Goa. The national average for India is around 60%. Even a state such as Bihar is above the all-India average in terms of groundwater exploitation.

Figure 3: State-wise distribution of area under various sources of irrigation



(Source: Fertiliser Statistics 2009 - 10, FAI)

Though ground water is one of the most reliable sources of water and has its advantages like better productivity and yield over other sources [Effect of Groundwater on Other Water Sources], excessive draft has also created problems especially in the over exploited regions of Punjab, Haryana, Rajasthan and Gujarat. These problems include falling water tables, waste in the use of water particularly for irrigation, water logging and salinity, and inadequate access to safe drinking water and sanitation (Narain, 2000). As population grows, the pressure on ground water resources is only expected to increase. As agriculture utilizes most of our water resources it is imperative that we focus our efforts on implementing water saving technologies especially for irrigation.

1.2.3 Micro-Irrigation and its Promise

Loss of Water used by crops has two components to it – a part of it, called Evapotranspiration (ET), and is spent as evaporation losses from the soil and the crop. The other part includes all the losses resulting from the distribution of water to the land (Fereres and Soriano, 2006). Irrigation efficiency may be defined as the ratio of volumes of water required for consumptive use by the crop for its growth to the water delivered from the

source (Planning Commission, 2004). A basin wise study done at the Madras Institute of Development Studies estimated the overall irrigation efficiency in India to be 38% which is quite low by global standards. This is mainly because the efficiency of conventional flood irrigation technique, practiced in large parts of India, has been found to be low (35 – 40%) due to substantial conveyance and distribution losses (Narayanamoorthy 2007).

Micro – irrigation (MI) techniques, including drip and sprinkler irrigation, were introduced as water conserving technologies in India. In the drip irrigation technique, water is directly applied to the root zone of the crop in small quantities using a low pressure delivery system with a network of pipes with small emitters (or drippers) built in to them. This method helps retain the soil moisture at consistent levels as against the flood irrigation method where there is a huge variation in soil moisture levels. Various field experiments have shown this technique to increase water use efficiency up to 80 - 90% depending on the crop and soil type (INCID, 1994; Sivanappan, 1994).

The benefits of micro irrigation and drip irrigation are not restricted to water saving. Various researchers have established other benefits of the technology as listed below (See ICID 2006; Andal 2010; Mitra 2011; CICR 2011):

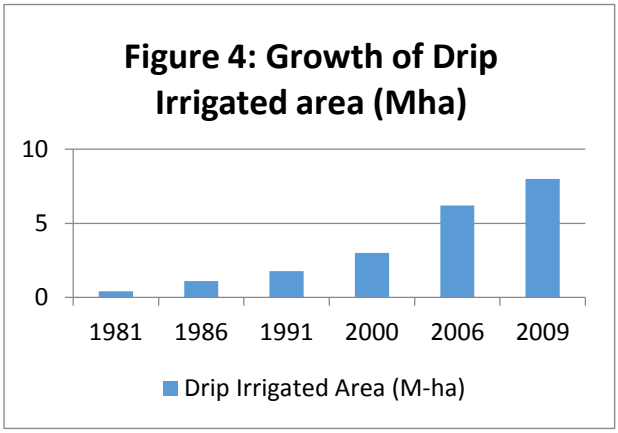
1. It increases the productivity and yields of crops due to better air: water ratio thus increasing farm incomes.
2. It reduces weed problems and soil erosion as the water is applied directly to the root zone in very small quantities. The technique also reduces atmospheric humidity which may reduce the occurrence of pests.
3. It also reduces problems of water logging, salinity and ground water pollution. The continuous application of water in small quantities helps keep the salt concentration below the harmful levels.
4. It reduces the cost of cultivation mainly due to savings in labour costs and energy savings. There is a reduction in labour costs due to reduced costs of weeding. The system reduces electricity costs as well because the same output can be obtained by using a low HP motor run for a short period of time every day. According to some estimates, the system can save electricity of 278 kWhr/ha for wide spaced orchard crops and 100 kWhr/ha for closely grown crops. [Raman 2009]
5. Better crop output quality. The continuous and uniform application of water across the field will improve the quality of produce.
6. Balanced use of nutrients and better fertilizer use efficiency (Narayanamoorthy, 2010). The use of water soluble fertilizers (WSF) is recommended with drip irrigation systems. These fertilizers are highly suitable for fertigation which ensures supply of

nutrients to the root zones, hence causing marginal or no loss of nutrients. The fertilizer use efficiency can be increased up to 95% using this system when compared to conventional methods of water application. (as per KRIBHCO)

7. It is well suited to all soil types and undulating terrains as the water flow rate can be controlled [INCID 1994]
8. It can lead to social empowerment especially for women in villages [IWMI 2006]

1.2.4 Development and Spread of Micro-Irrigation

Experiments with micro – irrigation technology were first conducted in Germany in the 1860s where water was pumped through clay pipes for irrigation. Research done by E.B. House at Colorado State University in 1913 concluded that the technology was too expensive to be used commercially and no further studies were done till the 1920s (CICR Report, 2011). Use of perforated pipes (Germany, 1920s) was one of the major breakthroughs in the industry. However, current micro – irrigation technology relates to the work of Symcha Blass of Israel in the 1930s.He accidentally discovered the concept when a farmer drew his attention to a large tree that showed a much more rigorous growth than other trees in the area because it received water from a leaking faucet nearby. Based on this observation, he developed the first patented drip irrigation system and subsequently took major steps in the development of his idea with the advent of cheap plastics in 1950s after the World War II. The availability of low cost plastic pipe for water delivery lines helped popularise the use of drip irrigation systems. From Israel the drip irrigation concept spread to Australia, North America and South Africa by the late 1960s and eventually throughout the world. The development of LDPE (Low density poly ethylene), HDPE (High density poly ethylene) and LLDPE (Low linear density poly ethylene) in 1977, suitable and economical material, resulted in the sudden growth of micro – irrigation industry.



The large scale use of drip irrigation system started in 1970s in Australia, Israel, Mexico, New Zealand, South Africa and USA to irrigate vegetables and orchards and its coverage was reported as 56,000 ha then (Kulkarni et al, 2006). Figure 4 gives the growth of area under drip irrigation from 0.41 Mha (1981) to about 8.0 Mha in 2009 (Kulkarni SA, et al. 2006).

In India, the use of drip irrigation started in 1970 with experiments in Tamil Nadu University in Coimbatore. Drip irrigation system was first installed at Patidar Farms in village Jodpur Madhya Pradesh) in 1971 and inaugurated by the then Deputy Chief Minister. The area under drip irrigation has increased from 1500 ha in 1985 to 70,859 ha in 1991-92 and further to 0.5 million ha in 2003 (INCID 1994; GOI 2004 as mentioned in Narayanamoorthy 2005). The most recent data collected by ICID shows that an area of 1.32 million ha (6.5% of total irrigated area) was under micro irrigation in 2008 which increased to 1.89 million ha (8.1% of total) in 2010. The spread of drip irrigation and its coverage with respect to the total area equipped for irrigation across various countries, as per latest available and comparable data, is given below in Table 1.3.

Table 1.3: Country wise coverage of drip and sprinkler irrigation (Mha in 2010)

Sr. No.	Country	Total area equipped for irrigation	Sprinkler Irrigation	Drip - Irrigation	Total Micro Irrigation	% of Total Irrigated Area	Year of Reporting
1	USA	24.7	12.3	1.64	13.99	56.6%	2009
2	India	60.9	3.04	1.90	4.94	8.1%	2010
3	China	59.3	2.93	1.67	4.60	7.8%	2009
4	Russia	4.5	3.50	0.02	3.52	78.2%	2008
5	Brazil	4.45	2.41	0.32	2.74	61.6%	2006
6	Spain	3.41	0.73	1.63	2.36	69.3%	2010
7	Italy	2.67	0.98	0.57	1.55	58.1%	2010
8	France	2.9	1.38	0.10	1.48	51.1%	2011
9	South Africa	1.67	0.92	0.36	1.28	77.0%	2007
10	Saudi Arabia	1.62	0.72	0.19	0.91	56.4%	2004
	Total	211.8918	35.07	10.08	45.15	21.3%	

(Source: Working Group on Farm Irrigation Systems, ICID)

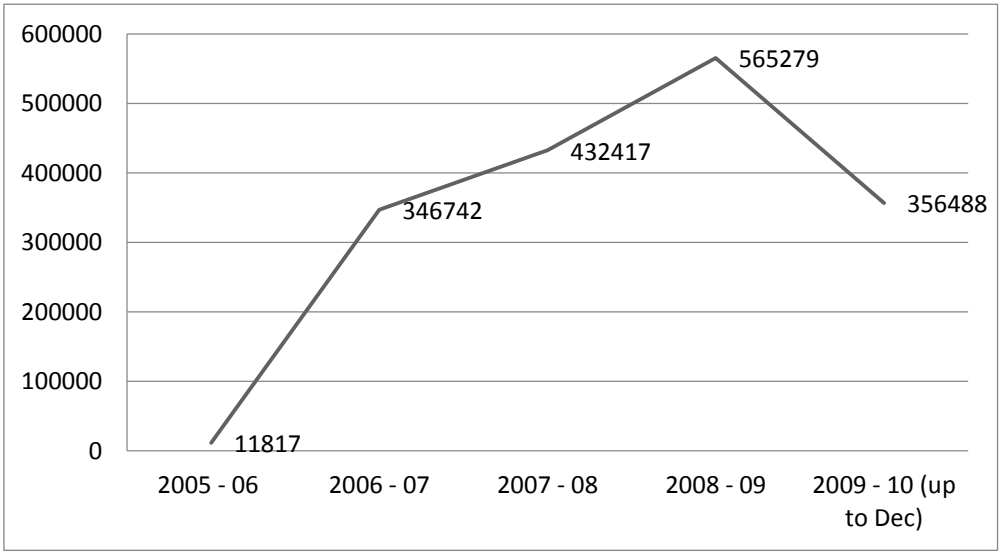
At present, United States (1.64 million ha), China (1.67 million ha) and Spain (1.63 million ha) are the other leading countries which have adopted drip irrigation (Table 1.3). Considering the world's total irrigated area as 212 million ha, only 4.75% of it currently comes under drip irrigation which shows the huge potential that still remains untapped.

In India, drip irrigation is practiced using different kinds of systems like the conventional drip systems, indigenous pot and bucket drips, subsurface drips, family drip kits and locally manufactured and assembled kits like Pepsee (Verma, 2004). Pepsee systems are low cost drip irrigation substitutes made up of low density polyethylene pipes which can easily be set up at about Rs. 4000 per acre for cotton which is almost one - fourth the cost of conventional

drip systems[1]. Such systems are not promoted by anyone apart from manufacturers. The growth (new area added in ha.) of Micro – irrigation in India over the years is shown in figure 4 below.

India, with a total arable area of 140 million ha with almost 42% of arable land irrigated, too has a huge potential for micro – irrigation which is still underutilized. However, actual calculations for potential area done under different studies show conflicting results. While the Task Force on Micro – Irrigation (2004) estimated a potential of 27 million ha for drip irrigation based on the area under crops most suitable for that form of irrigation, the Indian Committee on Irrigation and Drainage (INCID) estimates a potential of 10.5 million ha.

Figure 5: Growth of Micro-Irrigation in India over the years



(Source: NABCONS 2009)

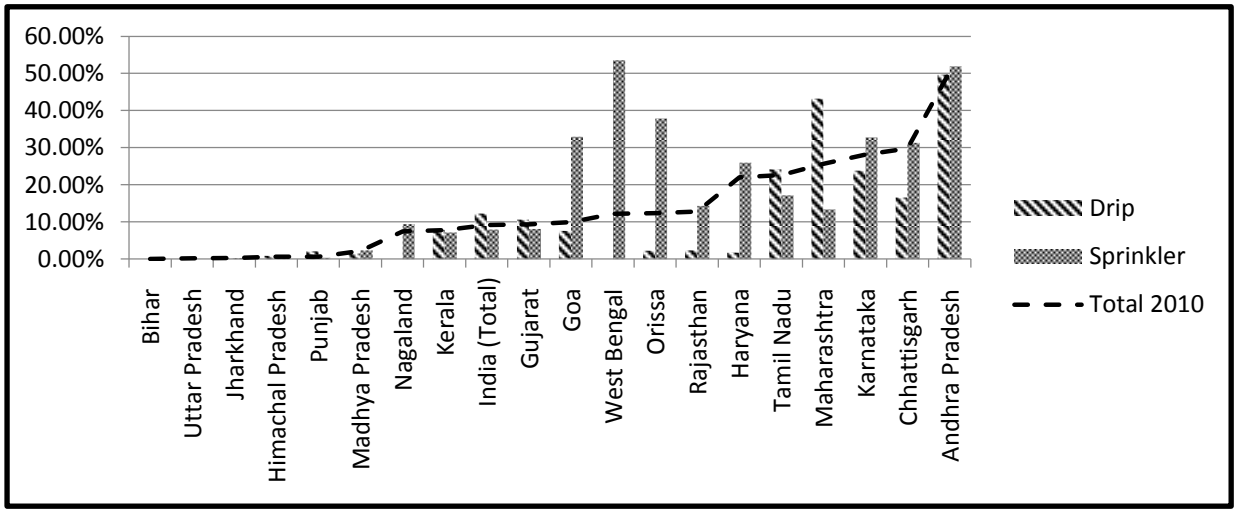
Yet another study by Narayanamoorthy (2005) estimated the potential based on the crops most suitable for drip irrigation and the area under irrigation and pegged the figure at 21.27 million ha (using land utilization data for 1994 – 95). Most recently, S. Raman (2012) has come up with a conservative estimation for the potential at 11.6 million ha. This estimation is based on the crops most suitable for drip irrigation like cotton, sugarcane, fruits and vegetables, spices and condiments, and some pulse crops. Also, area under canal irrigation has been excluded as the use of drip irrigation in canal irrigated areas is minimal. There are exceptions like Ozar though (Bhamoriya, 2014).Out of these figures, the figure presented by the Task Force on Micro – irrigation (27 million ha) is the most quoted across literature while the estimation by S. Raman may be a more practical estimate and is used in this report

[1]http://www.cseindia.org/dte-supplement/water20031115/rural.htm (8/5/2012)

ahead. The figure below shows the utilization of potential of drip and sprinkler systems across some states.

In India, Maharashtra (0.48 million ha), Andhra Pradesh (0.36 million ha) and Karnataka (0.17 million ha) account for more than 70% of the total area under drip irrigation. However, the total area covered under drip irrigation (1.42 million ha[2]) is still quite low as compared to the potential area of 11.6 million hectare [Raman 2010]. While Andhra Pradesh (50% of Potential) and Maharashtra (43% of Potential) have been able to bring substantial area under drip irrigation, other states lag far behind as shown in figure 5 below.

Figure 6: Actual area v/s Potential area for drip and sprinkler irrigation across states



(Source: Raman 2010)

The main factors responsible for the variation in spread as quoted widely in literature may be the type of crops grown, the soil types in the region, availability of water for irrigation and subsidies given by the state governments. Micro – irrigation is more suitable for widely spaced horticultural crops, plantation crops like bananas, orchard crops like orange, grapes, pomegranate, flowers, vegetables and some other crops like cotton, sugarcane etc. which are grown in large areas in Andhra Pradesh, Maharashtra and Gujarat. Also, flood irrigation may not be suitable in these areas as majority of the soils are black or black and red in mixture which create problem in irrigation due to development of deep and wide cracks on drying up after irrigation. Another reason may be the undulating topography of these soils which create hindrance in proper distribution of irrigation water through flood irrigation method. Besides these, irrigation water is also precious and limited due to poor recharge

[2] The figures for total area under drip irrigation in India also vary according to sources. ICID 2010 quotes a figure of 1.89 million ha while Raman 2010 quotes it as 1.42 million ha.

capacity of irrigation wells. Hence, micro (drip and sprinkler) irrigation may be best alternative for irrigation of crops in this region (Bhaskar et. al, 2011).

Maharashtra has been the leading state in granting subsidies for the use of micro – irrigation systems. Andhra Pradesh (APMIP), Gujarat (GGRCL), Tamil Nadu (TANHODA) and Karnataka have set up their own special purpose vehicles for promoting and monitoring the spread of micro – irrigation within the state. The following section provides an overview of the various government schemes introduced for promoting micro – irrigation in the country.

1.2.5 Water Productivity and Efficiency with Drip Irrigation and Basin Level Impacts

Surface irrigation is also known to incur heavy losses and one can frequently read that two thirds of the water diverted never reaches the plant (e.g. FAO 1998, WRI 1998). Irrigation water usage across the country is inefficient. As per figures released by the Union Government in 1999, it projected that irrigation efficiency would have to increase to 60 percent by 2050 to bring a balance in the demand and supply of water. A model of water demand and supply for 118 countries accounting for 93 percent of the world's population developed by the International Water Management Institute (IWMI), shows that a 50 percent increase in demand of water by 2025 can be met by increasing the effectiveness of irrigation.

Different researchers have used different methods to measure the effectiveness of a drip irrigation system. The methods basically seek to quantify the two main advantages of drip irrigation – water savings and productivity enhancement as compared to flood irrigation. Irrigation efficiency can be defined as the crop water requirement (actual evapotranspiration minus effective precipitation) divided by the water withdrawn or diverted from a specific surface – water or groundwater source (Palanisami and Ramesh 2007). Water Productivity usually refers to the crop yield per unit of water applied. It can be calculated by measuring the crop output (in terms of weight or in monetary terms) divided by the total water used (in m^3). Various studies on single crops grown using micro – irrigation on experimental fields confirm that it results in increased water use efficiency and water savings. In drip irrigation, water is applied in small quantities according to the evapotranspiration needs of the crops and seepage, evaporation and conveyance losses are reduced to a minimum. Notably, researchers have confirmed the water savings for a variety of the crops shown in Table 1.4.

Since the farm level situation is totally different from that of the experimental station (Verma 2004), one requires a detailed study using data from properly designed survey for making

any firm conclusion about its water use efficiency (Narayanamoorthy 2005). Thus, looking at the technology from a farmers' point of view may give us contradictory results.

Table 1.4: Water saving through drip method of irrigation - Experimental results

Crop's Name	Water Consumption (mm/ha)		Water Saving over FMI	Water consumed(mm) / Yield (quintals)	
	Flood	Drip	(%)	Flood	Drip
Ash gourd	840	740	12	77.49	61.51
Beet root	857	177	79	187.53	36.2
Sweet potato	631	252	61	148.82	42.78
Onion	602	451	25	64.73	36.97
Radish	464	108	77	441.9	90.76
Tomato	498	107	79	80.58	12.06
Chillies	1097	417	62	259.34	68.47
Cauliflower	389	255	34	46.67	22
Papaya	2285	734	68	175.77	31.91
Banana	1760	970	45	30.61	11.09
Grapes	532	278	48	20.15	8.55
pomegranate	1440	785	45	26.18	7.2
Sugarcane	2150	940	65	16.79	5.53
Cotton	856	302	60	329.23	92.64
Coconut	-	-	60	-	-
Groundnut	500	300	40	292.4	105.63

(Source: Narayanamoorthy, 2005)

An evaluation of the Centrally Sponsored Scheme on micro-irrigation found that while a farmer appreciated the water savings effect of drip irrigation, it wasn't a sufficient condition for adoption. Adoption was more due to management convenience, labour savings and amenability of farms to mechanization and shifting of crops to high value cash crops. (NCPAH, 2009). A farmer may not give priority to conserving water especially in areas where irrigation water is abundant. Moreover, determining the exact water requirement of each crop may be difficult and hence, farmers invariably end up giving more water than what is actually needed by the crop (Fereres and Soriano, 2006).

Further, there is a need to go beyond the field level to the basin level in order to understand if water savings at the field level really translate to savings at the basin level which may be a better indicator of the 'real' water savings or the wet water savings (Seckler, 1996). Apoorva Oza (India Infrastructure Report 2007) also highlights the issue by mentioning that investments in drip technologies can result in an estimated annual water savings of 2.2 million cubic metres of water in India. However, the report cautions that shifting from rainfed irrigation to drip irrigation may result in loss of water saving benefits because of a net expansion in irrigated area (India Infrastructure Report 2007). Micro – irrigation systems may

also promote an increase in cropping intensity or a shift to high value water intensive crops which in turn increases the pressure on ground water resources (IWMI 2006). Empirical studies highlighting this aspect of the technology may give us more insight into the complex nature of the problem.

Moreover, basin level studies on the wet water savings of the technology have come to the conclusion that increased subsidies may help in reducing water applied to farmlands but will increase the total water consumed due to increased yields, evapotranspiration from crops and acreage under drip irrigation [Frank A. Ward, 2008; Ahmad et al 2007].

The increased water use efficiency can allow an expansion in the area irrigated, increase in overall cropping intensity or to shift cropping patterns to high-value, water intensive crops. If the result is an increase in total water use, there could be conflict between the positive impact on poverty and food security and the sustainability of water resource use, especially groundwater.

Table 1.5: Comparison of the cropping patterns of Micro-Irrigation adopters and non-adopters

Crop	Gujarat		Maharashtra	
	Adopters (%)	Non-adopters (%)	Adopters (%)	Non-adopters (%)
Groundnut and other oil seeds	54.7	63.7	1.2	7.1
Cotton	20.1	6.7	31.1	48.8
Cereals	9.7	15.5	28.7	25.0
Fruit crops	7.6	10.3	25.0	3.6
Vegetables	6.0	2.9	4.8	4.8
Sugar cane	0.9	0.7	0.8	1.2
Pulses	0.3	0.0	8.2	9.6

(Source: IWMI RR 93)

According to Ray Huffaker, an economist at Washington State University, inefficient irrigation practices like flooding result in the excess water being soaked back into the ground to recharge underground aquifers. His model shows that though water saving techniques like drip irrigation can result in lesser water being applied, it can also affect the aquifer recharge cycle and hence, the environment suffers a net loss. (Huffaker, 2007). The existing literature clearly shows that efficiency at the field level may not always translate to efficiency at the basin level and hence, separate basin level studies are required to understand the effect of micro – irrigation on ground water resources in the region (Molden and Sakthivadivel, 1999).

Due to micro-irrigation adoption in the two study locations, Gujarat and Maharashtra there is a tendency towards the greening of farmlands year round resulting in more

evapotranspiration. In the same study, the category of women from the landless category was negatively affected due to the reduction of the labour requirement caused by the technology.

1.2.6 Issues with Drip Irrigation Adoption

In spite of these advantages, the spread of micro – irrigation has been restricted to only a few pockets across India. The main factors responsible for the limited spread of the technology have been documented by quite a few researchers. These factors are enlisted below:

1. High initial costs make the technology unfeasible for small and marginal farmers. Installation of a drip irrigation system requires an initial investment of up to Rs. 1,25,000 per hectare (as per rates set by Gujarat Green Revolution Company) depending upon the nature of crops (wide or narrow spaced) and the quality of material used for the system. Such a huge investment requires advance crop planning on the part of the farmers and an assured income for the produce which may be true only for high value crops.
2. High emitter clogging rates due to dust and salinity. The system requires proper filtration so that dust and other particles do not block the small emitter holes.
3. Unsuitable cropping patterns. Drip Irrigation has been used for irrigating only a few selected crops in India. It is adopted mostly for coconut (19% penetration), banana (11%), grapes (10%), mango (9.4%), citrus fruits (7.9%) and pomegranate (6.2%) [Task Force Report, 2004]. It may not be suitable for closely planted crops like cereal grains which are grown across large areas in the country.
4. It requires a lot of technical and management skills for setting up and upkeep. Lack of technical support and follow up by the government, private companies and NGOs may be a hindrance for adoption.
5. The process of applying and being approved for the subsidy however is complex and involves numerous agencies. As a result, farmers are dependent on manufacturers and middlemen to facilitate the process. (AgWater Solutions, 2012).
6. Only selected, pre-approved drip kits qualify for the subsidy which stifles creative marketing strategies on the part of manufacturers as well as efforts to bring down the cost of drip systems through innovative technology or product designs. (AgWater Solutions, 2012).
7. Mechanical damage by farm labour, birds and animals
8. Easy availability of irrigation water especially in northern parts of the country.

These factors have hindered the widespread use of this technology all over the country. Besides these, lack of demonstrability of the advantages at the field level may also be one of the reasons for the slow spread. Savings in energy may be particularly difficult to demonstrate. Free or nearly free power also takes away the incentive from power savings. Moreover, some studies have also shown the costs of cultivation to increase due to high cost of management, use of improved quality of seeds and increased fertilizer use to sustain increased yields. (See NABCONS, 2009 and Narayanamoorthy, 1997). High rates of subsidies provided by the state and central governments (50 to 70% in most cases) have ensured that the technology is available to small farmers to some extent. However, delays in disbursement of subsidies and revision of unit cost rates may still be hampering the spread of these systems (Palanisami et. al, 2011).

For many years there was at best a lukewarm response to initiatives and incentives promoting micro irrigation in India. At present there are many pockets in potential areas which have not adopted the technology despite several targeted programs and initiatives. The lukewarm response has been attributed to several causes including lack of access to groundwater, lack of cash, crop specificity and lack of know-how, poor product quality and absence of credit facilities (Narayanamoorthy 1996 and IWMI Policy briefing 23).

There are some technical issues reported as well. A disadvantage of drip irrigation as stated in literature is the accumulation of salt near the periphery of the wetted area especially in the salinity prone regions. This will be a concern if emitter placement is improper (Hanson and May, 2011). Drip irrigation also gives benefits in growth of crops but there are other factors which influence whether this advantage can be transformed into actual yield and economic advantage. (Myburgh, 2012)

Micro irrigation in general and drip irrigation specifically has often had to overcome the general conclusion from earlier experiences that costs outlay, even of small systems, is too high relative to the benefits and the little scientific irrigated agricultural technology is being applied in most irrigation schemes. (Dittoh et.al, 2010). These are often depended on external factors and macroeconomic trends.

Drip irrigation has been found to be promoted for reasons that do not match the farmers concerns. Farmers are in the search for short term solutions to problems and the short cut to prosperity whereas the government initiatives focus on drip and micro irrigation as long term investments aimed at water saving and sustainable agriculture with prosperity mentioned only as a by-product (IWMI Policy Briefing, 23).

Research has shown that there is a high variability in yield improvements and water savings from micro irrigation technologies as they are dependent on the crops grown and the type of irrigation system used (Sakthivadivel and Bhamoriya, 2004). The magnitude of land productivity advantage has often been found to be lower than that of water productivity but farmers rarely have to pay market rates for water or the electricity used to pump out the water from the source or for irrigating the fields, hence there is little incentive to improve on water productivity.

The availability of cheap labour and disguised unemployment also work to dampen the incentive for adoption of drip irrigation technology. Government extension systems at the same time have not been of much help to the cause of this technology either. A group of researchers has believed for a long time that a huge crevice exists between the policy and the farmers with respect to the adoption and use of drip irrigation technology (IWMI Policy Briefing 23).

The shift to micro-irrigation without the attendant measures is expected to compound the over exploitation of the aquifer (IWMI, 2009). The attendant measures have to be driven by policy and this usually where a policy paralysis exists as of now. The policy of providing subsidies may have only jeopardised the willingness to pay once the ability to pay exists for many farmers. Therefore many researchers find that the spread is driven by subsidies however there are many areas where even subsidies have not been able to spread the technology. The policy of allocating fixed but limited amounts for subsidy has limited the market size to the subsidy limit as well.

1.2.7 Present Status of Drip Irrigation Adoption

Micro-irrigation technologies are supported largely for one or more of the following profits: means of saving water in irrigated agriculture and averting the impending water crises (Narayanmoorthy, 2003; Polak et al., 1997, Shah and Keller 2002), as a strategy to increase income and reduce poverty among the rural poor; to enhance the food and nutritional security of rural households (Bilgi, 1999); and as means to extend the limited available water over a large cropped area (Palanisami et al., 2012). The financial paybacks have been proved in many studies. Puran *et al.,* (2010) have reported that the incremental increase in irrigated areas was about three-fold and the decline in labour use per hectare was by 78%. Also the economic returns to farmers' investments in micro-irrigation technologies are substantial (Dhawan, 2002). Financial resources and crop suitability are the stimulus for adoption of drip irrigation. Though a key argument is that membership in a high caste group,

poverty index and share of income from off-farm and non-farm activities, have a significant effect on the decision regarding the adoption of micro-irrigation technology (Namara, 2005).

Under these situations, it is highly required to analyse the issues, facts and constraints that are hindering the adoption and spread of micro-irrigation in different states which will give appropriate signals for the expansion of the MI in the country, wherein researchers, extension workers and policy makers could play a key role (Palanisami et al., 2012).

1.3 Literature Gaps and Areas of Interest

The review of literature and interaction with experts led to the recognition of several gaps in the existing research on micro irrigation and drip irrigation adoption and promotion. Most of the recent studies on the economics of adoption have been done about half a decade ago and are from a technical point of view and have failed to capture the adopters' viewpoint on the economics. Thus there is a need to include the perceptions of the adopters on the economics of adoption of drip irrigation into the studies.

Most of the studies deal with the actual results and fail to capture the perceptions of the users about adoption and experience of drip irrigation apart from economics. Some of these could be perceived ease of usage and ability to gain expertise about the technology and its application. The perception about the technology and its impact has often been compromised for the real and actual benefits derived post adoption. The perception will be more important from the pre-adoption consideration of whether to adopt or not. These aspects need to be included to get a better picture of the perceptions of usefulness of the technology. These are important to frame better policies and incentives to promote the technology.

The existing studies have mentioned about the adoption process but have not gone in depth about the adoption process and its various stages and are therefore are unable to evolve useful insights into the adoption process and managing it better to promote the technology and its impacts.

Similarly there is a dearth of literature that talks about the role of various actors in the adoption process and the usage of the drip technology needs to be explored further to come up with better insights to promote adoption.

Not enough studies have dealt with the various aspects associated with sales like after sales service and hassles of repairing the equipment. This often would impact the perception and experience of the technology of an adopter and what advice they would offer to a

prospective adopter. This is an important area that impacts the transaction cost of using the equipment and affects the cost-benefit streams and calculations.

Last but not the least the studies done so far have looked at drip irrigation, issues in adoption or performance and related issues in a limited geography only. Thus many of the findings are difficult to generalize. In order to be able to generalize the results and conclusions from studies geographical and crop specificity has to be lost and a broader study in terms of geography and crops is required.

While many studies have tried to show the farm level water savings from the technology there are some challenges to the argument in conditions of a larger geography than just a farm and also in case of increasing adoption rates in a limited area as well. Thus the impact of technology on resource conservation itself over a larger area than a farm and over increasing adoption rates is yet to be studied.

The impact of technology across crop, geography and irrigation specificity on agriculture as an overall is also often missing. To the farmer the adoption decision is at the agriculture domain level and not just the irrigation or water consumption level as has been clearly enunciated in literature.

1.4 Research Objectives

As there are certain pockets of high adoption across various geographies, the timing is right to study the impacts of higher adoption rates across various agro-climatic zones and social settings. This is a good opportunity to study the impacts of use of drip irrigation technology on resource conservation and sustainability of agriculture.

At scale with more adopters in a region it would also be possible to study the experience and perception of economics of agriculture in pockets of significant adoption. Extending this possibility a need was felt and also deemed possible to study the experience and perception of economics of irrigation to interconnect the considerations of economics and sustainability.

In the light of the arguments that the technology will be counterproductive for water conservation it is also of greater interest, to study the implications of popular adoption of drip irrigation on the sustainability of agriculture itself.

The research needs identified guide this study that seeks to study the impact of micro-irrigation in terms of water conservation, sustainability of agriculture and commercial agriculture including the economics of irrigation and agriculture.

The Research objectives are as follows:

a) To study the impact of micro irrigation on water resource availability, use and conservation from a water conservation approach

b) To study the impact of micro-irrigation on economics of agriculture in the regions of adoption under study

c) To study the economics of irrigation in the regions of micro-irrigation adoption by combining the water resource conservation and agriculture economics

d) To suggest probable implications of adoption of micro-irrigation on sustainability of agriculture

Chapter 2

Government Institutions, Schemes and Subsidies for Micro-Irrigation in India

2.1 History of Micro-Irrigation in India

The National Committee on use of Plastics in Agriculture (NCPA) was set up in 1981 under the Department of Chemicals and Petrochemicals (DCPC). The NCPA took up various schemes for the promotion of use of plastics, and in particular micro – irrigation systems, in agriculture. This was seen as the first major step taken by the government towards promoting drip irrigation in India. Realising the agriculture sector as the major consumer of plastics in India, the NCPA was transferred to the Ministry of Agriculture in 1993 and renamed as National Committee on Plasticulture Applications in Horticulture (NCPAH) in 2001-02. The NCPAH mandate includes to popularizing adoption of various plasticulture applications in horticulture. It provides guidance and reviews progress on the area covered under micro–irrigation. 17 PDCs (Plasticulture Development Centres) (renamed to Precision Farming Development Centres in 2003) were formed to promote precision farming & plasticulture applications for high-tech horticulture in the different agro-economic zones. They provide technical and research support for development of micro – irrigation.

NABARD has also been financing micro–irrigation systems since 1985. Rs. 385 crore was earmarked in 1985 – 86. This increased to Rs. 499.76 crore in 1989–90. However, actual disbursement was quite low (Rs. 49.85 lakhs for drip and Rs. 686.50 lakhs for sprinkler till 1988 – 89) as compared to the targets mainly because of lack of awareness and technical support for the farmers. [IPCL, 1992]

The government has launched various subsidy schemes to promote and stimulate the wider adoption of micro–irrigation (including drip irrigation) in the country in sixth, seventh and eight five year plans since 1980 (World Bank, 1998: 116-118). A central scheme was introduced in 1982 – 83 when all farmers were eligible for subsidy. The 7th Five year plan proposed an outlay of Rs 10 crore with subsidies of 25% for small farmers and 50% for SC/ ST farmers. The subsidy for small farmers was increased to 50% in the 8th Five Year Plan (IPCL, 1992).

In the table 2.1 the total IPC (Irrigated Potential Created) over all the periods shows a positive growth, but the trend line for total IPU (Irrigation Potential Utilized) over the years shows a negative growth till date.

Table 2.1: Plan-wise irrigation and potential created and utilised in India (1951-1956 to 2007-2012) (Unit: '000 Hectare)

Period	Major and Medium Irrigation Surface Water		Minor Irrigation						Total (Major, Medium and Minor Irrigation)	
			Surface Water		Ground Water		Surface and Ground Water			
	IPC	IPU	IPC	IPU	IPC	IPU	IPC	IPU	IPC	IPU
Pre-plan (upto 1951)	9705	9705	6401	6401	6500	6500	12901	12901	22606	22606
First Plan(1951-56)	2486	1280	29	29	1130	1130	1159	1159	3645	2439
Second Plan(1956-61)	2143	2067	24	24	647	647	671	671	2814	2738
Third Plan(1961-66)	2231	2123	26	26	2243	2243	2269	2269	4500	4392
Annual Plans(1966-69)	1530	1576	32	32	1988	1988	2020	2020	3550	3596
Fourth Plan (1969-74)	2608	1937	450	450	3930	3930	4380	4380	6988	6317
Fifth Plan(1974-78)	4014	2475	538	538	3362	3362	3900	3900	7914	6375
Annual Plans(1978-80)	1895	1482	500	500	2200	2200	2700	2700	4595	4182
Sixth Plan(1980-85)	1083	929	1698	1011	5823	4238	7521	5249	8604	6178
Seventh Plan (1985-90)	2225	1893	1289	957	7797	6914	9086	7871	11311	9764
Annual Plans (1990-92)	821	848	470	321	3273	3097	3743	3418	4564	4266
Eighth Plan(1992-97)	2216	2126	843	596	6702	5656	7545	6252	9761	8378
Ninth Plan(1997-02)	4097	3079	80	-	12855	-	12935	4544	17032	7623
X Plan (2002-07)	5296	3410	1847	1166	3725	2705	5572	3871	10867	7281
XI Plan Target(2007-2012)	9000	-	1500	-	4500	-	7000	-	16000	-

(Source: Central Water Commission, Govt. of India, ON153)

The focus of most irrigation development schemes and initiatives of the government have been civil engineering feats and this has helped the nation achieve major gains in terms of the irrigation potential created. However, utilization of irrigation potential involves people and societies and therefore is social, socio-cultural and socio-economic in nature apart from

being demographic and behavioural. Such aspects have been found to be weak or lacking in the implementation of most government backed schemes and initiatives leading to poor gains in utilization of irrigation potential.

The area covered under various states is given in Table 2.2. Even with a budget of Rs 250 crore and a limit of Rs. 20,000 per hectare the area that can be covered is only 125,000 hectares across 15 states which are considered high potential for the application of drip irrigation technology. This on average would be only 15,000 hectares in each state.

Table 2.2: State-wise area covered under drip and sprinkler irrigation system in India

		(Area in Hectare)
States	**2010-11**	**2011-12 (till Jan., 2012)**
Andhra Pradesh	122758	91774
Bihar	13485.04	14620.80
Chhattisgarh	21830.93	16129
Goa	119.065	34.00
Gujarat	78294	60492
Haryana	9340.2	2556.92
Jharkhand	1217.1	0.00
Karnataka	87447	36695
Kerala	2340.01	3078.64
Madhya Pradesh	41238.24	36544.88
Maharashtra	118025.08	70116.86
Odisha	12013.96	8605.24
Punjab	4925	4026.31
Rajasthan	147613	87207
Tamil Nadu	26153.16	14228.05
Uttar Pradesh	3108.63	3419.86
West Bengal	294	0
Arunachal Pradesh	0	0
Mizoram	0	0
Meghalaya	0	0
Tripura	0	0
Sikkim	0	0
India	**690202.42**	**449528.56**

(Source: IndiaStat, 2013)

2.2 The Government Schemes

The government has devised various schemes across time for the promotion of micro irrigation. Some of the notable central government schemes introduced after the seventh plan to promote the use of micro – irrigation are mentioned in this section. This also presents

a timeline of sorts of the various government efforts at promoting and popularizing the technology.

2.2.1 Centrally Sponsored Scheme on Use of Plastic in Agriculture (1992)

This centrally sponsored scheme was introduced during eighth plan to popularize plasticulture applications like drip irrigation, mulching and green house all over the country Rs. 81 crore was provided for this scheme during 1997-98.

This pattern of assistance (from 1996-97) for drip installation was up to 90% of the cost of the system or Rs. 25,000 per ha whichever is less for small & marginal farmers, SC/ST farmers and women farmers. For other farmers the cap was 70% of cost or Rs. 25,000 per ha, whichever is less. For setting up drip demonstration farms subsidy was Rs. 22,500 or 75% of the system cost per ha whichever is less.

2.2.2 Rural Infrastructure Development Fund (1995)

NABARD initiated the Rural Infrastructure Development Fund in 1995–96 with a corpus of Rs. 2000 crore to provide loans to the state governments for financing rural infrastructure projects and 31 activities including irrigation. The cumulative amount sanctioned till 31st March 2007 was Rs. 61,540 crore. Under the scheme, NABARD provides assistance at a fixed interest rate (currently 6.5%) for a period of 7 years. Rural roads and bridges (44% of the funds till 2007 – 08) and Irrigation (34%) are the two most funded sectors under this scheme.[3] Not too long ago NABARD sanctioned Rs. 230 million for the Andhra Pradesh Micro – irrigation project under its RIDF – XVII (2012) to increase the spread to 114,000 hectares in the state. It had earlier sanctioned Rs. 19 crore to bring 11,180 hectares under micro – irrigation in Punjab in 2008.

2.2.3 Accelerated Irrigation Benefit Programme (AIBP) (1996)

This programme was launched in 1996-97 by the Government of India with an outlay of Rs. 900 crore, subsequently revised to Rs. 500 crore to accelerate the completion of selected on going irrigation projects such that the envisaged benefits from locked investments in these projects are accrued. Initially, this programme had two components. The first component was designed to include major/multipurpose projects, each with the project cost exceeding of Rs.1000 crore and the project being beyond the resource capability of the States. The other component was for irrigation projects where, with just a little additional resource, the projects could be completed and farmers could get the assured water supply to the extent of one lakh

[3]http://megplanning.gov.in/programmes/ridf_nabard.pdf

ha. in the following 4 agricultural seasons (two agriculture years). Post revision an irrigation project with its cost exceeding Rs. 500 crore is eligible. The funding for AIBP is in the form of loan to the states on 50% matching basis. During the Annual Plan 1996-97, a sum of Rs. 500 crore was released to various States and, as reported by the Ministry of Water Resources about 16180 ha. of additional irrigation potential was created. During Annual Plan 1997-98 and 1998-99, the approved outlays under AIBP were Rs.1300 crore and Rs. 1500 crore respectively.

2.2.4 Integrated Scheme of Oilseeds, Pulses, Oil-Palm and Maize (ISOPOM) (2004)

The technology mission on oilseeds was launched by the Central Government to improve production of edible oils in the country. Subsequently, pulses, oil palm and maize were also brought within the purview of the Mission in 1990-91, 1992 and 1995-96 respectively. During the Tenth Plan (2004), Department of Agriculture & Cooperation restructured the development programmes of oilseeds, pulses, oil palm and maize into a Centrally Sponsored Integrated Scheme of Oilseeds, Pulses, Oil palm and Maize (ISOPOM) which is being implemented in 14 major states for oilseeds and pulses, 15 States for maize and 10 States for oil palm. Under this scheme, financial assistance is provided to farmers for purchase of sprinkler systems and water distribution pipes, besides other activities to encourage farmers to grow pulses.

Under the scheme, assistance is mainly provided for women farmers taking up cultivation of oilseeds, pulses or oil palm. Assistance is upto 50% of the cost of sprinkler sets or Rs. 15,000 whichever is lesser. In case of irrigation pipes it is Rs 15,000 for 210 metres of pipe and 50% of the cost in case drip systems are used for oil palm cultivation. The State Governments are advised to ensure that of the total assistance at least 15% to SC farmers and 7.5% to ST farmers was distributed. 8790 sprinkler sets were distributed for oilseeds, 5086 sets for pulses and 13,253 sets for maize under the scheme in 2005 – 06 though the target was set at 13,560 sets, 10,253 sets and 6162 sets respectively. Also, 909 hectare was brought under drip irrigation for oil palm cultivation in the same period.

2.2.5 Centrally Sponsored Scheme on Micro-Irrigation (2006)

The Task Force on Micro Irrigation (2004) had indicated a potential of 69 million ha out of which only about 2 million hectare was covered till 2006. A centrally sponsored scheme on micro – irrigation was launched in January 2006 during the Tenth Plan for implementing drip and sprinkler irrigation in the country. The scheme was to be implemented by an identified

agency at the district level with focus on horticulture crops being covered by the National Horticulture Mission (NHM). It was proposed that out of the total cost of the MI System, 40% be borne by the Central Government, 10% by the State Government and the remaining 50% by the beneficiary either through her own resources or soft loan from financial institutions. All categories of farmers were eligible for subsidy under the scheme including, at least 25% small & marginal farmers, 30% women and the subsidy could be availed for a maximum area of 5 ha. The scheme aimed at achieving better water use efficiency (60-70 per cent), increase in yield (30 – 100 per cent), savings in fertilizer consumption (of up to 40 per cent), reduction of weeding costs and inter-cultural operations, better quality of produce, and enhanced productivity. The initial targets set for the scheme were to cover an area of 1.5 million hectares under drip irrigation and 0.5 million hectares under sprinkler irrigation.

A three tier organizational set – up was set up for implementing the scheme. At the National level, NCPAH was responsible for coordinating the scheme, while the Executive Committee on Micro Irrigation (ECMI) approved the Action Plans. At the State level the State Micro Irrigation Committee coordinated the programme, while at the District level the District Micro Irrigation Committee was responsible to oversee the implementation of the programme. PFDCs were assigned to provide research and technical support for the implementation of the scheme at the state level.

Rs. 280.48 crore were released under the scheme in 2005-06 to cover an area of 0.21 Mha. Similarly, Rs. 337 crore were released in 2006-07 to cover 0.33 million ha across 16 states. The scheme aimed to cover 0.4 Mha in 2007-08 with a budgeted expenditure of Rs. 550 crore. The implementation of this scheme since 2005-06 increased the area under Micro – irrigation by 800 percent in Madhya Pradesh, 150 percent in Orissa and 300 percent in Punjab during 2006-07 to 2007-08. (NABCONS 2009).

2.2.6 National Horticulture Mission (2005)

National Horticulture Mission (NHM) was launched during the year 2005-06 as a Centrally Sponsored Scheme to promote holistic growth of the horticulture through an integrated approach of water management, protected cultivation, nutrition & pest management, post-harvest, processing & marketing. It aimed to increase the production of horticulture produce from 153 MT to 300 MT by 2012. This also included micro-irrigation as a primary strategy for growth of horticulture.

2.2.7 Rashtriya Krishi Vikas Yojana (2007)

The Rashtriya Krishi Vikas Yojana (RKVY) or the National Agriculture Development Plan (NADP) was launched during 2007 to improve growth in the agriculture and allied sectors. The scheme focused on agricultural development strategies to achieve an agricultural growth rate of 4%. The scheme aimed to incentivise state spending in the agricultural sector by providing them with financial assistance for expenditure incurred over and above the average of the expenditure in the previous years. The RKVY funds would be provided to the states as 100% grant by the Central Government. Under this scheme the government further incentivises use of technology like micro – irrigation to further improve the productivity of horticultural crops and vegetables.

The funding has been provided to states to take up agricultural and allied activities as defined by the planning commissions. The states are required to prepare a State Agricultural Plan (SAP) and a District Agricultural Plan (DAP) which would highlight the areas of focus within each district and state. The funding would be provided based on these plans.

Recently, the central government has also introduced the Vegetable Initiative for Urban Clusters under RKVY. Under this initiative, the central government has allocated Rs. 300 Crore for the financial year 2011 – 12 to increase production and supply of vegetables in and around the urban clusters in each state [Dept. of Agriculture and Cooperation, 2011].

2.2.8 Technical Mission for Integrated Development in North – East States

In order to improve the improve livelihood opportunities and bring prosperity to the North Eastern Region (NER) including Sikkim; Government of India has launched Technology Mission (TM), which is now known as Horticulture Mission for North East and Himalayan States (HMNH). The Mission is based on the "end to end approach" taking into account the entire gamut of Horticulture development, with all the backward and forward linkages, in a holistic manner. An amount of Rs. 400 crore was assigned during 2005-06 for promoting micro irrigation techniques, including drip and sprinkling, among all categories of farmers under the scheme. This will be in addition to 6 lakh hectares bought under drip irrigation and another 14 lakh hectares under sprinkler irrigation till March 2004. The scheme was also being implemented in Jammu and Kashmir, Himachal Pradesh and Uttaranchal besides the north – east states.[4]

[4]http://articles.economictimes.indiatimes.com/2005-12-06/news/27509041_1_drip-irrigation-govt-plans-rs-scheme

2.2.9 National Food Security Mission

The National Development Council (NDC) during 2007 launched a Centrally Sponsored Scheme, 'National Food Security Mission' comprising rice, wheat & pluses to increase the production of rice by 10 million tons, wheat by 8 million tons & pulses by 2 million tons by the end of the eleventh five year plan (2011-12). This can also be used to fund micro irrigation.

2.2.10 National Mission on Micro-Irrigation (2010)

The micro–irrigation scheme being implemented by the ministry of agriculture since 2005–06 to promote use of drip / sprinkler irrigation was reintroduced as a national mission during the 11^{th} Plan period (2010). Under this scheme, the central subsidy was revised to 60% of the total cost of the system for small and marginal farmers and 50% for general farmers, including 10% of state share.

Some of the states have increased their share of subsidy to 20–50% instead of 10%, to reduce the burden on farmers. The cost norms have also undergone a revision and, about 3 million ha has been brought under micro-Irrigation. The NMMI scheme is being implemented in the entire country including North Eastern States and Himalayan States as the micro–irrigation system is more suitable for the hilly terrains.

The area covered under drip/ sprinkler irrigation was 0.6 Mha during 2009–10 and 0.42 Mha in 2010-11 till October. The ministry of agriculture had set a target of covering 0.7 million ha under the scheme in 2010 – 11 (MoA, 2010). The progress achieved by the scheme during 2005-2012 is given in Table 2.3.

The NMMI has promoted cultivation of vegetables with close spacing of laterals and use of micro and mini sprinklers in the field saving water and increasing production within a short time so that the farmers get more income on same land. NMMI includes latest technologies like different types of valves, filters and fertigation component etc. so that there will be an increase in water use efficiency, productivity of crops and savings of use of fertilizers, water and electricity.

The Govt. of India Task Force on Micro Irrigation under N. Chandrababu Naidu had recommended increasing the area under micro irrigation by 3 million ha in the Tenth Plan and 14 million ha in the Eleventh Plan with investments of Rs.10,500 crore and Rs.51,000 crore respectively. The total subsidy provided by the Government of India in 2009 – 10 was Rs. 341 Crore with Andhra Pradesh (124 Crore) and Maharashtra (86 Crore) being the main

beneficiaries (IndiaStat, 2010). Tamil Nadu, another high potential state was not provided with any assistance over these two years.

Table 2.3 Selected state-wise areas under National Mission on Micro-Irrigation (NMMI)

States	Area Covered (In ' 000 Hectare)
Andhra Pradesh	718
Bihar	41
Chhattisgarh	112
Goa	0.5
Gujarat	361
Haryana	51
Jharkhand	8
Karnataka	448
Kerala	12
Madhya Pradesh	159
Maharashtra	619
Odisha	46
Punjab	24
Rajasthan	589
Tamil Nadu	103
Uttar Pradesh	17
West Bengal	0.77
North Eastern and Himalayan States*	0.78
India	**3310.05**

(Source: Indiademographics.com)

The Table 2.4 gives the details of the assistance provided by the government to the various states in 2008-09 and 2009-10. The major beneficiaries have been Andhra Pradesh, Maharashtra and Gujarat followed by Madhya Pradesh and Karnataka giving an idea of the geographical spread.

Besides these central government initiatives, the state governments, especially in Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu have also taken steps to promote micro – irrigation. The Government of Andhra Pradesh launched the Andhra Pradesh Micro – Irrigation Programme (APMIP) in November 2003.

The special programme was launched under the state horticulture department to guide, supervise and monitor the implementation of state and centrally sponsored schemes on micro – irrigation. The project aimed at bringing 2.50 lakh hectare area under micro – irrigation in 22 districts of Andhra Pradesh with a financial outlay of Rs 1176 crore. Out of this, 1.66 lakh hectare areas had been brought under micro – irrigation till 2005. While the

figures in lakh hectares may seem daunting they are small in percentage terms of the total irrigated area in the country or the total area under agriculture in India.

Table 2.4: Government assistance provided for Drip Irrigation in various states

States	Assistance Provided for Drip System (Rs. in Crore)		
	2008 – 09	**2009 – 10**	**Total**
Andhra Pradesh	86.17	124.20	210.36
Maharashtra	123.17	86.54	209.71
Gujarat	40.86	33.87	74.73
Rajasthan	9.66	29.12	38.78
Madhya Pradesh	37.15	27.67	64.83
Karnataka	37.14	25.21	62.36
Punjab	4.51	7.50	12.01
Chhattisgarh	2.29	3.22	5.51
Haryana	2.97	2.01	4.98
Orissa	1.66	1.63	3 .29
India	**34608.13**	**34099.14**	**687.07**

(Source: IndiaStat, 2010)

The area covered under APMIP over the years is shown in Table 2.5. A jump in achievement levels is visible from 2007-08 onwards. This is partially ascribed to NMMI support. Andhra Pradesh has become one of the leading states in area under micro irrigation and specifically drip irrigation thanks to APMIP. It is one of three Special Purpose Vehicles (SPV) launched by state governments for promotion and popularization of micro irrigation through subsidy.

A similar SPV called the Gujarat Green Revolution Company Limited (GGRCL), promoted by Gujarat State Fertilizers and Chemical Limited, Gujarat Narmada Valley Fertilizers Company Limited and Gujarat Agro Industries Corporation Limited, has been created in Gujarat for implementing various micro- irrigation schemes in the state of Gujarat.

Table 2.5: Area covered in Andhra Pradesh under APMIP

Year	**Area covered under APMIP (ha)**		
	Sprinkler	**Drip**	**Total**
2003-04	20770	3780	24550
2004-05	40020	24905	64925
2005-06	25000	51811	76811
2006-07	23750	66258	90008
2007-08	30000	90000	120000
2008-09	37000	94000	131000
2009-10	37500	109341	146841
Total	214040	440095	654135

(Source: Reddy and Satyanarayana, 2010)

The organizational structure for implementing central and state government schemes in some states is shown below in Table 2.6.

Table 2.6: Organizational structure for implementation of Micro–Irrigation schemes across states

Particulars	Andhra Pradesh	Gujarat	Karnataka	Madhya Pradesh	Punjab	Orissa
Implementing Agency	APMIP	GGRC	DoA, DoH	DoH	Department of Soil & Water Conservation	Horticultural Development Society (OHDS)
Main Focus	Horticulture Department	Micro Irrigation	Agriculture & Horticulture	Horticulture	Soil & Water Conservation	Nodal Agency for NHM
Nature of Association	SPV – Relatively autonomous unit within Horticulture department	Registered under Company's Act; Public Limited	Government Departments	Government Department	Government Department	Registered under Society Registration Act, 1860
Structure & Outreach	III Tier *State APMIC *Dist. APMIC *Resource Center at Mandal level	Centralized; Support from GNFC Depots at District level	III Tier *State *District *Blocks	II Tier *State *District	IV Tier *State *Division *District *Circles	II Tier *State *District

(Source: NABCONS, 2009)

TANHODA or the Tamil Nadu Horticulture Development Agency is registered as a society to enable functioning as an implementing and nodal agency for horticulture development programs in the state. It also works as a SPV for the promotion of micro irrigation in the state along with horticulture.

In Tamil Nadu, the drip irrigation companies were empanelled in the year 2007-08. With the provision of adequate staff this scheme was expected to take off. During the year 2007-08, micro irrigation scheme was implemented with a financial outlay of Rs.68.11 crore for an area of 12621 hectares. During 2008-09, the scheme will be implemented in an area of 38000 ha. Under Horticultural crops and non-horticultural crops at an approximate cost of Rs. 90 crore (SPC, Govt. of Tamil Nadu, 2012)

We clearly see that, a lot of effort has been put in by the state and central governments to promote micro – irrigation especially in states like Maharashtra, Andhra Pradesh, Gujarat, Rajasthan, Karnataka, etc. The government clearly sees better irrigation efficiency and water

saving as the primary advantage of the technology. For example, the National Horticulture Mission Scheme involves implementation of drip irrigation and sprinkler irrigation with the aim of achieving better water use efficiency (60-70%), increase in yield (30-100%), better quality of produce, saving in fertilizer usage (40%) and weeding cost along with easy intercultural operation in all types of soil including saline soil.[5]

The efforts of various governments have been enormous in terms of any indicator possible – funding, duration, and coverage in terms of area of number and types of farmers. However like other initiatives the actual achievement has not been perfect. The government has sought to evaluate the progress and also to reorient its efforts in the right direction and this long history presented in this chapter only bears testimony to the efforts of the governments despite the modest success.

[5][See http://agricoop.nic.in/OUTCOME-PRINTING/4.%20Flagship%20prog.%20write%20up.pdf; AgriSummit Report 2005]

Chapter 3

Methodology

The survey of literature and identification of the research gaps combined with the salient points from the discussion with experts in the domain led to the framing of the research questions for the study. Beyond the identification of research questions it was important to lay down the methodology for the study and describe how the study proceeded.

Since majority of the issues inquired in the study have never been looked at in the same depth or across the various geographical regions or application of drip irrigation across various crops, it was assumed that there were features and aspects to this study that were not very well known to the researcher as such. It was decided to conduct the study using an extension mixed methodology study. The methodology is to explore the topic with a case study approach followed by a structured survey to get results and test some of the trends or propositions from the case studies.

The first part of the study was a qualitative inquiry based exploratory study to ascertain dimensions, aspects and relationships not identified or captured by earlier researchers in existing studies and literature. These could be used to formulate propositions that can then be tested by an organized quantitative study.

It was required to choose case studies to maximise the variation in the qualitative study and analyses. The case studies were conducted using an exploratory approach using various qualitative technique like focussed group discussions, in-depth interviews and rapid rural appraisals.

The case studies were then used to conceptualize and prepare a survey instrument (questionnaire) that can be put to a pre-test to confirm and finalize the instrument with modifications based on the findings of the pre-test.

The exploratory study is followed by a structured survey across a closer sample based on a carefully structured design. Thus is a large size sample consisting of approximately 500 respondents across different zones and states was planned to try & test some of the propositions emerging from the case studies.

3.1 Choice of States

For the study it was essential to have pockets of significant adoption such that the effects of drip irrigation are studied as proposed. As such it was evident that the suitable geographies

and regions for the study were the southern states and the western zone of India. Based on the spread of drip irrigation and the importance accorded to the technology two states each were to be chosen from each of the two zones -. Gujarat and Maharashtra were chosen In the Western zone and Tamil Nadu and Andhra Pradesh were chosen from the south.

As clearly seen in tables presented earlier in this report, the spread of micro irrigation and drip irrigation in the western zone was highest in the states of Maharashtra, Gujarat and Rajasthan. However expert interviews and data revealed that the micro irrigation technology popular in Rajasthan is not drip irrigation but sprinkler irrigation. Due to the difference in the two technologies and their applications as well it was decided to study only drip irrigation as the water saving potential is much higher in drip compared to sprinkler. Gujarat is one of the three states where a special purpose vehicle for promotion of drip irrigation and the administration of subsidy. Gujarat has also made leaps and bounds in covering new area under drip irrigation in the last few years thus making it an apt decision to choose Gujarat over Rajasthan for the study.

From amongst the southern states, the choice was obvious as the states with the largest spread of drip irrigation are Andhra Pradesh and Tamil Nadu. Also both the states have promoted drip irrigation in different ways. In Tamil Nadu the task of promoting drip and micro irrigation was handed over to an agency called TANHODA from the horticulture department. TANHODA is also set up by the department of horticulture, govt. of Tamil Nadu. It has been able to make rapid strides and achieve success with significant drip irrigation adoption in many crops such as coconut, banana, turmeric and chillies.

Andhra Pradesh was the first state to innovate and create a special purpose vehicle in the form of Andhra Pradesh Micro Irrigation Programme (APMIP) during the tenure of the then chief minister Chandra Babu Naidu. APMIP benefitted by channelizing NMMI funds to upscale the spread of micro irrigation and more specifically drip irrigation. The rapid gains catapulted Andhra Pradesh at once to the forefront of the drip irrigation adoption and many manufacturers decided to set up shop in Hyderabad and even Nagarjuna Fertilizers expanded their business and entered the drip irrigation manufacturing business. The spread across various districts and pockets and the state government was able to link it up with various other initiatives and programs like the watershed development program and horticulture promotion programme increasing the gains be significant.

Thus the final sample consists of four states – Andhra Pradesh and Tamil Nadu in the southern and Gujarat and Maharashtra in the western zone.

3.2 Choice of Pockets within each State

There were a total of 4 states to be covered in the two zones –west and south. The chosen states as stated earlier were Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu. Within each state two districts were to be sampled to provide variation across topography and cropping patterns in the application of drip irrigation. However in some states the desired variation was available within a single district. For logistical ease and reduction of cost and time for surveying different pockets in the same district was sampled. Within each district two pockets or villages were to be sampled and the pockets or villages were to be chosen to have maximum variation in the crops and social settings and if possible market accessibility and distance from the dealers.

Each state was divided into various pockets such as to maximize variation in terms of different crops and social settings. The attempt was to select at least two districts in each state with a signification amount of drip irrigation. In the choice of districts in a state and across the states as well the attempt was to get variation either in the climatic or crop profile of drip application.

Based on data and expert advice the districts of Amreli and Sabarkantha were chosen in Gujarat. These are the districts with the maximum drip irrigation penetration in the state and have different climatic and soil conditions. Amreli is located in Saurashtra region with very scarce water endowments, limited soil depth and limited number of tubewells. Sabarkantha is situated in the northern part of the state with partly hilly and plain alluvial topography. The alluvial plains of Sabarkantha are very fertile and tubewell irrigation is popular here like the neighbouring Mehsana district. Cotton is a major cash crop here and also vegetables are very popular here as Ahmedabad is a major market center and is located about 70 kms from the district headquarters. Commercialization is very different across the two districts chosen. At the time of the survey (in January 2013) Amreli was undergoing a very bad drought and Sabarkantha was alive with vivid agriculture based on tubewells and canal flows. It was decided to sample two pockets of adoption in different parts within each district with different principal crops adopting irrigation.

The pockets chosen in Amreli were in Savarkundla taluka and the principal crops were cotton, groundnut apart from vegetables in small area. They were located in different directions from the taluka headquarter of Savarkundla each at a distance of about 10-15 kms and several villages in between. In Sabarkantha district, the pockets chosen were situated in different directions of the district headquarters and each about 25 kms in different talukas.

In Maharashtra, the choice was narrowed down to Nashik district which has considerable spread of drip irrigation apart from the districts of Jalgaon and Ahmednagar. Nashik was chosen to avoid the impact of location of Jain Irrigation (one of the largest drip irrigation manufacturers across the world) in Jalgaon which we were advised by experts could influence and enter the study as a variable in itself in the other two districts. Nashik provides considerable variety in crops and topography across the talukas of Niphad and Dindori. The villages chosen were about 30 kms apart in different directions and topographies. The villages in Niphad are fairly gentle sloping and mainly grow grapevine and sugarcane whereas those in Dindori are more undulating and lesser well connected to the market and grow many other crops like bananas, tomatoes and vegetables apart from grapevines.

In Tamil Nadu as the survey was conducted with the help of TNAU, due to language barriers and limited availability of interpreters, to ease the logistics and reduce cost the survey was located around Coimbatore district in two different directions about 60 kms away from each other and each about 40 kms away from Coimbatore in different directions. The major crops in the two pockets were mainly coconut and vegetables in one and turmeric and capsicum and other vegetables in the other pocket.

In the case of Andhra Pradesh, the variation was available in different parts of Rangareddy and Medak Districts. The pockets were chosen considerably apart despite in neighbouring districts. It was difficult to identify a single crop as the main crop in these areas and the difference in variety of crops led to the selection of the pockets which were identified with the help of local APMIP and Acharya N.G. Ranga university experts.

3.3 The Survey Methodology

The case studies were conducted and the findings are presented in the next chapter. The findings of the case studies, the conceptual framework of the project, the discussions with experts and from the cues and variables identified from literature were all used to develop a questionnaire (instrument) to collect the information from the farmers.

It was decided to administer the survey instrument at the farm level to the main farmer.

The questionnaire was composed of different sections. The first section sought responses about the farmers and farm profiles and consisted of mainly factual information including about crops and cropping sequence. The second section profiled the water situations and resources on the farm. Another section solicited responses to drip irrigation adoption stages, role of various actors, subsidy availed and experience and the impact of drip as experienced

by the respondents. The last section profiled the perceived performance of drip irrigation and also suggestions on improving the promotion and servicing of drip irrigation

The sample was to cover 16 such pockets (4 states X 2 districts each X 2 pockets each). Minimum of 16 villages were to be covered for the survey. Within each pocket or village the sampling design was to cover about 25 adopters and 10 non–adopters. The respondents were spread across various landholding and caste classes within each pocket. Thus the total sample was expected to be around 500 farmers with around 380-400 adopters and at least a 100 non–adopters.

In the states of Andhra Pradesh and Tamil Nadu personnel were hired to administer the survey who could interpret between English and the local language. They were chosen on the basis of exposure to local farming and drip irrigation technology, to enable to ask the questions and solicit the responses as experiential data. They were also trained prior to collection of data and during data collection they were closely monitored by a research associated hired with the project also prior trained for the purpose.

Perception data at the farm level is fairly reliable as provided by the farmer who are involved in farming day in and day out. Also a large part of data can be cross checked by probing, challenging and triangulation and seeking explanations from the respondents. Thus data collected was of perceptions but was cross checked before enumerating the response.

Perception of farmers is very important especially related to benefits, costs, enablers, hindrances and impacts of adoption as perception has a distinct link with the behaviour of farmers and often perception has a direct link with the behaviour of farmers and often perception can be a stronger influence than actual information of economics in leading to mass behavioural trends. What must be realised most importantly is the fact that the perceptions are based on experiences of users or non-adopters that have closely watched and interacted with users. Thus these cannot be treated as mere perceptions otherwise.

3.4 Limitations of the Study

This study has some limitations and it is in order that the limitations are spelt out clearly.

The major limitation of this study is by its design. The survey was used to collect perception data. Perception data lends itself only to a limited amount of analysis. The use of perception data makes it more difficult to establish causality.

The resource conservation impacts of drip irrigation are best studied through observation of actual ground water and surface water data. However ground water measurement stations are rarely located at a location suitable for observation of impact of drip irrigation adoption even in high adoption pockets. Also monitoring this data is time consuming, costly and also the monitoring needs to be done on a larger duration across seasons and years to get authentic results. The time frame of 1-2 years does not allow this methodology. Therefore perception data based study methodology was decided upon as this is the next best.

This is one of the rare studies on micro irrigation which have collected data from across different zones and states. This study ensures generalizability beyond most other studies on micro irrigation. However, the data collection is limited from two zones and that will impose limits on generalizability across all regions. The two zones considered for this study were the southern and the western zones of India. Thus this study is set apart from existing studies.

The sampling design based on the study design conducted the survey in selected pockets or clusters of high adoption of drip irrigation. These selection criteria can cause bias on the data collected for certain variables such as awareness and the like. In a cluster of high adoption the general awareness about the technology can be expected to be high even amongst the non-adopters.

Another limitation that the study design and sampling plan introduce to the study is that the effort to identify scale effects can mask some of the point or local effects. This means that the measures of many variables included in the survey may have an error due to the simultaneous collection of data about the aggregate level as well. However collecting data at the farm level reduces this to some extent by triangulation across users in a location.

The survey instrument collected perceptions as responses on a five point scale. This is theoretically a case of censoring a measurement and therefore induces some limitations on the measures and the analysis that can then be carried out using them.

Another limitation was the survey instrument being administered in languages other than the one in which it was prepared originally. This was reduced to some extent by choosing survey administrators who had knowledge of farming and also local rural exposure to be able to ask the right questions. They were also trained on the instrument and its administration prior to administering the survey. However some error may have remained due to fieldwork across multiple language locations.

The time of survey administration may have introduced some bias in some of the responses of some of the respondents. Two events are worth mentioning here which represent two

possibilities of such a bias. The survey was conducted in Amreli in Gujarat when it was reeling under the impact of a severe drought. Thus the perceptions about the use and success of drip irrigation may have been exaggerated due to this. In some other parts of Gujarat the survey was conducted just before the general elections to the state assembly. One tenth of the total sample has some experience of village leadership position and hence the probability of a bias due to involvement of politics and leaders cannot be ruled out for some of the respondents.

These limitations impose certain restrictions on the study which is otherwise based on a robust design and process.

Chapter 4

Findings from the Case Studies

As explained in the previous chapter the research questions, study design and methodology adopted for the study necessitated that exploratory research be carried out to understand the existing diversity. The diversity was of secular features of change and variation in causes, process and impact of adopting drip irrigation. Researcher's prior engagement with the domain and expert advice was considered to choose the case-study locations. Five case studies were conducted across the 4 states as follows:

1) Gujarat – Chandrala village (Distt. Gandhinagar) and Kamana Village (Distt. Mehsana)

2) Maharashtra – Janori Village (Nashik District)

3) Andhra Pradesh – Pamena and Chanvelly villages (Rangareddy district)

4) Tamil Nadu – informal case studies were carried out with visits to two villages near Coimbatore in two different blocks. These have not been reported as these do not qualify as true case studies.

All the five case studies listed above are attached as annexes to this report. The case studies revealed a lot of rich information that was used later on to design and structure the survey instrument (questionnaire) to be administered for data collection. The following are the main findings from the case studies presented in brief.

4.1 Labour Shortage

One of the resounding findings of the case studies is the shortage of labour in all the five villages and faced by all farmers who do not have enough family labour availability. However labour shortage as reported across villages and by adopters and non-adopters could be a secular change that influences adoption in some way. One of the benefits reported in the case studies is that farmers do not have to employ labour for irrigation anymore as they can easily operate the drip irrigation system with the push of a button or a switch. The added benefit reported by the case studies is that due to this farmers do not have to visit their fields at odd hours of electricity supply for irrigation. This was necessary earlier to supervise the irrigation labour employed by the farmer.

The farmers also reported a rise in wages for labour and different mechanisms are being worked out to arrest or dampen the rise if not arrest it. The multiple pressures of labour

shortage, increased wages and odd hours have forced farmers to look for solutions and some farmers felt that drip irrigation is a good solution for these challenges.

The labour reported that due to increased agricultural activity and production the labour requirement has shifted from irrigation to other agricultural activities. Thus they have not suffered because of the adoption of drip irrigation. In fact, labour even reported that due to drip irrigation they do not have to venture into the farms at odd hours as farming is now practiced in a more planned manner. Thus some labourers (but not all) claimed that drip irrigation had improved their lives by reducing drudgery of odd hours. The labourer also reported that due to increased agricultural activity and production the labour requirement has shifted from irrigation to other agricultural activities. Thus they were not worse off by the adoption of drip irrigation but gained some advantages as well.

4.2 Special Purpose Vehicles Promoting Drip Irrigation in a Big Way

The case studies in both Gujarat and Andhra Pradesh reported the positive impact that the special agencies entrusted with promoting and managing the subsidy for drip irrigation have had. In Gujarat the farmers felt that the creation of Gujarat Green Revolution Company Limited (GGRCL) has led to reduced corruption due to direct involvement of only one agency with better technology and more transparent processes and increased farmer choice of dealers and companies. They also seem satisfied with the application of GPS and CAD technologies to facilitate faster, better and correct application and installation. In Andhra Pradesh the APMIP was lauded for having helped many farmers irrespective of their landholding or any such characteristic in adopting drip irrigation successfully. It cannot be ignored that three of the four states chosen due to increased popularity of drip are states where the SPVs were created to promote the spread of drip irrigation.

Another major benefit that these SPVs have brought about in their respective states is with the dovetailing of various schemes they have been able to make more capital available for subsidizing farmers and therefore making it possible for more farmers to benefit from the government schemes and increasing the area under drip irrigation.

In an interview the CMD of one of the major drip producers said that a SPV helps the companies to function throughout the year with the same motivation and efforts as it eradicates delays in subsidy payments.

4.3 Water Table Benefits

The case studies unanimously report a benefit in terms of farm level water application and farmers usually have reported that they are able to irrigate as much as double the area with the application of drip irrigation as compared to without drip earlier. However the benefit varies across farmers with soil quality, crop shifts and agricultural practices. The Variation makes it interesting to pursue an inquiry on the same.

While some farmers have reported benefits of micro irrigation (drip irrigation) in terms of water table rise however there are others like those in Chandrala who point that the water table has not actually come up but its fall has been arrested. However it must be borne in mind that the village has a history of more than 20 years since the first adoption and a scale of more than 80% adoption in the village at the time of the study. The village has been deregulated from a dark to a grey zone because of these changes signifying an improvement in the water availability in the region.

Many farmers on the other hand believe that water availability in general is a secular change feature and is also dependent on many other factors apart from drip adoption and cropping shifts. Thus some farmers are also unsure if improved water availability is due to drip irrigation or not. The perception of farmers with this respect is important to aid adoption profitably and allay the fears or concerns of the farmers about the threat to sustainability of farming due to water shortage.

It is also believed by some farmers that the water availability has greater impact pre-adoption than post adoption while others believe it is important irrespective of all this. Many farmers decided not to apply drip irrigation sensing that they had enough water in their well or tubewell for their own use and / or the marginal benefit of this cost was very low.

4.4 Increase in Irrigated Area and Consolidation of Landholding

Almost every adopter has mentioned that they have been able to increase the area under irrigation with the application of drip irrigation. Many farmers reported that they were increasing the area irrigated by using the same amount of water as before. Others believed that they were able to save on water consumption even with increased area under irrigation. The proportion of area increased also varied from farmer to farmer and from village to village. One case reported the change in soils or the diversity in soils across the same village and therefore the need to partition land in various parcels to fairy distribute it to the progeny. This had resulted in fragmented land holding.

The case studies revealed that the presence of fragmented or consolidated land holdings could also influence the adoption of drip irrigation through the benefits that can accrue from the same. Fragmented landholdings not only reduce economies of scale but also impact the management bandwidth of the farmer across various plots. They also make it difficult to ensure safety of the equipment from theft and therefore more difficult to adopt drip irrigation with fragmented landholdings. Many farmers are found to bring only one plot or nearby plots under drip irrigation whereas other further ones are left under traditional irrigation for better management and safety. Farmers with consolidated landholdings suggested it was easier for them to relay pipes and cover the whole farm with lesser drip equipment.

4.5 Fertigation and Savings on Fertilizers

Some farmers claimed savings due to decreased application of fertilizers and pesticides as well. They extended the logic that fertilizer when applied through fertigation will impact only the root zone and therefore they save on total fertilizer consumption compared to flood irrigated agriculture. However some farmers did not report any savings in monetary terms as fertigation required the application and shift to liquid fertilizers. Farmers also mentioned that fertigation often results in a better yield and therefore it was advantageous to apply drip irrigation along with fertigation only. This also enabled them to get advantage of reduction in labour requirement for fertilizer application. Liquid fertilizers are not subsidized by the government unlike common fertilizers used in traditional agriculture. This might be one of the ways in which the government is reducing its fertilizer subsidy bill. Thus there are mixed views on cost savings on account of pesticide and fertilizer consumption.

4.6 Shift in Cropping Pattern

Drip irrigation was also claimed to enable a shift in crops and cropping pattern for most farmers. Farms or villages near to cities where a ready market was available appeared to prefer vegetable cultivation despite fluctuations in price. Villages with not very good connectivity to cities and nearby markets preferred other plantation and horticulture crops which could attract traders to buy the produce from the farm gate itself. The shift to a cash crop or a more profitable crop was often the result of adoption of drip irrigation. However some farmers pointed out that some of these cash crops were also more risky due to price fluctuations. This was witnessed in the case of crops like capsicum (including coloured varieties) and turmeric where the prices had fallen in the last few years changing the economics and pay back periods expected by the farmers initially.

It was also found that while drip irrigation led to significant labour savings due to less weed growth, easier fertigation and no need for labour during irrigation, it also resulted in a shift to cash crops which required more care during the growth and therefore involved more labour intensive operations. This was pointed out by the agricultural labourers as well as they said in irrigation operation that this made up for the loss of employment on account of labour savings in irrigation operations. They also said now that they were better off as wages had risen slightly and now they seldom had to go into the fields and work at odd hours. Thus even the labourers supported the shift in crops caused by drip irrigation and deemed it a favourable technology.

4.7 Increased Incomes

With the adoption of drip Irrigation higher yields and/ or shift to cash crops resulted in increase in income. However this was not always the case. In general the higher yields appeared to be the biggest cause for increased incomes as compared to other causes. Some farmers attributed the increase in incomes to crop shifts to more market savvy or niche crops.

However the farmers also pointed out that there was rarely a price advantage on account of better quality products due to drip irrigation. While the plant growth was observed to be better as farmers believed that the quality of produce grown with the help of drip irrigation was better but it seldom resulted in a price advantage and premiums were rarely available. This meant the drip irrigated produce was also subject to the price risks as that of non-drip irrigated commodities and therefore the profits and payback period also varied with the prices. This made the realization streams from drip irrigation uncertain and some farmers did not agree that drip irrigation led to increased prosperity. For them it was a tool to cope up with the water and labour scarcity which they faced.

4.8 Erratic Electricity and Coping with Untimely Supply

Farmers found drip irrigation very effective in coping with the situations of electricity shortage often combined with scarcity or limited supply of water. They found it especially useful in scenarios where power or water was made available in the wee hours or odd hours of the day and night. Normally it would be difficult to have labour availability as required at these hours and erratic times and a lot of labour stayed idle waiting for the water to arrive. With the application of drip irrigation it was easy to carry out the irrigation operation by the push of a switch or a button even at odd hours. Thus it appeared to be an excellent coping mechanism against scenarios of uncertainty of power, labour and water supply.

4.9 Scale Neutrality or Lack of thereof

Many farmers recounted that a significant part of the cost of adoption of drip irrigation is a fixed cost irrespective of the area applied upon. The area-based costs increase telescopically and hence the cost per unit area of drip irrigation adoption is higher for smaller farms and decrease with an increase in area adopted. This almost offsets the step function in terms of pump and pipe sizes and costs. Some farmers also pointed out that though this was true it did not preclude or exclude smaller farmers from benefitting from the system and there were many small holders who were benefitting from the application of drip irrigation.

4.10 Other Multiple Benefits of Adoption

Farmers reported multiple benefits from the application of drip irrigation. They can be classified into two major categories – one are the type of benefits that allow the farmer to cope up with adverse agricultural conditions due to the application of drip irrigation and the second type are the benefits which bring prosperity to the farmers and result in better economics and financial gains for the farmers.

Across both the types of benefits the multiple benefits claimed by farmers were increase in yield, reduction in weeds, improvement of irrigation efficiency, reduction in consumption of power and labour, reduction in water consumption, better growth of plants, increased incomes and better soil quality are expected by farmers.

4.11 Different Adoption Levels

The case studies show different adoption levels across villages and farmers. While some farmers are initiating with a little experimental patch there are others who have sought to put all their area under drip irrigation. At the same time some farmers have shifted their crops to suit drip irrigation and get more benefit out of adoption. There was variation in terms of application of fertigation or many other such practices creating a huge variability across such activities on the farms.

On the whole we find that the case studies showed a wide variation in the benefits reported and there were certain features that were ambiguous in whether they benefitted farmers or not. Also some complications in terms of lack of awareness and different actors playing a role in spreading awareness and providing information about drip irrigation were found. The subsidy process was also found to vary and different perception prevailed about the clarity and ease of availing subsidy amongst the farmers. Thus there were many variations that

were identified as worth investigating in a field survey data collection exercise. These were then prioritized and selected based on the research objectives set for the study.

Chapter 5

The Sample and its Characteristics

The survey was conducted as planned across a total of 4 states and 16 identified pockets and a total of 499 respondents were administered the survey instrument and their responses collected. The survey forms from Tamil Nadu had some blanks and some parts could be completed only after 2-3 attempts and multiple communications back and forth and yet responses to some question could not be obtained from about 38 respondents. These 38 respondents were then dropped from consideration for any statistical analysis.

The spread of the sample across the various states and adopters –non adopters is given below in Table 5.1 and the sample is described after the table.

Table 5.1 Sample spread across states

	Andhra Pradesh	Gujarat	Maharashtra	Tamil Nadu	Sub-total
Adopters	121	76	91	82	370
Non-adopters	39	32	23	35	129
Total	160	108	114	117	499

A Total of 499 responses were collected from 370 adopters and 129 non-adopters. The total number of adopters varied across the states with maximum in Andhra Pradesh where responses of a total of 160 respondents were collected. Out of this, 121 were adopters and 39 non-adopters. From Gujarat, 108 respondents out of which 76 were adopters and 32 non-adopters were surveyed. The numbers of adopters surveyed from Gujarat were reduced due to rejection of some forms as bias of drought in the responses was noted at the time of the survey itself. From Maharashtra the responses were collected for a total of 114 respondents out of which 91 were adopters and 23 non-adopters. In these pockets it was difficult to find a non-adopter farmer and getting their agreement for a survey about drip irrigation. From Tamil Nadu we were able to collect the responses of a total of 117 respondents out of which 82 were adopters and 35 non-adopters.

The distribution of adoption status of drip irrigation in the overall sample and by the states is presented in the Table 5.2. The table also provides the percentage split of the sample state wise and combined between the adopters and the non-adopters.

Table 5.2 Sample spread: State-wise percentage of adopters and non-adopters of Drip Irrigation

Adoption status	Andhra Pradesh	Gujarat	Maharashtra	Tamil Nadu	Overall
	No. of households (%)	No. of households (%)	No. of households (%)	No. of households (%)	No. of households (%)
Non-Adopter	39 (***24.4***)	32 (***29.6)***	23(***20.2)***	35 (***30.5)***	129 (***25.85***)
Adopter	121***(75.6)***	76 (***70.3)***	91(***79.8)***	82 (***69.5)***	370 (***74.15)***
Total	160 (***100***)	108 (***100)***	114(***100)***	117 (***100)***	499 (***100)***

5.1 Farmer Profile

The basic survey unit was the farm and for each farm surveyed the perception of the main farmer was recorded as responses. The profiling of farms and farmers was done to understand the secular features that could have impacted or influenced the responses of the farmers. A summary of some of the main profiling characteristics of the farms and the farmers and their households are given in this chapter.

Table 5.3 below presents the age profile of the overall sample and by the states. In Gujarat and Tamil Nadu, the age distribution curve shows a strong right hand tilt. Farmers surveyed in these states had a higher average age.

Table 5.3: Age profile of farmer-respondents (state wise and combined)

Age (years)	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
<21	0	0	0	0	0
21-30	17.5	11.1	13.2	1.7	10.87
31-40	39.4	18.5	40.4	6.8	26.27
41-50	26.3	35.2	26.3	36.4	31.05
51-60	13.1	21.3	15.8	44.9	23.77
61-70	3.8	11.1	3.5	6.8	6.3
71-80	0	2.8	.9	2.5	1.55
81-90	0	0	0	.8	0.2
>90	0	0	0	0	0
Total	100.0	100.0	100.0	100.00	100
Mean Age	41.36	47.28	41.74	51.57	45.14
Standard Deviation	0.81	1.169	0.96	0.86	0.50

Among the respondents more than one-third in Gujarat and more than half of the respondents in Tamil Nadu were above the age of 50. Almost two-thirds of the respondents in Andhra Pradesh and Maharashtra are in the age group of 31-50 years. However this age group has little over half the respondents for Gujarat and less than half for Tamil Nadu. The average age of farmers in Andhra Pradesh and Maharashtra is about 41 years and a few months more whereas the average respondent is about 47 years and a few months more in Gujarat and over some months over 51 years in Tamil Nadu. In the overall sample there is a generous spread between the ages 31-60. The overall distribution of the sample by age looks like a good normal distribution bell curve.

Table 5.4 presents the education profile of the overall sample and by the states. About two thirds of the respondents in the overall sample have been educated till the middle school. The number of illiterate farmers is highest in Andhra Pradesh where almost one fifth of the farmers are illiterate. In contrast, almost the same proportions are graduates or have higher degrees in Gujarat and Maharashtra.

Table 5.4: Education profile of farmer-respondents (state wise and combined)

Education	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Illiterate	19.4	4.6	1.8	1.7	6.87
Primary school	14.4	14.8	7.0	27.4	15.9
Middle school	25.0	45.4	56.1	39.3	41.45
High school	20.0	13.0	14.9	15.4	15.82
Diploma/Certificate degree	9.4	3.7	3.5	4.3	5.22
Graduation or higher degree	11.9	18.5	16.7	12.0	14.77
Total	100.0	100.0	100.0	100.0	100.0

The number of respondent farmers with high school or more education is almost the same across the four sample states at about one third of the respondents. However a large number of farmer respondents seem to have stopped education beyond high school in AP and TN. Gujarat appears to have the maximum number of ‘gentlemen farmers’ with a balance of age and education - mean age of 47.28 and with 22.20% having certified and higher education degrees.

Each of the state sub-samples of the survey show a variation in the average sizes of the families. In table 5.5 Maharashtra reports the largest families with an average family size of 8.11 members per family and the minimum is in Andhra Pradesh at 5.25 members per family which is closer to the national average. Even Gujarat reports a higher average family size at 6.39 members per family. This in itself may not tell much apart from the possibility of prevalent joint family system in some states compared to others.

Table 5.5 Family size profile of respondents (state wise and combined)

Family size	Andhra Pradesh	Gujarat	Maharashtra	Tamil Nadu	Overall
Mean	5.25	6.39	8.11	5.34	6.17
Std. Deviation	2.07	3.13	4.20	1.62	3.07
Minimum size	2	2	3	1	1
Maximum size	16	19	26	10	26

A common belief is that villagers who are more progressive and also early adopters often occupy village leadership and other important positions. It is also alleged that they often corner the benefits of schemes like the micro irrigation subsidy. Thus responses were collected with respect to respondent's experience of being in or having been in a village leadership position. Table 5.6 collates these responses.

Table 5.6 Village leadership profile of respondents (state wise and combined)

Village leadership	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
No	96.3	86.1	84.2	97.0	91.3
Yes	3.8	13.9	15.8	3.0	8.7
Total	100.0	100.0	100.0	100.0	100.0

Around 9 percent of the respondents in the overall sample and state samples have held village leadership positions indicating a significant amount of leadership experience amidst the respondents. However on detailing the positions held by these respondents as given in table 5.7, it is found that majority of the respondents were chairmen or working committee members in other cooperatives or committees. They account for over half the respondents who have held leadership positions. In Andhra Pradesh more than two quarters (60%) of the leaders were from other cooperatives and committees and about 40 percent had experience in representing the village ward. The sub-sample from Maharashtra showed a more varied leadership experience pattern with different positions in other cooperatives. Sarpanches were part of respondents only in Gujarat.

Table 5.7 Village leadership positions held by respondents (state wise and combined)

Village position held	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Working committee member in other cooperative	40.0	33.3	17.6	0	22.72
President in other cooperative	0	0	11.8	50.0	15.45
Village ward member	40.0	33.3	0	0	18.32
Chairman in other committee	20.0	0	58.8	50.0	32.2
Board members in another institution	0	16.7	5.9	0	5.65
Sarpanch	0	16.7	0	0	4.17
Total	100.0	100.0	100.0	100.0	100

Table 5.8 shows the tabulated responses regarding the caste profile of the sample. In the overall sample more than two quarter of the respondents were from OBC category and other minorities. 63.2% of respondents in Maharashtra were from the general category, while 94.5% of the farmer respondents in Tamil Nadu were from other backward classes. Respondents from other minorities constituted half the sample in Andhra Pradesh and about two thirds of the sample in Gujarat. This contradicts the popular notion that only “higher caste farmers” can afford drip irrigation. The low participation of the Scheduled tribes as respondents is also noticeable in the sample. The surprising fact is the low participation of the scheduled castes in the survey despite special incentives provided by most of the governments in terms of higher subsidy rates for SC farmers.

Table 5.8 Caste wise breakup of respondents (state wise and combined)

Caste	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Scheduled castes	10.0	.9	2.6	2.7	4.05
Scheduled tribes	0.6	0	4.4	0	1.25
Other backward classes	27.5	8.3	23.7	94.5	38.5
Other minority	58.1	67.6	6.1	2.7	33.65
General category	3.8	23.1	63.2	0	22.55
Total	100.0	100.0	100.0	100.0	100

5.2 Farm Profile

The landholding details are presented in the Table 5.9 below. The Mean owned area is 7.53 acres across the sample and the leased out area is nil whereas the mean leased in area stands at 4.9 acres. This again shows that the technology is either accepted by gentleman farmers or adopters transform into gentleman farmers with no leasing out and leasing beyond the land owned to increase the landholding operated upon. This strengthens the case of drip case as an enabler of prosperity. The mean cultivated area across the sample is 7.68 acres and this is much below the addition of the mean owned and leased in areas. This probably signifies that drip irrigation is popular in regions where the smaller farms are able to lease in land such that the average operated landholding is just above the average owned landholding. This usually is the case of regions where agriculture is prosperous in general. The mean irrigated area is 5.07 acres which is about two thirds of the mean cultivated area for the sample. The mean drip irrigated area is 6.34 acres which is a higher value than the mean irrigated area. This clearly signifies that the larger farmers in the sample have higher drip irrigation adoption rates and hence also larger drip irrigated areas as compared to the smaller farmers. However the bias seems to be reducing when compared to many of the earlier studies about a decade ago or so. That the smaller farmers have also been able to afford and adopt drip irrigation is borne by the very high standard deviation values which almost equal the mean values. Thus some very small farmers have also been able to adopt drip irrigation. The minimum drip irrigated area for a respondent in the sample is just half an acre and this speaks a lot for the availability and accessibility and affordability of the technology for the smallholders.

Table 5.9 Landholding profile of farmer-respondents (state wise and combined)

Landholding (Acres)	No. of households	Mean	Std. Deviation	Minimum	Maximum
Owned area	497	7.53	6.53	0.50	55.00
Leased-in area	19	4.90	4.49	1.00	16.00
Leased-out area	0	0	0	0	0
Total cultivated area	500	7.68	6.55	0.75	55.00
Irrigated area	318	5.07	6.48	0.50	95.00
Rainfed area	46	4.24	4.02	1.0	15.0
Drip irrigated area	367	6.34	6.24	0.50	55.00

It is interesting to compare the drip irrigated areas across the states. As per table 5.10 the highest mean drip irrigated area per farmer is in Gujarat at 7.46 acres followed by Maharashtra at 6.49 acres. The minimum is in Andhra Pradesh at 4.63 acres and Tamil

Nadu has a modest mean at 4.83 acres. Here again across all the states the standard deviation is observed to be very high and almost equal to the mean values. Thus in almost all states there are small holders present who have been able to adopt drip irrigation on their farms. At the same time the higher than mean values of standard deviation in Gujarat and Maharashtra signify that here there are some very large farmers who have adopted drip irrigation on very large areas and for every such farmer there are large numbers of very small farmer who has adopted drip irrigation on a very limited lot of land. This belies the claim that the technology is adopted by only the large farmers. The technology now seems to be universally adopted irrespective of landholding.

Table 5.10 Drip Irrigated area of farmer-respondents (state wise and combined)

Drip irrigated area (Acres)	Andhra Pradesh	Gujarat	Maharashtra	Tamil Nadu	Overall
Mean	4.63	7.46	6.49	4.83	6.34
Standard Deviation	4.32	9.70	8.67	5.25	6.24

Table 5.11 tabulates the sources of irrigation on the sampled farms. The common sources of irrigation for the respondents were tube well, open well, canal as reported by 78.5 percent, 45 percent and 12.4 percent respondents respectively. Majority of the farmers had more than one source for irrigation water.

Table 5.11 Sources of water of respondent farms (state wise and combined)

Sources of Water	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Tube Well	95.0	58.3	74.6	78.4	78.5
Open Well	3.1	43.5	97.4	52.6	45.0
Canal	.6	0.0	1.8	50.9	12.4
Lift from Canal	3.1	.9	10.5	0.0	3.6
Tanks	.6	.9	4.4	0.0	1.4
Lift from Stream/River	.6	0.0	2.6	1.7	1.2
Check Dams	0.0	0.0	0.0	2.6	0.6
Lift from Tanks	0.0	0.0	1.8	0.0	0.4
Other	0.0	0.0	1.8	0.0	0.4

In Andhra Pradesh, Gujarat and Tamil Nadu, the major source of irrigation water was tube well (95.0 percent, 58.3 percent and 78.4 percent) followed by open well (3.1 percent, 43.5 percent and 52.6 percent). In Maharashtra 97.4 percent of farmers reported open well as the major source of irrigation, 74.6 percent and 10.5 percent of respondents source their irrigation water requirement from tube wells and lift irrigation from canal. There is a high degree of variation in the water sources for the sampled farms with some farmers accessing other sources as well.

Table 5.12 compiles the location of the respondent farms relative to the order of water flow from the sources. The benefits from adoption maybe impacted by the flow characteristics of the farm as well as other farms and therefore the location of the farm maybe an important variable influencing the responses. The table shows the distribution of location of farms in the sample as 71.1 percent in the middle, 23.30 percent in the head end and 5.70 percent in the tail end. Andhra Pradesh, Gujarat and Maharashtra showed a similar trend in majority of the land being located in the middle area of the command area. Tamil Nadu showed an exception with 84.3 percent of the farmlands at the head end probably due to higher levels of water scarcity.

Table 5.12 Location of respondent farms (state wise and combined)

Location of Farm	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Head end	12.7	4.7	10.5	84.3	23.3
Middle	84.7	86.8	84.2	7.2	71.1
Tail end	2.5	8.5	5.3	8.4	5.7

Thus we find that the profiles of respondents are very varied and no conclusions can be drawn with respect to the profile or adoption of drip irrigation based on the profile of the farms. This might go a long way in breaking many myths about drip irrigation adoption by only certain types of farmers by wealth, landholding, resource endowment or 'gentlemanly-ness' and it is difficult to conclude any of these. The sample shows only high variety in the profile and this indicates more equitable adoption than is commonly believed along any of the parameters indicated above.

The sample ratio of non-adopters to adopters is small enough to make these generalizations for the adopters from the overall sample results.

Chapter 6

Findings from the Primary Survey

This chapter presents the findings from the primary survey. These are collated and tabulated information from 499 respondents. This causes the impact of drip adoption on water, soil, irrigation practices, agriculture and agricultural economics, farm economics. It also presents the impact of irrigation practices on energy-irrigation nexus and the new technical issues associated with the drip adopter. The chapter concludes with the overall impact of drip irrigation.

6.1 Impacts on Water

6.1.1 Impact on Water Quality

The change in water quality with the popularity of drip is shown in Table 6.1. For the overall sample, around 41.4 percent or every 2 out of 5 respondents reported that the popularity of drip coincided with an improvement in quality of water. However more than half of the respondents (55%) responded that use of drip had no impact on quality of water. This trend was more pronounced in Gujarat (71.3%) and Tamil Nadu (88.5%). None of the farmers reported a sharp fall in the quality of water since the popularity of drip irrigation. The farmers in Andhra Pradesh (60.6%) and Maharashtra (57.9 %) reported that water quality had improved since the use of drip irrigation technology became popular.

Table 6.1 Quality of water since popularization of Drip Irrigation

Change in water quality over the years since drip became popular	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Large improvement	0.0	4.6	4.4	0.0	2.1
Improvement	60.6	21.3	57.9	9.2	41.4
No change	39.4	71.3	37.7	88.5	55.4
Deterioration	0.0	2.8	0.0	2.3	1.1
Sharp fall	0.0	0.0	0.0	0.0	0.0

The perception of farmers of the impact of drip irrigation on quality of water was also inquired. Table 6.2 collates the responses. Most farmers across the sample reported a high or medium impact. It is in interesting to note than one out of every ten farmers perceives the impact of drip irrigation on improvement of water quality to be very high. This number was nearly one in six farmers in Gujarat. More than 40% farmers perceived the impact to be high in Andhra Pradesh and Maharashtra. The impact was perceived to be medium by almost

44% farmers in Andhra Pradesh and 50 % in Gujarat. Three out of every five farmers in Tamil Nadu perceived the benefit on water quality to be low or very low.

Thus almost half the farmers perceived an improvement in overall quantity of water with the popularity of drip and more than 80% farmers believe drip irrigation has an impact on water quality. This implies a large proportion may lead to think/believe that larger adopter of drip will result in an improvement of water quality. However there are many other variables that could impact water quality as well.

Table 6.2 Perceived impact of Drip Irrigation on quality of water

DI is beneficial for water quality	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high impact	8.8	16.7	0.9	12.9	9.7
High impact	42.5	26.9	40.7	10.3	31.2
Medium impact	43.8	50.0	54.9	12.9	40.4
Low impact	4.4	0.9	3.5	20.7	7.2
Very low impact	0.6	5.6	0.0	43.1	11.5

6.1.2 Impact on Water Availability

The change in water availability with the popularization of drip irrigation was inquired. The enquiry was with respect to only time and the responses are collated in table 6.3 below. The popular perception was improvement in water availability coinciding with popularity of drip irrigation. 3 out of every 5 respondents said they coincide and one third of the sample feels there is no change. Over 40% respondents believed there was no change in Andhra Pradesh and Gujarat. Whereas almost 75% respondents in Maharashtra feel that there was an improvement in the water availability since the popularity of drip irrigation in the area.

Table 6.3 Change in water availability with popularity of Drip Irrigation

Change in water availability over the years since drip became popular	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Large improvement	0.6	7.4	8.8	2.4	4.5
Improvement	51.9	49.1	74.6	71.8	60.4
No change	46.9	41.7	16.7	24.7	32.5
Deterioration	0.6	0.9	0.0	1.2	0.6
Sharp fall	0.0	0.9	0.0	0.0	0.2

It was also enquired whether the farmers perceived drip irrigation to be beneficial for water availability and the responses are presented in table 6.4. Almost 95% respondents perceived drip irrigation is beneficial for water availability. In the overall sample 31.2% reported a medium impact, 35% a high impact and 28% a very high impact of drip irrigation on water

availability. In Tamil Nadu almost 80% of the respondents perceive a very high impact whereas the numbers are 45.6% for Andhra Pradesh and 38% for Gujarat. The response is most dilute in Maharashtra where 53% respondents perceive only medium impact and almost 40% perceive high or very high impact.

Table 6.4 Water availability benefit of Drip Irrigation

DI is beneficial for water availability	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	11.3	25.0	1.8	79.3	28.0
High	45.6	38.0	38.1	14.7	35.0
Medium	35.0	33.3	53.1	2.6	31.2
Low	6.9	.9	7.1	2.6	4.6
Very low	1.3	2.8	0.0	0.9	1.2

6.1.3 Performance of Drip as an Irrigation Technology and Impact on Water Situation

The success of drip irrigation as an irrigation technology can be assessed especially on two parameters – the timely and adequate availability of irrigation water. These were inquired and responses collected are presented in table 6.5 and 6.6. Around 55.5% of the respondents in the overall sample perceived a positive impact on the timeliness of water availability. This was similar to the impact as perceived in the states of Andhra Pradesh (51.3%), Gujarat (61.1%) whereas the positive impact was perceived by a very high proportion in Maharashtra (94.7%). However Tamil Nadu farmers have reported a perception of highly positive impact on timely water availability due to drip irrigation by 80.5% respondents. The trends are almost similar across the adopters and non-adopters (See Annexure 6).

Table 6.5 Timeliness of water availability with Drip Irrigation

Timely water availability	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	20.3	18.5	0.9	80.5	29.8
Positive	51.3	61.1	94.7	18.6	55.5
No impact	27.8	19.4	3.5	0.8	14.1
Negative	0.6	0.9	0.9	0.0	0.6
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.6 gives the tabulated responses to the adequateness of water availability with drip irrigation. Almost 60% of the respondents in the overall sample perceived a positive impact of drip irrigation on adequateness of water availability. The proportion was significantly higher in Maharashtra where 87.6 % saw a positive impact and in Tamil Nadu almost three

fourths of the sample perceived a highly positive impact on adequateness. A look at the disaggregated data across the overall sample shows more respondents amongst non-adopters having a highly positive perception compared to adopters who have a higher positive perception. It appears that the adopters are more balanced about their expectations but there seems to be a buzz about drip irrigation in the non-adopters (See Annexure 6).

Table 6.6 Adequateness of water availability with Drip Irrigation

Adequate water availability	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	10.1	18.5	0.9	76.1	25.4
Positive	63.9	61.1	87.6	22.2	58.9
No impact	25.3	18.5	10.6	0.9	14.7
Negative	0.6	1.9	0.9	0.9	1.0
Highly negative	0.0	0.0	0.0	0.0	0.0

It is expected that drip irrigation as a water saving technology, has a positive impact on the water table and the overall water situation in the village. The responses on these factors are presented in tables 6.7 and 6.8 respectively. Table 6.7 shows that a third of the overall sample did not report any impact on the water table whereas the remaining two thirds reported a high or very high positive impact on the water table. The impact was seen less positive in Maharashtra where 54% reported no impact and 43.4% reported a high impact. Contrasted with this is Andhra Pradesh where 14.6 % reported a very high impact and another 50% reported a high impact of drip irrigation on the water table in the region. In general in the disaggregated data the non-adopters had a very slightly dampened view of the benefit of drip irrigation and its impact on water table increase compared to the adopters. (See annexure 6)

Table 6.7 Positive impact on water table with Drip Irrigation

Water table increase	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	14.6	12.0	1.8	3.5	24.7
Positive	50.0	37.0	43.4	47.0	41.7
No impact	33.5	48.1	54.0	48.7	32.4
Negative	1.9	2.8	0.9	0.9	1.2
Highly negative	0.0	0.0	0.0	0.0	0.0

In response to perceptions of impact of drip irrigation on the overall water situation of the village 38.1% reported no impact whereas 53.8% reported a positive impact. Within states some variation was seen and more than half of the respondents in Gujarat reported no impact whereas about 53% report a positive impact in Andhra Pradesh and Maharashtra, the

proportion swelled to 75% of the respondents in Tamil Nadu. The disaggregated data of adopters and non-adopters showed nearly similar trends. (See Annexure 6)

Table 6.8 Overall water situation in the village with Drip Irrigation

Overall water situation in the village	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	5.1	4.6	0.9	3.6	3.7
Positive	53.2	33.3	53.1	75.0	53.8
No impact	41.1	54.6	44.2	11.6	38.1
Negative	0.6	7.4	1.8	9.8	4.5
Highly negative	0.0	0.0	0.0	0.0	0.0

The non-adopters reported higher performance expectation from drip irrigation vis-a-vis the adopters. This signifies a possibility that some non-adopters may not have adopted as they were let down by the performance against their own very high expectations. This indicated a need to correct the communication to the non-adopters and make them aware that drip irrigation is not a panacea for their ills (See Annexure 6).

6.1.4 Impact of Water Saving

The impact on water savings was inquired by asking if drip irrigation saves water and if it impacted the water quantity used for irrigating a farm. The responses are compiled in tables 6.9 and 6.10 respectively. A simple yes/no inquiry if drip irrigation saves water evoked overall 97.3% respondents to agree in a yes and not even a single farmer in Andhra Pradesh disagreed. It must be noted here that the overall sample included the non-adopters. The perception that drip irrigation saves water is very strong amongst both adopters as well as non-adopters alike. In table 6.10, it is seen that 44% respondents agreed that drip irrigation had a high or very high impact on reduction in water quantity used for irrigating a farm. The maximum proportion of respondents (about 40%) perceived only a medium impact. One fourth of the respondents of Gujarat reported a very high impact on reduction of water quantity used for irrigation.

Table 6.9 Saving of water on farms with Drip Irrigation

Drip irrigation saves water	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Yes	100.0	98.1	99.1	89.6	97.3
No	0.0	1.9	0.9	10.4	2.7

At the same time 19% respondents in both Andhra Pradesh and Tamil Nadu perceived a very low or low impact on reduction in water quantity used for irrigating a farm using drip

irrigation. This indicates a segment of farmers having adopted drip irrigation for reasons other than water saving.

Table 6.10 Reduction in water quantity used for irrigation with Drip Irrigation

Reduction in water quantity used for irrigation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	8.6	24.1	5.3	8.6	10.9
High	26.7	41.7	31.9	26.7	34.6
Medium	44.8	31.5	54.0	44.8	43.3
Low	19.0	2.8	8.8	19.0	11.1
Very low	0.9	0.0	0.0	0.9	.2

There is a very important facet of water saving with drip irrigation researchers have asked that what happens to the 'saved' water? It appeared that for many farmers the saving was notional and the 'saved' water was used up for other purposes within and off the farm. case studies corroborated this. The survey inquired the respondents what they did with the 'saved' water and the responses are collated in Table 6.11. The percentages do not add up to 100% as a farmer may put the saved water to more than one use.

That table shows most of the saving to be notional as two thirds (67.4%) of the respondents used the 'saved' water for irrigating more crops and therefore used it rather than save it from a resource conservation standpoint. 60.6% farmers used the saved water to expand the area under agriculture which is very beneficial to the farmer but does not really result in 'saving' the water from being used up. This surely improves the water productivity at an aggregate level. This often results in significant quality and yield benefits. Almost two out of every five farmers (37%) use the saved water to provide increased irrigation to the same crops. In a way these farmers make up for deficit irrigation in traditional irrigation techniques with the application of drip irrigation. One fourth (25.8%) respondents put the saved water to use for other agriculture and related purposes where 16.8% put it to non-agricultural uses as well.

Bringing new trends as responses, 10.8% or one out of every nine farmers report that the water was not used up and gets recharged and contributes to raising the water table in the region. This is a very promising result and might be partly due to the scale effects of drip irrigation with significant adoption in certain pockets. This has not been reported earlier from farm level studies. Another interesting observation is that in all states apart from Tamil Nadu, at least some farmers have responded that they were able to sell or share water with other farmers in need of irrigation water due to the adoption of drip irrigation. These two responses combined bring out a possibility that when drip irrigation is adopted at a scale within a region or area there are possibilities of real 'savings' of water as well both at the farm level and at

the area or region level as well. Theoretically real 'savings' are possible at the basin level as well.

Table 6.11 What happens to 'saved' water?

What happens to the saved water?	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Used for irrigating more crops	56.3	55.0	31.3	30.0	67.4
Used for expanding area under agriculture	70.0	36.9	64.4	23.1	60.6
Used for more irrigation to the same crops	28.1	21.9	6.9	47.5	37.0
Used for other agriculture and related purposes	53.8	10.6	45.0	9.4	25.8
Used for other non-agricultural purposes	41.9	6.9	8.1	.6	16.8
Water table rises	***11.3***	***18.1***	***1.3***	***1.3***	***10.8***
Used to share/sell to other farmers in need of irrigation water	*2.5*	*4.4*	*2.5*	*0.0*	*2.2*
Don't know/Can't say	2.5	4.4	1.9	.6	2.4

A look at the state wise responses tabulated in table 6. 11 reveal that the most popular use that saved water was put for expanding area under agriculture, irrigating more crops, for other agriculture and non-agriculture purposes in Andhra Pradesh and other states as well. The proportions were much lower in Gujarat for expanding area under agriculture, and very low for other agricultural and non-agricultural purpose. In Gujarat almost one fifth of the respondents reported that the water saved was actually allowed to recharge the water table. Amongst the states the maximum response to sharing or selling saved water to another (in need of) irrigation is maximum in Gujarat at almost 5%. The respondents from Maharashtra reported use for expanding agriculture and other agricultural purposes to be major consumers of saved water and the use for other non-agricultural purposes was restricted to less than ten percent responses. The primary use of the 'saved' water was for expanding the area under agriculture in Tamil Nadu and Maharashtra whereas in Gujarat for irrigating more crops and in Tamil Nadu the primary use was for providing more irrigation to the same crops. In Tamil Nadu the use for other agricultural and related purposes is restricted to negligible.

6.1.5 Impact on Water Distribution within the Farm

The technology of drip irrigation has often been appreciated for its ability to distribute water uniformly across a land parcel which causes other benefits like improvement in soil quality and compaction. The survey instrument inquired the impact of drip irrigation on the water distribution within the farm and the responses are given in table 6.12.

The respondents from the sample in Tamil Nadu perceived a highly positive impact (75.7%) of drip irrigation on equitable distribution of water to each crop whereas this figure was a 24.7% for the overall sample. This proportion was lowered in Andhra Pradesh and Maharashtra where 55.1% and 46.9% respondents respectively reported a positive impact instead of a highly positive impact. All the same in Maharashtra 51.3% respondents reported no impact of drip irrigation on the distributive equality within a farm. This proportion was 32.4% for the overall sample and 41.7% reported a positive impact in the overall sample. Overall, almost 66% reported a positive or highly positive impact.

Table 6.12 Equitable distribution of water with Drip Irrigation

Equitable distribution of water to each crop	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	5.7	22.2	1.8	75.7	24.7
Positive	55.1	49.1	46.9	11.3	41.7
No impact	36.1	27.8	51.3	13.0	32.4
Negative	3.2	0.9	0.0	0.0	1.2
Highly negative	0.0	0.0	0.0	0.0	0.0

6.1.6 Impact on Misuse/Abuse of Water and Conflicts

It is believed by many that a truly beneficially technology would result in behavioural changes for the better in farmers. The survey instrument therefore inquired the impact of drip irrigation on the misuse or abuse of water by farmers and also on the resolution of conflicts. The responses are tabulated in tables 6.13 and 6.14 respectively. Overall, the respondents perceived no impact (54.4%) on the misuse or abuse of water. This is similar to Gujarat (51.9%) and more pronounced in Tamil Nadu (85.1%). In Andhra Pradesh and Maharashtra, 49.4% and 50.4% of respondents, respectively asserted the positive impact of drip irrigation on the misuse / abuse of water. A look at the disaggregated results shows that the non-adopters have a higher proportion in the overall sample who perceive no impact and a lesser proportion of those who perceive a positive impact (see Annexure 6 Table 7).

Table 6.13 Impact on misuse/abuse of water

Misuse/abuse of water	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	7.6	9.3	0.9	0.0	4.7
Positive	49.4	23.1	50.4	12.3	35.3
No impact	39.9	51.9	46.0	85.1	54.4
Negative	2.5	15.7	2.7	1.8	5.3
Highly negative	0.6	0.0	0.0	0.9	0.4

Due the very nature of the resource and complexities in distribution of water across various users and uses conflicts around it are common and the amenability to reduce conflicts is also a measure of the success of an irrigation technology. The responses to the query about resolution of conflicts are given in table 6.14. 42.3% of respondents in the overall sample perceived no impact on the resolution of disputes whereas 54% reported a positive or highly positive impact. Out of the respondents in Gujarat 68.5% and in 54% in Maharashtra perceived similar. However, 44.9% of the respondents in Andhra Pradesh perceive a positive impact on the resolution of disputes while almost 88%of the respondents in Tamil Nadu perceived a positive or highly positive impact on the resolution of disputes. The disaggregated data shows a higher proportion of non-adopters (36.2%) than adopters (9.1%) perceived a highly positive impact especially in the sample from TN.

Table 6.14 Impact on resolution of disputes

Resolution of disputes	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	12.0	6.5	1.8	45.2	16.2
Positive	44.9	23.1	41.6	42.6	38.9
No impact	38.0	68.5	54.0	12.2	42.3
Negative	5.1	1.9	2.7	0.0	2.6
Highly negative	0.0	0.0	0.0	0.0	0.0

The non-adopters reported a higher expectation from drip irrigation vis-a-vis by the adopters on this criterion. The non–adopters expectation may be unrealistically high. The adopters perceive a more limited role of the technology in resolution of disputes (See Annexure 6). It seems the non–adopters see the technology as a panacea for all ills and therefore end up missing on what needs to be added on top of drip irrigation technology to make it successful on many of these non-technical criteria.

6.2 Soil Health and Quality

Adoption of drip technology is claimed to benefit the soil properties as well. This section compiles the information collected about the impact of drip irrigation on soil and its properties. The respondents were asked about secular changes in soil quality over the years on their farms since the popularity of drip technology. Table 6.15 gives us the compiled results. 44.8% of the overall sample respondents perceive an improvement in the soil quality and around 54% respondents in Andhra Pradesh and 62% respondents in Maharashtra had a similar opinion. But 51% of farmers surveyed in Gujarat and 90.5% of respondents in Tamil Nadu and an overall 52.4% did not perceive any change in the soil quality due to adoption of drip irrigation.

Table 6.15 Changes in soil quality since popularization of Drip Irrigation

The soil quality on the farm has changed over the years after drip became popular	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Large improvement	0.0	6.5	2.6	0.0	2.1
Improvement	53.8	40.7	62.3	9.5	44.8
No change	45.6	50.9	35.1	90.5	52.4
Deterioration	0.6	1.9	0.0	0.0	0.6
Sharp fall	0.0	0.0	0.0	0.0	0.0

Responses to the claim that drip irrigation is beneficial for soil quality or impacts it positively were also collected and are presented in table 6.16. About one fifth of the respondents perceived low or very low beneficial impacts on soil quality whereas more 70% perceive a high or very high beneficial impact. In TN a significant 44% responded a very low impact including non-adopters and another 24.1% to low impact. In Gujarat 17.6% reported a very high impact and another 38% high impact. Andhra Pradesh and Maharashtra had most of the responses split between medium and high benefits of drip irrigation to soil quality (Also see Annexure 6 – Table 10).

Table 6.16 Does Drip Irrigation benefit soil quality?

DI is beneficial for soil quality	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	6.9	17.6	1.3	4.3	7.4
High	46.3	38.0	41.6	9.5	34.8
Medium	40.6	39.8	52.2	18.1	37.8
Low	5.6	0.0	4.4	24.1	8.5
Very low	0.6	4.6	0.0	44.0	11.5

6.3 What Impacts the Success of Drip Irrigation?

The success of drip irrigation is also believed to get influenced by certain other factors and situations or situational conditions. Dependence of the success of drip irrigation on some of these where inquired and the responses are presented in this section. The factors include soil specificity, terrain specificity and the specificity to need for irrigation.

6.3.1 Soil Specificity

It was inquired if drip irrigation technology is successful irrespective of soil quality and situation or specific to soil types. Table 6.17 gives us the responses to the same. Responses revealed a wide variation in the responses. 32.8%, 33.4% and 23.5% of the overall respondents perceive a medium, high and very high success of drip irrigation irrespective of

soil quality and only 10% perceive low or very low success. In Andhra Pradesh more than 90%, in Gujarat about 90%, in Maharashtra and Tamil Nadu about 86% of the respondents perceive a medium or higher possibility of success of drip irrigation irrespective of the soil quality. This translates that most respondents reported the success of drip irrigation across soil quality and type.

The non-adopters perceive a higher expectation from drip irrigation vis-a-vis the adopters on this criterion. Thus there is a need to correctly communicate and set the expectations right such that they do not harbour false hopes as prospective adopters (See Annexure 6).

Table 6.17 Success of Drip Irrigation and soil specificity

DI successful irrespective of soil quality	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	10.6	36.1	4.4	48.3	23.5
High	37.5	29.6	33.6	31.0	33.4
Medium	44.4	25.0	49.6	7.8	32.8
Low	7.5	5.6	12.4	10.3	8.9
Very low	0.0	3.7	0.0	2.6	1.4

6.3.2 Terrain Specificity

Terrain of a particular village or farm could impact the success of drip irrigation technology. This was pursued in the survey and table 6.18 presents this information. 30.5%, 38.6% and 24.8% of the overall respondents perceive the success of drip irrigation irrespective of the terrain to be medium, high or very high respectively. In Gujarat 38.9% respondents perceive the success of drip to be very highly non terrain specific. The proportion is even higher at 50% in Tamil Nadu whereas in Maharashtra more than half or 52.25 respondents perceive only a medium success of drip irrigation technology irrespective of terrain. Thus drip irrigation appears to make a positive impact across all terrains.

Table 6.18 Success of Drip Irrigation and terrain specificity

DI is suitable to all terrains	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	11.3	38.9	1.8	50.0	24.8
High	45.6	31.5	41.6	41.2	38.6
Medium	36.3	23.1	52.2	7.0	30.5
Low	6.9	3.7	8.8	0.9	5.3
Very low	0.0	2.8	0.0	0.9	0.8

6.3.3 Irrigation need Specificity

Irrigation is not just a one-dimensional activity and the same or different farmers at different or points of time can have various and different irrigation needs. Drip irrigation also needs to be evaluated on the ability to serve a variety of irrigation needs successfully. Responses to this query are given in table 6.19. More than 35% of overall respondents were satisfied and another 22.6% highly satisfied that their varied irrigation needs were met by drip adoption. The number of those highly satisfied is maximum in Tamil Nadu at 68% and minimum in Maharashtra at less than 1%. Maharashtra also records 43.4% respondents who are dissatisfied with drip irrigation on this criterion. The non-adopters reported a higher expectation from drip irrigation vis-a-vis by the adopters on this criterion. (See Annexure 6)

Table 6.19 Drip Irrigation meets varied irrigation needs successfully

DI has met the varied irrigation needs successfully	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly satisfied	4.4	23.1	0.9	68.1	22.6
Satisfied	58.2	41.7	13.3	20.7	35.6
Undecided	34.2	33.3	39.8	9.5	29.5
Dissatisfied	3.2	0.9	43.4	1.7	11.5
Very dissatisfied	0.0	0.9	2.7	0.0	0.8

6.4 Impact on Irrigation Practices

Adoption of drip irrigation is claimed to change irrigation practices on the farm. The responses to this are collated and presented in table 6.20. Over 70% respondents ratify the claim. This trend is seen across all the 4 states. Maximum agreement is in Maharashtra (78.3%) and minimum in Tamil Nadu (57.3%). But on the whole the drip irrigation seems to impact irrigation practices significantly.

Table 6.20 Change in irrigation practices with Drip Irrigation

Irrigation practices changed due to adoption of DI	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Yes	74.4	64.8	78.9	57.3	70.1
No	25.6	35.2	21.1	42.7	29.9

6.5 Impacts on Agriculture and its Economics

The adoption of drip irrigation, due to the changing economics and its amenability to enabling shifting of cropping patterns and changing of many irrigation and agricultural

practices, is claimed to have a deep and massive impact on agriculture. This is pursued in this section through various inquiries.

Agriculture needs to adapt to various weather and other variables and factors outside the control of agriculture. It is often claimed that drip irrigation is one such technology that allows farmers to cope with weather and resource adversities. The following table 6.21 shows the responses to how adaptive agriculture became for the farmer with drip irrigation. More than 86% respondents perceive agriculture to become adaptive or very adaptive with the adoption of drip irrigation whereas one tenth of cannot decide upon the same. 72.6% and 68.75 respondents in Maharashtra and TN perceive the impact of drip irrigation to make agriculture highly adaptive. The proportion is significantly lower at 35.2% in Gujarat and even lower at 7% in AP but another\r 47.2% and 69.6% respectively reported that agriculture became adaptive post adoption. In the overall sample and for the state sub-samples as well the numbers who think that agriculture becomes less adaptive and more rigid post adoption of drip irrigation are a miniscule and negligible proportion.

Table 6.21 Adaptiveness in agriculture with Drip Irrigation

Assessment about the adaptiveness in agriculture with the popularity of DI	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very adaptive	7.0	35.2	72.6	68.7	42.5
Adaptive	69.6	47.2	23.0	27.8	44.3
Cannot decide	14.6	14.8	2.7	3.5	9.3
Rigid	8.2	1.9	1.8	0.0	3.4
Very rigid	0.6	0.9	0.0	0.0	0.4

Drip irrigation is expected to free up more water for use in irrigation and promote shift to less water intensive crops for both adopters and non-adopters. The responses to if drip irrigation popularizes less water intensive crops are recorded in table 6.22 below.

Table 6.22 Increase in area under less water intensive crops

Increased area under less water using crops	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	16.5	10.2	0.9	8.9	9.8
Positive	53.8	25.9	48.7	15.2	37.7
No impact	29.1	63.0	50.4	75.9	52.1
Negative	0.6	0.9	0.0	0.0	0.4
Highly negative	0.0	0.0	0.0	0.0	0.0

The table presents that 52.1% of the respondents believe it had no impact, whereas 46% felt it had a positive or highly positive impact. The impact seen is mildest in TN where only

8.9% find the impact highly positive and another 15.25 find it positive. In Maharashtra the impact is reported to be positive and hardly any farmer finds the impact to be highly positive. The maximum positive impact is reported in AP where 16.5% and 53.8% farmers perceive the impact to be highly positive and positive respectively.

It is also claimed by some farmers that drip irrigation helps to reduce the hassles in farming whereas other farmers claim that due to maintenance of the equipment and its technical nature the hassles increase. Table 6.23 collates the responses of farmers on the impact of drip irrigation on reduction of hassles in farming. 39.7%, 37.1% and 14.7% of the overall respondents perceived a medium, high or very high impact on reduction in hassles. In Gujarat 12% respondents reported a low impact on reduction in hassles whereas in TN 31.3% respondent farmers perceived very high impact in reduction of hassles in farming with the adoption of drip irrigation.

Table 6.23 Reduction in hassles with Drip Irrigation

DI reduces the hassles in farming	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	10.6	15.7	2.7	31.3	14.7
High	36.3	33.3	33.6	45.2	37.1
Medium	44.4	38.0	54.9	20.0	39.7
Low	7.5	12.0	8.8	2.6	7.7
Very low	1.3	0.9	0.0	0.9	0.8

The effectiveness of drip irrigation was inquired and the responses are collected in table 6.24. Around 35% of the respondents perceive high effectiveness and 25% very high effectiveness of drip systems. Around 70% respondent farmers in TN perceived the effectiveness of drip irrigation as very high. This number was only 2.7% in Maharashtra where 20.4% and 67.3% perceive high or medium effectiveness

Table 6.24 Effectiveness of Drip Irrigation

DI is very effective	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	11.9	24.1	2.7	69.6	25.8
High	48.1	38.9	20.4	27.0	34.9
Medium	31.9	32.4	67.3	1.7	33.1
Low	7.5	2.8	8.0	0.9	5.0
Very low	0.6	1.9	1.8	0.9	1.2

It was also enquired if drip irrigation was beneficial to farming as a whole. This was asked before we delve deeper into the specific benefits or impacts on agriculture further. Table 6.25 shows the responses and we find that 31.9%, 36.95 and 27.9% respondents found drip

irrigation to be medium, high or very highly beneficial to farming. In TN 68.6% respondents found the technology highly beneficially for farming where only 1.8% in Maharashtra perceived it as such and 60.2% as medium beneficial. The proportion of respondents who found drip irrigation technology highly beneficial for farming was 31% in Maharashtra, 36.1% in Gujarat and 50% in AP.

Table 6.25 Is Drip Irrigation beneficial to farming?

DI is beneficial to farming	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	12.5	33.3	1.8	68.6	27.9
High	50.0	36.1	31.0	25.4	36.9
Medium	33.8	29.6	60.2	4.2	31.9
Low	3.8	0.0	7.1	0.8	3.0
Very low	0.0	0.9	0.0	0.8	0.4

6.5.1 Pest Incidence, Diseases and Weeds

Some farmers and researchers claim that drip irrigation impacts the pest incidence and also the pesticide usage and the responses to the concerned inquiry are collated in tables 6.26 and 6.27. The overall sample shows a lot of variation and about one fourth of the respondents' perceived low or very low impact on pest incidence whereas another 36.3% perceived medium impact. Almost every two out of five respondents, perceived a high or very high impact. While there was a more favourable perception in Gujarat, it was milder in AP and Maharashtra whereas in TN more than three fourths of the farmers reported low or very low impact on pest incidence.

Table 6.26 Reduced pest incidence with Drip Irrigation

DI reduces pest incidence on crops	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	5.6	18.5	3.5	3.4	7.4
High	41.3	34.3	36.3	7.6	30.7
Medium	40.6	38.9	53.1	11.9	36.3
Low	10.6	3.7	6.2	34.7	13.8
Very low	1.9	4.6	0.9	42.4	11.8

Table 6.27 shows that about half the respondents perceived no impact of drip irrigation on the use of pesticides. At the same time about 41% perceived a positive impact on the reduction of usage of pesticides. This proportion was highest in AP at 51% and lowest in TN at 13.7%. Amongst those reporting no impact the proportion was highest in TN at 78.6% and lowest in Gujarat at 35.2% where the proportion of those perceiving the impact to be very high was maximum at 13%.

Table 6.27 Reduction in pesticide usage with Drip Irrigation

Reduction in pesticides use	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	6.3	13.0	1.8	0.9	5.4
Positive	51.3	49.1	46.9	13.7	40.9
No impact	41.1	35.2	49.6	78.6	50.6
Negative	1.3	2.8	1.8	6.0	2.8
Highly negative	0.0	0.0	0.0	0.9	0.2

If the claim on decrease in pest incidence and usage of pesticides due to drip irrigation is true then it is also expected to directly affect the cost of pesticides consumed. Table 6.28 presents that 50.2% respondents in the overall sample and 89% in Tamil Nadu perceived no such impact. However 55.7% in Andhra Pradesh, 48.1% in Gujarat and 50.4% in Maharashtra have perceived a positive impact on the cost of pesticides.

Table 6.28 Reduction in cost of pesticides consumed with Drip Irrigation

Cost of pesticides	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	5.1	10.2	1.8	0.0	4.3
Positive	55.7	48.1	50.4	3.5	40.7
No impact	34.8	38.0	44.2	88.7	50.2
Negative	4.4	3.7	3.5	7.0	4.7
Highly negative	0.0	0.0	0.0	0.9	0.2

Use of drip systems is claimed to reduce the moisture content in the plant canopy and this is in turn expected to reduce disease infestation in crops. Table 6.29 shows that 34.3% of the overall sample perceived a medium level impact alike 51.3% of respondents in Maharashtra and 42.5% in Andhra Pradesh. On the other hand 44.4% in Gujarat have reported a high reduction in the disease infestation and 19.4% a very high reduction. Yet 41.9% respondents in Tamil Nadu reported a very low impact on disease infestation by drip adoption.

Table 6.29 Impact of Drip Irrigation on disease infestation

DI reduces disease infestation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	6.9	19.4	3.5	1.7	7.6
High	42.5	44.4	38.1	6.0	33.3
Medium	41.3	31.5	51.3	11.1	34.3
Low	8.1	2.8	6.2	39.3	13.9
Very low	1.3	1.9	0.9	41.9	10.8

The impact of drip irrigation on the occurrence of weeds in the field was inquired and Table 6.30 gives the results. Around 40% of the overall farmer respondents perceived a medium

impact, 37.9% a high impact and 16.2% a very high impact. In the state samples from Maharashtra and Andhra Pradesh, a medium impact was prominent with 55.8% and 41.3% responses respectively. Tamil Nadu (38.4%) and Gujarat (38.9%) have observed a high reduction in weed occurrence due to adoption of drip systems and also 21.4% and 31.5% responses of a very high impact on weed reduction were reported.

Table 6.30 Reduction of weeds due to Drip Irrigation

DI reduces weeds during farming	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	12.5	31.5	1.8	21.4	16.2
High	38.1	38.9	36.3	38.4	37.9
Medium	41.3	27.8	55.8	33.0	39.8
Low	8.1	0.9	6.2	7.1	5.9
Very low	0.0	0.9	0.0	0.0	0.2

6.5.2 Fertilizer Consumption and Costs

Fertigation is often believed to be necessary to get the benefits of drip irrigation and was reported as highly beneficial by some farmers in the case studies as well. Table 6.31 reports that 45.3% of overall respondents perceived a high or very high impact on the reduction of fertilizer consumption. In Gujarat 24.1% perceive very high impact and another 38% perceived high impact. In Maharashtra 59.3% reported medium impact while 30.1% reported a high impact. Also 43.8% respondents in AP reported a high impact. However, 32.8% respondents in TN reported a very low impact and another 19% a low impact.

Table 6.31 Reduction of fertilizer consumption

DI reduces the fertiliser in farming	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	8.8	24.1	3.5	10.3	11.3
High	43.8	38.0	30.1	20.7	34.0
Medium	40.0	34.3	59.3	17.2	37.8
Low	7.5	3.7	7.1	19.0	9.3
Very low	0.0	0.0	0.0	32.8	7.6

Table 6.32 gives the responses to the perception about changes in costs of fertilizers consumed. Overall, 48.5% of the respondents reported no impact on the total cost of fertilizers consumed. However in Gujarat 18.5% observed a highly positive impact and another 50% perceived a positive impact. In the states of Maharashtra and AP these proportions were only 4.4%, 57.6% and 1.8% and 43.4% respectively. In Maharashtra and TN 54% and 80% respondents did not perceive an impact.

Table 6.32 Reduction in the cost of fertilizers consumed

Cost of fertilizers	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	4.4	18.5	1.8	1.7	6.3
Positive	57.6	50.0	43.4	15.5	42.8
No impact	35.4	27.8	54.0	80.2	48.5
Negative	2.5	3.7	0.9	2.6	2.4
Highly negative	0.0	0.0	0.0	0.0	0.0

6.5.3 Other Costs in Agriculture

It is seen in table 6.33 that more than half of the sample did not report an impact on the cost of harvesting (53% overall and 87.6% in TN). However in AP 10.8% and 44.9% respondents reported a highly positive and positive impact of drip irrigation on the cost of harvesting. In Maharashtra 56.6% respondents reported of positive impact on harvesting costs. The farmers argued that due to spacing and row crops, harvesting was faster and easier helping to reduce costs despite higher yields.

Table 6.33 Cost of harvesting with Drip Irrigated Agriculture

Cost of harvesting	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	10.8	8.3	1.8	1.8	6.1
Positive	44.9	39.8	56.6	2.7	36.8
No impact	41.8	49.1	38.9	87.6	53.3
Negative	2.5	1.9	2.7	8.0	3.7
Highly negative	0.0	0.9	0.0	0.0	0.2

In the case studies one of the major arguments put forth by the farmers for adopting drip irrigation was the reduction in labour requirement in farming with drip irrigation. Table 6.34 collates the survey responses to this impact of drip irrigation usage.

Table 6.34 Reduction in total labour due to Drip Irrigation

DI reduces the total labour used in farming	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	10.0	21.3	2.7	40.7	18.0
High	50.0	38.9	28.3	45.8	41.7
Medium	32.5	35.2	58.4	12.7	34.3
Low	7.5	2.8	8.0	0.8	5.0
Very low	0.0	1.9	2.7	0.0	1.0

Of the overall sample 18% reported a very high reduction, another 41.7% a high reduction and yet another 34.3% a medium reduction in labour due to the adoption of drip irrigation. Thus it is fairly certain that the adoption of drip irrigation reduced the labour use in

agriculture. However maximum responses for reduction and higher reduction were from Tamil Nadu followed by Gujarat and the minimum impact was seen in Maharashtra where labour intensive crops like grapes / banana had become popular thereby offsetting the gains.

If drip irrigation impacts the component costs then an impact on the total cost of farming should also be observed and these responses are presented in table 6.35. Overall 48.2% respondents observed a positive impact while another 6.9% observed a very positive impact of drip irrigation on reduction of costs of farming. However, in the overall sample another 42.1% observed no impact on the total costs of farming. Probably the gains were offset by other increases in either per unit costs or total consumption. Within the states more than half of the respondents in AP and Gujarat perceive a positive impact whereas more than half of the respondents in Maharashtra and TN reported no impact of drip irrigation on the total costs of farming.

Table 6.35 Cost of farming with Drip Irrigation

Cost of farming	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	5.1	16.7	3.5	3.4	6.9
Positive	53.8	50.9	46.0	40.2	48.2
No impact	36.1	29.6	49.6	54.7	42.1
Negative	5.1	2.8	0.9	1.7	2.8
Highly negative	0.0	0.0	0.0	0.0	0.0

6.5.4 Quality of Produce

A majority of respondents observed a positive (45.6%) or highly positive (20.9%) impact of drip irrigation on the consistency of crop growth as shown in table 6.36.

Table 6.36 Consistency of crop growth with Drip Irrigation

Consistency of crop growth	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	14.6	25.0	1.8	44.7	20.9
Positive	45.6	45.4	42.5	49.1	45.6
No impact	37.3	28.7	54.0	6.1	32.0
Negative	2.5	0.9	1.8	0.0	1.4
Highly negative	0.0	0.0	0.0	0.0	0.0

Around 60% in AP, 70% in Gujarat, 44% in Maharashtra and 94% in TN observed a positive or highly positive impact. However 54% respondents in Maharashtra reported the absence of any impact of drip irrigation on the consistency of crop growth in drip irrigated agriculture.

Almost 70% of overall respondents reported a positive (55.1%) or highly positive impact (14%) of drip irrigation on achieving consistency of produce quality. In Maharashtra around 50% of the respondents did not perceive an impact whereas in other state 68-87% reported a positive impact on consistent produce quality. This could be important for enabling cheaper and easier grading operation by farmer themselves.

Table 6.37 Consistent produce quality with Drip Irrigation

Consistency of produce quality	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	14.6	23.1	3.5	14.8	14.0
Positive	53.8	48.1	45.1	73.0	55.1
No impact	29.1	27.8	50.4	12.2	29.8
Negative	2.5	0.9	0.9	0.0	1.2
Highly negative	0.0	0.0	0.0	0.0	0.0

The impact of drip irrigation on the improvement of the produce quality is shown in Table 6.38. In AP, Gujarat and TN significant respondents reported a very high impact with 10%, 21.3% and 14.35 responses respectively in the three states. Almost 40% respondents in all states observed a high impact. However, overall around 42% observed medium level of improvement in the produce quality and similar proportions were observed in the states of Tamil Nadu (35.7%), Maharashtra (54%) and Gujarat (38.9%) and AP (40.6%) as well.

Table 6.38 Improvement of produce quality with Drip Irrigation

DI improves the produce quality	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	10.0	21.3	1.8	14.3	11.6
High	46.3	38.0	40.7	38.4	41.4
Medium	40.6	38.9	54.0	35.7	42.2
Low	3.1	0.9	3.5	11.6	4.7
Very low	0.0	0.9	0.0	0.0	0.2

Table 6.39 shows the impact of drip irrigation on the quality of the produce used for own consumption. Of the overall sample 47.8% of the respondents reported a positive impact. A similar trend was observed in Gujarat (42.6%), Andhra Pradesh (58.2%) and also Maharashtra (41.6%). However 54% respondents in Maharashtra and 75.5% in Tamil Nadu perceived no impact of drip irrigation on the quality of produce used for own consumption.

Table 6.39 Improvement of produce quality for own consumption with Drip Irrigation

Better quality produce for own consumption as well	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	9.5	13.0	3.5	4.5	14.8
Positive	58.2	42.6	41.6	17.3	47.8
No impact	31.6	39.8	54.0	75.5	35.6
Negative	0.6	4.6	0.9	2.7	1.8
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.40 provides us a snapshot of the responses to the query if drip irrigated agriculture resulted in better market prices for the produce. This is important as if the technology enables better quality produce then a price advantage should also be available to the farmers. However this will also depend on the market linkages and the quality of these market linkages. 51.5% of respondents observed no impact of drip irrigation. This was more pronounced in Maharashtra (54.9%) and Tamil Nadu (75.5%). However, a positive or very positive impact was perceived by 58.2% in AP, 57.4% in Gujarat, 45.25 in Maharashtra and 21.8% in TN. These are significant proportions considering that the proportion of adoption in these clusters has increased in the recent past thereby making more sense for integrating with the markets.

Table 6.40 Better market prices for Drip Irrigated produce

Better market prices for the produce	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	8.2	14.8	2.7	4.5	7.6
Positive	50.0	42.6	42.5	17.3	39.3
No impact	39.9	40.7	54.9	75.5	51.5
Negative	1.9	1.9	0.0	2.7	1.6
Highly negative	0.0	0.0	0.0	0.0	0.0

6.5.5 Other Specific Benefits of Drip Irrigation

One of the major criticisms of drip irrigation has been its specificity to row and spaced crops and preference for larger spacing to help reduce costs. Table 6.41 presents the snapshot of responses on this impact of drip irrigation and a very varied response was reported with 14.6% and 12% reporting very low and low specificity. At the same time 12.4% and 28.1% reported very high and high crop specificity of drip irrigation. 32.9% were undecided and observed medium level crop specificity. A little over half the respondents in TN reported very low specificity, 53.1% and 42.5% respondents in Maharashtra and AP respectively reported medium specificity whereas in Gujarat 32.4% and 24.1% reported very high and high crop

specificity. The farmers appear to believe that drip irrigation has lower crop specificity than most academicians think.

Table 6.41 Crop specificity of Drip Irrigation

DI is successful for only few crops	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	8.8	32.4	8.0	3.4	12.4
High	36.3	24.1	30.1	18.6	28.1
Medium	42.5	25.9	53.1	6.8	32.9
Low	10.6	9.3	8.0	20.3	12.0
Very low	1.9	8.3	0.9	50.8	14.6

Table 6.42 shows the responses to the perception that shift in varieties of crops is caused by adoption of drip irrigation. Of the overall sample 44% reported a positive relation and 9.5% a strong positive relation. At the same time 45.3% reported no relationship as such. These respondents are mainly from the states of Gujarat and TN (46.3% and 68.1% of the state samples). On the other hand in Gujarat one out of every six farmer respondents reported a strong positive relation and 55.7% in AP and 56.6% in Maharashtra reported a positive correlation between the adoption of drip irrigation and the shift in varieties of the various crops grown.

Table 6.42 Shift in varieties of crops grown due to Drip Irrigation

Shift in varieties of crops	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	10.8	14.8	2.7	9.5	9.5
Positive	55.7	37.0	56.6	22.4	44.0
No impact	32.3	46.3	38.9	68.1	45.3
Negative	1.3	1.9	1.8	0.0	1.2
Highly negative	0.0	0.0	0.0	0.0	0.0

One of the criticisms of drip irrigation is that it promotes mono-cropping whereas in the case studies farmers claimed that they are growing new crops and thus have increased the crop diversity on their farms. Table 6.43 collates the responses to the query regarding this impact of drip irrigation and more than half of the total respondents observed a positive impact on crop diversity. Gujarat stands out as an exception where 56.5% respondents failed to observe an impact on diversification of cropping pattern. The sample from Maharashtra was split into equal values of about 47% each reporting no impact or a positive impact. In TN almost 30% of the sample respondents reported a very highly positive impact on diversification of cropping pattern due to drip irrigation adoption.

Table 6.43 Diversification of cropping pattern due to Drip Irrigation

Diversification of cropping pattern	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	10.1	5.6	2.7	21.9	10.1
Positive	57.0	37.0	48.7	56.1	50.5
No impact	29.7	56.5	47.8	21.9	37.9
Negative	3.2	0.9	0.9	0.0	1.4
Highly negative	0.0	0.0	0.0	0.0	0.0

6.6. Impact on Irrigation Practices and Energy Irrigation Nexus

6.6.1 Impact on Irrigation Practices

Table 6.44 shows the responses about changes in irrigation practices. Almost 62% of the total respondents reported improved post-adoption irrigation practices. This impact was very strong and more positive in Maharashtra and TN where more than 90% respondents agreed or strongly agreed. The largest proportion of undecided respondents was in Gujarat at 30.6% but here also almost 65% agreed/strongly agreed to the improvement in irrigation practices.

Table 6.44 Adequateness of water availability with Drip Irrigation

Irrigation practices have improved after the adoption of drip irrigation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Strongly agree	2.5	13.0	40.4	46.3	21.9
Agree	83.8	51.9	52.6	45.0	61.9
Undecided	13.1	30.6	7.0	8.8	14.9
Disagree	0.0	3.7	0.0	0.0	0.9
Strongly disagree	0.6	0.9	0.0	0.0	0.4

It is intuitive to believe that drip irrigation improves the control on irrigation and the perceptions of respondents have been collected about this in table 6.45. Around 38.8% of the total respondents were satisfied and another 28.9% were highly satisfied with the control exercised on irrigation. The agreement is strongest in TN followed by Gujarat and weakest in Maharashtra where more than 16% were dissatisfied or very dissatisfied.

Table 6.45 Control on irrigation management with Drip Irrigation

DI leads to greater control to manage the irrigation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly satisfied	9.5	31.5	3.5	77.6	28.9
Satisfied	48.1	55.6	28.3	20.7	38.8
Undecided	38.0	12.0	51.3	1.7	26.9
Dissatisfied	2.5	0.9	13.3	0.0	4.0
Very dissatisfied	1.9	0.0	3.5	0.0	1.4

6.6.2 Impact on Energy Irrigation Nexus

Only 7.7 % of the total respondents agreed to having changed the size of pumpset post adoption. The proportion was higher in AP at over 14% and lowest in TN at less than 2% as given by table 6.46. This necessitates looking at other indicators to understand the impact of adoption on the energy irrigation nexus.

Table 6.46 Change in pumpset size with Drip Irrigation adoption

Did the pump size change post adoption of drip irrigation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Yes	14.4	8.3	3.5	1.8	7.7
No	85.6	91.7	96.5	98.2	92.3

As per table 6.47 about more than 30% respondents reported a decrease or sharp decrease in pumping durations post adoption and at the same time 12% reported an increase or sharp increase. More than half of the respondents (55.6%) reported an unchanged pumping duration. The maximum benefit of decreased pumping duration was reported in TN followed by Maharashtra and Gujarat respectively whereas a significant increase in pumping duration was observed in AP.

Table 6.47 Change in pumping duration with Drip Irrigation adoption

Change in pumping hours for irrigation using drip irrigation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Sharp decrease	1.3	8.3	5.3	0.0	3.4
Decrease	5.6	26.9	41.2	50.9	28.9
Unchanged	64.4	61.1	52.6	41.4	55.6
Increase	26.9	3.7	0.9	6.0	11.0
Sharp increase	1.9	0.0	0.0	1.7	1.0

As per table 6.48 about one fourth of the respondents reported a decrease or sharp decrease in the consumption of electricity for irrigation whereas a little over 12% reported an increase in consumption. The majority of respondents (60.6%) reported no observable change in the electricity consumption for irrigating the fields. The decrease was reported by maximum proportion of respondents in Gujarat followed by Maharashtra and TN whereas almost one third of the respondents in AP reported an increase in the consumption of electricity for irrigation. The fact that electricity is highly subsidised and often changed at flat tariff could also explain these responses.

Table 6.48 Change in electricity consumption with Drip Irrigation adoption

Change in electricity consumption for irrigation using drip irrigation	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Sharp decrease	0.0	10.2	1.8	1.7	3.0
Decrease	6.3	25.0	38.6	31.9	23.7
Unchanged	62.5	61.1	57.9	60.3	60.6
Increase	29.4	1.9	1.8	6.0	11.6
Sharp increase	1.9	1.9	0.0	0.0	1.0

As per table 6.49 more than two thirds of the respondents reported a medium to high impact in reduction of power used for irrigation. However there is a wide variation observed across responses from the various state sub-samples. Maharashtra had similar observation with around 62% respondents reporting a medium impact and another 25.7% a high impact. Andhra Pradesh and Gujarat reported a higher reduction in power used with 48.8% and 38.9% responses respectively. From Tamil Nadu the maximum numbers of respondents reported a low or very low reduction in power usage and they total to about half the respondents from the state.

The non-adopters reported a very high benefit in terms of power saved in irrigation with the adoption of drip irrigation but the adopters did not seem to perceive as much benefit probably as the benefit was offset by increased irrigation to same crops or other crops or other plots itself (See Annexure 6).

Table 6.49 Reduction in power usage with Drip irrigation

Reduction in power used for irrigating the fields	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	6.3	21.3	3.5	9.4	9.6
High	48.8	38.9	25.7	23.9	35.5
Medium	36.3	32.4	61.9	17.1	36.7
Low	8.1	5.6	8.8	17.1	9.8
Very low	0.6	1.9	0.0	32.5	8.2

6.7 Impact on Farm Level Economics

Table 6.50 shows that more than half of the respondents reported a positive or highly positive impact on water pricing post adoption in clusters. On the other hand 43.5% of the total respondents failed to perceive any such impact. More than half in Maharashtra and almost two thirds in Gujarat reported no impact whereas 57% in AP and 66.4% in TN reported a positive impact.

Table 6.50 Impact on water pricing

Lower prices/cost of water	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	6.3	6.5	2.7	5.2	5.3
Positive	57.0	25.9	44.2	66.4	49.5
No impact	35.4	65.7	50.4	26.7	43.4
Negative	1.3	1.9	2.7	1.7	1.8
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.51 shows that of the total 41.6% respondents reported a medium and another 38% high increase in cropping intensity. In TN 20.5% of the respondents reported a very high increase and another 35% and 37.6% reported a high and medium increase respectively. Gujarat and AP also reported a similar spread between very high, high and medium increases in cropping intensity due the adoption of drip irrigation.

Table 6.51 Is Drip Irrigation beneficial to farming?

DI increases the cropping intensity	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	13.1	18.5	0.9	20.5	13.3
High	44.4	33.3	36.3	35.0	38.0
Medium	36.9	41.7	52.2	37.6	41.6
Low	5.6	4.6	9.7	6.0	6.4
Very low	0.0	1.9	0.9	0.9	0.8

Table 6.52 shows that more than 60% of the total respondents reported a high or very high increase in total production from their farm post-adoption. However 45.4% in Gujarat and 53.3% in Maharashtra reported only a mild increase. Overall the production gain appears to be significant from drip irrigation.

Table 6.52 Increase in total production with Drip Irrigation

DI increases the total quantity produced	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	17.5	24.1	1.8	15.8	14.9
High	38.1	27.8	39.8	77.2	45.3
Medium	36.9	45.4	53.1	4.4	34.9
Low	7.5	1.9	5.3	2.6	4.6
Very low	0.0	0.9	0.0	0.0	0.2

Table 6.53 shows that one third respondents reported a moderate yield advantage whereas a little less than a half (46.6%) reported a high yield advantage. The perception of the yield advantage existed across all states however the perception was more widespread and stronger in TN and Gujarat as compared to AP and Maharashtra where it is more moderate.

Table 6.53 Yield advantage with Drip Irrigation

DI gives more yield	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	14.4	25.0	4.4	20.5	15.9
High	40.0	42.6	35.4	70.1	46.6
Medium	40.6	30.6	53.1	7.7	33.5
Low	4.4	0.9	7.1	1.7	3.6
Very low	0.6	0.9	0.0	0.0	0.4

Table 6.54 shows that almost two fifths of the total samples reported a positive impact and no impact of drip irrigation on the expansion of cropped area. Almost one fifth of the samples in TN and AP report perceiving a very high impact and another 60.7% and 41.8% respectively report a perceiving a high impact. A little over a half and slightly less than half of the respondents in Gujarat and Maharashtra perceived no impact. The survey reports a significant experience in cropped area due to adoption of drip irrigation.

Table 6.54 Expansion of cropped area with adoption of Drip Irrigation

Expanding cropped area	**Andhra Pradesh (%)**	**Gujarat (%)**	**Maharashtra (%)**	**Tamil Nadu (%)**	**Overall (%)**
Highly Positive	18.4	15.7	0.9	19.7	14.1
Positive	41.8	32.4	41.6	60.7	44.2
No impact	37.3	49.1	57.5	19.7	40.3
Negative	2.5	2.8	0.0	0.0	1.4
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.55 shows that almost three fifths of the total samples reported a high or very high impact of drip irrigation adoption on aiding the expansion of irrigated area. Almost one fifth of the samples in TN and Gujarat reported a very high impact yet 46.8% in AP and 38.9% in Gujarat, 39.8% in Maharashtra and 26.7% in TN reported no influence. No significant perception difference was noticed between adopters and non-adopters about this impact (See Annexure 6).

Table 6.55 Expansion of irrigated area with adoption of Drip Irrigation

Expanding irrigated area	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	5.1	18.5	0.9	19.0	10.3
Positive	45.6	42.6	58.4	54.3	49.9
No impact	46.8	38.0	39.8	26.7	38.6
Negative	2.5	0.9	0.9	0.0	1.2
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.56 shows that more than half the respondents reported a positive impact and another 10.7% reported a very high impact of drip irrigation adoption on the increase in area under high value crops. This is an important indicator for the prosperity story due to drip irrigation. The trend was similar across three states leaving Gujarat where 52.8% respondents reported a positive or highly positive impact and on the other hand 44.4% respondents perceived no such impact.

Table 6.56 Increase in high value crop area with adoption of Drip Irrigation

Increased area under high value crops	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly Positive	12.0	18.5	0.9	11.3	10.7
Positive	58.2	34.3	58.4	67.8	55.3
No impact	25.9	44.4	40.7	20.9	32.2
Negative	3.8	1.9	0.0	0.0	1.6
Highly negative	0.0	0.9	0.0	0.0	0.2

Table 6.57 shows that almost three fourths of the respondents observed that drip irrigation has helped them increase their incomes. The proportions of those who observed a highly positive impact were 23.1% in each of Gujarat, Maharashtra and TN (33.3%). 56.3% in AP observed the impact to be positive as well. Drip irrigation seems to have made a definite impact on increasing income of adopters and carving out a growth story for them.

Table 6.57 Increase in overall income with adoption of Drip Irrigation

Increased Income	**Andhra Pradesh (%)**	**Gujarat (%)**	**Maharashtra (%)**	**Tamil Nadu (%)**	**Overall (%)**
Highly positive	10.1	23.1	23.1	33.3	16.5
Positive	56.3	48.1	61.9	60.7	56.9
No impact	33.5	28.7	36.3	6.0	26.6
Negative	0.0	0.0	0.0	0.0	0.0
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.58 reports that most respondents had a positive outlook towards the role of drip irrigation in aiding income increase. (40% reported satisfaction and another 20% high satisfaction). In Maharashtra about half the respondents were undecided about this whereas in the other three states satisfaction existed but the level of satisfaction varied. 48.3% in TN and 26.9% in Gujarat were highly satisfied whereas in AP 60.1% were satisfied and another 8.9% were highly satisfied. No significant perception difference was noticed between adopters and non-adopters on this aspect (See Annexure 6).

Table 6.58 Role of Drip Irrigation in increasing income

DI has helped in increasing your income	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly satisfied	8.9	26.9	2.7	48.3	20.6
Satisfied	60.1	46.3	19.5	26.7	40.0
Undecided	27.2	21.3	53.1	24.1	31.1
Dissatisfied	3.8	4.6	21.2	0.9	7.3
Very dissatisfied	0.0	0.9	3.5	0.0	1.0

In Maharashtra almost three fourths of the sample did not see drip irrigation causing assurance of income. In the other three states and also the overall sample a positive impact was indicated by 43.9% respondents of positive impact and another 22.1% respondents reported highly positive impact in the overall sample. TN had 68.7% respondents reporting highly positive impact. No significant perception difference was noticed between adopters and non-adopters.

Table 6.59 Assured income with Drip Irrigation

Assured Income	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	10.8	11.1	0.9	68.7	22.1
Positive	64.6	51.9	27.4	24.3	43.9
No impact	24.1	36.1	70.8	7.0	33.4
Negative	0.6	0.9	0.9	0.0	0.6
Highly negative	0.0	0.0	0.0	0.0	0.0

An increase in assured income is expected to impact the savings and investment of the farmer if the household and occupational economics are in good health. Table 6.60 shows in the overall sample around 46% of the farmers did not observe any impact on their savings and investments. However about half the respondents in the overall sample observed positive or highly positive impact of drip irrigation on the savings and investments of farmers. 60.8% respondents in AP reported a positive impact. No significant perception difference was observed between adopters and non-adopters on this aspect.

Table 6.60 Increase in savings and investments with Drip Irrigation

Increase in savings and investment	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	0.0	10.2	0.0	17.2	9.9
Positive	60.8	38.0	28.3	37.1	42.8
No impact	26.6	48.1	70.8	45.7	45.9
Negative	1.3	3.7	0.9	0.0	1.4
Highly negative	0.0	0.0	0.0	0.0	0.0

Table 6.61 shows that more than 40% respondents reported a positive or highly positive impact on market power (in dealing with traders) where 54.2% respondents did not observe any impact on market power. In AP (47.5%), Gujarat (31.5%) and Maharashtra (47.8%) respondents reported a positive impact of drip irrigation on the market power of farmers. More adopters reported a positive impact than non-adopters and more non-adopters reported no impact compared to adopters. (See Annexure 6)

Table 6.61 Market power with Drip Irrigation

Better market power when dealing with traders	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	7.6	12.0	2.7	1.8	6.1
Positive	47.5	31.5	47.8	7.0	34.7
No impact	38.6	54.6	47.8	81.6	54.2
Negative	6.3	1.9	1.8	9.6	5.1
Highly negative	0.0	0.0	0.0	0.0	0.0

More than half of the total respondents reported a positive impact of adoption on the social status of the farmer. The respondents in Tamil Nadu (63.6%), Gujarat (43.5%) and Andhra Pradesh (56.3%) reported a positive impact whereas this number was 43.4% in Maharashtra where another 53.1% reported no impact. No significant perception difference was observed between adopters and non-adopters on this aspect.

Table 6.62 Improved social status with Drip Irrigation

Better social status	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly positive	2.5	23.1	2.7	5.1	7.6
Positive	56.3	43.5	43.4	63.6	52.3
No impact	37.3	32.4	53.1	22.9	36.4
Negative	3.8	0.9	0.9	7.6	3.4
Highly negative	0.0	0.0	0.0	0.8	0.2

6.8 Technical Issues Associated with Drip Irrigation Adoption

6.8.1 Issues Pertaining to After-sales Service

Some issues with the after sales service were reported by the farmers. More than half of the total respondents reported issues with availability of timely after sales service. While 18.5% respondents in Gujarat indicated very high satisfaction with the availability of timely after sales service, 27.6% in TN rated it low and another 39.1% very low. Maharashtra and AP showed more variation across their respective sub samples as in table 6.63.

Table 6.63 Timeliness of after-sales service

Timely after sales service was available	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	6.3	18.5	0.9	2.6	6.9
High	37.5	28.7	27.4	8.7	26.6
Medium	45.6	32.4	54.9	22.6	39.5
Low	10.0	13.9	11.5	27.0	15.1
Very low	0.6	6.5	5.3	39.1	11.9

There were also issues with the cost of the after sales service. As shown in table 6.64, from Gujarat a significant proportion of farmers responded to very high and also low and very low agreement that the after sales service was costly. While across the other states there was largely medium agreement but variation was rich indicating that after sales issues can still saddle an adopter.

Table 6.64 Cost of after-sales service of Drip Irrigation equipment

After sales service was costly	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	9.4	16.7	5.3	3.5	8.7
High	33.1	23.1	23.9	24.3	26.8
Medium	45.0	30.6	56.6	59.1	47.8
Low	10.6	16.7	13.3	10.4	12.5
Very low	1.9	13.0	0.9	2.6	4.2

Table 6.65 clearly shows that there were some issues with the quality of after-sales service in certain regions. Almost two thirds of respondents were not satisfied with the quality whereas in Gujarat some respondents were very highly satisfied with the quality. The perception of quality was also favourable in AP and medium in Maharashtra.

Table 6.65 Quality of after-sales service

Good after sales was available	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	5.7	15.7	0.0	6.8	7.6
High	42.8	20.4	29.2	5.9	28.9
Medium	40.3	42.6	58.4	18.6	37.1
Low	10.7	12.0	8.8	41.5	17.5
Very low	0.6	9.3	3.5	27.1	8.8

6.8.2 Maintenance of Equipment (also see Annexure 6 for disaggregated data)

Clogging of drip irrigation pipes was a problem for some farmers in Gujarat and Andhra Pradesh (18.5% and 15.6%) (Table 6.66). The variation in perception on this aspect was

noticeable and about 37% respondents in Tamil Nadu rated that the clogging of pipes in drip irrigation as low and another 25.6% as very low.

Table 6.66 Clogging of Drip Irrigation pipes

Clogging of DI is a big problem	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	15.6	18.5	4.4	9.4	12.2
High	37.5	16.7	31.9	13.7	26.1
Medium	38.8	40.7	55.8	14.5	37.3
Low	6.9	17.6	8.0	36.8	16.4
Very low	1.3	6.5	0.0	25.6	7.8

Also damage to pipes (as shown by table 6.67) was an issue for farmers in Gujarat and a dampener for adopters in AP, Gujarat as well as Maharashtra. However for farmers in TN the situation appeared to be different as they had evolved their own ways to reduce the damage to the pipes and more than 70% rate this problem as low or very low.

Table 6.67 Damage to Drip Irrigation pipes

Damaged pipes were a big problem	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	3.8	15.7	1.8	6.1	6.5
High	43.1	21.3	27.4	7.9	26.7
Medium	43.1	45.4	61.9	14.0	41.2
Low	7.5	13.9	8.0	43.0	17.2
Very low	2.5	3.7	0.9	28.9	8.5

Many farmers used the same equipment over a larger area by turning it over and relaying the pipes on different plots. This had developed as a standard practice due to the high initial cost of the equipment. The relaying was perceived as a hassle in parts of Gujarat whereas a minor problem in TN and also in the overall sample. Some incidence of these issues was reported in AP as well (Table 6.68).

Table 6.68 The hassle of relaying of pipes

Relaying of pipes is a big hassle	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	6.3	15.7	0.9	4.5	6.7
High	38.8	20.4	27.4	6.3	24.7
Medium	43.1	42.6	63.7	12.5	40.8
Low	9.4	12.0	7.1	44.6	17.4
Very low	2.5	9.3	0.9	32.1	10.3

A large proportion of farmers in the overall sample and also the states of AP, Gujarat and TN agreed that drip irrigation equipment was very easy to maintain. An even larger proportion

rated it mildly easy to maintain. Yet there were about 10% respondents who rated the ease of maintenance as low or very low. It appears that with popularization a lot of maintenance issues had been locally resolved and that tacit knowledge had been shared and made available to the farmers (Table 6.69).

Table 6.69 Ease of maintenance of Drip Irrigation equipment

DI equipment is easy to maintain	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	15.6	20.4	0.9	47.5	20.8
High	38.1	34.3	23.0	46.6	35.9
Medium	38.8	35.2	69.0	4.2	36.7
Low	5.6	8.3	6.2	0.8	5.2
Very low	1.9	1.9	0.9	0.8	1.4

Across all the inquiries on maintenance of equipment it was generally found that the perception of non-adopters treated it as more difficult to maintain compared to the adopters. The non-adopters had a more negative perception of after sales service than the adopters. These differences were more pronounced in Tamil Nadu than in other states. This is very intuitive and offers little comprehension of what is expected in this form. It does imply need for better communication of after sales services and their affordability.

6.8.3 Competence and Ease of Adoption

In the states of Gujarat, Maharashtra and TN there were large and significant proportion of respondents who rated the difficulty of learning to use drip irrigation as very low or low.

Table 6.70 Difficulty in learning to use Drip Irrigation

DI is difficult to learn	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	2.5	11.1	0.0	33.1	11.0
High	40.0	17.6	14.2	4.2	20.8
Medium	31.3	30.6	20.4	17.8	25.5
Low	21.3	17.6	35.4	22.0	23.8
Very low	5.0	23.1	30.1	22.9	18.8

However, almost 40% in AP and 33% in TN felt that the difficulty high or very high (Table 6.70). Thus there is a case for training the farmers for adopting drip irrigation and this is usually missing. Out of total non-adopters 31.5% reported learning to be very difficult whereas only 3.8% of the adopters observed this.

Mastering the use as an expert is another level and takes different tasks and skills to achieve when compared with learning to use the technology. Table 6.71 shows that a

significant proportion of farmers across all the sampled states reported the difficulty in mastering the use as high or very high. At the same time an equal or larger proportion of farmers reported it to be low or very low in Gujarat, Maharashtra and TN. Thus there is also a case for providing training for advanced users/advanced uses of the technology. The disaggregated data in annexure 6 shows that there was no significant difference in the responses of the adopters and the non-adopters.

Table 6.71 Difficulty in mastering the use of Drip Irrigation

DI is difficult to master	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	4.4	10.2	0.0	11.4	6.3
High	28.1	16.7	9.7	3.5	15.8
Medium	50.6	29.6	35.4	12.3	33.7
Low	13.1	21.3	31.9	50.9	27.9
Very low	3.8	22.2	23.0	21.9	16.4

Almost two fifths of the samples in each of the states reported that drip irrigation was highly or very highly cumbersome to use. This opens up the possibility to use psychometric segmentation in order to do targeted marketing of the technology. More importantly it signifies the need for handholding support for a sizeable chunk of farmers and also the scope for innovation in reducing the cumbersomeness of use of technology. The maximum proportion of farmers who found the use very less cumbersome was maximum in Maharashtra as shown in table 6.72. The disaggregated data in annexure 6 shows that 24.6% of total non-adopters reported drip irrigation to be very cumbersome against only 10% of adopters. Similar differences existed for different level of difficulty but the gap reduced between adopters and non-adopters.

Table 6.72 Is Drip Irrigation cumbersome to use?

DI is very cumbersome	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	22.5	11.1	0.9	20.7	14.7
High	26.3	19.4	19.5	23.3	22.5
Medium	28.7	29.6	19.5	8.6	22.1
Low	6.9	15.7	18.6	26.7	16.1
Very low	15.6	24.1	41.6	20.7	24.5

Almost 45% respondents in AP, more than half in Gujarat, one fifth in Maharashtra and TN reported that drip irrigation was a very costly technology. Also near about one fifth of the respondents in AP and TN found the technology not so costly as well. The famers indicated high returns as responsible for this perception.

Table 6.73 Cost of Drip Irrigation

DI is very costly	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very high	9.4	23.1	6.2	8.5	11.4
High	35.6	29.6	11.5	7.6	22.2
Medium	34.4	41.7	66.4	65.3	50.5
Low	16.9	2.8	11.5	14.4	12.0
Very low	3.8	2.8	4.4	4.2	3.8

6.9 Overall Impacts of Drip Irrigation

Despite that the technology has so many positives to offer, a large variation is observed across various aspects leading to, during and post adoption which combine to influence and impact the overall success of the technology. However the farmers overall view on the success of drip irrigation is also important as under certain conditions it can be treated as a proxy for willingness to adopt (but the results will be strictly conditional in nature).

Table 6.74 shows the collated ratings for the overall impacts and benefits provided by drip irrigation. Across the surveyed sample, the respondents were highly satisfied by the performance of drip irrigation (>90% of total sample). The satisfaction levels were higher in Tamil Nadu and comparatively lower in Maharashtra where also more than 95% respondents gave the overall rating of either satisfied or highly satisfied.

Table 6.74 Overall satisfaction with impacts and benefits of Drip Irrigation

Overall, the impacts and benefits provided by DI	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly satisfied	54.4	53.7	45.1	88.1	60.2
Satisfied	35.4	34.3	50.4	11.0	32.8
Undecided	7.0	10.2	4.4	0.8	5.6
Dissatisfied	2.5	1.9	0.0	0.0	1.2
Very dissatisfied	0.6	0.0	0.0	0.0	0.2

The sample appeared largely satisfied with the positive role of drip irrigation in helping farmers to achieve their larger goals as shown by the information presented in table 6.75. 27.2% of the total respondents rated a very high satisfaction level whereas another 49.6% rate a high level of satisfaction. However across the states there was some variation and almost three fifths of the respondents in TN were undecided if this was indeed true and only 9.7% in Maharashtra had rated a very high level of satisfaction. A high of 28.7% respondents in Gujarat had rated a very high satisfaction level on this count. A third of the respondents in Maharashtra had reported undecided on this aspect.

Table 6.75 Role of Drip Irrigation in helping farmers to achieve their larger goals

DI helps to achieve goals	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Highly satisfied	13.9	28.7	9.7	6.8	27.2
Satisfied	53.2	58.3	54.0	32.5	49.6
Undecided	28.5	13.0	33.6	60.7	21.2
Dissatisfied	4.4	0.0	2.7	0.0	2.0
Very dissatisfied	0.0	0.0	0.0	0.0	0.0

Table 6.76 shows the assessment about the success of drip irrigation. The assessment appeared more positive than the individual aspects about the same. Out of total respondents 44.6% assessed drip irrigation to be successful another 37.2% assessed it as very successful and 17.4% as satisfactory. The assessment indicates success throughout the states but the assessment was comparatively lower in Andhra Pradesh and Gujarat than in Tamil Nadu and Maharashtra.

Table 6.76 Is Drip Irrigation successful?

Assessment about the success of DI	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very successful	8.2	32.4	58.4	60.3	37.2
Successful	56.3	42.6	40.7	34.5	44.6
Satisfactory	32.9	25.0	0.9	5.2	17.4
Poor	2.5	0.0	0.0	0.0	0.8
Very poor	0.0	0.0	0.0	0.0	0.0

Conclusion

The study found the technology to make a lot of sense to economics of irrigation and also to economics of agriculture. However the latter appears to be conditional on certain other services and inputs such as better market linkages and ability to master the technology and adopt new and more effective irrigation and agricultural practices. The study also found that there are various stages of adoption and use of the technology and the farmers have various needs at various stages and this necessitates the roles of different actors at different stages to enable the farmers to harness full or better potential of the technology. Also there is a need to improve the procedures for availing the subsidies and handholding the farmers through it with the help of special purpose management vehicles. It is also found that while the economics seem to be very positive at the farm level, the realization of the water conservation benefits at the aggregate level is possible only when there are concentrated clusters of relatively high proportion of adoption such that the scale effects of micro irrigation technology appear and these effects are primarily of resource conservation type thereby showing that the technology has to potential to impact the resource conservation. This is

conditional and many more inputs apart from a mere subsidy financing are needed to achieve that scale and resource conservation benefits.

Chapter 7

Conclusions and Policy Recommendations

The results of the survey have been presented in the last chapter. Some of the major conclusions derived from the conclusions are presented here in this chapter.

7.1 Success of Drip Irrigation

It was found from the survey that 4 out of every 5 adopters rated the technology as good or very good signifying a very high level of satisfaction with the experience and results of the technology. Out of the many reasons for the high satisfaction levels was the impact of drip irrigation on making agriculture more adaptive. Adopters and non-adopters alike (89% and 81% as in figure 6) rated a positive impact of drip irrigation on agriculture. Thus it is clear that drip irrigation has emerged as one of the main coping mechanisms to protect the farmer and agriculture from the various problems that plague modern agriculture such as shortage of power, labour and also water. Figure 7 indicates the responses of adopters towards their assessment of success of drip irrigation and it is clear that most adopters rate DI as successful.

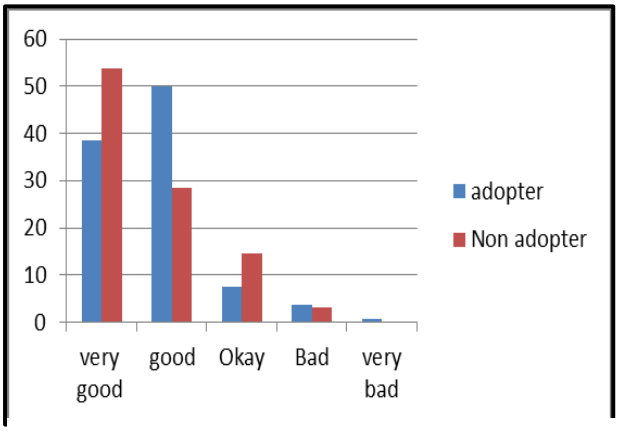


Figure 7: Drip and adaptiveness of agriculture

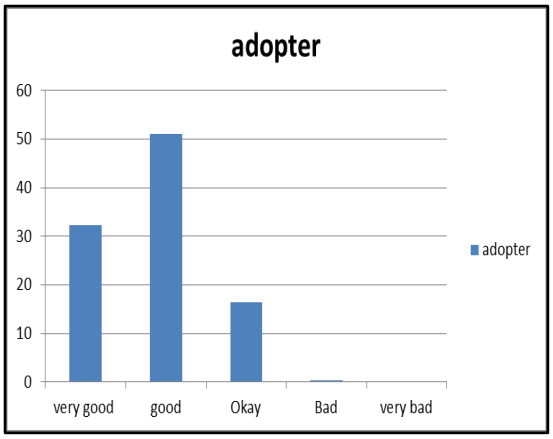


Figure 8: Success of Drip Irrigation

Drip irrigation needs a better financial model to ease adoption as is borne out by the result that only 16% adopters and 12% non-adopters agreed to drip irrigation as a financial proposition without subsidy. Subsidy acts as a sweetener and the responses jump to 46% and 42 % with the inclusion of subsidy in the package. Thus there is a need to work out better financial models to ease adoption of drip irrigation financially. This is shown in figures 8 and 9.

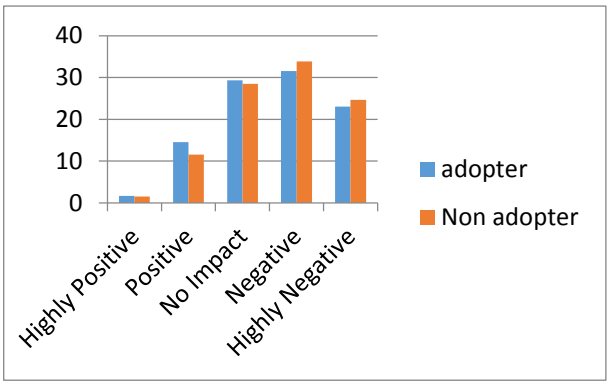


Figure 9: DI as a financial proposition

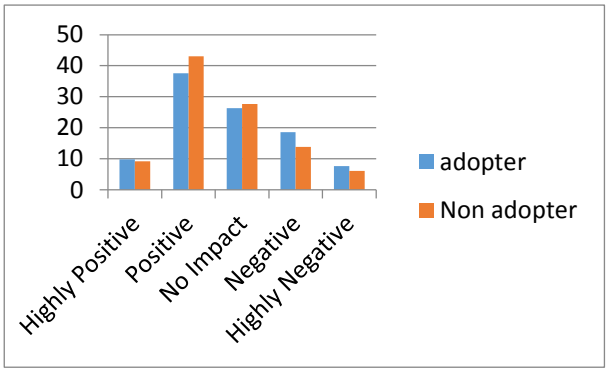


Figure 10: DI as a financial proposition with subsidy

7.2 Impact on Water Resource Conservation

7.2.1 Macro Level Impact on Water Resource Conservation across Space and Time

Drip irrigation definitely has a beneficial impact on water sources at various levels. Even at the macro level of the village and beyond about 60% of both adopters and non-adopters reported it to be beneficial for water availability. Also the impact on water table was observed by many farmers. More than 57% of the adopters and also 43% non-adopters observed the water table to have increased or improved. This is a very tangible measure for most farmers and it appears that the immediate impact for the adopter is more than that for the non-adopter but this also points out that as the percentage of adoption in a particular village or contiguous cluster increases the impact of water conservation in tangible form should be visible.

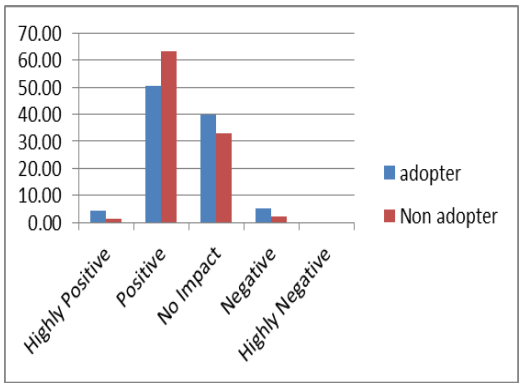


Figure 11: Overall water situation in village

However before the tangible impact on water resource becomes visible and observed there are many intangible observations which can bear testimony to the water conservation potential of drip irrigation technology. Almost 55% of adopters reported an improvement in overall water situation in the village (also 64% non-adopters) as shown in figure 10. Thus it can be believed that in villages or clusters with high adoption percentages the impact of water conservation is being perceived to have impacted the overall water situation of the village. This is a longer term variable than the immediate measure of water table.

About 70% of adopters and 38% of non-adopters reported that improvement in water availability was witnessed since drip became popular in the cluster of villages. This implies that if the adoption is fairly large scale (ensured by sample design and selection of clusters with high adoption) and continues for a significant duration across years the impact on water resource can be visible in many cases. However this is not confirmed as there is a significant difference reported by the adopters and the non-adopters. Thus the long term impact on resource conservations is not ascertained by this study.

7.2.2 Water Resource Conservation Impact at the Farm Level

Figure 11 shows 86.6% adopters and 99.23% non-adopters reported that drip irrigation results in water savings at the farm level. Such a high level of positive responses after years of adoption cannot be based on beliefs alone but has to be based on actual experiences of the farmers either on their own farms or on other farms and farmers that they have seen or interacted with.

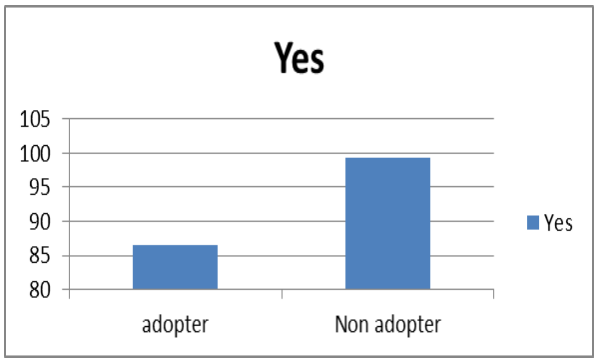


Figure 12: Water savings at farm level

The major conclusion of this report comes from the responses to the question that what happens to the 'saved water'? The responses show that in states like Maharashtra and Gujarat the major use of the saved water is used for irrigation more crops while in Andhra Pradesh it is used for expanding the area under agriculture. In Tamil Nadu the major use of the 'saved' water is for providing more irrigation to the same crops. There drip irrigation enables farmers to overcome deficit irrigation that they have been forced to practice so far. There are many other uses of the saved water as well. In Andhra Pradesh the water is also used for other agriculture related purposes thereby clearly signifying that the technology when adopted in a large scale and for a sustained period of time has the potential to conserve the resource across multiple uses in agriculture and related activities. There is also some evidence that the saved water is also used for other non-agriculture related purposes as used in Andhra Pradesh and Gujarat by a few farmers. At a very high adoption level the technology has the potential to influence and impact inter-sectorial allocations and consumption of water positively when implemented in the cluster mode.

In Gujarat and Andhra Pradesh an observation is made that the selling or sharing of saved or excess water with another farmer is also being done as this technology enables the

farmers to share the save water. However what is a bigger conclusion here is that under the present circumstances the farm level savings are lost to the alternative uses of the notionally saved water thereby resulting in no or very little real savings. At the same time based on results in section 7.2.1 and this section the technology clearly shows the potential for real savings. This is conditional on the large scale adoption (maybe within a cluster) and also sustained use of the technology over multiple seasons and years.

The technology is also able to impact the behaviour of users in a positive way as a significant proportion of respondents' report that the misuse of water has reduced due to the impact of adoption of drip irrigation. Also the technology has been found to help reduce the quantity of water used for irrigation. This is also impacted by the reduction in misuse of water and many other small savings which can help the technology and its impacts go a long way. Clearly the scale impacts of the technology are seen only in parts but should prove to be equally beneficial for resource conservation in the long run.

7.3. Drip Irrigation and Economics of Irrigation and Agriculture

7.3.1 Economics of Agriculture

The technology is shown to impact the economics of agriculture positively by virtue of various positive impacts. Some of these positive impacts are the increased number of crops per year that can be grown with the adoption of the technology as there is water available for the next season as well. The technology therefore helps to increase the cropping intensity and which itself results in higher income and better agronomics. The technology is also shown to help in expanding cropped area which also helps to derive advantages of economics of scale as well into the agronomics. The technology also helps to increase the yield from existing crops and thus it positively impacts the land productivity as well and therefore makes agriculture more profitable for the adopters.

The technology also has a direct impact on the prosperity of farmers as majority of adopters confirmed a positive impact on the income and increased incomes and not even a single disagreement was reported. Two thirds of the adopters also responded that the technology helps to assure income and also increase income thereby reducing the vulnerability for smallholders and ensuring progress for both small holders as well as large holders who have adopted drip irrigation. The technology has also enabled more than half the adopters to increase both savings and investments from the assured and increased incomes.

The impact of adoption is positive on reduction of total labour used on the farm. This helps in two ways – it helps the farmers to cope up with the shortage of labour being witnessed

across the villages and rural India. It also helps the farmer save a lot on labour costs in two ways – the labour days employed as well as the wage increase for agricultural labour. The technology also impacts the agriculture economics as well as the sustainability of agriculture by reduction of use of fertilizers which should have a positive impact on the economics as well as the soil quality. The respondents have also confirmed this with a similar response to the positive impact of adoption on total cost of farming as well as cost of harvesting thereby giving significant advantage in cost terms due to the adoption.

The technology also helps farmers to become more prosperous as it is shown to influence the adoption of high value and less water intensive crops. It also has a positive impact on water sustainability and productivity of agriculture. The technology also impacts the total quantity produced and this helps to increase the total revenues as well. The technology creates a steady stream of benefits on both cost and revenue side on a recurring basis to offset the initial capital expenditure.

The technology also helps to make agriculture more sustainable and profitable by having a positive impact on better market prices as well as better market power. Both of these impacts help the famers get a better deal out of the agricultural production in the markets and protect against the price risk which the technology cannot directly protect from.

7.3.2 Impact on Economics of Irrigation

The technology also has a positive impact on the economics of irrigation as it has a positive impact on the pumping hours required for irrigating a field. This helps save a lot of cost and energy as well and also helps to reduce the wear and tear of the pump and increase its longevity. This is enabled by the reduction in water quantity used for irrigating a field due to the implementation of this technology and this is perceived by both adopters as well as non-adopters.

However the cost of economics might work out but the resource conservation can take a hit as these savings in irrigation also help to expand the irrigated area thereby increasing the total water quantity used to earlier levels and also more energy will be required to irrigate the expanded area. Thus some of the benefits of drip irrigation in terms of irrigation economics can be lost as well for better farm economics. However to irrigate this expanded area without drip irrigation would result in considerable increase in draught of water which could have very detrimental environmental impacts. Drip irrigation helps to avoid such extremes.

The economics of irrigation is also positively impacted by the technology in many other indirect ways as it ensures adequate and timely water supply to the farm this helps take

away most of the variability of farming and productivity thereby assuring yield and productivity and revenue to the farmer. The assurance of yield and total production enables a farmer to enter into long term contracts and exercise greater market power as well.

The technology also has a positive impact on transaction costs of irrigation as it helps to reduce the conflicts and increases adaptability in irrigation. However the true economics of irrigation will be beneficial only once the scale of adoption in space and time is significant to transform savings into inter-farm and inter sectorial transfers even if only at the village or household level.

7.4 Limitations of the Technology

There is a divided house in terms of crop specificity of the technology and this imposes serious limitations in terms of spread of the technology. This can however be used to spread the technology in certain pockets or clusters based on amenable crops. It also suggests that targeted extension is needed for the spread of technology. The targeting being suggested due to high crop specificity would be crop specific targeting and extension. It also signifies that more research and development could be a possibility to help reduce crop specificity.

The technology is shown to have a very high potential and it can bestow at the various levels and to various stakeholder but it suffers from certain limitation as well which can take away the benefits that. After sales is still costly for many farmers and therefore hinders them from discovering or utilizing the full potential of the technology over a sustained period of time.

The technology experience post adoption is still to be smoothened for every farmer and a number of farmers face problems in terms of the clogging of drip irrigation pipes and filters as well as the damage to the pipes by various animals etc. or due to poor quality pipes. A significant proportion of farmers still find the technology very hassle-some and difficult to master.

7.5 The Role of Various Actors in the Adoption and Utilization Process

The role of various actors is shown in the table 7.1 given below. Multiple stages or steps in the processes were identified as first mention of the technology, increasing the awareness about the technology followed by convincing the farmer for adoption on the farm. The availing of the subsidy along with the adoption decision and the actual act of buying by making the choice of design and vendor and also the financing mechanism for the cost in excess of the subsidy amount.

Once the equipment has been bought and installed new agricultural practices need to be learnt in order to apply the technology successfully. Once the produce comes in, better marketing efforts are also needed to protect the farmer from price risks and other market risks. Beyond all this complete value chain there is still some high level tacit knowledge about the use of the technology or the agriculture as a whole with drip irrigation or the total farm economics which has to be understood and applied profitably to get the maximum out of the drip irrigation technology. Most farmers need considerable support with this.

The various actors considered here are neighbours, friends and family, drip dealers, drip company sales persons, government officials and institutions, bank officials and other financial institutions, the panchayat, and any others apart from these and also the community or the NGOs that are often active in the rural / agriculture space.

The table clearly shows that the government officials and institutions are prominent in their near absence across the various stages. The same is the case with the local government bodies i.e. the Panchayats. Some individual government officials do impact the adoption decision of farmers but they are few and far apart to create a huge impact in terms of the adoption of the technology. Thus, the government efforts need to be strengthened by either better focus or by involving more actors. It is also observed that neighbours are critical for getting information, building awareness and in the adoption decision as well as also in applying the technology on the farm and also the marketing and other associated functions. Thus new communication has to be developed which can help farmers by spreading the word faster through neighbours.

The drip dealers are important for the farmers as sources of information and awareness and the buying of the drip irrigation and also to some extent in availing the subsidy. The drip company salesperson act as an extension of the drip dealer but becomes more useful in availing subsidy and also for learning how to market better the produce from drip irrigated farms. The family and friends also play an important part. Thus apart from the sales channel the informal information channels play an important part in dissemination of information. This might mean that the strategy of official communication needs to change radically in order to cut some ice in the probable markets. The community and NGO have a unique and limited role to play in enabling the farmer to get the maximum out of the adoption and application of the technology. They are best suited to the role of knowledge delivering agencies and therefore need to be roped in for this activity only. They do not seem to be involved in the other tasks of spreading information and awareness about the technology or in convincing the farmer to adopt. They may be most useful post adoption. It may make sense to make

them partners in the after sales service as well but this needs to be conceptualized and worked out.

The table 7.1 suggests that an overhaul of the communication strategy of not just the government but also the private players is due after understanding the farmers' needs in the various stages better and finding innovative ways of fulfilling the needs.

Table 7.1: The role of various agents who had/have influence on the process of awareness, adoption and use of Drip Irrigation

Nos.	First Heard	Awareness	Convincing	Adoption	Subsidy	Buying	New Agriculture	Better Marketing	Get Maximum From Drip	Sub Total	%
Neighbours	218 (48.6)	113 (36.2)	96 (28)	110 (27.9)	59 (16.5)	70 (21.7)	131 (36.7)	132 (38.5)	129 (45.3)	1058	32.82
Community NGOs	16	12	7	10	13	8	6	9	37(13)	118	3.66
Drip Dealer	62 (13.84)	72 (19.3)	62 (18.07)	86	139	73	40	46	28	608	18.86
Drip Company Salesperson	58	68	54	49	72	54	43	50	25	473	14.67
Govt. Officials	25	27	36	53	17	25	24	12	6	225	6.98
Govt. Institutions	4	13	8	29	13	32	17	24	1	141	4.37
Bank Officials/ financial institutions	0	2	7	6	2	4	7	2	2	32	0.99
Panchayat	4	5	4	4	4	4	6	5	16	52	1.61
Family and Friends	48	47	54	38	31	40	50	41	31	380	11.79
Others	8	10	10	8	7	11	23	13	5	95	2.95
sub total	448	373	343	394	358	323	357	343	285	3224	100.00
%	13.90	11.57	10.64	12.22	11.10	10.02	11.07	10.64	8.84	100.00	

7.6 Subsidy and Related Issues

The subsidy amount is important to the farmers especially the smaller farmers in order to sweeten the financial deal of adoption of a costly technology. Table 7.2 shows us that there are still many farmers for whom the subsidy amount is still not enough and they number to close to half. The subsidy procedure is far from convenient as there are significant numbers either disagreeing with the convenience of current procedures or who are undecided or do

not know the procedures. A similar situation exists with the clarity of the procedure to avail the subsidy. Lack of clarity can go a long way in increasing the transaction costs and thus make the decision more difficult to take and also more adverse for more farmers. The duration of availing subsidy it still believed to be very long by most of the farmers and innovations are needed along with simpler procedures to reform this. A very major concern with the whole procedure for availing the subsidy is the perception of fairness associated with it. A very significant numbers of farmers are not convinced about the fairness of the subsidy procedures, thereby reduced the number of people who will want to avail the benefits of subsidy and adopt the technology. Subsidy or financing to make up for the investment is required before the start of the season and in the initial stages of adoption.

Table 7.2: Experiences with the process of availing subsidy for Drip Irrigation adoption

Item	Adopters agreeing	Adopters disagreeing	Non-adopters agreeing	Non-adopters disagreeing
The subsidy amount is enough	>52%	>30%	>52%	>23%
Convenient subsidy procedure	>49%	28%	>30%	>26%
Clarity of subsidy procedure	>39%	33%	>22%	>49%
Duration of availing subsidy	>29%	>41%	>16%	>51%
Fairness in the subsidy process	>38%	>32%	>27%	>48%

(*For more details see Annexure 7*)

7.7 Trainings and other Capacity Development Efforts

The awareness levels of farmers were very low for trainings concerning the use of drip irrigation and almost one third of the adopters felt the need for special training to be given for drip irrigation and to make it more profitable for farmers. This will help reduce the payback period for the farmers investments as well as the government social investment. Most of the farmers desire the involvement of more technical professionals in the process to ensure the technical soundness and quality of design and materials. They also want more economic issues to be understood and detailed priori to adoption.

The farmers are hopeful that the drip company salesperson can play a major and better role than at present in the whole adoption process and post adoption also. The inclusion of insurance is not understood by all farmers but many farmers prefer this by understanding that it can be a useful tool to absorb some adoption risks for the farmers to some extent.

Better after sales service and crop advice are well identified needs of the farmers to enhance adoption and use of the technology.

7.8 Other Issues

The time taken to process applications and approve the subsidies or financing of the excess cost and finally procuring and installing the equipment can be substantial for the farmer and as the subsidy cover is not full often a significant amount of investment is needed to be put in by the farmers and such lump sums are available with the famers only in certain parts of a year according to the agricultural seasons and cropping. Thus the farmers have a small window of time to effect the purchase of equipment and the systems should ensure that the time for processing of applications and purchase to installation of equipment can be executed in that window otherwise it will only add to costs of capital for the farmer and increase the idle time for capital invested.

7.9 Propositions Arising out of Summary of Results thus Far

The summarization of the results and larger trends from this study are given in the following diagram.

The results of the study tell that most farmers see other farmers or are forced by constraints to look for options to keep doing agriculture. Thus the first interest in the technology arises either due to the desire for the prosperity of others or due to the need to cope up with the constraints of either power, labour or water itself. Beyond this stage the adoption of drip irrigation results in a series of impacts.

As the farmers adopts in greater detail they need to master the technology in order to be assured of higher yields. Once better marketing facilities and interlinkages are made available to the farmers they can assure of better incomes. With the provision of better financial services they can invest and save better out of the assured incomes. This is the saturation axis in terms of saturation of the potential of the technologies.

Adoption also leads to impacts on the agriculture and irrigation including the state of the resource itself. The adoption of drip irrigation is often accompanied by either a shift in crops or in expanding the irrigated area. Either of these enables saving some water which in turn enables expansion of area under agriculture. If more water is saved and available due to scale or saturation it can be used for other agricultural uses Once scale is attained in this along with an increase in saturation achieved by each farmer, there will be more water

available which can be used for other purposes other than agriculture. This is the scale and saturation at which the technology starts influencing the inter-sectorial allocation positively.

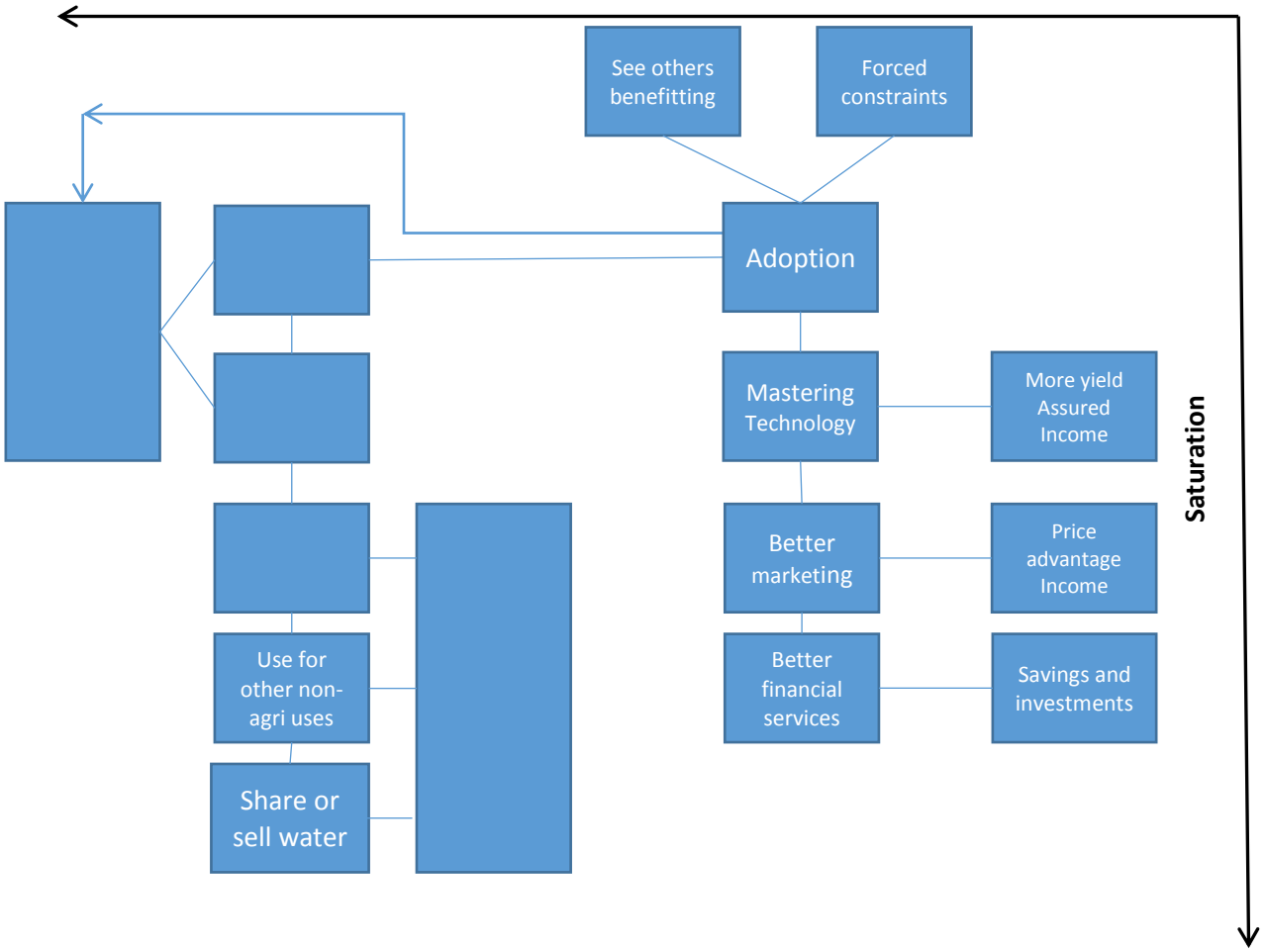


Fig 7.1: Study summary visual

Thus the true water savings will be effected from the technology only when both saturation and scale are achieved. These propositions need to be tested by further research.

7.10 Regression Model

In order the confirm the preliminary results obtained above a number of regression models were run on the database and the best fitting conceptual model was chosen and is presented in this section.

A number of dependent variables or measures as well as independent variables or causal antecedents (models) were tested. The best fit model is presented below. This model tests the correlations between various antecedent factors like costly DI systems, Benefit to farming, increase in cropping intensity, ex pansion of irrigated area and better market prices associated with drip irrigation adoption and the benefit to water availability as the dependent

variability. Four variables, namely age, education, caste and reliance on drip irrigation were used as control variables in the model as these could bias the responses for the other variables.

The model is depicted below:

Benefit to Water Availability α	*Control Variables:* i. Age ii. Education iii. Caste iv. Reliance on drip
	Independent Variables: i. Costly system ii. Beneficial for farming iii. Increase in cropping intensity iv. Expansion of irrigated area v. Shift in varieties of crops vi. Better market prices vii. Effective technology viii. Reduction in fertilizer consumption ix. Increase in area under high value crops

Water availability in general at an aggregate level is an indicator of the status of the water resource. If the various aspects of drip irrigation impact it positively a positive relationship will show up in the model.

The results of the simple linear regression model are given below in tabular format:

Model Summary					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	0.634	0.402	0.385	0.714	1.796

ANOVA					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	156.853	13	12.066	23.667	0.000
Residual	232.985	457	0.510		
Total	389.839	470			

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Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	156.853	13	12.066	23.667	0.000
Residual	232.985	457	0.510		
Total	389.839	470			

Coefficients				
Model	**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**
	Beta			**VIF**
(Constant)		2.336	0.020	
Age	0.048	1.238	0.216	1.158
Education	0.059	1.510	0.132	1.160
Caste	-0.071	-1.820	0.069	1.162
Drip reliance	-0.023	-0.578	0.564	1.224
Costly system	0.072	1.926	0.055	1.081
Effectiveness	0.113	2.492	0.013	1.571
Beneficial to farming	0.481	10.622	0.000	1.571
Reduction in Fertilizer Consumption	-0.065	-1.497	0.135	1.423
Increase in Cropping Intensity	0.054	1.338	0.182	1.237
Expansion of irrigated area	0.069	1.780	0.076	1.146
Shift in varieties of crops	-0.042	-0.967	0.334	1.427
Increase in area under High value Crops	-0.030	-0.729	0.466	1.286
Better market prices	0.038	0.992	0.322	1.117

This model, as we see in the results of the regression testing, is able to explain about 40% of the variation in the dependent variable. Thus in simple words it shows that the water availability benefit can be explained to an extent of 40% by the antecedent variables which are in turn impacts of drip irrigation adoption. Thus we find that drip irrigation through its various impacts influences water availability.

The variables significant in the model are as follows:

Control variables: Only 'caste' is significant and this is the only remnant of the gentleman farmer theory that prevailed earlier. Age and education are not found to be significant. The significance of caste may be due to differential subsidy benefits available for particular

castes only. This signifies that drip irrigation is no more limited to ‘gentleman farmer’ (rich, educated or large landholding).

Independent Variables: Costly System, Beneficial to farming, Expansion of Irrigated area and effectiveness of the drip equipment are the four significant variables at the 10% level. All four of the significant independent variables have a positive sign. This means that they are directly proportional.

As the effectiveness of the drip irrigation equipment increases and it becomes more beneficial to farming causing an expansion in irrigated area at the farm level (presumably a significant part of this is under drip irrigation), due to the expanded area the cost of the system would also rise apart from better quality systems costing more due to the better and more costly LLDPE being used as the raw material for the manufacture. Thus when these entire combine a net positive impact on the water availability is also observed.

7.11 Policy Recommendations

The following policy recommendations are made on the basis of the conclusions drawn from the results obtained from the extensive survey exercise.

1. Drip irrigation technology has the potential to show conservation effects but these effects are visible only when the adoption is large scale and preferably at a cluster level. This is contrasted with the economic benefits that are available at the farm level. Thus the government needs to focus on the cluster approach and focus on geographic pockets based on hydrology and crop economics (farm level) to get the best conservation impact from the adoption of drip irrigation. This also requires policies and institutional support which help farmers to regularly use the technology over a sustained period of time.
2. It also needs to be born in mind while framing agriculture and irrigation policies related to drip irrigation and its promotion that the technology impacts not only irrigation and its economics but also agriculture as a whole and its economics positively as well. Thus multiple benefits can be pooled in to get a better deal from the higher adoption rates and also to increase the adoption rates by benefiting the farm level adoption economics. In fact the benefits to agriculture appear to outweigh the benefits to irrigation alone and therefore the farmers need to be incentivized for better agriculture economics rather than for only water savings which appear at the cluster level and not at the farm level.
3. Drip irrigation aids more and assured income to the farmers and this opens up the possibility of using low cost drip irrigation technology as a tool to reduce vulnerability

and also for poverty alleviation for the vulnerable masses. This will need a radical shift and political will on part of the government as so far it has only dealt with the BIS certified high quality and high cost drip irrigation technologies.

4. There is an urgent need to create better market linkages in order to ensure better market prices for those adopting drip irrigation. The technology provides many advantages but provides very little price advantage or protection against price risks. This until the adoption is at a fairly large scale to stabilize the commodity market of a particular drip amenable crop. The current adoption rates are low due to this. Therefore there is a need for government participation for fulfilment of pre-conditions for an efficient market to function. One of the initiatives successful in setting up good marketing linkages forward in the value chain with drip irrigated farming was the SIMI project in Nepal (Smallholder Irrigation and Marketing Initiative) executed by the International Development Enterprises (IDE)
5. Drip irrigation currently suffers from many shortcomings such as costly after sales service. Thus there is a need to innovate in business models rather than innovate in the technology to overcome these shortcomings. The government should promote private entrepreneurs to take up the challenge of evolving the solutions for these challenges rather than control the business so tightly.
6. The crop specificity of drip irrigation must be borne in mind and therefore research funding has to focus in increasing the success with more crops whereas the awareness generation and information dissemination and communication should make use of such specificity and capitalize with a cluster approach overlaying on a crop specific cluster. This will ensure that farmers get their farm level benefits whereas the conservation impacts are realized at the cluster level with higher rate of adoption and sustained use of the technology by the adopters.
7. Drip irrigation has many nuances to it and therefore is not as easy to master by the famers which is why trainings are important to enable to farmers to benefit from the adoption of the technology and get maximum out of its application as well. The trainings will need to focus on not only the technical aspects but also on the managerial aspects like marketing and value chain fundamentals and institution formation to enable the farmers the best economic deal possible. The community and NGOs need to be roped in for achieving this.
8. It is recommended that the needs of the farmers in the various stages of adoption need to be understood better and also the role of various actors in each of these stages therefore defined and understood better. This is intended to enable more targeted an focused efforts at not only promoting drip irrigation but also ensuring that the farmers make the maximum profit out of drip irrigation. This is expected to help

us achieve the scale in a cluster such that the conservation benefits are also realized. The role of NGOs and the community institutions needs to be used by the drip companies more successfully and to leveraged for after sales service and also to maximize the financial returns for the farmers.

9. The bank and formal financial institutions and their personnel are prominent in their near absence in the drip irrigation adoption and utilization stages. Similar is the case of the government institutions. It appears they also need incentives to play the roles as exemplified by the special purpose vehicles in the states of Gujarat, Tamil Nadu and Andhra Pradesh. The special purpose vehicles partly acted like banks and financial institutions to increase the throughput with an eye on managing the subsidy funds in a manner such that maximum was achieved at minimum cost. This was based on simplification of procedures, reduction in change of hands for an application, using technology for faster processing and increasing trust to reduce corruption, and last but not the least in faster processing to increase throughput. The focus was on time productivity enhancement as well as employee productivity enhancement. This will be possible only when the policy in the respective state supports such an attempt as was the case with these three states.
10. The subsidy procedure is viewed as largely opaque, complicated and cumbersome as well as time consuming by many farmers and this calls for reforming policies to overhaul the subsidy procedure to make it more convenient , clear, faster and much more fair towards all sections of the society.

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Annexure 1: Micro-Irrigation in Village Chandrala (District – Gandhinagar)

Chandrala is one of the villages of Gandhinagar taluka in the state of Gujarat. The village is situated on the Ajmer highway around 25 kilometres away from its taluka main town and state capital, Gandhinagar. Ahmedabad, situated 47 kilometres away is the other major town. Chhalla (3 kilometres), Chilloda (14 kilometres) and Prantij (27 kilometres) are the other villages near Chandrala. Being located on the state highway, the village is well connected to the cities Ahmedabad and Gandhinagar which are also the main markets in its vicinity. The district of Gandhinagar is a part of the area called as northern plains of Gujarat which also consists of the districts Sabarkantha, Mehsana and Banaskantha. This region falls under the semi – arid zone and receives low rainfall (average rainfall is about 750 mm annually[6]). It is considered as one of the water scarce regions of Gujarat. The case study is based on informal discussion with farmers in Chandrala, MIS[7] dealers, Panchayat functionaries and other officials associated with MIS in the region. Secondary sources have been used to add information or to corroborate statements made by individuals wherever required.

The village of Chandrala is a decently big village located around 25 kms away from Gandhinagar on the Ajmer highway. As per Census 2011, the village had 779 households with a total population of 4417 (2124 males and 2293 females)8. Agriculture, animal husbandry, government services and local business are the major sources of employment for the villagers. The total number of farmers in the village is 269 and their distribution according to land – holding size is shown in the table 1 below. The total arable land in the village is around 1189 ha. Non-agricultural land (115 ha) and grazing land (34 ha) constitute the rest of the land in the village with forest and waste lands being negligible. The total The total arable land in the village is around 1189 ha. Non-agricultural land (115 ha) and grazing land (34 ha) constitute the rest of the land in the village with forest and waste lands being

Total Farmers	269
Marginal (less than 1 ha)	122
Small (less than 2 ha)	84
Medium (less than 10 ha)	62
Large Farmers (more than 10 ha)	1

Table 1: Farmers profile according to land holding size (as per panchayat records for 2010)

[6] Presentation on District Agriculture Plan/ State Agriculture Plan for Gujarat under RKVY by WAPCOS, 2008

[7] MIS refers to Micro – Irrigation Systems

[8] http://censusindia.gov.in/PopulationFinder/Sub_Districts_Master.aspx?state_code=24&district_code=06 (3rd May, 2012)

negligible. The total geographical area of the village is thus 1313 ha. The land use profile is shown in the table 2.

The average land holding in the village is about 4 ha. Thus most of the farmers have significant amount of lands. A unique feature of the village is its consolidated land holdings. Most of the farmers in the village have a consolidated block of land in one part of the village unlike a lot of other villages in India where small and dispersed land holdings are a norm9. The farmers in the village took benefit of a government of Gujarat scheme (under the Consolidation of Holdings Act, 1951) for the consolidation of land in the early 1970s. Under this scheme, farmers were encouraged to redistribute their land among family members or relatives in such a way that each one of them got a consolidated piece of land. The government helped the farmers by fast tracking the legal and documentation process which was done at the village level itself.

The scheme was also promoted by the district collector and other district officials amongst the villagers. Consolidated land holdings have various advantages like it gives farmers better economies of scale and it makes the farm amenable to mechanization. The biggest advantage for the farmers is the time and costs they can save in travelling from one plot to another. This also translates into better farm management over the contiguous plot of land. This is especially beneficial in the context of adoption of drip irrigation and also in order to increase are under drip irrigation. With better education levels, the newer generations are more aware about these benefits and hence, the land holdings have remained consolidated over the years. In many cases, the later generations have moved to cities leaving their parents to take care of the land or they have stayed back in a joint family system where the agricultural work can be shared amongst different members.

Total Geographical Area (ha)	1313
Forest Land (ha)	0
Wasteland (ha)	1
Non Agricultural use Land (ha)	115
Arable Land (ha)	1189
Grazing Land (ha)	34

Table 2: Land usage profile in Chandrala (as per panchayat records for 2010)

The major crops grown in the village are vegetables, cotton, wheat, castor and fodder with vegetables grown in almost 50% of the total cultivated area10. Mostly alluvial sandy loam to sandy clay soils is found in the regions which are known to be quite productive. This soil type is very deep, well drained and reddish brown in colour. The soil has good content of phosphorus and nitrogen but is deficient in some micro nutrients like

[9] http://www.thehindubusinessline.com/industry-and-economy/agri-biz/article2021516.ece (14th May, 2012)

[10] As estimated by farmers. Exact figures for area under each crop were not available.

zinc [Soils of Gujarat, INSEDA]. Most of the land in the village is irrigated and thus farmers are able to harvest 2 or 3 crops on their lands every year.

The gross cropped area of the village is 2018 ha with two crops harvested on 829 ha. Tubewells form the major source of irrigation in the village. A small part of the village (around 5% – 10%) also receives water from a canal through Himmatnagar (the hathmati canal system). The canal is only operational for a couple of months during the rabi sowing season and farmers use the canal water to grow wheat. The village has around 82 tubewells. A tubewell can be shared by 3 – 4 farmers and can irrigate up to 10 ha of agricultural land with a drip irrigation system. Some families living in farm houses or structures built on their farm lands also use water from their tubewells for their daily activities and household consumption. A large number of households in the village are also connected with tap water supply. The tap water supply is restricted to households in the main residential part of village and not to farmhouses. This tap water, provided through 2 overhead tanks, is only used for drinking and household purposes. The water in these tanks used to be pumped from government owned tubewells earlier but since the last three years, Narmada canal water is being supplied to the village.

There is a shortage of labour in the village especially for agriculture. A big portion of the labour currently employed in agriculture is from the village itself and comprises of the marginal farmers who do not have enough land to sustain the whole family. Thus the family diversifies into many occupations and agricultural labour is one such occupation. However with the later generations getting educated and moving to cities in search of better opportunities, the labour from the village has also reduced over the years. A part of the labour also migrates from slightly distant places like Santrampur in Gujarat and some districts of Rajasthan. However, migrant labourers from Rajasthan mostly work in industries where they get better wages and don't work in fields where wages are low (Rs 100 per day). Tribal labourers from Santrampur come in search of agricultural work and are preferred at times for their hard working nature.

According to some labourers, the adoption of drip irrigation by the farmers over time has been a part of the overall transformation of agriculture. Usage of machines like tractors for various operations like land preparation and sowing has increased significantly. Irrigation is taken care of by the drip irrigation systems which are amenable to fertigation thereby further reducing the requirement of labour for the same. According to these labourers, the only labour intensive activity on traditional crops is harvesting. However, the labourers are not against the adoption of drip irrigation as it has led to shift in cropping patterns towards more labour intensive crops such as vegetables and cotton and also the increased yields or

greater area under irrigated agriculture have made up for the loss of work. The labourers say that on a net basis the adoption of drip irrigation has not taken away work from them. The labourers also narrated that due to the adoption of drip irrigation and the non – availability of electricity at night, they don't have to go to the fields at odd times for irrigation activities now.

History of Irrigation and Adoption of MI in the Village

Wells and tubewells have been the major source of irrigation in the village since the 1970s when wells were first dug. Agriculture in the village was mostly rainfall dependent before that. However continuous extraction of groundwater since then has resulted in the water levels dropping drastically over the years. The water levels were around 40 – 50 feet in the 1960s which dropped to 500 feet in 2005. The region was declared a dark zone in 1995 when the water levels dipped to below 400 feet and since then, no new tubewells have been dug in the village. The village also has quite a few progressive famers with considerable land holdings who have adopted drip irrigation since 1989 – 90. The adoption of drip irrigation has continuously increased over the years with 61 farmers adopting drip irrigation in the last three years itself. The area under drip irrigation has also shown a corresponding increase with almost 32 ha, 39 ha and 53 ha covered in the village in each of the last three years till 201111. Currently, as per estimates by most of the farmers interviewed, 80% of the farmers in the village have now adopted drip irrigation in their fields. As more and more farmers adopt drip, the water level in tubewells has stopped reducing and is now almost constant at 500 feet since the last few years. This has led to the state government removing the village from the dark zone by a notification last year. However the situation in terms of groundwater availability is far from rosy. A study done by the Columbia Water Center[12] has documented the impact that excessive depletion of groundwater has had in the region. Groundwater levels have decreased drastically over the last few years and have gone below the Mean Sea Level (MSL) in a few places. This puts the aquifers at a risk of permanent salinization, thus making the water unsuitable for agriculture. Moreover, farmers are forced to spend huge amounts of money in digging deeper tubewells and buying more powerful pumps each year which in turn leads to higher energy consumption. Under this situation, the government has been forced to provide higher subsidies on electricity because farming would otherwise become uneconomical for the farmers. The study finally concludes that introduction of technologies with better water use and energy efficiency could be a solution of the problem. The government too has been giving subsidies on drip equipment since 1995 and that has helped encourage the adoption of drip irrigation particularly in the village Chandrala.

[11] As per records maintained at GNFC Depot, Chilloda

[12] Lall, U., Modi, V., Narula, K., Fishman, R., Polycarpou, L., *Addressing the Water Crisis in Gujarat, India*, Columbia Water Center, 2011

The setting up of Gujarat Green Revolution Company Limited (GGRCL) in 2005 also helped promote drip irrigation. The establishment of GGRCL has reduced the hassles faced by farmers for applying for drip irrigation and the overall processing time. The drip irrigation system is designed and delivered to the farmers' field in around 15 – 20 days of submitting an application to GGRCL. Moreover, GGRCL has helped integrate all schemes related to MI (e.g. RKVY, construction of tanks, etc.) so that farmers do not need to apply separately for availing different government schemes.

According to the farmers and the drip equipment suppliers, earlier there was rampant corruption and huge delays in processing applications for drip irrigation when the subsidy was availed through the panchayat on the gram sevaks recommendation. A farmer found it almost impossible to avail of the subsidy without oiling the officials. Also, as the subsidy was given to the farmer, he then had to pay to the manufacturer or seller which led to deduction of draft charges which were to be borne by him thereby adding a cost burden which is now removed. The subsidy is now provided to the seller/ manufacturer directly so that there is one transaction less involved and the farmer does not have to incur the draft charges. Also with the setting up of GGRCL, the process is much easier and faster and it does not have to wait for the oiling of offices for movement of the files. The processes exploit the use of technology for GPS based verification and CAD based designing for the drip irrigation system design. Also the use of technology has helped reduce the time and burden of paperwork across the chain and also enabled the merging of various subsidies to make them available for the farmers.

Support Structures and Institutions in the Village

The sharing of water from tubewells is monitored by informal investment partnerships set up by the farmers among themselves. The allotment of water to each farmer is done based on the total water requirement and the frequency of irrigation required in the fields. With furrow irrigation, a farmer usually irrigates his field once in 8 – 10 days while with drip irrigation, water has to be pumped for around 1 hour in every 2 – 3 days. Thus, with the adoption of drip irrigation, the system of division of water has undergone a change amongst the farmers. In most cases, farmers are aware of the benefits of drip irrigation and the all the farmers sharing water from a tubewell have adopted drip irrigation in their fields which makes the water distribution system simpler. In cases when some farmers have adopted drip while others use furrow irrigation, particular days are assigned to farmers for furrow irrigation. Rest of the farmers using drip irrigation can run the borewells to irrigate their fields as per their requirement. This would also encourage the use of drip irrigation as the farmer can irrigate a

larger land area in the same or lesser time duration. Moreover, labour required for irrigation in the case of drip irrigation is much lesser.

Though, earlier electricity was supplied for 14 hours, it is now available to the farmers for only 8 hours every day. Misuse of electricity by fixing jumpers has also reduced since the last few years. This may be attributed to increased awareness among the farmers as well as some steps taken up by the Gujarat Electricity Board such as different voltages in different phases at a time so that use of jumpers is difficult and inefficient.

Various dealers have set up shop in the village for selling MI equipment for different companies like Jain Irrigation Systems and Harvel Agua India. Netafim has its dealer in Chilloda. Most of the farmers have bought their equipment from Netafim and Jain Irrigation. Some farmers have also bought it from Harvel Agua India. The dealers help farmers fill up the forms required for setting up the drip irrigation in their fields. They also help them with minor repairs and replacement of parts in case of problems. The companies also send in their engineers for the GPS survey of the farmers' field and designing the system according to their needs. Some of the designing activities are taken up by the dealers themselves, thus making the process faster.

The huge initial investment required for setting up a drip irrigation system is one of the main hindrances that farmers face. Even after availing the government subsidy, the farmers have to spend around Rs. 60,000 from their own pockets. Though the larger farmers can fund the cost themselves, some farmers also avail loans from the banks (at 13% interest) or the much cheaper Kisaan Credit Card (4% interest) loans can be channelized to pay for the drip equipment purchase. On an average, the total cost of a drip irrigation equipment turns out to be around Rs. 1,20,000 per ha. The government subsidy (through GGRCL) for micro – irrigation is about Rs. 60,000 per ha. The cost of MIS equipment as well as the subsidy is decided based on various parameters like the shape of the field, jantri rates, spacing of crops, location of water source and the salt and minerals content in the water. Farmers using drip irrigation for cotton cultivation are also eligible for an additional subsidy of Rs. 20,000 per hectare up to a maximum of Rs 40,000 under the RKVY scheme for cotton. Besides these, farmers may avail additional subsidy on construction of tanks for micro – irrigation based on some standard sizes (See Annexures). Tribal farmers in the state receive an additional subsidy of 50% of the subsidy given to other farmers. The actual costs and subsidies for a typical non – tribal farmer in Chandrala are shown below.

Name of the farmer	Patel Ambalal Jethidas
Crop Grown	Cotton
Lateral Spacing	1.40 m
Total Land Area	1.41 ha
Total MIS Cost	**1,83,594.96**
Head Unit Cost	18,865.19
Field Unit Cost	1,61,941.40
Other Costs (Consultancy, Installation, Insurance, Taxes)	2788.37
Subsidy Approved by GGRC	75,276.38
Subsidy under RKVY	28,200
Total Subsidy	**1,03,476.38**
Difference amount to be paid	**80,119.00**

Table 3: Costs and subsidies on MIS for a typical farmer in Chandrala (as per dealer records)

Presence of major urban markets like Gandhinagar and Ahmedabad in the vicinity of the village has played an important role in ensuring better price realisation for the farmers right at their farm gates especially for vegetables. Since 2007, Reliance Fresh – an organized food and grocery retail chain, has set up its collection centre just three kilometres away from Chandrala on the Talod road near Majra. Farmers prefer selling their produce at this collection centre as they get better prices without any delays. However, Reliance Fresh buys these vegetables only in limited quantities as per their demand and that too of only the best quality. Hence, farmers also sell their vegetables in Jamalpur and Kalupur markets of Ahmedabad. The prices in these markets are typically lower by about Rs 1 – 2 per kg as compared to the prices offered by Reliance Fresh. Cotton is directly sold either in the market at Mandsa or to milling and ginning factories situated in Tajpur which is 7 kilometres from Chandrala. Easy access to markets may have played an important role in better price realisation for the farmers as according to some farmers, they are now able to earn up to Rs. 3,00,000 per hectare of land annually with a drip irrigation system.

Besides these, there aren't any government or non – government agencies monitoring the status of agriculture or irrigation in the village. Gujarat State Watershed Management Agency (GSWMA) has just set its office up in the village six months ago. It will take up projects related to watershed development for the improvement of groundwater resources in the village. Also, GNFC has set up its depot in Chilloda and oversees the implementation of MI in the entire region. Each farmer setting up a micro – irrigation system has to sign a tri – party agreement with the MIS supplier and the GNFC depot. Village wise records of farmers adopting drip irrigation are maintained at each depot. The depot also takes up the task of

promoting MIS amongst the farmers. Promotion is mostly done through word – of – mouth and pamphlets or other promotional material distributed to the farmers in person or during melas and festivals organized in the village. The Venn diagram showing various institutions in Chandrala is depicted on the following page (Figure 1).

Benefits and Impact of MI

The drastic reduction in groundwater levels in the village has played an important role in encouraging farmers to use drip irrigation in the village. They have also benefitted out of it as the water level has remained constant for the last few years arresting the sharp decline in water levels witnessed earlier for more than 3 decades. Besides the perception of water saving, increase in quantity and quality of the yield is the major reason why farmers have adopted drip irrigation. According to some farmers, they have managed to increase the yield of vegetables like tomatoes and bottle guards by up to 20 – 30% on the same land. Also, the quality of produce with drip irrigation is much better than with flood irrigation there are no mud or water spots on the fruit as is usually the case with flood irrigation. Farmers are able to get up to 20% higher prices for their yield with drip irrigation. The restriction on electricity supply for duration of 8 hours every day may also have played a role in changing the mentality of the farmers towards water availability.

Farmers have also observed better water use efficiency as they are now able to irrigate almost twice as much area as they were able to irrigate without a drip irrigation system (3 acres earlier to 5 – 6 acres now with 8 hours of electricity). Thus, most of them are of the view that with drip irrigation the quantity of water used for irrigation may not reduce but a larger area can be irrigated. However, even with substantial adoption, groundwater levels in the village have only remained constant and have not increased as according to the farmers, ground water level may also be dependent on various other factors like amount of rainfall in the region, seepage through the hard rock surface and overflows.

Though some farmers suggested that there was no savings on cost of fertilizer, they did mention that drip irrigation helps reduce the government's subsidy bill as there is no subsidy on water soluble fertilizers used with drip irrigation. Most farmers in the village are using fertigation with water soluble fertilisers. Also, there is a labour shortage in the village and farmers' have been able to reduce their labour requirement by using drip irrigation. The savings in labour is mainly because there is no weed growth and labour is not required for irrigation.

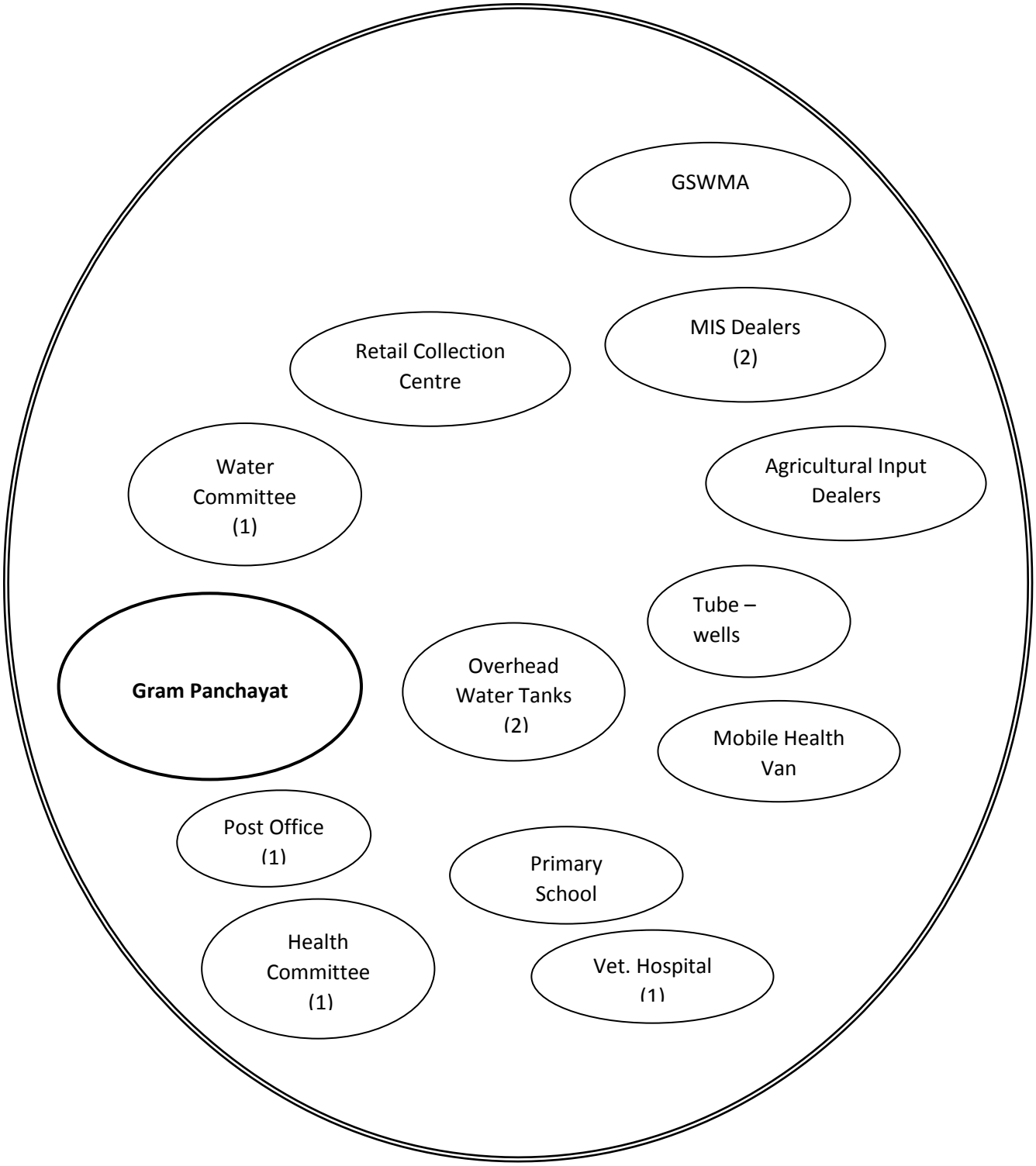


Figure 1: Venn diagram of institutions in Chandrala

The adoption of drip irrigation along with various enabling factors like consolidated land holdings, easy access to markets, etc. have clearly had a positive impact on the village. Farmer incomes have seen a substantial increase in the last few years since they have shifted to vegetable cultivation from wheat and paddy cultivation. Most of the farmers are aware of the impact of drip irrigation and do not hesitate in investing huge amounts to set up the system on their entire farms all at once. In fact, farmers with large land holdings have also experimented with growing exotic vegetables and flowers under polyhouses.

Farm Economics with Micro-Irrigation

Our interactions with various farmers in the village revealed that mostly farmers owning more than 10 – 12 bigha13 of land own a tubewell in the village as only they can afford to invest Rs 8,00,000 to Rs 10,00,00 required to construct the tubewell which is 550 feet deep. The other farmers, who do not own a tubewell, buy water from these farmers at fixed rates which depend on the water drawing capacity of the motor. A farmer using a 50 HP motor may charge up to Rs 70 per hour for the water supply. However, such transactions only happen occasionally for a couple of reasons:

A farmer can irrigate around 20 – 25 bigha of land in 8 hours with a 30 HP motor without using a drip irrigation. With drip irrigation, the area covered may go up to 30 – 35 bigha. Hence, if a farmer has more land than what can be irrigated in 8 hours, he may have to construct a larger tank to store water and may not able to share water with his neighbours

These transactions also depend on the relationship shared between the two farmers. Larger farmers would prefer giving water to their friends or relatives and so, some smaller farmers are not able to buy water from their farmer neighbours.

Thus, some of the smaller farmers who do not own a tubewell can harvest only one crop during the rainy season. During the Rabi season, they may sometimes also grow crops like castor or jowar (for fodder) which need to be watered only a few times. Such farmers prefer growing vegetables like ladies finger, bottle gourd or bitter gourd as compared to cotton or wheat mainly because of the returns that they get on their investment. The risk associated with cotton or wheat is much higher than that for vegetables as explained in the example of Jayantibhai. Jayantibhai is a farmer owning around 4 bigha of land in Chandrala village. He does not own a tubewell and buys water from his neighbours. He mostly grows vegetables in his farm because he cannot take the risk with cotton or wheat. Cotton is a long duration crop. A requires higher investment on fertilizers and seeds. Moreover, it often gets infested by

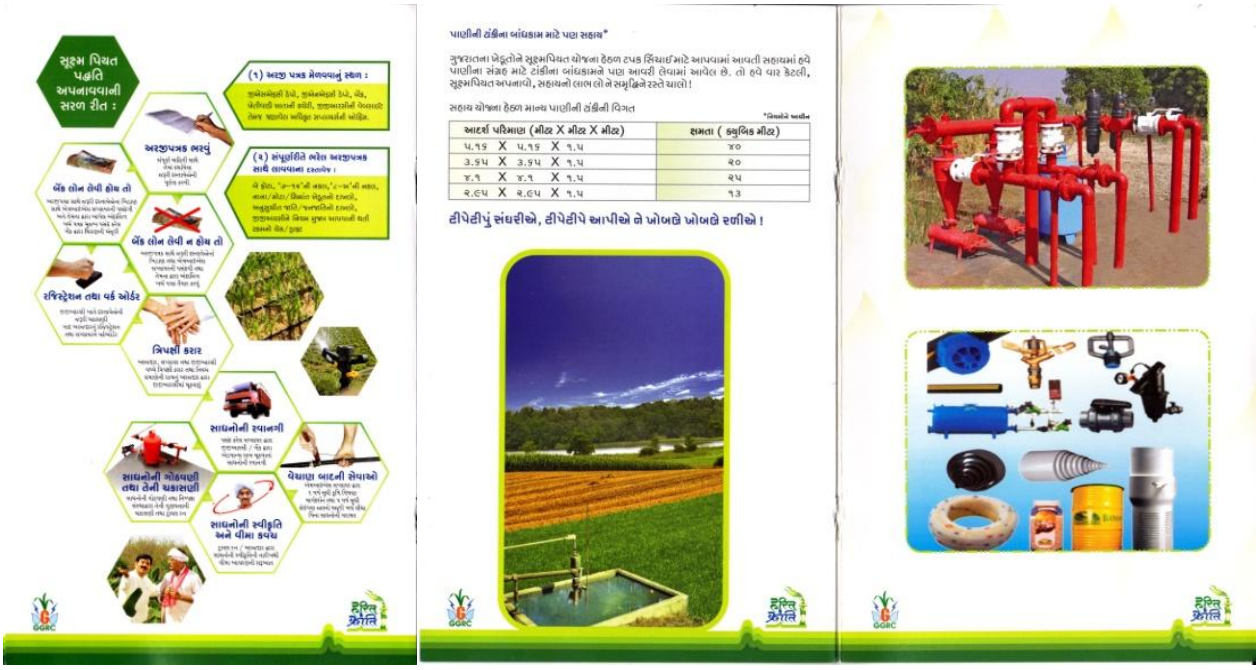
[13] *Bigha*is the traditional units of measurement of area. 1 hectare (2.47 acre) is equivalent to 3 *bigha*.

insects during the rainy season and farmers have suffered losses due to poor quality. Wheat cultivation requires a lot of labour which is always in short supply in the village. The benefit that jayantibhai sees with vegetables is that he can harvest his crops within four months and he gets immediate returns in cash.

Installing a drip irrigation system is also a greater risk for smaller farmers as compared to larger farmers especially because of the huge costs involved. For example, Hargovindbhai, a farmer in Chandrala had to spend almost Rs 80,000 (including a subsidy of 40%) for installing a drip irrigation system over 3 bigha out of his total 9 bigha land. He has been growing vegetables (mostly bottle gourd) in his field. Drip irrigation helps farmers save costs on labour and fertilizers and Hargovindbhai would be able to save almost Rs 1500 per crop per bigha on fertilizers and around Rs 2500 on labour. Thus, the total savings in cost that he may get with two crops over a year is around Rs 24,000 which is only around 15% of the total cost he incurs on cultivating the 3 bigha land each year. Thus, the advantages offered by a drip irrigation system in terms of reduced cost of cultivation and better crop quality have an impact on the overall economics of cultivation only when the farmers have a significant area under drip irrigation. According to some of the farmers interviewed, a farmer using drip irrigation over 10 – 12 bigha of land and having his own tubewell for water supply would be able to get the best returns on the investment made on his drip system. Owning a tubewell is also one of the criteria as according to GGRCL laws, a farmer not owning a tubewell (and thus, buying water from some other larger farmer) needs to get an agreement signed with the larger farmer that will assure water supply to him at least for the next five years. The larger farmer may not always be willing to sign such an agreement if he does not have too much of excess water or if he does not share a good relationship with the smaller farmer.

Thus, even after the government subsidy, installing a drip irrigation system may still be more suitable for larger farmers as compared to smaller farmers.

Annexure 1.1



GGRCL Promotion material for farmers – Process for application and subsidy for tank construction

Annexure 1.2

Nageenbhai Patel is a farmer in Chandrala who owns around 6 bigha of land. He gets 3 crops every year and mostly grows vegetables such as cauliflower, ladies finger during the kharif season and castor during the rabi season. All 6 bigha of his land is cultivated with no fallow or uncultivated land and he hasn't leased in or leased out any land. He also has his own tubewell which is 500 feet deep. The water from his tubewell is distributed in 20 bighas of land owned by his neighbours. He sells water to his neighbours at Rs 50 per hour. One of his neighbours has also installed a drip irrigation system on his land of 10 bighas.

Nageenbhai is educated till 12th standard and is well aware of the advantages of drip irrigation systems such as better productivity, no weeds growth, less fertilizer use and better quality of produce. He also owns an agriculture input shop and lives with his brother and parents in the village, who help with labour in the field. In spite of being aware of the advantages of drip irrigation, he has not installed the system on his own field because according to him investing around Rs 1,00,000 for the drip irrigation equipment would not give him enough additional returns. Moreover, since he himself owns a tubewell, he has sufficient water to irrigate his own field and is already paying a fixed charge to Gujarat electricity board of Rs 5000 per month for the borewell. Thus, he does not have an incentive to save water by installing a drip irrigation system. According to him, if a farmer uses his tubewell to irrigate more than 15 bigha land, then it would make greater economic sense for

him to install a drip irrigation system as he would easily be able to irrigate his land in 8 hours and would also save money on labour, fertilizers and electricity.

According to Nageenbhai, the cost of cultivating bottle guard on 1 bigha land without drip irrigation would be as follows:
Seed – Rs 800
Fertilizer – Rs 2500
Labour – Rs 1000 for land preparation and seeding
Fertilizer after crop start flowering – Rs 3000 – 4000
Pesticide – Rs 3000 – 4000
Harvesting labour – Rs 5000 – 6000
Electricity bill – Rs 5000 per month (fixed charges)
The total cost of cultivation one 1 bigha land would thus be around Rs. 25,000 – 30,000.

The corresponding yield of bottle gourd on 1 bigha land would be around 100 quintals or 10,000 Kg which is sold at a price Rs 7 – 10 per Kg. The produce is sold at the Reliance collection centre on Talod Road, Majra which is 3 kilometres away from Chandrala or is taken to markets in Ahmedabad such as Jamalpur or Kalupur because the Reliance Collection centre buys only the best quality produce and that too as per its demands.

Annexure 1.3

Hargovindbhai is a small farmer who owns 9 bigha of land in Chandrala. Interestingly, he also owns his own tubewell (550 feet) but does not have an electricity connection. The village was declared a dark zone in 1995 and the government had stopped giving permission to dig borewells in the village. However, now that the dark zone status has been removed, Hargovindbhai has applied for an electricity connection and is waiting for the electricity board to respond to his application.

Hargovindbhai has also installed a drip irrigation system on 3 out of 9 bighas of land. He has installed the drip irrigation system because he is well aware of its advantages and wants to stay prepared so that he can start using his system as soon as he gets the electricity supply. The Gujarat Electricity Board gives priority to farmers wanting an electricity connection to run their drip irrigation systems and so, that might be another reason why Hargovindbhai has installed the drip irrigation system. The drip irrigation system has cost him around Rs 80,000 including a GGRCL subsidy of 40%.

Hargovindbhai also owns a grocery shop in the village. He only grows vegetables in his farm during the kharif season and may sometimes grow castor or jowar in the rabi season if there

is water available. According to him, a tubewell can irrigate 30 bigha without drip and 40 bigha with drip in 8 hours. He hopes to start using his drip irrigation soon because, growth of weeds growth is much lesser with drip and so labour requirement is less. For every bigha of land cultivated, he expects to save Rs 1500 on fertilizer and Rs 1000 on labour costs. Drip irrigation does not impact the electricity charges as that cost is fixed at Rs 5000 per month. He earlier tried using the drip irrigation system with a diesel generator pump but with rising diesel prices, it turned out to be very costly and so, he has stopped running the diesel generator.

Besides the lack of electricity connection, the other problems that Hargovindbhai faces in farming are as follows:

- Price realisation of vegetables is less – Reliance gives good price but does not take all the produce. It only takes the best quality produce and that too as per their demands.
- Also, there is huge variation in prices according to the supply in the Ahmedabad markets
- The village faces shortage of labour especially for labour. The later generations in the village have got better education and have moved to cities in search of better employment opportunities. Migrant labour from Rajasthan also prefers working in industries in and around Ahmedabad as they get better wages there.

Annexure 2: Micro-Irrigation in Village Chanvelly, (District – Rangareddy)

Chanvelly is a village in the Chevella taluka of Rangareddy district in Andhra Pradesh. It is around 5 kilometres away from the taluka headquarters Chevella and 30 kilometres from the district headquarters Rangareddy. The state capital Hyderabad is almost 45 kilometres away from the village. The village is situated off the Shabad – Shadnagar highway and is well connected by road to the taluka head quarter as well as the state capital. The other villages in the vicinity of Chanvelly are Khanapur (3 kilometres), Regadighanapur (4 kilometres) and Damergidda (4 kilometres). The main towns near Chanvelly are Chevella (5 kilometres), Shabad (14 kiometres), Pudur (14 kilometres) and Shankarpally (20 kilometres)

The total number of households in the village is around 500. Farming is the major occupation in the village. Some farmers have also taken up animal husbandry. The average land holding in the village would be around 10 acres. Thus most of the farmers are large farmers. Some farmers also have up to 50 acres land and have set up poly houses for cultivating roses. Though the landholdings are fragmented in the village, the parcel sizes are generally about 2 – 3 acres each. Fragmented land holdings has not hindered adoption of drip irrigation as generally the parcel sizes are large and farmers are able to install pipes to carry water over a few metres with the subsidy available.

The farmers in the village were introduced to drip irrigation around five years ago when some of them were taken on exposure visit to nearby villages like Chevella where the government has developed model farms. They also met other farmers in these villages who had adopted drip irrigation and came to know about the various benefits of the system. According to the dealers, the farmers in this village are aware about the benefits of the system as a result of which, the number of farmers adopting drip irrigation has continuously grown over the last five years.

Currently, 345 farmers have adopted drip irrigation over a total area of 410 acres. Besides this, 6 farmers have adopted sprinkler irrigation over a total area of 15 acres. Thus almost 70% of the farmers in the village have adopted micro – irrigation. Farmers mainly use drip irrigation to cultivate vegetables. Some have also taken up drip irrigation for cultivation of ground nut and roses (in polyhouses).

Since the village is close to the city, most of the farmers have been growing vegetables since a long time. The main vegetables grown are tomatoes, cabbage, chillies, brinjals, etc. Hyderabad, Secunderabad and Rangareddy are the main markets for vegetables grown in the village. Vegetables are sold in the Rythu bazaars in Kukatpally or in Erragadda where

farmers can directly sell vegetables to consumers thereby eliminating middlemen. The nearest market is around 30 kilometres away. Farmers have to carry their produce to the markets themselves. However, under a government of Andhra Pradesh scheme called 'Farmers on Wheels', farmers are given 50% subsidy for transportation of vegetables to markets. Under this scheme, 4 - 5 farmers can pool their produce together and hire a vehicle to transport the produce to the market. 50% of the cost of transportation is bore by the government.

Reliance and Spencers have also set up their collection centre in Chevella to procure vegetables from farmers since 2006 - 07. However, there is no formal contract system in place for these retailers to procure vegetables from the farmers as a result of which farmers are exploited by the retailers quite often. Moreover, these retailers insist on buying only the best quality produce while the rest of the produce has to be sold in the city APMC at lower prices.

Wells and tubewells are the main source of irrigation in the village. The village does not receive water from canals and hence, is completely dependent on groundwater and rainfall for water for irrigation as well as household purposes. The ground water level in the village is at around 200 feet and all farmers in the village own private tubewells and most of the land in the village is irrigated. According to farmers, the ground water is sufficient for all their purposes and the village does not face a scarcity of water even during the summer months

Even though there is no scarcity of water, farmers in the village have realised that installing drip irrigation has helped them irrigate more land with the same amount of water. According to some of them, they are now able to irrigate almost double the area that they were able to irrigate with flood irrigation.

Another major advantage of the system is the savings in labour. It is also the main reason why farmers have adopted drip irrigation in the village. The village faces a huge shortfall of labour and labour wages for agricultural work have increased drastically in recent times. The current labour wages are around Rs 200 – 250 per day for males and Rs 150 per day for females. Installing drip irrigation has helped farmers reduce the labour requirement especially for irrigation. With flood irrigation, creating channels and bunds was a major problem for the farmers which are not required now. They can irrigate their fields on their own with a switch of a button.

Besides these, there are other advantages that the farmers mentioned like there is no weed growth and it improves the yield of land.

However, according to the dealers, the current subsidy pattern is somewhat of a hindrance for increasing the area under drip irrigation. Under the current regulations for subsidy, a farmer can avail subsidy for a maximum of Rs 1, 00,000. Thus a general farmer who gets 50% subsidy may only be able to cover 4 – 5 acres and will have to pay the entire cost if he wishes to cover more area. Moreover, the smaller farmers too demand that they should be given a subsidy of Rs 1, 00,000 and not just a percentage of the total system cost. They feel that they are being cheated by the dealers and hence, avoid installing the system itself. Thus, awareness about the pattern of subsidy is required amongst farmers.

Annexure 2.1

Mangaldas is a large farmer in Chanvelly village. His total land holding is 25 acres. He has installed drip irrigation only on 4 acres about two years ago. His total land is divided in to 4 parcels of 4 acre, 5 acre, 8 acre and 8 acre respectively. The entire land is irrigated with wells and tubewells.

The total system cost of the inline drip irrigation system installed by Mangaldas was almost Rs 2, 00,000 out of which he got a subsidy of Rs 1, 00,000. He hasn't installed drip irrigation on the entire area as he doesn't have enough money. He has himself experienced the advantages of drip irrigation like lesser labour requirement, better yield and lesser weeds and would have installed drip irrigation on his entire area if the government gave him subsidy on the system cost for the remaining area as well.

Mangaldas grows vegetables like chillies, tomatoes, carrots, cabbage and beet root in his farm. Besides these he also grows fodder. According to him, the main advantage of drip irrigation is that it has helped reduce his labour costs. Most of the farmers in the village face problems in hiring labour and thus have adopted drip irrigation. Drip irrigation has helped Mangaldas save almost Rs 20,000 on total labour costs every year. There are 4 working members in his family who contribute to farm labour currently.

His estimated cost of cultivation for growing chillies on 1 acres is as follows
Labour – Rs 3000 – 4000
Seeds – Rs 1000
Fertilizer – Rs 5000
Pesticides – Rs 3000
Labour for harvesting – Rs 3000 (usually own household labour)
Thus the total cost of cultivation is around Rs 14000 – 16,000 per acre per crop.

Annexure 2.2

Krishna Reddy is another farmer in Chanvelly village of Chevella taluka. Krishna owns 6 acres of land which is divided in two parcels of 3 acres each. He grows vegetables like tomatoes and cabbages in his entire farm. He has wells on both his farms which have enough water to irrigate the entire area.

Krishna has not installed drip irrigation currently. The major hurdle he faces in installation of drip irrigation is lack of funds. He has already taken a loan earlier and so, cannot take a loan again. Moreover, he has sufficient water in his wells to irrigate the fields and thus, does not plan to invest in drip irrigation anytime soon.

He does face labour problems sometimes but is able to manage with his household labour. His two brothers and parents contribute in the agricultural work.
The cost of cultivation for tomatoes is as follows:
Labour for land preparation – Rs 4000 – 5000
Seeds – Rs 1200
Fertilizer – Rs 6000
Pesticides – Rs 3000 – 4000
Electricity – RS 1500 – 2000
Thus, the total cost is around Rs. 18,000.

Annexure 3: Micro-Irrigation in Village Janori (District – Nashik)

Janori is one of the villages in Dindori taluka in Nashik district of Maharashtra. The village is situated around 5 kilometres off the Mumbai – Agra Road from Nashik. Ozar is the nearest town which is on the Mumbai – Agra road and is around 10 kilometres away from Janori. The district headquarters, Nashik is almost 15 kilometres away. The other major towns near Janori are Dindori (12 kilometres), Niphad (23 kilometres) and Sinnar (32 kilometres). Ambad, Akrale, Ambegan, Ahiwantwadi, Ambaner etc. are some of the other villages of Dindori taluka in the vicinity of Janori.

The village is a part of the grapes growing belt of Maharashtra and almost 70 – 80% farmers in the village grow grapes. Some farmers have also set up poly houses are experimenting with growing roses and capsicums. These are also the main crops for which drip irrigation is used in the village. The other crops grown in the region are tomatoes, groundnut and bajra during the kharif season and wheat, fodder and onions during the rabi season. The black soils and the local climate are most suited for growing grapes and cotton.

As per the 2001 census, the village had 1063 households with a total population of 6025 (3068 Males and 2957 Females)14. Out of the total households, 997 have some land and are registered as farmers. The total area of the village is 2137 hectares out of which 1265 hectares is agricultural land. The agricultural land statistics are shown in table 1 below. According to some farmers, the average land holding in the village would be around 2 – 3 acres.

Agricultural Area	1265
Irrigated Area	1055
Non - Irrigated Area	210
Other lands	872
Total Village Area	2137

Table 1: Land statistics in Janori (as per panchayat records)

Wells is the major source of irrigation in the village. Wells and tubewells are used conjunctively with the canal water which may be available for 4 – 5 irrigation cycles every year during the rabi and summer growing season. The ground water level in the village is around 50 – 55 ft. and so open wells can work nicely. Most farmers own private wells and there is no mechanism of sharing water between farmers. However, water user associations have been made in each village for the distribution of canal water. The association has farmers as its members who use the canal water for flood irrigation. The canal water is available at Rs. 100 per hour during the rabi season and Rs 400 per hour during the summer season. Availability of canal water has helped increase the ground water levels in the village.

[14] www.censusindia.gov.in/PopulationFinder/Sub_Districts_Master.aspx?state_code=27&district_code=20 (30/6/2012)

Farmers have been using drip irrigation system for more than the last 20 years especially for cultivation of grapes. Even small farmers with less than 1 acre land – holding have adopted drip irrigation. The setting up of the manufacturing plant of Jain Irrigation Systems Ltd. in Jalgaon which is around 250 kilometres from Nashik has played an important role in promoting drip irrigation amongst the farmers. According to one of the farmers who has been using drip irrigation since 1995, grapes have been grown in the region since a long time. A single cropping of grapes can yield fruits for up to 12 years provided it is sustained with regular irrigation especially during the summer months. Around the 1990s, farmers started facing problems in sustaining the crops all through the year and especially during the summer season when water availability would be at its minimum. That is when companies like Jain Irrigation started promoting drip irrigation to the farmers so that they could reduce water consumption and increase yields. That is also the time when the village started receiving water from the Waghad Canal Irrigation project which increased the water tables in the region. Thus, with the increased water availability and reduced consumption, the farmers realised that they could bring more area under grapes. The area under grapes cultivation has continuously increased since then.

Maharashtra is also amongst the first states to start a state scheme to subsidise drip irrigation. Government subsidy has also played its part in popularising drip irrigation as farmers can save almost 50% of the cost of equipment. However, with time, the government has introduced new criterion for availing this subsidy. For example, the two child norm was introduced in 2001 wherein farmers with more than 2 children could not take advantage of the subsidy. Also, in 2010, the guidelines for disbursing grants were changed. Under the new guidelines, the subsidy amount would directly be transferred to the farmers' bank account instead of being given to the company after the installation of the system15. According to the government, this would reduce corruption and bad practices amongst the company dealers. However, according to the farmers, it would increase their hassles since they would have to pay the entire amount to the dealers and then wait for the government to return back the subsidy amount. Moreover, the farmers also suggested that the prices for subsidy calculation are not regularly updated as a result of which they actually receive a subsidy of less than 50%. According to one of the farmers, installing drip irrigation for cultivating grapes on 1 acre land (4 feet spacing) would cost somewhere around Rs. 20,000. However, the government only gives a subsidy of about Rs 6000 because the subsidy is calculated according to old prices.

[15]http://www.thehindubusinessline.com/todays-paper/tp-agri-biz-and-commodity/article1029915.ece (28/6/2012)

Dealers for various micro – irrigation companies like Jain Irrigation, Azud and Netafim are located in Ozar who manage the dealership for 2 – 3 neighbouring talukas. According to the dealer, they don't have to visit the villages to tell farmers about the benefits of drip irrigation as all the farmers are aware of it. They themselves come to the dealers to buy the equipment. Jain irrigation is the highest selling company. The dealers take care of maintenance of the system in case of major breakage.

Labour shortage is also one of the main factors that has led to the adoption of micro – irrigation on such a large scale. Labour rates have increased from Rs 60 per day to Rs 150 per day in the last 3 – 4 years. According to the farmers, labour supply has drastically reduced over the last few years. Improved canal irrigation in villages of Gujarat is one of the reasons behind it. Most of the agricultural labourers now come from the tribal areas in Gujarat and the Konkan area where farming is not possible in the rabi season. These labourers migrate back to their villages during the rainy season. Another reason for the increased labour rates is the increased demand. As suggested earlier, with improved access to water, the area under grapes cultivation has increased drastically. Cultivation of grapes requires a lot of labour especially for spraying pesticides, pruning, weeding and harvesting during the winter and summer seasons (December to May). Though the adoption of drip irrigation has reduced labour requirement, increased area and improved yields have increased demand with the net effect being that the labour wages going up. A unique feature of the region is the contractual labour system. Labourers have formed informal groups consisting of 20 – 30 members with one of them acting as their representative. The prices are fixed for different activities which are negotiated by the representative with the farmer. For example, the current price for pruning is Rs 1500 per acre irrespective of the number of labourers working. The representative divides the total income into the members of the group according to the hours worked. This system has benefitted the farmers hugely. Firstly, they don't have to negotiate with individual farmers for the wages. Also, this helps develop an informal relationship between the labourers and farmers which ensures that the same labour group is hired year after year. This reduces the time and money spent on training labourers every year especially for activities like pruning, monitoring the drip irrigation equipment, etc.

According to the farmers, they have experienced the following advantages with drip irrigation:

- It has drastically reduced the water requirement. The quantity of water required to irrigate 1 acre of wine yards earlier can now irrigate up to 10 acres. Thus there is a 90% saving of water.

- With drip irrigation, water is only given to the root zone of the crop which reduces evaporation losses. It also helps in the aeration of soil and in maintaining proper moisture levels.
- Liquid fertilizer can be used with drip irrigation which gives better yields even when applied in lesser quantities.
- Weed growth is less and farmers now have to carry out weeding only twice a year. Earlier grass and other weeds had to be removed every two months.
- No labour is required especially for irrigation. They do not need to make canals in the field every time. Once the structure is assembled it remains like that for years
- Water can be given with switch of a button. Moreover, the time for which water is given to each crop can also be easily controlled depending on the season, temperature and other factors.
- Water can be given during early morning or evenings to avoid root shocks during the afternoon.
- The quality of yield especially in the case of grapes and tomatoes is very good. The quality becomes important in the case of grapes because prices may vary from Rs 12 per kilogram for poor quality grapes to Rs 30 per kilogram for export quality grapes.

As against the numerous advantages, the only disadvantage that the farmers feel is the high initial cost. Though, they only have to pay about Rs 15,000 per acre for installing drip irrigation for grapes, small and marginal farmers may find it difficult to afford it. Moreover, installing drip irrigation for growing vegetables like tomatoes does not make economic sense to them because the crop is mostly grown during the rainy season and stands for only 4 – 5 months. Added to this, the farmers may have to pay much higher amounts (up to Rs. 50,000) for installing drip irrigation for cultivating vegetables in one acre (2 feet spacing). Since water is not very scarce in the region, farmers are still hesitant in adopting drip irrigation for cultivating vegetables. Another disadvantage with adopting drip irrigation for vegetables is that the system has to be disassembled after 4 months once the crop is harvested. It is then reinstalled when the next crop is sown. This creates unnecessary hassles for the farmers. There is also a risk of breaking the pipes or damaging the system while assembling and disassembling. In the case of grapes, once planted, the crops give fruits for 10 – 12 years and so the system can be left assembled for that period.

Annexure 3.1

Vilas Satbhai is one of the farmers in Janoti who owns 15 acre land. He has been growing grapes on his farms for a long time and has installed drip irrigation since 1995. Currently 12 – 13 acres of his land is under grapes cultivation and he plans to grow a new crop of grapes on the remaining land this season.

His complete land is irrigated and he owns a well at about 50 feet and a borewell which is 200 feet deep. Besides this he also receives canal water whenever possible. The canal water helps increase the level of water in his wells especially during the summer season.

The main reason why Satbhai adopted drip irrigation is that grapes require a lot of water especially during summer. Continuous irrigation is required for the crops to tide over the hot summer months. Thus drip irrigation is most beneficial during the summer months and he can now irrigate his entire field in half an hour every day

According to Satbhai, almost all the farmers are aware of the benefits of drip irrigation and almost 100% farmers growing grapes have adopted drip. However, only 25% of the farmers growing tomatoes and 5% of those growing sugarcane would have adopted drip irrigation. Farmers growing cotton are just starting to use drip irrigation. The main reason for variation in adoption is that water availability is not really a problem in the area. Labour availability is a bigger factor and since grapes require a lot of labour, adopting drip irrigation results in maximum savings. Most of the farmers growing other crops are able to manage with their own household labour or with hired labour.

Since Satbhai has been growing grapes for a very long time and is aware of the best practices, he is also able to export grapes to European countries. Exporters directly procure the produce from his field after carrying out stringent tests. The fees for these tests, which may be up to Rs 25000 has to be paid by the farmers themselves and thus cannot be afforded by smaller farmers. The rejected quality produce is sold in the local markets.

According to Satbhai, the cost of cultivation of grapes per acre would be around Rs 1,10,000 per year. Besides, this the farmer has to incur an additional cost of Rs 3,00,000 on installing the angle structure and drip irrigation which once installed, can last for 10 years.
The breakup of the costs would be as follows:
Fertilizer – Rs. 30,000
Cow dung manure – Rs 5,000
Labour – Rs 30,000
Water and Electricity – Rs 20,000

Pesticides – Rs 25,000
The total yield is around 10 - 20 tonnes per acre. Also, the income can vary from Rs 1,00,000 to Rs 5,00,000 depending on the quality of the grapes.

The best quality grapes are sold for up to Rs 30 per kg while the minimum rates can go down to Rs 12 per kg. Including Rs 1,00,000 for wastage, the net income can thus vary from Rs 1,00,000 to 5,00,000.

According to Satbhai, only 20% - 25% of the farmers are able to produce the best quality grapes and get the best prices while almost 50% farmers would be able to produce grapes worth Rs 1,00,000 – Rs 1,50,000 in 1 acre of land every year.

The weeding in the area between the wines is done using weedicides. Labour is not used – no crop is grown in the space between grape wines so weedicide can be used. Interspacing crops are not grown because sunlight is very less and crops will be destroyed by tractors, labour, etc. For the same reason, the drip lines are placed at a height of 2 – 3 feet from the ground. Though this may result in water not being directly applied to the root zone of the crops, it protects the drip lines from damage by tractors and labourers.

Labour for pruning, pesticide spraying, etc. is trained by the farmers themselves – the same labourers come back again and again every year and so the farmer does not need to train them again. Not only this, maintenance of the drip irrigation system is carried out by the farmers themselves as well. It isn't a big problem as the online drip system is very easy to clean and repair. Online drippers are more robust than the inline drip system and can last for more than 10 years. Moreover, they can be easily washed or replaced so farmers prefer that. Engineers from the company rarely visit the field except in cases of major breakage. Satbhai has even hired a boy is to monitor the emitters regularly. In case of clogging, he knows how to clean it and has extra spare emitters to repair it there itself. No

According to Satbhai, with drip irrigation, the well water level has improved. The well now has water even during peak summer season. If that water was used in flood irrigation, it would get over in a single irrigation itself. With drip irrigation he has also been able to bring the entire area under grapes cultivation. Earlier, with limited water, he cultivated grapes on half of the area and cotton or fodder in the remaining area.

Annexure 3.2

Kashinath Janardhan is another farmer owning 5 acres land. The crops grown are tomato, soyabean, wheat and groundnut. He has not installed drip irrigation. He grows tomatoes on 2 acre land, soyabean on 2.5 acre, groundnut on 0.5 acre, wheat on 1 acre and onion on 1 acre. Fodder is cultivated in the rest of the area. He is sometimes able to get three crops in a year if water is available.

All of the land is irrigated with well which is just 20 feet deep and canal water. The well dries up during summers. Canal water helps recharge the well water to some extent.

He has not installed drip because he does not cultivate grapes. The farmers mostly don't use drip irrigation for vegetables, cotton and other crops because they are short term crops.

Kashinath does not cultivate grapes because he does not have sufficient water to cultivate drips. Moreover, grapes cultivation requires a huge initial investment which he cannot make.

Lack of finance is also a problem he faces.

Labour shortage is also a problem that he has to face. Most of the farm labour has to be managed by his family members only. He has two brothers, two children and two women in his family who help him with farm work. Labourers do come from nearby villages as well but they are not sufficient.

He does not feel that application for drip irrigation is a big hassle as it is completely taken care of by the dealers. He is now planning to install drip irrigation for cultivating tomatoes
Cost of cultivation for tomatoes without drip
Fertilizer – Rs 3000
Manure – Rs 4000
Water is not paid for as it is cultivated during the rains
Insecticides – Rs 8000
Labour for land preparation and weeding – Rs 5000
Harvesting is done by the family members but that would be around Rs 5,000
Thus the total cost is about Rs 20,000 per acre
The yield in 1 acre is 6 to 8 tonnes
The price in the market is Rs 100 per 20 kg. Thus he is able to sell the produce for Rs 30,000 to Rs 40,000

With drip irrigation, he expects his yield to increase by 50% from 6 tonnes to 9 tonnes. He would also be able to save costs on fertilizers and labour. Thus he is planning to install drip irrigation within the next one year.

Annexure 4: Micro-Irrigation in Village Kamana (District – Mehsana)

Kamana is a village in the Visnagar taluka of the Mehsana district in Gujarat. The village Kamana is around 8 kilometres from its Taluka main town Visnagar and at a distance of 12.5 kilometres from its district headquarters Mehsana and 47 kilometres from the state capital Gandhinagar. The other villages in the vicinity of Kamana are Becharpura (2 kilometres), Savala (3 kilometres), Magroda (3 kilometres), Dadhiyal (3 kilometres), Saduthala (3.5 kilometres). Nearby towns are Visnagar (8 kilometres), Mehsana (14 kilometres), Vadnagar (20 kiometres) and Unjha (22 kilometres) The district of Mehsana is a part of the area called as northern plains of Gujarat which also consists of the districts Sabarkantha, Gandhinagar and Banaskantha. This region falls under the semi – arid zone and receives low rainfall (average rainfall is about 750 mm annually16). It is considered as one of the water scarce regions of Gujarat. The case study is based on informal discussion with farmers in Chandrala, MIS17 dealers, Panchayat functionaries and other officials associated with MIS in the region. Secondary sources have been used to add information or to corroborate statements made by individuals wherever required.

The village of Chandrala is a decently big village located around 25 kilometres away from Gandhinagar on the Ajmer highway. As per the panchayat records, the village has 1204 households with a total population of 5909 (3207 males and 2702 females). Most of the households belong to the general and OBC category. Most of the villagers are well educated with more than 80% of the total population educated up to the secondary level or above. Agriculture, animal husbandry, government services and local business are the major sources of employment for the villagers. However, with improving education levels, a lot of youngsters have left agriculture and animal husbandry and have moved to cities in search of better employment opportunities. The total number of farmers in the village is 1719 and their distribution according to land – holding size is shown in the Table 1 below.

Total Farmers	1719
Marginal (less than 1 ha)	1135
Small (less than 2 ha)	475
Large Farmers (more than 2 ha)	109
Farm Labourers	281

Table 1: Farmers profile according to land holding size (as per panchayat records for 2010)

The total arable land in the village is around 1049 ha. Besides this, non-agricultural land covers 64 ha and the total geographical area of the village is 1114 ha. Out of the total arable land of 1049 ha, almost 966 ha is irrigated. Tubewells form the major source of irrigation in the village. The area irrigated under different sources is shown in Table 2. Based on the total agricultural land and the number of farmers, the average land holding would be

[16] Presentation on District Agriculture Plan/ State Agriculture Plan for Gujarat under RKVY by WAPCOS, 2008

[17] MIS refers to Micro – Irrigation Systems

less than 1 ha which is also reflected in the large number of marginal farmers. Besides the small land holdings, another factor that affects farmers in the village is fragmented land holdings. In most cases, the total agricultural land owned by a household is divided into 3 – 4 smaller parcels of 2 - 3 bigha18each.

Total Arable Land (ha)	1049
Non - Irrigated Area (ha)	83
Irrigated Area (ha)	966
Tubewells (ha)	864
Canal (ha)	80
Wells (ha)	70

Table2: Area irrigated under different sources (as per panchayat records)

Fragmented land holdings are a major hindrance for farmers who wish to adopt farm mechanization as the farmers have to bear extra costs of travelling and moving the equipment from one plot to another. This also makes it difficult for the farmers to adopt drip irrigation as farmers have to incur extra costs on assembling pipelines and other equipment to carry water over long distances.

As explained by one of the farmers, the main reason for fragmented land holdings is the wide variance in the quality of soil. Quite often, when a farmer has to divide his land amongst his sons, he is forced to further fragment his already fragmented land. For example if a farmer owns 4 bigha land in 2 parcels of 2 bigha each and has to divide the land amongst his two sons, he may be forced to divide each of his two parcels into two because the quality of land in each of his parcels will be different. Thus, two parcels are converted into four parcels.

The major crops grown in the village are castor and cotton during the kharif season and wheat, bajra and guar seed during the rabi season. Some farmers have also taken to growing vegetables like carrots and brinjal in recent times. Mostly alluvial sandy loam to sandy clay soils is found in the region which is known to be quite productive. This soil type is very deep, well drained and reddish brown in colour. The soil has good content of phosphorus and nitrogen but is deficient in some micro nutrients like zinc [Soils of Gujarat, INSEDA]. Most of the land in the village is irrigated and thus farmers are able to harvest 2 or 3 crops on their lands every year.

Tubewells form the major source of irrigation in the village. A small part of the village (around 5% – 10%) also receives water from a canal through Dharoi. The canal is only operational for a couple of months during the rabi sowing season and farmers use the canal water to grow wheat. The village has 35 tubewells and 9 wells. Tubewells have to be dug up to 900 feet deep as the soil in the region is very sandy and gets settled at the bottom of the tubewell. A 900 feet deep tubewell may function for 10 years after which the sand has to be cleared. Since land holdings are small and fragmented, a tubewell can be shared by 30 – 40

[18] *Bigha*is the traditional units of measurement of area. 1 hectare (2.47 acre) is equivalent to 5 *bighas*.

farmers and each farmer may be a member of 4 – 5 tubewell user associations. The tap water supply for drinking and washing purposes is provided through the government overhead tank. The overhead tank receives water from government tubewells and the canal.

A non – perennial river, River Khari also flows around 3 – 4 kilometres away from the village. Water is available in the river only during the rainy season and is thus, not used for cultivating crops. However, the river provides suitable habitation for animals like wild pigs and nilgais which attack farms in groups and destroy the crops. Farmers thus have to keep continuous vigilance over their fields to protect their crops from damage by these animals.

The tubewell user associations are not formally registered though proper record books are maintained. Each association has its chairman and secretary who are elected amongst the members. They also appoint an operator and an account book keeper who look after the day – to – day functioning of the tubewell and maintain the daily records of water used by each member. The operator is paid Rs 2500 per month. Besides the association record, each member also maintains his personal records called the personal khata which records the amount of water supplied to him every day. The bills are settled twice every year – on Diwali (October – November) and on Akha Teej (April – May) when farmers are required to pay the amount billed for the water use, salaries and any other maintenance charges incurred during the year. Besides this, the members might have to contribute to the association's funds for repairs in case of major breakdowns of the tubewell. The unit of measurement used for measuring water is called a pesa. One pesa refers to 5 hours of water supply with a 50 HP motor. Each pesa is sufficient to irrigate one bigha land and costs Rs. 72. The farmers receive water on a rotational basis depending on each member's demands. Each farmer usually gets his turn in 15 – 17 days. These tubewell associations only monitor the sharing of the water from the tubewell and have not taken up tasks like pooling up of farm produce or collective buying of farm inputs. According to some farmers, each association has 30 – 40 members which increase cases of politics and corruption. This has hindered the functioning and progress of the associations in the past.

There is a shortage of labour in the village especially for agriculture. A big portion of the labour currently employed in agriculture is from the village itself and comprises of the marginal and land – less farmers who do not have enough land to sustain the whole family. Thus the family diversifies into many occupations and agricultural labour is one such occupation. However with the later generations getting educated and moving to cities in search of better opportunities, the labour from the village has also reduced over the years. According to the farmers interviewed, labourers migrated from villages of Rajasthan around Sanchore and from various districts of Gujarat like Panchmahal, Godhra, Banaskantha,

Sabarkantha earlier. These labourers have stopped migrating now because these places have canal water for 12 months and farming is possible in these regions all through the year. Moreover, migrant labourers from Rajasthan get better opportunities to work in industries where they get higher daily wages. The current agricultural wages are around Rs 150 per day.

The village does not have any micro – irrigation dealers in the village. The task of informing villagers about the government subsidy and creating awareness about the benefits of drip irrigation is taken up by the gram sevak himself. Most of the farmers were aware of the benefits of drip irrigation but couldn't install the system because of their small and fragmented land holdings. The nearest micro – irrigation dealer is in Visnagar which is 8 kilometres away. Despite this, according to the farmers interviewed, any farmer willing to install drip irrigation in his field wouldn't have a problem as they can always contact the gram sevak who will inform the dealers or they can directly contact the dealers. Thus, they don't feel that absence of dealers in the village has created extra hassles for them.

Besides this, the village has two agricultural input shops which supplies seeds, fertilizers and pesticides to the farmers. The farmers can buy urea and DAP fertilizers at subsidized rates from the IFFCO shop located in the village itself. The nearest GNFC depot is located in Visnagar.

Annexure 4.1

Patel Dashrath Ambalal is a farmer in Kamana village who owns 7 bigha land which is divided into three fragments 2 bigha, 2 bigha and 3 bigha respectively. He is a member of 3 tubewell user's associations. The main crops grown by Dashrathbhai are cotton over 3 bigha, wheat over 1 bigha, castor over 1.25 bigha and jowar over the rest. Most of the farm produce, including castor, wheat and cotton is sold in the APMC market at Visnagar. Cotton mills are supplied cotton by the traders in the APMC only and they do not source it directly from the farmers.

According to Dashrathbhai, the cost of cultivating cotton over 1 bigha land would be as follows:

Cost of Seeds – Rs 1000

Land preparation with tractor – Rs 1500

Fertilizers DAP – Rs 1000

Urea – Rs 600

Water for irrigation – Rs 2000

Weeding with bulls animal labour – Rs 600 to Rs 1000

Insecticides – Rs 500
Own family labour for irrigation, monitoring of crops – Rs 1500
Labour for harvesting – Rs 3000 to Rs 4000

Thus the total cost for cultivating cotton in 1 bigha land is around Rs 12000.

Against this, the produce would be around 20 to 24 mands (20 kilograms is 1 mand) which is sold at Rs 1000 per mand. Thus Dashratbhai is able to earn around Rs 10,000 – 12,000 per bigha in 6 months which is the time taken to harvest cotton crops.

The main problems that a farmer in Kamana faces according to Dashrathbhai are as follows:

Labour is one of the main problems. Inspite of the high wages of about Rs 150 per day, it becomes difficult to find trained labour in the village.

Dashrathbhai also feels that the prices of fertilizers are highest in Gujarat and there is shortage of fertilizer in the market. Farmers also have to buy it in black market at up to 1.5 times the actual cost.

The crop grown is completely weather and rainfall dependent. This year Dashrathbhai had to suffer a loss on his cotton crop due to excessive rainfall which damaged the crop and resulted in reduced ball size.

Besides this, the prices that farmers receive at the APMC are very low especially for vegetables and hence farmers don't prefer growing vegetables. Prices for wheat and castor are slightly better. However, Wheat grown using canal water is almost 6 times cheaper than that grown using tubewell water. But the price received for both is the same – so it does not make sense to grow wheat using tube well and most farmers use canal water only. According to Dashrathbhai, a lot of farmers are moving away from agriculture and especially food grains because of the low prices. Increasing diesel and petroleum prices have also increased cost of transportation, tractor and other machines.

Another problem that they face is attack by animals. Animals like nilgai, wild pigs, monkeys destroy the crops quite frequently and so famers have to stay in the farms for whole day.

Annexure 4.2

Kamleshbhai Prahladbhai Patel is one of the larger farmers in Kamana who owns 10 bigha land. His land is fragmented into 3 parcels of 4 bigha, 3 bigha and 3 bigha. He has installed

drip irrigation on one of the parcels of 4 bigha for growing cotton. The other crops grown by Kamleshbhai are castor, wheat and fodder.

The main reason why Kamleshbhai opted for drip irrigation is the labour shortage in the village. His sons are well educated and have settled in Ahmedabad. Thus he does not have enough farm hands to work in his fields and it was difficult to hire labour even after paying high wages. According to Kamleshbhai, the government subsidy on drip irrigation is beneficial to farmers like him who would not have been able to afford it without the subsidy.

Besides reducing labour costs, drip irrigation has helped Kamleshbhai reduce costs on fertilizers and water. He has also experimented with growing vegetables like brinjals under drip irrigation. However, the produce did not fetch good prices in the market and so Kamleshbhai prefers growing cotton under drip. According to him, he is able to save almost Rs 2000 – 2500 on labour costs in cultivating cotton on 1 bigha land with drip irrigation. Besides this, the cost of fertilizers has reduced to half. Thus Kamleshbhai is able to save more than Rs 12,000 every 6 months because of the drip irrigation on 4 bigha land.

Kamleshbhai has not installed drip irrigation on his other parcels because he feels that the other two parcels are too small the savings in cost would not be much as compared to the investment required. Moreover maintaining the system over two fields and preventing damage from animals is a difficult task and so he does not want to take a risk.

He also suggested that if his land was consolidated at one place, he could have installed drip irrigation over the entire area which would have been extremely beneficial.

Annexure 5: Micro-Irrigation in Village Pamena (District – Rangareddy)

Pamena is a village in the Chevella taluka of Rangareddy district in Andhra Pradesh. It is around 15 kilometres away from the taluka headquarters Chevella and 22 kilometres from the district headquarters Rangareddy. The state capital Hyderabad is almost 50 kilometres away from the village. The village is situated off the Shabad road and a kuccha road connects the village with the Shabad road. Thus, there is also a connectivity problem with the taluka head quarter as well as the state capital especially during the rainy season when the kuccha road becomes waterlogged. The other villages in the vicinity of Pamena are Chevella (3 kilometres), Tadlapally (3 kilometres), Damergidda (5 kilometres) and Gundal (5 kilometres). The main towns are near Pamena are Shabad (13 kilometres), Pudur (17 kilometres.) and Moinabad (17 kilometres).

The ground water level in the Rangareddy district is very low (average is around 250 feet) and tubewells have to be dug up to 500 feet deep in order to pump water in some places . The region faces severe drinking water problems especially during summer. The water level has reduced drastically in the last few years due to poor rainfall as well.

Pamena is a medium sized village with almost 600 families staying in the village. Out of these, around 156 farmers have adopted drip irrigation over an area of 180 hectares. 6 farmers have adopted sprinkler irrigation over 15 acres of land19. Farmers have been adopting drip irrigation since the last five years when they were made aware of the benefits of the system by the government officials and the company dealers. The farmers are slowly realizing the benefits of the system and more and more farmers are adopting drip irrigation. According to the dealers, lack of awareness is still a major hurdle to increasing the area under drip irrigation in the village.

Farming and animal husbandry are the major sources of income for the villagers. The average land holding in the village would be around 5 acres with each household owning some cows and buffaloes as well. Most of the farmers in the village grow vegetables along with fodder for the livestock.

Water availability is not a very big problem particularly in this village. Water is available in open wells which are up to 50 feet deep in some parts of the village. A farmer digging a borewell up to 200 feet can be assured of water all through the year. According to the farmers, the ground water level hasn't receded in this village because it does not have a rocky terrain like the nearby areas. Hence water from nearby areas also flows down to the

[19] As per data provided by APMIP PD for Rangareddy district

village and recharges the ground water. Wells and tubewells are the major source of irrigation in the village. The village is not served by any canals and hence, the village is completely dependent on groundwater and rainfall for irrigation as well as household purposes.

Since the village is close to the city, most of the farmers grow vegetables. The main vegetables grown are tomatoes, cabbage, chillies, brinjals, etc. Hyderabad and Rangareddy are the main markets for vegetables grown in the village. Reliance and Spencers have also set up their collection centre in Chevella to procure vegetables from farmers since 2006 - 07. However, there is no formal contract system in place for these retailers to procure vegetables from the farmers as a result of which farmers are exploited by the retailers quite often. Moreover, these retailers insist on buying only the best quality produce while the rest of the produce has to be sold in the city APMC at lower prices.

Under APMIP regulations for claiming subsidy, there is a limit on the amount of subsidy that can be availed. Under the latest regulations, limit has been fixed at a maximum of Rs 1,00,000 or a percentage of the system cost whichever is less. The percentage of total cost is determined on the basis of whether the farmer belongs to SC/ST community and his total land holding. Moreover, each farmer can avail subsidy for a maximum of 5 acres and only once in 10 years. This has restricted the area covered under drip irrigation as a farmer may not be able to adopt drip irrigation on his total land holding at once because of lack of funds. Generally farmers prefer increasing the area under drip gradually which is not possible under this system. However, this has been done to ensure that all farmers and not just the large farmers or well off farmers avail the subsidy.

Besides subsidy on fertilizers, seeds etc., farmers are also given subsidy on setting up structures for cultivating vegetables like bottle gourds, bitter gourds, etc. and also for setting up polyhouses. Currently farmers can avail a subsidy of up to Rs 6,00,000 for setting up a poly house. APMIP offices are set up at the mandal level with each office handling 2 – 3 mandals. Each office has a field coordinator and an agronomist who advice the farmers about crops that can be grown with drip irrigation. Farmers can approach these offices to collect information about these schemes where the staff helps them fill up the forms. This has reduced the hassles faced by farmers in applying for subsidy. It generally takes 40 – 50 days for the complete process from application to installation of drip system at the field. Once a farmer comes with the necessary documents, the company dealers and staff at the APMIP office forwards it to the APMIP district office for verification. Once verified, a work order is generated for the company. The company is instructed to carry out the survey and

the designing of the system which is then installed on the farmers' field. The dealers have to install the drip irrigation system in 15 days after the work order has been generated.

Companies generally set up their dealer shops at the mandal level. Dealers help farmers with applying for the drip irrigation and maintenance of the system. However, APMIP does not have any control over these dealers. Hence sometimes it may happen that the farmers are charged by the dealers for filling up forms for application. Lack of availability of spare parts and poor quality spare parts is also a problem that the farmers have faced in the village. According to the dealers, there have been a few cases where poor quality spare parts were given to the farmers but they generally follow stringent quality norms. They suggest that cases of clogging of emitters and breakage of pipes happen because of improper usage and maintenance by the farmers. Thus, the farmers need to be trained in using the system properly so that they don't face problems later.

Labour shortage is also a problem in the village which is also one of the main reasons why farmers have started adopting drip irrigation in the village. Migration of labour from nearby villages has completely stopped in recent times because they are able to find work in their own villages itself. Numerous schemes for rural development such as NREGA are being run by the Andhra Pradesh government to check migration and ensure that villagers are able to get work in their own villages. Under these schemes the farmers have to work lesser and get wages on time. Thus they prefer working for such schemes as compared to working in agricultural farms. According to the farmers interviewed, labour rates in the village have increased to Rs 200 per day in recent times and yet, they find it difficult to hire labour especially during the rainy season.

Another problem that the villagers face is the lack of availability of fertilizers in the village. The farmers feel that the cost of fertilizers is high in spite of the subsidy provided by the government. They are not get sufficient fertilizers like urea and DAP even after paying huge costs. Moreover, there are no agri – input shops in the village. Farmers have to travel to Chevella to buy seeds, fertilizers and pesticides. The water soluble fertilizers that are used with drip irrigation are also not easily available at these shops. According to the farmers who have adopted drip irrigation, they have seen an increase in yields after adopting drip irrigation. However, they might be able to increase their yields further if water soluble fertilizers are made available to them in adequate quantities.

Narsimbhai is a farmer in Pamena who owns 4 acres land. His land is in two parcels of 1 acre and 3 acres. He mainly grows vegetables like tomatoes and cabbage in his field along with fodder for his livestock. He is able to get 4 crops every year with staggered cropping.

He has installed drip irrigation last year over 2 acres land. He has installed drip on the parcel of 1 acre and 1 acre out of the 3 acre parcel. The total cost of the system was Rs 1,10,000 and he was table to get 90% subsidy. Thus he had to pay only about Rs. 12,000 for the entire system. However, 2 acres was the maximum area that he could cover with his limited finances. The subsidy also included the cost of the pipe required to carry water from his tubewell to the field which is around 20 – 25 metres away.

Under staggered cropping, the entire area is not cultivated all at once. Instead, Narsimbhai cultivates 2 acre at a time after every two months. This system helps him minimize his market risks i.e. risk of low prices and risks of insect attacks. Another advantage that he has is that he can use the same drip equipment that is installed over 1 acre to cover 2 acres by shifting the laterals to the nearby plot once the crops on one plot of 1 acre are harvested. Extra connections are made on the subline so that laterals can be attached to cover the entire area.

Annexure 5.1

Narsimbhai has his own tubewell which is 200 feet deep. Thus, water availability is not a problem for him which is also one of the factors that helps him cultivate his fields all through the year. The main problem that Narsimbhai faced was that of labour shortage. He only has three working members in his family who could not take care of the fields along with the livestock. Thus he installed the drip irrigation system which helped him reduce labour required especially for irrigation. Another advantage that he has is that even when the electricity supply is erratic or supplied at odd hours, he can start/ stop the system with a switch of a button.

Narsimbhai does not feel that there is a risk of animals or rodents damaging the drip irrigation equipment as that are a bigger risk in villages near forests. According to him, the approximate cost of cultivating tomatoes on 1 acre of land would be as follows:
Labour for land preparation- Rs 3000
Seeds – Rs 1500
Fertilizer – Rs 4000 - 5000
Pesticides – Rs 3000
Labour for harvesting – Rs 3000

Water and Electricity – Rs 1500 – 2000
Thus the total cost of cultivating tomatoes on 1 acre would be around Rs 16,000.

According to Narsimbhai, he is able to get 20% more yields than farmers who have not installed drip irrigation in the village

Annexure 5.2

Vijay Allam is another farmer in Pamena village who owns 3 acres of land. His land is also divided into two parcels of 2 acres and 1 acres. He mostly cultivates vegetables like tomatoes, chillies and cabbage in his field.

Vijay has a well which is 50 feet deep but it does not have enough water to last for the entire year especially during the summer months in case of delayed rainfall. According to Vijay, lack of water availability and erratic electricity supply are the main reasons why he hasn't adopted drip irrigation. However, it was clear that he wasn't aware about the water savings that he could get as a result of installing drip irrigation. He felt that with flood irrigation he only had to water the fields in 14 – 17 days whereas with drip irrigation he would have to do it every day which would require more water. Thus he hadn't installed drip irrigation system

Vijay was also not aware about the procedure to be carried out for applying for drip irrigation. Lack of funds for the system was another problem that he faced. He was not interested in the system right now because he did not have money but would think of installing it on his farms next year if he had enough money.
According to Vijay, the cost of cultivating tomatoes on 1 acre land would be approximately as follows
Labour for land preparation, sowing, etc. – Rs 5000
Seeds – Rs 1500
Fertilizer – Rs 6000
Pesticides – Rs 3000
Labour for harvesting – Rs 2000 – 3000
Water and Electricity – Rs 1500 – 2000
Thus the total cost of cultivation would be around Rs 20,000

Annexure 6: Some Additional Data Tables

Table 1: Timely water availability disaggregated by adopters and non-adopters

Timely water availability	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	21.8	15.4	19.7	15.6	1.1	0.0	72.0	100.0	27.5	36.2
Positive	50.4	53.8	63.2	56.3	94.4	95.7	26.8	0.0	58.6	46.9
No impact	26.9	30.8	15.8	28.1	4.4	0.0	1.2	0.0	13.4	16.2
Negative	0,8	0.0	1.3	0.0	0.0	4.3	0.0	0.0	0.5	0.8
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2: Adequateness of water availability disaggregated by adopters and non-adopters

Adequate water availability	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	10.1	10.3	17.1	21.9	1.1	0.0	65.4	100.0	21.6	36.2
Positive	63.9	64.1	65.8	50.0	86.7	91.3	32.1	0.0	62.8	47.7
No impact	25.2	25.6	14.5	28.1	12.2	4.3	1.2	0.0	14.5	15.4
Negative	0.8	0.0	2.6	0.0	0.0	4.3	1.2	0.0	1.1	0.8
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3: Water table increase disaggregated by adopters and non-adopters

Water table increase	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	16.0	10.3	17.1	0.0	2.2	0.0	5.1	0.0	10.4	3.1
Positive	47.9	56.4	34.2	43.8	43.3	43.5	59.5	19.4	46.4	40.8
No impact	34.5	30.8	44.7	56.3	54.4	52.2	34.2	80.6	41.5	54.6
Negative	1.7	2.6	3.9	0.0	0.0	4.3	0.0	0.0	1.4	1.5
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.3	0.0

Table 4 : Overall water situation disaggregated by adopters and non-adopters

Overall water situation in the village	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	5.9	2.6	5.3	3.1	1.1	0.0	5.3	0.0	4.4	1.5
Positive	52.1	56.4	28.9	43.8	55.6	43.5	63.2	100.0	50.4	63.1
No impact	42.0	38.5	56.6	50.0	42.2	52.2	17.1	0.0	39.9	33.1
Negative	0.0	2.6	9.2	3.1	1.1	4.3	14.5	0.0	5.3	2.3
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5: Reduction in water quantity used disaggregated by adopters and non-adopters

Reduction in water quantity used for irrigation	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	6.6	10.3	28.9	12.5	5.6	4.3	12.5	0.0	12.3	6.9
High	38.0	35.9	43.4	37.5	35.6	17.4	27.5	25.0	36.2	30.0
Medium	44.6	35.9	27.6	40.6	52.2	60.9	31.3	75.0	40.1	52.3
Low	10.7	17.9	0.0	9.4	6.7	17.4	27.5	0.0	11.2	10.8
Very low	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.3	0.0

Table 6: Distribution of water availability disaggregated by adopters and non-adopters

Equitable distribution of water to each crop	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	5.9	5.1	25.0	15.6	2.2	0.0	64.6	100.0	21.7	33.1
Positive	56.3	51.3	51.3	43.8	47.8	43.5	16.5	0.0	44.5	33.8
No impact	34.5	41.0	23.7	37.5	50.0	56.5	19.0	0.0	32.7	31.5
Negative	3.4	2.6	0.0	3.1	0.0	0.0	0.0	0.0	1.1	1.5
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7 : Misuse/Abuse of water disaggregated by adopters and non-adopters

Misuse/abuse of water	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	7.6	7.7	9.2	15.6	2.2	0.0	0.0	0.0	4.7	4.6
Positive	52.9	38.5	22.4	43.8	47.8	47.8	17.9	0.0	38.6	26.2
No impact	36.1	51.3	50.0	37.5	50.0	47.8	78.2	100.0	50.4	65.4
Negative	2.5	2.6	18.4	3.1	0.0	4.3	2.6	0.0	5.8	3.8
Highly negative	0.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.6	0.0

Table 8: Impact on resolution of disputes disaggregated by adopters and non-adopters

Resolution of disputes	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	10.1	17.9	3.9	12.5	2.2	0.0	20.3	100.0	9.1	36.2
Positive	46.2	41.0	23.7	21.9	40.0	47.8	62.0	0.0	43.4	26.2
No impact	37.8	38.5	69.7	65.5	56.7	43.5	17.7	0.0	44.8	35.4
Negative	5.9	2.6	2.6	0.0	1.1	0.0	0.0	0.0	2.7	2.3
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9: Impact on water pricing disaggregated by adopters and non-adopters

Lower prices/cost of water	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	4.2	12.8	3.9	6.3	3.3	0.0	7.5	0.0	5.2	5.4
Positive	56.3	59.0	23.7	25	43.3	47.8	51.3	100.0	45.8	60.0
No impact	39.5	23.1	69.7	68.8	51.1	47.8	38.8	0.0	47.4	32.3
Negative	0.0	5.1	2.6	0.0	2.2	4.3	2.5	0.0	1.6	2.3
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 10: Impact on soil quality disaggregated by adopters and non-adopters

DI is beneficial for soil quality	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	8.3	2.6	19.7	12.5	2.2	0.0	6.3	0.0	8.7	3.8
High	47.1	43.6	38.2	37.5	41.1	43.5	13.8	0.0	36.5	30.0
Medium	39.7	43.6	38.2	43.8	51.1	56.5	26.3	0.0	39.2	33.8
Low	4.1	10.3	0.0	0.0	5.6	0.0	35.0	0.0	10.4	3.1
Very low	0.8	0.0	3.9	6.3	0.0	0.0	18.8	100.0	5.2	29.2

Table 11: Drip Irrigation is successful irrespective of soil quality

DI is successful irrespective of soil quality	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	10.7	10.3	38.2	31.3	4.4	4.3	25.0	100.0	18.0	39.2
High	39.7	30.8	32.9	21.9	31.1	43.5	45.0	0.0	37.3	22.3
Medium	41.3	53.8	21.1	34.4	51.1	43.5	11.3	0.0	33.0	32.3
Low	8.3	5.1	6.6	3.1	13.3	8.7	15.0	0.0	10.6	3.8
Very low	0.0	0.0	0.0	9.4	0.0	0.0	3.8	0.0	1.1	2.3

Table 12: Drip Irrigation is suitable to all terrains

DI is suitable to all terrains	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	13.2	5.1	40.8	34.4	5.6	4.3	26.9	100.0	20.0	38.5
High	45.5	46.2	38.2	15.6	32.2	34.8	60.3	0.0	43.8	23.8
Medium	37.2	33.3	15.8	40.6	54.4	47.8	10.3	0.0	31.2	28.5
Low	4.1	15.4	3.9	3.1	7.8	13.0	1.3	0.0	4.4	7.7
Very low	0.0	0.0	1.3	6.3	0.0	0.0	1.3	0.0	0.5	1.5

Table 13: Drip Irrigation has met the varied irrigation needs successfully

DI has met the varied irrigation needs successfully	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly satisfied	5.0	2.6	19.7	31.3	1.1	0.0	53.8	100.0	17.8	36.2
Satisfied	58.8	56.4	47.7	28.1	11.1	21.7	30.0	0.0	38.4	27.7
Undecided	31.9	41.0	31.6	37.5	38.9	43.5	13.8	0.0	29.6	29.2
Dissatisfied	4.2	0.0	1.3	0.0	47.8	26.1	2.5	0.0	14.0	4.6
Very dissatisfied	0.0	0.0	0.0	3.1	1.1	8.7	0.0	0.0	0.3	2.3

Table 14: Assessment about the adaptiveness in agriculture with the popularity of DI

Assessment about the adaptiveness in agriculture with the popularity of DI	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very adaptive	6.7	7.7	31.6	43.8	72.2	73.9	54.4	100.0	38.5	
Adaptive	73.1	59.0	55.3	28.1	23.3	21.7	40.5	0.0	50.0	
Cannot decide	10.1	28.2	10.5	25.0	3.3	0.0	5.1	0.0	7.4	
Rigid	9.2	5.1	1.3	3.1	1.1	4.3	0.0	0.0	3.6	
Very rigid	0.8	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.5	

Table 15: Drip Irrigation leads to greater control to manage the irrigation

DI leads to greater control to manage the irrigation	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly satisfied	10.1	7.7	35.5	21.9	4.4	0.0	67.5	100.0	26.6	35.4
Satisfied	46.2	53.8	51.3	65.5	25.6	39.1	30.0	0.0	38.6	39.2
Undecided	39.5	33.3	11.8	12.5	53.3	43.5	2.5	0.0	29.0	20.8
Dissatisfied	1.7	5.1	1.3	0.0	12.2	17.4	0.0	0.0	3.8	4.6
Very dissatisfied	2.5	0.0	0.0	0.0	4.4	0.0	0.0	0.0	1.9	0.0

Table 16: Reduction in power used for irrigating the fields

Reduction in power used for irrigating the fields	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	5.8	7.7	25.0	12.5	4.4	0.0	13.6	0.0	11.1	94.6
High	49.6	46.2	44.7	25.0	27.8	17.4	34.6	0.0	39.9	23.1
Medium	34.7	41.0	26.3	46.9	57.8	78.3	24.7	0.0	36.4	37.7
Low	9.1	5.1	2.6	12.5	10.0	4.3	24.7	0.0	11.4	5.4
Very low	0.8	0.0	1.3	3.1	0.0	0.0	2.5	100.0	1.1	28.5

Table 17: Increased Income due to Drip Irrigation

Increased Income	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	12.6	2.6	26.3	15.6	2.2	0.0	22.2	58.3	15.0	20.8
Positive	51.3	71.8	52.6	37.5	62.2	60.9	69.1	41.7	58.2	53.1
No impact	36.1	25.6	21.1	46.9	35.6	39.1	8.6	0.0	26.8	26.2
Negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 18: Drip Irrigation has helped in increasing your income

DI has helped in increasing your income	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly satisfied	8.4	10.3	27.6	25.0	3.3	0.0	25.0	100.0	14.8	36.9
Satisfied	59.7	61.5	44.7	50.0	17.8	26.1	38.8	0.0	41.6	35.4
Undecided	27.7	25.6	23.7	15.6	53.3	52.2	35.0	0.0	34.8	20.8
Dissatisfied	4.2	2.6	3.9	6.3	21.1	21.7	1.3	0.0	7.7	6.2
Very dissatisfied	0.0	0.0	0.0	3.1	4.4	0.0	0.0	0.0	1.1	0.8

Table 19: Assured income due to Drip Irrigation

Assured Income	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	10.9	10.3	11.8	9.4	1.1	0.0	54.4	100.0	18.1	33.1
Positive	63.9	66.7	52.6	50.0	30.0	17.4	35.4	0.0	47.0	35.4
No impact	24.4	23.1	34.2	40.6	68.9	78.3	10.1	0.0	34.3	30.8
Negative	0.8	0.0	1.3	0.0	0.0	4.3	0.0	0.0	0.5	0.8
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 20: Increase in savings and investment

Increase in savings and investment	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	12.6	7.7	11.8	6.3	0.0	0.0	25.0	0.0	12.1	3.8
Positive	58.8	66.7	39.5	34.4	31.1	17.4	45.0	80.6	44.9	36.9
No impact	26.9	25.6	43.4	59.4	68.9	78.3	30.0	19.4	41.4	58.5
Negative	1.7	0.0	5.3	0.0	0.0	4.3	0.0	0.0	1.6	0.8
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 21: Better market power when dealing with traders

Better market power when dealing with traders	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	6.7	10.3	14.5	6.3	3.3	0.0	2.6	0.0	6.6	4.6
Positive	51.3	35.9	34.2	25.0	48.9	43.5	10.3	0.0	38.3	24.6
No impact	37.0	43.6	48.7	68.8	45.6	56.5	73.1	100.0	49.3	67.7
Negative	5.0	10.3	2.6	0.0	2.2	0.0	14.1	0.0	5.8	3.1
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 22: Better social status

Better social status	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Highly positive	2.5	2.6	27.6	12.5	3.3	0.0	7.3	0.0	9.0	3.8
Positive	53.8	64.1	50.0	28.1	46.7	30.4	47.6	100.0	49.9	59.2
No impact	41.2	25.6	22.4	56.3	48.9	69.6	32.9	0.0	37.3	33.8
Negative	2.5	7.7	0.0	3.1	1.1	0.0	11.0	0.0	3.5	3.1
Highly negative	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.3	0.0

Table 23: Timely after sales service was available

Timely after sales service was available	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	7.4	2.6	23.7	6.3	1.1	0.0	3.8	0.0	8.5	3.1
High	40.5	28.2	26.3	34.4	26.7	30.4	12.7	0.0	28.1	22.3
Medium	44.6	46.2	25.0	50.0	56.7	47.8	32.9	0.0	41.0	34.6
Low	6.6	20.5	15.8	9.4	11.1	13.0	39.2	0.0	16.7	10.8
Very low	0.8	2.6	9.2	0.0	4.4	8.7	11.4	100.0	5.7	29.2

Table 24: After sales service was costly

After sales service was costly	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	9.9	7.7	19.7	9.4	4.4	8.7	5.1	0.0	9.6	6.2
High	35.5	25.6	18.4	34.4	24.4	21.7	35.4	0.0	29.2	20
Medium	43.0	51.3	26.3	40.6	56.7	56.5	40.5	100.0	42.3	63.1
Low	9.1	15.4	18.4	12.5	13.3	13.0	15.2	0.0	13.4	10.0
Very low	2.5	0.0	16.9	3.1	1.1	0.0	3.8	0.0	5.5	0.8

Table 25: Good after sales was available

Good after sales was available	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	6.7	2.6	23.7	9.4	0.0	0.0	9.8	0.0	9.2	3.1
High	47.5	28.2	32.9	34.4	30.0	26.1	8.5	0.0	31.5	21.5
Medium	35.8	53.8	21.1	53.1	58.9	56.5	26.8	0.0	36.4	39.2
Low	9.2	15.4	14.5	0.0	7.8	13.0	43.9	36.1	17.7	16.9
Very low	0.8	0.0	7.9	3.1	3.3	4.3	11.0	63.9	5.2	19.2

Table 26: Clogging of Drip Irrigation is a big problem

Clogging of DI is a big problem	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	15.7	15.4	19.7	15.6	4.4	4.3	13.6	0.0	13.3	9.2
High	38	35.9	14.5	21.9	33.3	26.1	19.8	0.0	28.0	20.8
Medium	38.8	38.5	35.5	53.1	53.3	65.2	12.3	19.4	35.9	41.5
Low	5.8	10.3	21.1	9.4	8.9	4.3	53.1	0.0	20.1	6.2
Very low	1.7	0.0	9.2	0.0	0.0	0.0	1.2	80.6	2.7	22.3

Table 27: Damaged pipes were a big problem

Damaged pipes were a big problem	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	4.1	2.6	19.7	6.3	2.2	0.0	9.0	0.0	7.9	2.3
High	43.8	41.0	21.1	21.9	31.1	13.0	11.5	0.0	29.0	20.0
Medium	42.1	46.2	36.8	65.6	57.8	78.3	12.8	16.7	38.6	48.5
Low	7.4	7.7	17.1	6.3	7.8	8.7	62.8	0.0	21.4	5.4
Very low	2.5	2.6	5.3	0.0	1.1	0.0	3.8	83.3	3.0	23.8

Table 28: Relaying of pipes is a big hassle

Relaying of pipes is a big hassle	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	7.4	2.6	18.4	9.4	1.1	0.0	6.6	0.0	8.0	3.1
High	38.0	41.0	14.5	34.4	30.0	17.4	9.2	0.0	25.1	23.8
Medium	45.5	35.9	38.2	53.1	61.1	73.9	11.8	13.9	40.8	40.8
Low	6.6	17.9	15.8	3.1	6.7	8.7	65.8	0.0	20.9	7.7
Very low	2.5	2.6	13.2	0.0	1.1	0.0	6.6	86.1	5.2	24.6

Table 29: Drip Irrigation equipment is easy to maintain

DI equipment is easy to maintain	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	15.7	15.4	25.0	9.4	1.1	0.0	42.7	58.3	20.1	23.1
High	40.5	30.8	31.6	40.6	20.0	34.8	48.8	41.7	35.5	36.9
Medium	36.4	46.2	30.3	46.9	72.2	56.5	6.1	0.0	37.1	35.4
Low	5.0	7.7	10.5	3.1	5.6	8.7	1.2	0.0	5.4	4.6
Very low	2.5	0.0	2.6	0.0	1.1	0.0	1.2	0.0	1.9	0.0

Table 30: Drip Irrigation is difficult to learn

DI is difficult to learn	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	2.5	2.6	10.5	12.5	0.0	0.0	3.7	100.0	3.8	31.5
High	39.7	41.0	10.5	34.4	13.3	17.4	6.1	0.0	19.8	23.8
Medium	32.2	28.2	25.0	43.8	21.1	17.4	25.6	0.0	26.6	22.3
Low	19.8	25.6	23.7	3.1	31.1	52.2	31.7	0.0	26.0	17.7
Very low	5.8	2.6	30.3	6.3	34.4	13.0	32.9	0.0	23.8	4.6

Table 31: Drip Irrigation is difficult to master

DI is difficult to master	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	5.0	2.6	7.9	15.6	0.0	0.0	5.1	25.0	4.4	11.5
High	28.1	28.2	13.2	25.0	8.9	13.0	5.1	0.0	15.3	16.9
Medium	51.2	48.7	25.0	40.6	34.4	39.1	12.8	11.1	33.4	34.6
Low	12.4	15.4	28.9	3.1	33.3	26.1	44.9	63.9	27.9	27.7
Very low	3.3	5.1	25.0	15.6	23.3	21.7	32.1	0.0	18.9	9.2

Table 32: Drip Irrigation is very cumbersome

DI is very cumbersome	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	23.1	17.9	10.5	12.5	0.0	4.3	5.0	55.6	10.9	24.6
High	27.3	25.6	15.8	28.1	17.8	26.1	33.8	0.0	24.0	18.5
Medium	28.1	30.8	25.0	40.6	22.2	8.7	12.5	0.0	22.6	20.8
Low	5.0	12.8	21.1	3.1	13.3	39.1	18.8	44.4	13.4	23.8
Very low	16.5	12.8	27.6	15.6	46.7	21.7	30.0	0.0	29.2	11.5

Table 33: Drip Irrigation is very costly

DI is very costly	Andhra Pradesh (%)		Gujarat (%)		Maharashtra (%)		Tamil Nadu (%)		Overall (%)	
	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter	Adopter	Non Adopter
Very high	9.1	10.3	23.7	21.9	4.4	13.0	12.2	0.0	11.7	10.8
High	34.7	38.5	30.3	28.1	12.2	8.7	11.0	0.0	23.0	20.0
Medium	33.9	35.9	38.2	50.0	63.3	78.3	50.0	100	45.5	64.6
Low	19.0	10.3	3.9	0.0	14.4	0.0	20.7	0.0	15.2	3.1
Very low	33.	5.1	3.9	0.0	5.6	0.0	6.1	0.0	4.6	1.5

Annexure 7: Subsidy Process Experience Tables

Table 1: Use of Subsidy support for adopting Drip Irrigation

Did you avail subsidy support for DI	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Yes	71.9	67.6	67.5	32.8	60.8
No	28.1	32.4	32.5	67.2	39.2

Table 2: Adequacy of subsidy support for adopting Drip Irrigation

The subsidy amount is enough	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	40.0	2.8	0.0	11.0	16.5
Good	50.6	27.8	5.3	61.6	35.6
Okay	7.5	29.6	13.2	26.0	17.1
Bad	.6	29.6	67.5	1.4	24.4
Very bad	1.3	10.2	14.0	0.0	6.4

Table 3: Convenience of subsidy procedure for adopting Drip Irrigation

Convenience of the subsidy procedure	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	21.9	9.3	0.0	2.8	10.4
Good	49.4	44.4	4.4	27.8	33.5
Okay	25.6	35.2	8.8	51.4	27.8
Bad	1.9	8.3	57.9	16.7	19.8
Very bad	1.3	2.8	28.9	1.4	8.6

Table 4: Ease of availing subsidy support for adopting Drip Irrigation

The ease of availing subsidy	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	11.3	7.4	0.0	0.0	5.7
Good	49.4	38.0	3.5	7.0	28.5
Okay	31.3	38.9	6.1	43.7	28.7
Bad	6.9	13.9	32.5	42.3	20.5
Very bad	1.3	1.9	57.9	7.0	16.6

Table 5: Clarity of procedure to avail subsidy support for adopting Drip Irrigation

Clarity of subsidy procedure	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	11.3	10.2	0.0	1.4	6.6
Good	49.4	32.4	3.5	13.7	28.1
Okay	35.6	41.7	4.4	27.4	27.9
Bad	1.9	11.1	30.7	45.2	18.2
Very bad	1.9	4.6	61.4	12.3	19.1

Table 6: Behavior of officials / agency involved in granting subsidy support

The behavior of officials/agencies involved	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	5.0	13.0	0.0	0.0	4.9
Good	51.9	27.8	.9	14.1	27.4
Okay	37.5	50.0	6.1	71.8	38.0
Bad	3.8	5.6	43.0	14.1	15.7
Very bad	1.9	3.7	50.0	0.0	14.1

Table 7: Duration to availing subsidy support for adopting Drip Irrigation

The duration of availing subsidy	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	4.4	12.0	0.0	1.4	4.6
Good	32.5	37.0	0.9	4.2	21.1
Okay	36.3	38.9	5.3	27.8	27.8
Bad	22.5	8.3	43.0	34.7	26.2
Very bad	4.4	3.7	50.9	31.9	20.3

Table 8: Cost of availing subsidy support for adopting Drip Irrigation

The cost of availing the subsidy	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	6.3	5.6	0.0	1.4	3.8
Good	59.4	25.9	0.9	2.9	27.9
Okay	30.0	47.2	4.4	62.3	32.6
Bad	3.1	14.8	36.8	31.9	18.8
Very bad	1.3	6.5	57.9	1.4	16.9

Table 9: Transparency in process of availing subsidy support for adopting Drip Irrigation

Transparency in the process to avail subsidy	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	4.4	4.6	0.9	1.4	3.1
Good	42.5	36.1	0.0	18.3	26.5
Okay	49.4	48.1	7.0	25.4	34.7
Bad	3.1	8.3	35.1	45.1	19.0
Very bad	.6	2.8	57.0	9.9	16.8

Table 10: Fairness in process to avail subsidy support for adopting Drip Irrigation

Fairness in the process to avail subsidy	Andhra Pradesh (%)	Gujarat (%)	Maharashtra (%)	Tamil Nadu (%)	Overall (%)
Very good	3.1	10.2	0.9	1.4	4.0
Good	56.3	37.0	0.0	4.3	29.4
Okay	35.6	43.5	6.1	31.4	29.4
Bad	4.4	7.4	27.2	50.0	17.9
Very bad	.6	1.9	65.8	12.9	19.2

Annexure – I

Review Report

1. **Title of the Draft Study Report Examined:**

   An Analysis of Resource Conservation Technology: A Case of Micro-Irrigation System (Drip Irrigation)

2. **Date of Receipt of the Draft Report: 20th January, 2014**

3. **Date of Dispatch of Comments: 24th March, 2014**

4. **Comments on the Objective of the study:**

   The subject of the report is very important in context of agricultural development and resource use efficiency. However, the analysis is almost entirely qualitative in nature, relying on subjective judgments rather than quantitative measurements. Nevertheless, perceptions of the users of technology are also useful information in assessment and policy planning. In any case, the limitations are stated in the report.

5. **Comments on the Methodology:**

   The analysis is mostly based on primary data of perceptions of users, categorized in terms of intensity by the author and is subjective. As such the title of the report somehow fails to convey this impression. Also, since the methodology is based on mostly on sampling techniques with a fairly large sample size, if possible the title may be modified with a sub-title to be more informative of the contents. This analysis is however supplemented by case studies summarized in Chapter 4 and presented in details in the Annexures, where both qualitative and quantitative insights are presented. The write-up, especially the introductory chapters can be shortened considerably.

6. **Comments on the Presentation, Get up etc.**

   i) The first two chapters require careful editing. There are repetitions, overlaps and contradictions that may be minimized, resolved or commented on (E.g. page 4, 1.2.1, table 1.2 and section 1.2.3). There is no need for a grand total in all table 1.1. Short forms in tables (eg. Table 2.1) can be explained.

   ii) The methodology section in chapter 2 needs to be more explicit about the types of responses solicited and interpretations. In particular the introductory section of Chapter 3 ends abruptly only talking of the first part of 'enquiry' which is planned to employ 'case studies' approach. That survey method is also a part of the methodology and probably needs mention in this section.

iii) Tables may be made more user friendly, such as

a) Table 1.3 can be more consolidated (in mill. Hectares).

b) Sub-title of table 1.4 ‘water productivity’ is misleading and may be revised.

c) Table headings in chapter 6 are not suitable and should mention that they reflect perceptions on certain aspects.

d) Table 6.21 ‘adaptiveness in agriculture’ and ‘how adaptive agriculture has become’ in section 6.5 is not clear. Respondents are not passive observers of changes in agriculture.

iv) May add a table in chapter 1 on water resources, reducing the text.

v) Some section headings may be made more suitable such as

a) Sections 4.1, 4.2 to convey the ‘advantage’ aspect such as ‘Water saving’ in 4.1

b) The title ‘global…’ of section 1.2.1 in chapter 1 is not suitable for the whole section – may be broken up to other section for ‘Indian’ aspects and another for ‘micro irrigation in India’ aspects.

vi) The regression in chapter 7 is weak, the independent variables are not convincing – presentation of the table is not clear (what is the dependent variable?).

vii) The case studies in Annexure and especially some of the quantitative insights stored in them are very useful and some highlights from these findings can also be given in text boxes in the main text to make the report more appealing and useful.

7. Overall View on Acceptability of the Report:

The report should acceptable after suitable editing and condensing of the text.

Annexure – II

Action Taken Report

The following comments were received and the actions taken on each have been listed in the table to highlight that the report titled **"An Analysis of Resource Conservation Technology: A Case of Micro-Irrigation System (Drip Irrigation)"** has been updated as suggested and needed.

Sl. No.	Comment Received	Action Taken
1	Comments on Objective	
a	The subject of the report is very important in the context of agricultural development and resource use efficiency. However the analysis is almost entirely qualitative in nature relying on subjective judgements rather than quantitative measurement. Nevertheless, perceptions of the users of technology are also useful information in assessment and policy planning. In any case the limitations are stated in the report.	The study is not entirely based on subjective judgements. The perceptions of users have a good basis and are manifestations of the experience of users and non-users of the technology over a period of many years as the technology is not new. Such measurements also lend themselves to sophisticated non-parametric statistical analysis and are valid measures. Also the perceptions of users matter more in adoption and usage when the technology has failed to scale-up over decades and has suddenly assumed scale. The paybacks have not changed but the experiences and perceptions are what has changed to enable this and hence the data used in this study is important and has been ignored by most studies thus far.
2	Comments on Methodology	
a	The analysis is mostly based on primary data of perceptions of users, categorized in terms of intensity by the author and is subjective. As such the title of the report somehow fails to convey this impression. Also, since the methodology is based on mostly on sampling techniques with a fairly large sample size, if possible the title may be modified with a sub title to be more informative to the contents. This analysis is however supplemented by case studies summarized in Chapter 4 and presented in details in the Annexures, where both quantitative and qualitative insights are presented. The write –up, especially the introductory chapters can be shortened considerably.	The analysis is based on non-scale measures of experiences of users and their observations in non-numerical terms using Likert–like scales for much of the data collection and analysis which is an established scientific approach. As such the title ought not to be changed. The introductory chapters have been shortened considerably without compromising the richness of information after careful deliberation.

Sl. No.	Comment Received	Action Taken
3	Comments on the Presentation get up etc.	
a	The first two chapters require careful editing. There are repetitions and contradictions that may be minimized, resolved or commented on (e.g. page 4, 1.2.1, table 1.2 and section 1.2.3). There is no need for a grand total in all tables 1.1. Short forms in tables can be explained (e.g. table 2.1).	The chapters have been carefully edited and shortened wherever possible. The contradictions are not actually contradictions but give situations at different points of time and the same has been mentioned upfront and comment included in text as suggested. The grand total has been removed from table 1.1 and short forms in table 2.1 have been explained. A similar approach has been adopted for other tables of the report as well.
b	The methodology section in chapter 2 needs to be more explicit about the types of responses solicited and interpretations. In particular the introductory section of chapter 3 ends abruptly only talking of the first part of "enquiry" which is planned to employ 'case studies' approach. That survey method is also a part of the methodology needs mention in this section.	This is modified and more detail added explicitly and also more text added explaining the survey method in the methodology section. The comments have been therefore addressed.
c	Tables maybe made more user friendly, such as Table 1.3 can be more consolidated (in Mill. Hectares).	This has been done across the report.
d	Sub-title of table 1.4 'water-productivity' is misleading and may be revised.	The title has been changed to a suitable title.
e	Table headings in chapter 6 are not suitable and should mention that they reflect perceptions on certain aspects.	These have been reviewed and changes made wherever necessary.
f	Table 6.21 'ádaptiveness in agriculture' and 'how adaptive agriculture has become' in section 6.5 is not clear. Respondents are not passive observers of changes in agriculture.	Suitable text has been introduced to explain this.
g	May add a table in chapter 1 on water resources, reducing the text.	Text has been reduced without adding table to make the text crisp. Table is not needed. A Graph has been added to replace the text.
h	Some section headings may be made more suitable such as Sections 4.1, 4.2 to convey the	Suitable changes have been made in these wherever necessary.

Sl. No.	Comment Received	Action Taken
	'advantage' aspect such was " Water saving' in 4.1.	
i	The title 'global..."of section 1.2.1 in chapter 1 is not suitable for the whole section – maybe broken up to other section for 'Indian' aspects of another for 'micro irrigation in India' aspects.	This has been modified.
j	The regression in chapter 7 is weak, the independent variables are not convincing – presentation of the table is not clear (what is the dependent variable).	The regression has an adjusted R-square of 38.5% which is high for such studies, and with a significant control variable and many explanatory variables and therefore can be considered strong and valid. The explanation is given in the text and has been modified to explain the regression and its results better.
k	The case studies in Annexure and especially some of the quantitative insights stored in them are very useful and some highlights from these findings can also be given in text boxes in the main text to make the report more appealing and useful.	This is a good suggestion but this would only make the report longer and go against the earlier comment on need to shorten or condense the report. Instead a visual summary has been added in chapter 7 which collects the findings from the case studies and the survey and build up propositions for further research.

Gandhi

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