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Full Length Research Paper

Role of Micro irrigation in producing more with less

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Abstract

The paper briefly reviews the growth and spread of micro irrigation (MI) in India. The analysis uses the data available in public domain and those collected from the government sources. The components of the irrigation system and the assistance given by the government in extending the technology are mentioned. The role of industry in the extension and adoption of MI is also discussed. The paper also explains the role of micro irrigation in the extension of Precision Farming (PF) and how it impacted on several crops. The field data for the latter study were collected from farmers of many states in India with whom the author worked.

Key words: Micro irrigation, Adoption, Extension, Precision farming, Fertigation, Water harvesting, Irrigation Industry, Energy, Economic Viability, Accelerated Irrigation Benefit Program, Integrated micro Irrigation Project.

INTRODUCTION

Agriculture in India is climate restricted; 48% of the geographical area of the country receives less than 1000 mm rain and the rest 1000-2500 mm. The difficulty is that the rainfall only lasts for 3-4 months' duration making it imperative for rainwater storage and irrigation. But the available water for irrigation is not enough to cover the net cultivated area. Only 42% of cultivated area is presently irrigated. Irrigation cover cannot be increased as the available 1143 BCM water would be insufficient. By 2050 our water need (both irrigation and total need) would cross the availability level. This is a grim situation. It is made more so by the need for increasing food production. To achieve the increased food production of 494 million t by 2050, our net irrigated area should increase from 62 million ha to 146 million ha. This cannot happen as water is limited. Production cannot be increased by increasing in area alone; area will increase only by 2 million ha during 2010-2050. So we are into a very difficult situation.

The only way out is to identify water conserving irrigation methods. Incidentally, the technology of micro irrigation serves better in this scenario. It offers a way of irrigating more land with less water (water security); more yield with less water (food security) and more food production with less energy use (energy security). Micro irrigation methods offer effective solutions in the area of water conservation and efficient and sustainable water use.

Other water conservation solutions are:

- Water harvesting technologies which will avoid loss by surface run –off and will help in recharging aquifers.
- Technologies for re-engineering and enhancing soil storage capacity. Addition of organic manure ensures higher water holding capacity and holding duration of the soil.
- Mulching of soil surface to regulate unwanted evaporation.
- Sub soil drainage by piping systems to drain excess water during heavy rain fall and to reuse this in other parts of the year.
- Piped conveyance in canal command saving water loss through evaporation and seepage. Water use efficiency will increase from 40% to up to 80-90% by piped conveyance.
- Conversion of flow irrigation practice in command area into micro irrigation in conjunction with piped conveyance. A

total approach where circumstantial water wastage is totally avoided.

- Creation of small farm ponds where farmers can store rain water and use through micro irrigation for “lifesaving irrigations” for pulses and other rainfed crops and thereby increase their water productivity.
- Technologies for recycling water and use for irrigation in non-food crops.
- Use of solar powered pumps in conjunction with farm ponds in areas where access to power is wanting and water is scarce.

These solutions in the long-term would lead to water, food and energy security. That is what we believe sustainability is about.

The paper first gives the current status of the spread of MI in different parts of India and highlights the high adopter states (Provinces) and points out the need for further growth in other states. The adoption in the field and impact in farming comes from the changes in agronomy that are associated with each crop when micro irrigation and fertigation are introduced. These changes result in precision farming and help farmers to increase crop yields. Finally the question of economic viability of the MI technology is addressed briefly.

Brief History of Micro Irrigation (MI) in India

Drip or micro irrigation was in use since the early 70’s in Israel, USA and Australia. Copying those systems as such by traders to Indian farms have resulted in gross failures during the early phase of drip adoption in this country. Such failures were attributed to the lack of understanding of Indian farming conditions- small packets of land holdings, problem water sources, poor quality water, difficulty in accessing power sources, low level of literacy among the user farmers etc. The traders went ahead treating micro irrigation systems and components as mere commodities. The approach, though failed to increase adoption of the technology, has taught several lessons. Jain irrigation, a native micro irrigation company entered the scene in late 1980 and fast realized that a unique model of business needs to be developed if this water conserving technology has to stay in the country. Live demonstration of the technology and education of farmers of the different aspects of micro irrigation is a pre-requisite for right adoption by them. This realization helped in sculpturing a business model where engineering services of irrigation (hardware) is amalgamated with appropriate agronomy (software) and extension packages are thus developed. This unique method followed the basic principle of *seeing is believing* and farmers were exposed to systematically set-up crop demonstrations both in research and farmers’ farms. Today, micro irrigation technology has become very popular and been adopted in large areas in several states of the country.

Model of Extension work developed by Jain Irrigation to extend the technology

More crop per drop, the tagline of Jain Irrigation systems ltd., Jalgaon, Maharashtra, India amplifies the concern on water scarcity and offers practical solutions. They have created a 1000 plus acre Research, and Demonstration farm among the dry parched hills located 9 km from Jalgaon town in the state of Maharashtra, India, where the principle of *more crops per drop* is truthfully in operation. Here principles of land, soil and water *conservation* are seen in operation along with the most modern methodology of irrigation, drip and sprinkler systems, thus creating a paradise for crop production extending all the way to organic farming and food processing. This farm receives 80,000 or more farmers a year who come to study and experience irrigation, fertigation and high-tech crop growing methods working successfully and get excited about the potential of high-technology in crop production. Experts educate the farmers in the use and benefits of micro irrigation using the approach of “SEEING is BELIEVING”. Later they established such Research, and Demonstration farms in Tamil Nadu and Rajasthan to cater to the needs of different soil and agro climatological regions.

These R&D farms have well equipped Training Centres for farmers in modern methods of agriculture. The centre has been recognised by several Indian and foreign universities and FAO as centre of excellence. This capacity building activities seems to have played a role in the acceptance of MI in India.

Present Micro-irrigation scenario in the country

Micro irrigation technology is gradually emerging as a DEMAND driven technology in India. This stage has come about over a period of past 30 years. The role of private manufacturers, government policies and level of farmer awareness and the assistance of media etc. have helped to arrive at the present situation. From a scantily respected “forced in technology” in the 80s micro irrigation has now grown to a “sought after” technology.

The coverage of micro irrigation is 16.6 million ha (drip + sprinkler) in India (Table 1) (2022 March end, PMKSY, GoI). The awareness level however has grown tremendously. The spread of technology has however, been restricted to states like, Andhra Pradesh, Gujarat, Karnataka, Rajasthan, Tamil Nadu, and Madhya Pradesh, the so called TOP 7 of India (Table 1). The government subsidising the system cost first began in Maharashtra (at State level), and later spread to other states. Top 7 states’ administration implemented the Central (Federal) government subsidy schemes with more ardour and commitment. Some of these states also toped up the subsidy amounts from their own resources. Few of these states like Andhra Pradesh (APMIP), Gujarat (GGRC) and Tamilnadu (TanHODA) have created special purpose administrative entities for extension and administration of MI provision in their states. These special purpose bodies and

Table 1. Current status of reach of micro irrigation in Indian States.

Micro irrigation coverage in different states in India as on June 2022**						
	STATES	**Drip (ha)**	**Sprinkler (ha)**	**Total Micro Irrigation (ha)**	**Share of Drip**	**Share of Sprinkler**
TOP 7						
1	Andhra Pradesh	1716673	626915	2343588	0.73	0.27
2	Gujarat	1135403	999476	2134879	0.53	0.47
3	Karnataka	953297.7	1762250.14	2715547.9	0.35	0.65
4	Maharashtra	1572242	691906.41	2264148.1	0.69	0.31
5	Rajasthan	385044	1840484	2225528	0.17	0.83
6	Tamil Nadu	963714.8	448785.91	1412500.7	0.68	0.32
7	Madhya Pradesh	476572.3	334840.18	811412.48	0.59	0.41
	Sub total	7202946	6704657.64	13907604	0.52	0.48
North zone						
8	Haryana	47662.79	652795.84	700458.63	0.07	0.93
9	Himachal Pradesh	5160	4130	9290	0.56	0.44
10	Jammu & Kashmir	24	70.1	94.1	0.26	0.74
11	Punjab	36640.81	15359.19	52000	0.70	0.30
12	Uttar Pradesh	58837	270300	329137	0.18	0.82
13	Uttrakhand	18161.64	12644	30805.64	0.59	0.41
	Sub total	166486.2	955299.13	1121785.4	0.15	0.85
East zone						
14	Bihar	21370.62	113635.1	135005.72	0.16	0.84
15	Chhattisgarh	39257.6	368440.2	407697.8	0.10	0.90
16	Jharkhand	41159.45	17969.61	59129.06	0.70	0.30
17	Odisha	37495.02	166114.11	203609.13	0.18	0.82
	Sub total	139282.7	666159.02	805441.71	0.17	0.83
WB, Assam and North East						
18	Arunachal Pradesh	2841	781	3622	0.78	0.22
19	Assam	3767.8	10302	14069.8	0.27	0.73
20	Manipur	288	2924	3212	0.09	0.91
21	Meghalaya	308	307	615	0.50	0.50
22	Mizoram	3428.43	1428	4856.43	0.71	0.29
23	Nagaland	4895	6072	10967	0.45	0.55

24	Sikkim	6383	5617	12000	0.53	0.47
25	Tripura	2304	3204	5508	0.42	0.58
26	West Bengal	10649.11	109073.64	119722.75	0.09	0.91
	Sub total	34864.34	139708.64	174572.98	0.20	0.80
27	Goa	1186	1129	2315	0.51	0.49
28	Kerala	23274.89	8438.17	31713.06	0.73	0.27
29	Telangana	355825.2	140389.2	496214.4	0.72	0.28
30	Others	15169	30636	45805	0.33	0.67
	Sub total	395455.1	180592.37	576047.46	0.69	0.31
	INDIA TOTAL	**7939035**	**8646416.8**	**16585452**	**0.48**	**0.52**
*** Data sources: Compiled using the data reported in the following sources*						
1. Department of Agriculture, Cooperation & Farmers Welfare						
Pocket Book of Agricultural Statistics 2018- 19 (data up to 2019 March)						
2. PMKSY, Ministry of Agriculture and Framers' Welfare Report June 2021						
(Data from 2019-2021)						
3. Personal communication (2021 March to 2022 June) from PMSKY						

horticulture and/or agriculture departments in other states took over the effective administration of the introduction, spread and farmer level utility of MI systems in collaboration with the large MI suppliers who opted to work with the governments in these states. Farmers and other users of the MI systems are getting trained in the farm on the operation and effective use of the MI components. Most of these training and capacity building is initiated and jointly done by private supplier companies working hand in hand with the public extension bodies. Thus a silent revolution has been occurring in the remote farming villages of not only the in the TOP 7 but other states also. In the years to come, this era of rapid reach of MI in Indian farms would probably be designated as Golden Era of irrigated crop production. Among the TOP 7 states Andhra Pradesh, Karnataka, Maharashtra, Tamilnadu and Gujarat have covered more than 30% of their respective net irrigated area with MI (Table 3). Smaller states like Sikkim and Mizoram also find a place in this list of *honour.*

In the TOP 7 states except Karnataka and Rajasthan, the preferred MI is the drip method with an approximate 65 % drip and 35% sprinkler systems (Table 1). In Karnataka and Rajasthan Sprinkler adoption is more (65 % and 85 % respectively). In Karnataka large Coffee plantations went for large scale adoption of sprinkler systems. For large land holdings with desert sandy soil in Rajasthan farmers preferred sprinklers in the earlier phase of MI adoption. In most cases MI system distributors and traders also found it easier for convincing farmers of sprinkler method than drip. Even extension workers found sprinkler as the easy route to convince. Farmers also liked sprinklers more because of operational ease and lower cost/ha. However, there is a late realisation that sprinkler systems require high energy and result in low water use efficiency which is slowly settling in the minds of the users, especially large land holding coffee and tea plantations.

The crop to be irrigated is also another factor deciding the system preference. Right now it is sugarcane crop that has the highest area under drip method in India; which itself is an unexpected turn in the adoption history. Because the original concept (wrongly held) in this country and in many other countries in the world is that drip is suitable for horticulture (fruits, and nut trees that are planted at wider crop spacings) only. Introduction of drip, both surface and sub- surface, to closely planted row crops (like sugarcane, cotton, cereals, pulses and oil seeds and flower crops and vegetables) has really caused a revolution in MI reach.

The Indian north and eastern states still have not come into the main picture yet. States like Haryana and Uttar Pradesh (UP) are slowly getting into the groove. Only if states with large net irrigated area like UP, Madhya Pradesh, Punjab, West Bengal, and Bihar convert large irrigated areas into MI irrigation the overall impact of MI on Indian agriculture would be felt. These states have about 5% or less net irrigated area under MI at present (Table 4). The recent elevated interests shown in the of-take of MI in these states is a welcome sign. It may seem if one looks at the absolute numbers that the northern states have very low adoption; the rate of change during the last 5 years would indicate otherwise (Table 2). The increase noticed from 2015-16 to 2020-2021 in Karnataka, a

Table 2. Progress in adoption of micro irrigation in Karnataka (high adoption state) and Uttar Pradesh (low adoption state).

ADOPTION OF MICRO IRRIGATION (ha/yr)		
Year	**Karnataka**	**Uttar Pradesh**
2015-16	64,219.91	1,597.30
16-17	1,39,405.52	32,511.78
17-18	2,36,108.17	28,235.00
18-19	2,34,853.15	55,074.00
19-20	2,50,590.48	56,953.00
20-21	3,21,177.52	58,104.00

Data source : Min Agri. GoI.

Table 3. States with plus 30% of irrigated area under micro irrigation (MI) (based on data of 2021 year end).

STATES WITH MORE THAN 30% AREA UNDER MI				
States	**Net irrigated area (x000 ha)**	**Drip x000ha**	**Sprinkler x 000 ha**	**% NET IRRIG AREA under MI**
Sikkim	16	6.35	5.26	73
Andhra Pradesh	2719	1388.13	519.17	70
Karnataka	3104	752.82	1148.7	61
Maharashtra	3163	1314.78	561.65	59
Mizorum	16	5.09	2.45	47
Tamilnad	2385	735.81	311.06	44
Gujarat	4233	852.02	747.75	38
Source : Directorate of Economics and Statistics DAC& FW Loksabha 2021				

TOP 7state with more dry land and water stressed tract, is only 400 times while that in UP (high water availability and low fraction of dry land), was 3537 times. Micro irrigation technology aims to enhance crop productivity and quality, besides reducing water used for crop production. It is applicable to all regions of the country irrespective of being water sufficient or water deficit. Even States with sufficient water resources are adopting micro irrigation which is a good sign. Haryana, for example, has the highest adoption rate of Sprinkler systems among the states in the country.

There is an overall potential of 27.80 million ha in India suitable for providing drip irrigation alone. This includes fruits, vegetables, Sugarcane, Cotton, Tobacco, spices, Tea, Coffee, Rubber and Coconut and floriculture crops. Additional potential may come in the future by more crops getting adapted to drip method of irrigation with modified cultivation practices. For example, trials are underway with positive results in the case of pulses, especially pigeon pea *(Tur* dhal). Of the potential area for Drip irrigation only 58% comes under irrigation cover at present. Similarly, 38.7 million ha area grows crops that can be suitably irrigated by Sprinkler method.

The idea of rain water harvesting, and farm pond concept would have to be taken with high priority to bring in the presently rain-fed areas also under micro irrigation. According to the latest data from Min. Agri. GoI. (2021) Andhra Pradesh (1,68,613) Maharashtra (1,23,399) and Tamil nadu (57,114) followed by Rajasthan (30,482) are the leading states with most micro- level water harvesting/storage structures. The micro storage structure in combination with micro irrigation offers possible sustainable means of increasing the irrigation cover. It is a heartening trend that this combo is getting acceptance. This strategy also leads to convert more rainfed land into irrigation. And when micro irrigation is the first choice in such combos the mind-set issue against micro irrigation may not become a challenge in the adoption process.

MI status in the world

The spread of MI is world-wide. Many countries, Israel, USA, Australia, Brazil, China, have adopted the MI technology in large stretches of their irrigated area (data compiled by ICID 2017). However, these data requires updation which is in the

Table 4. States with very low MI cover as percentage irrigated area.

States	Net irrigated area (x000 ha)	Drip x000ha	Sprinkler x 000 ha	% NET IRRIG AREA under MI
Uttarpradesh	14337	33.52	179.64	1
Madhyapradesh	9876	322.27	249.24	6
Punjab	4128	36.03	13.7	1
West bengal	3106	10.32	78.12	3
Bihar	3101	12.49	106.98	4

process now (Personal communication from ICID). However, few comparisons of the reach of MI in India *vis-à-vis* other major MI adopted countries will be of interest. Though a late comer in the practice of MI, India captured number 1 position in absolute coverage of drip and number 2 in sprinkler making the country one of top micro irrigated countries in the world as per existing complied data (Figs.1 & 2). 16.6 million ha of MI accounts for 26.7% of irrigated area of India (Table 5). In most of high cover MI countries the area under irrigation is comparatively very low. Only China and USA has double figure percent irrigated area other than India. Considering very high area under irrigation India's achievement of MI cover of 26.8 % is commendable though modest.

MI system components and costs

Micro Irrigation is a broad term and mainly categorized as Drip and Sprinkler Irrigation Systems. The Sprinkler irrigation systems based on discharge, area coverage and operating pressure range are categorized into Overhead Sprinkler Systems and Rain gun systems whereas Drip, Mini and Micro Sprinkler Irrigation Systems require lower operating pressures from 1 to 2.5 kg/cm2 and are broadly categorized under Drip Irrigation systems. The costing and limits of Subsidies for Drip and Mini-sprinklers are comparable to each other.
delivery. Therefore the system requires very clean water free from suspended impurities. Thus, filtration of water before allowing it to flow into the network of MIS is required. Jains have developed two main types of filtration units Sand Filter Sand filters are used to remove algae impurities and suspended materials by allowing water to pass through a bed of specified sand. Sand filters of different capacities, like 10, Hydraulically operated differential pressure valves, a simple technology free from the hazards of maintenance.

Screen Filters

Screen filters are used in the drip system to remove the suspended particles those could pass through sand filter.

MI system components

Water conveyance system

PVC or PE pipes of different diameter form the conveyance system from water source to the drip/sprinkler lateral tubes.

Water distribution system

Polytube and online drippers
Inline tubing which include;
Turboline -Inline system with cylindrical drippers both PC and Non PC.
Turbo Aqura with inline flat emitter.
Drip tape
Drippers or Emitters for online system
Apart from drippers, Jains have introduced micro & mini sprinklers, spray jets and floppy sprinklers also as per the various specific crop requirements.

Filtration System

In MIS, as the water is permitted to let out through very small orifices, the impurities of water can block the orifice and affect

18, 27 & 40 m3/h and additional capacity by introducing duplex, triplex and quadruplex filter in parallel were introduced. These filters have Epoxy polyester powder coated MS body with PVC header pipe and filtration candles. The manually operated sand filters have been converted to operate as automatic or semi-automatic filters with the help of

These are developed in the 14, 25 and 40 m3/h capacities. There are two types of them, the plastic body and the metal body screen filters.
The plastic body filter has a total plastic body, light in weight, non-corrosive and leak-proof. It can be easily dismantled, cleaned and installed back and is ideally suitable for the Indian farmer. Farmers need for a lightweight; long lasting and easy

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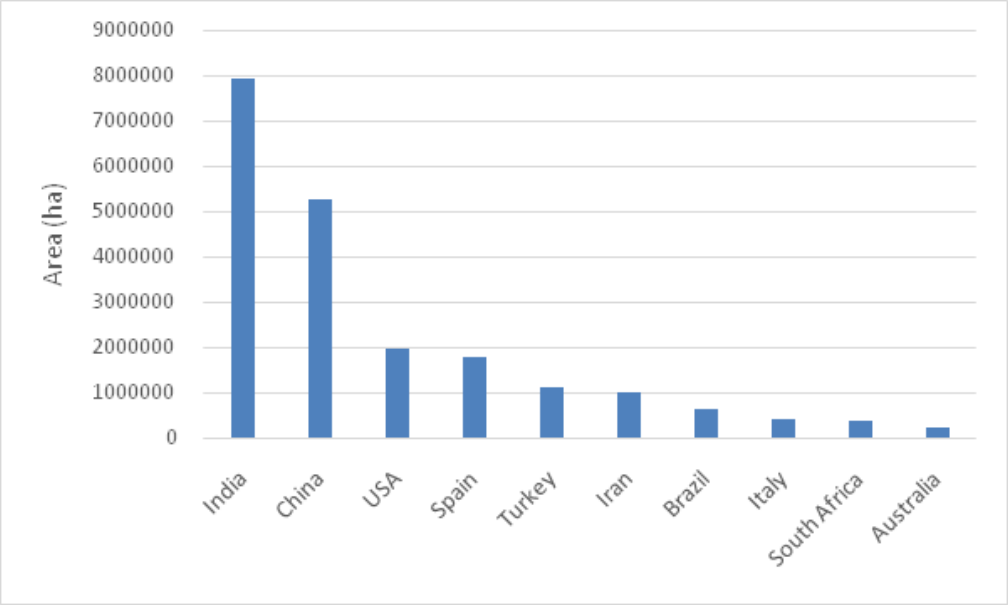

Fig.1. Area under drip in some of the top most adopter countries of MI.

to handle plastic filter for use in MI is bound to prove an impetus to the growth of MI in India.

The PVC low cost slotted screen element having more effective filtration area was also developed as a substitute for expensive, low strength stainless steel perforated screen. Later, a plastic mesh between the shell and screen to increase the filtration surface area was also introduced.

Hydro Cyclone Filter

It is a pre-filter installed in conjunction with either sand or screen filters for separation of heavier sand or dirt particles from water especially if the source of water is river or canal.

Fertigation Equipments

Fertigation, the incorporation of liquid or water-soluble solid fertilizer into the MI is an important aspect of micro irrigation technology. The main addition to the system is the fertilizer tank or the ventury for this purpose.

Fertilizer Tank

Fertilizer tanks of 90,120 & 160 l capacities are developed. They also have MS body with epoxy polyester powder coating. An air release valve is installed on the fertilizer tank for removing the trapped air from the empty tank during filling up & filtration element is provided on the outlet to avoid the entry of solid or undissolved particles of fertilizer into the system. The operational instructions to work out the fertigation time, concentration and flow to the farmer/operator are also given by the manufacturer.

Ventury System

Ventury is based on the principle of ventury tube following the

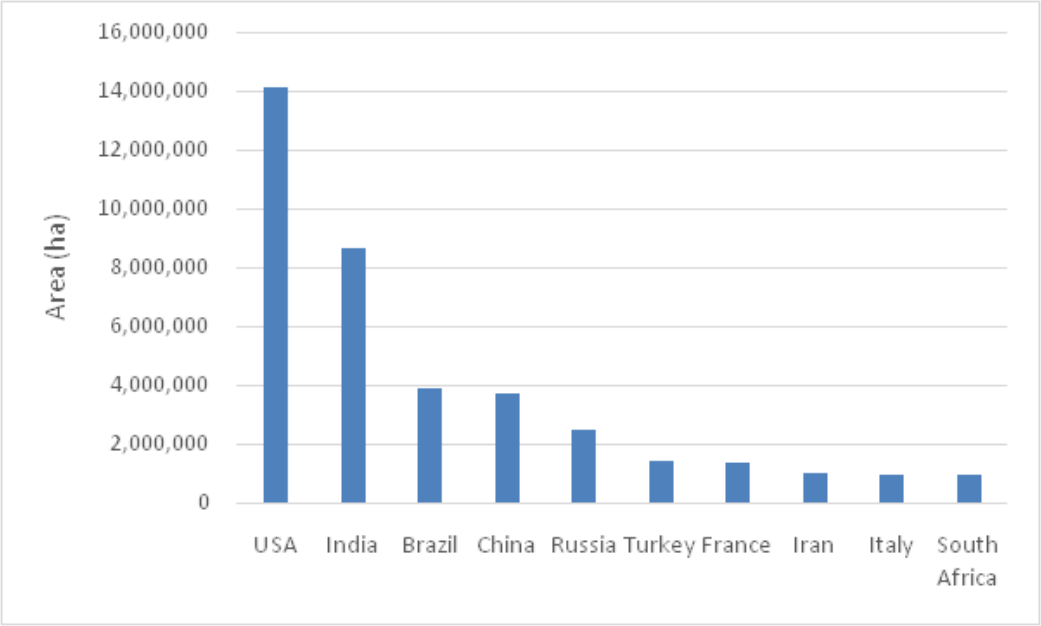

Fig.2. Area under Sprinkler in some of the top most adopter countries. (Data source. ICID website).

Table 5. MI cover in few top MI adopter countries as % of irrigated area.

Country	Total Irrigated Area (M ha)	% of total irrigated area
South Africa	1.6	80.3
Brazil	5.8	77.2
USA	23.5	68.6
Italy	2.4	57.1
France	2.6	57.0
Russia	4.5	56.6
Turkey	6.7	38.3
India	62.0	26.8
Iran	8.5	23.9
China	65.9	13.7

(Data source. ICID website).

Bernoulli's theorem as the area of cross section decreases, the velocity of flow increases and the pressure decreases to such a level that a partial vacuum is generated at the junction of the convergent and divergent cones. Due to this vacuum the chemical fertilizer that is at the atmospheric pressure is sucked inside. The ventury delivers the fertilizer at a constant concentration depending upon the water flow.

The above components are the major parts in a micro irrigation system. MI also have several types of *valves* in plastic material suitable for the system. A valve is used for controlling the flow through a pipeline. The valves in MI are located at the inlet of the sub-main and main line pipes. Later smaller valves are also developed to control the flow into the laterals.

Cost of System and components

The system costs in Table 6 are for basic system for Tamilnadu. The costs will vary among states for the same crop. Subsidy is applicable only to the basic cost. Automation cost is to be borne fully by the farmers. This is given here as most of the farmers now prefer to have simple automation that gives more accuracy and timeliness in the operation of the system.

The basic system comprises of the Head control (filters, fertilizer injector, control valves), Water carrier system and water distribution system. The pumping system is not included as most farmers would have a pump and motor at their water source.

Government support and focussed public funded programs for MI

The federal government intervened in the process of extension of MI and introduced farmer support schemes from time to time. These interventions are;

1. Financial support

To promote the concept of micro-irrigation system at farmers level various development schemes under Dept. of Agriculture and Co-operation, Government of India as given below are being implemented in the country.Under all the above schemes assistance to farmers are provided up to the extent of 50% to 75% of the capital cost of the system for all the crops.

Micro irrigation technology was introduced in the country in early 1980s sporadically. Later with large private manufacturers through focussed implementation programs and successful field trials proved that the technology can be adapted to Indian small farms. In 1992, the Centrally Sponsored Scheme for use of Plastics in Agriculture was launched and Maharashtra being the largest horticulture state, was first to implement the scheme on a massive level. Initially, this scheme was applicable mainly for horticulture crops though over a period of time almost all crops have been covered.

Government of India constituted a Task force in 2003-04 for promotion of MI in a mission mode. India has net sown area of 141.4 mha out of which net irrigated area is 62 m ha which translates in to 44% farmers having source of water for irrigation leaving the rest with rain-fed farming**.** The Task Force recommended for coverage of entire irrigated area with micro irrigation by bringing investment and an enabling environment. Since then various initiatives were undertaken by the Central Government. In 2005 the National Horticulture Mission (NHM), in 2006 the Centrally Sponsored Scheme on Micro Irrigation (CSS), from 2010-14 the National Mission on Micro Irrigation (NMMI) followed by The National Mission for Sustainable Agriculture (NMSA) in 2014-15 where in Micro Irrigation was implemented under the On Farm Water Management (OFWM) component of the scheme.

As on date Micro Irrigation is covered under the *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) launched in 2015 under *Per Drop More Crop* (PDMC). The four components implemented by different Ministries under PMKSY are:

(i) Accelerated Irrigation Benefit Programme (AIBP) with Ministry of Jal Shakti

(ii) *Har Khet Ko Paani*, by Ministry of JalShakti

(iii) Watershed Development by Department of Land Resources.

(iv) *Per Drop More Crop* (PDMC) under Ministry of Agriculture and Farmers Welfare.

Central Government assistance thru PMKSY scheme

The pattern of assistance payable to the beneficiary under the micro irrigation scheme will be 55% for small and marginal farmers and 45% for other farmers which will be met by both Central Government and State Government in the ratio of 60:40 for all states except the North Eastern and Himalayan 2 states. In the case of these states, ratio of sharing is 90:10. For the Union Territories, funding pattern is 100% grant by the Central Government.

The subsidy payable to the beneficiary will be limited to an overall ceiling of 5 hectare per beneficiary.

The subsidy payment will be limited to the unit costs specified in the scheme guidelines. 25% higher amounts have been taken into calculation of subsidy for the North Eastern and Himalayan states and 15% higher for states with low penetration of MI namely Bihar, Chhattisgarh, Jharkhand, Odisha, Uttar Pradesh, West Bengal and Union Territories.

India is one of the top five countries in the world as far as area coverage by micro irrigation is concerned with 26.8% of the irrigated area has been covered under micro irrigation. Government assistance in the range of approximately 50 % and above on the capital investment to the grower has helped in the spread of MI (Table 7). The annual rate of coverage of micro irrigation in the country since 2017-18 has been around 1mha/annum. At this rate of coverage, it may take another 5 to 6 decades to bring entire irrigated area under micro irrigation**.** It has been established that micro irrigation adoption leads to nearly 30 – 40 % increase in yields(Food security) , saving in water to the extent of 80 % (Water Security) and saving in Energy(Energy Security) in almost all the crops , yet the slow pace of adoption by the growers in the country calls for serious review of the process and strategy of implementation.

2. Standardization of irrigation equipment

The use of standard/ quality material plays important role in MI for its large scale promotion. The Bureau of Indian Standards (BIS) is actively involved in developing the standards of various components of the irrigation system. Only those manufacturers who strictly follow the standards in the manufacture of the components are permitted to supply MI systems under any of the government assisted schemes.

The important standards are as given below:

Table 6. Cost of drip system for few crops with varying geometry##.

Sl No	Crop	System	Spacing m x m&&	Cost of Basic Drip	Cost of Basic Automation	Approximate Govt Subsidy @70%**
1	Paddy/Turmeric	Inline	1 x 0.4	237547.83	132708.13	89251
2	Vegetable	Inline	1.2 X 0.4	211708.52	112476.00	89251
3	Sugarcane	Inline	1.5 x 0.4	187851.01	112476.00	76672
4	Banana	Inline	1.8 x 0.4	154216.94	97090.34	64092
5	Tea	Inline-PC	1.95 x 0.6	182940.48	97090.34	No Subsidy
6	Moringa	Online	3 x3	110714.81		33426
7	Mango-UHDP	Online	4 x2	99031.25	82262.43	29074
8	Amla	Online	5 x5	75282.05		27565
9	Coconut	Online	8 x8	63861.45		20144
10	Oil Palm	Jet	7.9 x9	82943.57		20144

Costs are estimated using current price of components applicable in Tamilnadu, India.
***The subsidy for general category farmers (70 %) is given for each crop wherever subsidy provision is applicable and is based on the guide line value for the system given in PMKSY scheme and not based on the system cost given in column 5.*
&& The spacing is given as Lateral-Lateral spacing and emitter spacing on the lateral

IS 10799: 1984 Code of practices of design and installation of trickle irrigation
IS 11711: 1986 Recommended criteria for adaptability of different irrigation methods
IS 12785: 1994 Strainer type filters
IS 12786: 1989 Polyethylene pipes for laterals
IS 13487: 1992 Emitters
IS 13488: 1992 Emitting pipe systems
IS 13062: 1991 Guidelines for evaluating field irrigation efficiencies
IS 14178 :1994 Pressurized Irrigation Equipment - Terminology
IS 14482 :1998 Polyethylene micro tubes for drip irrigation systems
IS 14483 ;1997 Fertilizer and Chemical Injection system Part 1 Ventury Injectors
IS 14605 :1998 Micro Sprayers
IS 14606 :1998 Media Filters
IS 14743 :1999 Hydro-cyclone filters

Standardization is a dynamic process. All the standards shall be subject to periodic revision and be kept up to date in respect of the latest advancement of technology and the progressively changing conditions of nation's economy. Feedback on these Indian Standards on the basis of field experience, need to be evaluated ,it may be taken up by executing agency from time to time, BIS officials and research scientists. It is an important activity that may also be coordinated at Central Government level to have a better impact.

Farmers and public in general found these interventions are supportive to the cause of MI adoption. Even system and component manufacturers found in the long run these interventions as a positive and helping in making MI popular. Some of the large manufacturers taken up issues with the government to bring in more guidelines for the good of right of technology adoption. These are expectations from the Governmental agencies.
Government while registering the micro irrigation companies must take several factors into consideration:

- They should have well defined production capacity.
- They must stick to approved quality standards to match international guidelines and service norms.
- They must be capable of establishing wide network of service centers in the country.
- They should place experienced Agronomists and Extension Officers to guide the farmers.

Government should take assistance from the Agricultural Universities and Indian Agriculture Research system to be fully involved with the farming activities at all seasons. These agencies should be provided with adequate funds to carry out these activities. This area still warrants attention. When industry gets involved seriously, they can bring lot of developmental changes in agriculture within the scope of crop diversification as well as introduction of new crops. With the help of Government they can bring in hitherto uncultivated area under agriculture with assured irrigation. The whole idea of spreading of micro Irrigation technology depends on very strong Public-Private –Participation (PPP). The partners should clearly understand this and commit to this principle.

Table 7. The percentage top up subsidy given by different states in addition to the central govt. Assistance.

Percent top up subsidy by States			
		MF/SF	**Other Farmers**
	Telangana	55	35
	Andhra Pradesh	40	
	Gujarat	25	
	Karnataka	40	
	Maharashtra	30	
	Rajasthan	50	
	Tamil Nadu	50	35
	Madhya Pradesh	20	
North zone			
	Haryana	50	
	Himachal Pradesh	10	
	Jammu & Kashmir	10	
	Punjab	35	
	Uttar Pradesh	10	
	Uttrakhand	10	
East zone			
	Bihar	10	
	Chhattisgarh	30	
	Jharkhand	50	
	Odisha	50	42.5
WB, Assam and North East			
	North Eastern states	10	
	West Bengal	45	

MF/SF –Marginal and small farms.
Data compiled from different state web sites.

Micro irrigation Industry

Micro Irrigation Industry is certainly one of the star industry that has been growing rapidly (40-60%), a phenomenal rate of growth, indeed in the last 15-20 years in India. From a little known industry struggling to stand up, it has now become a very high profile industry with demand driven growth. In brief, micro Irrigation improves yields & quality and saves on labour, energy & crop protection costs and helps to double the area under irrigation with the same quantity of water. It is much more than merely a method of applying water and minerals. It is a total plant support system and a crop production and management tool.

Prior to 1965, some of the Plantation crops like Coffee, Tea etc., mostly owned by corporates, were irrigated with imported Sprinkler systems. With the arrival of the Indian manufacturer into Irrigation Industry, with their deep knowledge of Indian farmer and farming conditions the whole concept and its application changed. While the foreign seller sold tubes, emitters and pipes, the Indian manufacturer established the practice of delivering a package of crop production technology to the farmer. In the first 15 years, Sprinkler and then from the 80s Drip equipment were popularized in the country.

The growth in the adoption of the technology is made possible by several factors acting together.

1. Demand creation; awareness among farmers and conviction generated among the policy makers and government.
2. Product and technology generation by industry.

3. Financial out lays provided by the government and highly focused administration of the funds by governmental agencies.
4. Combined effort by Industry and Governmental agencies in educating the user.
5. Interest and Input from research institutions.
6. A limited but vital role by media in popularizing the technology.

All these factors together is causing paradigm shift from bamboo pole and earthen pitcher as delivery devices (Drip) to high precision automated machine molded LLDPE drip lines. Here comes the modern methods of irrigation and the industry is there to make it possible.

Attributes Needed in the Industry

The industry should have proper understanding of the concept with "farmers` welfare" in mind. While running their units successfully and profitably, the captains of the industry must have the sense of service and spirit of education towards farming. Industry, eventually become a store house of not only materials but the entire gamut of high -tech crop production technology which clearly optimizes inputs and increases returns. In a country like India this is especially essential as the public funded extension systems are woefully ineffective or inadequate.

- Industry should keep up with the technology developments
- Industry should persevere for cost effectiveness.
- Industry should have large capacity for multi-product manufacturing be capable of keeping stocks of all necessary material.
- Industry should establish a system of delivery.
- Industry should have the infrastructure and will for committed training of users.
- Marketing infrastructure and reach is of great importance for the industry.
- Industry should update the requirements continually based on accurate market information
- Industry should work with Public agencies for capacity building of the farmers.

Responsibilities of Irrigation Industry

Presently, the irrigation industry in the country has an immense responsibility in carrying forward the momentum. The industry also has to come up to the expectations of the Governments in achieving the targeted adoption rates as well as the intended benefits of such programs. The industry also has to prove itself that the concepts bring benefits to the farmers and consolidate the trust reposed on the industry and on the concept by the poor and ignorant farmers in the country. Any lapse on the part of Industry, can have wider ramifications and not only detrimental to their existence but would be a set back to the promising technologies at large.

Today, the program for massive adoption of drip & sprinkler irrigation systems in India is being considered as a role model for many developing countries. The industry has to ensure that the programs in India are successful so as to be able to meet the expectations of millions of farmers in such other countries where these concepts are being promoted on large scale.

It is expected that the Industry evolves strategies for sustaining the momentum and support given by the governments as well as the enterprising farmers for the adoption of drip & sprinkler technologies. Following can serve as a broad base for such strategies:

1. The industry has to evolve location and crop specific products, systems and practices for success in the hands of farmers. The farm sizes being small and as the farmers are new to the concept, the hardware and software parts of the system should be compatible to such requirements. The industry should avoid imposing products that are not relevant to the farmer, in the name of "new-generation" products.
2. The success of micro irrigation in the fields depends upon the way the farmer is able to manage and use their systems. Hence, the industry should create adequate resources and mechanisms for imparting the knowledge to the farmers in efficient management and maintenance of their systems.
3. The industry should upgrade its manufacturing capabilities in order to match the expected progress rates of the Governments and Institutions funding the programs.
4. The industry should create outlets and expertise across the country to be able to service the farmers and to be able to provide the necessary spares and technical/agronomical support to the farmers.
5. The industry should also avoid mal-practices by taking advantage of the farmer ignorance and/or pilferage of public funds; so as to avoid any negative image to not only to the industry but also to the concept. Thus, the industry has an immense responsibility to be a part of success story of these concepts and in the growth of the country at large.

Micro irrigation as one component in Precision Farming

Micro irrigation implies, not a simple regulation of irrigation water but a whole new package of practices for crop production. This comprehensive approach has helped in building the popularity and acceptance of MI.

The current awareness level of micro- irrigation in the country is high; its positive role in increasing water use efficiency may be less understood by the farmers; but its role in enhancing crop yields is well regarded by them. This level of awareness has come over a long period of time, some 25 years or so during which the micro irrigation technology underwent a number of changes both in the material components assembled as an irrigation system and the scientific knowledge of management of water, fertilizer, and other chemicals in crop production. The scientific information available on crop water requirements, plant nutrient requirements, both in terms of growth time (when) and type

(what) were available in publications for years; but they suddenly found a methodology and instrumentation of precision so that even a small farmer in a remote village can do irrigation and fertigation with efficiency. Does the irrigation expert, the extension person, or the farmer ever considered *crop water requirement* while irrigating a crop in the conventional scenario? That is the change the past three decades brought in. Farmers began asking: How much water does my crop need?

Drip irrigation is not about water delivery alone. One of the major co-evolved science is the application of fertilizers through the drip systems. The equipment part of this evolution could easily be solved by addition of a simple ventury, or a fertilizer tank, or any one of the high precision injectors. The science of fertigation took more time and efforts to develop in terms of application of nutrients as per the requirement of the crop; the scheduling of fertigation. Historically, it started with just increasing the frequency of application from original one or two (splits) during the life span of the crop to as many as convenient. But the real knowledge of each nutrient and its role in the crop growth and development was not looked at as a field applicable issue. With the arrival of micro irrigation system with fertilizer applicators helped in enhancing the precision in terms of meeting the requirement *per se*, and the time of that requirement (during crop life) and the essentiality of different nutrient types to match with the physiological progress during crop growth. Now as we dwell on this issue, there are very effective fertigation schedules (what, when and how much of nutrient) those are scientifically tested and made available to farmers (P.Soman, 2020 &2022).

Precision breeds efficiency. Here in the field of irrigation, fertilizer application, chemical application, and other agronomic actions, were once thought of as very "*casual"* activities and not taken as "*life threatening"*. Now we are in an era, where such levels of efficiencies are required in every such activity in agriculture.

Interventions in Precision farming includes the following;

- Land preparation
- Seed Bed formation
- Land Surface management
- Soil improvement
- Crop selection
- Selection of planting material
- Crop Geometry and Plant architecture
- Irrigation and fertigation
- Pest management
- Weed management
- Harvest
- Post-harvest management
- Market requirement and identification

Precision in the application of inputs is ensured through the micro irrigation systems- irrigation water, fertilizers, many agro-chemicals and even selected organic inputs. Thus the role of micro irrigation technology has become catalytic in nature. Along with micro irrigation, the farmer is trained to adopt high-tech methods in every aspect of crop management. Changing crop varieties, use of improved seed/seedling, changing crop geometry, practicing fertigation and efficient and need based pest management methods and finally effective post- harvest practices; all these helped to enhance crop productivity. The business of micro irrigation brought trained and experienced crop experts to the small farmers' fields and they supplemented the efforts of public extension system. All these efforts proved to be successful and crop performances soared to a higher level.

Material science associated with micro irrigation systems has also come up with drippers that need lower quantities of raw material and more precision and lower clogging (blockages in drippers) opportunities. So are the control and filtration systems ensuring acute precision in the delivery of water, fertilizer and other chemicals directly to the rhizosphere, even placing them below the soil surface? And this progression is not ending there; research and development continue. The benefits of such efficient delivery systems are there everyone to see.

Micro irrigation technology enhances crop yield

One of the very positive benefit to a farmer from adopting drip irrigation is the direct yield enhancement of the crop; a factor that has been proved in India in almost all the crops, both horticultural and agricultural. These yield improvements are noted by research institutions and universities also. We have been monitoring our client farmers' crops and collecting data over a number years. The following table (Table 8) depicts the performance of 45 different crops to drip irrigation or other micro irrigation systems adopted by the farmers in various states of the country.

The above table unequivocally establishes the yield benefit due to proper application of drip irrigation technology. Drip irrigation actually acted as a catalyst in these cases as mentioned above.

Micro irrigation technology reduces energy consumption

As the volume of water applied to irrigate a crop under drip irrigation is lower compared to that applied in conventional method, the power consumption for pumping automatically decreases. Thus in case of the Paddy crop above, drip paddy consumed only 565 units/ha as against 1167.5 units/ha consumed in the flood irrigated paddy. Table 10 below also reports on the power saving in Sugarcane production because of drip irrigation.

Are micro irrigation methods economically viable?

The following tables (Tables 11, 12, 13 and 14) illustrate the viability of an investment made for MI system. These estimates are based on the full system costs (subsidy not

Table 8. Comparative yield performances of several crops under drip or other micro irrigation and fertigation systems (Data from Indian farms).

No.	CROP	Yield under Conventional irrigation method (t/acre)	Yield under Drip or other micro irrigation +fertigation (t/acre)
1	Rice	2.0	3.9
2	Wheat	1.8	2.9
3	Maize	2.4	4.0
4	Pigeon pea	0.6	1.4
5	Cotton	0.7	2.0
6	Sugarcane	32	70
7	Oil palm (Jain 270 degree jet)	7	12
8	Coconut	6000 nuts/yr/acre	8400 nuts/yr/acre
9	Banana	20	36
10	Pomegranate	6 (10th yr)	9 (5th yr)
11	Mango	2.5 (12th yr)	6.5 (5th yr)
12	Guava	4	10
13	Papaya	23	35
14	Citrus- Orange	4	8
15	Citrus-Sweet lime	9	15
16	Custard apple	3	5
17	Water melon	10	19
18	Grapes	10	25
19	Cashew nut	0.65	1.2
20	Apple **	2.4	4.8
21	Strawberry$	…	15
22	Onion	6	14
23	Potato	10	21
24	Brinjal	14	26

25	**Tomato**	**25**	**40**
26	Okra	6	13
27	Beans	7	11
28	Gourds (bitter gourd)	6	10
29	Chilly (dry)	2.5	4.0
30	Gherkin (cucumber)	7.0	11.0
31	Capsicum	12.0	30.0
32	Radish	9.0	15.0
33	Coffee (Robusta)	0.45	0.60
34	Tea	1.0	1.8
35	Cardamom	50.2 kg/acre/yr	232 kg/acre/yr
36	Curry leaf (2nd year)	1.8	3.2
37	Ginger	6.0	9.0
38	Turmeric (dry)	2.5	5.3
39	Canola/Mustard	0.7	1.3
40	Sunflower	0.45	1.0
41	Ground nut (rain port sprinkler)	0.4	1.2
42	Soybean	0.6	1.4
43	Castor	1.0	1.5
44	Cassava	10.0	16.0
45	Tobacco (cured leaf)	0.58	1.00

$ Straw berry is grown only with micro irrigation
*** Indian Apple yields are generally low*
Source: P.Soman, Jain Irrigation; Collected from a large population of farmers.

considered) to show that the investment on irrigation system is repayable in six months to 2 year period based on the crop and its market value. The data set represents a number of crops and varied locations. Benefits to farmers outweigh the investment cost of installation of drip system. In the last few years a number analyses by economists have been in public domain demonstrating the viability of drip or sprinkler irrigation (K.Palanisami et al. 2012).

Again, the benefits in water saving and power saving are not taken into account in the estimates indicating a very high return from investing in drip technology.

Table 9. Enhancing water use efficiency through drip irrigation, cases of two high "water requiring" crops.

I	**Sugarcane**	
	IRRIGATION WATER REQUIRED TO PRODUCE 1 KG SUGAR	
	UNDER CONVENTIONAL IRRIGATION	
1	ADSALI sugarcane crop (16-17 month) in Maharashtra	24.8 million l/ha
2	SURU sugarcane crop (11-12 month) in Maharashtra	16.9 million l/ha
3	Sugarcane crop (8-9 month) in UP	5.6 million l/ha
	Water used (only irrigation) for producing 1 kg sugar in Maharashtra	2068 liter
	Water used (only irrigation) for producing 1 kg sugar in UP	1044 liter
	Source: CACP, 2012	
	UNDER DRIP FERTIGATION	
	Under Drip fertigation with a productivity of 125 ton cane/ha water consumption to produce 1 kg Sugar	1000 liter
	Under Drip fertigation with a productivity of 250 ton cane/ha water consumption to produce 1 kg Sugar	476 liter
II	**Rice**	
	IRRIGATION WATER REQUIRED TO PRODUCE 1 kg Paddy	
	UNDER CONVENTIONAL IRRIGATION	
	With an yield of 7.75 t/ha	3065 liter
	UNDER DRIP FERTIGATION	
	With an yield of 9.5 t/ha	842 liter

Source: CACP 2012 &Soman and Narayanan, 2012

Time for integrated micro irrigation project

These high water use efficiencies in irrigation resulting from the use of sprinkler or drip methods are further scaled up by the formulation and implementation of large community based integrated irrigation projects, involving pipe conveyance from source to the farm and micro irrigation.

Modernization of Canal Command Areas through Adoption of Piped Networks and/or Micro Irrigation Systems

Some of these integrated projects are briefly described below.
Indira Gandhi Nahar Pariyajana, Bikaner, Rajasthan: This project is one of the first that conceptualized enhancing irrigation efficiency by conduting conveyance and field distribution. This is a sprinkler irrigation project having HDPE pipes as mains and lateral lines. There is a common sprinkler irrigation system for a farmers' group of 8-12 ha area. A *Diggi* (water storage ponds) is provided along the canal. Each command having one or two diggies serves approximately 100 to 250 ha area. Diggi is provided adjacent to the minor canal for getting water directly from canal through pipes. In case of two Diggies, one Diggi is provided adjacent to the canal and the other one is away from the canal. Monoblock pump set of 10-30 HP is provided on the Diggi. The capacity of the Diggi is 84 hour storage. The total area brought under this project is 15775 ha at a cost of Rs 23.48 million.
As there is no local storage, the model is suitable for locations where: i) Water is available up to Diggi ii) Farmers are ready to

Table 10. Benefits of drip - water and power consumption (pumping) and yield due to drip irrigation adoption in Sugarcane production in India.

Particulars	Drip	Flood	Gains over flood
Productivity (t)	85	55	30 (54.5 %)
Water saving (mm)	1200	2200	1000 (45.5 %)
Electricity consumption (kWh)	900	2160	1260 (58.3 %)
Water used per ton cane (mm)	14.1	40	25.9 (64.75 %)
Cost per t Cane (Rs)	379.4 (5.8 $)	541 (8.3 $)	161.6 (29.9 %)
Electricity used per t Cane (Kwh)	**10.6**	**39.3**	**28.7 (73 %)**

Source: (Data extracted from Narayanamoorthy 2005).

Table 11. Individual farmer case study- Banana with drip irrigation.

Name of Farmer	**R.Thangavelu**
Address	S/o Ramasamy
	259/3,Malaikaran Thottam,
	Bagavathinagar,Kallipatty,Gobi(tk).Erode (dt)
Crop	Banana
Variety	Karpooravalli (tissue culture)
Soil	Clay loam
Drip system (Inline)	16mm,4lph,60cm
Area under Banana crop	7 acre
Date of planting	October 2016
Lateral spacing	2.4m
Planting distance	2.4m
Yield (t/ac)	25
Selling price (INR/ton)	21000
Total income (INR Lakhs/ac)	5.25
*Cost of cultivation (INR in lakhs/ac)	1.29
Net income (INR lakhs/ac)	3.96
Benefit to Cost ratio	3.06

utilize common sprinkler irrigation system.

Krishna Bhagya Jal Nigam Ltd, Almati, Karnataka

Also known as the Ramthal Drip Irrigation Project of Karnataka govt. being implemented by M/s Jain Irrigation Systems Ltd. in Hungund taluka of Bagalkot District in Karnataka is one of the largest integrated micro irrigation project. Ramthal lift irrigation project is under a scheme of the Krishna Valley Irrigation Project. Under this project, about 26,200 hectare dry lands located on the right bank of the Malaprabha river, in Hungund taluka are brought under drip irrigation. Out of the 2.77 tmcft water allotted for the drip irrigation project, the Western package has been allotted 1.34 tmcft water and the Eastern package has been allotted 1.43 tmcft water. For both these packages, drip irrigation systems

Table 12. Individual farmer case study- Sugarcane with Sub surface drip irrigation.

Name of Farmer	**P.Chandrasekhar**
Address	SVR Puram, BalasamudramMandal,
	Chitoor dist. Andhra Pradesh
	Mob: 9701126609
Crop	Sugarcane
Variety	2003 - V46
Soil	Sandy loam
Drip (Sub surface Inline)	16mm,4lph,50cm
Area under Banana crop	3.5 acre
Date of planting	Dec-17
Lateral spacing	1.8 m
Planting distance	1.8 m (Double row)
Yield (t/ac)	72.5
Selling price INR/ton	2525.00
Total income (INR Lakhs/ac)	1.83
*Cost of cultivation (INR in lakhs/ac)	0.71
Net income (INR lakhs/ac)	1.12
Benefit to Cost ratio	1.58

*****yearly fraction of the drip system cost is added to the cost of cultivation.

have been designed separately and irrigation is provided to each of them through separate sets of pumps.

The project area has normally hot and dry climate, with average rainfall of 562 mm .In Hungund taluka, 40% of the rainfall occurs between June and August. Here during summer the maximum temperature is 38°C to 40°C, while the winter temperature range from 15C° to 18°C.

The entire project area is covered with shallow, medium deep and deep black soils. The organic matter status of the soils is very low.

Components of Ramthal Integrated micro Irrigation project:

- Pumping Units with SCADA to pumping machinery.
- Centralized self-cleaning filtration units at pumping unit.
- HDPE/PVC Pipe Distribution Network from centralized pumping unit to Block level (Approx. 100ha area of each block) (Total 129.54Km)
- Secondary filtration units at each block level (129 No's).
- Secondary PVC Pipe Distribution network from block level to each farmer level (Total 1980Km)
- Drip Irrigation System (12300ha area x 2 blocks)
- Wireless automation system with SCADA to Drip Irrigation System.
- Formation of Water User Associations
- Training to the farmers / WUA's and the Dept. officials.
- Operation and Maintenance of the project for 5 years.

The adoption of drip irrigation system with closed pipe network for conveyance results in the increase of on farm water use efficiency from 34% to 90%. Usually part of the water is lost during transportation through canals and fields and the maximum achievable efficiency of the canal system will be 60% only. Due to the use of drip irrigation system, there will be saving of fertilizers, inputs and increase in yield due to precision application of all inputs which results in the increase in income / profit.

In Ramthal, the project adopted the use of fully automated drip Irrigation system to each farm. The water is transported from outlet of a 100 Ha block to individual farmer's field in the command area through PVC pipeline and drip lines. The Drip lines are laid at 1.52m spacing. The complete drip irrigation system is automated and can be controlled and monitored up to every farmer's field valve. Water meters are provided on

Table 13. Individual farmer case study – Rice with Sprinkler irrigation.

Name of Farmer	**Rajdeep Singh**
Address	Dabrikhana, Faridkot
	Punjab
Crop	Rice
Variety	PR 124
Soil	Loamy soil
Sprinkler	Jain Sprinkler type 5022
Area under Banana crop	7 acre
Date of planting	Jun-20
Planting	On flat land (no bed and furrow)
Yield (t/ac)	2.8
Selling price INR/ton	18880.00
Total income (INR/ac)	54752.00
*Cost of cultivation (INR/ac)	12714.00
Net income (INR/ac)	45752.00
Benefit to Cost ratio	3.58

*****yearly fraction of the sprinkler system cost is added to the cost of cultivation.

each distribution line for measurement of water flow of each zone. The automation of the Ramthal project is in 4 levels for easy operation of the scheme.

LEVEL-1: Control of Main Pump House, Filter Station and Rising Main
LEVEL-2: Control of Block Level Distribution System
LEVEL-3: Control of Farmer Level Valve to Operate Drip Irrigation
LEVEL-4: Monitoring, Data Acquisition and Report Generation Operation and Maintenance of the Integrated Micro Irrigation Project: The service provider is responsible for proper operation of the installations during the first 5 years by engaging suitable qualified manpower. The following are the specific responsibilities of the Service provider.

i) The Agency will be responsible for the daily operation of pumping stations, other components of the scheme.
ii) The Agency will be totally responsible for the Preventive maintenance of every component
iii) The Agency is responsible to make necessary arrangements to keep trained & qualified personnel accessible all the 24 hours.
iv) The Agency shall be responsible for watch & ward of the Pumping Stations, Head works,
v) The Agency will provide the farmer the exact specification for the new Drip Irrigation System Operation requirements and guidelines for cropping pattern, Crop geometry, fertigation and irrigation.
vi) Training of end users in operation of the irrigation system in proper manner including subsystems like fertigation & control systems etc. for five years after commissioning of the system as outlined.
vii) For ready reference of the farmer an "As Built" map will be laminated and erected at the block level.

A Corpus Fund of Ramthal Integrated Micro Irrigation Project is created and managed by the Water Users' Cooperative Society (WUCS). The amount collected for five years will form a corpus fund for the societies for further operation and maintenance. This corpus fund provides for costs of Manpower, Energy, and Service besides replacement of materials (laterals) after 5 years. Because the agency is maintaining the project for first 5 years ,all expenses will start from 6th year. The responsibility of managing the irrigation water and all the related issues are through the formation of water users' cooperative societies (WUCS).
Ramthal project is the largest integrated micro irrigation project in Asia in terms of following points:

- Area under single micro irrigation project
- Irrigation project with complete closed pipe network from source to individual field
- Fully web-based wireless auto micro irrigation project

Table 14. The benefit analysis of few crops grown under drip/sprinkler irrigation.**

No	CROP	B C ratio under Drip -fertigation *	Payback period for Drip system cost *	State
1	Rice	1.6	1 year 6 months (3 seasons)	TN
2	Wheat	2.3	1 year 6 months (3 seasons)	Punjab
3	Maize	1.7	1year 6months (3 seasons)	AP
4	Pigeon pea	4.4	6 months (1 season)	Maharashtra
5	Cotton	2.9	6 months (1 season)	Haryana
6	Sugarcane	2.64	1 year	Karnataka
7	Oil palm	3.35	1 year	AP
8	Coconut	6.33	less than a year	TN
9	Banana	2.25	1 year	TN
10	Pomegranate	2.1	1 year 6 months	Maharashtra
11	Mango (after 3 years)	5.1	3 year	TN
12	Papaya	4.2	1 year	Telengana
13	Onion (rainport sprinkler)	2.1	6 months (1 season)	Karnataka
14	Potato	5.7	6 months (1 season)	MP
15	Brinjal	2.2	1 year (2 seasons)	AP
16	Tomato	3.8	6 months (1 season)	Telengana
17	Chilly (dry) export	5.3	6 months (1 season)	Telengana
18	Gherkin (cucumber) export	2.5	6 months (1 season)	AP
19	Curry leaf (2nd year)	1.4	2 year	TN
20	Radish	2.1	6 months (1 season)	Punjab
21	Turmeric (dry)	2.7	1 year (2 seasons)	Telengana
22	Canola/Mustard	1.88	1 year (2 seasons)	Rajasthan
23	Sunflower	1.40	1 year (2 seasons)	Maharashtra
24	Ground nut (rain port sprinkler)	2.05	1 year (2 seasons)	AP
25	Soybean	2.63	1 year	Karnataka

** Subsidy benefit to farmer is not taken into account (The BC ratio will increase when only the farmer share is taken in the calculations)*

*** Source: P.Soman, Jain Irrigation; Data Collected fromfarmers who adopted the Jain MI systems.*

- Largest number of farmers in a single micro irrigation project
- Largest community based micro irrigation project with market linkages.

The total area of the project is 24000 ha and involves 13500 farmers.

The project now completed 5 years and transition to farmer organization is in place. Through the crop management demonstration and farmer training some 21 new high value crops were introduced in addition to the usual dryland low value cereals.

A study of the impact of such projects on farmer incomes and water use efficiencies are needed. One such study is in progress by an independent study group in the Ramthal project area. Table 15 shows the initial crop yield improvements that occurred in the project area.

Other recent developments in MI spread

1. Use of Solar energy for pumping water in combination with one of the MI system is beginning to make entry into the Irrigation scenario of India.
2. IOT based real time control of irrigation with root sensors (moisture sensor) are also beginning to appear in the horizon of MI. These sensors add to the precision of irrigation scheduling.
3. Research is also in progress in material science to reduce/optimize the amount of plastic required for a unit system. This would eventually help in cost reduction.

Requirements for successful promotion of Modern Irrigation methods in India

Adoption of modern irrigation methods in India has gone through a process of evolution ever since they were introduced in late Seventies. Drip Irrigation was introduced in the country initially with import of hardware by certain companies, but the efforts did not succeed due to approach of selling the systems as hardware without any support services to the farmers. Sprinkler irrigation also existed in a small scale in those years.

Since late 1980s, these modern methods have been promoted on an innovative “Total System Approach” in which the systems are packaged with a host of support services starting from data collection/Survey to training of farmers in management of their irrigation systems as well as the crop agronomy, combined with timely maintenance support. The primary requirements for successful promotion of drip and sprinkler irrigation methods can be summarized as below:

The increase in crop yields is the only economic basis for the farmer for adoption of modern irrigation methods in India, as savings in water and energy are not an incentive for the farmers to adopt these methods given the fact both water and energy for pumping are either subsidized or given free of cost by the Governments. Thus crop productivity with modern irrigation methods is the only economic criteria for promotion of these methods. Hence, the demonstration of higher crop yields alone becomes important for promotion

1. The adoption of drip/sprinkler methods depends upon the success of knowledge transfer to the farmers. As the farm holdings in India are substantially small and also as the farmers cannot handle/manage their systems without adequate training, knowledge transfer to the millions of farmers in achieving the productivity gains is important and is a stupendous task without which the large scale adoption of these methods is not feasible.
2. The availability of technical support along with the material at locations as close as possible to the farmers is also important. Thus trained dealers and service agencies have to be created deep into rural areas. The transfer of knowledge to such dealers/agencies in the distribution network forms the key for reaching the farmers.
3. In the event that the dealers are not able to meet the requirements of supporting the farmers, the companies should be in a position to meet such requirements by themselves and adequate resources and their timely availability at the locations are also important.
4. The role of governments (Central, State as well as local) in creating awareness in the farming community is also essential.

Challenges in Promotion of Drip & Sprinkler Irrigation methods in India

The days when a speaker attributes low adoption rate of micro irrigation to cost, poor awareness level among farmers, system related issues etc. are far from over. The main challenge still is the public investment in providing the physical system itself to those large population of small farmers. In states like, Maharashtra, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Chhattisgarh, Haryana, Punjab, Rajasthan, Tamil Nadu and Telengana, the awareness levels are relatively high and the adoption is also high. More active role of governments and special purpose administrative bodies (like TANHODA, GGRC, APMIP etc.) of these states have certainly helped in achieving higher levels of penetration of the technology. Over the years, research by institutions, both public and private, have helped in addressing scientific issues and providing solutions, those also helped in adapting the technology to Indian farming situations. Nevertheless, the penetration of micro irrigation (as a percentage of Arable land) in India is still low compared to other countries, especially, US, Brazil and China (with large Arable land areas). This becomes very critical considering, India has the largest area under irrigation cover. But in absolute terms, India has one of the largest cover of micro irrigation, nevertheless, there is a long way to go before adoption of micro irrigation can create a perceptible country wide impact on water and power resources, besides crop production and productivity.

Though the developments in the country are favouring the Irrigation Industry, there are several hurdles/difficulties that the industry has to face while promoting these concepts:

1. India being a large country, there is a need for large scale production/sales/servicing network for reaching the millions of farmers.
2. Small and fragmented nature of landholding demands higher efforts than those required in typical large landholding in many other countries.
3. Uptrend in Polymer prices creates pressure on profitability and frequent changes in polymer prices create innumerable revisions in pricing strategy.
4. Each irrigation system being a tailor made system consisting of variety of products and components; manufacture, inventory and bundling of all these products into useful systems; is quite an intensive task in Supply Chain Management.
5. The intensity of documentation requirements for availing the Government subsidies and Bank Loans also hinders the speed of implementation.
6. Varying Tax laws in different states, makes the business processes complex.
7. Delays in release of funds by the funding departments and loans by the banks, creates immense pressure on financial management of the irrigation companies
8. Presence of spurious companies without serious approach leading to system failures, deter the farmers from adopting the concept itself.
9. As there is no incentive or pressure on the farmers for saving water and energy, crop yield improvements alone have to justify the investment on these technologies
10. Delays and/or non-provision of matching funds by the State Governments, sometimes cripple the promotion of these technologies in several states.

Remarks

Field research is critical for the focussed outreach and effective utilization of micro irrigation technology. It is essential to study each time we introduce the micro irrigation solution to a new crop or a new situation. Merely disseminating information on micro irrigation will not lead to successful adoption or scaling up. Farmers need to experience the technology and see its impact in real life situation and they need customised support (depending on their field situation) from pre-system acquiring stage till the post installation phase. Recognise this need for integrated support and the extension agronomists are trained to provide this support to farmers.

The policies of the central Government and most of the states' are supportive. The States that are lagging behind should be encouraged to participate in the national program. They should focus in extending governmental support, building up farmer awareness through training and extension and begin to implement the micro irrigation program through a well-focussed single implementation agency.

All state governments should consider micro irrigation as a necessary component of high- tech crop production package. From the past it is learned that States which formed single focused agency for implementing the program could make impressive progress in adoption of the technology. Restrictions regarding, crops, location, cumbersome procedures etc. only limit the adoption and spread of the technology.

As such micro irrigation sector has little limitation for growth. Every crop can get a suitable micro irrigation system type based on its characteristics. It is quite possible for a growth of 30-40 % every year in the next 10 years as long as we keep a farmer- centric strategy.

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