Spread and Economics of Micro-irrigation in India: Evidence from Nine States

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The adoption of micro-irrigation projects has resulted in water saving, yield and income enhancement at the farm level. However, the overall impression is that they are capital-intensive and suited to large farms. In this context, a study was undertaken in nine states, mainly to examine the actual area covered compared to the potential area and to understand the adoption level of MI as well as to analyse the cost and returns under different farm categories. The results indicated that only about 9% of the MI potential is covered in the country. Key suggestions include reduction in capital cost of the system, provision of technical support for operation after installation, relaxation of farm size limitation in providing subsidies and the establishment of a single state level agency for implementation of the programme.

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1 Introduction

Water is becoming increasingly scarce in many parts of the world and thereby limiting agricultural development. The capacity of large countries like India to efficiently develop and manage water resources is likely to be a key determinant for global food security in the 21st century (Seckler et al 1998). In India, almost all the easily possible ways for viable irrigation potential have already been tapped. However, the water demand for different sectors has been growing continuously (Saleth 1996; Vaidyanathan 1999) and demand management becomes the overall key strategy for managing scarce water resources (Molden et al 2001). Since agriculture is the major water-consuming sector in India, demand management in agriculture in water-scarce and water-stressed regions would be central to reduce the aggregate demand for water to match the available future supplies (Kumar 2008).

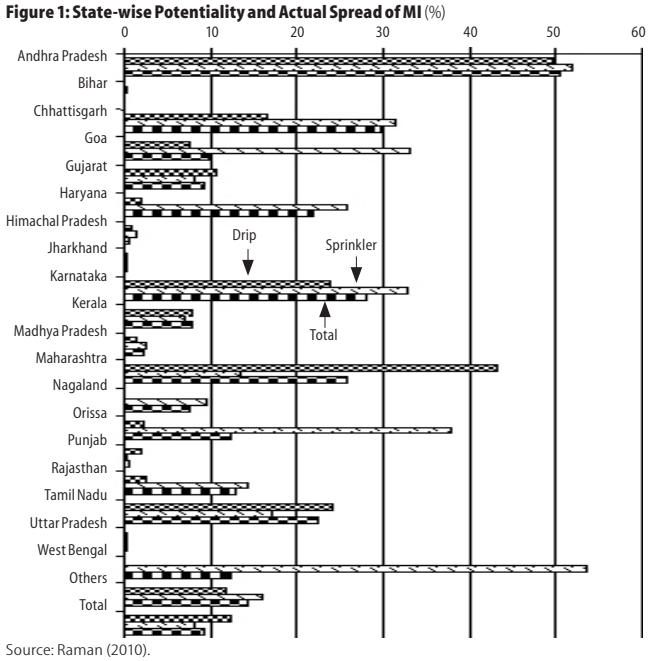
Various options are available for reducing water demand in agriculture. First, the supply-side management practices include watershed development and water resource development through major, medium and minor irrigation projects. The second is through the demand management practices which include improved water management technologies/practices. The micro-irrigation (MI) technologies such as drip and sprinkler are the key interventions in water saving and improving crop productivity. Evidence shows that up to 40% to 80% of water can be saved and water use efficiency (WUE) can be enhanced up to 100% in a properly designed and managed MI system compared to 30-40% under conventional practice (INCID 1994; Sivanappan 1994 cited in Suresh Kumar 2008). The successful adoption of MI requires, in addition to technical and economic efficiency, two additional preconditions, viz, technical knowledge about the technologies and accessibility of technologies through institutional support systems (Namara 2005).

2 Research Questions and Methodology

With regard to MI, much of the research has been conducted with respect to its economics and its suitability for various crops. The available empirical evidence is comparatively limited with respect to its adoption and economics under different farm categories. Hence, the key questions are: who has access to MI and what is the economics of MI in different farm groups (viz, marginal, small and large farmers)? What are the interventions needed to upscale MI adoption? This paper aims to answer these questions to some extent.

The study was undertaken during 2010. All the states were covered for an analysis of the potential MI area and actual spread.

Figure 1: State-wise Potentiality and Actual Spread of MI (%)



Source: Raman (2010).

Table 1: Potential and Actual Area under MI in Different States (Area in '000 ha)

State	Drip			Sprinkler			Total		
	P	A	%	P	A	%	P	A	%
Andhra Pradesh	730	363.07	49.74	387	200.95	51.93	1,117	564.02	50.49
Bihar	142	0.16	0.11	1,708	0.21	0.01	1,850	0.37	0.02
Chhattisgarh	22	3.65	16.58	189	59.27	31.36	211	62.92	29.82
Goa	10	0.76	7.62	1	0.33	33.20	11	1.09	9.95
Gujarat	1,599	169.69	10.61	1,679	136.28	8.12	3,278	305.97	9.33
Haryana	398	7.14	1.79	1992	518.37	26.02	2,390	525.50	21.99
Himachal Pradesh	14	0.12	0.83	101	0.58	0.58	115	0.70	0.61
Jharkhand	43	0.13	0.31	114	0.37	0.32	157	0.50	0.32
Karnataka	745	177.33	23.80	697	228.62	32.80	1,442	405.95	28.15
Kerala	179	14.12	7.89	35	2.52	7.19	214	16.64	7.77
Madhya Pradesh	1,376	20.43	1.48	5,015	117.69	2.35	6,391	138.12	2.16
Maharashtra	1,116	482.34	43.22	1,598	214.67	13.43	2,714	697.02	25.68
Nagaland	11	0.00	0.00	42	3.96	9.43	53	3.96	7.48
Orissa	157	3.63	2.31	62	23.47	37.85	219	27.10	12.37
Punjab	559	11.73	2.10	2,819	10.51	0.37	3,378	22.24	0.66
Rajasthan	727	17.00	2.34	4,931	706.81	14.33	5,658	723.82	12.79
Tamil Nadu	544	131.34	24.14	158	27.19	17.21	702	158.52	22.58
Uttar Pradesh	2,207	10.68	0.48	8,582	10.59	0.12	10,789	21.26	0.20
West Bengal	952	0.15	0.02	280	150.03	53.58	1,232	150.18	12.19
Others	128	15.00	11.72	188	30.00	15.96	316	45.00	14.24
Total	11,659	1,428.46	12.25	30,578	2442.41	7.99	42,237	3,870.86	9.16

P=Potential; A= Actual area.
Source: Raman (2010) and Indiastat 2010.

For the farm level analysis on the costs and returns among the different farm groups, nine states were covered, viz, Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Punjab, Rajasthan and Tamil Nadu. Both secondary and primary data were collected. Secondary data was collected covering the state-level MI sources, cropping pattern, existing area under MI and government subsidies. Primary data was collected from a 150 farmer sample from each selected state using a semi-structured questionnaire covering the source of irrigation, farm size, irrigated area, area under MI, crops grown, subsidy availed, crop income and expenditure under crops with and without MI. Farm-level constraints on adoption of MI and suggestions for better adoption were also obtained from the field surveys. The sample was post stratified into marginal, small and large farmers. The secondary data was used to work out the potential for MI in each state and the primary data was used to work out the access to and economics of MI under different farm categories as well as to document the suggestions of the farmers for better adoption of MI in the state. The internal rate of return due to MI was worked out using the annualised capital cost of the system, average life of the MI system and the additional crop income that will occur during the life period of the MI system in the farm. Annualised cost of MI = [(capital cost of MI) *(1+i) ^{AL} * i] ÷[(1 +i) ^{AL}-1]. where, AL = Average life of MI system (eight years); i=discount rate (10%)

Using the farm level data, the following regression equation was fitted to study the influence of various factors on area under MI.

$$Y_i = \beta_o + \beta_1 X_i + \beta_2 D_{1i} + \beta_3 D_{2i} + \varepsilon_i$$

Where,

Yi = Area under MI by ith farmer (ha), X = Farm size of ith farmer (ha), D_{1i} and D_{2i} = Dummy variables for the ith farmer representing marginal and small farmer category respectively, ε_i = error term

Analysis of variance without replication was used to test the significance of additional income earned by different categories of farmers under MI across the nine states.

3 Results and Discussion

3.1 Potential and Current State of Micro-Irrigation

Potential of different MI systems in terms of drip and sprinkler was assessed using the state-wise secondary data (Raman 2010). For assessing the potential of MI in different states the variables considered were: state-wise and source-wise irrigated area, cropped area and crop-wise suitability for different MI systems. While making the assessment, the irrigated area under paddy and crop area under canal irrigation were not considered. It has been assessed that there is the potential of bringing around 42 million ha under drip and sprinkler in the country (Raman 2010). Out of this, about 30 million ha are suitable for sprinkler irrigation for crops like cereals, pulses and oilseeds in addition to fodder crops. This is followed by drip with a potential of around 12 million ha under cotton, sugar cane, fruits and vegetables, spices and condiments; and some pulse crops like red gram, etc.[1]

The percentage of actual area against the potential estimated under drip irrigation in different states varied between nil in Nagaland to as much as 49.74% in Andhra Pradesh, followed by Maharashtra (43.22%) and Tamil Nadu with 24.14%. In case of sprinkler irrigation, the percentage of actual area against the potential estimated was as much low as 0.01% (Bihar) and the highest of 51.93% (Andhra Pradesh). Compared to the potential of 42.23 million ha in the country, the present area under MI accounts for 3.87 million ha (1.42 million ha under drip and 2.44 million ha under sprinkler) which is about 9.16% (Table 1), (Figure 1). The present figures thus reflect the extent of MI systems covered under different government programmes as well as

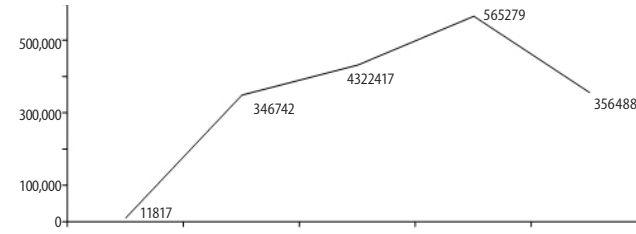
own investment by the farmers. However, the actual area under MI may vary according to the extent of use by the farmers.

3.2 MI and Government Subsidy

Since the introduction of MI in India, government agencies are fully aware of the fact that the cost is high particularly for the marginal and poor farmers. Realising this, the central and state governments, apart from announcing subsidy schemes, mediate with the manufacturers from time to time and try to keep the unit cost as low as possible. The central government also has launched a massive country-wide scheme to promote MI, viz, a centrally sponsored scheme (CSS) on MI which came into effect in 2005-06. But even before the start of the CSS, Andhra Pradesh and Karnataka states had MI schemes. However, the subsidy levels were comparatively low and the range varied among different states from 50 to 65%, depending upon the MI systems. The implementation of MI has gradually accelerated in all the states due to CSS on MI and the increase in physical performance was of the order of nearly 800% in Madhya Pradesh, 300% in Punjab and 150% in Orissa during 2006-08 (NCPAH 2009). In a span of five years (April 2005 and December 2009) an area of around 3.56 lakh ha was brought under MI in the country (Figure 2). The level of subsidy being followed in different states and the implementing agencies are given in Table 2. The major crops vary from field crops (cotton, maize, groundnut, sugar cane) to vegetables, fruits (banana, papaya, mango, grapes) and plantation crops.

Many a time there is a time lag between the decision taken on the quantum of the subsidy and its actual implementation. For example, the subsidy for drip systems for banana in 2010 was Rs 65,000 per ha which is based on the calculation done in 2008. Any increase in the raw material prices during the intervening period will reflect on the actual cost of the system which will be Rs 80,000 per ha, thus decreasing the subsidy percentage at the end users' level. Hence a periodical review of the unit cost is important so that the full benefit of the subsidy is realised.

Figure 2: MI Adoption in the Country (2005-09, in ha)



Source: NCPAH (2009).

3.3 MI Adoption by Various Farm Categories

3.3.1 Farm Size and Area under MI

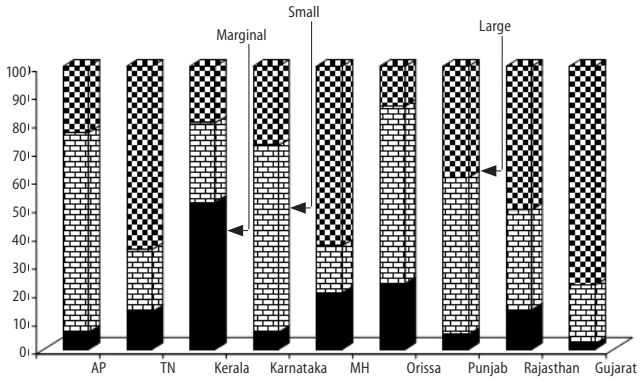
Table 3 reveals that the majority of the farmers adopting MI in Kerala (52%) are marginal farmers, whereas the majority of farmers in Andhra Pradesh (70.67%), Karnataka (66%), Orissa (62.67%) and Punjab (55.34%) are small farmers. Only in Maharashtra (63.33%) and Tamil Nadu (64.67%) are the majority of the farmers large farmers (Figure 3). Namara et al (2005) reported that the majority of the farmers who adopted drip and sprinkler irrigation systems in Gujarat and Maharashtra are rich to very rich farmers. Even after providing the much needed support for promotion of MI, the percentage of area under MI is not remarkable and this has been assessed by farmer category in nine states. Even though the return is high under MI, farmers are reluctant to expand the area due to other constraints like a high initial capital cost, lack of technical knowledge in the operation and maintenance of the systems and type of crops grown. The story is as in the SRI adoption where the SRI results in higher yields and income, but the adoption level is much less due to operating constraints like a lack of skilled labour, high management intensity, etc (Palanisami and Karunakaran 2010).

Table 2: Subsidy Levels Prevailing and Implementing Agency in Different States

State	Subsidy (%)		Major Crops under MI	Implementing Agency
	Drip	Sprinkler		
Andhra Pradesh	70	70	Chillies, mango, sweet orange, groundnut	Andhra Pradesh Micro Irrigation Project (APMIP) Autonomous body under department of horticulture
Bihar	90	90	Sugar cane, banana, coconut, maize, groundnut	State horticultural mission
Chhattisgarh	70	70	Sweet orange, vegetables	Department of agriculture
Goa	50	50	Vegetables	Department of agriculture
Gujarat	50	50	Cotton, vegetables, groundnut	Gujarat Green Revolution Corporation
Haryana	90	50	Orchard crops	Department of agriculture
Himachal Pradesh	80	80	Orchard crops, cole crops	Department of agriculture, Himachal Agro.
Jharkhand	50	50	Vegetables	Department of agriculture
Karnataka	75	75	Grapes, vegetables, groundnut	Department of agriculture and department of horticulture
Kerala	50	50	Coconut, areca nut, pepper	Department of horticulture
Madhya Pradesh	70	70	Sweet orange, banana, vegetables	Department of horticulture
Maharashtra	50	50	Grapes, banana, sugar cane, cotton	Department of agriculture
Orissa	70	70	Vegetables, mango, cashew, banana	Orissa Horticultural Development Society (OHDS)
Punjab	75	75	Vegetables, orchard crops	Department of soil and water conversation
Rajasthan	70	60	Groundnut, maize	Department of horticulture
Tamil Nadu	65	50	Sugar cane, banana, coconut, maize, groundnut	Tamil Nadu Horticultural Development Agency
Uttar Pradesh	50	100	Vegetables and mango, sugar cane	Special Agricultural Department Scheme for Bundlekhand
Uttrakhand	50	50	Potato, groundnut, orchard crops	Department of horticulture
West Bengal	50	50	Banana, maize, mango	Department of FPI and horticulture

Source: Raman (2010); Field survey.

Figure 3: Adoption of MI System with Respect to Different Farmers' Categories (%)



3.3.2 Relationship between MI Area and Farmer Categories

The regression results (Table 4) show that the coefficient of farm size is significant at the 1% level whereas coefficient of dummy variable for small farmers is significant at 10% level, whereas the dummy variable for medium farmers is not significant. The average farm size of small farmers in the nine states was 0.91 ha, 2.41 ha and 8.51 ha for marginal, small and large farmers, respectively. On the average, each farmer could allot about 0.32 ha of every additional ha of land to MI irrespective of the farm size category.

Table 3: Farm Size and Area Irrigated by MI Systems

State	Farmer Category	% of Farmers	Average Farm Size (ha)	Average Area under MI (ha)	% of Area under MI
Andhra Pradesh	Marginal	6.00	0.82	0.76	92.68
	Small	70.67	1.7	0.90	52.94
	Large	23.33	14.08	2.96	21.02
Tamil Nadu	Marginal	13.33	0.62	0.48	77.42
	Small	22.00	1.72	1.31	76.16
	Large	64.67	4.67	2.41	51.61
Kerala	Marginal	52.00	0.54	0.15	94.44
	Small	28.00	1.44	1.25	86.80
	Large	20.00	2.38	2.22	93.27
Karnataka	Marginal	6.00	1.89	1.33	70.37
	Small	66.00	5.71	1.82	31.87
	Large	58.00	18.12	6.59	36.37
Maharashtra	Marginal	20.00	1.80	0.90	50.00
	Small	16.67	3.75	2.25	60.00
	Large	63.33	6.60	3.40	51.52
Orissa	Marginal	23.33	0.51	0.07	13.72
	Small	62.67	1.74	1.23	70.44
	Large	14.00	15.52	9.56	61.60
Punjab	Marginal	5.33	0.8	0.40	50.00
	Small	55.34	2.7	1.30	48.15
	Large	39.33	8.2	4.30	52.44
Rajasthan	Marginal	14.00	0.43	0.4	93.02
	Small	35.33	1.16	0.95	81.90
	Large	50.67	3.41	2.54	74.49
Gujarat	Marginal	02.00	0.8	0.58	72.50
	Small	20.67	1.75	1.13	64.57
	Large	77.33	3.65	3.0	82.19

The experiences of the GGRC in Gujarat indicated that in the recent years more of small and marginal farmers are adopting the MI (personal communication from Raman 2010).
Source: Survey data.

Table 4: Relationship between Area under MI, Farm Size and Category of Farms

Variables	Coefficients	Std Error	t-stat	P-value
Intercept	1.4249	0.5686	2.5058	0.0197
Farm size (ha)	0.3152	0.0553	5.6963	0.0000
Dummy variable for marginal farmers (D1)	-1.1491	0.6161	-1.8650	0.0750
Dummy variable for small farmers (D2)	-0.8350	0.5629	-1.4834	0.1515

Dependent variable: Area under MI (ha), $R^2 = 0.814$, Adj $R^2 = 0.7902$.

3.4 Cost and Returns with Micro-Irrigation

The cost of the MI system and farmers' share after subsidy varied across farm sizes. It is comparatively low in larger farms compared to the other farms due to economies of scale (Table 5, p 85). In Kerala, due to intercropping of the wide spaced perennial crops like rubber, coconut and areca nut, the unit cost of the system is comparatively less. In all the states, the quantum of the actual subsidy is more than 30% which is considered lower than the subsidy announced. Hence, this may be one of the reasons for the slow spread of the MI in different states. Even though MI could pay for investment, farmers still expect a subsidy because of the following reasons: (a) it is capital intensive as it varies from Rs 70,000 to 1.3 lakh per ha depending upon the crops and type of systems (drip or sprinkler) and farmers are reluctant to make this investment quickly, (b) farmers' knowledge in the operation and maintenance of the MI systems is very limited as often the systems are facing a lot of problems in terms of clogging of the filters and drippers; also the required pressure from the pumps is not always maintained due to the poor conditions of the pumpsets resulting in low pump discharge, (c) except for wide spaced and commercial crops, MI is not suitable for all crops and spacing. Except in groundwater over-exploited regions, farmers in other regions do not see MI as an immediate need. Hence, providing incentives in terms of subsidy helps the farmers introduce MI in their farms and save the water.

The internal rate of return (IRR) also varies across states and farm categories, where it was ranging from 3 to 35% in the case of marginal farmers, 14 to 88% for small farmers and 15 to 128% for large farmers. The IRR is higher among the large farmers of Kerala and Maharashtra as they have a diversified intercropping pattern in the orchard/plantation crops, ensuring higher rate of returns. In addition, the plantation crops are widely spaced and the cost of investment is low.

The net income earned is significantly different between states (P value = 0.0.0594) at 10% level of significance (Table 6, p 85). The average additional income varies between Rs 8,351 (Kerala) and Rs 20,000 (Punjab). However, the net incomes are *not* significantly different between the three categories (P value = 0.18128) of farmers. The average additional income due to drip irrigation for a marginal farmer is Rs 14,512 per ha, small farmer Rs 16,476 and large farmer Rs 18,353.

3.5 Farmers' Suggestions for Better Adoption of MI Systems

Even with the proved benefits and applicability of MI systems under different farm categories, the overall adoption level is not high. This might be due to other constraints. This paper further examines the suggestions from farmers and also the policy recommendations at different levels.

The major suggestions include provision of technical support for MI operation after installation, relaxation of farm size limitation in providing MI subsidies, supply of liquid fertilisers, improved marketing facilities and access to more credit to expand the area under MI. The results indicate that small farmers from Andhra

Table 5: MI Cost and Returns across States and Farm Categories

State	Farmer Category	Average Total Cost of the System (Rs/ha)		Net Income (Rs/ha)		IRR (%)	
		Drip	Sprinkler	Drip	Sprinkler	Drip	Sprinkler
Andhra Pradesh	M (9)	71,380	-	15,340	-	16	-
	S (91)	69,794	23,282	17,612	6,104	25	27
	L (50)	65,373	-	17,112	-	27	-
Tamil Nadu	M (20)	81,302	-	12,842	-	3	-
	S (33)	74,509	-	15,339	-	14	-
	L (97)	66,908	-	26,039	-	60	-
Kerala	M (78)	15,900	-	5,310	-	35	-
	S (42)	18,833	-	9,217	-	88	-
	L (30)	18,462	-	10,525	-	128	-
Karnataka	M (9)	57,906	-	15,699	-	29	-
	S (99)	56,950	-	15,439	-	29	-
	L (42)	56,553	-	15,331	-	29	-
Maharashtra	M (25)	42,053	-	10,026	-	22	-
	S (20)	48,085	-	13,000	-	29	-
	L (105)	45,400	-	24,360	-	115	-
Orissa	M (15)	95,600	25,800	20,770	15,000	17	138
	S (114)	89,750	22,330	21,515	13,977	22	167
	L (21)	73,800	22,100	16,365	14,667	18	197
Punjab	M (8)	98,456	-	22,000	-	18	-
	S (83)	89,745	57,000	20,000	9,500	18	5
	L (59)	86,563	42,000	18,000	9,500	15	11
Rajasthan	M (25)	-	-	-	-	-	-
	S (50)		19,736		6,500	-	43
	L (75)		11,765		5,860	-	98
Gujarat	M (3)	61,795		14,106		19	-
	S (31)	72,482	19,300	19,683	12,617	29	188
	L (116)	73,195	10,512	19,089	10,864	27	410

S=Small farmer; M=marginal farmer; L=large farmer; IRR=Internal Rate of Return.
Figures in the parenthesis indicate number of farmers under each farm category.
Source: Survey data.

Table 6: ANOVA for Net Income under Drip Irrigation Systems

Source of Variation	SS	Df	MS	F	P-value	F Crit
Rows	2.8E+08	7	39958830	2.618697	0.059385	2.193134
Columns	59023216	2	29511608	1.93404	0.18128	2.726468
Error	2.14E+08	14	15259048			
Total	5.52E+08	23				

Pradesh and Punjab and large farmers from Tamil Nadu are in need of more technical support for the adoption and management of MI. Liquid fertilisers are requested from Karnataka. Market facilities of MI systems are also important in the adoption as indicated by farmers in Tamil Nadu and Punjab. At the same time farmers from these two states suggested the provision of more credit facilities to increase the area under MI (Table 7).

4 Conclusions and Recommendations

Spread of MI India has been widely noticed in the last 10 years. Even after substantial promotional efforts by the government and private organisations, the rate of adoption of MI technology is still very low compared to the potential. Only a few states like Andhra Pradesh, Maharashtra and Tamil Nadu have expanded the area under MI. The poor adoption can be attributed to number of factors such as high cost, complexity of the technology and other socio-economic issues such as a lack of access to credit facilities, fragmented landholdings, localised crop pattern, etc.

Reducing the capital cost and increasing technical know-how will help the spread of the MI in a bigger way. Keeping this in mind, discussions were held with the MI companies, experts and farmers to identify the ways and means of reducing the cost. For example, the International Development Enterprise (IDE) uses the low cost drip and sprinklers to benefit smallholders, where the cost is very low but the life period of the system is also comparatively short. Also they do not come under the government subsidy norms as well as under the norms of the Bureau of Indian Standards (BIS) due to their fragile structure. Jain Irrigation is now introducing the thin walled pipes (Chapin tubes) and also help in the economic design of the MI systems at farm level where tubes with varying sizes are used to minimise the cost. The following cost reduction and capacity building options are also important:

(i) Field Level: There is good scope for reducing the system cost by slight modifications in the agro-techniques to suit small and medium farms like paired row planting. Enough orientation needs to be given to the manufacturers/dealers/farmers such that the most economic crop specific design can be made. Soil texture should be one important parameter in fixing the emitter spacing. This can also reduce the system cost significantly as presently, irrespective of the soil type, the dripper spacing adopted is 60 cm and less. There is a need to redesign low cost drip and MI systems to suit the needs of the small and marginal farmers.

(ii) State Level: Often there is a large time lag between the decision taken about the subsidy and actual implementation. Hence a periodical review of the unit cost is important as is done in few states.

Table 7: Suggestions by the Farmers for Better Adoption and Management

State	Farmer Category	Percentage of Farmers Who Suggested					
		More Technical Support	Supply Liquid Fertilisers	Providing Marketing Facilities	Credit to Cover More Area under	No Farm Ceiling	Scientific Knowledge on Crop Production
Andhra Pradesh	M (9)	100.00	11.11	0.00	11.11	33.33	0.00
	S (91)	96.70	5.49	0.00	0.00	10.99	6.59
	L (50)	10.00	0.00	2.00	0.00	56.00	0.00
Tamil Nadu	M (20)	90.00	50.00	100.00	100.00	90.00	50.00
	S (33)	90.91	42.42	60.61	96.97	96.97	48.48
	L (97)	92.78	30.93	97.94	97.94	97.94	49.48
Kerala	M (78)	50.00	7.69	29.49	24.36	20.51	7.69
	S (42)	66.67	9.52	30.95	33.33	4.76	9.52
	L (30)	70.00	0.00	10.00	63.33	73.33	3.33
Karnataka	M (9)	11.11	88.89	11.11	66.67	0.00	0.00
	S (99)	5.05	19.19	22.22	44.44	5.05	4.04
	L (42)	4.76	21.43	23.81	50.00	59.52	0.00
Maharashtra	M (25)	20.00	24.00	16.00	32.00	8.00	88.00
	S (20)	25.00	30.00	90.00	100.00	40.00	70.00
	L (105)	5.71	21.90	54.29	53.33	55.24	50.48
Orissa	M (15)	80.00	40.00	40.00	40.00	6.67	0.00
	S (114)	47.37	12.28	32.46	14.91	25.44	7.89
	L (21)	100.00	85.71	66.67	90.48	80.95	9.52
Punjab	M (8)	0.00	0.00	0.00	100.00	0.00	0.00
	S (83)	93.98	0.00	97.59	95.18	30.12	91.57
	L (59)	89.83	38.98	96.61	94.92	54.24	89.83
Rajasthan	M (25)	40.00	0.00	56.00	20.00	0.00	48.00
	S (50)	46.00	60.00	86.00	64.00	24.00	58.00
	L (75)	1.33	20.00	74.67	80.00	64.00	24.00
Gujarat	M (3)	66.67	33.33	0.00	33.33	0.00	66.67
	S (31)	19.35	19.35	25.81	19.35	12.90	38.71
	L (116)	23.28	11.21	18.10	10.34	39.66	37.07

M = marginal; S = small; L = large farmers.
Figures in the parenthesis indicate number of farmers under each farm category.
Source: Survey data.

Discussions with the MI companies and officials also indicated that the differential subsidy pattern for different crops being followed in different regions is affecting the farmers and the implementing agencies. Hence it is important to introduce a uniform subsidy across the state. Currently, different government departments or agencies are involved in the implementation of the subsidy-oriented MI schemes. Due to the variation in the norms of different schemes which are implemented by different agencies, it is difficult to get all the details as and when required.

One of the major suggestions rendered by the farmers during the study was the need for of technical support. In this connection, the capacity building of the implementing team is important which, in turn, can train the farmers in the use of MI systems including routine operation and maintenance. Fertigation (the application of fertilisers through irrigation) is not done in most of the sample farms and hence to increase the crop productivity and income, fertigation should be adopted in all the MI systems. Capacity building units should be encouraged in each region. Recent experiences indicated that in Tamil Nadu, the introduction of the TNDRIP capacity building programme in 2009 covering 100 villages and 1,000 farmers had resulted in a 17% yield increase and a 23% water saving in different crops compared to drip farmers without capacity building activities. Training for unemployed village youths to reduce the time lag in installation and for entrepreneurship development is also important. A special purpose vehicle such as the Gujarat Green Revolution Company in each state should be created to handle MI implementation.

NOTE

1 In addition to drip and sprinklers, there is potentiality for bringing an area of about 2.8 million ha under mini-sprinkler for crops like potato, onion, garlic, groundnut, cabbage, cauliflower, etc (Raman 2010).

REFERENCES

INCID (1994): *Drip Irrigation in India*, Indian National Committee on Irrigation and Drainage, Government of India, New Delhi.

IWMI-Tata Water Policy Program (2011): "TNDRIP Capacity Building Programme", Evaluation Report 1/2011, International Water Management Institute, Hyderabad.

Kumar, Suresh (2008): *Promoting Drip Irrigation: Where and Why? Managing Water in the Face of Growing Scarcity, Inequity and Declining Returns: Exploring Fresh Approaches*, IWMI TATA 7th Annual Partner Meet, Vol 1, pp 108-20.

Molden, D R, R Sakthivadivel and Z Habib (2001): *Basin-Level Use and Productivity of Water: Examples from South Asia,* IWMI Research Report 49, International Water Management Institute (IWMI), Colombo, Sri Lanka.

Namara, R E, B Upadhyaya and R K Nagar (2005): *Adoption and Impacts of Micro-irrigation Technologies: Empirical Results from Selected Localities of Maharashtra and Gujarat of India*, Research Report 93, International Water Management Institute, Colombo, Sri Lanka.

NCPAH (2009): *Evaluation Study of Centrally Sponsored Scheme on Micro-irrigation*, National Committee on Plasticulture Application in Horticulture (NCPAH), Ministry of Agriculture, Department of Agriculture and Cooperation, New Delhi.

Palanisami, K and R Karunakaran (2010): "Adoption of SRI under Different Irrigation Sources and Farm Size Categories in Tamil Nadu", India, unpublished Paper IWMI-TATA Water Policy Programme, South Asia Regional Office, Hyderabad, India.

Raman, S (2010): "State-wise Micro-Irrigation Potential in India-An Assessment", unpublished paper, Natural Resources Management Institute, Mumbai.

Saleth, R M (1996): *Water Institutions in India: Economics, Law and Policy* (New Delhi: Commonwealth Publishers).

Seckler, D, U Amarasinghe, D Molden, D Radhika and R Barker (1998): *World Water Demand and Supply, 1990 to 2025: Scenarios and Issues*, Research Report 19, International Water Management Institute, Colombo, Sri Lanka.

Sivanappan, R K (1994): *Prospects of Micro-Irrigation in India*, Irrigation and Drainage Systems, 8(1): 49-58.

Vaidyanathan, A (1999): *Water Resources Management: Institutions and Irrigation Development in India* (New Delhi: Oxford University Press).