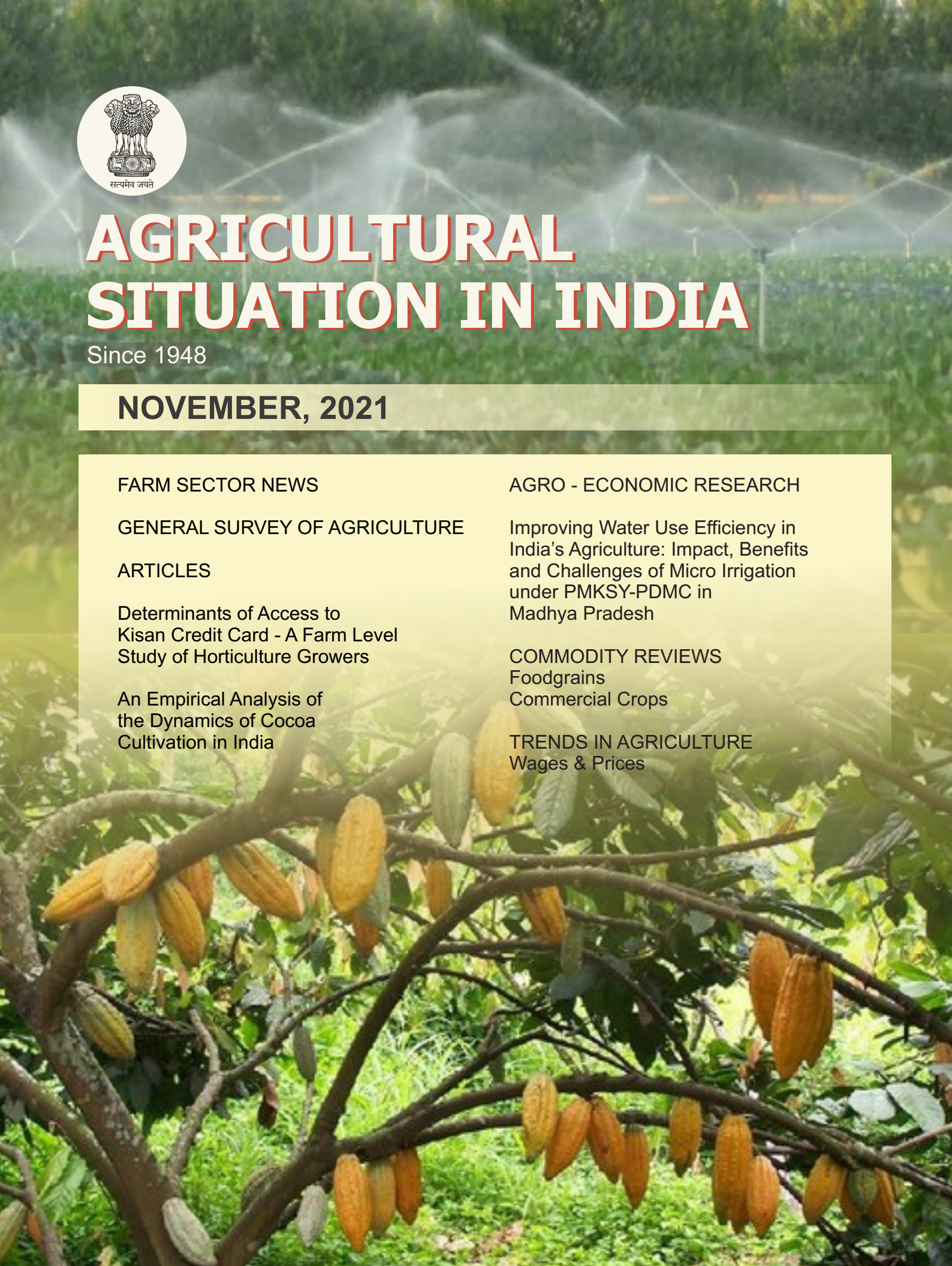

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Agro-Economic Research

Improving Water Use Efficiency in India's Agriculture: Impact, Benefits and Challenges of Micro Irrigation under PMKSY-PDMC in Madhya Pradesh

HARI OM SHARMA[1], DEEPAK RATHI[2], PRADEEP PATIDAR[3] AND H. K. NIRANJAN[4]

1. Introduction

Water is considered to be a scarce resource in Indian agriculture. It is the largest water user, consuming about 83% of the total available water. Increasing demand for industrial and domestic water will result in reduction in water diversion to agriculture (Bhowmik *et al*., 2018). The surface methods of irrigation causes uneven distribution of water, water loss in the form of seepage and deep percolation, promotes excessive weed growth besides creating salinization, water logging and thus affecting the land and crop productivity (Shankar *et al*., 2015). In India, both surface and ground water are dependent on monsoon. More than 85% of the water used for irrigation is groundwater. Thus, agriculture irrigated by surface water and groundwater suffers from the vagaries of monsoon. In the world, India has the second largest net irrigated area after China. The irrigation efficiency under canal irrigation is not more than 40% and for ground water schemes, it is 69%. The net irrigated area in the country is about 61 Mha, which is about 43% of the total sown area (Ashoka *et al*., 2015). It is reported that in the next three decades, the global food systems will need 40-50 percent more fresh water than what is required today. Municipal and industrial demand for water will increase by 50-70 percent during this period, while demand for energy sector will increase by 85 percent. India faces high water stress and is amongst those countries with the most fragile and uncertain water resources in the world (Tripathi *et al*., 2019). It is projected that by 2020-25, availability of water for agricultural use in India may be reduced by 21%, resulting to reduction in productivity of irrigated crops thereby production, especially rice, thus resulting in price rise and non-accessibility of food for poor masses.

Irrigation is a major determinant of agricultural productivity. Indian agriculture has been constrained by limited irrigation with only about 40% of arable land under irrigation and the remaining 60% dependent on rainfall. The irrigation and rainfed cultivation cleavage is a major influence on agricultural productivity, earning opportunities, and welfare of the rural population (CAPE India, 2016). To cater to the alarming rise in population, efficient use of available irrigation water is essential for increasing the agricultural productivity. The only solution will be enhancing the micro irrigation facilitates for Indian agriculture.

Micro irrigation refers to the slow application of water on, above or below the soil by surface drip, subsurface drip, bubbler and micro-sprinkler systems. Water is applied as discrete or continuous drips, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line adjacent to the plant row (Rao and Anitha, 2015). Micro irrigation has proved to be an efficient method in water saving. The projected additional returns from saved water should be considered as compared to conventional surface method of irrigation. It is necessary to further evaluate and confirm the best system for local producers that will result in the highest profits so that repayment of irrigation investment loans can be achieved (Suryavanshi and Buttar, 2016).

The Ministry of Agriculture and Farmers' Welfare, Government of India, launched the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) to

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address India's key agricultural challenges in the 21st century *i.e.,* to reduce poverty and ensure food security for the growing population in the face of climate change, scarce and limited water and land resources. This initiative proposes to provide irrigation to every farm in the country (Har Khet Ko Pani) and improve water use efficiency (Per Drop More Crop and income). It aims to bring together various schemes and programmes for water harvesting, conservation and efficient management in order to ensure enough water for agriculture (Anonymous, 2016).

PMKSY has been formulated to promote micro irrigation facilities at farmer's field by amalgamating ongoing schemes *viz*., Accelerated Irrigation Benefit Programme (AIBP) of the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR, RD&GR), Integrated Watershed Development Programme (IWMP) of Department of Land Resources (DoLR) and On Farm Water Management (OFWM) of Department of Agriculture and Cooperation (DAC).

The Per Drop More Crop component of PMKSY mainly focuses on water use efficiency at farm level through precision/micro irrigation (drip and sprinkler). An area of 690 Mha is proposed to be brought under micro irrigation in India for achieving the target of "Har Khet Ko Paani." But the scheme looks to have hit the roadblock due to poor response to such initiatives from small and marginal farmers, who constitute majority of workforce in agriculture (Spehia and Verma, 2019).

At present, area under micro irrigation is only 11.41 million hectares which is dismal when compared to area under rainfed in India. The major states having area under micro irrigation are Rajasthan (21.80%), Maharashtra (16.45%), Andhra Pradesh (15.05%), Karnataka (10.96%), Gujarat (10.73%), Haryana (7.42%), Madhya Pradesh (4.56%), Tamil Nadu (4.15%), Chattisgarh (3.12%), Bihar (1.32%) and Rest of India (4.25%).

During the period 2015-16 to 2019-20, the micro irrigated area under PMKSY increased from 0.55 Mha to 1.18 Mha, out of which, the area under drip and sprinkler increased from 0.35 Mha to 0.63 Mha and 0.20 Mha to 0.56 Mha, respectively. In Madhya Pradesh, micro irrigated area under PMKSY is found to be 0.21 Mha with 0.15 Mha and 0.06 Mha under drip and sprinkler irrigation, respectively, for the period 2015-20.

1.1 Objectives of study

The study has been conducted with the following objectives:

1. To examine the savings of various inputs such as water, fertilizers, power, pesticides and labour.

2. To examine the enhancement of productivity, quality and other benefits in selected agricultural horticulture crops.

3. To examine the adoption of MI including some or its determinants/features such as need/importance of subsidy, culture of water conservation, issues of fragmented land holdings, capital cost, maintenance cost and the distribution of subsidy across states.

4. To study overall impact of MI on farmer's income.

5. To identify any issues/problems in the benefit transfer work flow and monitoring by the implementing agency.

2. Data sources and methodology

Both primary and secondary data were used in the study. The primary data for the agriculture year 2019-20 were collected from the adopter and non-adopter farmers of micro irrigation on various aspects. The secondary data were collected from PMKSY website (https://pmksy.gov.in/), officers of the Farmer Welfare and Agriculture Development Department, Madhya Pradesh and Commissioner Land Record & Settlement, Government of Madhya Pradesh for the period from 2015 to 2018.

A multi-stage stratified random sampling method is used for selection of districts, blocks,

villages and respondents. In the first stage, districts were selected based on higher irrigated area under different systems of micro irrigation. Among all the districts of Madhya Pradesh, Dhar district (5792 ha.) was selected for drip irrigation system and Sagar district (856 ha.) for sprinkler irrigation system. In the second stage, two blocks having maximum area under micro irrigation, namely Badnawar and Manawar, were selected in Dhar district and Khurai and Deori blocks were selected from Sagar district. In third stage, 3 villages in each selected block were selected randomly from the list of micro irrigation villages. In the fourth stage, a list of all the adopters and non-adopters in the selected villages was prepared and out of which, 8 adopters and 2 non-adopters from each village were selected. Thus a total of 120 farmers constituting 96 adopters and 24 non-adopters from both districts (48 adopters and 12 non-adopters from each district) were selected for the study.

The selection of crops was done on the basis of one having higher area under micro irrigation. Hence chilli & ginger under drip system and wheat crop under sprinkler system have been selected for the study.

3. Results and discussion

The initial investment in micro irrigation; annual maintenance cost; cropping pattern with micro irrigation; change in area and yield; changes in production, income, input and cost of cultivation; and determinants affecting the adoption of micro-irrigation have been analysed in the study.

3.1 Initial investment in micro irrigation

An average adopter of drip and sprinkler were found to invest Rs. 199788.14 and Rs. 53074.87, respectively, in installment of drip and sprinkler irrigation system in their field for crop production.

TABLE 1: Initial Capital Cost/Investment in Micro Irrigation (Rs./kit)

Item	Amount Paid	Subsidy Amount	Total Cost
Drip irrigation Kit (n=48)			
Pipe, Micro tube & other DIE	74875.00 (41.91)	103770.83 (58.09)	178645.83 (100)
Pumps (Avg. 5 HP)	21142.31 (100)	0.00 (0.00)	21142.31 (100)
Total	**96017.31(48.06)**	**103770.83(51.94)**	**199788.14(100)**
Sprinkler irrigation (n=48)			
Pipe, nozzle & other SIE	19665.10 (61.58)	12267.46 (38.42)	31932.56 (100)
Pumps (Avg. 5 HP)	21142.31 (100)	0.00 (0.00)	21142.31 (100)
Total	**40807.41 (76.89)**	**12267.46 (23.11)**	**53074.87 (100)**

Source: Primary data

In the investment of total funds, the owned capital and subsidy was found to be 48.06 percent and 51.94 percent, respectively, in case of drip irrigation system/kit and 76.89 and 23.11 percent, respectively, in case of sprinkler irrigation system kit (Table 1). An average adopter was found to invest Rs. 21142.31 for purchase of pump for micro irrigation system under both the systems. Thus an average adopter was found to invest more in drip as compare to sprinkler micro irrigation system.

3.2 Annual maintenance cost of micro irrigation

The average annual maintenance cost of micro-irrigation as reported by an average respondent was found to be Rs. 6877.44. Out of

this, the items which incurred maximum cost were filter (35.41%), followed by pipes (24.17%), other maintenance charges (19.30%) and valves (9.49%). None of the farmer was found to report loan as a source of funds for annual replacement and maintenance cost of micro irrigation in the study area (Table 2).

TABLE 2: ANNUAL REPLACEMENT/MAINTENANCE COST OF MICRO IRRIGATION (RS.) N=96

Item	Total Cost	% to total cost
Filters (Cyclone, disc, others)	2435.29	35.41
Pipes (Micro, distribution, drip, PVC, PE, others)	1662.28	24.17
Valves	652.73	9.49
Any other maintenance/replacement/repairs charges	1327.14	19.30
Any others	800.00	11.63
Total	**6877.44**	**100.00**

Source: Primary Data

3.3 Source of equipment

Jain Irrigation System Ltd. (26.04%), Pragati Irrigation System Pvt. Ltd. (16.67%) and Netafim Pvt. Ltd. (13.54%) were found to be major companies involved in installation of micro irrigation set/kit as reported by the adopters. In maintenance of micro irrigation systems, Jain Irrigation System Ltd. (39.58%), Netafim Pvt. Ltd. (33.33%) and Kasta Pipes Pvt. Ltd (18.75%) played an important role as reported by the maximum numbers of adopters in the area under study (Table 3).

TABLE 3: COMPANIES AS SOURCE OF EQUIPMENT/PARTS/SERVICE

Micro-irrigation Set/Kit/Initial Capital			Micro-irrigation Maintenance		
Company/Brand Name	**Number Reporting**	**Percent Reporting**	**Company/Brand Name**	**Number Reporting**	**Percent Reporting**
Jain Irrigation System Ltd.	25	26.04	Jain Irrigation System Ltd.	38	39.58
Pragati Irrigation Systems Private Limited	16	16.67	Netafim Pvt. Ltd.	32	33.33
Netafim Pvt. Ltd.	13	13.54	Kasta Pipes Pvt. Ltd.	18	18.75
Others (Apolo, Jaldeep and Shakti etc.)	42	43.75	Others (Nimbus, Pragati irrigation Pvt. Ltd. etc.)	8	8.33
Total	**96**	**100**	**Total**	**96**	**100**

Source: Primary data

3.4 Cropping pattern with micro irrigation

In kharif season, out of 96 adopters, maximum were found to cultivate soybean (72.92%) followed by urad (41.67%), cotton (26%) and paddy (15.63%), while 36.46 percent were found to cultivate ginger followed by chilli (34.38%) in the area under study. On an average, the maximum area was allocated under cotton (2.21 ha) followed by soybean (1.73 ha), urad (1.11ha) and paddy (0.94 ha), while among vegetables, the maximum area was allocated under chilli (0.66 ha) and ginger (0.54 ha) by the adopters of micro irrigation (Table 4). With regards to micro irrigation, the maximum area was found to be irrigated through drip irrigation in kharif season in case of chilli (0.57 ha) followed by ginger (0.52 ha) and cotton (0.51 ha). The sprinkler was found to be utilized in case of soybean on an average 0.05 ha of cultivated area. The irrigated area under non-micro irrigation sources among kharif crops was found to range between 0.02 ha (ginger) to 1.70 ha (cotton).

During the rabi season, 86.46%, 71.88% and 16.67% of the adopters were reported to cultivate wheat, chickpea and lentil, respectively, on their farms. On an average, the maximum area was found to be allocated by the adopters under wheat (1.53 ha.), chickpea (1.41 ha) and lentil (0.60 ha.). As regards to micro irrigation, an average adopter was found to allocate more under sprinkler system as compared to drip. An average area under non-micro irrigation was found to be vary between 0.03 ha (lentil) to 0.41 ha (wheat) and the un-irrigated area was found to vary between 0.01 ha (chickpea) and 0.04 hectare (lentil). In case of perennial crops, lemon was found to be major crop grown by 15.63 percent of adopters on an average area of 0.08 ha, out of which 50 percent was found to be under micro-irrigation (drip) and 50 percent under non-micro irrigation sources.

Maximum fertigation was found in area under ginger (96.29%), followed by chilli (86.36%) and cotton (23.08%). Overall fertigation in kharif crops was found to be 25.45 percent of total crop cultivated area. For rabi crops, fertigation was found to be practiced in 13.47 percent area of chickpea, 51.25 percent of area under lemon and 26.56 percent area of other crops.

TABLE 4: CROPPING PROFILE AND AREA WITH MICRO-IRRIGATION

Sr. No	Crop	No. of Adopters	% of Adopters	Area - average in ha. (based on reporting adopters)					
				Crop cultivation	Drip	Sprinkler	Irrigated non-micro	Un-irrigated	Fertigation (% to crop cultivation area)
Kharif season									
1	Soybean	70	72.92	1.73 (22.47)	0 (0)	0.05 (100)	1.67 (29.51)	0.01 (33.33)	0.00
2	Urad	40	41.67	1.11 (14.42)	0 (0)	0 (0)	1.09 (19.26)	0.02 (66.67)	0.00
3	Cotton	25	26.04	2.21 (28.7)	0.51 (26.02)	0(0)	1.70 (30.04)	0(0)	23.08
4	Paddy	15	15.63	0.94 (12.21)	0(0)	0(0)	0.94 (16.61)	0(0)	0.00
5	Chilli	33	34.38	0.66 (8.57)	0.57 (29.08)	0(0)	0.09 (1.59)	0(0)	86.36
6	Ginger	35	36.46	0.54 (7.01)	0.52 (26.53)	0(0)	0.02 (0.35)	0(0)	96.29

Sr. No	Crop	No. of Adopters	% of Adopters	Area - average in ha. (based on reporting adopters)					
				Crop cultivation	Drip	Sprinkler	Irrigated non-micro	Un-irrigated	Fertigation (% to crop cultivation area)
7	Other Kharif	60	62.50	0.51 (6.62)	0.36 (18.37)	0 (0)	0.15 (2.65)	0 (0)	70.58
	Total kharif	96	100	7.7 (100)	1.96 (100)	0.05 (100)	5.66 (100)	0.03 (100)	25.45
	Rabi season								
1	Wheat	83	86.46	1.53 (36.60)	0 (0)	1.12 (41.64)	0.41 (37.96)	0 (0)	0.00
2	Chick pea	69	71.88	1.41 (33.73)	0.19 (52.78)	0.82 (30.48)	0.39 (36.11)	0.01 (20.00)	13.47
3	Lentil	16	16.67	0.60 (14.35)	0 (0)	0.53 (19.70)	0.03 (2.78)	0.04 (80.00)	0.00
4	Other Rabi	32	33.33	0.64 (15.31)	0.17 (47.22)	0.22 (8.18)	0.25 (23.15)	0 (0)	26.56
	Total rabi	96	100	4.18 (100)	0.36 (100)	2.69 (100)	1.08 (100)	0.05 (100)	8.61
	Perennial crops								
1	Lemon	15	15.63	0.8 (40.2)	0.41 (25.63)	0 (0)	0.39 (100)	0 (0)	51.25
2	Other Perennial	12	12.50	1.19 (59.8)	1.19 (74.37)	0	0	0	100.00
	Total perennial			1.99 (100)	1.6 (100)	0 (0)	0.39 (100)	0 (0)	80.40

Source: Field survey.
Note: Figure in parenthesis show percentage to total.

3.5 Changes in area and yield due to micro irrigation

Various crops grown by the adopters in the area under study were found to observe a change in area and yield of due to introduction of micro irrigation. These changes were categorized into: large increase, increase, no change, decrease, large decrease (Table 5).

TABLE 5: CHANGE IN AREA AND YIELD DUE TO MICRO IRRIGATION (% HHs)

Sr. No.	Crop	No. of Adopters	% of Adopters	Large Increase	Increase	No change	Decrease	Large Decrease
				Area				
1	Soybean	1	1.04	0	0	100	0	0
2	Cotton	22	22.92	5	18	55	18	5
3	Chilli	33	34.38	9	45	45	0	0
4	Ginger	35	36.46	20	31	49	0	0

Sr. No.	Crop	No. of Adopters	% of Adopters	Large Increase	Increase	No change	Decrease	Large Decrease
5	Other kharif	64	66.67	8	56	36	0	0
6	Wheat	48	50.00	13	88	0	0	0
7	Chickpea	46	47.92	4	48	30	17	0
8	Other Rabi	23	23.96	4	13	83	0	0
9	Lemon	13	13.54	0	23	77	0	0
10	Other Perennial	13	13.54	0	62	38	0	0
				Yield				
1	Soybean	1	1.04	0	100	0	0	0
2	Cotton	22	22.92	5	59	36	0	0
3	Chilli	33	34.38	33	61	6	0	0
4	Ginger	35	36.46	63	34	3	0	0
5	Other kharif	64	66.67	33	61	6	0	0
6	Wheat	48	50.00	63	34	3	0	0
7	Chickpea	46	47.92	25	77	2	0	0
8	Other Rabi	23	23.96	17	33	50	0	0
9	Lemon	13	13.54	15	85	4	0	0
10	Other Perennial	13	13.54	46	46	8	0	0

It is clear from the data that 50 percent adopters were found to cultivate wheat followed by chickpea (48%), ginger (36.46%), chilli (34.38%), cotton (22.92%) and lemon (13.54%). It is also observed that more than 20 percent adopters of micro irrigation reported their area under cotton, chilli, ginger, wheat, chick pea, other kharif crops, other rabi crops and perennial crops (lemon) to increase (increase to large increase) after introduction of micro irrigation in their farms.

An increase in area was reported by majority of adopters growing wheat (88%) followed by chickpea (48%), chilli (45%), ginger (31%) and lemon (23%), while large increase in area was reported by adopters in ginger (20%), followed by wheat (13%) and chilli (9%). The cent percent adopters reported no change in area of soybean cultivation after the adoption of micro irrigation facilities on their farm.

More than 50 percent adopters reported that after of adoption of micro irrigation facilities on their farms, the yield of all the crops increased and varied between increase to large increase. None of adopters reported decrease or large decrease in yield across all the crops after adoption of micro irrigation facilities on their farms.

3.6 Changes in production, income, input and cost of cultivation

After adoption of MI facilities, the production of all major crops of an average farmer was found to have increased by 33.91 percent from 96 q/ha (without MI) to 129 q/ha (with MI) in the area under study. Total sale value of the product (Gross Return) was also found to increase by 98.96 percent, from Rs. 245664 (without MI) to 488781/ha (with MI), while price of the product increased by 48.03 percent after adoption of MI facilities.

The expenditures on cultivation of all major crops were found to increase like seeds/plants cost (129.44%), fertilizer cost (44.08%) FYM/organic manure (35.79%), pesticide cost (47.46%), other stacking cost (44.98%), farm power/equipment cost (59.37%), labour cost (36.41%) and marketing cost (44.31%) except the cost of irrigation which was found to decreased by 37.56% in an average beneficiary's farm. The increased costs may be due to adoption of improved production technologies for cultivation of crops, better variety of seeds, superior plant protection chemicals, etc. Assured irrigation during crop growth period encouraged adopters to invest in superior quality of input in cultivation of crops without any hesitation.

The per rupee return over the expenditure of Re. 1.00 was also found to have increased by 17.74 percent from Rs. 2.39 (without MI) to 2.82 (with MI). The cost of production was found to increased by 25.75 percent from Rs. 1068.81/q (without MI) to 1344.08/q (with MI) in the area under study.

TABLE 6: CHANGES IN PRODUCTION, INCOMES, INPUTS AND COST WITH MICRO IRRIGATION OF MAJOR CROPS

(in Rs./ha)

Particulars	Crop - Chilli		Crop - Ginger		Crop - Wheat		All Crop	
	n=33		n=31		n=48		n=112	
	With MI	Without MI	With MI	Without MI	With MI	Without MI	With MI	Without MI
Production (q)	182 (54.24)	118	163 (22.56)	133	42 (10.53)	38	129 (33.91)	96
Price	2352 (21.36)	1938	7166 (76.46)	4061	1848 (10.07)	1679	3789 (48.03)	2559
Total Sales Revenue	428064 (87.19)	228684	1168058 (116.26)	540113	77616 (21.65)	63802	488781 (98.96)	245664
Cost of Cultivation								
Seeds/ Plants cost	21866 (39.64)	15659	164821 (159.37)	63547	5240 (17.91)	4444	63976 (129.44)	27883
Fertilizer cost	28414 (46.97)	19333	18361 (53.49)	11962	5766 (11.48)	5172	17514 (44.08)	12156
Farm Yard Manure/ Organic cost	21269.97 (453.47)	3843	13647 (40.71)	9699	1752 (92.53)	910	6542 (35.79)	4817
Pesticides cost	32581 (38.45)	23532	16326 (84.85)	8832	811 (-40.01)	1352	16573 (47.46)	11239
Cost of Irrigation								
Electricity cost	2435 (37.03)	3867	1418 (-55.82)	3181	1838 (-11.08)	2067	1897 (-37.56)	3038
Water charge paid	0.00	0.00	0.00	0.00	37 (15.63)	32	12 (15.63)	11
Diesel cost	0.00	0.00	0.00	0.00	1330 (14.46)	1162	443 (14.46)	387
No of irrigations	55 (266.67)	15	70 (266.67)	15	6 (0.00)	6	44 (263.89)	12
Hours of pumping	412 (-32.68)	612	468 (-24.15)	617	92 (-67.49)	283	324 (-35.71)	504
Farm power & equipment cost	16502 (102.28)	8158	14095 (61.25)	8741	5581 (-3.79)	5801	12059 (59.37)	7567
Total mandays	317 (32.64)	239	246 (7.17)	265	40 (-6.98)	43	201 (10.24)	182

Particulars	Crop - Chilli		Crop - Ginger		Crop - Wheat		All Crop	
	n=33		n=31		n=48		n=112	
	With MI	Without MI	With MI	Without MI	With MI	Without MI	With MI	Without MI
Labour cost	51163 (56.19)	32756	38424 (23.66)	31072	7530 (2.24)	7365	32372 (36.41)	23731
Marketing cost	18200 (99.65)	9116	16300 (10.52	14749	888 (35.16)	657	11796 (44.31)	8174
Other Cost								
Mulching	(-) 14828	00	0.00	0.00	0.00	0.00	4943	0.00
Stacking	15672 (44.98)	10810	0.00	0.00	0.00	0.00	5224 (44.98)	3603
Total Cost	190812.44 (50.16)	127074	283432.71 (86.74)	151783	30865.53 (6.57)	28962	173386.81 (68.98)	102606
Net Profit/ Income	237251.56 (133.49)	101610	884625.29 (127.80)	388330.00	46750.47 (34.19)	34840	315394.19 (120.47)	143058
Cost of Production	1048.42 (-2.64)	1076.90	1738.85 (52.35)	1141.23	734.89 (-3.58)	762.16	1344.08 (25.75)	1068.81
Per Rupee Return	2.24 (24.66)	1.80	4.12 (15.81)	3.56	2.51 (14.15)	2.20	2.82 (17.74)	2.39

Source: Field survey.
Note: Figure in parenthesis show percentage change over without MI

3.7 Factors affecting adoption of MI

The opinions of the respondents were observed with respect to agronomical potential, agro-economic potential, effective demand, aggregate supply and distribution of micro-irrigation system and categorized into different categories; strongly agree, agree, partially agree, disagree (Table 7).

TABLE 7: DETERMINANTS/FACTORS AFFECTING THE ADOPTION OF MICRO IRRIGATION (%)

(N=96)

S. No.	Factors	Strongly Agree	Agree	Partially Agree/ Disagree	Disagree	Strongly Disagree
		5	4	3	2	1
	Agronomic Potential					
1	Micro irrigation increases yield/output	33.33	65.63	1.04	0.00	0.00
2	Micro irrigation saves water/ reduces water use	50.00	47.92	2.08	0.00	0.00
3	Micro irrigation reduces fertilizer use	13.54	36.46	36.46	11.46	2.08
4	Micro irrigation reduces pest problems/ pesticide use	0.00	19.79	63.54	15.63	1.04

S. No.	Factors	Strongly Agree	Agree	Partially Agree/ Disagree	Disagree	Strongly Disagree
		5	4	3	2	1
5	Micro irrigation reduces weed problem	12.50	59.38	25.00	3.13	0.00
6	Micro irrigation reduces labour use	21.88	38.54	36.46	2.08	1.04
	Agro- Economic Potential					
1	Capital cost of Micro irrigation is not high	5.21	16.67	29.17	27.08	21.88
2	Micro irrigation raises output quality/profit	15.63	57.29	27.08	0.00	0.00
3	Micro irrigation reduces input use/costs	10.42	32.29	46.88	9.38	1.04
4	Micro irrigation increases profitability/ incomes	14.58	63.54	21.88	0.00	0.00
5	Subsidy on Micro irrigation is substantial/ important	28.13	51.04	19.79	1.04	0.00
	Effective Demand					
1	Information on Micro irrigation is easily available	21.88	55.21	21.88	1.04	0.00
2	Micro irrigation technology is easy to understand and operate	17.71	64.58	17.71	0.00	0.00
3	Subsidy for Micro irrigation is easy to get	8.33	29.17	44.79	12.50	5.21
4	Finance for Micro irrigation is easy to get	5.21	41.67	25.00	28.13	0.00
5	Electricity supply for Micro irrigation is available/reliable	15.63	62.50	16.67	4.17	1.04
6	Water supply for Micro irrigation is sufficient	39.58	42.71	15.63	2.08	0.00
	Aggregate Supply					
1	There are a large number of companies supplying Micro irrigation equipment	14.58	54.17	30.21	1.04	0.00
2	The quality and reliability of the Micro irrigation equipment is good	9.38	51.04	38.54	1.04	0.00
	Distribution					
1	There are a number of Micro irrigation dealers located nearby	7.29	52.08	40.63	0.00	0.00
2	The dealers provide good quality products you can trust	14.58	54.17	29.17	2.08	0.00
3	The dealers charge a reasonable price	7.29	48.96	39.58	4.17	0.00
4	The dealers arrange for subsidy/credit	20.83	63.54	14.58	1.04	0.00
5	The dealers provides after-sales service	8.33	53.13	31.25	6.25	1.04

Source: Field survey

3.7.1 Agronomic potential

More than 60 percent of adopters were in agree and strongly agree category in expressing that there was an increase in output/yield of crops (98.96%), reduced use of water (97.92%) and reduction in fertigation and problem of weeds (71.88%) on their fields after introduction of micro irrigation facilities. The majority of respondents partially disagree with the statement that micro irrigation reduces pest problem/pesticide use (63.54%).

3.7.2 Agro-economic potential

More than 40 percent adopters agreed and strongly agreed with the fact that micro irrigation facilities raised output quality (72.92%), profitability/ income (78.12%) and reduces input use & cost of input (42.71%). They also expressed that the subsidy on MI is substantial/important (79.17%).

3.7.3 Effective demand

In the area under study, more than 45 percent adopters agreed and strongly agreed on the factors that information of micro irrigation is easily available (77.09%), technology of micro irrigation is understandable and operational (82.29%), proper financial facilities, supply of electricity is available and reliable and water supply is sufficient (78.13%) for adoption of micro irrigation facilities in their farm. 44.79 percent adopters partially agreed upon the fact that finance for micro irrigation was available easily, while 37.50 percent agreed and strongly agreed with easily availability of subsidy for micro irrigation.

3.7.4 Aggregate supply

In the area under study, more than 60 percent adopters agreed and strongly agreed in expressing that supply of micro irrigation equipment is sufficient as there were large number of companies for the supply of micro irrigation equipment (68.75%) and the quality of these equipment was also good (60.42%).

3.7.5 Distribution

In the area under study the majority of adopters were found to agree and partially agree with the distribution of micro irrigation facilities as there are large number of dealers located nearby (59.37%), dealer provide good quality products (68.75%), charge reasonable price (56.25%), arrange subsidy/credit (84.37%) and provide after sale services (61.46%) for distribution of micro irrigation equipment.

3.8 Conclusions and policy implication

The following conclusions and policy implications could be drawn from the above findings:

1. Madhya Pradesh is one of the leading state which has successfully introduced micro irrigation facilities under PMKSY-PDMC in almost all the districts to ensure food security for the growing population in the face of climatic change, scare and limited water & land resources and to provide irrigation to every farm through improvement of water use efficiency. Government of Madhya Pradesh has put great efforts in creating MI facilities by providing subsidy, equipments, technical knowledge, etc. to beneficiaries under the programme. Efforts should be made to ensure that all the districts across the State will be benefitted by this programme of the Government of India.

2. After adoption on MI facilities in cultivation of crops, the expenditure on cost of irrigation (electricity) was found to have decreased by 37.56 percent. Although the expenditure of all the other items *viz.*, seed, fertilizer, manures, pesticides, labour, etc. were found to have increased, but the per rupee return on investment of Re. 1.00 increased by 17.77 percent from Rs. 2.40 to 2.82 after adoption of MI technology in the farms. It is also clear from the findings that introduction of MI facilities in adopters fields raised profitability and income of adopters.

3. MI facilities are easy to adopt as information on micro irrigation is easily available; it is easy to operate; proper financial facilities available and there is a reliable supply of

electricity and water. A large number of dealers are also located nearby and charge reasonable prices and also provide after sale services with quality MI equipment in the area under study.

4. MI facilities are advantageous as they result in higher yield; better quality of products; high output price; need less water, labour, fertilizer and there is easy marketing of output.

5. After adoption of micro irrigation, there was a change in cropping pattern of the area with adopters shifting from low value to high value crops. This calls for building a new market infrastructure including efficient supply and value chain management; farm get level processing and bringing institutional reform in place for establishing efficient economic environment in the area under study. This will not only ensure remunerative prices for farming communities but also provide non-farm employment avenues for youth in a big way.

Hence, overall impact of PMKSY-PDMC is found to be positive in case of water conservation and overall environment. Efforts should be made to promote MI in all the districts of the State with proper awareness programmes. Attempts should also be made to lower down the price of MI equipments in order to reduce the subsidy in a gradual manner for the horizontal expansion of the technology on large scale, provision/support for farm fencing should be provided, process of getting subsidy/Govt. assistance for latest and improved MI technology should be made easier, better training of farmers in MI is required for betterment of programme.

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