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Examining the spread of micro irrigation in Haryana: Adoption determinants and challenges for adopters and non-adopters

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Abstract
Micro irrigation system coverage has grown at a good pace in Haryana. However, the growth is focussed on western Haryana only. The gap between budgets allocated and utilised needs to be narrowed as only two-thirds of the allocated budget utilized during the study period. Positive and highly significant effects of Years of schooling of household head, the share of fruits and vegetables and significant effect of training suggest that household heads may be involved in agricultural training promoting micro irrigation and diversification to fruits and vegetables because decision-making regarding making changes lies in their hands. Reducing the weight of heavy initial investment by way of back-ended subsidy, increasing the number of slots available and provisions for demonstration of micro irrigation can help a long way. Also, ensuring uninterrupted electricity supply to the farms will help accelerate its adoption.

Keywords: Micro-irrigation, factors affecting, growth, constraints, adoption

Introduction
Water is fundamental for sustaining human life and its development. Of the total freshwater available (2.5% of the total), only 29.9% is present as groundwater, while the rest (0.3%) is available in lakes, rivers, and 0.9% in soil moisture, etc. (GoI, 2015) [7]. With the rising population, the per capita availability of water in India has dropped from 5178 m3/year in 1951 to 1441 m3/year in 2015. By the year 2050, it is projected to further decline to 1139 m3/year. Moreover, the gross water requirement for all users in India was 813 BCM in 2010 and is expected to grow up to 1447 BCM in 2050 (CWC, 2010) [3].

In India, the net irrigated area in the country increased from 20.85 million hectares (Mha) in 1950-51 to 68.38 Mha in 2014-15 (DES, 2019) [4]. Still, half of the total cropped area (51%) remains rainfed. Moreover, the share of groundwater in the net irrigated area increased from 38% to 62% during the same period. The over-dependence on groundwater sources has raised several sustainability issues in many pockets of the country (Kumar *et al*., 2013) [8]. At present, the WUE (Water Use Efficiency) in Indian agriculture is assessed between 35% to 60% for surface and groundwater irrigation. The main reasons attributed to this are the dominant use of conventional flood method of irrigation. (Chand *et al.*, 2020) [2].

Under the National Water Mission, the Government aims to achieve at least a 20% improvement in WUE from the existing level (Swaminathan, 2006) [14]. Micro irrigation technologies result in net water savings by reducing evaporation and conveyance loss, thereby improving WUE. Also, improvement in yield, reduction in labor requirement, improvement in output quality, etc., influence their adoption decisions (Molden *et al*., 2001; Narayanmoorthy *et al*., 1997) [10, 11]. Witnessing the rising demand and reduced availability, the promising nature of micro-irrigation technologies is adopted. The study tried to embark upon this problem by looking at three basic objectives: the current status of micro irrigation in the state, factors affecting the adoption, and constraints hindering the faster spread.

Methodology

Sampling procedure

The study was conducted in Haryana state. Both primary and secondary data were utilised for studying the objectives. For getting the primary data multi-stage purposive sampling was followed and to get a representative sample of the farmers. Bhiwani and Mahendragarh districts were selected based on the highest area under micro irrigation systems. Further two blocks and two villages from each block were selected for the selection of respondents (Figure 1).

Selection of respondents

A total of 120 farmers i.e. 60 adopters and 60 non-adopter farmers were surveyed using a pre-tested schedule for the collection of required data. Data related to socio-economic variables, financial variables, land, capital, cropping patterns, incentives etc. was collected. The secondary data regarding Number of beneficiaries' area coverage and financial assistance provided was secured from various Published and unpublished government sources.

Statistical Analysis

Compound annual growth rate was calculated for assessing physical and financial progress of micro irrigation in the state as well as for individual districts. Logistic regression method was used to identify the factors that affected the adoption of micro irrigation systems in Haryana. In this case, the micro irrigation adoption variable is a discrete dichotomous variable (a farmer is either a micro irrigation adopter or a non-adopter). Thus the definition includes partial adopters. The non-adopters, or non-micro irrigation farmers, are those who have not used micro irrigation during the year. In instances where the adoption variable is binary (0/1), logit and probit models are most commonly used to analyze technology adoption processes (Aldrich and Nelson 1984; Feder *et al.* 1985) [15, 16]. Here the logit model is used to explain the micro irrigation adoption process. The specification of the logit model is as follows:

$$P_i = probability\ (F_i = 1) = \frac{\exp(z)}{1 + \exp(z)}$$

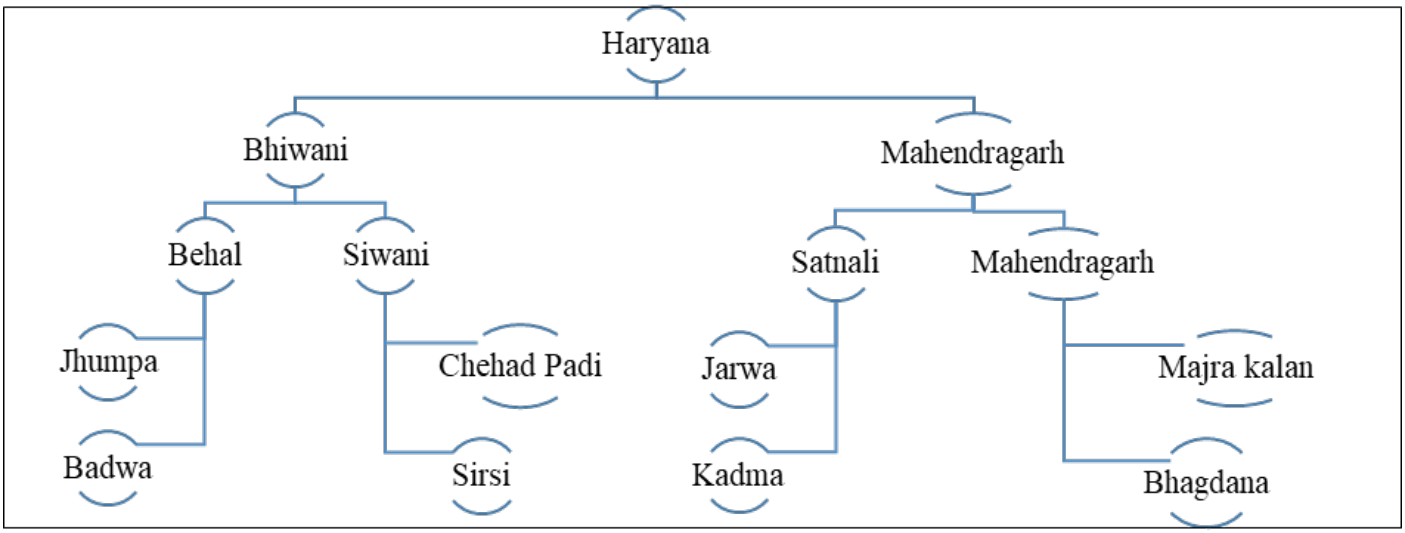
Where Pi denotes the probability that the ith farmer has adopted micro irrigation technology (Fi = 1) and

$$Z = \beta_0 + \sum_i^m \beta_i X_i$$

Where β0 is the intercept, βi is a slope parameter in the model, and Xi is an independent variable. In the logit model, like in any nonlinear regression model, the parameters are not necessarily the marginal effects (Greene 2000; Kennedy 2001) [17, 18]. They rather represent changes in the natural log of odds ratio for a unit change in the explanatory variables. The marginal effect (or the quantitative importance of the explanatory variables) for the logit model is expressed as follows:

$$\delta P_i / \delta X_j = \frac{\exp(z)}{1 + \exp(z)} \left(\frac{1}{1 + \exp(z)} \right) \hat{\beta}_j$$

Constraint analysis was done using Garrett Ranking Method. In this method the farmers were asked to rank the given constraint according to the severity of the problem.



Note: Siwani and Satnali were OE blocks whereas Behal and Mahendragarh were non-OE blocks; Adopter farmers were selected from OE blocks and non-adopters from non-OE blocks

Fig 1: Sampling design of the study

Results and Discussion

Status of micro irrigation in Haryana

The state-wise proportion of area under MI in India is given in Table 1. The states with the highest area under micro irrigation as a proportion of gross irrigated area are Andhra Pradesh, Maharashtra and Karnataka. Whereas, Haryana ranked 9th with 10.40 per cent of the gross irrigated area under micro-irrigation. However, Andhra Pradesh, Karnataka and Gujarat were the top three states when seen according to the share of micro irrigation in gross cultivated area and Haryana ranked fourth in this list.

Table 1: State-wise proportion of area under MI in India (2018-19

S. No.	States	Share in MI in GIA (%)	Share in MI in GCA (%)
1.	Andhra Pradesh	38.7	20.6
2.	Maharashtra	33.9	6.9
3.	Karnataka	31.3	10.5
4.	Gujrat	21.6	10
5.	Rajasthan	18.6	7.6
6.	Chhattisgarh	17.0	5.2
7.	Tamil Nadu	15.2	8.4
8.	Jharkhand	13.6	2.1
9.	Haryana	10.4	9.1
10.	Orissa	7.5	2.2
11.	Telangana	7.0	4.2
12.	Kerala	6.7	1.2
13.	Madhya Pradesh	5.3	2.2
14.	Himachal Pradesh	4.6	1.0
15.	Punjab	0.6	0.6
16.	Uttar Pradesh	0.5	0.4
17.	Others	5.6	2.8

The district-wise proportion of the area under micro-irrigation in Haryana up to 2019 is presented in Table 2. The districts with highest area under micro irrigation are Bhiwani (229397 Acres), Mahendragarh (193259 Acres) and Rewari (66495 Lakh Acres). The proportion of cultivated area under micro irrigation was highest in the case of Mahendragarh (51.77 %) followed by Rewari (23.37 %) and Bhiwani (21.16 %). In addition to these three districts, Gurugram, Jhajjar and Mewat had a significant area under micro irrigation. Rest of the districts of the state had less than 1.15% of their cultivated area under micro irrigation. In total, Haryana had 546455 acres of the area under micro-irrigation i.e. 6.1 per cent of cultivated area.

Table 2: District-wise proportion of area under MI in Haryana (2019-20) (in Acre)

District	Cultivated area	Area under MI	Percentage
Mahendragarh	373280	193259	51.77
Rewari	284580	66495	23.37
Bhiwani	1015954	229397	21.16
Gurugram	133750	8550	6.39
Jhajjar	290500	15991	5.5
Mewat	276638	15030	5.43
Yamuna nagar	299610	3416	1.14
Hisar	756303	6216	0.82
Rohtak	337022	1274	0.38
Karnal	522190	1224	0.23
Sirsa	1082702	2399	0.22
Panchkula	48062	99	0.21
Panipat	325662	619	0.19
Fatehabad	544305	929	0.17
Sonipat	441205	551	0.12
Faridabad	100000	93	0.09
Jind	606058	546	0.09
Ambala	294848	125	0.04
Palwal	265762	89	0.03
Kurukshetra	300972	74	0.02
Kaithal	656248	79	0.01
Total	89,55,651	5,46,455	6.1

The physical progress of micro-irrigation in Haryana in the period 2006-07 to 2018-19 is presented in Table 3. The area under drip irrigation during this period has grown by a cagr of 11.20 per cent whereas, the area under sprinkler irrigation has grown by a cagr of 15.5 per cent. The composite growth rate of micro-irrigation in the state stood at 14.40 per cent. As per the latest figures, the share of sprinkler irrigation in the state is 78.42 per cent whereas that of drip irrigation system is 21.58 per cent.

Table 3: Physical progress of MI in Haryana (2006-07 to 2018-19) (in ha)

Year	Drip	% of Total	Sprinkler	% of Total	Total
2006-07	812	30.34	1864	69.66	2676
2007-08	1041	13.39	6735	86.61	7776
2008-09	2139	9.59	20170	90.41	22309
2009-10	2468	75.75	790	24.25	3258
2010-11	3900	42.60	5254	57.40	9154
2011-12	2751	31.58	5961	68.42	8712
2012-13	2645	40.33	3914	59.67	6559
2013-14	2504	39.35	3860	60.65	6364
2014-15	1550	45.59	1850	54.41	3400
2015-16	1756	56.35	1360	43.65	3116
2016-17	1158	20.03	4624	79.97	5782
2017-18	2105	20.20	8315	79.80	10420
2018-19	2903	21.58	10549	78.42	13452
CAGR (%)	11.20		15.53		14.40
Total	27732	26.93	75246	73.07	102978

The financial progress of micro-irrigation in Haryana in terms of allocated budget, expenditure and utilization for the period 2006-07 to 2018-19 is presented in Table 4. During this period, the available budget and expenditure have grown by a cagr of 24.23 per cent and 27.28 per cent, respectively. Utilisation of the budget provided has fluctuated from as low as 25.34 per cent in 2016-19 to as high as 99.4 per cent in 2011-12. Cumulatively, out of the total budget of 540.63 crores 364.55 crores was spent that i.e. 67.43 per cent.

Table 4: Financial Progress of MI in Haryana (2006-07 to 2018-19) (Rs. in Cr)

Year	Available budget	Expenditure	Percent Utilization
2006-07	5.83	2.35	40.31
2007-08	11.24	6.45	57.38
2008-09	21.13	18.91	89.49
2009-10	9.42	8.51	90.34
2010-11	26.24	25.94	98.86
2011-12	40.65	40.34	99.24
2012-13	66.48	62.60	94.16
2013-14	67.84	61.89	91.23
2014-15	30.51	30.29	99.28
2015-16	44.16	20.00	45.29
2016-17	82.21	20.83	25.34
2017-18	56.08	23.87	42.56
2018-19	78.78	42.52	53.97
CAGR (%)	24.23	27.28	2.46
Total	540.63	364.55	67.43

The compound annual growth rate for the period 2012-19 for number of beneficiaries, area coverage and financial growth is presented in Table 5. The highest growth in terms of number of beneficiaries/area covered/ finances was seen in the districts of Rewari, Nuh, Sirsa Bhiwani and Mahendragarh. There were eight districts where the cagr of number of beneficiaries and area covered was found negative and 13 districts with negative cagr for the growth in finances. In total, the number of beneficiaries in Haryana state grew by 18.94 per cent, area covered has grown by 7.79 per cent and the finances have increased by a CAGR of 12.72 per cent.

Table 5: CAGR of MI spread in Haryana (2012-2019) (in per cent)

District	Beneficiaries	District	Area	District	Financial
Rewari	75.08	Rewari	85.72	Rewari	71.96
Nuh	44.11	Bhiwani	43.93	Bhiwani	40.61
Sirsa	38.71	Sirsa	37.08	Sirsa	31.83
Bhiwani	34.22	Nuh	35.65	Nuh	31.62
Mahendragarh	24.84	Mahendragarh	24.64	Mahendragarh	20.70
Yamunanagar	9.57	Yamunanagar	16.52	Yamunanagar	10.16
Hisar	9.00	Hisar	13.95	Hisar	7.70
Faridabad	8.32	Rohtak	7.89	Fatehabad	0.22
Panchkula	4.92	Kaithal	7.86	Jhajjar	-2.28
Palwal	4.20	Faridabad	7.40	Gurugram	-3.68
Ambala	3.66	Fatehabad	7.24	Jind	-10.70
Rohtak	3.24	Ambala	6.21	Rohtak	-10.75
Fatehabad	2.74	Jhajjar	1.96	Ambala	-12.71
Gurugram	-0.93	Palwal	-1.14	Kaithal	-14.81
Kaithal	-5.63	Gurugram	-1.24	Panchkula	-16.23
Jhajjar	-5.91	Panchkula	-3.21	Palwal	-16.30
Kurukshetra	-11.56	Jind	-3.27	Faridabad	-20.27
Jind	-15.91	Kurukshetra	-18.57	Kurukshetra	-24.16
Karnal	-18.56	Karnal	-20.81	Karnal	-27.49
Sonepat	-19.12	Sonepat	-25.18	Panipat	-34.21
Panipat	-23.46	Panipat	-28.80	Sonepat	-34.26
Total	18.94	Total	7.79	Total	12.72

Factors affecting adoption

The results of the logistic regression analysis of factors affecting adoption decision of farmers regarding micro irrigation technologies are presented in the Table 6. All of the variables had signs as hypothesized. The variables such as years of schooling of household head, family type and dependency ratio were found to be negatively related with the adoption decision of the farmer. However, all three of these variables were found to be insignificant. The variable of land holding was found to be positively related but was insignificant.

The effect of the variable, HP of pump was found positive and significant at 1% level. Moreover, Years of schooling household head, off farm income and Share of fruits and vegetables in the total cultivated were found to be related positively with the probability of adoption and were significant at 5% level. The variable showing the effect of any type of agriculture related "Training" availed by the farmer was also found to be positive and significant at 10 % level. Alcon *et al*, (2011) [1] in their research found age to negatively contribute towards adoption but education of household head, area of fruits and vegetables and training Showed positive effect on the adoption of such irrigation technologies. Senyolo, *et al*., (2018) [13] observed negative effect of age in adoption due to difficult to change attitude of older people. Singh, *et al*. (2015) [12] had similar observations about the education, age of HH, Dependency ratio =, HP of pump impacting adoption of micro irrigation to a great extent.

Table 6: Factors affecting adoption of micro-irrigation technologies in Haryana

	Variables	Description	Coefficient	Marginal effect
	Constant		-6.370*	–0.99841
1	Age of HH#	Years	-0.0027	–0.00001
2	Years of schooling of HH	Years	1.0447**	0.16373
3	Family type	(1: Nuclear, 0: Joint)	- 0.0006	0.00009
4	Dependency ratio$		- 0.0022	–0.00007
5	Off farm Income	Yes= 1, No = 0	0.5569**	0.08728
6	Landholding	Acres	3.1345	0.49126
7	HP of pump		0.5342***	0.08372
8	Training	Yes= 1, No = 0	0.0545*	–0.00855
9	Share of F&V##	Area under F&V/ Total	0.0032**	0.00050
	R^2		83.9	

Household head; * Total members in the family/Earning members; $ Total members below 14 and above 65/Total members; ##Area under F& V/Total cultivated area

Constraints faced by adopters and non-adopters

The results of the analysis of constraints faced by adopters are presented in Table 7. According to the ranks given based on the mean percentage score, the top five constraints faced by adopters were heavy initial investment (92.67), less number of subsidy slots available annually (88.33), unavailability of training/demonstration of MI technologies (83.67), high time taken from application to installation (80.00), lack of repair and maintenance services (74.00). Furthermore, erratic supply of electricity (71.00), unavailability of spare parts (69.33), unavailability of original spare parts (67.00), and the spare parts being expensive (65.00) were the next five pressing constraints. There were some less problematic but considerable constraints such as the requirement of several

documents at the time of application (37.00), problem of theft (28.33) and the inferior quality of some parts (20.67). Friedlander & Lazarovitch (2013) [5] witnessed problems related to inferior quality spare parts, damage caused by animals gendered adoption and training in Repair and maintenance could increase the likelihood of reduced dis-adoption. Long (2016) [9], Senyolo, *et al.*, (2018) [13] and Greenland (2019) [6] also identified heavy initial investments repair and maintenance services as primary inhibitors of micro irrigation adoption.

Table 7: Constraints faced by adopters of micro-irrigation technologies in Haryana

S. No.	Particulars	Mean score	Mean % score	Rank
1	Heavy initial investment	4.63	92.67	1
2	Less number of subsidy slots	4.42	88.33	2
3	Proper training/demonstration unavailable	4.18	83.67	3
4	Time from application to installation is high	4.00	80.00	4
5	Repair and maintenance services	3.70	74.00	5
6	Erratic electricity	3.55	71.00	6
8	Unavailability of spares	3.47	69.33	8
9	Original spares unavailable	3.35	67.00	9
10	Expensive spare parts	3.25	65.00	10
11	Documentation issues	1.85	37.00	11
12	Theft	1.42	28.33	12
13	Inferior quality parts	1.03	20.67	13

Constraints faced by non-adopters

Results of the constraints faced by farmers who did not adopt micro-irrigation are presented in Table 8. The top five constraints faced by these farmers were the requirement of a large amount of money to be invested initially (98.33), availability of less number of subsidy slots (97.33), unavailability of demonstration of micro irrigation technology (90.00), small land holding of farmers (77.33), most of the farmers being in either institutional or non-institutional debt (67.33). Moreover, some more constraints in descending order of importance were high cost of maintenance (66.33), spare part-related issues (62.33), the number of documents required (54.00) and irregular supply of electricity (53.33). Long (2016) and Greenland (2019) [6] identified heavy initial investments unavailability of demonstrations or training facilities and high maintain costs forced farmers away from Micro irrigation technologies.

Table 8: Constraints faced by non-adopter farmers in Haryana

S. No.	Particulars	Mean score	Mean % score	Rank
1	Heavy initial investment	295	98.33	1
2	Less number of subsidy slots	292	97.33	2
3	Demonstration unavailable	270	90.00	3
4	Small landholding	232	77.33	4
5	Already in debt	202	67.33	5
6	Maintenance cost is high	199	66.33	6
7	Spare part issues	187	62.33	7
8	Documents required are many	162	54.00	8
9	Irregular electricity supply	160	53.33	9

Conclusion

Micro-irrigation (MI) coverage in Haryana has shown significant progress, with the state ranking 9th in MI adoption, covering 10.4% of its gross irrigated area. Bhiwani, Mahendragarh, and Rewari emerged as the leading districts, demonstrating successful adoption, with Mahendragarh showing the highest proportion of cultivated area under MI at 51.77%. Factors affecting the adoption of micro-irrigation systems include pump horsepower, years of schooling of household heads, off-farm income, and the share of fruits and vegetables in total cultivation. The availability of agricultural training also positively influenced adoption decisions. Despite the progress, adopters faced challenges such as heavy initial investment, limited annual subsidy slots, and the lack of training and maintenance services. Non-adopters encountered financial constraints and institutional debt, hindering their adoption decisions. In conclusion, Haryana's progress in MI adoption shows promise for sustainable water management and agricultural practices. Addressing the identified factors and constraints can further enhance MI adoption, promoting efficient water usage and increased agricultural productivity in the state.

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