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Re-looking into micro-irrigation implementation to enhance adoption in India[1]

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Abstract

Introduction: Climate change is a global phenomenon affecting agriculture unevenly across the world. The warmer temperatures create longer growing seasons and faster growth rates for plants, increasing the metabolic rate. Plants will consume more water to sustain and meet the evapotranspiration losses and the turgidity. In such prevailing conditions for efficient use of water, micro-irrigation is one of the best available alternative technologies. In India, use of plastic in agriculture started in the year 1992 and till date Government of India launched several schemes for financial assistance to farmers for micro-irrigation (MI). Since 2015, Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) has been formulated by the government to promote MI throughout country. India has more than 42 million ha MI potential area of which 13 million ha is only covered to date due to implementation challenges in the States.

Materials and Methods: In this context, present study was undertaken to evaluate the implementation mechanism of different States, based on the adoption rate of MI. The objective of the study is to identify the factors contributing to the adoption of MI system and to develop alternative up-scaling approach based on the successful implementation

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models. Data was collected from five state viz., Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, and Telanagana States based on the MI adoption rate. Primary and secondary was collected through questionnaires from different stakeholders engaged in MI implementation in the selected five states. The binary logistic regression and Garrett ranking was used to analyse the data.

Results: The results indicate that the farmers are very well aware of the benefits of MI but they need more technical guidance and training on the water scheduling, fertigation and maintenance. It was also realised from the results that lowest financial assistance i.e., subsidy is provided by Madhya Pradesh and highest by Telangana State. Stakeholder perceptions on implementation of MI showed that the efforts are needed to increase the subsidy rate, improve access to loans with low/free interest rate for MI and integration of MI to lift irrigation schemes. All the state are following online application system through e-portal of respective state and among them Gujarat Green Revolution Company (GGRC) portal from Gujarat found farmer friendly. It is observed that the GGRC model is best fit due to the easy application process, no capping limit on area, bank loan availability and renewable subsidy after seven years. Based on the findings, an alternative implementation method is suggested with mandatory training program to the farmers on irrigation and fertigation scheduling and providing insurance to MI in all of the states. A third party verification and geo-tagging of the fields also helps to monitor the performance and adoption of MI in the states.

Conclusions: The present research was conducted to understand the challenges and alternative options preferred by the stakeholders for re-looking in to implementation of the MI scheme. Increment in the subsidy percentage, trainings on the MI (water scheduling and fertigation) and its maintenance and providing low/interest free loans seems to be viable options in the implementation. The study recommends for preliminary field survey for approval of farmer application, tri-party agreement and third-party verification for effective implementation of the program. A mandatory training program on MI to the beneficiary can also be included into the implementation framework. As MI adoption is less in canal commands, there is a scope for MI in command areas and lift irrigation schemes. The suggested model or approach can show promising response from the beneficiaries as well as the implementing agencies. The model can be a cross learning to other developing countries to improve their implementation models and enhance the area under MI. Improvement in the adoption of MI can enhance the crop production and water productivity by combating the adverse impacts of water scarcity.

Keywords: Agriculture, Micro-irrigation Models, Per Drop More Crop, Awareness, Iirigation, Water productivity.

1. Introduction

Water scarcity is affecting agriculture unevenly across the world. Rapid population growth, moderate economic growth and slow technology change leaves many parts of the world vulnerable with low adaptive capacity (FAO, 2016). The warmer temperatures create longer growing seasons and faster growth rates for plants, increasing the metabolic rate of insects (Hatfield & Prueger 2015; Deutsch *et al*., 2018). Plants will consume more water to sustain in the warmer climatic conditions to meet the evapotranspiration losses and sustain the turgidity. For efficient use of water in such prevailing conditions, micro-irrigation (MI) technologies could be very useful. The MI techniques which include drip, sprinkler, mini sprinkler, micro jets, rain gun etc., are found to be a feasible solution to increase the water productivity. In drip irrigation, water is delivered to roots of the plants, which saves 80 to 90 percent of water and increase crop production from 30 to 50 percent (Bahuguna, 1996). The technology also reduces effect of yield with water deficit irrigation at 70% and 50% of crop evapotranspiration (Mattar *et al*., 2019). The fertigation process through MI also helps in the minimal use of fertilizer which results in the increased profit and quality of the product (Nakayama & Bucks, 1991; Maheswari, 2018). Looking at the benefits, the area under MI in the World has risen by 6.4 folds for the last two decades (Postel, 2012). United States, China and India have occupied the first three places in the MI adoption (ICID, 2018). There are many other Asian, African and Middle East countries lying far behind in adoption of MI

India is making efforts in improving water use efficiency by encouraging the MI technologies through different subsidy programs since 1990s. The present program where MI implemented is Prime Ministers Agricultural Irrigation Scheme/Pradhan Manthri Krishi Sanchayee Yojana (PMKSY–Per drop more crop) was initiated from 2015-16. The program helps in proper utilization of available water resources by increasing the area under cultivation and improving economic status of the farmer.

The estimated potential of MI in India is about 42 million hectare (Raman, 2010). It is in the process of revision as per which the potential is estimated to be 47 million hectares (NCPAH, 2014). However, the coverage under MI varies considerably amongst States in the country signalling the constraints in expanding the potential area. The current area under MI in the country as on March 2021 is about 13 million hectare (30%) (MIDH, 2017; The Hindu, 2021).

Improving the governance in providing incentives in terms of adequate and timely disbursal of subsidy could encourage the farmers to invest in MI

and help to save water. Figure 1 represents the general process of the MI implementation in the country, which starts with application process, followed by administrative approval, micro-irrigation system (MIS) installation, physical verification and financial sanction. But, the subsidy rates and the implementation process followed in the States vary as the State Governments should share 40 percent of the subsidy rate. MI system cost and farmers share after subsidy also varies across States and farm size categories. The unit cost of the system per hectare to a farmer is comparatively lower in the larger sized farms compared to small and marginal farms due to economies of scale (Palanisami *et al*. 2012). Further, the quantum of actual subsidy realized by farmers is lesser as compared to the percentage of subsidy announced by the government due to differences in MI system cost estimation and 12 percent Goods and Service Tax (GST) paid by the farmer (Ministry of Agriculture & Farmers welfare, 2017).

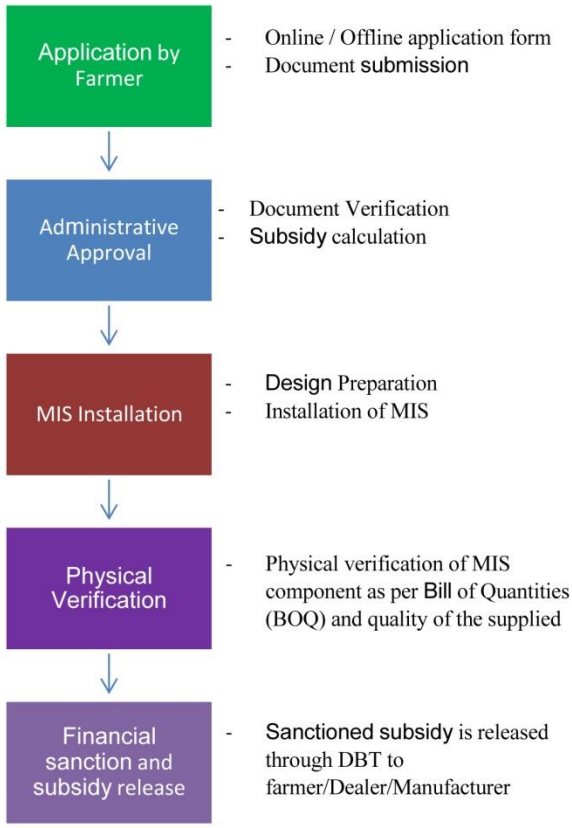

Fig.1. Micro irrigation implementation process

Therefore, the major constraints in expansion of MI is the capital cost of MIS, subsidy norms, credit supplies to the farming community and lack of proper awareness on the maintenance of the MIS (Verma & Sharma, 2017; Palanisami *et al*., 2012). Few states are also taking efforts to improve the adoption by increasing subsidy rates and strengthening the implementation of scheme. Therefore, the main objective of the present paper is to re-look in to the micro-irrigation implementation models by different States and suggest the appropriate options to escalate the adoption of MI. This can help in improving the adoption of micro-irrigation in India and can also help the other developing countries to review their implementation process.

2. Methodology

2-1. Study area

The MI area has increased steadily from 2015-16 with the initiation of PMSKY- Per drop more crop. The area has increased about 5.3 million ha during the past 6 years of which Karnataka (20%), Tamil Nadu (15%), Gujarat (14%), Andhra Pradesh (14%), Maharashtra (11%), Rajasthan (5.7%), Telangana (4.4%), Madhya Pradesh (4%), Uttar Pradesh (3.6%) and Chhattisgarh (1.7%) are top ten leading states (The Hindu, 2021). Nonetheless, the total area under MI in the country was only 18.3% (7.7 million ha) till 2015-16. The level of adoption in the states in comparison with the potential area is also low in Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab etc. Given the slow progress in the MI adoption levels on one side and the current integration of PMKSY (per drop more crop) on the other, it is important to see how best the MI area in the country can be further escalated. The MI adoption level can be increased substantially by either improving the performance of existing implementation mechanism based on success models and/or by introducing new approaches to up-lift the area.

In the present study, five states were selected to study the MI implementation models based on the area of adoption, success and failure of the MI scheme in the States. The states taken-up for the study are Gujarat, Rajasthan, Madhya Pradesh (MP), Uttar Pradesh (UP) and Telangana. Gujarat and Rajasthan states fall in the western part of India, Madhya Pradesh to the central, Uttar Pradesh to the northern and Telanagana to the southern part of the country.

2-2. Data collection

Data was collected by using pre-tested questionnaires from different stakeholders who were actively engaged in implementation of MI in the

States. It is important to understand the constraints in implementation at all levels (manufacturing to installation in field) from different stakeholders. Therefore, different questionnaires were prepared for different stakeholders' viz., MI State Nodal officer, Extension officers implementing the MI scheme in the districts, Researchers involved in the MI developmental activities from different State agricultural universities, dealers who are actively involved in selling, manufactures of MI equipment and farmers who are adopting to the MI systems (Figure 2). The farmers are divided into two categories such as adopted farmers, those are currently practicing the MI technology and potential farmers (non-adopters) who can use MI but still not using.

Two districts from each state were selected based on the rate of adoption. The highly adopted districts and moderately adopted districts were selected in concurrence with the state officials. Similarly, one Block (Mandal/Tehsil) was selected from each district with two villages from each. In total, data was collected from 340 people, which includes 5 State nodal officials, 12 Extension officers, 13 Dealers, 4 Manufactures, 6 Researchers and 300 Farmers (148 Adopted and 152 Potential).

2-3. Analytical tools

Garrett ranking was used to quantify the stakeholders' perceptions on alternative approaches that can enhance the adoption of MI. Stakeholders were asked to rank the opinions relevant to them according to the degree of importance. For example, direct benefit transfer to farmers, linking subsidy with production source i.e., subside at manufacturer level, removing subsidy limit to the area, low/interest free loans for MI from banks-open market, increase subsidy rate, community MI, extending MI under canal commands and awareness on MI are the factors presented to stakeholders. The respondents were requested to rank the opinions relevant to them. The stakeholders' rankings are first converted into score values with the following formula:

$$\text{Percent position} = [100(R_{ij}-0.5)]/N_i$$

Where,

R_{ij} = Rank given for i^{th} items by the j^{th} individual

N_j = Number of items ranked by j^{th} individual

The percent position of each rank was obtained by converting into scores by referring to the table given by Garrett &Wood Worth (1971). Then for each reason, the scores of individual respondents were added together and divided by the total number of respondents. These mean scores for all of the reasons

were arranged in the descending order and ranks were given. These ranks help to identify the predominant options

The study also used binary logistic regression model for assessing the factors of adoption and non-adoption of MI by potential farmers. The logistic function provides quantitative analysis of process of adoption and non-adoption of agricultural technologies. The model maintains the estimated probability between 0 and 1. In the model, the logit is assumed to be a linear function of the independent variables. Mathematically, this can be written as

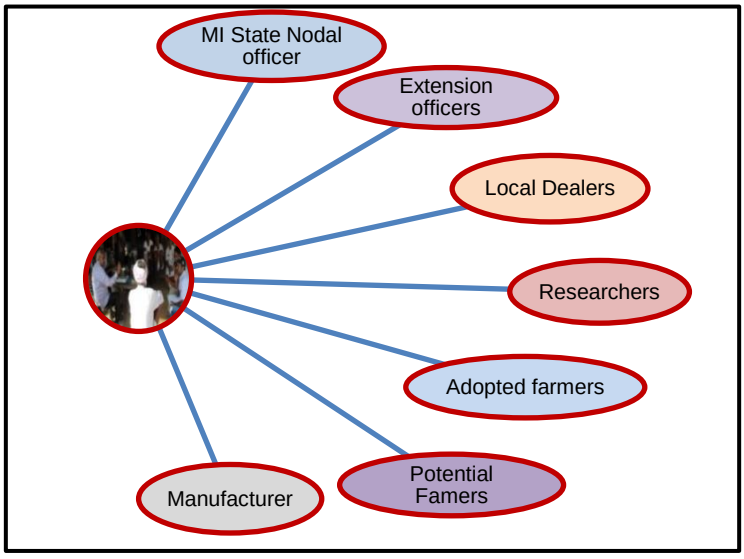

Fig.2. Stakeholders engaged in Micro Irrigation implementation

$$\ln Y = \ln\left(\frac{P}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \qquad (1)$$

Rearranging the equation it can be seen that

$$p = \Pr(Y = 1) = \frac{1}{1+e^{-z}} \qquad (2)$$

$$\text{Where } z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \qquad (3)$$

The equation can be expanded as:

Logit (Yi) = β_0 + $\beta_1$age + $\beta_2$edu + $\beta_3$family size+ $\beta_4$farmexp + $\beta_5$farmsize + $\beta_6$communitystatus + $\beta_7$dummy canal irrigation + $\beta_8$dummy awareness on MI+ $\beta_9$dummy awareness on fertigation + β_{10}dummy vegetable crops + β_{11}dummy flower crop + β_{12}dummy Rajasthan state + β_{13} dummy UP state + β_{14}dummy Telangana state + β_{15} dummy MP state +ε_i

Where, Y = dependent variable (where, 1= adopter of MI and 0 = potential farmer but not adopting MI), β_0 is constant, β_1, … $B_{15}$are coefficients of independent variables as specified in the equation. Categorisation of dummy was done for the crops cultivated (vegetables, fruits, flowers) and States (Telangana, UP, MP, Gujarat and Rajasthan).

The details of the selected independent variables and its descriptive statistics are provided in Table 1. The mean age of the household head from all the states is about 43 years. The farm size ranges from 0.2 to 28 ha with a mean of 3 ha. Similarly, family size ranges from 2 to 35 with a mean of 7 members. Farmers have 25 years of experience in agricultural production. Farmers' awareness on MI and maintenance is 0.96, fertigation0.27. In the community status, majority of the farmers belongs to other backward classes (OBC) category i.e., 54.3% followed by general category (33%). The subsidy rate varies with the Schedule cast (SC) &Schedule Tribes (ST) and general category (includes OBC as well).

Table 1. Descriptive statistics of variables used in analyzing MI adoption

Variable	Mean	Standard Deviation (SD)	Description
Household Age	43.47	12.71	Continuous in years
Household Education	7.28	5.46	Continuous in years
Farm Experience	25.08	12.97	Continuous in years
Farm size	3.08	4.00	Continuous in hectare
Family size	7.12	3.97	Continuous
Community status	0.12	-	Dummy Variable = 1 if scheduled caste and 0 otherwise
Access to canal irrigation	0.06	-	Dummy Variable = 1 if canal water and 0 otherwise
Awareness on MI and its maintenance	0.96	-	Dummy Variable = 1 if aware about MI and Maintenance and 0 otherwise
Awareness on Fertigation	0.27	-	Dummy Variable = 1 if aware about fertigation and 0 otherwise
Vegetables crops	0.70	-	Dummy Variable = 1 if cultivating vegetable crops and 0 otherwise
Flowers	0.03	-	Dummy Variable = 1 if cultivating Flowers and 0 otherwise
Rajasthan state	0.21	-	Dummy Variable = 1 if sample farmer is from Rajasthan and 0 otherwise
Uttar Pradesh state	0.20	-	Dummy Variable = 1 if sample farmer is from UP and 0 otherwise
Madhya Pradesh	0.20	-	Dummy Variable = 1 if sample farmer is from MP and 0 otherwise
Telangana State	0.18	-	Dummy Variable = 1 if sample farmer is from Telangana and 0 otherwise

3. Results and discussion

Stakeholder (State Nodal officer, Extension officer, Dealers, Manufacturers, Researchers and Farmers) perceptions on MI adoption from selected five states were taken and analysed (Table 3). Garrett ranking results suggests that the farmers and researchers propose to increase the subsidy percentage as the first option as the cost proposed under the PMKSY guideline does not match with the field conditions. Dealers and manufactures have proposed to provide low or free interest rate loans. The nodal and extension officers from the state and districts propose to create more awareness to the farmers on the MI benefits and management. The awareness of MI scheme among the potential farmers is also very low as most of the farmers have reported that they do not know about the application process and subsidy pattern. The sampled beneficiaries also revealed that no technical support/ guidance on agronomic practices is extended to the users as they were suggested to take the help of extension agencies.

The Direct Benefit Transfer (DBT) and subsidising at manufacturer level are less preferred options by the stakeholders. The farmers are not ready to give up subsidy at manufacture or production level, as they seem it will lead to more corruption and increased price of the MI system. DBT was also least preferred as farmers have to pay full amount in the beginning and later, he receives delayed subsidy amount into his bank accounts. But due to poor economic background they are unable to pay or choose the MI system. The community MI under bore / open well or canal commands / lift irrigation were less preferred by the respondents.

Table 2. Stakeholder perceptions on implementation of MIS

Parameters	Garrett Rankings				
	Nodal officers and Extension officer (n = 17)	Dealers (n = 13)	Manufacturers (n = 4)	Researchers (n = 6)	Farmers (n=300)
Direct Benefit Transfer (DBT)	7	8	8	5	7
Remove cap area for subsidy	8	4	5	7	6
Subsidy at manufacturing level	6	7	7	8	8
Increase subsidy %	4	3	2	1	1
Low/interest free loans for MI	2	1	1	4	3
Community micro-irrigation on bore or tube well	3	6	6	6	4
MI under canal commands/lift irrigation	5	5	4	3	5
Training on MI aspects	1	2	3	2	2

Note: Manufactures (Rivulis, Jain irrigation, Netafim, Meenesh irrigation), Researchers from respective state agricultural universities

Presently, subsidy is limited to maximum area of 5 hectare per beneficiary in all the state except Gujarat which is an impediment to the growth of area under MI in the other states. The farmer can avail subsidy once in a year without any area capping limit. So, farmers from Gujarat have increased adoption of MI from the study states. Therefore, increase in the limit of maximum area per beneficiary would not only lead to greater adoption of MI but also lead to combat water scarcity.

The binary logistic regression analysis also highlights that the awareness on the MI benefits and maintenance is an important factor for adoption (Table 3). The household education, farm size, awareness on MI and its maintenance and awareness on fertigation has positive impact on MI adoption. The community status and access to canal irrigation has a negative impact on MI adoption. The exponential coefficient of education indicates that with the increase in education level there is likely to increase in the adoption of MI by about 1.10 times. Similarly, farm size by 1.13 times, awareness on MI and its maintenance by 5.81 times, awareness on fertigation by 2.47 times. Inclusion of States in the variables of the model also indicate that, there is a likelihood to improve adoption in TS, MP and UP by more than 2 times at 5% level of significance. The binary logistic results also support the statement of stakeholders on the need of awareness on MI, fertigation and maintenance with proper water scheduling as a way forward (Likhi, 2019).

Table 3. Determinants of MI adoption

Variable	B	S.E	Sig.	Exp (B)
Household age	0.025	0.017	0.154	1.025
Household education	0.103	0.030	0.001	1.108
Farm experience	-0.011	0.017	0.529	0.989
Farm size	0.130	0.047	0.005	1.139
Family size	-0.042	0.035	0.235	0.959
Community status	-0.755	0.503	0.133	0.470
Access to canal irrigation	-2.969	0.849	0.000	0.051
Awareness on MI and its maintenance	1.760	0.833	0.035	5.814
Awareness on Fertigation	0.905	0.342	0.008	2.472
Vegetables crops	0.049	0.299	0.869	1.051
Flowers	0.718	0.831	0.388	2.049
Rajasthan state	0.260	0.443	0.557	1.297
Uttar Pradesh state	0.749	0.446	0.093	2.114
Madhya Pradesh	0.143	0.435	0.743	1.153
Telangana State	0.587	0.513	0.252	1.798
Constant	-3.735	1.124	0.001	0.024
Loglikelihood	349.78			
Nagelkerke R^2	0.259			

4. Proposed implementation model for enhancing mi adoption

The MI schemes have been implemented in India since 1992 through various programs. The programs are able to fund the MI and increase the area to a limited extent of the potential area. The funds are transferred to the States as per the budget approval and the States are leading the MI scheme implementation. The States are formulating the implementation framework and are varied in the implementation process. So, there is a need to revisit the implementation process in the states with the successful options and approaches. The present section has given focus on modification of the implementation process in the states as given in Figure 3.

The proposed MI model suggested for up-scaling is based on the observations and findings from the study. It includes the present implementation process with the changes in preliminary field survey, Tri-party agreement, third party verification, insurance coverage to the MI system, farmer's share payment and training programs on water scheduling, fertigation and maintenance. The training can improve the adoption of MI. The study from the other countries like Zimbabwe and Kenya also pointed that trainings and subsidy are important determinants to adopt to MI (Kulecho & Weatherhead, 2005; Musara *et al*., 2010). Yubing *et al.* (2018) point that decentralised participatory management is important to promote the MI adoption. But the participatory management is highly seen under canal commands in India. Integration of the canal commands and lift irrigation pumps with the MI system would promote the participatory management and MI adoption.

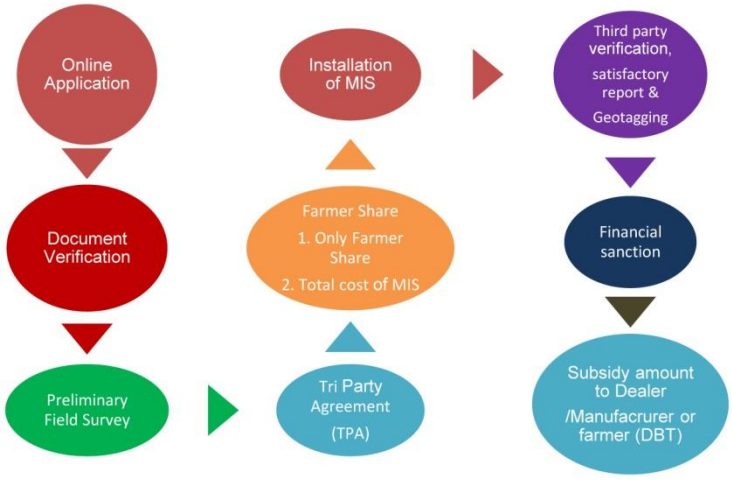

Fig.3. Proposed model for implementation of MI scheme in India.

In the proposed model/approach, farmers can apply through dedicated online portal of state agency by submitting the required documents (Land holding certificate, Aadhaar Card-Unique Identification number, live bank account proof, water source, etc.) for successful application. The documents must be verified and administrative approval can be released for preliminary inspection of land for the preparation of design and costing of MI system (Fig. 3). In many states preliminary inspection is not in practice (except in Telangana). After the preliminary inspection, farmer can be explained about the MI system design and costing, farmer share to be paid and number of days required to install the system. This can be done through a tri-party agreement (TPA) between farmer, government official and dealer. Farmer should have multiple options for the payment of farmer share i.e. demand draft, cheque, cash, national electronic fund transfer (NEFT). This can overcome the issues with Real Time Gross Settlement (RTGS) where signature of beneficiary is essential (as in case of MP). After the payment of farmer share, dealer or manufacturer can install the system and third party can verify it after successful trial run. After third party verification MI dealer or manufacturer can submit the farmer satisfactory report with geo-tagging. The payment can be released to the dealer or manufacturer or farmer (in case of DBT) based on the TPA. The entire process can be completed within 45-60 days from the date of application. Farmer can be made eligible to apply every year till the fulfilment of capping area limit. As implemented in GGRC, the MI system and farmers can be insured under TPA in case of any mishap.

5. Conclusions

In spite of the sustained efforts made by the governments, the adoption of MI in the countries is rather tardy. Over the last three decades only about 30% (13 million ha) of the potential area could be brought under the MI coverage in India. The main bottleneck is the initial cost of the MI system and the poor governance in implementing the subsidy disbursal mechanism by the States. The present study was conducted to understand the challenges and alternative options preferred by the stakeholders for re-looking in to implementation of the MI scheme. Increment in the subsidy percentage, trainings on the MI (water scheduling and fertigation) and its maintenance and providing low/interest free loans seems to be viable options in the implementation. The study recommends for preliminary field survey for approval of farmer application, tri-party agreement and third-party verification for effective implementation of the program. A mandatory training program on MI to the beneficiary can also be

included into the implementation framework. As MI adoption is less in canal commands, there is a scope for MI in command areas and lift irrigation schemes. The suggested model or approach can show promising response from the beneficiaries as well as implementing agencies. The model can be a cross learning to other developing countries to improve their implementation models and enhance the area under MI. Improvement in the adoption of MI can enhance the crop production and water productivity by combating the adverse impacts of water scarcity.

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