Gokhale Institute of Politics and Economics
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Pune – 411 004

AERC Report

Agro-Economic Research Centre (AERC)

Improving Water Use Efficiency in India's Agriculture: The Benefits, Impact and Challenges of Micro Irrigation under the Pradhan Mantri Krishi Sinchayee Yojana: Per Drop More Crop (PMKSY-PDMC) in Maharashtra

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Foreword

Irrigation is a crucial input for agriculture and the potential of other key inputs such as seed and fertilizer can only be realized with the combination of irrigation as a complementary input. However, water is a scarce resource, and its saving and efficient use assume great importance. This problem is further accentuated by declining water tables and poor recharge. Micro Irrigation technologies such as drip and sprinkler aim at addressing the issue of judicious use of water. Accordingly, the government both at the central and state level have implemented a number of schemes to promote the technology. In 2015, the *Pradhan Mantri Krishi Sinchayee Yojana* was launched, by amalgamating several on going schemes and *Per Drop More Crop* was an important component of the scheme.

In view of the above, a study was undertaken on "*Improving Water Use Efficiency in India's Agriculture: The Benefits, Impact and Challenges of Micro Irrigation under the Pradhan Mantri Krishi Sinchayee Yojana: Per Drop More Crop (PMKSY-PDMC) in Maharashtra".* The field survey was conducted in the districts of Pune and Jalgaon and the crops selected were sugarcane, banana and cotton. The study observed that in case of sugarcane, the yield increased by 35.5 percent when farmers switched to drip method of irrigation from flood method. In case of banana and cotton, the corresponding figures were 73.3 percent and 79.9 percent respectively. The increase in yield by drip method was possible because water is delivered to the root of the plant very slowly, and there is optimum use of water. There was considerable reduction in hours of pumping when drip method was adopted as compared to surface irrigation. Besides saving of water, there was also saving of other inputs, such as labour and electricity, and also improvement in the quality of produce. Although the cost of fertilizer and pesticides increased, the net returns to farmers were higher as they experienced higher yields.

The main problems faced by adopters of this technology was the maintenance of the device, as there is regular clogging of the laterals and emitters, which obstruct the smooth and regular flow of water. Another major issue was the destruction of the equipment by rodents and entry of wild animals due to lack of fencing in the fields. Erratic supply of electricity was yet another major constraint.

I am certain that the findings of the study will be very useful to policy makers, both at the central and state level and also useful for further research. I thank Prof Sangeeta Shroff and Dr. Varun Miglani for undertaking this study.

Professor (Officiating Director) Rajas Parchure
Gokhale Institute of Politics and Economics
(Deemed to be University Under Section 3 of the UGC Act,1956)
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Acknowledgement

The study *"Improving Water Use Efficiency in India's Agriculture: The Benefits, Impact and Challenges of Micro Irrigation under the Pradhan Mantri Krishi Sinchayee Yojana: Per Drop More Crop (PMKSY-PDMC) in Maharashtra"* was sponsored by the Ministry of Agriculture and Farmers' Welfare, Government of India, New Delhi. At the outset, we therefore thank Shri P.C. Bodh and the entire AER Division of Ministry for full support to conduct this study.

The study was coordinated by the CMA Unit of IIM (A) and our sincere thanks to Prof Vasant Gandhi under whose leadership this study was conducted. The team of Prof Gandhi, notably Nicky Johnson and Gurpreet, were very cooperative and helpful and made full efforts to ensure that the pilot survey was successful. A workshop was also conducted by the coordinating centre to design the methodology of the study, which brought about clarity in the collection of secondary and primary data.

Our sincere thanks to Prof Rajas Parchure, Officiating Director, Gokhale Institute of Politics and Economics, for overwhelming support while conducting this study.

The field survey was conducted in the districts of Pune and Jalgaon. and we thank the Sub Divisonal Officers, Taluka Agricultural Officers and Agricultural Assistants of both districts for extending wholehearted support for facilitating the field survey. The secondary data was obtained from Department of Horticulture, Commissionerate of Agriculture, Government of Maharashtra and we thank the authorities for providing us the relevant information.

I thank Prashant Warankar for doing the field survey and inputting the data. My thanks to Anil Memane for computer assistance and to Shri S.Dete for secondary data collection.

Finally I thank the administrative and library staff of the Institute for overall support and cooperation while conducting the study.

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Executive Summary

***Backdrop**:*

Irrigation serves as an engine to increase the productivity of crops as well as the cropping intensity, which in turns boosts the agricultural sector. Water is however a scarce resource and has several competing uses. In Maharashtra, agriculture is the largest user of water which consumes more than 80 percent of the state's exploitable water resources. The situation with respect to ground water, which is the major source of irrigation is precarious, and hence the need for judicious use of water is most important. It is largely in this context that Micro Irrigation (MI) technology is important and is being promoted since 1990s. Further, this technology also improves the yield of the crop and provides economic benefits to the farmer. This technology now forms a component of Pradhan Mantri Krishi Sinchayee Yojana.

In view of the above, this study on impact of Per Drop More Crop (PDMC) component of PMKSY has been undertaken. The government provides subsidy, payable to a beneficiary under PDMC which is 55 percent of the total cost of the MI equipment of small and marginal farmers and 45 percent for other farmers. The subsidy can be availed upto an area of 5 hectares.

***Objectives of the study**:*

The main objectives of the study were:

1. *To examine the savings in various inputs such as water, fertilizers, power, pesticides and labour for selected crops, viz sugarcane, banana and cotton;*
2. *To examine the enhancement of productivity, quality and other benefits for selected crops, and employment generation, if any;*
3. *To study the overall impact on farmers incomes and the net profits for the selected crops;*
4. *To observe the factors and determinants affecting Micro Irrigation and also the perceived advantages and disadvantages of Micro Irrigation;*
5. *To identify any issues/problems in the adoption of Micro Irrigation;*
6. *To suggest policy implications so that the adoption of Micro Irrigation technology can be strengthened.*

***Methodology and Analytical Framework**:*

The design adopted in the study is the comparison of the economics of Micro Irrigation before the selected sample farmers adopted the technology with the same after adoption. Therefore, data is collected for the same variables, such as production, costs, returns and yield, for the three selected crops, viz. sugarcane, banana and cotton, before the reference year and also for the Reference Year. The Reference Year is 2019-20. Further, the study also selected farmers who were Non adopters of this technology in order to study the reasons for their non adoption. The districts selected were Pune and Jalgaon.

The study was conducted with the help of Primary and Secondary data. The Primary data was collected from the field with the help of a well structured questionnaire that was addressed to adopters as well as Non adopters. While conducting field survey, it was observed that farmers were using mainly drip method, while Sprinkler system was not popular. Even from the secondary data, it was observed that in Pune district, out of total area under Micro Irrigation, 91.67 percent was under drip, while in Jalgaon 96.39 percent of area was under drip method. Thus, drip method covered almost the entire area under Micro Irrigation in the selected districts and hence the same was observed in our sample.

Sample Coverage

Sr. No.	***District surveyed***	***No. of Village***	***No. of Farmers surveyed***	***Drip Adopters***	***Sprinkler Adopters***	***Micro-Irrigation (Both)***	***Non-Adopters***
1	*Pune*	*7*	*64*	*51*	*0*	*1*	*12*
2	*Jalgaon*	*12*	*77*	*64*	*0*	*0*	*13*
	Total	*19*	*141*	*115*	*0*	*1*	*25*

The data after being inputted in Micro soft - excel format, was then converted into suitable tables which enabled the analysis to be conducted. The questionnaire also gauged the perceptions of farmers on advantages, disadvantages, constraints and problems in using Micro Irrigation by using 5 point-Likert scale: (i) strongly agree (score 5) (ii) agree (score 4), (iii) partially agree/disagree (score 3) (iv) disagree (score 2) (v) strongly disagree (score 1) which corresponding to each item/factor. A weighted mean was calculated based on the farmers who reported for each item.

The secondary data was obtained from the Office of the Commissionerate of Agriculture, Government of Maharashtra and portal of PMKSY.

With the help of the above methodology, the objectives outlined in the study were analysed.

Major Findings of the Study:

The major findings of the study are :

Changes in Area Under Micro Irrigation and Number of Beneficiaries:

1. *Maharashtra state is in the forefront in adopting MI technology which is practised since more than three decades. The progressive area under MI between the period 1986 to 2019-20 was 25.25 lakh hectares and 42.53 percent of gross irrigated area in Maharashtra was under drip irrigation.*
2. *During the period 2015-16 to 2019-20, when Per Drop More Crop (PDMC) component of PMKSY was launched, the cumulative area brought under MI in the state was 6.42 lakh hectares. This indicates that 25.43 percent of area under MI in Maharashtra was increased under PDMC scheme.*
3. *The number of beneficiaries who received subsidy under MI technology were 12.17 lakhs during the period 2014-15 to 2019-20. The highest number of beneficiaries was observed to be in 2017-18 when 2.64 lakh beneficiaries availed of the subsidy under the scheme. The number of beneficiaries in 2018-19 were 1.75 lakh while those in 2019-20 were 1.69 lakh which means that the number of farmers availing of subsidy has shown a decline over the years.*
4. *Out of 25.25 lakh hectares under MI, the maximum area was under cotton which was 6.07 lakh hectares or 24.04 percent of total area under MI. The share of sugarcane out of total MI area is 11.76 percent. Also MI technology is common for fruit crops such as banana, pomegranate, citrus fruits and grapes in Maharashtra.*

Profile of Sample Adopters and Non Adopters :

5. *In the sample of farmers adopting MI technology, it was observed that the average age of the adopters was 46 years and three fourths were in the age group of 30 to 60 years.*
6. *The level of literacy of the sample adopters, revealed that 21.55 percent had passed high school and 24.14 had completed intermediate level of schooling. Only 22.41 percent were graduates and 5.17 percent were post-graduates.*

7. *The average area operated by the sample adopters of MI was 3.04 hectares and 3.01 hectares was irrigated. Out of the total irrigated area, 87.4 percent was irrigated through MI, while 12.6 percent was irrigated through other sources.*
8. *Out of the area under MI among sample adopters, it was observed that 98.85 percent area was under drip irrigation and only 1.15 percent was under sprinkler irrigation. Hence drip irrigation seemed to be the main source of MI. All farmers in the sample had availed of subsidy given by government. For the state as a whole, it is observed from the data collected from the Department of Horticulture, Government of Maharashtra, that out of the total area under MI for the period 1986 till 2019-20 the share of area under drip is 71.2 percent and that of sprinkler is 28.8 which indicates that drip is the more popular form of MI. The two districts selected for our field survey are Pune and Jalgaon and it is reported that out of total area under MI in Jalgaon, the share of drip is 96.4 percent while the same for Pune is 91.16 percent. This indicates that in Maharashtra, drip method of MI is more popular as compared to Sprinkler.*
9. *The main source of irrigation was well and tubewell as 79 percent of respondents resorted to this source while 11.56 percent adopters had lift irrigation from river as the source. Three fourths of the respondents reported that they perceived that there was no scarcity of water. The soil of 94.83 percent of adopters was medium type, terrain was flat and on an average they had 4 years of experience in using drip technology.*
10. *Cotton emerged as the dominant kharif crop and cultivated in the selected district of Jalgaon. The average area of the farmers reporting cultivation of cotton was 2.59 hectares in the Kharif season. It can be observed that 91.1 percent of the area under cotton was under drip irrigation while 8.9 percent was irrigated by Non micro or conventional sources. The perennial crops cultivated were sugarcane and banana.*
11. *Sugarcane was the dominant crop in Pune district and our sample had 52 farmers who cultivated sugarcane with an average area of 1.76 hectares. The area under drip irrigation for sugarcane was 96.6 percent while 3.4 percent was under conventional sources.*
12. *Banana was also a perennial crop and sown either in June or November. Jalgaon district is a banana belt of the state of Maharashtra. In our sample, it was observed that farmers sow cotton in early kharif season – normally in the first week of June*

and harvest it by November. The harvest of cotton is followed by the sowing of banana. The average area under banana for the sample farmers was 3.23 hectares, with 93 percent of the area under drip and 7 percent being irrigated through conventional methods. Fertigation was also given to the crop.

Observation from Field Survey and Economics of Micro Irrigation:

13. *It was observed from the perception of farmers that, due to micro irrigation, the area under horticultural crops such as such as vegetables, chilli, onion and mosambi increased. Even wheat, a rabi crop, therefore requiring irrigation, seemed to have experienced an increase in area.*
14. *The farm economics with respect to **sugarcane** indicated that the average total variable costs for sugarcane cultivation under drip irrigation was Rs. 152,893 per hectare as compared to Rs. 168,890 per hectare without drip irrigation. Thus, it is observed that drip irrigation brought about reduction in costs. Labour mandays and labour costs in drip irrigation reduced by 37 percent and 40 percent respectively. The main reason for reduction in labour cost is that the farmer does not require labour for irrigating fields each time compared to flood irrigation. The farmer only requires two labour mandays in case of drip, once to put drip laterals at time of sowing and another removing the drip laterals after harvest from the field. Almost all farmers were using water soluble fertilisers through fertigation, which further reduced labour requirements and improved yields. The weed growth was negligible due to usage of drip, because water with fertigation goes straight to the root of the plant and the surrounding area is dry and there is thus limited scope for weeds to grow. This reduced the labor cost for weeding, intercultural operations and weedicides.*
15. *As water soluble fertilizers are more expensive, the cost of fertilizers for sugarcane were observed to be 7.7 percent higher in drip as compared to surface method. The same was observed with respect to plant protection costs and seed costs which were 12.7 percent and 11 percent higher in case of drip.*
16. *The use of drip for sugarcane resulted in huge reduction in water charge as the water charges paid reduced by 72 percent mainly because less water is consumed with drip in the cultivation of sugarcane. Further, less use of water also resulted in reduction in electricity cost which reduced by 20 percent. The total hours of pumping reduced by 57 percent in drip irrigation cultivation which brought about*

the reduction in electricity cost. Sample farmers reported that on an average they used to irrigate their sugarcane fields 57 times with flood method as compared to 52 times without drip. However, hours of pumping in per irrigation per hectare is 2.6 hours using drip method compared to 6.1 hours without drip. This leads to total hours of pumping of 145 hours in drip method compared to 332 hours without drip. Under drip method, more land is covered under irrigation in short time span and farmers are able to better manage their irrigation schedule compared to flood irrigation method.

17. *Under drip method, per hectare yield of sugarcane was 1446 quintals compared to 1067 quintals without drip which means that yield increased by 35.5 percent. The price received by farmers using drip was also higher. Hence reduced costs, higher yields and higher prices resulted in sugarcane farmers receiving net profit of Rs. 245,542 per hectare with drip compared to Rs. 81,247 per hectare without drip, ie. an increase of 202.2 percent.*

18. *In case of **banana** cultivation under drip irrigation, the total variable cost was Rs. 250,882 per hectare as compared to Rs. 213,909 per hectare without drip irrigation. This indicated that the total variable costs increased by 17 percent. Planting material, fertilizer, plant protection and marketing costs were higher in drip method of banana cultivation. It was reported that in the reference period 2019-20, farmer used tissue culture banana sapling (planting material) which costs Rs. 12 per sapling compared to normal banana sapling which costs Rs. 5 per sapling. Total planting material cost per hectare of land was Rs. 47,112 in drip method compared to Rs. 22,327 without drip. Similarly, fertiliser costs were 25 per cent higher in drip method compared to without drip. The reason being farmers using drip irrigation also used water soluble fertilisers, which enhanced the costs. However, this also brought about increase in yield.*

19. *Tissue culture plant for banana cultivation has a duration of 10-11 months, while traditional plant time duration is 12 months. Tissue culture plants also get 10-12 hands (bunch) compared to traditional banana plants which get 7-9 hands (bunch) per tree. Farmers also reported that average bunch weight per tree is around 23-25 kg incase of tissue culture plant compared 18-20 kg in traditional banana tree.*

20. *The labour mandays and labour costs in drip irrigation for banana cultivation reduced by 20.30 percent and 13.4 percent respectively. With drip 164 man days and without drip 206 mandays of labour use was reported. The number of irrigations with drip was 107 while without drip it was 76. Water charges and electricity charges, each reduced by 49 percent. There was reduction in electricity charges because total hours of pumping reduced by 60 percent in drip irrigation cultivation. Hours of pumping in per irrigation per hectare is 1.5 hours using drip method compared to 8.1 hours without drip. This leads to total hours of pumping 208 hours in drip method compared to 524 hours without drip.*

21. *Under drip method, per hectare yield of banana was 604 quintals compared to 348 quintals without drip which means that yield increased by as much as 73.3 percent. Besides yield increase, the farmer also higher price due to better quality of output. On an average, the price realization was Rs. 875 per quintal under drip method, compared to Rs. 640 per quintal without drip. Besides higher price realization due to considerable improvement in quality of the produce, the farmers adopting drip may have realized higher prices due to rise in price over time. The higher yields and higher prices resulted in banana farmers receiving net profit of Rs. 316,785 per hectare with drip compared to Rs. 6,048 per hectare without drip. This indicates that the profit from banana cultivation using drip method of irrigation was phenomenal as compared to cultivating the crop using surface method. However, it must be noted that farmers using drip also had the benefit of tissue culture technology which provides disease free seedlings, early maturity of the crop and uniform growth of the crop with increase in yield. The plants are also more densely planted which increases the yield. Since the density of the plantation is more, a suitable temperature is created for the plants which facilitates the growth and improves the quality and quantity of the yield.*

22. *It was observed that the marketing costs for the farmers cultivating banana increased after adoption of drip irrigation. This is expected because there was a huge increase in yield after adoption of drip method of banana cultivation. Since the farmers had more produce to sell, the cost of transport and other associated costs is likely to increase. Banana is a highly perishable crop and requires careful handling, failing which, the quality of the produce is likely to deteriorate. Hence,*

post harvest handling plays a very important role in the cultivation of banana and farmers have to therefore incur higher marketing costs.

23. ***Cotton*** *farmers were also included in the sample and it was observed that the total variable costs for cotton cultivation under drip irrigation was Rs. 91,262 per hectare, as compared to Rs. 76,562 without drip irrigation, i.e drip adoption had a higher variable cost as compared to use of surface irrigation by 19.2 percent. It was observed that fertilizer, pesticide cost and farm yard manure costs were higher by 71.4 percent, 67.5 percent and 59.1 percent respectively in drip method of cotton cultivation. Cotton crop has the tendency to get infested by pests and hence farmers began adopting Bt seeds to overcome the problem of American bollworm which used to always destroy the cotton crop. However, these seeds are highly priced, but farmers use them in the hope of higher returns. Once the farmer has invested in costly seeds, he ensures that the plant gets suitable fertigation and as soluble fertilizers are more costly, the fertilizer costs increased considerably. Further, while Bt seeds may not be susceptible to American bollworm, the cotton fields have begun to experience secondary pests such as aphids, whitefly, etc. Hence farmers continue to spray pesticides to save the crop from other pests. Overall, with drip, there is a higher usage of yield enhancing inputs viz. fertilisers, pesticides and farm yard manure because farmers have already invested in costly seeds and water and hence want to reap the benefits by suitable application of complementary inputs.*

24. *Labour mandays in drip irrigation for cotton reduced by 32 percent, while labour charges were similar to that without drip. With drip irrigation, 81 man days and without drip 120 mandays of labour use were reported. While drip farmers gave 30 irrigations, without drip the irrigations were 12 in number. Electricity charges reduced by 12 percent because total hours of pumping reduced by 46 percent in drip irrigation cultivation. Hours of pumping in per irrigation per hectare was 1.3 hours using drip method compared to 5.6 hours without drip. This led to total hours of pumping of 49.4 hours in drip method compared to 92 hours without drip. However, water charges increased by 55 percent from Rs. 633 to Rs. 984 among sample growers.*

25. *Under drip method, per hectare yield of raw cotton was 27 quintals compared to 15 quintals without drip, i,e increase by 79.9 percent. A farmer realised on an*

average Rs. 4929 per quintal under drip method compared to Rs. 3921 per quintal without drip. One reason for farmer realising higher prices is better quality of output and another is due to prices showing a rise during the period when drip was used as compared to the earlier period when the farmer used surface irrigation. With higher yields and higher prices, the cotton farmers received net profit of Rs. 43,198 per hectare with drip compared to losses of Rs. 22,057 per hectare in surface method. Thus the farmers adopting drip made 295.9 percent higher profits as compared to those who used surface irrigation. This huge difference in profits was largely due to yield increase which was higher by 79.9 percent for drip adopters as compared to use of surface irrigation. The drip method provides exact water requirement to the plant which facilitates it growth. Further, since the area surrounding the crop has less weed growth, less pests are likely to infest the plant. The farmers also spray pesticides as a precautionary method to prevent any pest attack on the crop and also use suitable fertigation. Hence despite higher total variable costs for drip farmers by 19.2 percent as compared to irrigation through surface method, the farmers reaped better harvest.

26. *Across all three crops, i.e sugarcane, banana and cotton, it was observed that overall net profit for farmers using drip method was 663.37 percent higher as compared to those using surface method while costs were only 15.67 percent higher. This indicates that though farmers had to spend more on certain inputs such as seed, fertilizer and pesticide, the economic benefits were far higher.*
27. *Out of the total cost borne by adopters of drip irrigation, the subsidy provided to the farmers was 53.73 percent. Besides drip equipment, the farmers had to also incur expenditure on filters, pumps, pipes, etc. which amounted to about 37 percent of their expenditure on drip installation. The farmers reported that on one acre of area cultivated, they required 3300 metres of pipe and the cost of the pipe was Rs 12.50 per metre. They also reported that the annual maintenance cost for MI equipment was Rs 5158 per annum.*

Agronomic Potential of Micro Irrigation :

28. *The **Agronomic Potential** of drip irrigation was captured as all respondents either strongly agreed or agreed that MI increases yield. There was not even a single farmer who even partially disagreed that MI does not increase yield/output. A more or less similar response was arrived at with respect to MI reducing water use and*

therefore saving water. As compared to conventional irrigation, in case of drip, the water is applied exactly near the root zone of the plants and hence there is no wastage due to deep percolation, seepage, conveyance losses and evaporation. Only one respondent was not confident about MI reducing water use.

29. *With respect to use of fertilizer and pest problems the opinion was divided although 35.34 percent farmers agreed that MI reduces fertilizer use. This happens because fertilizer losses such as leaching and denitrification are avoided and this leads to fertilizer use efficiency. Also since MI allows for precision use of water, the soil does not have excess water which normally causes diseases and pests. However, hardly one-fifth of the adopters felt that pests had been reduced due to MI.*
30. *Almost two-third of the farmers reported that MI reduces weed problem and labour use. Since water is applied to the root zone of the plant in controlled quantities, as per the requirement of the plant, there is limited scope for weeds to grow and also the space between two laterals is kept dry which controls the growth of weeds. Less labour is normally required as land preparation in the form of furrows and ridges is not normally required. The MI system is such that less labour is used to water the plants and also there is less growth of weeds and hence no labour may be required for cleaning the surrounding area. About 62.93 percent of adopters felt that MI reduces the use of labour.*

Potential Demand for Micro Irrigation :

31. *The **Agro-Economic Potential** revealed that only 27 percent of adopters agreed that the capital cost of MI is not high. It is clear that MI has a high fixed cost and considering that 61 percent farmers in the sample are marginal or small, it is expected that investment in MI is costly for them. About 62.07 percent of adopters strongly felt that subsidy on MI is important.*
32. *The response with respect to MI raising output quality/profit was encouraging as 76.72 percent of farmers agreed to this aspect.*
33. *About 59.8 percent of adopters reported that MI reduces input use/costs but 12.07 percent disagreed on this aspect. Almost all respondents strongly agreed or agreed that MI increases profitability.*
34. *Maharashtra is a leading state in the use of MI technology which is used largely for sugarcane and horticultural crops and hence about 95.69 percent of farmers in the sample either strongly agreed or agreed that information on MI is easily*

available and 98.82 percent strongly agreed or agreed that the technology is easy to understand. This response captures the effective demand for Micro Irrigation. However, the adopters did not seem to be fully satisfied with the availability of subsidy as 29.57 percent disagreed that subsidy was easy to get and 3.48 strongly disagreed that subsidy was easily obtained. About half the respondents felt that finance for MI is easy to get, but 28.45 percent partially agreed/disagreed and 12.93 partially disagreed.

35. *An important complementary input for MI is the availability of electricity. However, 48.28 percent of adopters strongly disagreed that electricity for MI is easily available/reliable. This appears to be a serious issue and needs to be addressed. A more or less similar problem arose with respect to sufficiency of water for MI as only 45 percent of adopters felt that the water for MI was sufficient. Hence more than half the farmers in the sample were by and large dissatisfied with the supply of water for MI.*

Potential Supply of Micro Irrigation :

36. *The **Aggregate Supply** of MI is equally important for the spread of this technology. Almost all adopters (99.13 percent), agreed that there are a large number of companies supplying micro irrigation equipment. This positive response is expected because Maharashtra is a leading state in adopting MI which was promoted by private sector. Jain Irrigation in Maharashtra provided full technical support to the farmers by adopting an integrated approach. The assessment of the feasibility of adopting MI, supply of equipment, installation of the system, capacity building, operation and maintenance were all provided by the company. NETAFIM is another major company in MI system and provides a wide range of solutions to provide cost effective irrigation. The company has also undertaken initiatives in Maharashtra to promote the use of MI through backward and forward linkage. With the support of global leaders in MI system, 92.24 percent of adopters felt that the quality of MI equipment was good. Hence, in Maharashtra, the aggregate supply of MI systems seemed to be pose absolutely no problem.*
37. *With respect to **distribution,** 97.42 percent of respondents strongly agreed or agreed that there are a number of MI dealers located in the vicinity. About 86.21 percent strongly agreed or agreed that the quality of product provided by the dealers was good and could be trusted. However, 40.52 percent partially*

agreed/disagreed that dealers charged a reasonable price. The important point was that 90.51 percent of adopters strongly agreed or agreed that dealers arrange for subsidy /credit. About 71.55 percent of adopters strongly agreed or agreed that the dealers provide after sales service. Hence as far as distribution is concerned the picture seems fairly good in Maharashtra as dealers help farmers by providing quality products and after sales service.

Perceived Advantages and Disadvantages of Micro Irrigation :

38. *The perceived advantages and disadvantages of MI revealed that almost all adopters found advantage that the use of MI results in increase in yields, better quality of produce, high output price and less water requirement While almost three-fourths of the adopters perceived that there was advantage in reduction of input costs due to MI, about 25 percent felt that it made no difference. With respect to labour use, about 31.03 percent of adopters felt that it did not make any difference, but the remaining felt that less labour was required. With respect to weed problem, 78.45 percent of adopters felt that it had reduced which is expected as the area surrounding the plant does not get water which only goes to the root of the plant.*
39. *However, the respondents felt that by and large there was no difference with respect to pest problem as 70.69 adopters stated that MI use did not reduce the pest attacks. The response was similar with respect to fertilizer use as 56.90 percent of adopters did not perceive that less fertilizers were required with the use of MI. However, the response was encouraging with respect to advantage due to easy marketing of output, higher profit and less risk/uncertainty. The quality of produce was better with use of MI due to appropriate input use in the form of water and irrigation. The advantage of risk reduction was also observed by 79.31 percent of adopters. Often during summer months the farmers suffer from severe water shortage which is required for perennial crops such as sugarcane. Since water in the well is saved due to drip irrigation, it is utilized in the summer months when the climate is hot and crops require water. In the absence of water, the adopters of MI stated that there was every possibility that the crop may dry and they may lose their harvest. Hence use of drip enabled them to save their crop which means that the use of MI reduces risk and enables them to reap good harvest. Also, the saved water due to drip can be used if monsoons are delayed or fail.*

40. *An important impact of promoting MI technology, was that it could create employment opportunities, both in the form of skilled as well as unskilled labour. In the field if output increases, then employment may be generated for post harvest handling. However only 39.66 percent felt that the use of MI had the advantage of creating employment for youth while 46.55 percent felt that it made no difference.*
41. *With respect to larger impacts of MI, almost all adopters felt that the environment in the village had become positive and water had also been conserved. However, only 43.10 percent of the adopters reported that there was a positive impact on women, and 48.70 percent it had impact on upper caste. The encouraging feature was that 65.5 percent felt that there was a positive impact on the lower caste and 67.24 percent felt that the impact of MI use was positive for the Labour/Poor section of the village.*
42. *Adopters of MI also faced problems and atleast 49.14 percent of adopters disagreed that the quality of MI equipment is poor and only 12.93 percent agreed that the quality is poor. The view on high cost of maintenance was divided although by and large it was felt that MI involved considerable maintenance. Water was also considered to be a problem by majority of adopters and only 31.89 percent disagreed that water was inadequate. The quality of water was however quite acceptable by the adopters.*
43. *While 45.69 percent of adopters agreed that there was difficulty in obtaining government subsidy, 31.90 percent partially agreed/disagreed. About 64.66 percent strongly agreed that that the supply of electricity was unreliable.*
44. *A major problem was that there was exploitation of ground water and the water table was going down very fast. About 77.59 percent of adopters faced this problem because there was huge mining of underground water which was not getting recharged.*
45. *The adopters were satisfied with the number of MI dealers in the village and their after sales service. There were a number of shops providing spare parts of reliable brands and they helped farmers to overcome any difficulty faced by them in the use of drip irrigation.*
46. *Half the adopters disagreed about land fragmentation being a problem in adopting micro-irrigation, while 28.44 percent felt that land fragmentation is a constraint in adoption.*

47. *A major problem facing users of MI was destruction of the system by animals. About 63.79 strongly agreed or agreed that their equipment and crop was destroyed by animals. The problem of animal infestation into the fields was also due to lack of fencing and 56.03 percent of farmers strongly agreed/disagreed to this problem.*
48. *Most adopters also felt that the process of getting the subsidy should be made simple as they are not comfortable with online registration and submission of application. Also, while subsidy was available to the tune of 55 percent of the cost, the farmers required loan for the balance amount. Majority of farmers utilized their own funds for the balance amount required after the subsidy was availed.*
49. *The sample farmers who were Non adopters reported that the main reason for not adopting drip irrigation was that there was not enough information on MI which was available to them while About 72 percent reported that MI was not suitable for their land.*

Policy Suggestions:

The following policy measures emerge from the study:

1. *Maharashtra is a water stressed state but also a major producer of sugarcane which is a water guzzling crop. While area under sugarcane was 11.54 lakh hectares (2018-19) in the state, only 2.97 lakh hectares or 25.73 percent of the area is irrigated by drip method. This indicates the huge untapped potential to adopt drip method and therefore save water. Extension services are therefore required and target beneficiaries should be educated on the technical and economic benefits of drip.*
2. *Drip technology must also be accessible to the farmers as the technology entails a huge fixed cost. Famers who were Non adopters often stated that they could not afford the fixed cost despite subsidy being provided by the government. Further, the installation of the device normally requires a filtration unit due to impurities in the water and subsidy is not provided for this component. The suggestion by farmers was that the subsidy for the drip equipment must be enhanced and subsidy should also be provided for filter unit.*
3. *The farmers also revealed that often the time taken for receiving the subsidy was long, often more than a year and the application should be processed faster with speedy release of subsidy.*

4. *Another issue with the use of drip irrigation was the regular maintenance that the devise required. There is regular clogging of the laterals and emitters which hinders the smooth and regular flow of water. As the equipment, mainly of plastic, is exposed to weather, there is need to replace parts, etc. This has served as a disincentive for Non adopters who remain reluctant to adopt MI technology.*
5. *Several farmers in the sample who were not adopting MI, were gradually getting encouraged about the benefits, but since they had easy access to water, they were reluctant to switch to MI and continued with the conventional method. Hence, more aggressive measures are required to encourage farmers to adopt drip method.*
6. *In Maharashtra, a major constraint faced by drip users was the shortage of electricity and its interrupted supply. Several farmers also had fear of short circuit which could cause fire. An important policy issue that emerged from the study was that the supply of electricity must not be erratic and the availability must be increased. Often farmers received power supply only at night when they are not present in the field to monitor the flow of water.*
7. *In view of erratic electric supply and fear of short circuit, many farmers preferred to use solar pumps. Their expectation therefore was that the subsidy on solar pumps must be further increased.*
8. *In view of the fear of short circuit, several farmers revealed that fire insurance should also be included in the subsidy that was given by the government.*
9. *Another major issue with respect to drip, was the damage caused to the lateral distribution line by rodents which led to uneven distribution of water. While the life of a drip device is considered to be 7 years, the destruction of the system by rats reduces the life and hence after incurring fixed costs which are considerable, the farmer cannot get optimum benefit of the system. The farms also did not have fencing and the fields were destroyed by stray animals. Hence, these issues have to be addressed to ensure that the device is not destroyed by animals.*
10. *Maharashtra ranks first in the country with respect to area under cotton which is about 42.1 lakh hectares. Despite cotton being a major crop, the state suffers from low yield which is much below most states and also below national average. The main reason for low yield is that the crop is mainly rainfed and failure of monsoons leads to crop failure. Further, in case of irrigated cotton, irrigation by drip gives much higher yield as compared to conventional irrigation. There is therefore huge potential to increase the yield of cotton by adopting drip method of irrigation. Our*

sample indicated that adoption of drip system, increased the yield by almost 80 percent as compared to surface irrigation. Drip method of irrigation will go a long way in increasing the production and productivity of cotton which will help to boost the agricultural economy of Maharashtra.

11. *The registration for subsidy is through the E Thibak portal. While this system ensures complete transparency and updates to the farmer on the status of his proposal, there was a complaint by the farmers on several challenges faced by them in using this portal. Often, the land was in the name of a minor child, or the Aadhar card was not linked to the mobile number and overall the online system was cumbersome. The dealers however helped the farmers to overcome their difficulties. However, it is important that farmers must complete all formalities and also become computer literate. Hence while providing extension services to farmers, computer literacy must be included.*

Overall, the study has clearly indicated the benefits of Micro Irrigation, notably drip irrigation which is much more popular in Maharashtra. Irrigation is a crying need for the state and use of Micro Irrigation technology will help to conserve the scarce water resources, especially in case of crops such as sugarcane. The state is also well known as a horticultural state which is high value agriculture and as Micro Irrigation further spreads, the productivity of crops will increase and farmers will reap higher returns with suitable marketing practises. This will not only strengthen the agricultural sector but also serve as a catalyst of growth for the manufacturing and service sector as easy supply of raw materials will be available for agro processing which in turn will stimulate the service sector. Micro Irrigation can therefore help to change the face of the economy of the state.

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Abbreviations

AIBP	Accelerated Irrigation Benefit Programme
ICT	Information Communication and Technology
MI	Micro Irrigation
NMMI	National Mission on Micro Irrigation
NeGP-A	National e-Governance Plan for Agriculture
ONFM	On Farm Water Management
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PDMC	Per Drop More Crop

Chapter 1

Introduction

1.1 Backdrop :

Irrigation is a crucial input for agriculture and has a major role to play in the production process. The potential of other key inputs such as seed and fertilizer can only be realized with the combination of irrigation as a complementary input. Further, there is very limited scope to increase the Net Sown Area, as land is a limited resource and hence production as well as diversification of agriculture is possible only by increasing gross cropped area. However, the cropping intensity can only be increased if protective irrigation is available.

Till date, agriculture is a major source of employment, but its contribution to Gross Value Added is declining very rapidly and is only 14.65 percent in 2019-20 (statisticstimes.com). Further, the growth rate in the agricultural sector has always been lagging behind that of other sectors and thus pulling down the overall growth of the economy. During the Tenth Five Year Plan (2002-03 to 2006-07) while the industry and service sector grew at a little more than 9 per cent per annum, that of the agricultural sector was a miniscule 2.3 per cent per annum. The Eleventh Plan (2007-08 to 2011-12) was equally discouraging as agriculture could not achieve its target growth rate of 4 per cent per annum. Finally, the recent Twelfth Plan ended in 2016-17 with a growth rate for agriculture of 3.2 per cent against an overall growth rate for the economy at 7 per cent per annum. The sector wise growth rates can be observed in Table 1.

Table 1.1: Sector –Wise Growth rates (Percent Per Annum, Constant Prices 2011-12) During 2014-15 to 2018-19

Sector	**Growth rate during 2014-15 to 2018-19**
Agriculture, Forestry and Fishing	2.94
Industry	6.42
Construction	4.76
Services	6.38
Gross Value Added	5.85

Note : The growth rates were calculated from data obtained on components of gross value added (at constant prices) for 2014-15 to 2017-18 from http://rbi.org.in/Scripts/Publications. For 2018-19, the data were obtained from http;//statisticstimes.com/economy/sectorwise-gdp-contribution-of-india.php.

In order to boost the agricultural sector and promote its growth, it is important to increase the production and productivity of crops. As mentioned earlier, this can largely be achieved by increasing cropping intensity which is possible if irrigation facilities are available. In India however, till date, agriculture is largely dependent upon monsoons. The yield of crops fluctuate widely over years depending upon monsoons. A good monsoon normally gives rise to a satisfactory yield while failure of monsoons causes huge crop loss. The gross irrigated area as a percentage of gross cropped area is 48.63 percent and cropping intensity in 2014-15 was 141.6 percent (Government of India, 2019). These percentages vary widely over states and several states have cropping intensity below national average. The benefits of any technology to increase yield will only be realized with the availability of protective irrigation.

1.2 Progress of Irrigation in India:

In view of the importance of irrigation for agricultural growth, priority has always been given to this sector since independence. In the First Five Year Plan ((1951-56) itself, the country launched major irrigation programmes and simultaneously, minor irrigation schemes were also given emphasis. These programmes continued in the Second and Third Five Year Plans as well as in the Annual Plans with new projects. Hence from the First Five Year Plan, till the end of the three Annual Plans (1966-1969), the irrigation potential increased from 26.66 million hectares to 37.10 million hectares respectively, i.e increase of 39.2 percent. The focus in the Fourth Five Year Plan (1969-74) was shifted towards completing, the on going projects, integrated use of surface and ground water, adoption of efficient management techniques and modernization of existing schemes which further increased irrigation potential created. However, while irrigation potential was being created, the irrigation potential utilized was not keeping pace and there was always a lag. Hence, during the Fifth Plan (1974-78), the Command Area Development Programme was launched as a Centrally Sponsored Scheme for the development of adequate delivery system of irrigation water upto the field of the farmer. The main objective of the scheme was to reduce the gap between the irrigation potential created and optimum utilization of water. While new start ups continued, greater emphasis was laid on completion of projects which were in the last stage of completion. The main components of the Command Area Development Programme included construction of field channels and field drains,

enforcement of *warabandis,* land levelling & shaping, modernization and maintenance of irrigation structures, promote water use efficiency, suitable cropping patterns, extension services, etc. This process continued in the successive Five Year Plans and in 1996-97 the Accelerated Irrigation Benefit Programme (AIBP) was launched. The AIBP was conceived as a facilitating programme with the aim of expediting the implementation of larger irrigation projects which were considered to be primarily lagging due to paucity of funds with state governments. Under the scheme, Renovation, Modernization and Rehabilitation of old irrigation projects gathered momentum and importance was also given to repairs and maintenance of minor irrigation projects.

Both programmes, namely Command Area Development and Watershed Management Programme functioned independently and aimed at increasing gross irrigated area. As a result, the irrigation potential created increased over the plan periods. However, the major issue was that the potential created was not fully utilized which is a major challenge for the irrigation sector. The water often does not reach the field of the farmers due to absence of a proper distribution system, silting, incomplete on -farm works and other technical issues. Further, economic issues, such as high operation and maintenance costs as compared to water charges often lead to poor maintenance of canals.

Water being a scarce resource, its saving and efficient use assume great importance. The Command Area Development Programme therefore also aimed at promoting Micro Irrigation (MI) to address the issue of judicious use of water. Infact, the use of MI was promoted by the government since 1992 when the Centrally Sponsored Scheme to promote the use of plastics in agriculture was launched as drip equipment involved the use of plastics. MI was also encouraged in a number of schemes of the government such as AIBP, Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize, National Horticulture Mission and National Mission on Sustainable Agriculture. Thus improved technologies for harnessing maximum benefits of available water resources, to enhance productivity and at the same time maintain soil health began to gain importance. To strengthen this, in 2005-06, a Centrally Sponsored Scheme on Micro Irrigation was launched. This scheme was scaled up in June 2010 as National Mission on Micro Irrigation which continued till 2014-15.

1.3 National Mission on Micro Irrigation (NMMI):

Micro Irrigation technologies such as drip and sprinkler, are being promoted in India, by the Central and State governments through the provision of financial, institutional and technical support. The purpose of these technologies is mainly to save water which is used for irrigation. Drip irrigation involves technology for irrigating plants at the root zone through emitters fitted on a network of pipes (mains, sub-mains and laterals). In case of sprinklers water is discharged under pressure in the air, through a set of nozzles attached to a net work of high density polyethylene pipes, simulating rainfall. These systems are suitable for irrigating crops where the plant density is very high.

There is an ever increasing demand for irrigation water but at the same time there is water scarcity as well as inefficient usage of available water resources. Much of the available irrigation water in India is applied through conventional surface irrigation methods, which involve huge conveyance and distribution losses resulting in poor irrigation efficiency.

It is well known that expansion of irrigation facilities helped the country to overcome the food shortage situation facing the country in the early decades of independence. The early 1950s witnessed significant investments in public irrigation schemes and canals served as a major source of irrigation. The Green Revolution which ushered in the late 1960s clearly established the crucial role played by irrigation along with high yielding varieties of seed and fertilizers, to achieve higher productivity and thus commercialize agriculture. Gradually, over the decades, the area irrigated by groundwater increased and private investment in agriculture gathered momentum through digging of tube wells and purchase of pumpsets. The area irrigated by canals in 1970-71 was 41.2 percent but declined gradually over the decades and reduced to 22.6 percent in 2015-16. Conversely, the area irrigated by tubewells sharply increased from 14.5 percent in 1970-71 to 47.9 percent in 2015-16. This increase in irrigated area by tube wells led to problems such as ground water exploitation and decline in water tables. Farmers often leave their pumps on, due to erratic supply of electricity and this leads to flooding of fields and wastage of water. This also causes water logging and decline in yields. Similarly, as discussed earlier, canal irrigation is also fraught with distribution losses, leakages and thus wastage of water.

The need to cope up with situations such as water scarcity, conserving water and improving water use efficiency led to the launching of Micro Irrigation programmes. The term micro irrigation refers to irrigation systems that distribute water through small devices directly in the plant root zone at prescribed rate and at regular intervals. Although micro irrigation was practised even in 1980s or so, the area under drip and sprinkler was negligible. The government had to therefore make concerted efforts to promote such technology and NMMI was one such scheme to capture the potential of increasing area under drip and sprinkler. The scheme therefore aimed at enhancing water use efficiency through use of micro technologies. It was expected that this technology besides saving water, will increase productivity of crops and thus increase income of farmers.

In 2014-15, the NMMI was subsumed under National Mission on Sustainable Agriculture and implemented as *On Farm Water Management* (ONFM). However, from 2015, the Micro Irrigation component of ONFM was subsumed under Pradhan Mantri Krishi Sinchayee Yojana .

1.4: Pradhan Mantri Krishi Sinchayee Yojana (PMKSY):

The PMKSY has been formulated in 2015 by amalgamating on going schemes. The major highlights of the four components of the scheme are:

(i) *Accelerated Irrigation Benefit Programme* -the main focus of this component is to expedite the completion of Major and Medium irrigation projects;

(ii) *Har Khet Ko Pani*- to create new water resources, harvest rain water, ground water development, rejuvenate traditional water storage systems and proper distribution of water;

(iii) *Per Drop More Crop* – to promote efficient water conveyance and use of micro irrigation systems;

(iv) *Watershed Development* – to ensure effective management of run off water, encourage soil and moisture conservation.

It can therefore be observed that PMKSY had several components but the overall objective of the programme was to improve irrigation facilities, save water and increase yields.

1.5 Outline of the study:

After an introductory chapter, the aim of the study is to study the water use efficiency in India's agriculture from the Per Drop More Crop component of PMKSY. The study is conducted for the state of Maharashtra. In chapter 2, the objectives and methodology of the study are indicated. The profile of Micro-Irrigation adoption in the state using secondary data is indicated in chapter 3. The study is largely based on Primary data and hence the sampling design and sample profile is discussed in chapter 4 and 5. The cropping profile and changes observed of the sample beneficiaries after adoption of Micro Irrigation is observed in chapter 6. A comparison of farm economics between adopters and non-adopters of Micro Irrigation is observed in chapter 7. The cost of Micro Irrigation system is indicated in chapter 8 and the factors and determinants of Micro Irrigation adoption is discussed in chapter 9. The larger impacts and problems associated with Micro Irrigation are discussed in chapter 10, followed by the assessment its overall performance in chapter 11. The study with respect to non-adopters is discussed in chapter 12. The specific major problems, needs, innovations and suggestions are observed in chapter 13. The broad conclusions and policy issues to be addressed are discussed in chapter 14.

Chapter 2

Study Background, Objectives and Methodology

2.1 Background:

Irrigation is the process through which controlled amount of water can be supplied through artificial means and thus stimulate agricultural productivity and diversification. Soon after independence, priority was given to the irrigation sector and the government made heavy investment in major irrigation projects. The expansion of irrigation facilities by the government, enabled the country to capitalize on the gains from the Green Revolution. This helped the country to overcome the crisis in food shortage and today India is not only more than self sufficient in food grain production but has gradually diversified to commercial and horticultural crops. Irrigation has played an important role in promoting the agricultural sector and private sector investment in irrigation gradually increased and became the dominant source. However, expansion of irrigation through canals and tube wells has also created a host of problems in the form of poor maintenance of canals, exploitation of ground water, wastage of water, etc.

The government since independence has launched several schemes, to expand irrigation facilities, in order to meet the increasing demand for water in agriculture. The programmes succeeded in bringing more area under irrigation. The gross irrigated area which was merely 22.56 million hectares in 1950-51, increased to 96.46 million hectares in 2014-15. The cropping intensity during the corresponding period increased from 111percent to 141.5 percent (Government of India, 2019). Hence while progress has been made through several schemes to provide the farmers with protective irrigation, the potential has not been fully realized. Several on going schemes were amalgamated in 2015 and a comprehensive scheme, namely, *Pradhan Mantri Krishi Sinchayee Yojana* was launched which included major components to strengthen the irrigation sector. The scheme has in its fold three Ministries, namely Ministry of Water Resources, River Development and Ganga Rejuvenation, Ministry of Rural Development (Department of Land Records) and Ministry of Agriculture and Farmers' Welfare. The PMKSY brought about convergence of investment in irrigation at the field level. The most important issues aimed at expanding cultivable area under irrigation and fast completion of on going irrigation projects, watershed, recharge of aquifers and soil conservation, strengthening field

channels so that water reaches every field etc. The policy makers also realized that equally important is the need to improve water use efficiency and avoid wastage of water. This was possible by adopting Micro Irrigation technologies such as drip and sprinkler. The promotion of such technologies is a component of PMKSY in the form of *Per Drop More Crop* (PDMC)

2.2 Components and Objectives of Per Drop More Crop (Micro Irrigation) of PMKSY:

The PMKSY has several components and the purpose of each component is to ensure that every attempt is made to make the irrigation sector efficient so that every farmer is ensured of water in his field and also there is optimum utilization of water. The **main components of the PDMC are**:

(i) Programme Management and preparation of State and District Irrigation Plan and approval of Annual Action Plan, Monitoring, etc;

(ii) Promotion of efficient water conveyance and precision water application devices such as drips, sprinklers, pivots, rain-guns in the farm;

(iii) Topping up of input cost particularly under civil construction beyond the permissible limit, under Mahatma Gandhi National Rural Employment Scheme for activities like lining inlet, outlet, silt traps, distribution system, etc;

(iv) Construction of micro irrigation structures to supplement source creation activities such as tube wells and dug wells, only in areas where ground water is available and not under semi critical/critical/over exploited category. However these tube wells should not be supported under other schemes such as Accelerated Irrigation Benefit Programme, *Har Khet Ko Pani*, Watershed, Mahatma Gandhi National Rural Employment Guarantee Scheme as per Block/District Irrigation Plan;

(v) Creation of secondary storage structures at the tail end of the canal system so as to store rain water or from perennial sources such as streams. This water can be used during dry periods through effective on-farm water management;

(vi) Water lifting devices like diesel/electric/solar pumpsets including water carriage pipes and underground piping systems;

(vii) Extension activities for promotion of scientific moisture conservation and agronomic measures including cropping alignment to maximize use of available water including rainfall and minimize irrigation requirement;

(viii) Capacity building, training and awareness programme including low cost publications, use of projectors and low cost films for encouraging potential use of water source through technological, agronomical management practises including community irrigation;

(ix) The extension workers will be empowered to disseminate relevant technologies under PMKSY only after requisite training is provided to them especially in the area of promotion of scientific moisture conservation and agronomic measures, improved innovative distribution systems like pipe and box outlet system, etc;

(x) Information Communication and Technology (ICT) interventions to be made use in the field for water use efficiency, precision irrigation technologies, on farm water management, crop alignment etc. and also for monitoring the scheme. The Programme of National e-Governance Plan for Agriculture (NeGP-A) should be used for use of ICT.

The **Per Crop More Drop** component had the following **objectives**:

(i) To increase the area under micro irrigation technologies so that water use efficiency is enhanced in the country;

(ii) To increase productivity of crops through precision water management. The increase in productivity will also help to increase incomes of farmers;

(iii) In case of water intensive crops such as sugar cane and banana, the use of micro irrigation should be encouraged and its use should further be extended to field crops;

(iv) Fertigation is enabled through micro irrigation and its potential must be realized;

(v) Ground water resource is over exploited which is causing water scarcity and water stress. A number of blocks have reached a critical stage and deeper and deeper aquifers are required to access water. Hence, promoting micro irrigation will help to reduce exploitation of water;

(vi) PDMC scheme aims at lining tube well/river-lift irrigation projects with micro irrigation technologies so that energy for lifting and pressurized irrigation is best utilized;

(vii) PDMC aims at converging and creating synergy with activities of other on going schemes, particularly with water sources created, integration with solar energy for pumpsets, etc;

(viii) To promote, develop and disseminate micro irrigation technology for agriculture and horticulture development using modern scientific knowledge;

(ix) Installation and maintenance of micro irrigation systems involves both skilled and unskilled labour. Hence installation of these systems will help to generate employment opportunities for youth.

2.3 Structure of the Scheme :

The Per Drop More Crop adopts the institutional set up and architecture of overall PMKSY framework as given in the operational guidelines of PMKSY. The broad institutional structure as per PMKSY guidelines are:

(a) A National Steering Committee under the chairmanship of Honorable Prime Minister with Union Ministers from concerned Ministries and Vice chairman of NITI Aayog as members to provide policy directions for the programme implementation and overall supervision;

(b) National Executive Committee under the Chairmanship of Vice-chairman, NITI AYOG with secretaries of concerned ministries/departments and chief secretaries of selected states as members, in order to oversee the programme implementation, allocation of resources, coordination with different ministries, monitoring &performance assessment and addressing administrative issues;

(c) The PMKSY Mission Directorate is responsible for overall coordination, outcome and monitoring of all components of the scheme in order to achieve the target;

(d) State Level Sanctioning Committee under the Chairmanship of Chief Secretary of the state to sanction projects and activities as represented by the Inter Departmental Working Group which is chaired by the Agriculture Development Commissioner and secretaries of line departments as members. States may also take the advice of manufacturers of Micro Irrigation systems, if required;

(e) District Level Implementation Committee under the Chairmanship of the Collector/District Magistrate/ Chief Executive Officer of Zilla Parishad, Joint Director/Deputy Director of line departments in the district. Representatives of

Micro Irrigation industry, NGOs, progressive farmers can also be members to oversee the implementation of PMKSY and inter departmental coordination.

The agricultural department of the state is the nodal department for implementing the PDMC component of PMKSY. The execution of the plan is undertaken by the Department of Horticulture, Government of Maharashtra.

The District Irrigation Plan is an important instrument for planning and implementation of the components of PMKSY. They identify the gaps in irrigation infrastructure and also consider the resources available and the addition possible due to state and central schemes. The District Irrigation Plan aims at a holistic development of the irrigation sector through integration of water resources, the distribution net work and water use applications. The annual action plan for PDMC (Micro Irrigation) is drawn from District Irrigation Plan and implemented taking into consideration the water resources created under PMKSY in cluster mode for overall development of the state.

2.4 Procedure to Obtain Subsidy for PDMC:

The state with the help of the National Informatics Centre, Pune, has developed a software, namely *E -Thibak,* which enables farmers to apply online for Micro Irrigation system. The software covers all stages of implementation, i.e application by the beneficiary, dealer's quotation, pre-sanction, bill invoicing, spot verification, subsidy fixation and payment and real time reporting. The entire process is online and therefore very transparent which prevents the possibility of leakages. Dealers have access to online customer data and can thus schedule after sales service. The manufacturers' can also access, crop wise customer data and therefore come to know the performance of dealers.

The state is taking considerable initiatives to promote the scheme so that maximum farmers can avail of the subsidy. The application for entry is open throughout the year and online manufacturer registration software is developed. The manufacturers can also register any time in the year or renew their license.

The state is also making the application simple so that the farmer can apply with minimum documents. The farmers have to register using their *Aadhar* number and the subsidy is transferred in the beneficiary's account which is seeded with his *Aadhar* number. The pre-sanction letter is auto generated. In order to bring about transparency and provide

the farmer with up to date information, a mobile message is sent to farmers using their registered mobile number through the software. This message will enable the farmer to know the stage of his application.

The **criteria** that is mandatory for selection of farmers is :

(i) The land should be in the name of the farmer;

(ii) The source of irrigation; In case the source of irrigation is not mentioned in the 7/12 document then the beneficiary must make a self declaration about well or any other source of irrigation such as canal , water conservation/water resources department.

(iii) The irrigation facility such as electric pump, diesel pump or solar power;

(iv) Permanent electricity connection;

(v) Caste certificate;

(vi) If a group of farmers apply for MI, then the group members have to submit a bond certificate;

(vii) After receiving pre-sanction approval, the farmers should purchase drip/sprinkler set from authorised dealer/distributor within 30 days.

The documents required to release subsidy are:

(i) On line application form;

(ii) Aadhar Card;

(iii) 7/12 Certificate

(iv) 8A Certificate

(v) Land Marking Graph

(vi) Bank Pass book copy linked with Aadhar Card;

(vii) Self-Declaration form;

(viii) Spot Verification form;

(ix) Bill Proof

(x) Pre-Sanction Letter;

(xi) Design or map of the Micro Irrigation installation in field which is prepared by the representative of the Company;

(xii) Photograph with Latitude and Longitude of the Plot;

Thus the system of availing of subsidy is transparent and the farmer receives information about his application through messages on his registered mobile number

2.5 Review Of Literature:

Maharashtra is a water stressed state and the availability of water in the state is extremely uneven both temporally as well as spatially. The state is also experiencing rapid urbanization and industrialization and hence besides agriculture, water has several competing uses. Barely 18 percent of the gross cropped area is irrigated and in view of the scarcity of water, the state is making all round efforts to increase area under micro irrigation. The state was an early adopter of micro irrigation technology and between drip and sprinkler methods, area under drip is much higher than that under sprinkler. A number of studies have been conducted which indicate the positive impact of micro irrigation and hence an attempt is made to highlight the findings of major studies. The state also has research institutions and Agricultural Universities which constantly conduct experiments on water saving technologies.

In a paper "*Bringing World Class Technology to Maharashtra Agriculture"* (Jadhav, 2019), it was brought to light that as early as 1987, Jain Irrigation System Private Limited was floated in Jalgaon district of Maharashtra. The company began popularising the use of drip and sprinkler with full technical back up support to farmers in Maharashtra in the form of survey design, installation, after sales services and agro-advisory services. This holistic approach provided substantial gains to farmers who experienced water savings and yield increase. The Government of India also launched centrally sponsored schemes to promote drip and sprinkler technology and this support began to increase the area under these technologies manifold. In the above mentioned paper, it was noted that sprinkler irrigation increased the yield of wheat by 100 per cent as compared to traditional method of irrigation, while that of maize and vegetables increased by 66 percent and the water saved was 25 percent. In case of groundnut the increase in yield was 11 percent but the water saved was 52 percent. The paper also noted that there was substantial increase in yield for horticultural crops by drip method of irrigation which was as high as 66 percent for water melon and 49.3 percent of pomegranate with considerable water saving over crops.

A detailed study on micro irrigation (www.iwmi.cgiar.org) was conducted as early as 1998-99, by Narayanamoorthy for the state of Maharashtra. The districts selected were

Pune and Ahmednagar and the crops selected were sugarcane, grapes and banana. The study revealed that the Benefit: Cost Ratio of drip method as compared to flood method was 1.9 for sugarcane, 1.76 for grapes and 2.28 for bananas. The study noted that that drip investment was economically viable even without subsidy. The study also noted that as the drip method reduces working hours of pumpsets through saving water it also reduces electricity consumption and increases its efficiency. Water saving in sugarcane due to drip method of irrigation was observed to be about 44 percent in sugarcane, while the same was estimated to be 37 percent in grapes and 29 percent in banana (Narayanamorthy, 2001).

An evaluation study was conducted (Global AgriSystem, 2014) to study the impact of the *National Mission on Micro Irrigation.* The study observed the impact on thirteen states which were using micro irrigation technology and considered all major crops grown in the state under micro irrigation. The study covered 20 crops mainly horticultural for the state of Maharashtra and observed that the Benefit: Cost Ratio of Micro Irrigation System ranged from 2.08 in tomato to 2.93 for grapes and 2.94 for guava. Hence installation of micro irrigation was beneficial and further the incomes of farmers in Maharashtra increased by 45.76 percent after installation of drip as compared to their income before adoption of Micro Irrigation. There was decrease in cost of irrigation by 31 percent, saving in electricity by 33.48 percent also saving in consumption of fertilizer by 22.96 percent. Overall the productivity of fruit crops increased by 49.18 percent and that of vegetable crops increased by 28.76 percent due to adoption of Micro irrigation and compared with the productivity before adoption. The farmers also reported increase in irrigated area by 22.28 percent in Maharashtra. The labor required for post harvest handling also increased, although it was reduced in the pre harvest practises. Overall there was increase in 5.26 percent man days required for cultivation. The study recommended that despite the economic benefits of micro irrigation, further awareness needs to be spread to promote this technology. Also since the cost of installation is high, farmers will not be able to afford it without subsidy.

Another major study on resource conservation technology (Drip irrigation) was conducted by Bhamoriya and Mathew (2014). The study covered six states and the state of Maharashtra was also covered. The study was based largely on primary data and mainly used perception method of studying the impact of drip irrigation. The highlights of the study revealed that 74.6 percent of the sampled farmers using drip method in Maharashtra reported that there was improvement in water availability due to drip and 94.7 percent revealed that there was timeliness in water availability. Drip system was having a positive

impact on water table was reported by 43.4 percent of farmers while 99.1 percent indicated that drip irrigation saved water. Also, 64.4 percent of sample farmers reported that the saved water due to drip was used to expand area under agriculture and 41.6 percent felt that drip method is useful in improving soil quality. However, with respect to other issues related to drip such as reduction in costs and quality of produce the response was not strongly positive. Further, 61.9 percent of farmers reported that they experienced increased income due to drip and 43.4 reported that their social status had improved. An important policy issue to be addressed was that after sales service is costly for farmers which serves as a constraint from utilizing the full potential of the technology over a sustained period of time. More awareness is required to spread this technology and hence government efforts in this direction must be strengthened.

Water is a scarce input for agriculture in Maharashtra and relatively a large part of the water is used for sugarcane cultivation which is a water guzzling crop. Vasantdada Sugar Institute (Deshmukh and Shinde, 2019) continuously conducts research on micro irrigation for sugarcane and results of their experiments revealed that the quantity of water saved in drip and *Raingun* sprinkler was 50.25 percent, 30.65 percent respectively as compared to surface irrigation. Further the cane yield increased by 23.40 percent in drip and 17.16 percent in *Raingun* Sprinkler as compared to surface irrigation. The water use efficiency also improved by 2.48 times in drip and 1.69 times in Sprinkler as compared to surface irrigation. The use of micro technology also saved use of fertilizers by 30 percent. The study recommended that in view of several benefits of drip irrigation, the technology must be promoted and quality systems must be supplied to farmers with prompt after sales customer services for maintenance of the systems and easy availability of spare parts.

Vishwanatha and Thokal (2019) also conducted, research studies for observing the feasibility of drip method of irrigation. The study was conducted for 14 crops which included sugarcane, summer groundnut, cotton and 11 horticultural crops. The water saved and yield increase in drip as compared to surface, was observed. The saving in water ranged from 25 percent for bitter gourd to 66 percent for chilli and water melon. In case of sugarcane, the water saved was 60 percent. The yield increase ranged from 9 percent in case of cabbage to 86 percent in case of summer groundnut. Sugarcane showed a yield increase by 13 percent in drip as compared to surface irrigation. The study indicated that while there are challenges to create new water sources, the available water should be used efficiently through adoption of water saving technology such as drip, canal lining, proper

irrigation scheduling, afforestation of catchment area, etc. as these are all complementary methods to conserve water.

A study on sugarcane and banana cultivation in Northern Maharashtra under drip irrigation system, was conducted using primary data by Gorain et al. (2020). The districts selected were Nasik and Jalgaon. The study noted that drip method of irrigation acts as a facilitating factor in saving water, produce was better quality, decreased tillage requirement, high fertilizer use efficiency and higher yield. Adoption of drip saved 26.43 percent of water as compared to flood method of irrigation in sugarcane and increased yield by 46.3 percent. In case of banana cultivation, 46.4 percent of water was saved and the yield increased by 16.75 percent. However, cropping intensity on drip farms was lower than non-drip farms on account of cultivation of more area under more water requiring and high value perennial crops.

Overall, the review of literature on MI clearly indicated the benefits of this technology and perhaps such assessment of MI through various studies and reports, brought about policy initiatives in favour of MI.

2.6 Objectives of the Study:

It is clear from the review of literature that Micro Irrigation has several economic benefits besides promoting optimal water use. The government too, realizing the importance of this technology has been promoting the use of drip and sprinkler to save water which is a scarce resource and also boost the agricultural sector. While several schemes have been on going in this direction since the last three decades or so, since the 2015-16 season, several schemes were consolidated into the *PMKSY*. The *PDMC* is an important component of the scheme and hence the impact of its implementation can provide useful insights for the agricultural sector. Accordingly, the study of the *PDMC* component of *PMKSY* was undertaken in the state of Maharashtra with the following objectives:

1. To examine the savings in various inputs such as water, fertilizers, power, pesticides and labour for selected crops, viz sugarcane, banana and cotton;
2. To examine the enhancement of productivity, quality and other benefits for selected crops, and employment generation, if any;
3. To study the overall impact on farmers incomes and the net profits for the selected crops;

4. To observe the factors and determinants affecting Micro Irrigation and also the perceived advantages and disadvantages of Micro Irrigation;
5. To identify any issues/problems in the adoption of MI;
6. To suggest policy implications so that the adoption of MI technology can be strengthened.

2.7 Methodology and Analytical Framework:

The study is an evaluation research in which the design adopted is the comparison of the economics of Micro Irrigation before the selected sample farmers adopted the technology with the same before adoption. Therefore, data is collected for the same variables, such as production, costs, returns and yield, for the three selected crops, viz. sugarcane, banana and cotton, before the reference year and also for the Reference Year. The Reference Year for the study is 2019-20. Further, the study also selected farmers who were Non adopters of this technology in order to study the reasons for their non adoption. The districts selected were Pune and Jalgaon.

The study was conducted with the help of primary and secondary data. The primary data was collected from the field with the help of a well structured questionnaire that was addressed to adopters as well as Non adopters. The sample size is indicated in Table 2.1. While conducting field survey, it was observed that farmers were using mainly drip method, while Sprinkler system was not popular. Even from the secondary data, it was observed that in Pune district, out of total area under Micro Irrigation, 91.67 percent was under drip, while in Jalgaon 96.39 percent of area was under drip method. Thus, drip method covered almost the entire area under Micro Irrigation in the selected districts and hence the same was observed in our sample.

Table 2.1: Sample Coverage

Sr. No.	District surveyed	No. of Village	No. of Farmers surveyed	Drip Adopters	Sprinkler Adopters	Micro-Irrigation (Both)	Non-Adopters
1	Pune	7	64	51	0	1	12
2	Jalgaon	12	77	64	0	0	13
	Total	19	141	115	0	1	25

Source: Field Survey

The data after being inputted in Micro soft - excel format, was then converted into suitable tables which enabled the analysis to be conducted. The questionnaire also gauged the perceptions of farmers on advantages, disadvantages, constraints and

problems in using Micro Irrigation by using 5 point-Likert scale : (i) strongly agree (score 5) (ii) agree (score 4), (iii) partially agree/disagree (score 3) (iv) disagree (score 2) (v) strongly disagree (score 1) which corresponding to each item/factor. A weighted mean was calculated based on the farmers who reported for each item.

The secondary data was obtained from the Office of the Commissionerate of Agriculture, Government of Maharashtra and portal of PMKSY.

With the help of the above methodology, the objectives outlined in the study were achieved.

Chapter 3

Profile of Micro Irrigation - Adoption in Maharashtra

Backdrop:

Per Drop More Crop is a component of the scheme of Pradhan Mantri Krishi Sinchayee Yojana. The purpose of the scheme is to increase the area under Micro Irrigation(MI) gradually over the years, and also spread it to more farmers. In order to achieve this objective, the government both at the central and state level are providing subsidy to the beneficiaries. The pattern of assistance payable to the beneficiary is 55 percent for small and marginal farmers and 45 percent for other farmers. The subsidy payable to the beneficiary is limited to an overall ceiling of 5 hectares per farmer.

In this chapter therefore, an attempt is made to observe the year wise growth under MI, the district wise adoption and the crop wise adoption.

3.1 Profile of Micro Irrigation Adoption in Maharashtra:

The funds allocated for PDMC under PMKSY in Maharashtra are indicated in Table 3.1. It can be observed that the funds have declined from Rs 687.70 crores in 2017-18 to Rs 378.81 crores in 2019-20. This is perhaps due to decline in number of beneficiaries availing of the subsidy. The number of beneficiaries who availed of the subsidy were 2,64,180 in 2017-18 and declined to 1,69,047 in 2019-20, i.e. a decline of 36 percent.

Table 3.1: Year-wise growth of Micro Irrigation in Maharashtra

Year	Funds Allocated/ Received under PMKSY-PDMC (Rs crores)	Area under Micro Irrigation (MI) (Lakh hectares)	Number of Beneficiaries	MI as % of Total Irrigated Area
2014-15	688.41	2.14	252676	4.52
2015-16	445.98	1.36	146142	2.87
2016-17	584.00	1.91	209987	4.04
2017-18	687.70	2.09	264180	4.38
2018-19	424.87	1.30	174618	2.74
2019-20	378.81	1.14	169047	2.39
Annual Growth rate	-11.26	-11.83	-7.72	-11.97

Source: Commissionerate of Agriculture, Horticulture Department, Government of Maharashtra

3.2 District Wise Share in Micro Irrigation:

Maharashtra is not only a leading state in adoption of Micro Irrigation, but also an early adopter. The state began using drip and sprinkler equipment, as early as 1986. The progressive area under MI is indicated in Table 3.2 (A). It can be observed that the progressive area under MI from the period 1986 till 2019-20 is 25,25,056 hectares. The progress of use of MI technology is very encouraging in several districts.

MI has a higher share in total irrigated area, in districts where horticulture is important such as Nashik, Jalgaon, etc. Hence in Nashik division, the share of MI in gross irrigated area is 60.99 percent. Micro Irrigation is also popular in Solapur district which cultivates cash crops as well as horticultural crops. It is observed that districts in Thane division have a negligible share in MI. The cropping pattern in these districts mainly comprises of rice which is rainfed. Hence, it can be observed that only 16.1 percent of gross irrigated area in Thane division is under MI.

Overall, it appears that the share of MI in gross cropped area is gaining importance in the districts of Maharashtra which cultivate cash crops such as cotton and sugarcane and also are well known for horticultural crops.

Table 3.2 (A) : District Wise Micro Irrigation Adoption :

District	Progressive MI (1986 to 2019-20) (ha)	District Gross Irrigated Area (ha)	Progressive MI as % of District Gross Irrigated Area
Thane	5,762	21,300	27.05
Palghar	494	18,447	2.70
Raigad	1,739	26,447	6.58
Ratnagiri	4,189	11,569	36.21
Sindhudurg	2,555	13,836	18.47
Thane Division	14,739	91,599	**16.10**
Nashik	158,838	199,816	79.49
Dhule	76,862	106,076	72.46
Nandurbar	31,196	138,792	22.48
Jalgaon	318,322	514,802	61.83
Nashik Division	585,218	959,486	**60.99**
Ahmednagar	153,880	394,803	38.98
Pune	95,847	422,652	22.68
Solapur	187,768	215,599	87.09
Pune Division	437,495	1,033,054	**42.35**
Sangli	101,429	176,500	57.47
Satara	51,500	217,363	23.69
Kolhapur	20,345	192,162	10.59
Kolhapur Division	173,274	586,025	**29.57**
Aurangabad	127,686	254,114	50.25
Jalna	115,507	157,894	73.15
Beed	71,093	278,390	25.54
Aurangabad Div	314,286	690,398	**45.52**
Latur	89,439	394,000	22.70
Osmanabad	66,776	191,713	34.83
Nanded	100,446	175,200	57.33
Parbhani	68,296	182,269	37.47
Hingoli	50,479	100,641	50.16
Latur Division	375,436	1,043,823	**35.97**
Buldhana	175,891	174,873	100.5
Akola	63,673	45,856	138.85
Washim	54,912	45,209	40.67
Amravati	127,909	229,853	55.64
Yavatmal	93,804	262,233	35.77
Amravati Division	516,189	758,024	**68.10**
Wardha	53,592	100,820	53.15
Nagpur	32,776	228,900	14.32
Bhandara	3,650	139,000	2.62
Chandrapur	15,082	118,000	12.78
Gondiya	2,771	113,815	2.43
Gadchiroli	1,042	73,809	1.41
Nagpur Division	108,913	774,344	**14.06**
Total Maharashtra	2,525,056	5,936,753	**42.53**

Source : Compiled from District Socio-Economic Abstract of various districts and slected websites : www.kvk.pravara.com; www.drikvkbeed.org; des3.mahaonline.gov.in; agricoop.nic.in>sites>default>file; mahasdb.maharashtra.gov.in>Hingoli

Note : The gross irrigated area in certain districts only has record of Major and Medium projects. Certain other sources of irrigation such as Farm Ponds may not be recorded. Figures are subject to change. ha: Hectares

3.2 (B) District wise Area under Micro Irrigation since PDMC Component of PMKSY

(Area Hectares)

District	2015-16	2016-17	2017-18	2018-19	2019-20	Total
Thane	11.1	26.9	68.9	73.2	69.8	249.8
Palghar	0.0	110.9	149.8	135.0	157.0	552.7
Raigad	0.0	22.1	44.7	43.8	11.6	122.1
Ratnagiri	0.0	84.0	111.9	207.5	157.0	560.4
Sindhudurga	33.3	84.6	57.8	94.1	93.8	363.5
Thane Division	**44.4**	**328.4**	**432.9**	**553.6**	**489.3**	**1,848.6**
Nashik	2,243.7	4,792.5	8,099.8	5,428.7	6,034.3	26,599.0
Dhule	822.0	4,859.4	6,388.0	3,042.7	4,617.3	19,729.4
Nandurbar	437.6	1,593.0	1,629.3	2,027.9	3,543.0	9,230.8
Jalgaon	3,724.6	10,936.1	19,504.8	14,090.4	15,970.6	64,226.5
Nashik Division	**7,227.9**	**22,181.0**	**35,621.9**	**24,589.7**	**30,165.1**	**119,786.0**
Ahmednagar	3,506.3	8,104.5	11,385.0	6,971.6	7,092.7	37,060.0
Pune	2,236.7	4,625.6	5,074.1	3,527.9	4,707.9	20,172.2
Solapur	2,411.4	4,896.1	8,258.4	5,240.9	7,951.9	28,758.6
Pune Division	**8,154.4**	**17,626.2**	**24,717.4**	**15,740.4**	**19,752.4**	**85,990.8**
Sangli	1,806.5	3,971.9	7,166.1	4,435.7	3,418.2	20,798.4
Satara	2,737.2	2,628.9	3,343.6	1,526.2	1,508.8	11,744.8
Kolhapur	621.2	1,525.8	1,984.8	1,070.5	732.2	5,934.5
Kolhapur Division	**5,165.0**	**8,126.6**	**12,494.5**	**7,032.4**	**5,659.1**	**38,477.6**
Aurangabad	1,717.8	6,756.4	14,033.3	8,797.5	6,907.4	38,212.3
Jalna	1,701.4	9,196.2	15,828.1	13,519.6	6,230.1	46,475.3
Beed	2,474.2	6,590.9	10,084.4	6,171.7	6,388.8	31,710.0
Aurangabad	**5,893.4**	**22,543.5**	**39,945.7**	**28,488.7**	**19,526.3**	**116,398.0**
Latur	1,564.3	3,933.5	10,463.6	4,385.1	3,355.9	23,702.4
Osmanabad	1,647.9	2,862.7	9,366.6	5,501.3	5,016.2	24,394.6
Nanded	2,099.6	4,000.8	6,338.1	5,720.3	4,741.6	22,900.3
Parbhani	1,466.9	4,697.7	5,636.9	3,779.5	2,880.5	18,461.5
Hingoli	1,305.0	3,802.5	4,920.7	4,016.1	2,495.2	16,539.4
Latur Division	**8,083.6**	**19,297.2**	**36,725.8**	**23,402.3**	**18,489.3**	**105,998.0**
Buldhana	1,113.6	9,310.0	14,812.6	8,565.2	11,177.7	44,979.1
Akola	723.4	5,301.7	7,571.8	2,566.8	1,941.7	18,105.5
Washim	490.1	5,617.3	5,745.0	3,647.7	2,886.8	18,386.8
Amravati	1,289.5	8,175.5	12,707.4	6,037.2	5,257.0	33,466.6
Yavatmal	1,590.6	6,799.5	8,226.1	4,811.1	4,667.9	26,095.3
Amravati Division	**5,207.3**	**35,203.9**	**49,063.0**	**25,628.0**	**25,931.1**	**141,033.0**
Wardha	368.9	5,174.8	4,397.2	1,895.5	2,104.2	13,940.5
Nagpur	140.5	2,044.6	3,665.2	2,186.6	2,631.2	10,668.1
Bhandara	48.5	91.7	141.8	118.0	303.7	703.7
Chandrapur	262.2	1,639.8	1,580.2	809.5	1,576.7	5,868.3
Gondia	69.8	93.2	213.1	81.2	165.3	622.5
Gadchiroli	5.8	3.2	17.9	18.0	280.2	325.0
Nagpur Division	**895.8**	**9,047.2**	**10,015.3**	**5,108.7**	**7,061.2**	**32,128.1**
Total Maharashtra	**40,672.0**	**134,354.0**	**209,017.0**	**130,544.0**	**127,074.0**	**641,660.0**

Source: Commissionerate of Agriculture, Horticulture Department, Government of Maharashtra

Table 3.2 (c) District wise Area under Drip and Sprinkler Irrigation from 1986 to 2019-20

(Area hectares)

District	Drip	Sprinkler	Total
Thane	5,632	129	5,761
Palghar	458	35	493
Raigad	1,693	47	1,740
Ratnagiri	4,103	87	4,190
Sindhudurga	2,451	104	2,555
Thane Division	14,337	402	14,739
Nashik	143,175	15,663	158,838
Dhule	73,520	3,342	76,862
Nandurbar	29,742	1,454	31,196
Jalgaon	306,830	11,492	318,322
Nashik Division	553,267	31,951	585,218
Ahmednagar	119,543	34,337	153,880
Pune	87,862	7,985	95,847
Solapur	178,106	9,662	187,768
Pune Division	385,511	51,984	437,495
Sangli	81,713	19,716	101,429
Satara	36,711	14,789	51,500
Kolhapur	18,236	2,109	20,345
Kolhapur Division	136,660	36,614	173,274
Aurangabad	112,153	15,533	127,686
Jalna	89,275	26,232	115,507
Beed	50,378	20,715	71,093
Aurangabad	251,806	62,480	314,286
Latur	41,024	48,415	89,439
Osmanabad	45,555	21,221	66,776
Nanded	57,984	42,462	100,446
Parbhani	51,065	17,231	68,296
Hingoli	21,338	29,141	50,479
Latur Division	216,966	158,470	375,436
Buldhana	87,591	88,300	175,891
Akola	21,834	41,839	63,673
Washim	9,208	45,704	54,912
Amravati	64,092	63,817	127,909
Yavatmal	22,467	71,337	93,804
Amravati Division	205,192	310,997	516,189
Wardha	12,802	40,790	53,592
Nagpur	15,887	16,889	32,776
Bhandara	1,555	2,095	3,650
Chandrapur	3,065	12,017	15,082
Gondia	1,360	1,411	2,771
Gadchiroli	129	913	1,042
Nagpur Division	34,798	74,115	108,913
Total Maharashtra	1,798,537	727,013	2,525,550

Source : Commissionerate of Agriculture, Horticulture Department, Government of Maharashtra

Table 3.2 (D) District wise Percent Share of Drip and Sprinkler from 1986 to 2019-20

District	Drip	Sprinkler	Total
Thane	97.76	2.24	100.00
Palghar	92.90	7.10	100.00
Raigad	97.30	2.70	100.00
Ratnagiri	97.92	2.08	100.00
Sindhudurga	95.93	4.07	100.00
Thane Division	**97.27**	**2.73**	**100.00**
Nashik	90.14	9.86	100.00
Dhule	95.65	4.35	100.00
Nandurbar	95.34	4.66	100.00
Jalgaon	96.39	3.61	100.00
Nashik Division	**94.54**	**5.46**	**100.00**
Ahmednagar	77.69	22.31	100.00
Pune	91.67	8.33	100.00
Solapur	94.85	5.15	100.00
Pune Division	**88.12**	**11.88**	**100.00**
Sangli	80.56	19.44	100.00
Satara	71.28	28.72	100.00
Kolhapur	89.63	10.37	100.00
Kolhapur Division	**78.87**	**21.13**	**100.00**
Aurangabad	87.84	12.16	100.00
Jalna	77.29	22.71	100.00
Beed	70.86	29.14	100.00
Aurangabad	**80.12**	**19.88**	**100.00**
Latur	45.87	54.13	100.00
Osmanabad	68.22	31.78	100.00
Nanded	57.73	42.27	100.00
Parbhani	74.77	25.23	100.00
Hingoli	42.27	57.73	100.00
Latur Division	**57.79**	**42.21**	**100.00**
Buldhana	49.80	50.20	100.00
Akola	34.29	65.71	100.00
Washim	16.77	83.23	100.00
Amravati	50.11	49.89	100.00
Yavatmal	23.95	76.05	100.00
Amravati Division	**39.75**	**60.25**	**100.00**
Wardha	23.89	76.11	100.00
Nagpur	48.47	51.53	100.00
Bhandara	42.60	57.40	100.00
Chandrapur	20.32	79.68	100.00
Gondia	49.08	50.92	100.00
Gadchiroli	12.38	87.62	100.00
Nagpur Division	**31.95**	**68.05**	**100.00**
Total Maharashtra	**71.21**	**28.79**	**100.00**

Source : calculated from Table 3.2 (C)

Table 3.2 (E) District wise Percent Share of Micro Irrigation from 1986 to 2019-20 (Percent to Maharashtra)

District	Drip	Sprinkler	Total
Thane	0.31	0.02	0.23
Palghar	0.03	0.00	0.02
Raigad	0.09	0.01	0.07
Ratnagiri	0.23	0.01	0.17
Sindhudurga	0.14	0.01	0.10
Thane Division	**0.80**	**0.06**	**0.58**
Nashik	7.96	2.15	6.29
Dhule	4.09	0.46	3.04
Nandurbar	1.65	0.20	1.24
Jalgaon	17.06	1.58	12.60
Nashik Division	**30.76**	**4.39**	**23.17**
Ahmednagar	6.65	4.72	6.09
Pune	4.89	1.10	3.80
Solapur	9.90	1.33	7.43
Pune Division	**21.43**	**7.15**	**17.32**
Sangli	4.54	2.71	4.02
Satara	2.04	2.03	2.04
Kolhapur	1.01	0.29	0.81
Kolhapur Division	**7.60**	**5.04**	**6.86**
Aurangabad	6.24	2.14	5.06
Jalna	4.96	3.61	4.57
Beed	2.80	2.85	2.81
Aurangabad	**14.00**	**8.59**	**12.44**
Latur	2.28	6.66	3.54
Osmanabad	2.53	2.92	2.64
Nanded	3.22	5.84	3.98
Parbhani	2.84	2.37	2.70
Hingoli	1.19	4.01	2.00
Latur Division	**12.06**	**21.80**	**14.87**
Buldhana	4.87	12.15	6.96
Akola	1.21	5.75	2.52
Washim	0.51	6.29	2.17
Amravati	3.56	8.78	5.06
Yavatmal	1.25	9.81	3.71
Amravati Division	**11.41**	**42.78**	**20.44**
Wardha	0.71	5.61	2.12
Nagpur	0.88	2.32	1.30
Bhandara	0.09	0.29	0.14
Chandrapur	0.17	1.65	0.60
Gondia	0.08	0.19	0.11
Gadchiroli	0.01	0.13	0.04
Nagpur Division	**1.93**	**10.19**	**4.31**
Total Maharashtra	**100.00**	**100.00**	**100.00**

Source: Calculated from Table 3.2 (C)

In Table 3.2 (B), the District wise under MI is indicated since the implementation of PMKSY. It can be observed that since the PDMC was launched, 641659 hectares was

brought under MI. It can be observed that during the period 2015-16 to 2019-20, i.e since PDMC was implemented, the area brought under MI was highest in Jalgaon district which was 64226.51 and the share in state total was 10 percent. The districts which ranked second and third were Jalna and Buldhana with a share of 7.24 percent and 7 percent respectively.

The District wise area under drip and sprinkler is indicated in Table 3.2 © and the percentage share of drip and sprinkler in each district is indicated in Table 3.2 (D). The important point to note is that in the state as whole, out of 2525550 hectares under MI, the share of drip is 71.21 percent, while that of sprinkler is 28.79 percent.

It is clear from Table 3.2 (D) that in Maharashtra, drip method of MI is much more popular as compare to sprinkler system. In fact in Nashik Division, 94.54 percent of area under MI is under drip, while in Pune and Aurangabad Division, the share of drip is 88.12 percent and 80.12 percent respectively. In Amravati and Nagpur division however, it appears that sprinkler system is more popular as compared to drip, as the share of sprinkler in MI is 60.25 percent and 68.05 percent respectively. In Latur division, the share of drip is 57.79 percent which is little more than half, which means that both methods are popular.

The District wise share of MI is indicated in Table 3.2 (E). It can be observed that the district with highest share in MI was Jalgaon which had a share of 12.60 percent and the share in state drip area was 17.06 percent. The district which ranked second was Solapur, followed by Buldhana which had share of 7.43 percent and 6.96 percent respectively. In Solapur however, the drip system was used and share of drip in total MI was 94.85 percent (Table 3.2 (D)).

Districts in western Maharashtra, notably in Thane division did not seem to use MI technology. The share of districts in this division was only 0.58 percent. These districts receive very heavy rainfall and perhaps the topography is not suitable for MI.

Overall, it can be observed that although Maharashtra is a leading state in MI, the usage is not spread evenly over districts. While the usage is very high in districts such as Jalgaon, there are several districts that are lagging behind in adoption of this technology.

3.3 Crop-Wise Adoption of Micro Irrigation :

The use of MI varies across crops, and the crop wise adoption is indicated in Table 3.3. It can be observed that the highest area under MI is for cotton crop with a share of 24.04 percent. This is indeed a positive signal for the cotton economy of Maharashtra

because the use of drip irrigation will certainly improve the yield of the crop. Besides cotton, another major cash crop in Maharashtra is sugarcane which is well known as a water guzzling crop. The Government of Maharashtra is making concerted efforts to increase the area under sugarcane under MI so that water is saved and yield is improved. This is gradually happening in the state and share of sugarcane in area under MI in Maharashtra is 11.76 percent.

It is well known that MI is used substantially for horticultural crops. The same is happening in Maharashtra and 21.70 percent of area under MI is under vegetables. Maharashtra is a leading state in production of fruits and MI is adopted for several major fruit crops in the state. It was observed that Jalgaon is a leading state in adopting MI, especially drip, and is a major banana growing region. The share of drip for banana is 6.53 percent. Further, it was also observed that Solapur is also a leading district in adoption of drip. This district also leads in pomegranate cultivation and share of this crop in total area under drip is 5.94 percent. Nasik district is well known for grapes and share of grapes in MI area is 5.19 percent.

Table 3.3: Crop-wise Adoption of MI (2018-19/latest year)

Sr. No.	Crop Name	Area under Micro Irrigation Lakh hectares	Percent
1	Cotton	6.07	24.04
2	Sugarcane	2.97	11.76
3	Vegetables	5.48	21.70
4	Banana	1.65	6.53
5	Pomegranate	1.5	5.94
6	Citrus Fruits	1.42	5.62
7	Grapes	1.31	5.19
8	Others	4.85	19.21
9	Total	25.25	100.00

Source : Department of Horticulture, Government of Maharashtra

Overall, it can be observed that in the state of Maharashtra, MI is popular with respect to cash crops such as cotton and sugarcane. Further, horticultural crops such as fruits and vegetables are also irrigated with the use of drip or sprinkler, although drip is much more popular in the state.

Chapter 4

Study Sampling and Sample Profile

Backdrop:

There exists a fairly large body of literature which proves the benefits of Micro Irrigation. This technology is considered to be an efficient method of irrigation as it enables the conservation of water, which in turn also reduces the consumption of electricity. It is in this context, that the government is promoting the use of MI, not only through extension services but also through subsidizing the equipment. This study is one more attempt to study the economics of drip irrigation through field survey and also understand other issues relating to MI technology.

In this chapter, the sample coverage and some features of sample profile such as age of adopters and their level of education is indicated.

4.1 Sample Coverage

The details of sample coverage, adopters of micro-irrigation, and also Non adopters in the sample under study is shown in Table 4.1. Our Sampling is four stage with selection of district at the first stage, followed by taluka and then village from which farmer households were selected. The sample comprised only of farmer households in the villages who were growing the reference crop before they adopted drip irrigation. The reference crops were sugarcane, banana and cotton. Hence those farmers who were not growing the reference crop before they adopted drip irrigation were excluded from the survey. The main purpose of selection of such farmer households was to compare their usage of inputs, yield, etc, before and after the use of drip irrigation.

The two districts selected were Pune and Jalgaon. As noted earlier, the main purpose of this project is to study the impact of drip irrigation in terms of input usage, notably water which is a scarce resource and also observe the net returns to farmers. In Maharashtra sugarcane is an important cash crop and the state also has the second largest area under the country under sugarcane. Since sugarcane is a water guzzling crop, farmers in certain sugarcane cultivating regions, began to adopt drip method of irrigation. In view of the water saving capacity of drip technology and concern about over exploitation of ground water resources, the government of Maharashtra made it mandatory for sugarcane cultivation to

be under drip in atleast about 30 percent of area under the crop in the first phase. Hence sugarcane was selected as a crop for the study and it comprises 11.76 percent of the total crop wise area under Micro Irrigation.

In Maharashtra, Pune Division, comprising the districts of Ahmednagar, Pune and Solapur, has highest area under sugarcane, comprising about 42.19 percent of area under sugarcane in the state. Hence this division was selected as a sample district. In Pune division, the district selected was Pune, because the use of drip irrigation by farmers for cultivation of sugarcane was quite popular and the area under sugarcane in this district comprised of 32 percent of the area of Pune Division. Further, in Pune District, two talukas namely, Indapur and Shirur were selected as these two talukas were major sugarcane growing regions in the district. While the share of Indapur taluka was 27.75 percent, that of Shirur was 13.41 percent and hence both these talukas constituted about 41.16 percent of the sugarcane area in Pune district.

The other district selected for sample was Jalgaon. The data from official sources reveals that out of total progressive area under Micro Irrigation in Maharashtra, the share of Jalgaon is highest at 12.60 percent. The districts which rank second and third in terms of share of area under Micro Irrigation in the state, barely have a share of 6 to 7 percent, which indicates that the district of Jalgaon is much ahead of other districts in adoption of Micro Irrigation. Hence this district was selected. In Maharashtra, it is observed that drip irrigation is largely used for horticultural crops, although cotton had the largest crop wise area under Micro Irrigation which was 24.04 percent (Table 3.3). With respect to horticultural crops, the share of banana was highest and constituted 6.53 percent. Jalgaon is a major banana growing belt, not only in Maharashtra but also in India. Hence, banana was selected as a sample crop in the district as drip irrigation is largely practised with respect to this horticultural crop. Further, in the recent past, farmers in Jalgaon have also begun to use drip for cotton cultivation. Cotton is a major commercial crop in Maharashtra which has one-third of the cotton area of the country. Further, cotton is largely unirrigated in the state which often suffers from drought. However, there are pockets in the state where the area is irrigated and the same is observed in Jalgaon. Since, drip method of irrigation is popular in Jalgaon, cotton farmers too have started adopting the technology for cotton. Hence, in Jalgaon both crops, banana and cotton were selected across five talukas.

The four stage sampling for the selected crops in the selected districts can be observed from Table 4.1.

Table 4.1 : Sample Selection

District	Taluka	Village	Adopter	Nonadopter	Crop
Pune	Indapur	Bavda	8	2	Sugarcane
		Bhandgaon	8	2	Sugarcane
		Bori	7	2	Sugarcane
	Shirur	Ganegaon Khalsa	8	2	Sugarcane
		Jambut	8	2	Sugarcane
		Jategaon Khurd	8	2	Sugarcane
		Mukhai	5	0	Sugarcane
Jalgaon	Jamner	Chinchkheda	8	2	Cotton, Banana
		Hiverkheda Bk	8	2	Banana
		Kekat Nimbora	4	0	Cotton, Banana
		Neri	8	2	Cotton, Banana
	Muktainagar	Chinchol	2	0	Cotton, Banana
	Pachora	Dighi	4	2	Cotton, Banana
		Neri	4	2	Cotton
		Rajuri	6	2	Cotton
		Vadgaon Mulane	4	0	Cotton, Banana
	Raver	Nandurkheda	2	0	Cotton
		Utkheda	6	0	Cotton, Banana
	Yaval	Damborni	8	1	Banana, Cotton
		Grand Total	**116**	**25**	

From Table 4.1, it can be observed that in Pune district, the number of adopters of drip irrigation for sugarcane selected were 52 while the number of Non adopters selected were 12. In case of Jalgaon however as noted above, the number of adopters selected were 64, while the number of Non adopters were 13. Within Jalgaon, 41 farmers cultivated banana, while 28 cultivated cotton and 5 farmers who cultivated both cotton and banana. In all 141 sample respondents have been selected, of which 116 are adopters of Micro-irrigation and 25 Non adopters of Micro Irrigation. On overall basis among 116 adopters, 115 adopted drip irrigation while one farmer adopted drip and sprinkler both. This one farmer belonged to Pune district as indicated in Table 4.2.

Table 4.2: Sample Coverage

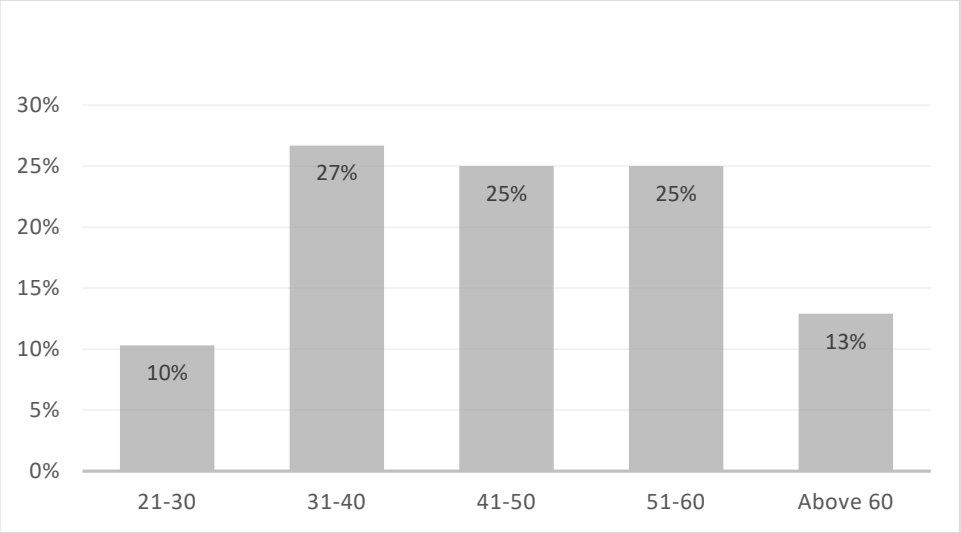
Sr. No.	District surveyed	No. of Village	No. of Farmers surveyed	Drip	Sprinkler	Micro-Irrigation (Both)	Non-Adopters
1	Pune	7	64	51	0	1	12
2	Jalgaon	12	77	64	0	0	13
	Total	19	141	115	0	1	25

Source : Field Survey

4.2 Age Profile of Sample Farmers :

The age profile of the sample farmers can be observed from Figure 4.1 and Table 4.3.

Figure 4.1 Age Profile of Respondents



Source: Field Survey

Table 4.3: Age of Adopters

Age	Number	Percent
Under 20	0	0
21-30	12	10
31-40	31	27
41-50	29	25
51-60	29	25
Above 60	15	13

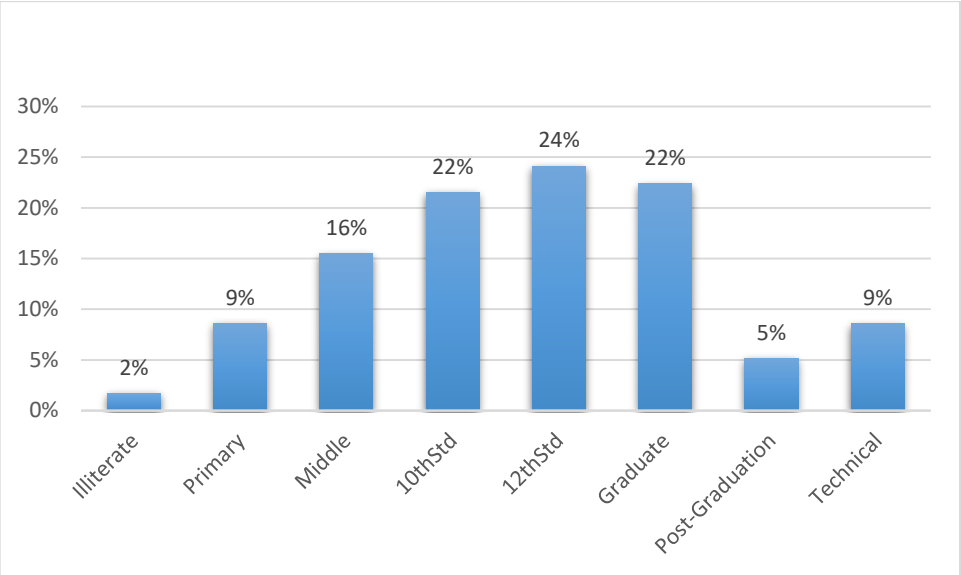
Source: Field Survey

The average age of the adopters is 46 years. It can be observed from Table 4.3 that about half of adopters were within the age group of 40-60 years. Only 10.3 percent of the sample adopters were in the age group 21-30 years. Further, 12.9 percent of the adopters were above 60 years. This is also encouraging as elderly farmers were encouraged to adopt the MI technology.

4.3 Education Profile of Sample Farmers:

The education profile of the sample farmers is indicated from Figure 4.2. It is observed that most of the adopters were literate and well educated, as three-fourth of respondents had completed 10th and above studies. Around 28 percent of respondents were graduates and postgraduates, while there were only 2 percent of respondents' illiterate.

Figure 4.2 Education Profile of Sample Adopters



Source : Field Survey

Thus after observing the age and literacy levels of sample farmers, in the next chapter we observe other characteristics such as water resources and land terrain which are very important for the usage of Micro irrigation.

Chapter 5

Land Area and Water Sources in Relation to Micro Irrigation

Micro irrigation as a source of irrigation is being promoted by the government in view of its multiple benefits such as saving of water as compared to other sources of irrigation and also reduction in use of other inputs which provide economic benefits to farmers. Hence farmers are gradually increasing their area under drip and sprinkler systems. In this chapter, an attempt is made to observe the area operated by sample farmers who are adopting Micro Irrigation, their sources of water, characteristics of soil and year of adoption of Micro Irrigation.

5.1 Land Area :

The total area operated by adopters of Micro Irrigation and the area irrigated by different sources is indicated in Table 5.1.

Table 5.1: Operational Landholding Profile (Hectares)

Group (ha)	Number of Farmers	Per cent (%)	Area Operated in Hectares - Average					
			Total Area Operated	Micro Irrigated area			Non-Micro Irrigated	Un-irrigated
				Total	Drip	Sprinkler		
Landless/ Tenant	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marginal (<1)	19	16.38	0.67 (100.0)	0.67 (100.0)	0.67 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Small (1-2)	42	36.21	1.38 (100.0)	1.32 (95.7)	1.32 (95.7)	0.00 (0.0)	0.06 (4.3)	0.00 (0.0)
Medium (2-10)	46	39.66	3.51 (100.0)	3.16 (90.0)	3.12 (88.9)	0.04 (1.1)	0.33 (9.4)	0.01 (0.3)
Large (>10)	9	7.76	13.26 (100.0)	10.18 (76.8)	10.03 (75.6)	0.15 (1.2)	2.99 (22.5)	0.09 (0.7)
Total	116	100.00	3.04 (100.0)	2.63 (86.5)	2.60 (85.5)	0.03 (1.0)	0.38 (12.6)	0.01 (0.3)

Source : Field Survey ; Note : Units in Parenthesis are percentage of total operated are

It can be observed from Table 5.1, that out of 116 adopters, none were tenants. While 16.38 percent were marginal farmers, small and medium were 36.21 percent and 39.66 percent respectively. The number of large farmers in the sample were only 9 which constituted 7.76 percent of the total adopters. While the average operated area across all groups was 3.04 hectares per farmer, the area operated by large farmers was 13.26 hectares. In case of medium farmers the average area operated was 3.51 hectares and in case of small

farmers the average area was 1.38 hectares. While marginal farmers were 16.38 percent in number, their average farm size was 0.67 hectare.

It can also be observed from Table 5.1 that drip system was the main method of irrigation while use of sprinkler was negligible. Medium and large farmers also resorted to other sources of irrigation which was 12.6 percent across all size groups, but 22.5 percent for large farmers. On an average across all size groups, only 0.01 percent of area cultivated was unirrigated.

5.2 Water Source and Availability:

The source of water used for micro irrigation and availability are indicated in Table 5.2 and Table 5.3 respectively. It can be observed that 58.50 percent of adopters resorted to well irrigation, while 20.41 percent of adopters had tube wells as their source of water. This indicates that 78.91 percent of adopters used well or tube well and hence well irrigation was the most important source of water. Lift from river was used by 11.56 percent of adopters while canal lift was used by 3.4 percent adopters. Only 4 adopters for each used canal or farm ponds as a source of irrigation.

Table 5.2: Water Sources

Source	Number	Percent of Respondents
Canal	4	2.72
Canal-Lift	5	3.40
River-Lift	17	11.56
Tubewell	30	20.41
Well	86	58.50
Tank	1	0.68
Pond	0	0.00
Farm Pond	4	2.72

Source : Field Survey; Note: Multiple responses applicable

The water situation available is indicated in Table 5.3. It can be observed that 75 percent of the adopters did not face any scarcity in availability of water. This high figure is possibly because sugarcane was a crop cultivated by adopters and normally the crop is cultivated mainly in areas where water is available. Infact 6.9 percent of farmers in the sample indicated that they had excess water. Only one farmer faced scarcity in water while no farmer reported that there was acute scarcity.

Table 5.3: Water Situation for Farming

Water situation	Number	Percent
Excess water	8	6.90
No scarcity	87	75.00
Occasional scarcity	20	17.24
Scarcity	1	0.86
Acute scarcity	0	0.00
Total	116	100.00

Source : Field Survey

5.3 Soil Type and Farm terrain:

The type of soil of the adopters and the type of terrain is indicated in Table 5.4 and Table 5.5. It can be observed from Table 5.4 that 94.83 percent of farmers reported that their soil was medium type. Only 3.45 percent of farmers reported heavy soil.

Table 5.4: Type of Soil

Soil	Number	Percent
Light	2	1.72
Medium	110	94.83
Heavy	4	3.45
Total	116	100

Source : Field Survey

The terrain of the farmers adopting drip irrigation was largely observed to be flat terrain as 98.28 percent of farmers reported the same. Only one farmer said that the soil was Up & Down and again one farmer indicated that the soil was hilly.

Table 5.5: Type of Terrain

Terrain	Number	Percent
Flat	114	98.28
Up & Down	1	0.86
Hilly	1	0.86
Total	116	100

Source : Field Survey

5.4 Rainfall situation (2019-20):

Rainfall is important because besides providing water for the crops, it also helps to recharge ground water. Heavy rainfall in the reference year (2019-20) was reported by 70.69 percent of the adopters in the sample. Very heavy rainfall was reported by 15 farmers which comprised 12.93 percent of the sample while 18 farmers who constituted 15.52 percent of the sample indicated that the rainfall was average. There was no reporting of very low rainfall and only one farmer reported that the rainfall was low.

Table 5.6: Rainfall Situation (2019-20)

Rainfall	Number	Percent
Very heavy	15	12.93
Heavy	82	70.69
Average	18	15.52
Low	1	0.86
Very low	0	0.00
Total	116	100.00

Source: Field Survey

5.5 Micro Irrigation adoption:

Maharashtra is a leading state in the usage of Micro Irrigation, but it is only in the recent years that the spread of this technology is increasing. Hence it can be observed from Table 5.7 that 5.17 percent of farmers have been adopting this technology since last ten years, prior to 2019-20 which is reference year. It can further be observed that 31.04 percent of farmers started to adopt drip irrigation 5 years prior to 2019-20. However, many farmers were recent adopters as 21.55 percent had adopted the technology only 3 years since reference year while 20.69 percent had adopted the technology just 2 years ago. Just a year before reference year, i.e in 2018-19, about 17.24 percent of farmers began to adopt micro irrigation while 4.31 percent adopted the technology in 2019-20.

Table 5.7: Year Started using Micro Irrigation

When did You Start Using Micro Irrigation	Number	Percent
Current Year (2019-20)	6	4.31
Last Year (2018-19)	19	17.24
2 years ago	24	20.69
3 years ago	25	21.55
5 years ago	36	31.04
10 years ago	6	5.17
More than 10 years	0	0.00
Total adopters	116	100.00
Overall Average is 4.01 years		

Source : Field Survey

The benefits of drip and sprinkler were gradually being realized by the government. This technology was more important in Maharashtra as it is a water stressed state and saving of water is of crucial importance. Further, in view of the financial gains which accrue by using drip or sprinkler, the government began to promote this technology by creating awareness to farmers and also providing subsidy. The drip or sprinkler system entails a considerable fixed cost and farmers are unable to afford it. The cost also increases with increase in farm size as the length of the pipe increases. Hence in order to encourage the

farmers to use this technology as compared to the conventional method of surface irrigation, the government launched several schemes and subsidy was provided to farmers as a motivation to switch over to drip or sprinkler system. It can therefore be observed from Table 5.8 that 100 percent of the adopters had availed of subsidy to invest in the drip or sprinkler system.

Table 5.8: Whether Availed of Subsidy?

Availed Subsidy	Number	Percent (%)
Yes	116	100.0
No	0	0

Source: Field Survey.

Hence from this chapter we can conclude that tube well is the main source of irrigation and the switch to MI is taking place gradually.

Chapter 6

Cropping Profile and Changes

Backdrop:

Micro irrigation technology in agriculture is largely driven by assistance from the Central as well as State governments. This is also made clear from the fact that all sample farmers had claimed subsidy to install drip or sprinkler systems. Micro irrigation often encourages farmers to change their cropping pattern and farmers also, often experience increase in yield due to better utilization of inputs. Hence, in this chapter an attempt is made to observe the cropping pattern of the sample farmers and the area devoted to micro irrigation. The same was also observed before the sample farmers had adopted micro irrigation. Further, the changes in area and yield after adopting drip and sprinkler systems was also observed by gauging the perception of farmers.

6.1 Cropping Profile and Area with Micro Irrigation:

In Table 6.1 the cropping profile and the area irrigated under the crop for the reference year (2019-20) is indicated. Notably, the area under different sources of irrigation is observed for each crop and use of fertigation was also observed.

Cotton emerged as the dominant kharif crop and cultivated in the selected district of Jalgaon. The average area of the farmers reporting cultivation of cotton was 2.59 hectares in the Kharif season. It can be observed that 91.1 percent of the area under cotton was under drip irrigation while 8.9 percent was irrigated by non-micro or conventional sources. Maize was another crop cultivated in the kharif season, but only 16 percent area was under micro irrigation while 80.6 percent of the crop was irrigated by other sources, and 3.4 percent of the area was unirrigated. Fertigation was done by all farmers for both cotton and maize. By and large, in the Kharif season, the crops were entirely irrigated except for 3.4 percent of area under maize.

It appeared from the sample that very few farmers, infact between one to three farmers only for each crop, cultivated in the rabi season. The crops cultivated in the rabi season were horticultural, besides maize, wheat and horse gram and bajra. However, it was noted that one farmer had 6.07 hectares under cotton, in rabi season and the entire area was irrigated by drip.

The perennial crops cultivated were sugarcane and banana. Sugarcane was the dominant crop in Pune district and our sample had 52 farmers who cultivated sugarcane with

an average area of 1.76 hectares. The area under drip irrigation for sugarcane was 96.6 percent while 3.4 percent was under conventional sources.

Table 6.1: Cropping Profile and Area With Micro Irrigation

S. No	Crop Name	No. of Farmers Reporting	Area - Average in Hectares (Based on Reporting Farmers)					
			Area Under the Crop	Drip Area	Sprinkler Area	Irrigated Non-Micro Area	Unirrigated Area	Fertigation (%)
Kharif								
1	Cotton	36	2.59 (100.0)	2.36 (91.1)	0.00 (0.0)	0.23 (8.9)	0.00 (0.0)	100.00
2	Maize	15	1.69 (100.0)	0.27 (16.0)	0.00 (0.0)	1.36 (80.6)	0.06 (3.4)	100.00
3	Vegetables	2	2.12 (100.0)	0.91 (42.9)	0.00 (0.0)	1.21 (57.0)	0.00 (0.0)	100.00
4	Moong	1	2.43 (100.0)	0.00 (0.0)	0.00 (0.0)	2.43 (100.0)	0.00 (0.0)	0.00
Rabi								
1	Watermelon	3	1.82 (100.0)	1.82 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00
2	Maize	3	2.16 (100.0)	2.16 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00
3	Wheat	2	0.61 (100.0)	0.40 (66.7)	0.00 (0.0)	0.21 (34.6)	0.00 (0.0)	100.00
4	Cotton	1	6.07 (100.0)	6.07 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00
5	Onion	1	4.86 (100.0)	0.00 (0.0)	1.42 (29.2)	3.44 (70.8)	0.00 (0.0)	0.00
6	Eggplant	1	0.81 (100.0)	0.81 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00
7	Lettuce	1	2.02 (100.0)	0.00 (0.0)	2.02 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00
8	Horse Gram	1	4.05 (100.0)	0.00 (0.0)	0.00 (0.0)	4.05 (100.0)	0.00 (0.0)	0.00
9	Bajra	1	0.61 (100.0)	0.00 (0.0)	0.00 (0.0)	0.61 (100.0)	0.00 (0.0)	0.00
Perennial								
1	Sugarcane	52	1.76 (100.0)	1.70 (96.6)	0.00 (0.0)	0.06 (3.4)	0.00 (0.0)	100.00
2	Banana	43	3.23 (100.0)	3.01 (93)	0.00 (0.0)	0.23 (7)	0.00 (0.0)	100.00
3	Pomegranate	3	1.01 (100.0)	1.01 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00
4	Chilli	1	0.81 (100.0)	0.81 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00
5	*Mosambi*	1	0.81 (100.0)	0.81 (100.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	100.00

Source : Field Survey;
Note: units in parenthesis indicate percentage of total area under respective crop.

Banana is also a perennial crop and sown either in June or November. Jalgaon district is a banana belt of the state of Maharashtra. In our sample, it is observed that farmers sow cotton in early kharif season – normally in the first week of June and harvest it by November.

The harvest of cotton is followed by the sowing of banana. The average area under banana for the sample farmers was 3.23 hectares, with 93 percent of the area under drip and 7 percent being irrigated through conventional methods. Fertigation was also given to the crop.

Pomegranate was cultivated by three farmers in the sample with an average area of 1.01 hectare and was entirely under drip irrigation with fertigation.

In Table 6.2, the cropping profile and area before adopting micro irrigation technology is indicated.

Table 6.2: Cropping Profile and Area Before Micro Irrigation

S. No	Crop Name	No. of Farmers Reporting	Area - Average in Hectares (Based on Reporting Farmers)		
			Total Area	Irrigated Area	Un-Irrigated Area
Kharif					
1	Cotton	42	2.56	2.56	0.00
2	Maize	16	1.80	1.80	0.00
3	Onion	3	1.35	1.35	0.00
4	Jowar	2	0.81	0.40	0.40
5	Horse Gram	1	0.81	0.81	0.00
Rabi					
1	Wheat	5	1.46	1.46	0.00
2	Jowar	3	2.61	2.61	0.00
3	Maize	3	1.01	1.01	0.00
4	Onion	2	2.83	2.83	0.00
5	Horsegram	1	4.05	4.05	0.00
6	Watermelon	1	1.21	1.21	0.00
7	Sweet corn	1	1.01	1.01	0.00
8	Groundnut	1	0.81	0.81	0.00
9	Eggplant	1	0.81	0.81	0.00
Perennial					
1	Sugarcane	53	1.56	1.56	0.00
2	Banana	41	2.42	2.42	0.00
3	Pomegranate	1	0.61	0.61	0.00
4	*Mosambi*	1	0.81	0.81	0.00

Source : Field Survey

It can be observed from Table 6.2 that cotton was the most important kharif crop before micro irrigation adoption and was entirely irrigated with the average hectare being 2.56 hectares. Maize was also cultivated by 16 farmers on an average of 1.80 hectares. Very few farmers, barely 1 to 5 in number, cultivated crops in the rabi season. Wheat was cultivated by 5 farmers on an average area of 1.46 hectares, while 3 farmers cultivated jowar on an average area of 2.61 hectares and another 3 farmers cultivated maize on an average area of 1.01 hectares. Being rabi season crops, the farmers had access to protective irrigation facilities.

Sugarcane is a perennial crop and was cultivated by 53 farmers, in an average area of 1.56 hectares. Banana was cultivated by 41 farmers in the sample and the average area under banana was 2.42 hectares.

Farmers were asked a likert scale[1] question on their perception of changes in area and yield due to micro-irrigation before and after micro-irrigation. The perception data at farm level is considered fairly satisfactory because farming is an age old activity with farmers and over time and experience their responses do provide insights.

Table 6.3: Change in Area and Yield due to Micro Irrigation

Sr. No.	Crop Name	No. of Farmers Reporting	Change in Area due to Micro Irrigation (%)						Change in Yield due to Micro Irrigation (%)					
			5	4	3	2	1	Mean	5	4	3	2	1	Mean
1	Sugarcane	52	5.77	13.46	75.00	5.77	0.00	3.19	23.08	73.08	3.85	0.00	0.00	4.19
2	Banana	41	4.88	29.27	56.10	9.76	0.00	3.29	4.88	78.05	17.07	0.00	0.00	3.88
3	Cotton	35	5.71	28.57	57.14	5.71	2.86	3.29	2.86	91.43	5.71	0.00	0.00	3.97
4	Maize	8	0.00	50.00	37.50	12.50	0.00	3.38	0.00	62.50	37.50	0.00	0.00	3.63
5	Vegetables	3	33.33	33.33	33.33	0.00	0.00	4.00	0.00	100.0	0.00	0.00	0.00	4.00
6	Watermelon	3	0.00	33.33	66.67	0.00	0.00	3.33	0.00	66.67	33.33	0.00	0.00	3.67
7	Pomegranate	3	33.33	0.00	33.33	33.33	0.00	3.33	0.00	66.67	33.33	0.00	0.00	3.67
8	Wheat	1	0.00	100.00	0.00	0.00	0.00	4.00	0.00	100.0	0.00	0.00	0.00	4.00
9	Onion	1	0.00	0.00	100.00	0.00	0.00	3.00	0.00	100.0	0.00	0.00	0.00	4.00
10	Mausambi	1	0.00	100.00	0.00	0.00	0.00	4.00	0.00	100.0	0.00	0.00	0.00	4.00
11	Chilli	1	0.00	100.00	0.00	0.00	0.00	4.00	0.00	100.0	0.00	0.00	0.00	4.00

Source: Field Survey

Note: Scale: Large Increase =5 Increase =4 No Change =3 Decrease =2 Large Decrease =1

[1] Scale: Large Increase =5 Increase =4 No Change =3 Decrease =2 Large Decrease =1

Farmers perception of changes in area and yield due to micro-irrigation before and after is presented in Table 6.3. It can be observed that the perception of farmers was that due to micro irrigation, the area under horticultural crops such as such as vegetables, chilli, onion and *mosambi* increase. Even wheat, a rabi crop therefore requiring irrigation seemed to have experienced an increase in area. After adopting micro irrigation, these crops also experienced increase in yield. Farmers cultivating sugarcane also reported increase in yield.

Overall it appears that majority of farmers revealed that Micro Irrigation has increased their yield and in case of horticultural crops and wheat, 100 percent of farmers reported that they perceived increase in yield.

This chapter thus gives us the overview of cropping pattern of adopters of Micro Irrigation, the same before using drip irrigation and also their perception on changes in area and yield due to usage of micro irrigation technology.

Chapter 7

Changes in Incomes and Farm Economics with Micro Irrigation

Backdrop:

Micro Irrigation is an efficient watering method which delivers water to the roots of the plant very slowly and this practise eliminates water loss due to evaporation which often happens when surface method of irrigation is used. Several studies as observed in the chapter on review of literature, indicated that besides saving of water, the drip method also results in saving other inputs, increases yield, improves the quality of the crop and finally increases the net returns of the farmers. In this chapter therefore, an attempt is made to observe the incomes as well as farm economics of adopters of MI and compare it with the same, prior to the adoption of MI.

7.1 Changes in Yield, Water Usage and Input Costs:

During the field survey, it was observed that most of the farmers in the sample completely shifted the cultivation of the selected crops, viz sugarcane, banana and cotton, from flood irrigation to drip irrigation. The data on cost of cultivation, yield, incomes and acreage with drip irrigation is of the reference year, while without drip irrigation is of the time period, when farmers cultivating the crop by using flood irrigation. The same is indicated in Table 7.1. However, it may be mentioned that there were some farmers, viz. 2 sugarcane, 9 banana and 6 cotton who cultivated the crops by devoting part of the area to drip method of irrigation and some part of the area was still under flood method. For these farmers, the necessary data on farm economics was collected from both methods of cultivation in the reference year. This also explains the reason that the figure indicated for acreage in Table 7.1, does not match with Table 6.1 and 6.2.

The acreage of sample sugarcane famers was slightly higher under drip irrigation as compared to flood irrigation. In case of banana however, it was observed that the average acreage was slightly more than double as compared to acreage without drip. In case of cotton, the area under drip was 6 percent higher than without drip.

7.1.1 Changes in Yield, water usage and input costs for sugarcane:

It can be observed from Table 7.1 that the total variable costs for sugarcane cultivation under drip irrigation was Rs. 152,893 per hectare as compared to Rs. 168,890 per hectare without drip irrigation. Thus we can say that drip irrigation brought about

reduction in costs. Fertilizer and labour costs are the major cost components of sugarcane. Labour mandays and labour costs in drip irrigation reduced by 37 percent and 40 percent respectively. The main reason for reduction in labour cost is that the farmer does not require labour for irrigating fields each time compared to flood irrigation. The farmer only requires two labour mandays in case of drip, once to put the drip laterals at the time of sowing and another removing the drip laterals after harvest from the field. Almost all farmers were using water soluble fertilisers through fertigation, which further reduced labour requirements and improved yields. The weed growth is negligible due to usage of drip, because water with fertigation goes straight to the root of the plant and the surrounding area is dry and there is thus limited scope for weeds to grow. This reduces labor cost for weeding, intercultural operations and weedicides.

Water soluble fertilisers deliver a more uniform nutrient supply to the crop as the fertilizer is applied as per the desired concentration and fertilizer losses such as denitrification are avoided. Water soluble fertilisers are more expensive as compared to the granular fertilisers which largely explains the reason that fertiliser costs and plant-protection costs are 7.7 percent and 12.7 percent higher in drip cultivation compared to without drip. The seed cost with drip irrigation is 11 percent higher than without, and this is due to rise in seed cost over time.

The use of drip has resulted in considerable reduction in water charges. It can be observed from Table 7.1 that water charges paid, reduced by 72 percent, mainly because less water is consumed with drip, in the cultivation of sugarcane. Further, less use of water also resulted in reduction in electricity cost which reduced by 20 percent. The total hours of pumping reduced by 57 percent in drip irrigation cultivation, which brought about the reduction in electricity cost. Sample farmers reported that on an average they used to irrigate their sugarcane fields 57 times with MI as compared to 52 times without MI. However, hours of pumping in per irrigation per hectare is 2.6 hours using drip method compared to 6.1 hours without drip. This leads to total hours of pumping of 145 hours in drip method compared to 332 hours without drip during the entire sugarcane cycle from sowing to harvesting. Under drip method, more land is covered under irrigation in short time span and farmers are able to better manage their irrigation schedule compared to flood irrigation method.

Marketing costs for sugarcane is low, as the entire sugarcane is procured by sugar mills. Some expenditure is incurred towards hospitality of the tractor person and labour person post harvest.

AERC Pune (Gokhale Institute of Politics & Economics) and CMA unit IIM A (coordinating unit) discussing various aspects of MI Adoption, with selected respondent.

AERC Pune (Gokhale Institute of Politics & Economics) and CMA unit IIM A (coordinating unit) discussing various aspects of MI Adoption, with selected respondent.

Under drip method, per hectare yield is 1446 quintals compared to 1067 quintals without drip which means that yield increased by 35.5 percent. The price received by farmers using drip was also higher. Hence reduced costs, higher yields and higher prices resulted in sugarcane farmers receiving net profit of Rs. 245,542 per hectare with drip compared to Rs. 81,247 per hectare, ie. an increase of 202.2 percent.

7.1.2 Changes in Yield, Water usage and Input costs for Banana:

The total variable costs for banana cultivation under drip irrigation was Rs. 250,882 per hectare as compared to Rs. 213,909 per hectare without drip irrigation. This indicates that the total variable costs increased by 17 percent. Planting material, fertilizer, plant protection and marketing costs were higher in drip method of banana cultivation. It was reported that in the reference period 2019-20, farmer used tissue culture banana sapling (planting material) which costs Rs. 12 per sapling compared to normal banana sapling which costs Rs. 5 per sapling. Tissue culture banana plant was more widely adopted by sample growers in 2019-20 compared to 2014-15. Total planting material cost per hectare of land was Rs. 47,112 in drip method compared to Rs. 22,327 without drip. Similarly, fertiliser costs were 25 per cent higher in drip method compared to without drip. The reason being farmers using drip irrigation also used water soluble fertilisers, which enhanced the costs. However, this also brought about increase in yield.

Tissue culture plant time duration is 10-11 months, while traditional plant time duration is 12 months. Tissue culture plants also get 10-12 hands (bunch) compared to traditional banana plants which get 7-9 hands (bunch) per tree. Farmers also reported that average bunch weight per tree is around 23-25 kg incase of tissue culture plant compared 18-20 kg in traditional banana tree.

The labour mandays and labour costs in drip irrigation reduced by 20.30 percent and 13.4 percent respectively. With drip 164 man days and without drip 206 mandays of labour use was reported. The number of irrigations with drip was 107 while without drip it was 76. Water charges and electricity charges, each reduced by 49 percent. There was reduction in electricity charges because total hours of pumping reduced by 60 percent in drip irrigation cultivation. Hours of pumping in per irrigation per hectare is 1.5 hours using drip method compared to 8.1 hours without drip. This leads to total hours of pumping 208 hours in drip method compared to 524 hours without drip.

Under drip method, per hectare yield of banana was 604 quintals compared to 348 quintals without drip which means that yield increased by as much as 73.3 percent. Besides yield increase, the farmer also fetched a higher price due to better quality of output. On an average, the price realization was Rs. 875 per quintal under drip method, compared to Rs. 640 per quintal without drip. Besides higher price realization due to considerable improvement in quality of the produce, the farmers adopting drip may have realized higher prices due to rise in price over time. The higher yields and higher prices resulted in banana farmers receiving net profit of Rs. 316,785 per hectare with drip compared to Rs. 6,048 per hectare without drip. This indicates that the profit from banana cultivation using drip method of irrigation is phenomenal as compared to cultivating the crop using surface method. However, it must be noted that farmers using drip also had the benefit of tissue culture technology which provides disease free seedlings, early maturity of the crop and uniform growth of the crop with increase in yield. The plants are also more densely planted which increases the yield. Since the density of the plantation is more, a suitable temperature is created for the plants which facilitates the growth and improves the quality and quantity of the yield.

It can also be observed that the marketing costs for the farmers increased after adoption of drip irrigation. This is expected because there was a huge increase in yield after adoption of drip method of banana cultivation. Since the farmers had more produce to sell, the cost of transport and other associated costs is likely to increase. Banana is a highly perishable crop and requires careful handling, failing which, the quality of the produce is likely to deteriorate. Hence, post harvest handling plays a very important role in the cultivation of banana and farmers have to therefore incur higher marketing costs. However, as observed in Table 7.1, the economic benefits from cultivation of banana is tremendous after adoption of drip system and hence the higher costs incurred in terms of seeds, fertilizer, farm yard manure and pesticides as compared to surface irrigation has also given substantial benefits.

7.1.3 Changes in Yield, Water Usage and Input costs for Cotton:

Cotton is an important cash crop cultivated in Maharashtra and the state ranks first in area with a share of 33 percent in the area under cotton in the country. However, despite this huge area, the state is not the largest producer and ranks second after Gujarat. The main reason for the state to lag behind in production, is because the state suffers from low yield

which is far below national average. The low yield is largely explained due to poor irrigation facilities as the crop is largely rainfed. Irrigation greatly helps to improve the yield which in terms further improves with the use of drip method.

Cotton farmers were included in our sample and it can be observed that the total variable costs for cotton cultivation under drip irrigation was Rs. 91,262 per hectare, as compared to Rs. 76,562 without drip irrigation, i.e drip adoption had a higher variable cost as compared to use of surface irrigation by 19.2 percent. It can be observed from Table 7.1 that fertilizer, pesticide cost and farm yard manure costs were higher by 71.4 percent, 67.5 percent and 59.1 percent respectively in drip method of cotton cultivation. Cotton crop has the tendency to get infested by pests and hence farmers began adopting Bt seeds to overcome the problem of *American bollworm* which used to always destroy the cotton crop. However, these seeds are highly priced, but farmers use them in the hope of higher returns. Once the farmer has invested in costly seeds, he ensures that the plant gets suitable fertigation and as soluble fertilizers are more costly, the fertilizer costs increased considerably. Further, while Bt seeds may not be susceptible to *American bollworm*, the cotton fields have begun to experience secondary pests such as aphids, whitefly, etc. Hence farmers continue to spray pesticides to save the crop from other pests. Overall, with drip, there is a higher usage of yield enhancing inputs viz. fertilisers, pesticides and farm yard manure because farmers have already invested in costly seeds and water and hence want to reap the benefits by suitable application of complementary inputs.

Labour mandays in drip irrigation reduced by 32 percent, while labour charges were similar to that without drip. With drip 81 man days and without drip 120 mandays of labour use were reported. While drip farmers gave 30 irrigations, without drip the irrigations were 12 in number. Electricity charges reduced by 12 percent because total hours of pumping reduced by 46 percent in drip irrigation cultivation. Hours of pumping in per irrigation per hectare is 1.3 hours using drip method compared to 5.6 hours without drip. This leads to total hours of pumping of 49.4 hours in drip method compared to 92 hours without drip. However, water charges increased by 55 percent from Rs. 633 to Rs. 984 among sample growers when they resorted to drip method.

Under drip method, per hectare yield of raw cotton is 27 quintals compared to 15 quintals without drip, i,e increase by 79.9 percent. Farmer realised on an average Rs. 4929 per quintal under drip method compared to Rs. 3921 per quintal without drip. One reason

for farmer realising higher prices is better quality of output and another is due to prices showing a rise during the period when drip was used as compared to the earlier period when the farmer used surface irrigation. With higher yields and higher prices, the cotton farmers received net profit of Rs. 43,198 per hectare with drip compared to losses of Rs. 22,057 per hectare in surface method. Thus the farmers adopting drip made 295.9 percent higher profits as compared to those who used surface irrigation. This huge difference in profits can largely be increased by yield increase which was higher by 79.9 percent for drip adopters as compared to use of surface irrigation. The drip method provides exact water requirement to the plant which facilitates its growth. Further, since the area surrounding the crop has less weed growth, less pests are likely to infest the plant. The farmers also spray pesticides as a precautionary method to prevent any pest attack on the crop and also use suitable fertigation. Hence despite higher total variable costs for drip farmers by 19.2 percent as compared to irrigation through surface method, the farmers reaped better harvest.

7.1.4 Changes in Yield, Water Usage and Input Costs Across all crops:

If we compare the differences in costs, yields, returns of all the three above mentioned crops together, it is observed that overall variable costs have risen by 15.67 percent. The seed cost indicated an increase of 88.81 percent which is mainly due to the increase in seed cost in banana cultivation with adoption of drip. As explained earlier, tissue culture banana planting material was used which is almost two and half times the cost of conventional plant. There was also increase in fertilizer cost by 34 percent because farmers use inputs more intensively in drip method to reap the full advantage of appropriate application of water. Similarly, the cost of farm yard manure increased by 20.20 percent and pesticide cost increased by 39.71 percent. Farmers after investing in costly seeds and water normally want to avoid the risk of the crop getting infested by pests and hence resort to spraying of pesticides to ensure a good harvest. Crop failure normally happens due to lack of protective irrigation and also due to lack of nutrients and possibility of pest attack. All these adverse impacts on crop production are taken care by drip method and this provides overall economic benefits to the farmers who adopt this method.

With the adoption of drip, the acreage of the farmer has also increased. The average area operated per farmer increased by 47.16 percent which indicates that drip method facilitated them to practise more cultivation. The farmers require less labour because across

all crops, it was observed that labour requirement reduced by 27 percent in terms of mandays and labor cost reduced by 19.19 percent.

The adoption of drip irrigation increased the overall marketing costs by 85.47 percent. This is expected because the overall production of the three crops increased by 30 percent and this was observed notably in case of banana and cotton. Hence increased production is likely to entail higher marketing costs such as transport and storage.

Drip besides saving water has also considerably reduced the electricity charges of farmers by 29.78 percent. Both water and electricity are scarce resources and saving on both these inputs is beneficial for the economy as a whole.

It can be observed that net profit for farmers using drip method was 663.37 percent higher as compared to those using surface method while costs were only 15.67 percent higher. This indicates that though farmers have to spend more on certain inputs such as seed, fertilizer and pesticide, the economic benefits are far higher.

The chapter therefore concludes that Micro Irrigation has benefitted the farmers and the government must continue to promote the usage of this technology through extension services as well as providing subsidy. Infact certain studies have even observed considerable benefits of drip method even if subsidy is not included in the cost. Hence, considering the scarcity of water resource and the limitations in creating more water resources as well as the importance of water as a yield enhancing input, the extension of area under this method of irrigation must be promoted as a far better alternative to surface method.

Banana fields in Jamner Taluka (Jalgaon District) irrigated through Drip Method

The benefits of Micro Irrigation are with respect to both the aspects of quantity as well as quality. While usage of Micro Irrigation increases yield, it also improves the quality of produce as the crop gets the exact requirement of inputs. The improved quality fetches a higher price and hence the overall returns to the farmer are higher. The same observations were observed among our sample farmers.

Table 7.1: Changes in Production, Incomes, Inputs and Costs with Micro Irrigation for Major Crops (Units in Rs. Per Hectare)

Item	Crop- Sugarcane			Crop-Banana			Crop- Cotton			All Crops/Total		
	No. reporting: 52			No. reporting: 41			No. reporting: 28			No. reporting: 121		
	With MI	Without MI	% diff	With MI	Without MI	% diff	With MI	Without MI	% diff	With MI	Without MI	% diff
Area (hectares)	1.76	1.55	9.82	3.11	1.45	114.15	2.31	2.18	5.98	2.32	1.57	47.16
Production (Quintals)	1,446	1,067	35.5	604	348	73.3	27	15	79.9	736.1	562.9	30.8
Price (Rs./quintal)	278	232	20.0	875	640	36.7	4,929	3,921	25.7	1,267.2	1,223.8	3.54
Total Sales Revenue	398,435	250,138	59.3	567,667	219,957	158.1	134,460	55,430	142.6	414,645	189,000	119.39
Seeds/Plants cost	18,194 (11.9)	16,369 (9.7)	11.2	47,112 (18.8)	22,327 (10.4)	111.0	3,696 (4.0)	3,583 (4.7)	3.1	28,012 (15.3)	14,836 (9.4)	88.81
Fertilizer cost	39,471 (25.8)	36,640 (21.7)	7.7	66,439 (26.5)	53,138 (24.8)	25.0	15,422 (16.9)	8,996 (11.8)	71.4	46,202 (25.2)	34,457 (21.7)	34.09
Farm Yard Manure	29,511 (19.3)	27,417 (16.2)	7.6	36,769 (14.7)	32,900 (15.4)	11.8	8,277 (9.1)	5,202 (6.8)	59.1	27,924 (15.2)	23,232 (14.7)	20.20
Pesticides cost	11,502 (7.5)	10,205 (6.0)	12.7	12,614 (5.0)	7,913 (3.7)	59.4	12,710 (13.9)	7,588 (9.9)	67.5	12,286 (6.7)	8,794 (5.5)	39.71
Electricity cost	2,587 (1.7)	3,230 (1.9)	-19.9	3,997 (1.6)	7,844 (3.7)	-49.0	2,523 (2.8)	2,869 (3.7)	-12.1	3,214 (1.8)	4,577 (2.9)	-29.78
Diesel cost	11 (0.0)	12 (0.0)	-8.9	4 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)		5 (0.0)	5 (0.0)	1.93
Water Charges paid	832 (0.5)	3,014 (1.8)	-72.4	142 (0.1)	279 (0.1)	-48.9	984 (1.1)	633 (0.8)	55.5	553 (0.3)	1,527 (1.0)	-63.75
No of irrigations (per farmer)	57	52	8.8	107	76	41.6	30	12	152.1	68	51	-36.67
Hours of pumping (per hectare)	144.6	332.1	-56.5	208.5	523.8	-60.2	49.4	91.9	-46.2	151.7	328.3	-53.8
Farm power & Equipment cost	18,501 (12.1)	17,819 (10.6)	3.8	21,366 (8.5)	24,362 (11.4)	-12.3	12,219 (13.4)	12,194 (15.9)	0.2	18,358 (10.0)	18,371 (11.6)	-0.07
Total man-days	128	206	-37.7	164	206	-20.3	81	120	-32.2	134	183	-27.0
Labour cost	32,024 (20.9)	54,111 (32.0)	-40.8	47,456 (18.9)	54,827 (25.6)	-13.4	33,210 (36.4)	32,718 (42.7)	1.5	39,318 (21.5)	48,654 (30.7)	-19.19
Marketing cost	259 (0.2)	73 (0.0)	253.4	14,982 (6.0)	10,319 (4.8)	45.2	2,222 (2.4)	2,779 (3.6)	-20.0	7,409 (4.0)	3,995 (2.5)	85.47
Total Cost	152,893 (100.0)	168,890 (100.0)	-9.5	250,882 (100.0)	213,909 (100.0)	17.3	91,262 (100.0)	76,562 (100.0)	19.2	183,281 (100.0)	158,447 (100.0)	15.67
Net Profit	245,542	81,247	202.2	316,785	6,048	5137.8	43,198	-22,057	295.9	231,364	30,308	663.37

Source: Field Survey
Note: Units in Parenthesis indicate % of total Cost; % diff: Percent Difference

Chapter 8

Capital and Maintenance Cost of Micro Irrigation

Backdrop:

It was observed in Chapter 7, that drip method of irrigation provided substantial economic benefits to farmers. However, the net profits earned by farmers was calculated only by considering variable or paid out costs. However, drip system entails considerable fixed cost which most farmers are unable to afford. Considering the benefits of this method in terms of saving water and increase in quantity and quality of yield, the government is providing subsidy to farmers to encourage the use of this technology.

The main components of the drip irrigation system are the network of pipes which consist of main lines, sub-main lines, laterals, emitters and control valves. Further, suitable filters may be required depending upon the impurities and quality of water. Also a pump has to be installed taking into consideration the availability of water and the area to be irrigated. Hence, a drip system entails considerable expenditure. Although the government provides subsidy, the farmer has to incur costs such as filter, pump, etc and also regular maintenance of the system. If the system is not maintained, the farmer will not be able to yield optimum benefits from this method of irrigation. Therefore, in this chapter, an attempt is made to observe the expenditure incurred by the farmer for the drip system, the subsidy received and also the repair and maintenance costs incurred.

8.1 Initial Capital Cost/Investment in Micro Irrigation

The details of initial capital cost/investment in micro irrigation are indicated in Table 8.1. It was observed that, on an average, for 116 drip irrigation adopters, the total cost incurred by farmers was Rs. 216,016. The subsidy received was Rs 117736.88 which is 54.5 percent of the cost.

The total cost on drip system, per hectare was approximately Rs. 89,377, of which an amount of Rs 48714 was received as subsidy which constitutes 54.5 percent of cost. The balance cost amounting to Rs 40663, which was 45.5 percent of the cost had to be borne by the farmer.

With respect to source of funds to purchase the drip system, it was observed that only 20.69 percent of the adopters availed of loans while 79.3 percent of adopters used their own funds for investing in the system.

There was one farmer who bought a sprinkler set, which was utilized for irrigating vegetables. However, he did not avail of any subsidy from the government. Drip system was used for the sample crops, viz. sugarcane, banana and cotton. Only five farmers had spent on pipes, and incurred an average expenditure of Rs. 28,100. Nine farmers had spent on pumps and the average cost was Rs. 20,889.

Table 8.1: Initial Capital Cost/ Investment in Micro Irrigation

Item	No. reporting	Average for All Reporting Farmers			Percent Reporting Loan as Source of Funds
		Amount Paid (Rs.)	Subsidy Amount	Total Cost	
1. Drip irrigation Set/Kit	116	98,278.71 (45.5)	117,736.81 (54.5)	216,015.52 (100.0)	20.69
2. Sprinkler irrigation Set/Kit	1	25,000.00 (100.0)	0.00	25,000.00 (100.0)	0.00
3. Filters (Cyclone, Disc, others)	1	8,000.00 (100.0)	0.00	8,000.00 (100.0)	0.00
4. Pipes (Micro, Distribution, Drip, PVC, PE, others)	5	28,100.00 (100.0)	0.00	28,100.00 (100.0)	0.00
5. Pumps (Avg. 5.8_hp)	9	20,888.89 (100.0)	0.00	20,888.89 (100.0)	0.00
6. Tube well cost (only if addl. For MI)	0	0.00	0.00	0.00 (100.0)	0.00
Total	116	10,1395.09 (46.3)	117736.81 (53.7)	219,131.90 (100.0)	20.69

Source : Field Survey
Note: Units in parenthesis indicate percentage of total cost

8.2 Annual Replacement/Maintenance Cost of Micro-Irrigation

Drip irrigation is a mechanical system that performs well only if it is well maintained. The system faces problems such as clogging of the laterals and emitters which prevent the easy flow and even distribution of water. The main reason for clogging is due to the presence of physical impurities or salts in fertilizers, etc and also biological impurities. Hence it is necessary to clean the system by acid wash while chlorination is required to remove the biological impurities.

Out of total 116 sample farmers, 70 farmers reported maintenance expenditure. Filters are an important part of the drip system and impurities collected in the filters have to be cleaned regularly besides other maintenance. In the sample, five farmers reported an average maintenance cost of Rs. 2358.66 on filters, discs, etc. Sixty-nine farmers practised acid wash on the drip sets annually to clean the dripper lines and the average cost was Rs. 844.54. Many farmers treat this as a routine annual maintenance and did not clean the dripper lines on daily or weekly basis. Other maintenance costs were spent by 47 farmers for minor repairs and replacement of drippers and parts of drip irrigation systems. Even, if the quality of material that is used is branded and high quality, the drip system is on soil and exposed to climatic conditions. Further, parts of the system may get destroyed by animals. Hence, the adopters do have to incur maintenance costs or even replace some parts. Overall, among adopters, 70 farmers had spent on an average Rs. 5,158 on annual replacement/maintenance cost of micro irrigation system.

Given that farmers net profit per hectare is Rs. 231,364 (for all 116 adopters as presented in Table 7.1). Farmers are able to recover the entire cost within the first year of investment.

Table 8.2: Annual Replacement/Maintenance Cost of Micro Irrigation

Item	No. reporting	Average for All Reporting Farmers			Percent Reporting Loan as Source of Funds
		Amount Paid (Rs.)	Subsidy Amount	Total Cost	
1. Filters (Cyclone, Disc, others)	5	2358.66	0.00	2358.66	0
2. Pipes (Micro, Distribution, Drip, PVC, PE, others)	8	25871.55	0.00	25871.55	0
3. Valves	4	662.50	0.00	662.50	0
4. Other maintenance/ replacement/repairs	47	1903.86	0.00	1903.86	0
5. Others (Acid Wash)	69	844.54	0.00	844.54	0
Total	70	5158.24	0.00	5158.24	0

Source : Field Survey

It may be noted that while the sample for adopters consisted of 116 farmers, only 70 farmers or 60.3 percent reported that they had maintenance costs while the others reported that they were not incurring any costs. However, the drip system needs regular maintenance in the form of atleast acid wash and cleaning of biological impurities in the pipes and if farmers avoid this, they will not be able to get the full potential benefits of Micro Irrigation.

8.3 Major Companies as Source of Drip System/Equipment/Parts/Service

There are several companies involved in the sales of drip irrigation systems and farmers can exercise their choice on selecting the company for purchase of the system. In Table 8.3, the companies from which the farmers sourced the dripsets/ initial capital items /parts is indicated.

It can be observed that out of 116 adopters in the sample, 60 farmers or 51.72 percent purchased the system from Jain Irrigation. This clearly indicates that Jain Irrigation was most popular among the farmers. This is however expected because in our sample, Jalgaon district was selected and the company is based in Jalgaon. As early as 1987, the company introduced this system to farmers in Maharashtra and those in Jalgaon got the advantage of location. The company used appropriate strategies to promote this technology with full technical support, installation, advisory and after sales service. Since most farmers were small, the company also developed components such as filters which were suited for small farmers. Hence since this company has its roots in Jalgaon and provides suitable

extension services to farmers, it is expected that farmers will have preference to this company.

About 21.55 percent of farmers purchased their equipment from Netafim and this company was preferred by some sugarcane farmers in Pune district. The company has introduced several initiatives in Maharashtra for sugarcane farmers such as sub-surface Drip Irrigation system as it improves the yield of the crop due to higher water and nutrient efficiency. This system also adapts to field size, shape and topography and reduces maintenance costs. On discussion with farmers in Pune district, it was revealed that Netafim had alliance with sugar mills for adoption of drip irrigation in sugarcane growing areas as well as with banks for financial assistance. The farmers were also provided help to avail the subsidy from the government. Hence these support services in terms of extension services as well as financial help, promoted the sales of Netafim. Further, the sugar mills benefitted as the sugarcane gave higher recovery.

Some farmers reported that they had used the services of Jain Irrigation and Netafim for repairs and maintenance. In some cases, the services of Finolex was also used.

Table 8.3: Major Companies as Source of Equipment/Parts/Service

Micro Irrigation Set/Kit/Initial Capital Items			**Micro Irrigation Maintenance**		
Company/Brand Name	**Number Reporting**	**Percent**	**Company/Brand Name**	**Number Reporting**	**Percent**
Jain	60	51.72	Jain	10	8.62
Netafim	25	21.55	Netafim	5	4.31
Parixit Irrigation Limited	8	6.90	Finolex	4	3.45
Botharo Agro equipment	4	3.45	Others	Not Reported	
Signet Group	4	3.45			
Kothari Agritech	3	2.59			
Others	12	10.34			

Source : Field Survey

Overall, it can be observed from this chapter, that fixed costs are an important component in the use of drip method of irrigation. Besides fixed cost, the mechanical device also requires regular maintenance as well as replacement of parts. The government provides subsidy, but the farmer has to also incur expenditure as well as maintain his system so as to secure maximum benefits from this method of irrigation. The companies selling these systems, also have to provide suitable extension services to farmers so that they can overcome any constraints while using this mechanical device.

Chapter 9

Factors and Determinants Affecting Micro Irrigation Adoption

Backdrop:

Water is a scarce input in Maharashtra and barely 18 percent of gross cropped area is irrigated. The monsoons are sometimes untimely and uncertain and there is over exploitation of ground water with poor recharge. In this scenario, MI technologies have tremendous potential to optimize on the usage of water, so that the area under protective irrigation can increase and farmers can also benefit from saving inputs and experiencing higher yields and earnings. However, MI can be promoted only if farmers perceive the inherent benefits of this technology, and are also able to afford it due to initial high fixed costs. Further, the farmers in order to adopt the technology must also be provided with awareness of the technology, and find it user friendly, besides having supporting infrastructure such as electricity, water and finance. Even if farmers are convinced that the technology is beneficial, they can only adopt it, only if there are several companies supplying MI equipment and of standard quality. Finally, for MI technology to spread, it is important that there are a number of dealers within reach of the farmers who provide them with reliable services as well as after sales service and also help the farmers in obtaining the subsidy provided by the government to purchase the MI system.

In this chapter therefore, an attempt is made to observe the perception of the farmers in the above mentioned requirements which can play an important role in promoting MI technology. The perception of farmers also provides useful insights as farmers are practising farming over years and have considerable experience in handling various inputs used by them as well as the conditions in the markets.

9.1 Determinants/Factors Affecting the Adoption of Micro Irrigation:

A framework reported in Gandhi (2014) has been adopted to conceptualise the determinants of adoption of MI system. The first and second group of determinants related to agronomic and agroeconomic potential of MI systems is reported in Table 9.1. The agronomic potential of drip irrigation was captured through questioning the adopters on yield increase and reduction in use of inputs. It was observed from Table 9.1, that all respondents either strongly agreed or agreed that MI increases yield. There was not even a single farmer who even partially disagreed that MI does not increase yield/output. A more

or less similar response was arrived at with respect to MI reducing water use and therefore saving water. As compared to conventional irrigation, in case of drip, the water is applied exactly near the root zone of the plants and hence there is no wastage due to deep percolation, seepage, conveyance losses and evaporation. Barely one respondent was not confident about MI reducing water use.

However, with respect to use of fertilizer and pest problems, more than half the sample farmers who adopted MI stated that they partially agreed/disagreed that MI reduces fertilizer use. Hence the opinion on this aspect is divided although 35.34 percent farmers agreed that MI reduces fertilizer use. This happens because fertilizer losses such as leaching and denitrification are avoided and this leads to fertilizer use efficiency. Also since MI allows for precision use of water, the soil does not have excess water which normally causes diseases and pests. However, hardly one-fifth of the adopters felt that pests had been reduced due to MI.

Almost two-third of the farmers reported that MI reduces weed problem and labour use. Since water is applied to the root zone of the plant in controlled quantities, as per the requirement of the plant, there is limited scope for weeds to grow and also the space between two laterals is kept dry which controls the growth of weeds. Less labour is normally required as land preparation in the form of furrows and ridges is not normally required. The MI system is such that less labour is used to water the plants and also there is less growth of weeds and hence no labour may be required for cleaning the surrounding area. About 62.93 percent of adopters felt that MI reduces the use of labour.

As far as the Agro-Economic Potential is concerned, 54.31 percent of adopters disagreed that the capital cost of MI is not high. It is clear that MI has a high fixed cost and considering that 61 percent farmers in the sample are marginal or small, it is expected that investment in MI is costly for them.

The response with respect to MI raising output quality/profit was encouraging as 76.72 percent of farmers agreed to this aspect. Normally fertigation through drip has the advantage of applying a proper dosage of fertilizer which gives better crop response than given through surface irrigation. Combining fertilizer with irrigation helps to improve the quality of the produce.

About 59.8 percent of adopters reported that MI reduces input use/costs but 12.07 percent disagreed on this aspect. Almost all respondents strongly agreed or agreed that MI increases profitability.

It is clear that MI has a huge fixed cost and 62.07 percent of adopters strongly felt that subsidy on MI is important. Most farmers are resource poor and in view of the high capital cost but also high benefits, the government has to provide subsidy in order to promote the use of this technology.

Table 9.1 Agronomic and Agro-Economic Potential Adoption of Micro Irrigation

Factors	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 2	Strongly Disagree (%) 1	Mean	No. Reporting
Agronomic Potential							
1.Micro irrigation increases yield/output	42.24	57.76	0.00	0.00	0.00	4.42	116
2.Micro irrigation saves water/ reduces water use	63.79	35.34	0.86	0.00	0.00	4.63	116
3.Micro irrigation reduces fertilizer use	1.72	35.34	55.17	7.76	0.00	3.31	116
4.Micro irrigation reduces pest problems/ pesticide use	1.72	19.83	68.10	10.34	0.00	3.13	116
5.Micro irrigation reduces weed problem	16.38	63.79	16.38	2.59	0.86	3.92	116
6.Micro irrigation reduces labour use	10.34	62.93	25.86	0.00	0.86	3.82	116
Agro-Economic Potential							
1. Capital cost of micro irrigation is not high	2.59	23.28	16.38	54.31	3.45	2.67	116
2. Micro irrigation raises output quality/profit	22.41	76.72	0.86	0.00	0.00	4.22	116
3. Micro irrigation reduces input use/costs	5.17	59.48	23.28	12.07	0.00	3.58	116
4. Micro irrigation increases profitability/incomes	31.03	68.10	0.00	0.86	0.00	4.29	116
5. Subsidy on micro irrigation is substantial /important	62.07	35.34	0.86	0.86	0.86	4.57	116

Source: Field Survey

Although there is a more or less unanimous opinion that MI increases profitability/incomes among the adopters, it is important that farmers must have awareness and information on this technology, for it to be further promoted as well as the availability of complementary inputs. These issues can capture the effective demand for MI system. The effective demand as well as the aggregate supply and easy availability of the MI products is gauged in Table 9.2. Since Maharashtra is a leading state in use of MI technology which is used largely for sugarcane and horticultural crops, about 95.69 percent of farmers in the sample either strongly agreed or agreed that information on MI is easily available and 98.82 percent strongly agreed or agreed that the technology is easy to

understand. However, the adopters did not seem to be fully satisfied with the availability of subsidy as 29.57 percent disagreed that subsidy was easy to get and 3.48 strongly disagreed that subsidy was easily obtained. About half the respondents felt that finance for MI is easy to get, but 28.45 percent partially agreed/disagreed and 12.93 disagreed.

An important complementary input for MI is the availability of electricity. However, 48.28 percent of adopters strongly disagreed that electricity for MI is easily available/reliable. This appears to be a serious issue and needs to be addressed. A more or less similar problem arose with respect to sufficiency of water for MI as only 45 percent of adopters felt that the water for MI was sufficient. Hence more than half the farmers in the sample were by and large dissatisfied with the supply of water for MI.

The Aggregate Supply of MI is equally important for the spread of this technology. Almost all adopters (99.13 percent), agreed that there are a large number of companies supplying micro irrigation equipment. This positive response is expected because Maharashtra is a leading state in adopting MI which was promoted by private sector. Jain Irrigation in Maharashtra provided full technical support to the farmers by adopting an integrated approach. The assessment of the feasibility of adopting MI, supply of equipment, installation of the system, capacity building, operation and maintenance were all provided by the company. NETAFIM is another major company in MI system and provides a wide range of solutions to provide cost effective irrigation. The company has also undertaken initiatives in Maharashtra to promote the use of MI through backward and forward linkage. With the support of global leaders in MI system, 92.24 percent of adopters felt that the quality of MI equipment was good. Hence, in Maharashtra, the aggregate supply of MI systems seemed to be pose absolutely no problem.

An important aspect is the distribution of the product and this is possible only if the dealers play a prominent role. With respect to distribution, 97.42 percent of respondents strongly agreed or agreed that there are a number of MI dealers located in the vicinity. About 86.21 percent strongly agreed or agreed that the quality of product provided by the dealers was good and could be trusted. However, 40.52 percent partially agreed/disagreed that dealers charged a reasonable price. The important point was that 90.51 percent of adopters strongly agreed or agreed that dealers arrange for subsidy /credit. If farmers receive such help from dealers, it will go a long way in promoting MI because farmers often find the process of obtaining subsidy/ credit very cumbersome and difficult. About 71.55

percent of adopters strongly agreed or agreed that the dealers provide after sales service. Again, this service is very important to encourage the use of MI systems because there are several problems associated with the use of the system such as choking, etc. Hence, if dealers provide satisfactory after sales service, it will definitely promote the use of this technology. Hence as far as distribution is concerned the picture seems fairly good in Maharashtra as dealers help farmers by providing quality products and after sales service.

Table 9.2 Effective Demand, Aggregate Supply and Distribution Factors of Micro Irrigation

Factors	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 2	Strongly Disagree (%) 1	Mean	No. Reporting
Effective demand							
1. Information on micro irrigation is easily available	50.86	44.83	2.59	1.72	0.00	4.45	116
2. Micro irrigation technology is easy to understand and operate	40.52	57.76	0.86	0.86	0.00	4.38	116
3. Subsidy for micro irrigation is easy to get	6.09	34.78	26.09	29.57	3.48	3.10	116
4. Finance for micro irrigation is easy to get	5.17	52.59	28.45	12.93	0.86	3.48	116
5. Electricity supply for micro irrigation is available/reliable	7.76	9.48	6.03	28.45	48.28	2.00	116
6. Water supply for micro irrigation is sufficient	9.48	35.34	34.48	19.83	0.86	3.33	116
Aggregate Supply							
1. There are a large number of companies supplying micro irrigation equipment	38.79	60.34	0.00	0.86	0.00	4.37	116
2. The quality and reliability of the micro irrigation equipment is good	28.45	63.79	2.59	4.31	0.86	4.15	116
Distribution							
1. There are a number of micro irrigation dealers located nearby	49.14	48.28	0.00	2.59	0.00	4.44	116
2. The dealers provide good quality products you can trust	17.24	68.97	9.48	2.59	1.72	3.97	116
3. The dealers charge a reasonable price	13.79	26.72	40.52	18.10	0.86	3.34	116
4. The dealers arrange for subsidy/credit	22.41	68.10	9.48	0.00	0.00	4.13	116
5. The dealers provide after-sales service	15.52	56.03	17.24	10.34	0.86	3.75	116

Source: Farmer survey

Availability of Spare Parts and Extension Services of Drip Irrigation

Availability of Spare Parts and Extension Services of Drip Irrigation Agency

Given the vast experience that farmers have, it was also considered important to note the perceived advantages and disadvantages of Micro Irrigation. The same is presented in Table 9.3. It can be observed that almost all adopters found advantage that the use of MI results in increase in yields, better quality of produce, high output price and less water requirement While almost three-fourths of the adopters perceived that there was advantage in reduction of input costs due to MI, there was an about 25 percent felt that it made no difference. With respect to labour use, about 31.03 percent of adopters felt that it did not make any difference, but the remaining felt that less labour was required. With respect to

weed problem, 78.45 percent of adopters felt that it had reduced which is expected as the area surrounding the plant does not get water which only goes to the root of the plant.

Table 9.3 Perceived Advantages and Disadvantages of Micro Irrigation

Item	Strong Advantage (%) 5	Advantage (%) 4	No Difference (%) 3	Disadvantage (%) 2	Strong Disadvantage (%) 1	Mean	No. Reporting
1. Higher Yields	21.55	78.45	0.00	0.00	0.00	4.22	116
2. Better Quality	25.86	73.28	0.86	0.00	0.00	4.25	116
3. High output price	18.10	78.45	2.59	0.86	0.00	4.14	116
4. Lower input cost	6.03	65.52	25.00	3.45	0.00	3.74	116
5. Less water need	64.66	32.76	0.00	2.59	0.00	4.59	116
6. Less labour need	6.90	62.07	31.03	0.00	0.00	3.76	116
7. Less weed problem	15.52	62.93	18.97	2.59	0.00	3.91	116
8. Less pest problem	1.72	20.69	70.69	6.90	0.00	3.17	116
9. Less fertilizers need	2.59	33.62	56.90	6.90	0.00	3.32	116
10. Easy marketing of output	7.76	76.72	13.79	1.72	0.00	3.91	116
11. Higher Profit	18.10	80.17	1.72	0.00	0.00	4.16	116
12. Less risk/ uncertainty	13.79	65.52	19.83	0.86	0.00	3.92	116
13. Employment for youth	0.00	39.66	46.55	13.79	0.00	3.26	116
14. Overall	23.28	68.97	6.90	0.86	0.00	4.15	116

Source : Field Survey

However, the respondents felt that by and large there was no difference with respect to pest problem as 70.69 adopters stated that MI use did not reduce the pest attacks. The response was similar with respect to fertilizer use as 56.90 percent of adopters did not perceive that less fertilizers were required with the use of MI. However, the response was encouraging with respect to advantage due to easy marketing of output, higher profit and less risk/uncertainty. The quality of produce is better with use of MI due to appropriate input use in the form of water and irrigation. Hence the farmers may be finding it easier to sell their produce and further due to higher yields, their profit is likely to increase. Therefore, farmers can benefit from both quality as well as quantity of produce. The advantage of risk reduction was also observed by 79.31 percent of adopters. Often during summer months the farmers suffer from severe water shortage which is required for perennial crops such as sugarcane. Since water in the well is saved due to drip irrigation, it

is utilized in the summer months when the climate is hot and crops require water. In the absence of water, the adopters of MI stated that there is every possibility that the crop may dry and they may lose their harvest. Hence use of drip enabled them to save their crop which means that the use of MI reduces risk and enables them to reap good harvest. Also, the saved water due to drip can be used if monsoons are delayed or fail.

An important impact of promoting MI technology, was that it can create employment opportunities, both in the form of skilled as well as unskilled. In the field if output increases, then employment may be generated for post harvest handling. Further, more shops may open for supply of spare parts, youth may be trained for installation of the system and after sales service, etc. However only 39.66 percent felt that the use of MI had the advantage of creating employment for youth while 46.55 percent felt that it made no difference.

Overall, considering all points, it was felt that MI had several advantages as reported by 92.25 percent of adopters.

The overall picture in the state of Maharashtra as revealed by adopters of MI revealed that MI increased yield, profits and saved water. However, subsidy was required to install the system as the fixed costs were high. Further, complementary inputs such as finance and electricity had constraints in the use of MI. The adopters were satisfied with the equipment supplied by companies and also with the dealers who helped them to obtain subsidy and also provide after sales service. The use of MI had several advantages and hence it appears that this technology should be further spread.

Chapter 10

Larger Impacts and Problems of Micro Irrigation

Backdrop:

The findings in the earlier chapters revealed that MI had substantial benefits, largely economic in nature. If large number of farmers in a village begin to adopt MI, they are bound to prosper which may improve the socio economic status of the village. Hence in this chapter an attempt is made to observe the larger impacts of MI as well as problems faced by adopters.

10.1 Larger Impacts of Micro Irrigation:

Micro Irrigation is popular in several districts/blocks of the state and there are several villages where a large number of farmers use MI. Taking into consideration that MI improves the economic status of farmers, it is possible that this may give rise to several positive externalities. The same is observed in Table 10.1.

Almost all adopters felt that the environment in the village had become positive and water had also been conserved. The prosperity in a village also percolates to women and different sections of the population residing in the village. However, only 43.10 percent of the adopters reported that there was a positive impact on women, and 48.70 percent reported that it had impact on upper caste. The encouraging feature was that 65.5 percent felt that there was a positive impact on the lower caste and 67.24 percent felt that the impact of MI use was positive for the Labour/Poor section of the village. A little less than half the respondents felt that MI had positive impact on Tribals and Youth but by and large there was no impact on upland and lowland farmers.

MI is expected to have a positive impact on the environment firstly because the village prospers, so there is an overall feeling of motivation for the residents of the village. Secondly, the soil health improves and precision water application does not cause flood in the field which reduces pests and diseases. This also helps to maintain the environment in the village. It is also possible that the village may suffer less from water borne diseases which improves the overall health of the residents.

Therefore, there is considerable scope for the use of MI to improve the village economy, not only in economic terms but also from the point of view of social and environmental aspects. The same has been observed to some extent in Table 10.1.,

Table 10.1: Larger Impacts of Micro Irrigation

Impact on	Substantially Positive (%) 5	Positive (%) 4	No Impact (%) 3	Negative (%) 2	Substantially Negative (%) 1	Mean	Number Reporting
1. Village as a whole	81.90	17.24	0.86	0.00	0.00	4.81	116
2. Water conservation/availability	57.76	42.24	0.00	0.00	0.00	4.58	116
3. Women	0.00	43.10	49.14	7.76	0.00	3.35	116
4. Upper Caste	0.87	48.70	49.57	0.87	0.00	3.50	115
5. Lower Caste	2.59	62.93	33.62	0.86	0.00	3.67	116
6. Labour/Poor	1.72	65.52	28.45	4.31	0.00	3.65	116
7. Tribals	0.00	47.89	50.70	1.41	0.00	3.46	71
8. Young farmers/Youth	0.00	47.41	37.93	14.66	0.00	3.33	116
9. Upland farmers	0.00	4.35	89.57	6.09	0.00	2.98	115
10. Lowland farmers	0.00	10.34	87.93	1.72	0.00	3.09	116
11. Environment	3.45	56.90	37.93	0.86	0.86	3.61	116

Source: Field Survey

The adopters of MI also face problems and the same is observed in Table 10.2. Atleast 49.14 percent of adopters disagreed that the quality of micro irrigation equipment is poor and only 12.93 percent agreed that the quality is poor. The view on high cost of maintenance is divided although by and large it was felt that MI does involve considerable maintenance. Water was also considered to be a problem by majority of adopters and only 31.89 percent disagreed that water was inadequate. The quality of water was however quite acceptable by the adopters.

While 45.69 percent of adopters agreed that there was difficulty in obtaining government subsidy, 31.90 percent partially agreed/disagreed. This indicates that the process of subsidy needs to be smoothened. MI system requires reliable supply of electricity, and 64.66 percent strongly agreed that that the supply was unreliable. This erratic supply of electricity causes substantial hardships to the farmers as the schedule to supply water to the plants gets disturbed. Farmers also suffered from lack of credit which

is necessary to invest in MI system. The farmers disagreed on lack of tube wells owned by them but 47.41 agreed that the cost of tube wells/wells was high.

A major problem was that there was exploitation of ground water and the water table was going down very fast. About 77.59 percent of adopters faced this problem because there was huge mining of underground water which was not getting recharged.

Farmers seemed satisfied with the training on MI imparted to them but their opinion on government support for use of MI was not clear. Possibly, even if farmers get support from the government, it appears that they are reluctant to recognize it, and always have more expectations from the government.

The adopters were satisfied with the number of MI dealers in the village and their after sales service. From the field visit also it was clear that there were a number of shops providing spare parts of reliable brands and they also helped farmers in several ways.

Farmers were satisfied with the profitability of their produce because their output increased due to MI, which in turn increased their income. About half the adopters in the sample felt that the marketing arrangements were poor but the other half were satisfied.

Half the adopters disagreed about land fragmentation, while 28.44 percent felt that there was land fragmentation.

A major problem facing users of MI was destruction of the system by animals. About 63.79 strongly agreed or agreed that their equipment and crop was destroyed by animals. This causes considerable losses and hardships to farmers. The problem of animal infestation into the fields was also due to lack of fencing and 56.03 percent of farmers strongly agreed/disagreed to this problem. The need for fencing the field is therefore important.

Table 10.2: Major Problems Faced by Farmers in Relation to Micro Irrigation

Problems	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 2	Strongly Disagree (%) 1	Mean	Number Reporting
1. Poor quality of micro irrigation equipment	0.86	12.93	17.24	49.14	19.83	2.26	116
2. High need/cost of maintenance in micro irrigation	1.72	35.34	42.24	18.97	1.72	3.16	116
3. Inadequate water	2.59	38.79	26.72	30.17	1.72	3.10	116
4. Poor water quality	0.00	27.59	23.28	44.83	4.31	2.74	116
5. Difficulty in obtaining government subsidy & support	3.45	45.69	31.90	15.52	3.45	3.30	116
6. Unreliable electricity supply	64.66	15.52	5.17	6.03	8.62	4.22	116
7. Lack of credit	2.59	25.00	43.10	26.72	2.59	2.98	116
8. Lack of own wells/tube wells	1.72	8.62	9.48	77.59	2.59	2.29	116
9. High cost of wells/tube-wells	1.72	45.69	27.59	22.41	2.59	3.22	116
10. Water table going down fast	18.97	58.62	6.03	12.93	3.45	3.77	116
11. Lack of knowledge/training for micro irrigation	0.00	10.34	8.62	55.17	25.86	2.03	116
12. Lack of government support	1.72	13.79	50.86	28.45	5.17	2.78	116
13. Difficulty in getting government support	0.00	18.10	40.52	35.34	6.03	2.71	116
14. Lack of micro irrigation dealers in area	0.00	1.72	2.59	47.41	48.28	1.58	116
15. Poor after sales service	0.00	11.21	12.07	62.93	13.79	2.21	116
16. Low output price/profitability	4.31	5.17	5.17	70.69	14.66	2.14	116
17. Poor marketing arrangements	17.24	27.59	6.90	38.79	9.48	3.04	116
18. Land fragmentation	10.34	18.10	21.55	33.62	16.38	2.72	116
19. Damage by animals	32.76	31.03	12.93	19.83	3.45	3.70	116
20. Lack of fencing	17.24	38.79	9.48	19.83	14.66	3.24	116

Source : Field Survey

Thus from the chapter it can be observed that while use of MI has brought about some positive features in the village, the users are also facing some major problems such as unreliable electricity, destruction of crops by animals and somewhat high maintenance cost of the system. These issues need to be addressed to promote the spread of Micro Irrigation.

Chapter 11

Overall assessment of the Performance of Micro Irrigation

Backdrop:

The adoption of Micro Irrigation is gaining popularity among farmers and there is strong potential to increase acreage under this method. The growth of this market is fuelled by several government initiatives for adoption of MI in order to conserve water. Equally important has been the role of private companies who manufacture the product and also research institutions who have conducted several trials to ensure the economic benefits accruing due to MI. Farmers have also begun to realize the benefits of this method over the conventional methods such as surface irrigation. While increasing water resources is an important but more difficult task, it is equally important to economize on the use of available resources. MI served as a solution as it is a water saving technology. In order to further promote MI, it is important to assess the performance of this method of irrigation and obtain suggestions for increasing the adoption and impact of MI. The same is attempted in this chapter.

11.1 : Overall Assessment of Micro Irrigation By Farmers :

The sample farmers who had adopted MI were addressed with questions related to the performance of MI and their interest in continuing with this method of irrigation. Their responses are tabulated in Table 11.1.

It can be observed from Table 11.1 that 88.79 percent of adopters reported that the performance of MI is good, while 7.76 percent found it excellent. The overall response clearly indicates that the adopters are largely satisfied with MI. They were also confident that MI had improved water use efficiency. About three fourths of the users felt that the system was good as it reduced input costs and 96.55 percent reported that use of MI increased incomes /profit. The most encouraging assessment was that almost all adopters, were certain that they would continue to use MI and even expand its use.

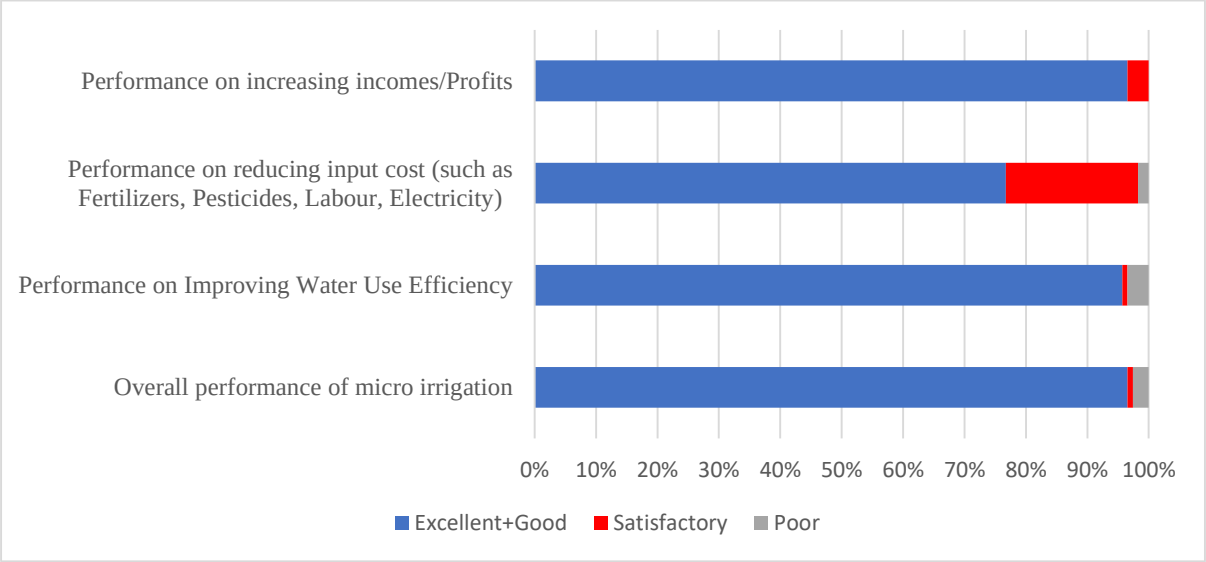
The above responses from the sample farmers who adopted MI is a clear indication that the users find the system good and more importantly they would continue with this method and even allocate more area under this method of irrigation. This will help to increase the yield per unit of volume of water.

Table 11.1: Overall Assessment of Micro Irrigation by the Farmers

Item	Excellent (%) 5	Good (%) 4	Satisfactory (%) 3	Somewhat Poor (%) 2	Very Poor (%) 1	Mean	Number Reporting
Overall performance of micro irrigation	7.76	88.79	0.86	1.72	0.86	4.01	116
Performance on Improving Water Use Efficiency	27.59	68.10	0.86	2.59	0.86	4.19	116
Performance on reducing input cost (such as Fertilizers, Pesticides, Labour, Electricity)	18.97	57.76	21.55	1.72	0.00	3.94	116
Performance on increasing incomes/Profits	22.41	74.14	3.45	0.00	0.00	4.19	116

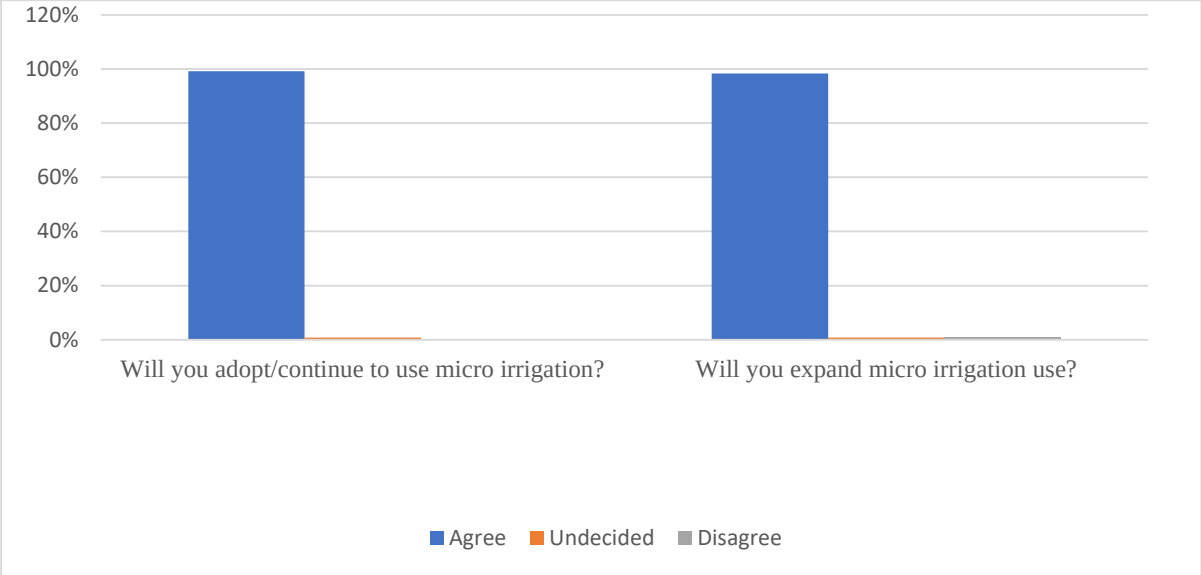
Source : Field Survey

Figure 11.1 Response of Sample Farmers (MI Adopters towards Performance of MI)



Source: Computed from Table 11.1

Figure 11.2 Farmers Willingness to Continue



Source: Field Survey

While there is almost unanimous response that the use of MI saves inputs, conserves water and increases yields, there is still scope for further improvement. Hence the adopters were questioned on their suggestions for increasing the adoption of this method of irrigation. Their responses are indicated in Table 11.2.

Almost all respondents strongly agreed or agreed that the MI equipment should be better and the price should also be lower. They perhaps want the MI system to be more convenient to operate through further automation and proper filtration as this will ensure efficiency of the system. Manufacturers too are making efforts to provide services to farmers so that the full potential of the system is realized. In fact manufacturers who supply the equipment to farmers have to apply online and only those manufacturers who can supply quality product as per BIS standards and provide prompt after sales service are allowed to register. Some farmers indicated that they had fear of short circuits and the possibility of the drip getting burnt due to fire. Further, although the system is beneficial to farmers, it entails a huge fixed cost and several other expenses associated with its use. Farmers felt that sand filter was required for drip system but no subsidy was available for the same. This added to the cost which was sometimes unaffordable. Use of MI is costly and hence 74.14 percent adopters strongly agreed and 23.28 percent agreed that the amount of subsidy should be increased so as to make the use more affordable. By and large the subsidy component was upto 55 percent

though it is increased in some districts and is limited upto a maximum of 5 hectares. However, farmers always have more expectations from the government and indicated that the subsidy component should be increased.

Table 11.2: Suggestions for Increasing the Adoption and Impact of Micro Irrigation

	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 2	Strongly Disagree (%) 1	Mean	Number Reporting
1. Better micro irrigation technology/equipment	56.90	37.93	4.31	0.86	0.00	4.51	116
2. Lower price of micro irrigation	48.28	45.69	2.59	3.45	0.00	4.39	116
3. More subsidy/ government assistance	74.14	23.28	2.59	0.00	0.00	4.72	116
4. Easier process for getting subsidy/ government assistance	37.93	57.76	1.72	1.72	0.86	4.30	116
5. More loans/ credit	20.69	72.41	3.45	3.45	0.00	4.10	116
6. Improve water availability	31.03	58.62	9.48	0.86	0.00	4.20	116
7. Better training for micro irrigation	17.24	51.72	27.59	3.45	0.00	3.83	116
8. Provision/support for farm fencing	72.41	24.14	2.59	0.00	0.86	4.67	116
9. Better marketing arrangements	40.52	46.55	5.17	6.90	0.86	4.19	116

Source : Field Survey

Most adopters also felt that the process of getting the subsidy should be made simple as they are not comfortable with online registration and submission of application. Also, while subsidy was available to the tune of 55 percent of the cost, the farmers required loan for the balance amount. Hence, they felt that more credit was required. However, the Government of Maharashtra realizing the importance of drip irrigation is gradually making it phase wise compulsory to use drip for sugarcane which is a water guzzling crop. Hence an incentive was announced for those farmers who repay their loan regularly. The loans are given to farmers at 7.5 percent interest and if the farmer regularly repays loans, then the state will bear the interest of 4 percent and sugar mills will bear 1.25 percent and farmers have to pay the balance interest which is barely 2 per cent. Also, in certain cases sugar mills provide loans to farmers and recover the amount while making payment to them.

Water is a scarce resource in Maharashtra and ground water is depleting and not getting recharged as there are years when droughts are consecutive. Hence water availability must be increased and water resources must be created. Farmers also agreed

that better training is required to adopt MI technology. Another problem facing farmers was that the crop was destroyed by animals and provision of fencing was required. Infact 72.41 percent of farmers strongly agreed that fencing was a pressing need to save their crop from wild animals.

With respect to marketing of the crop, majority farmers felt that the arrangements should be improved. In case of sugarcane the crop is sold to the cooperatives and hence the farmers have an assured market. With respect of bananas however, the produce needs to be handled properly as it is a highly perishable commodity. Hence proper arrangements for transport of produce to urban markets such as Delhi is required.

Overall, it can be concluded that MI, especially drip method used by adopters performed well and provided economic benefits to farmers. It was observed in chapter 7 that the net profit for farmers using drip method was 664.37 percent higher as compared to that when using surface method, while costs were only 15.67 percent higher. After investing in drip system, the farmers in order to get the optimum benefit, also invested more in better quality seed, fertigation and use of pesticide. Hence there was increase in cost of certain inputs but the economic benefits were far higher. The suggestions for further spread of MI, largely hinted at increasing the subsidy component as the system entailed huge fixed costs. Other factors to increase the output for farmers and promote drip irrigation, aimed at better extension services, fencing the field and strengthening the marketing arrangements.

Chapter 12

Non Adopters of Micro Irrigation: Profile & Issues

Backdrop:

Agriculture is an important economic activity in Maharashtra state which comprises of 36 districts and 255 talukas. The state hosts Mumbai- the financial capital of the country and totally urban, which brings down the percentage share of workforce in agriculture. However, majority of 36 districts in the state are still dependent on agriculture and allied activities for their livelihood. Despite agriculture being the main source of employment, farming is largely dependent on monsoons and there is lack of protective irrigation as only 18 percent of gross cropped area is irrigated. The biggest challenge for the state is to increase the area under irrigation and one way to achieve this is by utilizing the available water for irrigation in an optimal manner. MI is one of the solutions to this challenge and realizing its importance, both the central and state government have made attempts to promote this technology through awareness programmes, subsidy, backward and forward linkage, etc. While the government efforts have borne fruit, as the area under MI has increased over the years, there is still untapped potential.

In view of the above, in this study, besides observing the benefits and other issues relating to MI with respect to adopters, a sample of non-adopters of MI system was also considered. The main focus was to understand the reasons for which farmers were reluctant to adopt MI. This chapter attempts to study the cause of non adoption of MI, as this will provide a road map to further strengthen the adoption of such technology.

12.1 Profile of Non Adopters:

The profile of Non adopters of MI is indicated from Table 12.1 to 12.6. The same districts, namely Jalgaon and Pune which were selected for adopters were also selected for Non adopters. As observed in Table 12.1, the sample for Non adopters comprised of 13 farmers located across 7 villages in Jalgaon and 12 farmers spread over 6 villages in Pune. Hence total number of Non adopters was 25. It can also be observed from Table 12.1, that in Pune district, there was one farmer who was cultivating area under sugarcane without irrigation. The field survey revealed that the concerned farmer had about 2.43 hectares under sugarcane out of which half was irrigated and the other half was unirrigated.

The age composition of Non adopters indicated that 32 percent of Non adopters were above 60 years and from Table 12.2 it can be observed that older farmers were reluctant to switch to the use of MI technology. This maybe expected, because older farmers are used to a particular mode of farming and do not want to take the risk of switching over to a new technology. In contrast, the age profile of the Adopters of MI indicated that only 12.9 percent were above 60 years. Hence adopters were mostly in the younger age group and hence this served as an incentive to adopt the technology.

Table 12.1: Sample Coverage of Non Adopters

District Name	No. of Village	No. of Farmers Surveyed	With Irrigation	Without Irrigation
Jalgaon	7	13	13	0
Pune	6	12	11	1*

Source : Field Survey;
Note: * This farmer had 2.43 hectares under irrigation out of which half was irrigated and other half was unirrigated.

Table 12.2: Age Profile of Non Adopters

Particulars	Number	Percent
Under 20	0	0.0
20-30	3	12.0
30-40	4	16.0
40-50	5	20.0
50-60	5	20.0
Above 60	8	32.0
Total	25	100.0

Source : Field Survey

The education profile showed that the Non adopters belonged to different levels of education. About 28 percent were graduates and such educated farmers should be encouraged to use MI technology.

Table 12.3: Education Profile of Non Adopters

Particulars	Number	Percent
Illiterate	2	8.0
Primary	0	0.0
Middle	7	28.0
10thStd	5	20.0
12thStd	4	16.0
Graduate	7	28.0
Post-Graduation	0	0.0
Total	25	100.0

Source: Field Survey

The education profile of the adopters revealed that 51.72 percent were educated till Secondary school or higher whereas in case of Non-adopters, the same was 44 percent. Further, only 1.72 percent of adopters were illiterate, while in case of Non adopters, the share of illiterate in the sample was 8 percent. Perhaps, level of education is also an important factor which encourages the use of adopting MI technology.

The land profile of the Non adopters indicated that 36 percent were marginal, 20 percent were small and 44 percent were medium farmers. The average area operated by the Non adopters was 2.17 hectares out of which 97.7 percent was irrigated. However, in case of adopters, the average size of holding was 3.04 hectares. Also 7.76 percent of farmers were large farmers, while in case of Non –adopters, the sample did not have large farmers.

From Table 12.5, it is clear that the main source of water for Non-adopters was well and 57.58 percent reported that they used this source. Lift irrigation from river was the second most important source and 21.21 percent of farmers who were Non adopters used this source for irrigation. The majority of Non adopters felt that there was no scarcity of water and only 12 percent reported that there was scarcity of water. Perhaps, since about two-third of the farmers perceived that there was no scarcity of water, the need to adopt water saving technology through drip was not realized. In case of adopters also, the main source of water was well which was used by 58.50 percent of the sample. However, tube well was the second most important source and 20.41 percent farmers in the sample had used this source. The farmers using river lift among adopters was lower than those using the same among Non adopters. Hence, availability of river water which is often a perennial source of water, may be contributing to reluctance of farmers to be Non adopters of drip irrigation which is a water saving method. Assured supply of water discouraged Non adopters from using water saving technologies.

Table 12.4: Land Profile of Non Adopters

	Number	Percent	Total Area Average	Area Irrigated Average	Area Unirrigated Average
Landless/Tenant	0	0.00	0.00	0.00	0.00
Marginal (<1)	9	36.0	0.67	0.67	0.00
Small (1-2)	5	20.0	1.38	1.38	0.00
Medium (2-10)	11	44.0	3.75	3.64	0.11
Large (>10)	0.	0.00	0.00	0.00	0.00
Total	25	100.0	2.17	2.12	0.05

Source : Field Survey

Table 12.5: Water Sources and Situation

	Number	Percent
Water source		
Canal	0	0.00
Canal-Lift	2	6.06
River-Lift	7	21.21
Tubewell	3	9.09
Well	19	57.58
Tank	1	3.03
Pond	0	0.00
Farm Pond	1	3.03
Water situation		
Excess water	0	0.00
No scarcity	16	64.0
Occasional scarcity	6	24.0
Scarcity	3	12.0
Acute scarcity	0	0.00

Source : Field Survey

It can be observed from Table 12.6 that the main crop cultivated by Non adopters in the kharif season was cotton and cultivated by 7 Non adopters. The average area under cotton was 0.95 hectare and the entire area was irrigated. The main rabi crop was wheat which was also entirely irrigated. The perennial crops were sugarcane cultivated on an average area of 2.66 hectares and 0.88 hectare under banana which were entirely irrigated. In case of adopters, it was observed that the average area under sugarcane was 1.76 hectares which is lower than that of Non adopters. This indicates that Non adopters had larger area under sugarcane and assured supply of water. However, in case of banana, the picture was different. As the average area under banana by adopters was 3.23 hectares while in case of Non adopters it was 0.83 hectare. One Non adopter, in the sample cultivated pomegranate in an area of 1.21 hectares and another one farmer had a grape orchard of 2.83 hectares which was completely irrigated.

An overall comparison in the cropping pattern between adopters and Non-adopters of MI, revealed that adopters had a more diverse cropping pattern as compared to Non adopters.

Table 12.6: Cropping Profile of Non Adopters

Sr.No	Crop Name	No. of Farmers Reporting	Average Total Area	Average Irrigated Area	Average Un-Irrigated Area
Kharif					
1	Cotton	7	0.95	0.95	0.00
2	Maize	2	0.71	0.71	0.00
3	Grass	1	1.21	0.00	1.21
Rabi					
1	Wheat	5	0.77	0.77	0.00
2	Jowar	1	0.40	0.40	0.00
5	Horsegram	1	0.40	0.40	0.00
Perennial					
1	Sugarcane	12	2.66	2.66	0.00
2	Banana	6	0.83	0.83	0.00
3	Pomegranate	1	1.21	1.21	0.00
4	Grapes	1	2.83	2.83	0.00

Source: Field Survey;

After observing the profile of Non adopters and their cropping pattern, the most important issue was to observe the reasons for not adopting MI technology. The same is indicated in Table 12.7.

All Non adopters by and large agreed that the main reason for not adopting MI was that the equipment was not available. It is however surprising to note that Non adopters disagreed about the high investment cost on MI and its high operating cost. They also more or less agreed that the subsidy for MI is not available but three fourth of the Non adopters disagreed that the subsidy for MI is not sufficient. About two third of the Non adopters agreed or partially agreed/disagreed that credit for MI is not available.

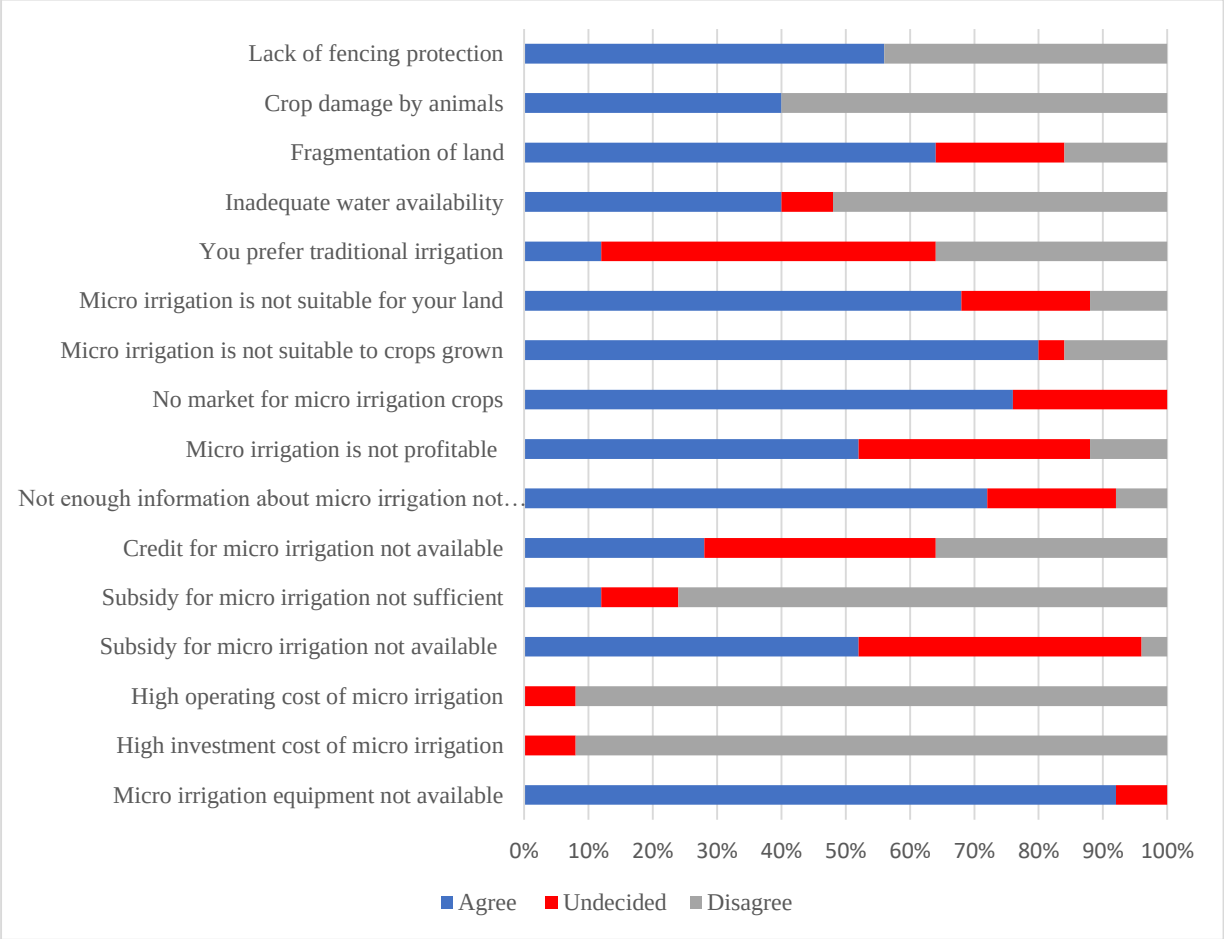
Majority of the Non adopters reported that there was not enough information on MI which was available to them. About 72 percent reported that MI was not suitable for their land and only partially agreed/disagreed or disagreed that they preferred traditional method of irrigation.

Table 12.7: Reasons for Non Adoption

Item	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 2	Strongly Disagree (%) 1	Mean	Number Reporting
1. Micro irrigation equipment not available	36.0	56.0	8.0	0.0	0.0	1.72	25
2. High investment cost of micro irrigation	0.0	0.0	8.0	52.0	40.0	4.32	25
3. High operating cost of micro irrigation	0.0	0.0	8.0	68.0	24.0	4.16	25
4. Subsidy for micro irrigation not available	4.0	48.0	44.0	4.0	0.0	2.48	25
5. Subsidy for micro irrigation not sufficient	0.0	12.0	12.0	48.0	28.0	3.92	25
6. Credit for micro irrigation not available	0.0	28.0	36.0	28.0	8.0	3.16	25
7. Not enough information about micro irrigation not available	12.0	60.0	20.0	4.0	4.0	2.28	25
8. Micro irrigation is not profitable	12.0	40.0	36.0	12.0	0.0	2.48	25
9. No market for micro irrigation crops	20.0	56.0	24.0	0.0	0.0	2.04	25
10. Micro irrigation is not suitable to crops grown	44.0	36.0	4.0	16.0	0.0	1.92	25
11. Micro irrigation is not suitable for your land	28.0	40.0	20.0	8.0	4.0	2.20	25
12. You prefer traditional irrigation	0.0	12.0	52.0	24.0	12.0	3.36	25
13. Inadequate water availability	12.0	28.0	8.0	28.0	24.0	3.24	25
14. Fragmentation of land	12.0	52.0	20.0	12.0	4.0	2.44	25
15. Crop damage by animals	24.0	16.0	0.0	24.0	36.0	3.32	25
16. Lack of fencing protection	40.0	16.0	0.0	24.0	20.0	2.68	25

Source : Field Survey

Figure 12.1 Reasons for Non Adoption



Source: Field Survey

With respect to water availability, the response was divided and 52 percent disagreed that there was inadequate water availability. The perception was by and large accepted that there was fragmentation of land and this could possibly be a reason for not using MI. However, 60 percent of Non adopters disagreed that the crop was damaged by animals but 56 percent agreed that there is lack of fencing protection.

Overall, while trying to perceive the reasons for farmers not to adopt MI technology, the important points which emerged was that they did not have sufficient information on MI and also subsidy was not available. They also perceived that the land was fragment which could serve as a constraint for MI. It therefore appears that more aggressive efforts are required to promote MI.

Chapter 13

Specific Major Problems, Needs, Innovations and Suggestions

Backdrop:

MI technology has several advantages and is gaining importance in the state of Maharashtra. The government, both at the Central as well as state level are making concerted efforts to promote this technology, in view of its substantial benefits for the farmers and also for the agricultural sector. Hence, it is important to understand from the grassroot level, the major problems faced while adopting this technology and suggestions for policy makers. Hence in this chapter, the specific major problems, innovations, needs, suggestions as well as issues pertaining to the subsidy given by the government are highlighted.

13.1 Major Problems, Needs, Innovations and Suggestions:

In Table 13.1 major problems, innovations, needs, suggestions have been presented in the form of 'Top 3", under each of various heads like (i) Major overall problems faced (ii) Major needs/requirements (iii) New Practises and Innovations (iv) Recommendations and Suggestion.

The observed results are as under:

(i) Major Overall Problems:

The farmers were asked open-ended questions on major problems faced by them in the adoption of Micro Irrigation. Overall 82 farmers out of 116 faced problems. The 'top 3' major overall problems faced by the farmers were:

(i) About 79.3 percent faced damage by rodents and squirrels which damaged the drip lines;

(ii) About 51.2 percent complained of damage by wild animals such as pigs and fox

(iii) Besides damage by animals, 19.5 percent of farmers faced major problems due to drip choke up.

The farmers complained that rodents/rats bite off the pipe and obstruct the smooth flow of water. If the damage is small, a small amount of water will continuously seep into spaces, causing toxic mold to accumulate which leads to considerable rotting of

any material in the field. As more and more water seeps, the damage caused increases which proves to be very costly for the farmer.

Besides, mice and rats tend to chew the water pipes which are already weakened and worn out due to exposure to the weather. This can result in the bursting of the pipe with a large amount of water loss.

Choke up in drip laterals was the third major reason. The chokeup can prevent the efficient functioning of the drip irrigation. Most of the farmers do not use filters either because it is costly or they do not feel that it is necessary. This causes the dirt/algae and other impurities from the water being conveyed from the wells to the fields to stick within the pipes. Also, if proper maintenance of the drip is not undertaken regularly and the drip laterals and pipes are not cleaned regularly, there is every possibility of chokeup of the device. Hence, using of filters and regular cleaning of drip laterals, will increase the life of drip irrigation.

AERC Pune (Gokhale Institute of Politics and Economics) team discussing problems related to Drip Irrigation with Adopters in Jalgaon District.

(ii) ***Major needs/ requirements for the success of micro irrigation***

Farmers were asked open-ended question on the major needs/ requirements for the success of micro irrigation. There were 30 responses generated by 24 farmers.

(i) 40 percent of the farmers who responded that the subsidy amount is insufficient and should be increased. Infact, several farmers reported that the subsidy amount should be increased to 80 percent and some felt that it should even by 100 percent.

(ii) The important point was that the subsidy was not available for filters which was quite costly. It is important for the drip device to have filters fitted so as to ensure clean and smooth flow of water. In fact many farmers did not adopt drip system despite subsidy, because they could not afford the cost of filters. Therefore about 20 percent of farmers suggested that subsidy should also be provided for filters.

(iii) The timely disbursal of the subsidy was also revealed by some farmers which will go a long way in promoting the scheme and making it successful. Some of the other suggestions that surfaced were advertisement about the scheme and also awareness about availability of loan for Drip system. Further, it was reported by some farmers that the period to avail the subsidy for drip again should be reduced. Presently the subsidy can be availed again after 7 years which is considered to be the life of the device. Some farmers stated that the period should be reduced to 5 years.

(iii) ***New practices and innovations undertaken while using micro irrigation***

The continuous use of a technology often leads to a new practise being adopted or even an innovation.

In the sample, 3 farmers reported that they began to use Mobile Starter Controller. It is a device to control and monitor agriculture pumpsets or any other electrical motors from a remote location, using mobile phone. This cell phone motor starter enabled the farmers to control the pumpset from a remote place which is at a distance from the farm. It also allowed the drip irrigation valves to be switched on/off by sending SMS to the starter. This

was made possible by the Drip irrigation valve controller which enables the pumpsets to be switched on and off from mobile phone through a missed call.

Few farmers also reported applying micro nutrients via drip irrigation tank. One farmer also reported using cow urine in the drip as liquid fertilizer.

(iv) *Recommendations & suggestions*

The three main recommendations of the farmers in the sample were that, the subsidy amount should be increased and there should be speedy disbursal of the same. They also reported that the device is fairly costly and the price should be reduced. The approval of the subsidy should preferably be within a month. With quicker approval, farmers will be able to take faster decisions and also adopt the system more quickly.

Another important suggestion received from the farmers was that the quality of the drip equipment must be such that the system is rat-proof and also there is fire insurance which should be included in the Government subsidy. Also, since there is considerable damage to the system by wild animals, fencing of the farm was very necessary and subsidy should be provided for the same. Subsidy.

The government under other schemes provides subsidy for solar pumpsets. Several farmers felt that this subsidy should be increased so that they can switch over to solar pumps and get the benefit of uninterrupted power supply which was often erratic. The erratic supply of electricity was a major problem among farmers and many farmers feared that this problem coupled with voltage fluctuation would cause a short circuit which in turn could lead to fire. Several farmers in the sample revealed that they received electricity only in the night and at that time they were not present in the field to monitor the flow of water. Hence a major suggestion among sample farmers was that the uneven supply of electricity must be adhered to, so that the use of MI would be more dependable and smooth.

Although Maharashtra has major companies such as Jain Irrigation Private Ltd and Netafim which are very active in extension services, many farmers still revealed that the service after sales, training to farmers on fitting the laterals and pipes of the system is very essential and needs to be strengthened.

As the drip device entails a considerable fixed cost, the Kisan Credit Card facility should be provided, to enable farmers to avail loans for purchasing the equipment and make

direct repayment to the company. One farmer reported that there should be more advertisement about loan facilities available for purchase of drip equipment.

Table 13.1: Major Problems, Innovations, Needs and Suggestions on Micro Irrigation

Top 3	Major Overall Problems Faced	Number Reporting	% of Respondents Reporting Problems (n=82)
1	Rodents, squirrel damage drip lines	65	79.3
2	Wild animals like pigs, fox damage the drip lines and pipes	42	51.2
3	Choke Up in Drip Laterals	16	19.5
Top 3	**Major Needs/ Requirements**	**Number Reporting**	**% of Respondents Reporting Problems (n=25)**
1	Higher subsidy	10	40.0
2	Quicker reimbursement of subsidy	8	32.0
3	Subsidy on pipes and filters	5	20.0
Top 3	**New Practices And Innovations**	**Number Reporting**	**% of Respondents Reporting Problems (n=12)**
1	Mobile Miss call Auto Start pump	4	33.3
2	Micro nutrients via Drip Irrigation tank	4	33.3
3	Using Cow Urine in the Drip for Liquid fertilizer	1	8.4
Top 3	**Recommendations And Suggestions**	**Number Reporting**	**% of Respondents Reporting Problems (n=34)**
1	Higher subsidy	12	35.3
2	Quicker reimbursement of subsidy	10	32.4
3	Reduction of price of drip	4	14.7

Source : Field Survey

13.2 Issues Pertaining to Government Subsidy in Maharashtra:

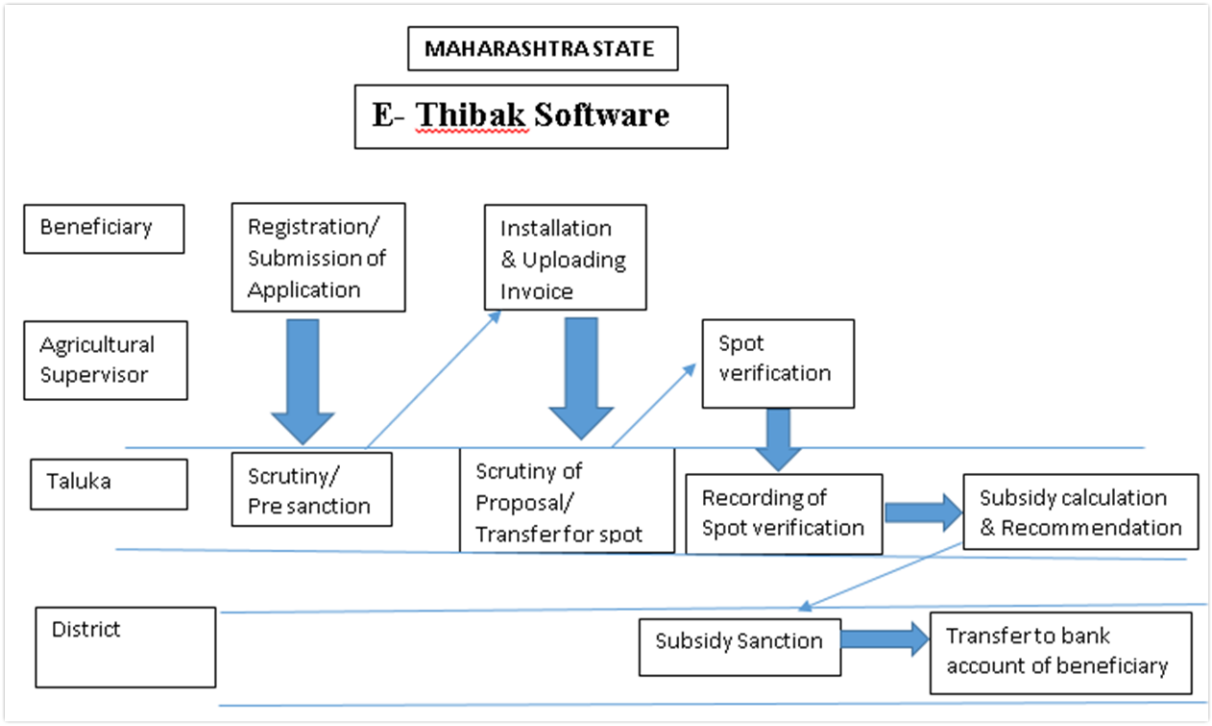
The state has a software namely *E-Thibak* for registration of subsidy and during the period 2012-13 to 2019-20, applications from farmers were accepted on this portal. Since farmers are not computer literate, the dealers normally fill up the applications and therefore help the farmers for registration. From 2020-21, the applications have to be made in

MAHADBT (Maharashtra- Direct Benefit Transfer) portal. The MAHADBT portal is not farmer friendly. The challenges faced by farmers in MAHA DBT portal and scheme are :

1. During registration the MAHA DBT portal has system issues: viz. Farmers having more than one plot of land are unable to fill the details; also in the case of some farmers, the land is in name of their children who are minor and the system does not have the provision to register the application of beneficiaries who are below the age of 18.
2. The system requires Aadhar linked mobile number for OTP. Many of the farmers do not have their Aadhar card linked to mobile. This prevent them from availing of the subsidy and hence the dealers first have to get the farmers' Aadhar card linked to their mobile number and then go in for registration.
3. Farmers do not fill the details as they are largely computer illiterate. The software is linked to their mobile number and through this they receive updates on the status of their applications. When the loan is sanctioned an SMS is received by the farmer.
4. However, it often happens that when the message is received by the farmer on approval of his subsidy, he has not seen the message or is unable to read it. This creates considerable disturbance for the farmers.
5. Once the application submitted, there is no edit option for the farmer, in case any changes are to be made during the process of registration.
6. The subsidy is received several months after registration and in some cases, it even takes more than a year.
7. The lottery system in DBT is huge disincentive for farmers not apply for the micro-irrigation scheme

The figure below explains the process of registering for the subsidy for MI in Maharashtra

Figure 13.1: Process of Availing Government Subsidy



Source : Commissionerate of Agriculture, Government of Maharashtra.

Since the system of registration is online, it creates transparency and also automatic updates to farmers on the status of their application. However, since the farmers are not well versed in online application and use of computer and mobile phones, they find the procedure cumbersome. Hence, it is very necessary for the farmers, especially those in the young and middle age group to become computer literate. This will enable them to not only register easily for government subsidies but also give them updates on several government schemes and also on use of technology in agriculture. Computer literacy will therefore be beneficial to the farmers and attempts in this direction will strengthen extension services.

Chapter 14

Conclusions and Policy Implications

Backdrop:

Irrigation serves as an engine to increase the productivity of crops as well as the cropping intensity, which in turns boosts the agricultural sector. Water is however a scarce resource and has several competing uses. In Maharashtra, agriculture is the largest user of water which consumes more than 80 percent of the state's exploitable water resources. The situation with respect to ground water, which is the major source of irrigation is precarious, and hence the need for judicious use of water is most important. It is largely in this context that Micro Irrigation (MI) technology is important and is being promoted since 1990s. This technology now forms a component of *Pradhan Mantri Krishi Sinchayee Yojana.*

In view of the above, this study on impact of *Per Drop More Crop* (PDMC) component of PMKSY has been undertaken. The government provides subsidy, payable to a beneficiary under PDMC which is 55 percent of the total cost of the MI equipment of small and marginal farmers and 45 percent for other farmers. The subsidy can be availed upto an area of 5 hectares. The study is based largely on primary data and field survey was conducted in two districts, namely Pune and Jalgaon. The crops selected were sugarcane, banana and cotton. The sample size consisted of 141 farmers, out of which 116 were adopters of drip irrigation and 25 were non-adopters. The reference year of the study was 2019-20.

14.1 Major Findings of the Study:

1. Maharashtra state is in the forefront in adopting MI technology which is practised since more than three decades. The progressive area under MI between the period 1986 to 2019-20 is 25.25 lakh hectares. As the gross irrigated area in Maharashtra is approximately 59.36 lakh hectares, it appears that 42.53 percent of gross irrigated area is under drip irrigation.

2. During the period 2015-16 to 2019-20, when *Per Drop More Crop* (PDMC) component of PMKSY was launched, the cumulative area brought under MI in the state was 6.42 lakh hectares. This indicates that 25.43 percent of area under MI in Maharashtra was increased under PDMC scheme.

3. The number of beneficiaries who received subsidy under MI technology were 12.17 lakhs during the period 2014-15 to 2019-20. The highest number of beneficiaries was observed to be in 2017-18 when 2.64 lakh beneficiaries availed of the subsidy under the scheme. The number of beneficiaries in 2018-19 were 1.75 lakh while those in 2019-20 were 1.69 lakh which indicates that the number of farmers who availed of the subsidy has declined over the years.
4. Out of 25.25 lakh hectares under MI, the maximum area was under cotton which was 6.07 lakh hectares or 24.04 percent of total area under MI. The share of sugarcane out of total MI area was 11.76 percent. Also MI technology is common for fruit crops such as banana, pomegranate, citrus fruits and grapes in Maharashtra.
5. In the sample of farmers adopting MI technology, it was observed that the average age of the adopters was 46 years and three fourths were in the age group of 30 to 60 years.
6. The level of literacy of the sample adopters, indicate that 21.55 percent had passed high school and 24.14 had completed intermediate level of schooling. Only 22.41 percent were graduates and 5.17 percent were post graduates.
7. The average area operated by the sample adopters of MI was 3.04 hectares and 3.01 hectares was irrigated. Out of the total irrigated area, 87.4 percent was irrigated through MI, while 12.6 percent was irrigated through other sources.
8. Out of the area under MI among sample adopters, it was observed that 98.85 percent area was under drip irrigation and only 1.15 percent was under sprinkler irrigation. Hence drip irrigation seemed to be the main source of MI. All farmers in the sample had availed of subsidy given by the government. For the state as a whole, it was observed from the data collected from the Department of Horticulture, Government of Maharashtra, that out of the total area under MI for the period 1986 till 2019-20 the share of area under drip was 71.2 percent and that of sprinkler is 28.8 which indicates that drip is the more popular form of MI. The two districts selected for our field survey were Pune and Jalgaon and it was observed that out of total area under MI in Jalgaon, the share of drip was 96.4 percent while the same for Pune is 91.16 percent.
9. The main source of irrigation was well and tubewell as 79 percent of respondents resorted to this source while 11.56 percent adopters had lift irrigation from river as the source. Three fourths of the respondents reported that they perceived that there was no scarcity of water. The soil of 94.83 percent of adopters was medium type,

terrain was flat and on an average they had 4 years of experience in using drip technology.

10. It was observed that the perception of farmers was that due to micro irrigation, the area under horticultural crops such as such as vegetables, chilli, onion and *mosambi* increased. Even wheat, a rabi crop therefore requiring irrigation seemed to have experienced an increase in area. After adopting micro irrigation, these crops also experienced increase in yield. Farmers cultivating sugarcane also reported increase in yield.

    The farm economics with respect to **sugarcane** indicated that the total variable costs for sugarcane cultivation under drip irrigation was Rs. 152,893 per hectare as compared to Rs168,890 per hectare without drip irrigation. Thus, it is observed that drip irrigation brought about reduction in costs. Labour mandays and labour costs in drip irrigation reduced by 37 percent and 40 percent respectively. The main reason for reduction in labour cost is that the farmer does not require labour for irrigating fields each time compared to flood irrigation. The farmer only requires two labour mandays in case of drip, once to put drip laterals at time of sowing and another removing the drip laterals after harvest from the field. Almost all farmers were using water soluble fertilisers through fertigation, which further reduced labour requirements and improved yields. The weed growth was negligible due to usage of drip, because water with fertigation goes straight to the root of the plant, and hence the surrounding area is dry. Therefore, there is thus limited scope for weeds to grow. This reduces labor cost for weeding, intercultural operations and weedicides.

11. Water soluble fertilisers deliver a more uniform nutrient supply to the crop as the fertilizer is applied as per the desired concentration and fertilizer losses such as denitrification are avoided. Water soluble fertilisers are however more expensive as compared to the granular fertilisers, which largely explained the reason that fertiliser costs and plant-protection costs are 7.7 percent and 12.7 percent higher in drip cultivation compared to without drip. The seed cost with drip irrigation is 11 percent higher than without and this is due to rise in seed cost over time.

The use of drip for sugarcane resulted in huge reduction in water charge as the water charges paid reduced by 72 percent mainly because less water is consumed with drip in

the cultivation of sugarcane. Further, less use of water also resulted in reduction in electricity cost which reduced by 20 percent. The total hours of pumping reduced by 57 percent in drip irrigation cultivation which brought about the reduction in electricity cost. Sample farmers reported that on an average they used to irrigate their sugarcane fields 57 times with flood method as compared to 52 times without drip. However, hours of pumping in per irrigation per hectare is 2.6 hours using drip method compared to 6.1 hours without drip. This leads to total hours of pumping of 145 hours in drip method compared to 332 hours without drip. Under drip method, more land was covered under irrigation in short time span and farmers were able to better manage their irrigation schedule compared to flood irrigation method.

12. Under drip method, per hectare yield of sugarcane was 1446 quintals compared to 1067 quintals without drip which means that yield increased by 35.5 percent. The price received by farmers using drip was also higher. Hence reduced costs, higher yields and higher prices resulted in sugarcane farmers receiving net profit of Rs. 245,542 per hectare with drip compared to Rs. 81,247 per hectare, ie. an increase of 202.2 percent.

13. In case of **banana** cultivation under drip irrigation the total variable cost was Rs. 250,882 per hectare as compared to Rs. 213,909 per hectare without drip irrigation. This indicated that the total variable costs increased by 17 percent. Planting material, fertilizer, plant protection and marketing costs were higher in drip method of banana cultivation. It was reported that in the reference period 2019-20, the farmers used tissue culture banana sapling (planting material) which costed Rs. 12 per sapling compared to normal banana sapling which costed Rs. 5 per sapling. The total planting material cost per hectare of land was Rs. 47,112 in drip method compared to Rs. 22,327 without drip. Similarly, fertiliser costs were 25 per cent higher in drip method compared to without drip. The reason being farmers using drip irrigation also used water soluble fertilisers, which enhanced the costs. However, this also brought about increase in yield.

14. Tissue culture plant for banana cultivation has a duration of 10-11 months, while traditional plant time duration is 12 months. Tissue culture plants also get 10-12 hands (bunch) compared to traditional banana plants which get 7-9 hands (bunch) per tree. Farmers also reported that average bunch weight per tree is around 23-25 kg in case of tissue culture plant compared 18-20 kg in traditional banana tree.

15. The labour mandays and labour costs in drip irrigation for banana cultivation reduced by 20.30 percent and 13.4 percent respectively. With drip 164 man days and without drip 206 mandays of labour use was reported. The number of irrigations with drip was 107 while without drip it was 76. Water charges and electricity charges, each reduced by 49 percent. There was reduction in electricity charges because total hours of pumping reduced by 60 percent in drip irrigation cultivation. Hours of pumping in per irrigation per hectare was 1.5 hours using drip method compared to 8.1 hours without drip. Thus total hours of pumping was observed to be 208 hours in drip method as compared to 524 hours without drip.

16. Under drip method, per hectare yield of banana was 604 quintals compared to 348 quintals without drip which means that yield increased by as much as 73.3 percent. Besides yield increase, the farmer also obtained higher price due to better quality of output. On an average, the price realization was Rs. 875 per quintal under drip method, compared to Rs. 640 per quintal without drip. The higher yields and higher prices resulted in banana farmers receiving net profit of Rs. 316,785 per hectare with drip compared to Rs. 6,048 per hectare without drip. This indicates that the profit from banana cultivation using drip method of irrigation is phenomenal as compared to cultivating the crop using surface method.
17. It was also observed that the marketing costs for the farmers cultivating banana increased after adoption of drip irrigation. This is expected because there was a huge increase in yield after adoption of drip method of banana cultivation. Since the farmers had more produce to sell, the cost of transport and other associated costs is likely to increase. Banana is a highly perishable crop and requires careful handling, failing which, the quality of the produce is likely to deteriorate. Hence, post harvest handling plays a very important role in the cultivation of banana and farmers had to therefore incur higher marketing costs.

18. **Cotton** farmers were also included in the sample and it was observed that the total variable costs for cotton cultivation under drip irrigation was Rs. 91,262 per hectare, as compared to Rs. 76,562 without drip irrigation, i.e drip adoption had a higher variable cost as compared to use of surface irrigation by 19.2 percent. It was observed that fertilizer, pesticide cost and farm yard manure costs were higher by 71.4 percent, 67.5 percent and 59.1 percent respectively in drip method of cotton cultivation.

19. Labour mandays in drip irrigation for cotton reduced by 32 percent, while labour charges were similar to that without drip. With drip irrigation, 81 man days and without drip 120 mandays of labour use were reported. While drip farmers gave 30 irrigations, without drip the irrigations were 12 in number. Electricity charges reduced by 12 percent because total hours of pumping reduced by 46 percent in drip irrigation cultivation. Hours of pumping in per irrigation per hectare was 1.3 hours using drip method compared to 5.6 hours without drip. This led to total hours of pumping of 49.4 hours in drip method compared to 92 hours without drip. However, water charges increased by 55 percent from Rs. 633 to Rs. 984 among sample growers.

20. Under drip method, per hectare yield of raw cotton was 27 quintals compared to 15 quintals without drip, i.e. increase by 79.9 percent. A farmer realised on an average Rs. 4929 per quintal under drip method compared to Rs. 3921 per quintal without drip. One reason for farmer realising higher prices is better quality of output and another is due to prices showing a rise during the period when drip was used as compared to the earlier period when the farmer used surface irrigation. With higher yields and higher prices, the cotton farmers received net profit of Rs. 43,198 per hectare with drip compared to losses of Rs. 22,057 per hectare in surface method. Thus the farmers adopting drip made 295.9 percent higher profits as compared to those who used surface irrigation. This huge difference in profits can largely be increased by yield increase which was higher by 79.9 percent for drip adopters as compared to use of surface irrigation.

21. Across all three crops, i.e. sugarcane, banana and cotton, it was observed that overall net profit for farmers using drip method was 663.37 percent higher as compared to those using surface method while costs were only 15.67 percent higher. This indicates that though farmers had to spend more on certain inputs such as seed, fertilizer and pesticide, the economic benefits were far higher.
22. Out of the total cost borne by adopters of drip irrigation, the subsidy provided to the farmers was 53.73 percent. Besides drip equipment, the farmers had to also incur expenditure on filters, pumps, pipes, etc. which amounted to about 37 percent of their expenditure on drip installation. The farmers reported that on one acre of area cultivated, they required 3300 metres of pipe and the cost of the pipe was Rs 12.50

per metre. They also reported that the annual maintenance cost for MI equipment was Rs 5,158 per annum.

23. The **Agronomic Potential** of drip irrigation was captured as all respondents either strongly agreed or agreed that MI increases yield. There was not even a single farmer who even partially disagreed that MI does not increase yield/output. A more or less similar response was observed with respect to MI reducing water use and therefore saving water.
24. With respect to use of fertilizer and pest problems the opinion was divided although 35.34 percent farmers agreed that MI reduces fertilizer use. This happened because fertilizer losses such as leaching and denitrification were avoided and this led to fertilizer use efficiency.
25. Almost two-third of the farmers reported that MI reduced weed problem and labour use. Since water is applied to the root zone of the plant in controlled quantities, as per the requirement of the plant, there is limited scope for weeds to grow and also the space between two laterals is kept dry which controls the growth of weeds. Less labour is normally required as land preparation in the form of furrows and ridges is not normally required. The MI system is such that less labour is used to water the plants and also there is less growth of weeds and hence no labour may be required for cleaning the surrounding area. About 62.93 percent of adopters felt that MI reduces the use of labour.
26. The Agro-Economic Potential revealed that only 27 percent of adopters agreed that the capital cost of MI is not high. It is clear that MI has a high fixed cost and considering that 61 percent farmers in the sample are marginal or small, it is expected that investment in MI is costly for them. About 62.07 percent of adopters strongly felt that subsidy on MI is important.
27. The response with respect to MI raising output quality/profit was encouraging as 76.72 percent of farmers agreed to this aspect.
28. About 59.8 percent of adopters reported that MI reduces input use/costs but 12.07 percent disagreed on this aspect. Almost all respondents strongly agreed or agreed that MI increases profitability.
29. Maharashtra is a leading state in the use of MI technology which is used largely for sugarcane and horticultural crops and hence about 95.69 percent of farmers in the sample either strongly agreed or agreed that information on MI is easily available and 98.82 percent strongly agreed or agreed that the technology is easy to understand.

This response captures the effective demand for Micro Irrigation. However, the adopters did not seem to be fully satisfied with the availability of subsidy as 29.57 percent disagreed that subsidy was easy to get and 3.48 strongly disagreed that subsidy was easily obtained. About half the respondents indicated that finance for MI is easy to get, but 28.45 percent partially agreed/disagreed and 12.93 partially disagreed.

30. An important complementary input for MI is the availability of electricity. However, 48.28 percent of adopters strongly disagreed that electricity for MI is easily available/reliable. This appears to be a serious issue and needs to be addressed. A more or less similar problem arose with respect to sufficiency of water for MI as only 45 percent of adopters felt that the water for MI was sufficient. Hence more than half the farmers in the sample were by and large dissatisfied with the supply of water for MI.
31. The **Aggregate Supply** of MI is equally important for the spread of this technology. Almost all adopters (99.13 percent), agreed that there are a large number of companies supplying micro irrigation equipment. This positive response is expected because Maharashtra is a leading state in adopting MI which was promoted by private sector. Jain Irrigation in Maharashtra provided full technical support to the farmers by adopting an integrated approach. The assessment of the feasibility of adopting MI, supply of equipment, installation of the system, capacity building, operation and maintenance were all provided by the company. NETAFIM is another major company in MI system and provided a wide range of solutions to provide cost effective irrigation. The company has also undertaken initiatives in Maharashtra to promote the use of MI through backward and forward linkage. With the support of global leaders in MI system, 92.24 percent of adopters felt that the quality of MI equipment was good. Hence, in Maharashtra, the aggregate supply of MI systems seemed to be pose absolutely no problem.
32. With respect to **distribution,** 97.42 percent of respondents strongly agreed or agreed that there are a number of MI dealers located in the vicinity. About 86.21 percent strongly agreed or agreed that the quality of product provided by the dealers was good and could be trusted. However, 40.52 percent partially agreed/disagreed that dealers charged a reasonable price. The important point was that 90.51 percent of adopters strongly agreed or agreed that dealers arrange for subsidy /credit. About 71.55 percent of adopters strongly agreed or agreed that the dealers provide after sales service.

Hence as far as distribution is concerned the picture seems fairly good in Maharashtra as dealers help farmers by providing quality products and after sales service.

33. The perceived advantages and disadvantages of Micro Irrigation revealed that almost all adopters found that the use of MI results in increase in yields, better quality of produce, high output price and less water requirement While almost three-fourths of the adopters perceived that there was advantage in reduction of input costs due to MI, about 25 percent felt that it made no difference. With respect to labour use, about 31.03 percent of adopters felt that it did not make any difference, but the remaining felt that less labour was required. With respect to weed problem, 78.45 percent of adopters felt that it had reduced which is expected as the area surrounding the plant does not get water which only goes to the root of the plant.
34. However, the respondents felt that by and large there was no difference with respect to pest problem as 70.69 adopters stated that MI use did not reduce the pest attacks. The response was similar with respect to fertilizer use as 56.90 percent of adopters did not perceive that less fertilizers were required with the use of MI. However, the response was encouraging with respect to advantage due higher profit and less risk/uncertainty. The quality of produce was better with use of MI due to appropriate input use in the form of water and irrigation. The advantage of risk reduction was also observed by 79.31 percent of adopters. Often during summer months, the farmers suffer from severe water shortage which is required for perennial crops such as sugarcane. Since water in the well is saved due to drip irrigation, it is utilized in the summer months when the climate is hot and crops require water. In the absence of water, the adopters of MI stated that there was every possibility that the crop may dry and they may lose their harvest. Hence use of drip enabled them to save their crop which means that the use of MI reduces risk and enables them to reap good harvest. Also, the saved water due to drip can be used if monsoons are delayed or fail.
35. An important impact of promoting MI technology, was that it could create employment opportunities, both in the form of skilled as well as unskilled labour. In the field, if output increases, then employment may be generated for post harvest handling. However only 39.66 percent felt that the use of MI had the advantage of creating employment for youth while 46.55 percent felt that it made no difference.
36. With respect to larger impacts of MI, almost all adopters felt that the environment in the village had become positive and water had also been conserved. However, only 43.10 percent of the adopters reported that there was a positive impact on women,

and 48.70 percent it had impact on upper caste. The encouraging feature was that 65.5 percent felt that there was a positive impact on the lower caste and 67.24 percent felt that the impact of MI use was positive for the Labour/Poor section of the village.

37. Adopters of MI also faced problems and atleast 49.14 percent of adopters disagreed that the quality of micro irrigation equipment is poor and only 12.93 percent agreed that the quality is poor. The view on high cost of maintenance was divided although by and large it was felt that MI involved considerable maintenance cost. Water was also considered to be a problem by majority of adopters and only 31.89 percent disagreed that water was inadequate. The quality of water was however quite acceptable by the adopters.
38. While 45.69 percent of adopters agreed that there was difficulty in obtaining government subsidy, 31.90 percent partially agreed/disagreed. About 64.66 percent strongly agreed that that the supply of electricity was unreliable.
39. A major problem was that there was exploitation of ground water and the water table was going down very fast. About 77.59 percent of adopters faced this problem because there was huge mining of underground water which was not getting recharged.
40. The adopters were satisfied with the number of MI dealers in the village and their after sales service. There were a number of shops providing spare parts of reliable brands and they helped farmers to overcome any difficulty faced by them in the use of drip irrigation.
41. Half the adopters disagreed about land fragmentation, while 28.44 percent felt that there was land fragmentation.
42. A major problem facing users of MI was destruction of the system by rats and rodents and 63.79 percent strongly agreed to this menace. Another problem was that of animal infestation into the fields due to lack of fencing and 56.03 percent of farmers strongly agreed/disagreed to this problem.
43. Most adopters also felt that the process of getting the subsidy should be made simple as they are not comfortable with online registration and submission of application. Also, while subsidy was available to the tune of 55 percent of the cost, the farmers required loan for the balance amount. Majority of farmers utilized their own funds for the balance amount required after the subsidy was availed.
44. The sample farmers who were Non adopters reported that the main reason for not adopting drip irrigation was that there was not enough information on MI which was

available to them while about 72 percent reported that MI was not suitable for their land.

14.2 Policy Suggestions:

The following policy measures emerge from the study:

1. Maharashtra is a water stressed state but also a major producer of sugarcane which is a water guzzling crop. While area under sugarcane was 11.54 lakh hectares (2018-19) in the state, only 2.97 lakh hectares or 25.73 percent of the area is irrigated by drip method. This indicates the huge untapped potential to adopt drip method and therefore save water. Extension services are therefore required and target beneficiaries should be educated on the technical and economic benefits of drip.
2. Drip technology must also be accessible to the farmers as the technology entails a huge fixed cost. Famers who were Non adopters often stated that they could not afford the fixed cost despite subsidy being provided by the government. Further, the installation of the device normally requires a filtration unit due to impurities in the water and subsidy is not provided for this component. The suggestion by farmers was that the subsidy for the drip equipment must be enhanced and subsidy should also be provided for filter unit.
3. The farmers also revealed that often the time taken for receiving the subsidy was long, often more than a year and the application should be processed faster with speedy release of subsidy.
4. Another issue with the use of drip irrigation was the regular maintenance that the devise required. There is regular clogging of the laterals and emitters which hinders the smooth and regular flow of water. As the equipment, mainly of plastic, is exposed to weather, there is need to replace parts, etc. This has served as a disincentive for Non adopters who remain reluctant to adopt MI technology.
5. Several farmers in the sample who were not adopting MI, were gradually getting encouraged about the benefits, but since they had easy access to water, they were reluctant to switch to MI and continued with the conventional method. Hence, more aggressive measures are required to encourage farmers to adopt drip method.
6. In Maharashtra, a major constraint faced by drip users was the shortage of electricity and its interrupted supply. Several farmers also had fear of short circuit which could cause fire. An important policy issue that emerged from the study was that the supply

of electricity must not be erratic and the availability must be increased. Often farmers received power supply only at night when they are not present in the field to monitor the flow of water.

7. In view of erratic electric supply and fear of short circuit, many farmers preferred to use solar pumps. Their expectation therefore was that the subsidy on solar pumps must be further increased.
8. In view of the fear of short circuit, several farmers revealed that fire insurance should also be included in the subsidy that was given by the government.
9. Another major issue with respect to drip, was the damage caused to the lateral distribution line by rodents which led to uneven distribution of water. While the life of a drip device is considered to be 7 years, the destruction of the system by rats reduces the life and hence after incurring fixed costs which are considerable, the farmer cannot get optimum benefit of the system. The farms also did not have fencing and the fields were destroyed by stray animals. Hence, these issues have to be addressed to ensure that the device is not destroyed by animals.
10. Maharashtra ranks first in the country with respect to area under cotton which is about 42.1 lakh hectares. Despite cotton being a major crop, the state suffers from low yield which is much below most states and also below national average. The main reason for low yield is that the crop is mainly rainfed and failure of monsoons leads to crop failure. Further, in case of irrigated cotton, irrigation by drip gives much higher yield as compared to conventional irrigation. There is therefore huge potential to increase the yield of cotton by adopting drip method of irrigation. Our sample indicated that adoption of drip system, increased the yield by almost 80 percent as compared to surface irrigation. Drip method of irrigation will go a long way in increasing the production and productivity of cotton which will help to boost the agricultural economy of Maharashtra.
11. The registration for subsidy is through the *E Thibak* portal. While this system ensures complete transparency and updates to the farmer on the status of his proposal, there was a complaint by the farmers on several challenges faced by them in using this portal. Often, the land was in the name of a minor child, or the Aadhar card was not linked to the mobile number and overall the online system was cumbersome. The dealers however helped the farmers to overcome their difficulties. However, it is important that farmers must complete all formalities and also become computer

literate. Hence while providing extension services to farmers, computer literacy must be included.

Overall, the study has clearly indicated the benefits of Micro Irrigation, notably drip irrigation, which is gaining popularity in Maharashtra. Irrigation is a crying need for the state and use of Micro Irrigation technology will help to conserve the scarce water resources, especially in case of crops such as sugarcane. The state is also well known as a horticultural state which is high value agriculture and as Micro Irrigation further spreads, the productivity of crops will increase and farmers will reap higher returns with suitable marketing practises. This will not only strengthen the agricultural sector but also serve as a catalyst of growth for the manufacturing and service sector as easy supply of raw materials will be available for agro processing industries which in turn will stimulate the service sector. Micro Irrigation can therefore help to change the face of the economy of the state.

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Appendix 1.1

(I) Title of the Draft Study Report Examined:

Improving Water Use Efficiency in India's Agriculture: The Benefits, Impact and Challenges of Micro-Irrigation under the Pradhan Mantri Krishi Sinchayee Yojana: Per Drop More Crop (PMKSY-PDMC) in Maharashtra

(II) Date of Receipt of the Draft Report: 18 February, 2021

(III) Date of Dispatch of Comments: 22 April 2021

Comments from Centre for Management in Agriculture, Indian Institute of Management Ahmedabad. Project Coordinator: Prof. Vasant Gandhi

(IV) A. General Comments

1. Given the topic and the objectives, this is a very important study in the context of India's agriculture and the efficient use of scarce natural resources. Water use efficiency and productivity are poor in India and there is a great need and scope for improving them. In this context, micro irrigation is a very promising and highly efficient water saving technology. Given the government objectives of substantially increasing its use, it is very important to understand the factors affecting its adoption, the impact, and the performance of micro-irrigation, and particularly the outcomes of the PMKSY-PDMC scheme which strongly promotes the adoption of micro irrigation in the state of Maharashtra.

2. The study objectives are sound and appropriate. They include examining the adoption of micro irrigation, and its efficiency in saving water and other inputs. They also include examining the impact of micro-irrigation on cropping patterns, crop productivity, input use, incomes and development in Maharashtra, also touching upon the constraints faced by the non-adopters of micro-irrigation.

3. The study has undertaken a very good investigation using sound research design and survey instruments and collecting good data through primary field investigation. The report presents the study and its analysis and findings very well and in great detail, providing some excellent insights into the adoption, performance and impact of micro irrigation in the state, as well as the efficacy of the PMKSY-PDMC scheme.

B. Comments on the Methodology, Analysis and Presentation

1. The methodology, analysis and presentation are sound, but some minor checking and editing is required,

2. Page 37: A few other concluding observations can be added on page 37 at the end of the chapter. Similarly, check other chapters to add/ improve concluding sentences.

3. Page 43-52-Chapter-7- This is a very important chapters. The changes between with-MI and without-MI should be highlighted more and discussed.

4. Page 54 – You can give the estimated rate of return on investment using net profit increase from previous chapter, and the total investment reported in this chapter

5. Page 57- Table 8.3- Few other company names can be added if possible

6. Page 59- The Table 9.1 is very important. The Table is too big and you can break the Table into parts by one or two factor group: Agronomic Potential, Agro-economic Potential, Effective Demand, Aggregate Supply, and Distribution. You already have write-ups on each, and these can be moved above each Table. The reference for the model is: Gandhi, Vasant P. 2014, "Growth and Transformation of the Agribusiness Sector: Drivers, Models, and Challenges", Indian Journal of Agricultural Economics, Vol.69, No.1, Jan-Mar.

7. Page 71: Electricity supply/ reliability is a serious problem – needs to be highlighted

8. Page 72-73 Table 11.1-This in an important Table showing the overall assessment of micro irrigation by farmers. A Figure can be added using 5+4 Excellent+Good, 3, and 2+1.

9. Page 75 last para – states that "performed well and provided economic benefits to farmers" - a little more emphasis/ stronger expression is required regarding the performance in light of the results.

10. Page 76-79 – some broad comparison between non-adopters and adopter profile is required. This can be at least be descriptively done comparing results across different Tables, such as on age, education, land holding, source of irrigation, and crops.

11. Page 79- Table 12.7- A Figure could be added highlighting a few important factors of non-adoption using the percentages (Strongly Agree + Agree).

12. Chapter 13 Page 81- This is a good chapter mentioning the important specific issues and problems seen in the field. The electricity supply/ unreliability problem should be added.

Other Comments on the Presentation of Report

A. Table and Figure Presentation:

You may check the format of all the Tables, some of the Tables required formatting, for example Table 13.1. Kindly check for consistency in Table and Figure Title/Sources. Other comments are already given above.

B. Other Issues:

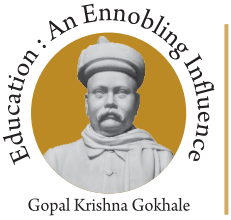
1. Please add subtitles in the executive summary to improve readability.

(V) Overall View on Acceptability of the Report

This is a very good report based on a good investigation, and presents the background, approach and findings of the study very well. It has a substantial amount of useful details and analysis on the important subject covered. The report should be accepted, and if the suggestions and comments made can be addressed to the extent possible, it will help to further improve the report.

Appendix 1.2

All suggestions made by the Coordinator have been addressed.



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