Study Number - 190

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

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Study sponsored by Ministry of Agriculture and Farmers Welfare
Government of India, New Delhi

Agro-Economic Research Centre
(For the States of West Bengal, Sikkim and Andaman & Nicobar Islands)
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PREFACE

The present study entitled "*Improving Water Use Efficiency in India's Agriculture: The Impact, Benefits and Challenges of Micro-Irrigation under the Pradhan Mantri Krishi Sichai Yojana: Per Drop More Crop (PMKSY-PDMC) in Sikkim*" was undertaken at the instance of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, Krishi Bhavan, New Delhi as a coordinated study, where the task of coordination has been entrusted with the CMA, IIM, Ahmedabad. This report has been an individual centre's report on the study concerned carried out in Sikkim and prepared by our centre, AERC, Visva-Bharati, Santiniketan.

As improving water-use efficiency in farming is expected to play a key role in bringing about growth in Indian agriculture, there are policy efforts to promote micro irrigation through schemes like PMKSY-PDMC (Pradhan Mantri Krishi Sinchayee Yojana-Per Drop More Crop). However, the results of such efforts are yet to be enumerated, and it is here that the present study intends to assess the impact and challenges of micro irrigation in the state of Sikkim.

The study has been primarily entrusted with Dr. D. Roy and Mr. D. Majumder, while Dr. R. K. Biswas and Mr. K. S. Chattopadhyay provided immensely valuable assistance in data collection and processing under the active supervision of the undersigned. Extensive support has also been obtained from Prof. Manesh Choubey of Sikkim University. I take this opportunity to convey my sincere thanks to the officials of the Agriculture and Horticulture Department of Government of Sikkim. Special mention should be made of Mr. Padam Subba, Principal Director, Dept. of Horticulture; Mr. Bhim Dahal, Addl. Director, Dept. of Horticulture; Mr. Jiwan Kr. Chettri, Addl. Chief Engineer, Dept. of Agriculture and Horticulture; and Mr. Dikendra Bhujel, Jt. Director (South District), Dept. of Horticulture for their immense cooperation in course of field survey. I offer my deepest thanks to all of them.

On behalf of this centre, the undersigned takes the opportunity to thank the study coordinator, viz. Center for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad, for their painstaking work on coordination of this immensely important study across the individual centers, especially for organizing the entire study design with detailed chapterization and table formats.

Sd/-

Santiniketan
Date: 30.09.2020

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EXECUTIVE SUMMARY

1: BRIEF INTRODUCTION OF THE STUDY

India has a population of nearly 130 crore and it is expected to rise at a steady pace in the coming years. To keep up with growth in population, agricultural production has to increase in order to meet the ever growing demand created with this population increase. In order to meet the future demand for food in a sustainable manner, each farm is required to have access to irrigation. It is here that the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is conceived in the year 2015 by the Government of India as an umbrella scheme for coverage of more and more area under assured irrigation as early as possible. Among the components of the PMKSY scheme, the PDMC component aimed at increasing on-farm water-use efficiency by using suitable water conveyance and precision water application devices like drips, sprinklers, pivots and rain-guns in the agricultural farms. Like other states in the country, the Pradhan Mantri Krishi Sichai Yojana (PMKSY) has also been implemented in the state of Sikkim, which is helping in the development of irrigation infrastructure, by supplementing existing irrigation facilities. It is here that this study tries to examine the impact of the component Per Drop More Crop (PDMC) of Pradhan Mantri Krishi Sichai Yojana (PMKSY) in the state of Sikkim.

2: OBJECTIVES OF THE STUDY

The main objective of the study is to analyze the various benefits of micro irrigation to the farmers including in input use, costs and returns. Specifically, the objectives are to examine the following:

1. to examine the savings of various inputs such as water, fertilizers, power, pesticides and labour;
2. to examine the enhancement of productivity, quality and other benefits in selected agriculture/ horticulture crops including water-intensive crops such as sugarcane and banana, and if there is employment generation due to MI;
3. to examine the adoption of MI including some of its determinants/ features such as need/ importance of subsidy, culture of water conservation, issues of fragmented land holdings, capital cost, maintenance cost and the distribution of subsidy;
4. to study overall impact on farmer incomes and the cost-benefit in selected crops; and

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

3: METHODOLOGY OF THE STUDY

The present study has been conducted based on both primary and secondary data. For collection of primary data in Sikkim, a multi-stage stratified random sampling method has been adopted. As such, in the first stage, two districts from Sikkim, namely districts East and South, have been selected in consultation with the officials of the Department of Agriculture and Horticulture of Government of Sikkim. While selecting the districts, scale of adoption of micro irrigation has been considered as a major determinant in the district selection process. In the second stage, two blocks from each of the selected districts have been selected following similar criteria, viz. scale of adoption of micro irrigation in the blocks. Next, lists of farmers of each block have been collected and the farmers were stratified into two categories based on adoption of micro irrigation i.e. adopters and non-adopters. Lastly, from each of the selected districts, 48 micro irrigation adopter farmers and 12 non-adopter farmers have been selected randomly spread more or less evenly across the respective blocks of the districts. Thus, a total of 120 farmers have been selected to form the sample size of the study of which 96 are adopters of micro irrigation and 24 are non-adopter farmers. The secondary data has been collected from the Department of Agriculture and Horticulture, Government of Sikkim.

4: MAJOR OBSERVATIONS OF THE STUDY

After a detailed analysis of various aspects of adoption of micro-irrigation system in the state of Sikkim, as described in the present study, some important concluding observations come out, which may be outlined as follows-

4.1: PROFILE OF MICRO-IRRIGATION ADOPTION IN THE STATE

- The implementation of PDMC-MI, PMSKY is executed through Horticulture Department, Govt. of Sikkim. The PDMC-OI, PMSKY Programme is executed by Agriculture Department, Govt. of Sikkim.
- The study finds that since 2015-16 funds allocated for *PMKSY-PDMC in Sikkim has increased over time at an annual growth rate of 6.69 percent*.

Year-wise Growth of Micro-Irrigation in the State

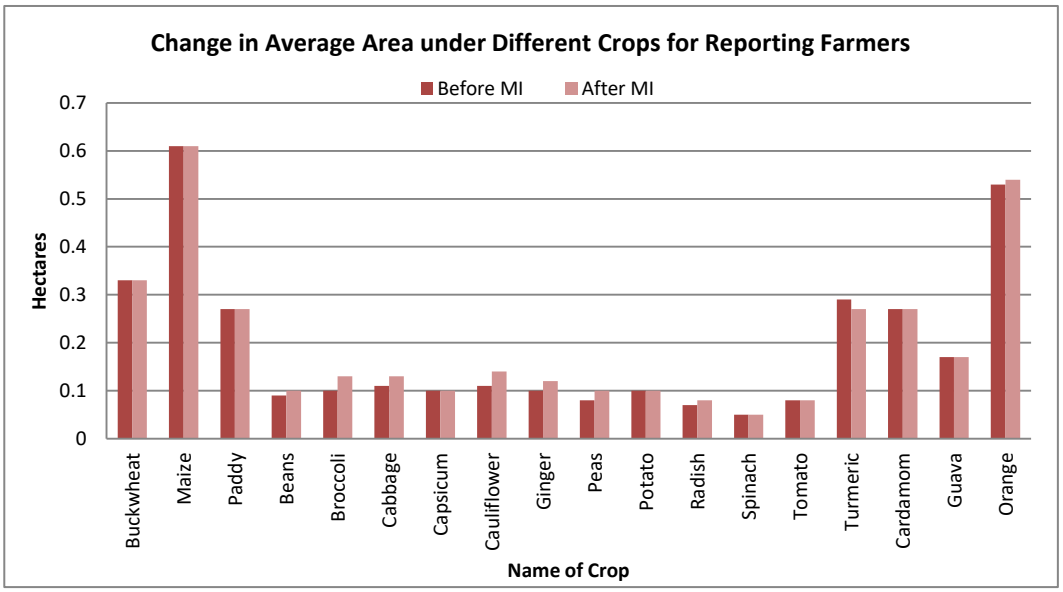
Year	Funds allocated/ received under PMKSY-PDMC (Rs. In Lakh)	Area under Micro Irrigation (MI) (in Ha)	Number of Beneficiaries	MI as % of total irrigated area
2014-15	Nil	Nil	Nil	Nil
2015-16	413.42	772.50	2083	4.29
2016-17	NA	NA	NA	NA
2017-18	436.00	663.60	1659	3.36
2018-19	2018.22	2524.00	6010	11.89
2019-20	1200.76	1724.00	4270	7.20
Annual Growth Rate				6.69

Source: Department of Horticulture, Govt. of Sikkim

- A district-wise breakup of area under MI during 2018-19 reveals that area under micro irrigation was highest in the East district followed by West, South and North.
- Among the various crops that were receiving micro irrigation of *various kinds vegetables including Peas and Beans accounted for 47.55 per cent of total area under micro irrigation in 2018-19.* Buckwheat, Barley and oil crops accounted for over 17 per cent while Cardamom plantation including Cardamom nursery had a share little over 12 per cent. Orchards, however, had 5.12 per cent share of total micro irrigation in that year.

4.2: CROPPING PROFILE AND CHANGES

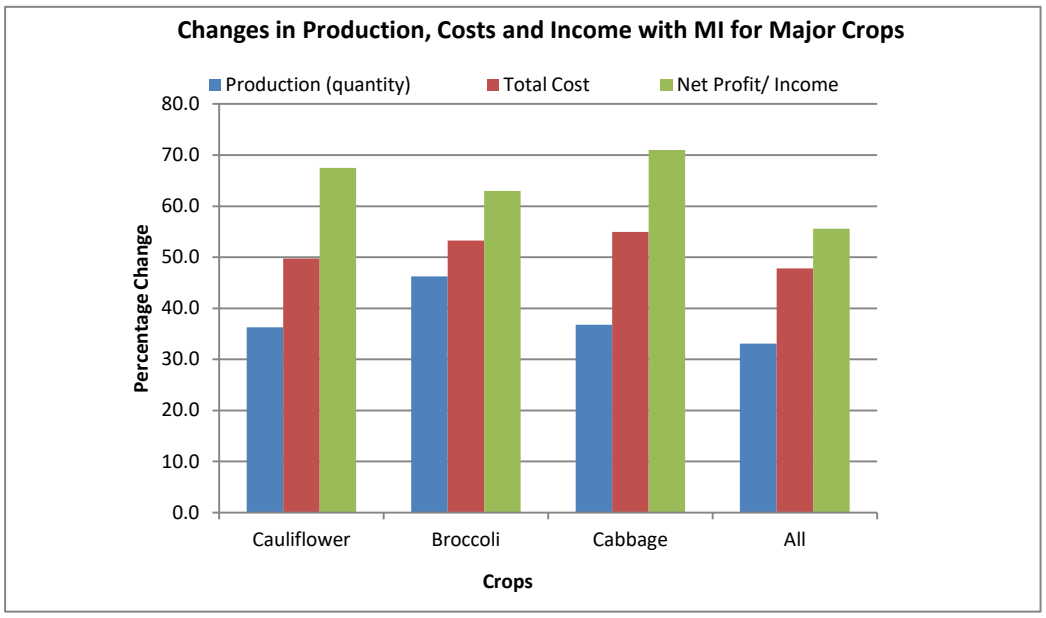
- With the introduction of micro-irrigation, *there has been a marked shift in the cropping pattern in favour of major vegetable crops like cauliflower, broccoli, cabbage, peas and beans by bringing in new land under cultivation*, irrigated through sprinkler irrigation method.



- Along with increase in area under cultivation, *the major vegetable crops in the Rabi season has also witnessed an increase in their yields* due to the introduction of micro-irrigation techniques.

4.3: CHANGES IN INCOMES AND FARM ECONOMICS WITH MICRO IRRIGATION

- In case of production of major vegetable crops, viz, cauliflower, broccoli and cabbage, it has been observed that while *production of broccoli increased by 46.23 per cent, that of cauliflower and cabbage comes out to be 36.26 percent and 36.75 per cent respectively*.
- Though total costs of cultivation for cabbage, broccoli and cauliflower increased by 54.96 per cent, 53.26 per cent and 49.75 per cent respectively, the corresponding *increase in profit stands much higher at 71.01 per cent, 67.48 per cent and 63.01 per cent respectively*.
- Similarly, decrease in labour cost as proportion of total cost comes out to be 6.14 per cent for cauliflower, 7.99 per cent for broccoli and 2.25 per cent for cabbage.



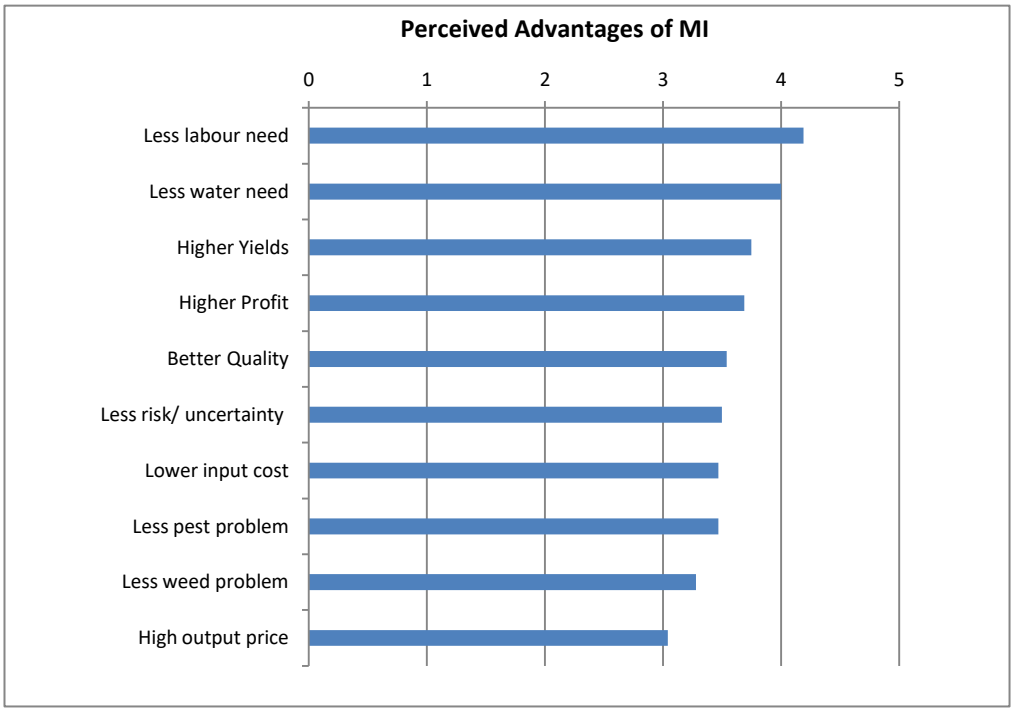
- Findings relating to farm-economics before and after the introduction of micro-irrigation thus indicate that, adoption of micro-irrigation comes out to be a profitable notion, which in turn induced an increase in the area under cultivation, higher yield and lower costs of account of labour power in particular. Thus, *micro-irrigation comes out to be a high-yielding, labour-saving and cost-efficient technology with positive acreage effect*.

4.4: Capital and Maintenance Cost of Micro Irrigation

- In the state of Sikkim that these concerns regarding *initial capital costs/investments remain largely inapplicable, as there has been 100% subsidy assistance* for adopting micro-irrigation for the adopter farmers, and they did not have to pay any money or take any loan for installation of micro-irrigation.

4.5: Factors and Determinants Affecting Micro-Irrigation Adoption

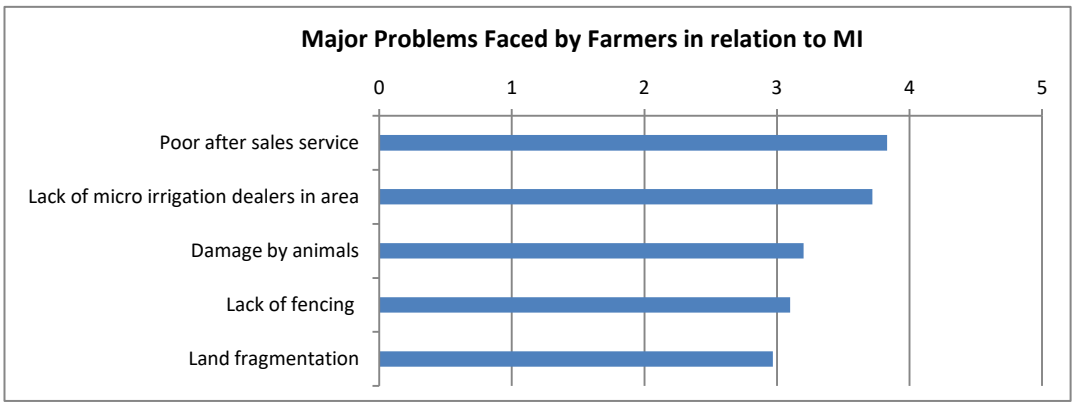
- In case of agronomic potential as a determinant of adoption of micro-irrigation, a large section of adopters agreed on the point that *MI had a positive impact in reduction of labour, water usage, and yield* as well.
- In view of agro-economic potential of micro irrigation, a sizeable proportion (over 97 per cent) of MI adopters were of the opinion that *subsidy on micro irrigation played the most important role in adoption of MI*.
- On the effective demand side, we observed that the *easy technology, available subsidy and availability of information regarding MI got priority in the responses* (respective mean values of response score were 3.84, 3.79 and 3.70) as determining factors of MI adoption.
- On the supply side, there were fewer complaints as regards to the quality of the instruments that were being provided as *82.3 per cent was in agreement that the kits being provided were good and reliable*.



- The *strongest advantage of MI, as perceived by the adopters, had been lesser usage of labour in MI and reduction in water usage*.
- On the whole, *implementation of MI had been advantageous to 90.6 per cent of adopters*.

4.6: LARGER IMPACT AND PROBLEMS OF MICRO-IRRIGATION

- It is found that *MI has had a positive impact in improving the condition of the village* as a whole as confirmed by 62.5 per cent of the respondents.
- *Impact of MI was significantly higher among the lowland farmers*, as perceived by the respondents, than their upland counterpart, which might have been due to an increase in water pressure by gravity pull as water went down the hilly terrain in Sikkim.
- Apart from young people, the *MI has been observed to have a positive impact across caste and gender of the respondents*. No discriminatory nature of programme implementation in view of caste/age/gender/economic position of the family is observed.
- There seemed to have little problem with quality of the MI equipments or high maintenance cost. However, there have been a *very poor after sales services provided by the MI dealers*.



4.7: OVERALL ASSESSMENT OF THE PERFORMANCE OF MICRO-IRRIGATION

- The general opinion regarding the overall performance of micro irrigation and *its role in improving water use efficiency were considered to be 'good' by a majority of adopters*.
- As regards to increase in income and profit the respondents answered in positive. However, *an overwhelming majority of the adopters (more than 92 per cent) agreed to continue with MI*.
- It turned out that provision of *better marketing arrangement and better training for micro irrigation is considered to be beneficial for earning more profit from MI*.

4.8: NON-ADOPTERS OF MICRO-IRRIGATION: PROFILE AND ISSUES

- *There has not been much difference between socio-economic profiles and cropping profile of the sample pool of adopters vis-à-vis non-adopters*, except for the fact that average availability of irrigation is far less for the non-adopters as compared to the adopters of MI.
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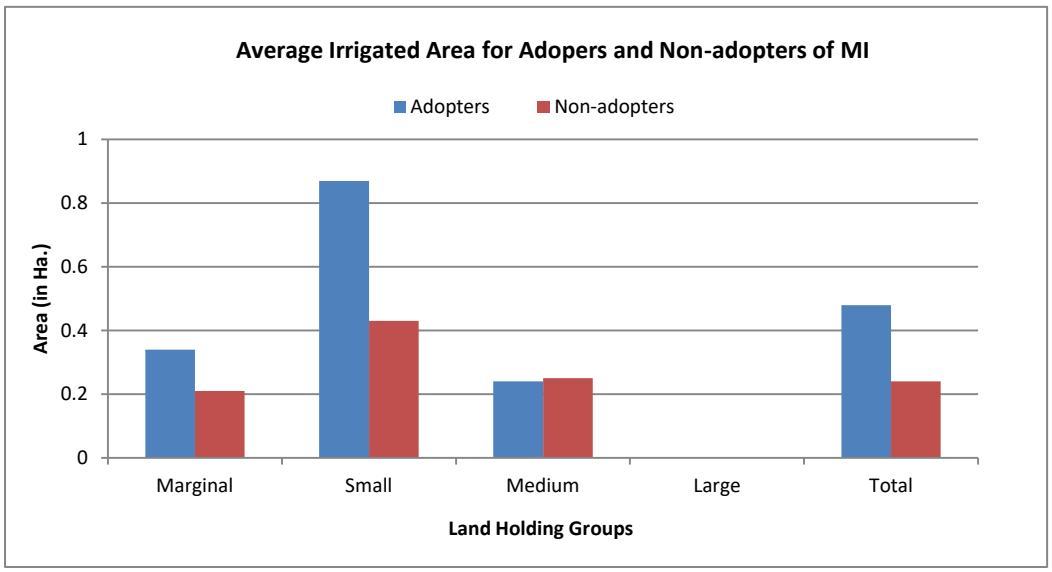
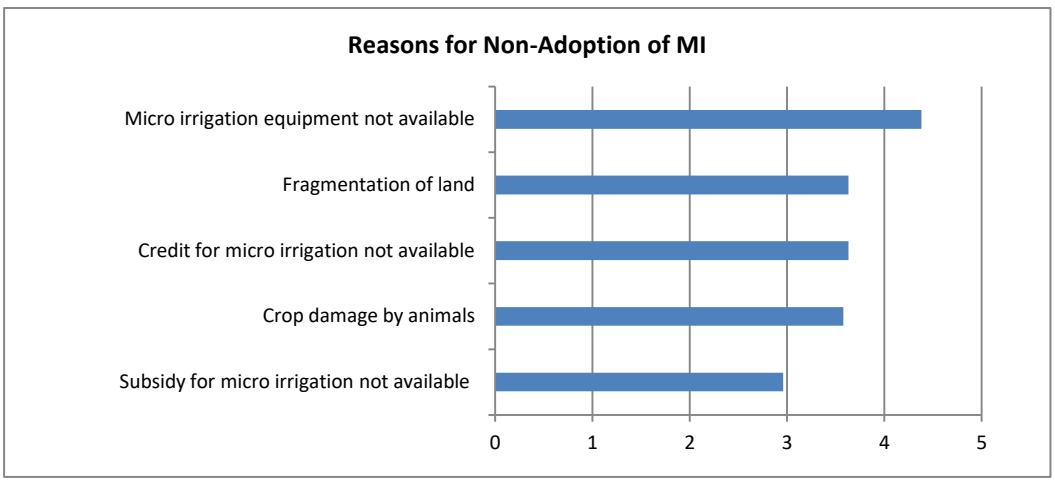


- The non-adopter farmers' response regarding non-adoption of micro-irrigation indicates that though they consider micro-irrigation as a suitable, profitable technique involving low operating cost and a ready market for output; the *non-availability of micro-irrigation equipments, credit for installation of MI and lack of government subsidy are the prominent reasons behind non-adoption on micro-irrigation*.



4.9: Specific Major Problem, Needs, Innovations and Suggestions

- *The major problems in the adoption of MI as perceived by the adopters relates to scarcity of water flow, followed by crop damage by wild animals and clogging of feeder pipes.*
- The most common *recommendation/suggestion was towards making provision for more MI clusters and setting up of micro irrigation at a larger scale* within the village cluster itself.

4.10: Work Flow and Monitoring by the Implementing Agency

- The implementation of PDMC-MI is executed through Horticulture Department, while the PDMC-OI Programme is executed by Agriculture Department *as per GoI guidelines* through online registration of beneficiaries, DBT and installation by certified companies.

5: Policy Recommendations

Based on the major observations of the study as stated earlier, a few policy recommendations may be sketched out as follows-

- As MI system has come out to be very effective in hilly slopes of a state like Sikkim, policies like *PDMC should be implemented proactively in hilly states* to reap out the benefits of MI.
- The agro-climatic condition of hilly state like Sikkim comes out to suit horticulture, particularly vegetables, enhancing area, productivity and reducing costs. As such, policies on *MI system should target expansion of area, particularly in hilly states*.
- The provision of 100 per cent subsidy comes out to have a significant and determining role in the adoption of MI. As such, while promoting MI system, the State and the Central *Government should continue subsidizing the initial costs of installation of MI*.
- In the absence of after-sales service by the MI equipment suppliers, there *should be training camps to impart basic knowledge on maintenance* of the MI kits provided.
- The government should step-in and form SHGs/ FPOs to *facilitate easy transportation and arrange for marketing of the crop output* to ensure reasonable price.

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LIST OF ACRONYMS

AIBP	Accelerated Irrigation Benefits Programme
DAC&FW	Department of Agriculture, Cooperation and Farmers Welfare
DBT	Direct Benefit Transfer
GoI	Government of India
HKKP	Har Khet Ko Pani
MGNREGA	Mahatma Gandhi National Rural Employment Gurantee Act
MI	Micro Irrigation
OI	Other Interventions
PDMC	Per Drop More Crop
pH	Potential of Hydrogen
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PVC	Polyvinyl Chloride
RCC	Reinforced Cement Concrete
RRR	Repair, Renovation and Restoration
SMIC	Sikkim Micro Irrigation Council
WD	Watershed Development

1

INTRODUCTION

1.1: BRIEF INTRODUCTION OF THE STUDY

India has a population of nearly 130 crore and it is expected to rise at a steady pace in the coming years. To keep up with growth in population, agricultural production has to increase in order to meet the ever growing demand created with this population increase. In order to meet the future demand for food in a sustainable manner, each farm is required to have access to irrigation. However, much of the available irrigation water in India is applied through the conventional surface irrigation methods, which not only involve poor irrigation efficiency, but also create environmental problems, like, lowering of water table due to overexploitation of sub-surface water resources, water-logging and soil salinity, thereby adversely affecting the crop yields (Global Agrisystem, 2014). This calls for improving the water use efficiency of the available water resources through proven water saving technologies such as micro irrigation systems, which deliver water through small devices directly in the plant root zone at prescribed rate at regular interval of time.

Hence micro irrigation is expected to play a key role for the future of Indian agriculture in fulfilling the goal of increasing productivity while saving water at the same time. It is here that the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is conceived in the year 2015 by the Government of India as an umbrella scheme for coverage of more and more area under assured irrigation as early as possible. Its major components are:

(i) Accelerated Irrigation Benefits Programme (AIBP) for major and medium irrigation including National Projects;

(ii) Har Khet Ko Pani (HKKP) which includes command area development and water management works, surface minor irrigation, irrigation through groundwater, and repair, renovation and restoration (RRR) of water bodies;

(iii) Per Drop More Crop (PDMC) through micro irrigation; and

(iv) Watershed Development (WD) for rain-water harvesting, effective management of the run-off water, prevention of soil erosion, regeneration of natural vegetation and recharging of the groundwater table.

These four components cover all sides of irrigation and address the need for enhanced water use efficiency; expansion of irrigation coverage; judicious use of water; and water

harvesting and conservation. The scheme put social emphasis on completion of incomplete projects and command area development, which offer large gain with small investments.

Among the components of the PMKSY scheme, the PDMC component focuses on micro level storage structures, efficient water conveyance & application, precision irrigation systems, topping up of input cost beyond MGNREGA permissible limits, secondary storage, water lifting devices, extension activities, coordination & management - being implemented by DAC&FW (Government of India, 2017). The component PDMC is aimed at increasing on-farm water-use efficiency by using suitable water conveyance and precision water application devices like drips, sprinklers, pivots and rain-guns in the agricultural farms. It also covers extension activities for promotion of scientific moisture conservation and agronomic measures including adoption of suitable cropping pattern so as to obtain maximum benefits with minimum use of available water.

`The main objectives of Per Drop More Crop (Micro Irrigation) are as under-

- Increase the area under micro irrigation technologies to enhance water use efficiency in the country.
- Increase productivity of crops and income of farmers through precision water management.
- Promote micro irrigation technologies in water intensive/consuming crops like sugarcane, banana, cotton etc and give adequate focus to extend coverage of field crops under micro irrigation technologies.
- Make potential use of micro irrigation systems for promoting fertigation.
- Promote micro irrigation technologies in water scarce, water stressed and critical ground water blocks/districts
- Link tube-well / river-lift irrigation projects with micro irrigation technologies for best use of energy both for lifting and pressurised irrigation as far as possible.
- Establish convergence and synergy with activities of on-going programmes and schemes, particularly with created water source for its potential use, integration of solar energy for pressurised irrigation etc.
- Promote, develop and disseminate micro irrigation technology for agriculture and horticulture development with modern scientific knowledge.
- Create employment opportunities for skilled and unskilled persons, especially unemployed youth for installation and maintenance of micro irrigation systems.

Like other states in the country, the Government of Sikkim has been implementing various minor irrigation schemes since 1976 from various sources of funds. The Pradhan Mantri Krishi Sichai Yojana (PMKSY) has also been implemented in the state, which is helping in the development of irrigation infrastructure, by supplementing existing irrigation facilities. The cultivation practices in hill slopes are done in terraces for which, irrigation water is applied through channels to these terraces and water is transferred from upper terraces to lower terraces in controlled manner and there is no major pumping of water through electric pumps are involved. Since, only minor irrigation schemes are implemented in Sikkim due to topographical limitation, the various components of irrigation infrastructures constructed are of small in nature (Government of Sikkim, 2020), and hence the micro-irrigation system may well suffice the irrigations requirements of the state.

It is here that this study tries to examine the impact of the component Per Drop More Crop (PDMC) of Pradhan Mantri Krishi Sichai Yojana (PMKSY) in the state of Sikkim. The objective of this study to analyze the various benefits of micro irrigation to the farmers including input use, costs and returns. It aims at examining the savings of various inputs including water, the enhancement of productivity, and overall impact on farmer incomes. The study also aims at examining the adoption of MI including some of its determinants such as need/ importance of subsidy, capital cost, maintenance cost and the distribution of subsidy and tries to identify problems in the benefit transfer work flow and monitoring by the implementing agency. The scope of this study is as follows. First, it provides an overview of the status of micro-irrigation adoption in state of Sikkim. Next, it deals with the socio-economic aspects in relation to micro irrigation, which is based on analysis of: i] sample profile of the adopters of micro-irrigation along with land area and water sources, ii] changes in cropping profile, income and farm-economics, along with capital and maintenance cost of micro irrigation iii] factors and determinants affecting micro-irrigation adoption, larger impacts and problems, and overall assessment of the performance of micro-irrigation. Also, in contrast to the adopters, the present study also covers non-adopters of micro-irrigation with an analysis of their socio-economic aspects and cropping profile. Then, the study attempts to examine major problems, needs innovations and suggestions. Lastly, the study draws conclusions and policy implications based on the findings.

2

BACKGROUND OF THE STUDY

2.1: BACKGROUND OF THE STUDY

In the face of inefficient use and concerns of growing water scarcity, the present day irrigation in Indian agriculture generally emphasizes and focuses on technological solutions. Micro irrigation technology such as those based on drip and sprinkler systems are being increasingly used as ideal technological solutions for achieving water conservation (Nama M, Balram, Suthar B K, Meena D, Meena D; 2016) and water use efficiency. It is often argued that irrigation efficiency in general and economic efficiency in the use of irrigation water in particular, shapes the economy of the farming sector (Palanisami K, Raman S, Mohan K, 2012).

A survey of literature on the impacts of micro-irrigation technologies indicate that adoption of micro-irrigation is usually promoted primarily for one or more of the following objectives: (1) as a means of saving water in irrigated agriculture, (2) as a strategy to increase income and alleviate poverty, (3) to enhance the food and nutritional security of rural households, and (4) as a means to extend the limited available water over a larger cropped area (Regassa E. Namara, Bhawana Upadhyay and R. K. Nagar, 2005). Various studies in India have shown a considerable return to farmers' investments in micro-irrigation technologies in terms of a number of ways. Some of these positive impacts are the increased number of crops per year that can be grown with the adoption of the technology as there is water available for the next season as well. The technology therefore helps to increase the cropping intensity and which itself results in higher income and better agronomics. The technology is also shown to help in expanding cropped area which also helps to derive advantages of economics of scale as well into the agronomics. The technology also helps to increase the yield from existing crops and thus it positively impacts the land productivity as well and therefore makes agriculture more profitable for the adopters (Bhamoriya V, Mathew S, 2014). In particular, a study by CIIE, IIM-Ahmedabad (CIIE-IIM Ahmendabad, 2018) has shown that micro-irrigation induces a savings of water in the rage of 33-50 per cent, savings in labour in the rage of 35-40 per cent, and savings in fertilizer in the rage of 21-25 per cent. It also estimated an increase in productivity by 25-30 per cent and increase in income by Rs.17000/- per hectare.

However, despite the reported significant economic advantages and the concerted support of the government and NGOs, the current area under micro irrigation in India

remains an insignificant proportion of its potential (Global Agrisystem, 2014). In particular, only 12.2 per cent of potential drip irrigation area and 7.8 per cent of potential sprinkler area is covered in the country with large variations across states (K. Palanisami and S.Raman, 2012). The poor adoption can be attributed to number of factors such as high cost, complexity of the technology and other socio-economic issues such as a lack of access to credit facilities, fragmented landholdings, localised crop pattern, etc. (Palanisami K, Mohan K, Kakumanu K R, Raman S; 2011). Even after 70 per cent or more subsidies provided by the central and state governments, the adoption rate is quite slow. Thus it is often argued that being capital intensive, the economic viability of MI systems is sound for high valued cash crops and orchards, especially in areas where groundwater availability is extremely limited (Kumar M D, Turral H, Sharma B, Amarasinghe U and Singh O P, 2008).

In this background, the present study attempts to analyze the various benefits of micro irrigation to the farmers including input use, costs and returns, savings of various inputs, enhancement of productivity, and overall impact on farmer incomes. The study also aims at examining the need/ importance of subsidy, capital cost, maintenance cost and the distribution of subsidy and tries to identify problems in the benefit transfer work flow and monitoring by the implementing agency, emphasizing on control and treatment farmers.

2.2: OBJECTIVES OF THE STUDY

The main objective of the study is to analyze the various benefits of micro irrigation to the farmers including in input use, costs and returns. Specifically, the objectives are to examine the following:

1. to examine the savings of various inputs such as water, fertilizers, power, pesticides and labour;
2. to examine the enhancement of productivity, quality and other benefits in selected agriculture/ horticulture crops including water-intensive crops such as sugarcane and banana, and if there is employment generation due to MI;
3. to examine the adoption of MI including some of its determinants/ features such as need/ importance of subsidy, culture of water conservation, issues of fragmented land holdings, capital cost, maintenance cost and the distribution of subsidy;
4. to study overall impact on farmer incomes and the cost-benefit in selected crops; and
5. to identify any issues/problems in the benefit transfer work flow and monitoring by the implementing agency.

2.3: METHODOLOGY OF THE STUDY

The present study has been conducted based on both primary and secondary data. For collection of primary data in Sikkim, a multi-stage stratified random sampling method has been adopted. As such, in the first stage, two districts from Sikkim, namely districts East and South, have been selected in consultation with the officials of the Department of Agriculture and Horticulture of Government of Sikkim. While selecting the districts, scale of adoption of micro irrigation has been considered as a major determinant in the district selection process. In the second stage, two blocks from each of the selected districts have been selected following similar criteria, viz. scale of adoption of micro irrigation in the blocks. Next, lists of farmers of each block have been collected and the farmers were stratified into two categories based on adoption of micro irrigation i.e. adopters and non-adopters. Lastly, from each of the selected districts, 48 micro irrigation adopter farmers and 12 non-adopter farmers have been selected randomly spread more or less evenly across the respective blocks of the districts. Thus, a total of 120 farmers have been selected to form the sample size of the study of which 96 are adopters of micro irrigation and 24 are non-adopter farmers. The secondary data has been collected from the Department of Agriculture and Horticulture, Government of Sikkim. Mostly tabular analyses have been adopted to fulfil the various objectives of the study.

3

PROFILE OF MICRO-IRRIGATION ADOPTION IN THE STATE

3.1: PROFILE OF MICRO-IRRIGATION ADOPTION IN THE STATE

PMKSY had an aim of making provision for an efficient solution in the supply chain of irrigation. The total supply chain incorporated water sources, distribution network and farm level applications. Under the scheme micro irrigation had been an integral component of the PMKSY scheme aiming towards maximizing water use efficiency at the farm level.

Sikkim, being hilly state, cultivable flat lands is scarce here. There are cultivable lands with varying degree of slopes and hence, large part of cultivation here is done in narrow terraces. Though Sikkim experiences abundant average rainfall, the distribution across the seasons is not uniform and the mountain streams are the main water source for irrigation. Moreover, the topography of the state poses ample hurdles in developing a suitable irrigation system. Hence, water saving application methods like sprinklers, drips etc. are more suited for this state.

We found that since 2015-16 funds allocated for PMKSY-PDMC in Sikkim has increased over time (Table 3.1). However, in the data provided by the Department of Horticulture, Govt. of Sikkim, there was no allocation of funds for the year 2017-18. But information from Ministry of Agriculture, Co-operation and Farmers Welfare suggest that central assistance released under PMKSY-PDMC for that particular year was to the tune of Rs. 4 crores (Table 1, Appendix I). It is apparent that work under PMKSY-PDMC for the year 2019-20 is in progress. At the time of the field survey we were reported that installations with respect to the reference year 2019-20 have just been taken up. The total area under micro irrigation and total number of beneficiaries for the particular year could not be ascertained for this reason. However, we found from the table that both the number of adopters and the area under micro irrigation increased substantially in 2018-19. It was also observed that over 13 per cent of the total irrigated area in 2018-19 was covered by micro irrigation.

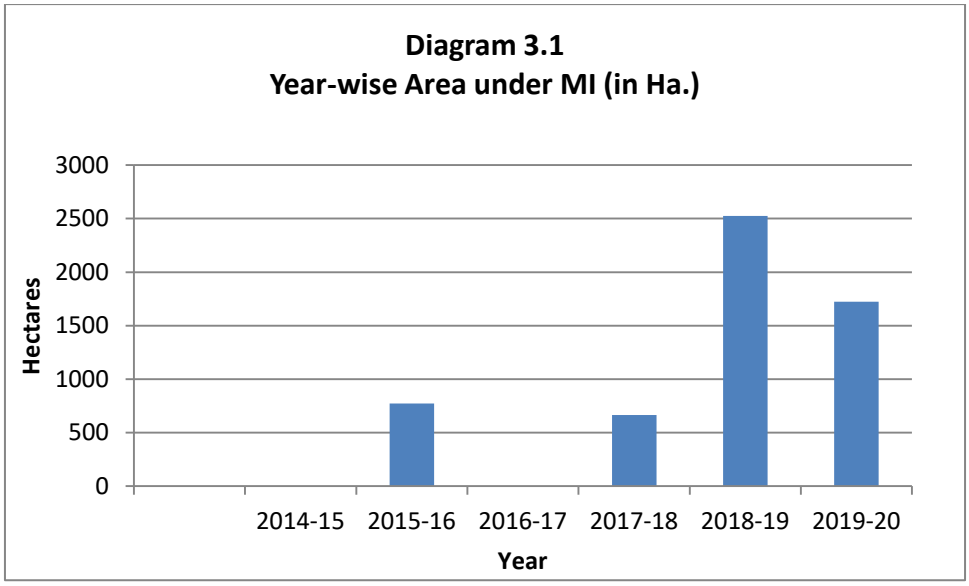
The implementation of PDMC-MI, PMSKY is executed through Horticulture Department, Govt. of Sikkim. Online registration of the beneficiaries is done. Subsidies as per GOI guidelines are disbursed to the benefitting farmer through DBT. The work on the field i.e. lying and installation of the MI system is done by the companies who are registered

with the Sikkim Micro Irrigation Council (SMIC). Trainings are imparted to the farmers regarding its maintenance before installation of MI system in the field is carried out. The PDMC-OI, PMSKY Programme is executed by Agriculture Department whose main objective is to create adequate water reservoirs/bodies from where the water is fed to the operation of Micro Irrigation System. All water applications on the fields are done through Micro Irrigation.

Table 3.1: Year-wise Growth of Micro-Irrigation in the State

Year	Funds allocated/ received under PMKSY-PDMC (Rs. In Lakh)	Area under Micro Irrigation (MI) (in Ha)	Number of Beneficiaries	MI as % of total irrigated area
2014-15	Nil	Nil	Nil	Nil
2015-16	413.42	772.50	2083	4.29
2016-17	NA	NA	NA	NA
2017-18	436.00	663.60	1659	3.36
2018-19	2018.22	2524.00	6010	11.89
2019-20	1200.76	1724.00	4270	7.20
Annual Growth rate				6.69

Source: Department of Horticulture, Govt. of Sikkim



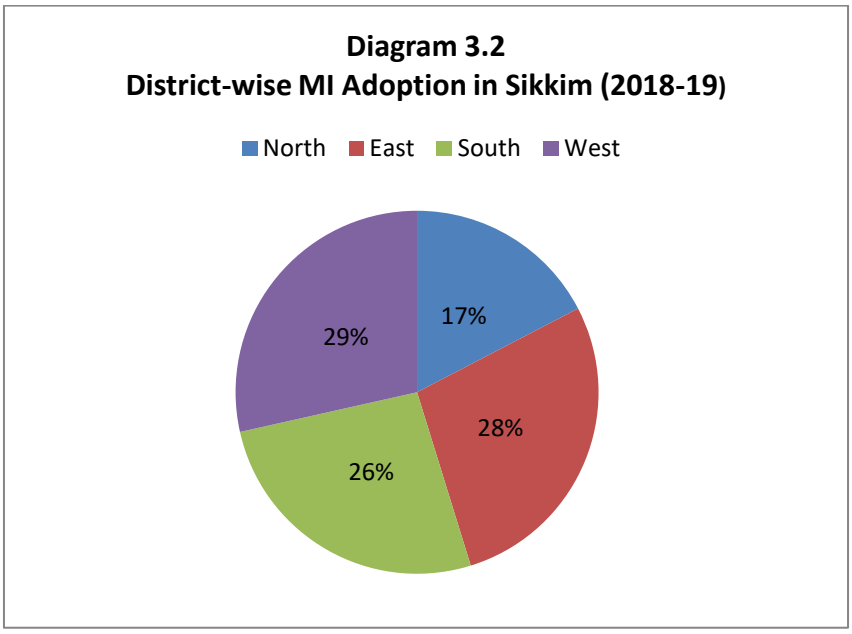
3.2: DISTRICT-WISE MI ADOPTION

It was evident from Table 3.2 that area under micro irrigation was highest in the East district followed by West, South and North in decreasing sequence in 2018-19. We had chosen two districts viz. East and South for the purpose of the present study where the proportion of area under micro irrigation registered 11.08 and 22.28 respectively. In these two districts a wide variety of vegetables are cultivated as field crops and East district had a lot of Orange orchards. The small and marginal vegetable growers were beneficiaries generally of mini sprinkler units provided for 0.22 hectare units. However, a section of adopters who had Cardamom cultivation were provided with installations 0.55 hectare units (sub component wise specifications and costs for micro irrigation are presented in Tables 2, 3, 4, 5 & 6, Appendix I). For orchards the growers availed the benefit of drip system of micro irrigation.

Table 3.2: District-wise MI Adoption (2018-19)

Sr. No.	District Name	Area under Micro Irrigation (in Ha)	MI as % of total irrigated area
1	North	438.40	23.00
2	East	702.80	11.08
3	South	663.20	22.28
4	West	719.60	16.60
5	Total	2524.00	

Source: Department of Horticulture, Govt. of Sikkim



3.3: CROP-WISE ADOPTION OF MI

It is observed that among the various crops that were receiving micro irrigation of various kinds vegetables including Peas and Beans accounted for 47.55 per cent of total area under micro irrigation in 2018-19 (Table 3.3). Buckwheat, Barley and oil crops accounted for over 17 per cent while Cardamom plantation including Cardamom nursery had a share little over 12 per cent. Orchards, however, had 5.12 per cent share of total micro irrigation in that year. We, in course of our survey in the two districts did take up various vegetables, being recipient of the lion's share of total micro irrigation in the state, as primary focus of our enquiry. These vegetables like Broccoli, Cabbage, Cauliflower, Tomato, Peas, Beans, etc. were mostly field crops being cultivated with sprinkler installations while some farmers were recipients of drip set for their orchards of which we would discuss in greater detail in the following chapters.

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

Sr. No.	Crop Name	Area under Micro Irrigation (in Ha)	Percent
1	Orchard	140.0	5.12
2	Protected Cultivation Green House	220.0	8.05
3	Cardamom Nursery	26.0	0.95
4	Mustard and Oil Crops	220.0	8.05
5	Buckwheat and Barley	260.0	9.50
6	Peas and Beans	300.0	10.97
7	Cherry Pepper	248.0	9.07
8	Cardamom	320.0	11.70
9	Vegetables	790.0	36.55
10	Total	2524.0	100.00

Source: Department of Horticulture, Govt. of Sikkim

Figure 3.1: Water Storage Tanks

4

STUDY SAMPLING AND SAMPLE PROFILE

4.1: STUDY SAMPLING AND SAMPLE PROFILE

We have discussed earlier that the state of Sikkim is segregated in four districts (viz. East, West, North & South). For the purpose of the present study we have chosen two districts (viz. East & South) for conducting the primary survey. In each district 48 farmers, those who are using micro irrigation (MI), were selected for the purpose of a detailed survey (whom we shall henceforth call Adopters). At the same time 12 farmers not using MI were chosen from each district as a control group (Non-adopters). Hence, our total sample was to the tune of 120 households (Adopters 96 + Non-adopters 24) (Table 4.1).

Table 4.1: Sample Coverage

Sr. No.	District surveyed	No. of Village	No. of Adopter Farmers surveyed	Drip	Sprinkler	Micro-Irrigation (Both)	Non-Adopters
1	East	4	48	0	33	15	12
2	South	5	48	3	45	0	12
3	Total	9	96	3	78	15	24

Source: Field Survey 2019-20

In Sikkim, however, due to the topography of the state, the MI implementation is done in cluster basis. Generally, some water source from stream is identified in the upper ridges of the hill and the water is stored in a RCC tank, been constructed for the purpose. Stored water is then transferred to the cropping fields in the lower ridges through pipes taking the advantage of the gravitational force. At the field level small PVC tanks are erected in a way to retain the water pressure in the hilly tract. Generally flexible PVC pipes are connected with the field level storage tanks to carry water to the cropping field and attached with the sprinkler or drip irrigation kits. Hence, the whole arrangement of MI depends on finding a perennial and sustainable water source in the vicinity. It is for this reason a cluster approach has been adopted with regard to implementation of MI in Sikkim.

We, in course of our primary survey, had the opportunity to visit four villages in the East district and five villages in the South district with functional MI clusters. In East district

33 (68.8%) farming families were found who were using only sprinkler sets for irrigation while there were 15 (31.2%) households using both drip and sprinkler irrigation. On the contrary, in the sample villages of South district, no farming household was found to have adopted both the methods of MI. There were 3 (6.2%) families adopted drip method of irrigation while the number of sprinkler users was 45 (93.8%). For the state as a whole 81.3 per cent of total farmers have adopted only sprinkler irrigation, 3.1 per cent adopted only drip irrigation and 15.6 per cent were using both types (Table 4.1).

In these two districts of Sikkim sprinkler sets were commonly used for irrigating the field crops like Buckwheat, Vegetables and Cardamom etc. The farmers prefer sprinkler sets for their field crops due to the advantage that the sprinkler kits could be detached from the feeder pipe and shifted to another plot through extending the flexible PVC feeder pipe. This has been a practice among the farmers for extension of MI command. On the other hand drip MI was used for protected cultivation under green house for flowers and some vegetables. Apart from green house drip was also used in orchards (e.g. Sikkim Mandarin Orange, Guava etc.).

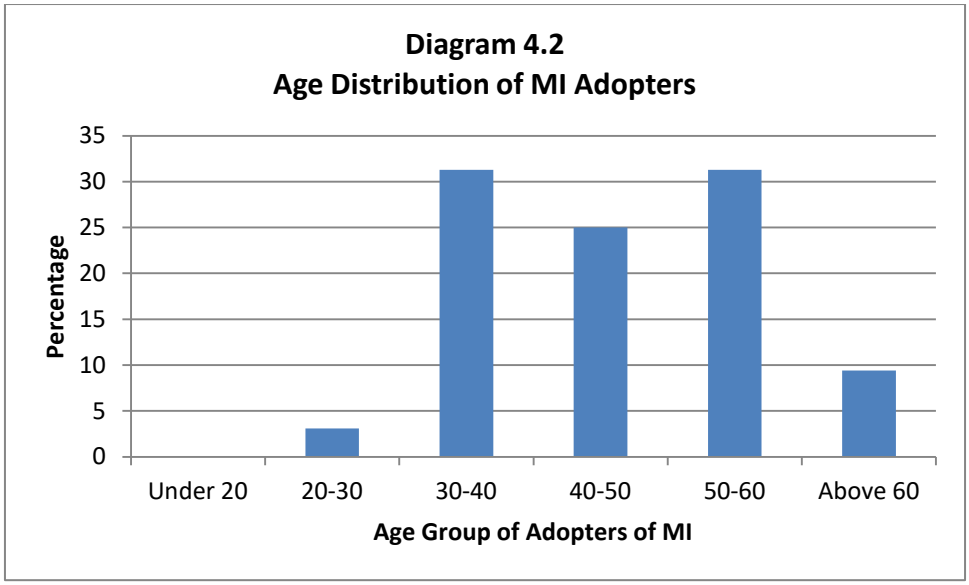
4.2: AGE OF ADOPTERS

As to the age of the adopters, we found that 87.6 per cent of the total farmers come under the age bracket of 30 to 60 years (Table 4.2). There were not much of a difference between the interim age groups i.e. 30 to 40 years, 40 to 50 years and 50 to 60 years. However, only 9.4 per cent adopters were at the age above 60 years. It was interesting to note that there were only 3.1 per cent adopters in the age group of 20 to 30 years. The fact remains that the new generation seems to be less interested in farming activities, a frequent complain foregrounded by our older respondents that gets corroborated at the field level data.

Table 4.2: Age of Adopters

Age	Number	Percent
Under 20	0	0.0
20-30	3	3.1
30-40	30	31.3
40-50	24	25.0
50-60	30	31.3
Above 60	9	9.4

Source: Field Survey 2019-20



4.3: EDUCATION OF ADOPTERS

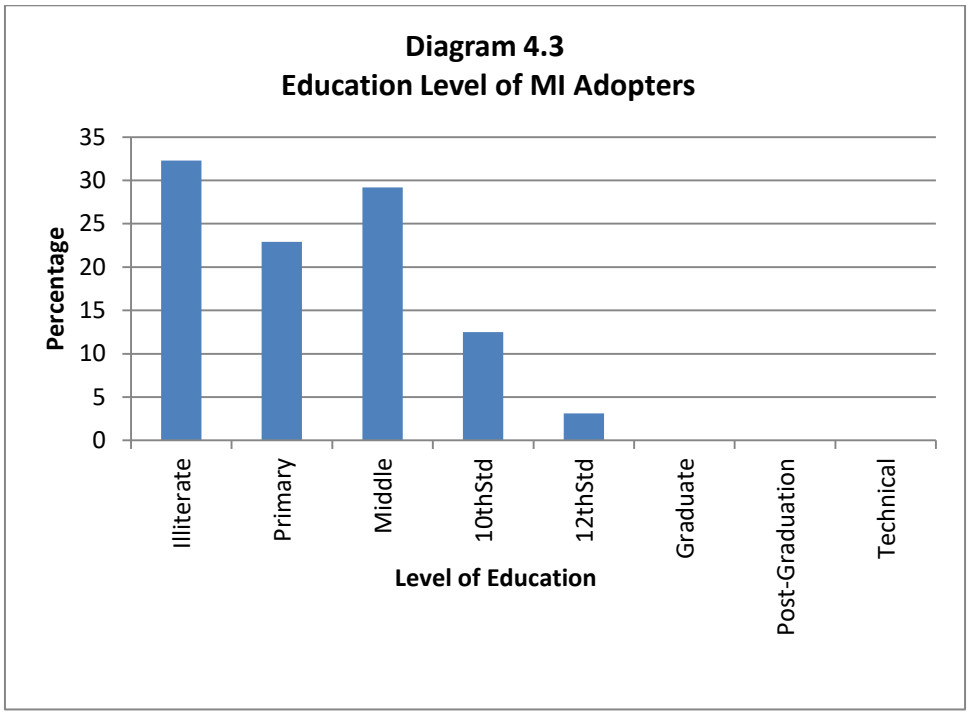
Education scenario among the MI adopters in the two districts of Sikkim reflected a mixed pattern where 32.3 per cent of farmers were found to be illiterate (Table 4.3). At the same time 67.7 per cent have had some formal education up to twelfth standard at most. Among the adopters 52.1 per cent had education up to middle school level while attainment at secondary level was 12.5 per cent. Only 3.1 per cent had an education till twelfth standard. Unfortunately, none of the adopters reported to have had either a technical education of any kind or had achieved an education above the school level.

Table 4.3: Education of Adopters

Level of Education	Number	Percent
Illiterate	31	32.3
Primary	22	22.9
Middle	28	29.2
10thStd	12	12.5
12thStd	3	3.1
Graduate	-	-
Post-Graduation	-	-
Technical	-	-

Source: Field Survey 2019-20

It was obvious to find that the proportion of illiterate respondents were higher in the elderly age groups. Over 77 per cent of illiterates were of the age over 50 years (Table 1, Appendix II). On the contrary, the younger adopters seemed to have more education than the elder ones, where more than 72 per cent were of the age group of 30 to 50 years. Hence, education among the respondents had an inverse relation with the age of the respondents.



5

LAND AREA AND WATER SOURCES IN RELATION TO MICRO-IRRIGATION

5.1: LAND AREA

As the hilly terrain in Sikkim demands, the farmers have adopted step cultivation for their field crops. At the same time the holding size was very small among most of the farmers. Out of 96 adopters 91 farmers were from either marginal or small land holding category (Table 5.1). The respective proportions of marginal and small farmers were 67.7 per cent and 27.1 per cent while medium farmers were only 5.2 per cent. However, there were no landless farmers within our sample for the fact that the selection of MI beneficiaries necessitates land ownership of the individual. Average area of operational land for marginal farmers was 0.34 hectares. The corresponding figures for small and medium categories were 1.45 hectares and 2.40 hectares respectively while overall average size of operational holding was to the tune of 0.84 hectares. Out of these 0.84 hectares, 0.48 hectares (57.1 per cent) of land were under MI, 0.07 hectares (8.3 per cent) were under irrigated non-micro and 0.29 hectares (34.5 per cent) were un-irrigated. It was interesting to find that the marginal and small farmers were using more of sprinkler irrigation.

Figure 5.1.1: Cropping in the Hill Slopes

Total area operated by the marginal farmers was 31.05 hectares which had been to the tune of 38.5 per cent of total operated area of the present study (Table 2, Appendix II). Area under small and medium farms was 37.70 and 12.00 hectares respectively while the corresponding proportions with respect to total operated area were 46.7 and 14.9. It was evident that the East district uses more drip irrigation as compared to its South counterpart (Table 3, Appendix II). It has been due to the fact that the East district has Orange (Sikkim Mandarin) orchards in ample numbers where drip method of irrigation is used.

Table 5.1: Land Area (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	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Marginal (<1)	65	67.7	0.48	0.34	0.01	0.33	0.05	0.09
Small (1-2)	26	27.1	1.45	0.87	0.22	0.65	0.12	0.47
Medium (2-10)	5	5.2	2.40	0.24	0.16	0.08	0.18	1.98
Large (>10)	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Total	96	100.0	0.84	0.48	0.07	0.40	0.07	0.29

Source: Field Survey 2019-20

Figure 5.1.2: Narrow Cropping Tract in the Ridges

5.2: WATER SOURCES

In Sikkim, as we have said earlier, that the whole micro irrigation system depended on the water flow from natural streams with construction of storage tank in the upper ridges of the hill and taking the advantage of altitude the water is carried to the cropping fields with the help to gravitation flow. This has been a unique system followed all over the hilly tract of Sikkim. Hence, it was no wonder that all the respondents of the present study had been using the same system of MI (Table 5.2).

Table 5.2: Water Sources

Source	Number	Percent (%)
Canal	0	0.0
Canal-Lift	0	0.0
River-Lift*	96	100.0
Tubewell	0	0.0
Well	0	0.0
Tank	0	0.0
Pond	0	0.0
Farm Pond	0	0.0
Check dam	0	0.0
Percolation Tank	0	0.0
Others	0	0.0

Source: Field Survey 2019-20

*Natural gravitational flow of water collected from various streamlets from upper reaches of the hills.

5.3: WATER SITUATION FOR FARMING

Generally these natural streams do not provide regular and substantial quantum of water throughout the year. During monsoon the volume of water from these streams is inflated. It is also quite common that the water flow from these streams get reduced during the dry seasons. At such times of the year the farmers are faced with occasional scarcity of water for irrigation (Table 5.3). The only way out to mitigate water scarcity might lie in increasing the capacity of water storage in the upper ridges of the mountain for maintaining a good perennial flow. However, that might again depend on the terrain and various other environmental concerns.

Table 5.3: Water Situation for Farming

Water situation	Number	Percent (%)
Excess water	0	0.0
No scarcity	0	0.0
Occasional scarcity*	96	100.0
Scarcity	0	0.0
Acute scarcity	0	0.0

Source: Field Survey 2019-20
* Occasional scarcity due to seasonal fluctuations in natural water flow from streamlets.

5.4: TYPE OF SOIL

In Sikkim, the trend of the mountain system is in east-west direction in general. Based on geomorphological specificities the state is congregated into 5 physiographic regions. The soil depth, however, varies considerably depending upon geographical position and slope. At the same time soil fertility also varies with the terrain, altitude and rock formation of the area. Generally in area of the present study in East and South districts the soil was moderately clay-loamy with a good drainage suitable for different types of crops including vegetables. The pH level normally varied between 5.0-6.0. It is commonly considered as the medium soil by the farmers (Table 5.4).

Table 5.4: Type of Soil

Soil	Number	Percent (%)
Light	0	0.0
Medium*	96	100.0
Heavy	0	0.0

Source: Field Survey 2019-20
* The survey area in East and South Sikkim is of the same nature, viz. was moderately clay-loamy.

5.5: TYPE OF TERRAIN

Sikkim is part of the Himalayan ranges and is characterized by mountainous terrain. The terrain had been moderately sloped hilly region, with an elevation ranging from 280 metres in the south to 8,586 metres in north. For the most part, the land is unfit for agriculture because of the rocky, precipitous slopes, though some hill slopes have been converted into terraces for farming (Table 5.5).

Table 5.5: Type of Terrain

Terrain	Number	Percent (%)
Flat	0	0.0
Up & Down	0	0.0
Hilly	96	100.0

Source: Field Survey 2019-20

Figure 5.4: Hilly Terrain

5.6: RAINFALL SITUATION

The state of Sikkim experiences very heavy rainfall in the months from May to August. These are the months when monsoon sets in causing heavy showers. Dry period starts from November and generally lasts till February. As per the data of 2018 we found that the East and South districts had annual rainfall to the tune of 2376.3 mm and 2086.9 mm respectively (Table 4, Appendix II). When asked about the rainfall situation during last agricultural year in course of our survey it was found that the year preceding had an average rainfall in both the districts (Table 5.6).

Table 5.6: Rainfall Situation (2019-20)

Rainfall	Number	Per cent (%)
Very heavy	0	0.0
Heavy	0	0.0
Average	96	100.0
Low	0	0.0
Very low	0	0.0

Source: Field Survey 2019-20

Figure 5.6: Cultivation in Green House /Poly House

5.7: YEAR STARTED USING MICRO-IRRIGATION

The PMKSY-PDMC schemes for the year 2019-20 had been in the early stage of execution at the time of our field survey. Adopters of the present study were all beneficiaries of earlier MI implementation schemes. Moreover, as we came to know from the Directorate of Horticulture, Government of Sikkim, that implementation of MI was earlier done by three departments viz. Departments of Agriculture, Horticulture and Forestry. Presently, the micro irrigation kits are being distributed by the Department of Horticulture and the other infrastructure is being provided by the Department of Agriculture.

However, it is evident that 29.2 per cent of the total adopters derived the benefit as early as in 2014, while 25 per cent in 2015 and rest 45.8 per cent in 2016 (Table 5.7). For

implementation of the scheme year marked for 2019-20 a thorough survey has been conducted and execution of MI was in progress by the Department of Horticulture.

Table 5.7: Year Started Using Micro-Irrigation

When started using micro-irrigation	Number	Percent (%)
Current Year (2019-20)	-	
Last Year (2018-19)	-	
2 years ago (2016)	44	45.8
3 years ago (2015)	24	25.0
5 years ago (2014)	28	29.2
10 years ago	-	
More than 10 years	-	
Overall Average	96	100.0

Source: Field Survey 2019-20

5.8: WHETHER AVAILED OF SUBSIDY

In the state of Sikkim micro irrigation benefits so far had been provided free of cost to the farmers. The departments bore all the cost of such installations. These were a sort of 'turn-key' benefits provided to the farmers in cluster basis. Moreover, no such kit was made available in the open market. The installation of the MI system was carried out by only those companies who were registered with the SMIC. Hence, it was a situation where all the adopters enjoyed 100 per cent subsidy for installation of MI (Table 5.8).

As it was reported by the officials of the department, the system of subsidising MI would undergo a change in implementation of PMKSY-PDMC, where a direct benefit transfer (DBT) method has to be adopted as required by the new scheme.

Table 5.8: Whether Availed of Subsidy

Availed of subsidy	Number	Percent (%)
Yes	96	100.0
No	0	0.0

Source: Field Survey 2019-20

6

CROPPING PROFILE AND CHANGES

6.1: CROPPING PROFILE AND AREA WITH MICRO-IRRIGATION

The cropping pattern of any region depends greatly upon availability of irrigation, weather, topography, soil quality among other factors. This study is carried out in the State of Sikkim where the climatic condition and topography of land is particularly suitable for vegetable cultivation, ginger, turmeric and perennial crops like mandarin oranges. This is reflected clearly while analysing the cropping profile of the sample adopters of micro-irrigation (refer table 6.1).

It can be observed here that crops like maize, buckwheat and paddy are cultivated by a number of adopters of micro-irrigation in the Kharif season mostly in un-irrigated tracts of land. In fact, in the slopes of Himalayas like in Sikkim, cultivation of Kharif crops like maize, buckwheat, paddy, etc. is possible only for those farmers who own comparatively large un-irrigated tracts of land, often following a step-cultivation method.

Figure 6.1.1: Sprinkler Irrigation in Operation

On the other hand, the climatic conditions and soil type of this part of the Himalayas is naturally suitable for crops like mandarin oranges and guava. As such, a few farmers with large plots in the slopes of the hills often can be seen having orchards of oranges and guava.

These crops are cultivated as perennial crops and irrigated using drip irrigation method. Another important perennial crop comes out to be cardamom, which also suits the climatic and soil condition of the survey area, and irrigated through sprinkler irrigation method. These perennial crops, just like Kharif crops, are cultivated in comparatively larger plots of land as compared to the crops grown in Rabi season.

Figure 6.1.2: Drip Irrigation in Operation

In Rabi season, a number of vegetables and roots are found to dominate the cropping pattern of the sample adopters of micro-irrigation. Crops like cauliflower, broccoli, cabbage, peas and beans are widely grown by these adopters of micro-irrigation. These crops are found to be irrigated primarily through sprinkler irrigation after the introduction of micro-irrigation techniques. Irrigation through methods other than micro-irrigation has been limited in use after the introduction of micro-irrigation for the adopter farmers. Other Rabi crops include crops like tomato, radish, capsicum and rarely spinach and potato. Roots like ginger and turmeric were also cultivated by a few adopter farmers, which are mostly un-irrigated crops.

Table 6.1: Cropping Profile and Area with Micro-Irrigation

Sr.No	Crop name	Season Kharif/Rabi/ other	No. of farmers reporting	Area - average in hectares (based on reporting farmers)					
				Area under the crop	Drip area	Sprinkler area	Irrigated Non-Micro area	Un-irrigated area	Fertigation (%)
1	Buckwheat	Kharif	19	0.33	0.00	0.02	0.00	0.31	0.00
2	Maize	Kharif	13	0.61	0.00	0.00	0.00	0.60	0.00
3	Paddy	Kharif	27	0.27	0.00	0.00	0.00	0.27	0.00
4	Beans	Rabi	51	0.10	0.00	0.07	0.02	0.00	0.00
5	Broccoli	Rabi	75	0.13	0.00	0.12	0.01	0.00	0.00
6	Cabbage	Rabi	60	0.13	0.00	0.11	0.02	0.00	0.00
7	Capsicum	Rabi	3	0.10	0.00	0.00	0.10	0.00	0.00
8	Cauliflower	Rabi	80	0.14	0.00	0.13	0.01	0.00	0.00
9	Ginger	Rabi	13	0.12	0.00	0.00	0.00	0.12	0.00
10	Peas	Rabi	52	0.10	0.00	0.07	0.02	0.00	0.00
11	Potato	Rabi	1	0.10	0.00	0.10	0.00	0.00	0.00
12	Radish	Rabi	14	0.08	0.00	0.03	0.05	0.00	0.00
13	Spinach	Rabi	2	0.05	0.00	0.05	0.00	0.00	0.00
14	Tomato	Rabi	15	0.08	0.00	0.02	0.06	0.00	0.00
15	Turmeric	Rabi	11	0.27	0.00	0.00	0.02	0.25	0.00
16	Cardamom	Perennial	16	0.27	0.00	0.27	0.00	0.00	0.00
17	Guava	Perennial	3	0.17	0.10	0.00	0.00	0.07	0.00
18	Orange	Perennial	16	0.54	0.37	0.00	0.00	0.17	0.00

Source: Field Survey 2019-20

Table 6.1 (a): Cropping Profile and Area with Micro-Irrigation (Percentages)

Sr.No	Crop name	Area - in hectares (percentages)				
		Area under the crop	Drip area	Sprinkler area	Irrigated Non-Micro area	Un-irrigated area
1	Buckwheat	6.2 (100.0)	0.0 (0.0)	0.4 (6.5)	0.0 (0.0)	5.8 (93.5)
2	Maize	7.8 (100.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	7.8 (100.0)
3	Paddy	7.4 (100.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	7.4 (100.0)
4	Beans	5.0 (100.0)	0.2 (4.0)	3.6 (71.7)	1.2 (24.2)	0.0 (0.0)
5	Broccoli	9.9 (100.0)	0.1 (1.0)	9.1 (91.9)	0.7 (7.1)	0.0 (0.0)
6	Cabbage	7.9 (100.0)	0.2 (2.5)	6.7 (84.7)	1.0 (12.7)	0.0 (0.0)
7	Capsicum	0.3 (100.0)	0.0 (0.0)	0.0 (0.0)	0.3 (100.0)	0.0 (0.0)
8	Cauliflower	10.8 (100.0)	0.1 (0.9)	10.1 (93.1)	0.7 (6.0)	0.0 (0.0)
9	Ginger	1.6 (100.0)	0.0 (0.0)	0.0 (0.0)	0.1 (3.1)	1.6 (96.9)
10	Peas	5.1 (100.0)	0.2 (3.9)	3.7 (71.6)	1.3 (24.5)	0.0 (0.0)
11	Potato	0.1 (100.0)	0.0 (0.0)	0.1 (100.0)	0.0 (0.0)	0.0 (0.0)
12	Radish	1.1 (100.0)	0.0 (0.0)	0.4 (31.8)	0.8 (68.2)	0.0 (0.0)
13	Spinach	0.1 (100.0)	0.0 (0.0)	0.1 (100.0)	0.0 (0.0)	0.0 (0.0)
14	Tomato	1.2 (100.0)	0.0 (0.0)	0.3 (26.1)	0.9 (73.9)	0.0 (0.0)
15	Turmeric	3.0 (100.0)	0.0 (0.0)	0.0 (0.0)	0.3 (8.3)	2.8 (91.7)
16	Cardamom	4.3 (100.0)	0.0 (0.0)	4.3 (100.0)	0.0 (0.0)	0.0 (0.0)
17	Guava	0.5 (100.0)	0.3 (60.0)	0.0 (0.0)	0.0 (0.0)	0.2 (40.0)
18	Orange	8.6 (100.0)	5.9 (68.6)	0.0 (0.0)	0.0 (0.0)	2.7 (31.4)
19	All Crops	80.7 (100.0)	7.0 (8.7)	38.5 (47.7)	7.0 (8.7)	28.2 (34.9)

Source: Field Survey 2019-20

6.2: CROPPING PROFILE AND AREA BEFORE MICRO IRRIGATION

Introduction of a new irrigation technology like micro-irrigation is expected to induce changes in the cropping pattern for those who adopted the new technology. Here too, we can analyze the cropping profile of the adopters of micro-irrigation before they adopted the new form of irrigation (refer table 6.2).

It can be observed here that there is not much change in the cropping pattern of adopters of micro-irrigation in Kharif season and for the perennial crops. The major Kharif crops grown were paddy, buckwheat and maize which remains largely un-irrigated. On the other hand, the crops grown as perennial crops were cardamom, orange and guava which remained partly irrigated. Here, the 'before' year refers to 2014-15 cropping year.

Table 6.2: Cropping Profile and Area before Micro Irrigation

Sr. No.	Crop name	Season Kharif/Rabi/ other	No. of farmers reporting	Area – average in hectares for reporting farmers		
				Total area	Irrigated area	Un-irrigated area
1	Buckwheat	Kharif	19	0.33	0.02	0.31
2	Maize	Kharif	13	0.61	0.00	0.61
3	Paddy	Kharif	27	0.27	0.00	0.27
4	Beans	Rabi	54	0.09	0.09	0.00
5	Broccoli	Rabi	76	0.10	0.10	0.00
6	Cabbage	Rabi	61	0.11	0.10	0.00
7	Capsicum	Rabi	3	0.10	0.10	0.00
8	Cauliflower	Rabi	82	0.11	0.11	0.00
9	Ginger	Rabi	12	0.10	0.00	0.10
10	Peas	Rabi	54	0.08	0.08	0.00
11	Potato	Rabi	1	0.10	0.10	0.00
12	Radish	Rabi	17	0.07	0.07	0.00
13	Spinach	Rabi	2	0.05	0.05	0.00
14	Tomato	Rabi	18	0.08	0.08	0.00
15	Turmeric	Rabi	12	0.29	0.02	0.27
16	Cardamom	Perennial	16	0.27	0.27	0.00
17	Guava	Perennial	3	0.17	0.10	0.07
18	Orange	Perennial	16	0.53	0.36	0.17

Source: Field Survey 2019-20

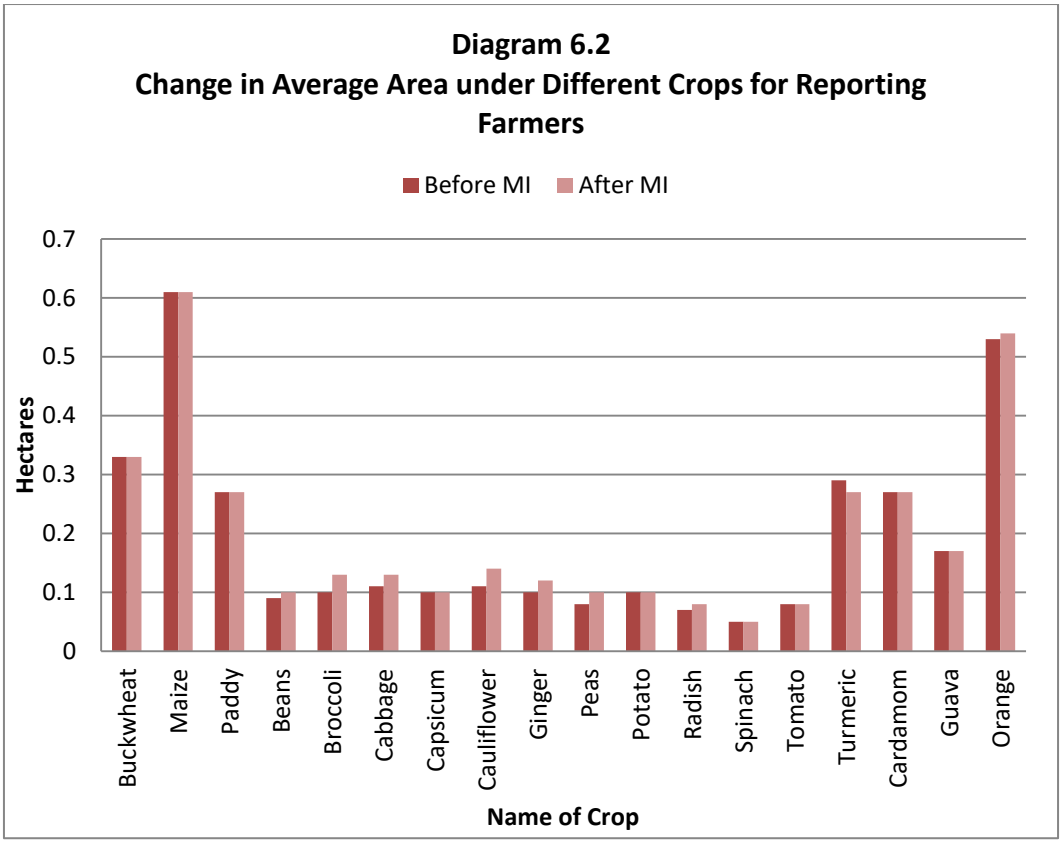
In case of Rabi crops, we observe that the crops grown after the introduction of micro-irrigation techniques were grown before the introduction of micro-irrigation too. As such, it comes out that adoption of micro-irrigation has not facilitated cultivation of new crops. However, a close comparison of the cropping patter before and after the introduction of micro-irrigation reveals that there has been a marked change in terms of increase in the area under cultivation of most of the Rabi crops. This has been particularly true for crops like

cauliflower, broccoli, cabbage, peas and beans. At the same time, there has not been much decrease in the area under cultivation of Rabi crops, except for turmeric. Moreover, a similar pattern of irrigated area under these crops can be observed, revealing that area under irrigation under these crops also increased with the introduction of micro-irrigation.

Table 6.2 (a): Cropping Profile and Area before Micro Irrigation (Percentages)

Sr. No.	Crop name	Area - in hectares (percentages)		
		Total area	Irrigated area	Un-irrigated area
1	Buckwheat	6.2 (100.0)	0.4 (6.5)	5.8 (93.5)
2	Maize	7.9 (100.0)	0.0 (0.0)	7.9 (100.0)
3	Paddy	7.4 (100.0)	0.0 (0.0)	7.4 (100.0)
4	Beans	4.9 (100.0)	4.9 (100.0)	0.0 (0.0)
5	Broccoli	8.0 (100.0)	7.9 (98.8)	0.1 (1.3)
6	Cabbage	6.6 (100.0)	6.4 (96.9)	0.2 (3.1)
7	Capsicum	0.3 (100.0)	0.3 (100.0)	0.0 (0.0)
8	Cauliflower	8.7 (100.0)	8.7 (100.0)	0.0 (0.0)
9	Ginger	1.2 (100.0)	0.1 (4.2)	1.2 (95.8)
10	Peas	4.6 (100.0)	4.6 (100.0)	0.0 (0.0)
11	Potato	0.1 (100.0)	0.1 (100.0)	0.0 (0.0)
12	Radish	1.3 (100.0)	1.3 (100.0)	0.0 (0.0)
13	Spinach	0.1 (100.0)	0.1 (100.0)	0.0 (0.0)
14	Tomato	1.5 (100.0)	1.5 (100.0)	0.0 (0.0)
15	Turmeric	3.5 (100.0)	0.3 (7.1)	3.3 (92.9)
16	Cardamom	4.3 (100.0)	4.3 (100.0)	0.0 (0.0)
17	Guava	0.5 (100.0)	0.3 (60.0)	0.2 (40.0)
18	Orange	8.4 (100.0)	5.7 (67.9)	2.7 (32.1)
19	All Crops	75.2 (100.0)	46.6 (61.9)	28.7 (38.1)

Source: Field Survey 2019-20



All these in turn indicate towards the fact that with the introduction of micro-irrigation, there has been a marked shift in the cropping pattern in favour of vegetable crops by bringing in new land under cultivation and irrigated through sprinkler irrigation method.

6.3: CHANGE IN AREA AND YIELD DUE TO MICRO IRRIGATION

In the present study, we have asked the adopter farmers of micro-irrigation about their experience regarding change in area and yield of crops they cultivate with the adoption of MI over time, i.e. in 2019-20 as against 2014-15, and mark the changes in a five-point scale (refer table 6.3), marking 5 for a large increase in the area to 1 for a large decrease in area. As such, mean response score above 3 indicates a positive change and vice-versa.

Here also, the observations made comparing table 6.1 and 6.2 is reflected again in the mean response scores for individual crops. In particular, it can be observed that there has been an increase in the area of cultivation for the vegetable crops like broccoli (3.39), cauliflower (3.36), cabbage (3.33), beans (3.16) and peas (3.15), the dominating crops in the rabi season in the study area, due to introduction of micro-irrigation. At the same time, area under cultivation for Kharif crops like paddy, maize, buckwheat and perennial crops like

oranges, cardamom and guava remained largely the same over time, showing little or no impact of micro-irrigation on these crops. This is understandable as the Kharif and perennial crops are largely grown in un-irrigated plots. All these again establishes the observation that there has been an increase in the area under cultivation for vegetable crops in the Rabi season by bringing in new previously uncultivated lands under cultivation, which is made possible due to the introduction of micro-irrigation.

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	Buckwheat	19	0	0	19	0	0	3.00	0	0	19	0	0	3.00
2	Maize	13	0	0	13	0	0	3.00	0	0	13	0	0	3.00
3	Paddy	27	0	0	27	0	0	3.00	0	0	26	1	0	2.96
4	Beans	51	0	8	43	0	0	3.16	0	26	25	0	0	3.51
5	Broccoli	75	0	29	46	0	0	3.39	0	53	22	0	0	3.71
6	Cabbage	60	0	20	40	0	0	3.33	0	38	22	0	0	3.63
7	Capsicum	3	0	0	3	0	0	3.00	0	0	3	0	0	3.00
8	Cauliflower	80	0	29	51	0	0	3.36	0	54	26	0	0	3.68
9	Ginger	13	0	0	13	0	0	3.00	0	0	13	0	0	3.00
10	Peas	52	0	8	44	0	0	3.15	0	28	24	0	0	3.54
11	Potato	1	0	0	1	0	0	3.00	0	0	1	0	0	3.00
12	Radish	14	0	1	13	0	0	3.07	0	6	8	0	0	3.43
13	Spinach	2	0	0	2	0	0	3.00	0	1	1	0	0	3.50
14	Tomato	15	0	0	15	0	0	3.00	0	5	10	0	0	3.33
15	Turmeric	11	0	0	11	0	0	3.00	0	0	11	0	0	3.00
16	Cardamom	16	0	0	16	0	0	3.00	0	10	6	0	0	3.63
17	Guava	3	0	0	3	0	0	3.00	0	1	2	0	0	3.33
18	Orange	16	0	1	15	0	0	3.06	0	1	11	4	0	2.81

Scale: Large Increase =5 Increase =4 No Change =3 Decrease =2 Large Decrease =1
Source: Field Survey 2019-20

On the other hand, in case of changes in yield, we observe that there has not been any change for kharif crops like buckwheat and maize, while yield of paddy exhibited a decline. In case of yield of perennial crops, while cardamom and guava witnessed positive changes, yield of orange showed a decline over time. However, as we noted earlier, these Kharif crops

are mostly grown in un-irrigated tracts, and has little to do with micro-irrigation, though the increase in the yield of cardamom and guava can be attributed partly to drip/sprinkler irrigation.

However, in case of change in yield for the Rabi crops, it comes out that apart from the vegetables potato and capsicum, all other vegetable crops exhibited an increase in yield due to micro-irrigation, especially for broccoli (3.71), cauliflower (3.68), cabbage (3.63), peas (3.54) and beans (3.51), which are the dominant Rabi crops in the study area. Hence it clearly comes out that along with increase in area under cultivation, the major vegetable crops in the Rabi season has also witnessed an increase in their yields due to the introduction of micro-irrigation techniques.

Thus, it can be said that the impact of micro-irrigation has been particularly observed in case of major Rabi crops grown for which the new irrigation technique has been widely adopted. The impact of micro-irrigation is observed here through an increase in the area under cultivation of these major Rabi crops by bringing in new previously fallow land under cultivation, as also through an even greater increase in yield of these crops.

Figure 6.3: Aero Sprinkler in Green House

7

CHANGES IN INCOMES AND FARM ECONOMICS WITH MICRO-IRRIGATION

7.1: CHANGES IN PRODUCTION, INCOMES, INPUTS AND COSTS WITH MICRO-IRRIGATION FOR MAJOR CROPS

The introduction of any new technology in farming is often analysed using a pre-post analysis framework, comparing performance of farms before (2014-15) and after (2019-20) the introduction of the particular technology (refer table 7.1). Here too, we have tried to analyse the farm-economics of adopters of micro-irrigation before and after the adoption of micro-irrigation system for farming. In particular, while the cropping year 2014-15 has been treated as the 'before' year or year 'without micro-irrigation', the 'after' year of year 'with micro-irrigation' refers to the cropping year 2019-20. For this exercise, we have selected three major crops, viz. cauliflower, broccoli and cabbage, depending upon the number of farmers reporting. At the same time, we have also tried to examine the changes in farm economics for the adopters of micro-irrigation for their farms as a whole, irrespective of individual crops they grow. Here we can briefly describe the outcome of such an exercise as follows-

In case of area under particular crops, we observe that average area under cultivation for all the three crops, viz. cauliflower, broccoli and cabbage, has shown a similar increase of 27.27 per cent after the adoption of micro-irrigation. This finding remains consistent with earlier observations on changes in cropping pattern for adopter farmers due to the introduction of micro-irrigation. It is interesting to note here that area measured in hectares remained the same across all three crops, both with and without micro-irrigation, revealing a similar acreage impact on all three crops. As we have considered the sum of any two of the three crops for arriving at the total for farm, the acreage effect at the farm level also comes out similar to be same as the individual crops, viz. 27.27 per cent.

Though the acreage effect of micro-irrigation comes out to be similar across the three crops we considered, but its effect on production varies across the crops. In fact, while production of broccoli increased by 46.23 per cent, that of cauliflower and cabbage comes out to be 36.26 percent and 36.75 per cent respectively. Now, comparing the increase in production with increase in area, it comes out that the growth in production of all the three

crops considered here outweighed the growth in area, implying obvious growth in yield for the individual crops. Comparing the difference in growth of area and production, it comes out that the highest growth in yield has been recorded by broccoli, followed by cabbage and cauliflower. For individual farms as a whole, the mean increase in production stands at 33.05 per cent. As a result of increase in area, production and yield, total revenue earned from all the three crops showed an increase with the adoption of micro-irrigation. In particular, there has been an increase of 58.92 per cent in sales revenue for cabbage, followed by broccoli (56.28 per cent) and cauliflower (55.16 per cent). At the farm level, the increase in sales revenue stood at 50.42 per cent.

However, the average sales price of these crops also increased in between the reference years, which also contributed to the increase in sales revenue of the respective crops. While there has been an increase of 17.16 per cent in the average sales price of cabbage, that for cauliflower and broccoli stands at 13.59 per cent and 7.77 per cent respectively. Considering the changes that took place in the sales price of the crops vis-à-vis changes in production, it comes out that the increase in sales revenue for the crops considered is driven more by changes in area, production (and yield), rather than increase in their respective sales prices.

Now, when analysing the details of cost of production of these individual crops and for the farm as a whole (the sum of the two major crops the respective farm grows), we should mention some characteristic features of cultivation practices in the survey area in the State of Sikkim.

First, while analysing cost of production of vegetables in Sikkim, we do not observe any cost on account of fertilizers and pesticides at all. This is because application of chemical fertilizers and pesticides are banned in Sikkim, and the crops are grown flowing organic cultivation techniques. Fertilizers are replaced with large volumes of manure and other organic fertilizers, and use of bio-pesticides is very limited. It is for this reason that the costs on account of fertilizers and pesticides are not present in table 7.1.

Second, the irrigation system in the survey area situated in the slopes of Himalayas in Sikkim largely follows a gravity flow technique, where water flows naturally due to gravitational pull. As such, use of electric/diesel pumps has limited use in drip/sprinkler irrigation systems applied in vegetables. During the survey, electric pumps were observed to be used in case of aero-sprinklers installed in greenhouses for floriculture. None of the

sample adopter farmers were seen using any kind of diesel/electric pumps. As such, there has been no cost accounted for in case of cost of irrigation for individual crops in table 7.1.

Now, as a substitute of chemical fertilizers, manure and (or) organic fertilizers are used widely in the cultivation of all the three crops considered here. With the introduction of micro-irrigation, costs on account of application of farmyard manure have increased a lot. In particular, increase in the cost of farmyard manure with the adoption of micro-irrigation has been the highest for broccoli (74.60 percent), followed by cauliflower (64.53 per cent) and cabbage (57.88 per cent). However, without taking into account of the increase in price of farmyard manure, we cannot arrive at any concrete observation regarding whether the increase in expenditure on account of farmyard manure has been due to an increase in price or quantity of the same. Nevertheless, it comes out clearly that increase in expenditure on account of farmyard manure for broccoli and cauliflower exceeded their respective increase in sales revenues, indicating assignment of higher importance as crucial inputs in farming.

In case of use of farm-power, it can be observed that with the adoption of micro-irrigation, costs on account of farm-power also increased for all three crops considered here. While the average increase for individual farms stands at 49.82 per cent, that for cabbage stands at 60.38 per cent, followed by cauliflower (50.09 per cent) and broccoli (45.83 per cent). Here too, without considering the change in the price of bullock power and power tiller (which are the component parts of farm-power), no concrete observations can be made.

However, while analysing the changes in labour application with the adoption of micro-irrigation, it has been observed that costs on account of labour power increased for all the three crops. In particular, the labour costs for cabbage increased by 41.10 per cent, followed by cauliflower (30.34 per cent) and broccoli (28.61 per cent). At the farm level, the increase in labour costs has been recorded at 30.74 per cent. Alongside with this, if we observe the increase in the changes in the average number of physical labour days, it comes out that there has not been a huge increase in the average number of labour days employed for the three crops. In particular, while the average number of man-days increased by 17.60 per cent for cabbage, that for cauliflower and broccoli stands at 7.45 per cent and 4.19 per cent respectively. The increase in average man-days at the farm level stood at 7.81 per cent only.

Here, a number of important observations come out. First, comparing the increase in expenditure of labour and actual labour days, it comes out that the increase in the application of labour remains far less than the increase in the expenditure on account of it, indicating that

the increase in labour cost has been largely due to an increase in the rate of labour days. Second, if we compare the increase in the average area under cultivation with the increase in average man-days employed, it comes out that the increase in labour-days remains far less than the increase in area under cultivation. This implies that with the adoption on micro-irrigation, the rate of labour application decreased, while there has been an increase in area under cultivation.

In case of marketing costs, we observe that with the adoption of micro-irrigation, costs on account of marketing also increased over time. Similarly, costs other than those considered above, termed here as 'other' costs, also increased over time. But these costs carry little significant as compared to other costs.

On the whole, total costs of cultivation for all these three crops increased by 54.96 per cent, 53.26 per cent and 49.75 per cent respectively for cabbage, broccoli and cauliflower. As the increase in costs of cultivation remains less than the increase in the sales revenue for each of these crops, it comes out that net profit also increased for these crops with the adoption of micro-irrigation over time. In particular, while there has been an increase of 71.01 per cent in profit for cabbage, that for cauliflower and broccoli stands at 67.48 per cent and 63.01 per cent respectively, which remains far higher than their respective increase in total costs of cultivation. It is also interesting to observe here that as profit as proportion to total costs incurred recorded an increase for all the three crops with the adoption of micro-irrigation.

This increase in profit and decrease in labour cost comes out clearly when we compare the changes in profit and labour cost in relation to proportionate changes in total cost. In particular, profit as percentage of total cost increased from 43.98 per cent to 49.18 per cent for cauliflower (an increase of 5.20 per cent), 44.96 per cent to 47.82 per cent for broccoli (an increase of 2.86 per cent), and 32.73 per cent to 36.12 per cent for cabbage (an increase of 3.39 per cent). Similarly, the decrease in labour cost as proportion of total cost comes out to be 6.14 per cent for cauliflower, 7.99 per cent for broccoli and 2.25 per cent for cabbage. For the farm as a whole, the relative increase in profit as proportion of total cost stands at 2.61 per cent, while cost of labour as proportion to total cost decreased by 5.97 per cent.

As such, adoption of micro-irrigation for the sample adopter farmers comes out to be a profitable notion, which in turn induced an increase in the area under cultivation, higher yield and lower costs of account of labour power in particular. Micro-irrigation here comes

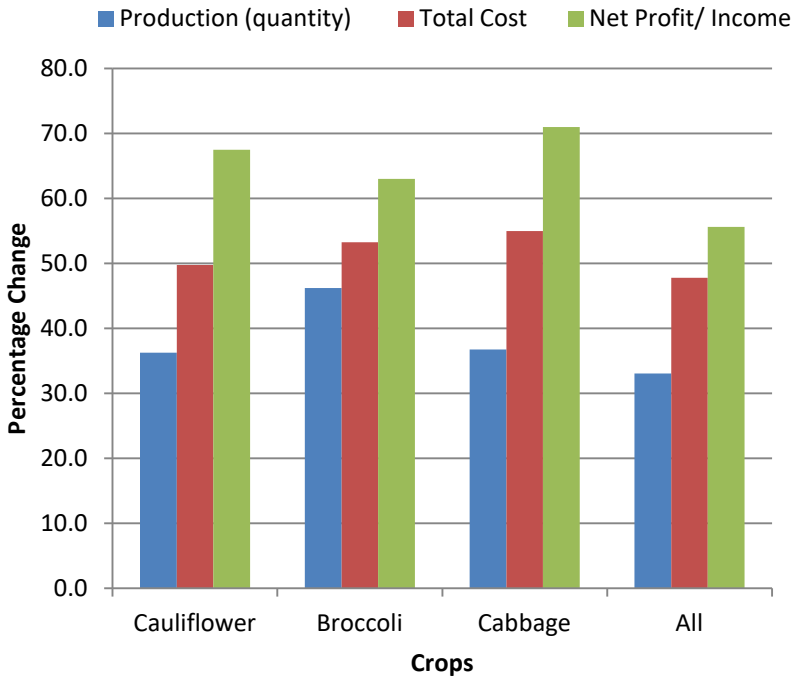
out to be a high-yielding, labour-saving and cost-efficient technology with positive acreage effect.

Table 7.1: Changes in Production, Incomes, Inputs and Costs with Micro-Irrigation for Major Crops

Item (approp. units)	Crop-1: Cauliflower		Crop-2: Broccoli		Crop-3: Cabbage		All Crops/Total	
	No. reporting : 69		No. reporting : 55		No. reporting : 31		No. reporting 96	
	With MI	Without MI	With MI	Without MI	With MI	Without MI	With MI	Without MI
	Average for reporting farmers							
Area	.14	.11	.14	.11	.14	.11	.28	.22
Production (quantity)	6.99	5.13	4.27	2.92	16.41	12.00	15.74	11.83
Price	37.86	33.33	69.05	64.07	22.94	19.58	41.09	36.44
Total Sales Revenue	26565.65	17121.16	29163.18	18660.27	37797.10	23784.03	60112.34	39962.45
Cost of Production								
Seeds/Plants cost	5097.97	2899.35	5757.18	2920.45	5301.13	2989.19	9076.09	5028.91
Fertilizer cost	.00	.00	.00	.00	.00	.00	.00	.00
Farm Yard Manure/Organic cost	1957.75	1189.93	2755.09	1577.91	4730.48	2996.29	4919.38	3027.71
Pesticides cost	.00	.00	.00	.00	.00	.00	.00	.00
Cost of Irrigation								
Electricity cost	.00	.00	.00	.00	.00	.00	.00	.00
Diesel cost	.00	.00	.00	.00	.00	.00	.00	.00
Water Charges paid	.00	.00	.00	.00	.00	.00	.00	.00
No of irrigations	9.22	9.22	8.36	8.36	10.97	11.23	19.63	19.54
Hours of pumping	.00	.00	.00	.00	.00	.00	.00	.00
Farm power & Equipment cost	1642.68	1094.49	1381.00	947.00	3398.23	2118.87	3527.45	2354.48
Total man-days	24.10	22.43	26.58	25.51	36.68	31.19	59.49	55.18
Labour cost	7343.48	5634.06	8226.36	6396.36	11003.23	7798.39	18072.40	13823.44
Marketing cost	1688.62	1053.48	1493.27	981.45	3275.32	1997.26	3750.47	2431.82
Other costs								
1.	76.81	20.29	115.36	49.09	59.68	19.35	141.09	48.96
2.	.00	.00	.00	.00	.00	.00	.00	.00
Total Cost	17807.32	11891.59	19728.27	12872.27	27768.06	17919.35	39486.88	26715.31
Net Profit/ Income	8758.33	5229.57	9434.91	5788.00	10029.03	5864.68	20625.47	13255.21

Source: Field Survey 2019-20

Diagram 7.1
Changes in Production, Costs and Income with MI for Major Crops



8

CAPITAL AND MAINTENANCE COST OF MICRO-IRRIGATION

8.1: INITIAL CAPITAL COST/INVESTMENT IN MICRO IRRIGATION

Adopting a new technology like micro-irrigation in farming has always been a subject of concern for the individual farmers as it often involves high initial capital costs. Often the farmers remain hesitant in making investments for a new technology, the outcome of which is yet to be known for certain.

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	0	0.00	NA	0.00	NA
2. Sprinkler irrigation Set/Kit	0	0.00	NA	0.00	NA
3. Filters (Cyclone, Disc, others)	0	0.00	NA	0.00	NA
4. Pipes (Micro, Distribution, Drip, PVC, PE, others)	0	0.00	NA	0.00	NA
5. Pumps (Avg._____hp)	0	0.00	NA	0.00	NA
6. Tube well cost (only if addl. for MI)	0	0.00	NA	0.00	NA
7. Any others	0	0.00	NA	0.00	NA
Total	0	0.00	NA	0.00	NA

Source: Field Survey 2019-20

* The entire initial capital cost / investment is borne out by the Dept. of Horticulture, Govt. of Sikkim. The unit cost of MI installation has been annexed in appendix I.

However, it has been observed in our study area in the state of Sikkim that these concerns regarding initial capital costs/investments remain largely invalid, as there has been 100% subsidy assistance for adopting micro-irrigation for the adopter farmers. In fact, the farmers do not need to pay any money or take any loan for carrying out initial capital costs of installation of micro-irrigation system in their plots of land (refer table 8.1). The entire cost is subsidized by the State Government for installation of micro-irrigation equipments in

farmers' plots. The beneficiary farmers of these subsidy schemes whom we questioned do not even know the subsidy amount provided by the State Government.

8.2: ANNUAL REPLACEMENT/MAINTENANCE COST OF MICRO IRRIGATION

Though the initial capital costs for installation if micro-irrigation system has been 100% subsidized by the Government if Sikkim, the maintenance cost of these fully subsidized equipments depend upon the beneficiary farmers themselves. As such, we observed zero subsidies by the State Government in maintenance/replacement of the micro-irrigation equipment for the adopter farmers of micro-irrigation (refer table 8.2). The only cost that the adopter farmers (less than 30% of adopters) had to bear is the cost of replacement or addition of pipes.

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)	0	0.00	0.00	0.00	0.00
2. Pipes (Micro, Distribution, Drip, PVC, PE, others)	27	1848.15	0.00	1848.15	0.00
3. Valves	0	0.00	0.00	0.00	0.00
4. Any other maintenance/ replacement/repairs	0	0.00	0.00	0.00	0.00
5. Any others	0	0.00	0.00	0.00	0.00
6.	0	0.00	0.00	0.00	0.00
Total	0	0.00	0.00	0.00	0.00

Source: Field Survey 2019-20

8.3: TOP 3 COMPANIES AS SOURCE OF EQUIPMENT/PARTS/SERVICE

It has been observed earlier in table 8.1 and 8.2 that while the initial capital costs of micro-irrigation system installation were fully subsidized by the State Government, the maintenance cost of these micro-irrigation sets/kits rested entirely upon the beneficiary farmers of the subsidy schemes (here, the adopters of micro-irrigation). It was also observed that a fraction of the adopter farmers (28%) had to purchase pipes for replacement and (or) addition to existing pipes for micro-irrigation.

However, when asked about the brand/company of the pipes purchased (refer table 8.3), we observed that the pipes were purchased from local traders, while the name of the manufacturer company of these pipes were not able to be recalled by the adopter farmers who purchased them. As per official of the Govt. of Sikkim, the MI kits are available with 4 companies as mentioned in table 8.3.

Table 8.3: Top 3 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**
Nil	0	0.00	Pipes (Micro, Distribution, Drip, PVC, PE, others) Company- Jain Irrigation Pvt. Ltd. Harvel Aqua India Pvt. Ltd. Netafim India Pvt. Ltd. Premier Irrigation Pvt. Ltd.	27	28.13
Nil	0	0.00	Nil	0	0.00
Nil	0	0.00	Nil	0	0.00

Source: Field Survey 2019-20

Figure 8.3: Sprinkler Irrigation Set

9

FACTORS AND DETERMINANTS AFFECTING MICRO-IRRIGATION ADOPTION

9.1 DETERMINANTS/FACTORS AFFECTING THE ADOPTION OF MICRO IRRIGATION

In course of the primary survey we carried out an opinion poll among the adopters of MI. This was a five point scale (strongly agree, agree, partially agree/disagree, disagree and strongly disagree) constructed for capturing the farmers' perception and judgement in respect of micro irrigation. Several attributes as regards to agronomic and agro-economic potential which might have an impact were included. In addition, there were questions relating to demand, supply and distributive impact of micro irrigation.

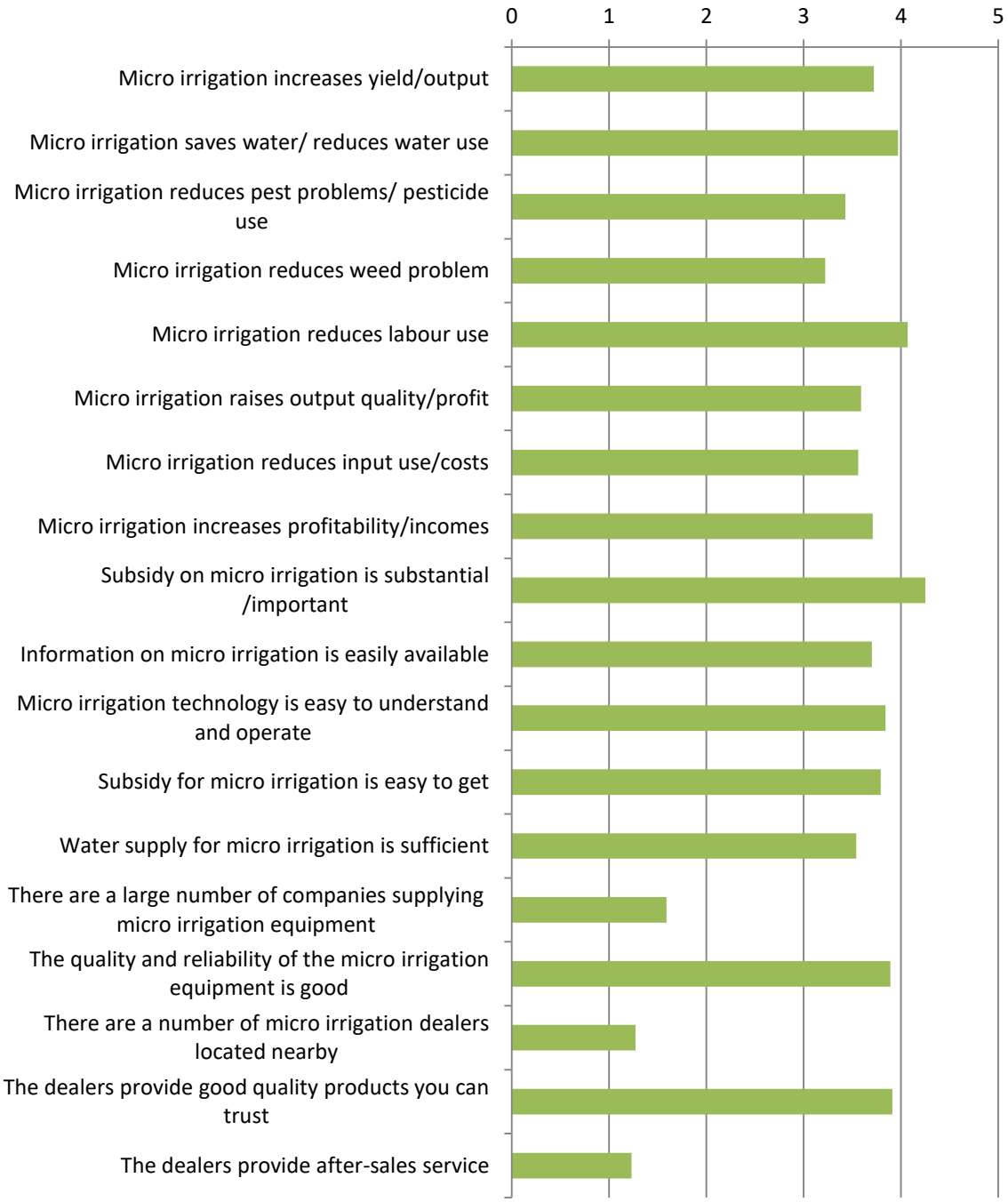
Agronomic factors incorporated attributes like increasing yield, reduction in water usage or labour use etc. as an impact of MI. It was observed that a large section of adopters agreed on the point that MI had a positive impact in reduction of labour and water usage. Proportion of adopters who agreed with such propositions was 92.7 and 96.9 per cent respectively while 7.3 per cent of total respondents had strong positive opinion as regards to reduction in labour usage due to installation of MI (Table 9.1). Out of 96 adopters 71.9 per cent was in agreement that MI had an impact on increasing yield and 28.1 per cent was in partial agreement with said proposition. However, as Sikkim has been practicing fully organic agriculture for over a decade the question as regards to impact on fertilizer use had been redundant. In course of our discussion during the survey the adopters responded very positively towards optimization of water usage which they achieved through MI. At the same time they were relieved, so far as their estimation goes, of a continuous monitoring of the irrigation process with installation of MI kits. Hence, overall agronomic potential centred on reduction in labour and water usage where over 95 per cent of the adopters were in agreement of its impact (mean responses were 4.07 and 3.97 respectively).

Table 9.1 Determinants/Factors Affecting the Adoption of Micro Irrigation

Factors	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 4	Strongly Disagree (%) 1	Mean	No. reporting
Agronomic Potential							
1. Micro irrigation increases yield/output	-	71.9	28.1	-	-	3.72	96
2. Micro irrigation saves water/ reduces water use	-	96.9	3.1	-	-	3.97	96
3. Micro irrigation reduces fertilizer use	NA	NA	NA	NA	NA	-	96
4. Micro irrigation reduces pest problems/ pesticide use	-	43.8	55.2	1.0	-	3.43	96
5. Micro irrigation reduces weed problem	-	22.9	76.0	1.0	-	3.22	96
6. Micro irrigation reduces labour use	7.3	92.7	-	-	-	4.07	96
Agro-Economic Potential							
1. Capital cost of micro irrigation is not high	NA	NA	NA	NA	NA	-	96
2. Micro irrigation raises output quality/profit	5.2	50.0	43.8	1.0	-	3.59	96
3. Micro irrigation reduces input use/costs	-	56.3	43.8	-	-	3.56	96
4. Micro irrigation increases profitability/incomes	4.2	64.6	29.2	2.1	-	3.71	96
5. Subsidy on micro irrigation is substantial /important	27.1	70.8	2.1	-	-	4.25	96
Effective Demand							
1. Information on micro irrigation is easily available	2.1	65.6	32.3	-	-	3.70	96
2. Micro irrigation technology is easy to understand and operate	6.3	71.9	21.9	-	-	3.84	96
3. Subsidy for micro irrigation is easy to get	5.2	68.8	26.0	-	-	3.79	96
4. Finance for micro irrigation is easy to get	NA	NA	NA	NA	NA	-	96
5. Electricity supply for micro irrigation is available/reliable	NA	NA	NA	NA	NA	-	96
6. Water supply for micro irrigation is sufficient	-	54.2	45.8	-	-	3.54	96
Aggregate Supply							
1. There are a large number of companies supplying micro irrigation equipment	-	-	16.7	26.0	53.7	1.59	96
2. The quality and reliability of the micro irrigation equipment is good	3.1	82.3	14.6	-	-	3.89	96
Distribution							
1. There are a number of micro irrigation dealers located nearby	-	-	-	27.1	72.9	1.27	96
2. The dealers provide good quality products you can trust	6.3	78.1	15.6	-	-	3.91	96
3. The dealers charge a reasonable price	NA	NA	NA	NA	NA	-	96
4. The dealers arrange for subsidy/credit	NA	NA	NA	NA	NA	-	96
5. The dealers provide after-sales service	-	-	-	22.9	77.1	1.23	96

Source: Field Survey 2019-20; NA- Not Applicable

Diagram 9.1
Determinants/Factors Affecting the Adoption of Micro Irrigation: Mean Response Score



In view of agro-economic potential of micro irrigation a sizeable proportion of respondents (i.e. adopters) were of the opinion that subsidy on micro irrigation played an

important role in adoption of MI and augmenting the agro-economic potential (over 97 per cent of total adopters responded in affirmative in this respect). Adopters also attributed importance to factors like increasing income, reducing input cost and augmenting output quality as agro-economic contribution of MI. However, as MI was fully provided by the Government of Sikkim where the farmer had to pay nothing for such installations, question as regards to capital cost for MI had no bearing.

Coming to the demand side of MI from adopters' point of view, we observed that the easy technology, available subsidy and availability of information regarding MI got priority in the responses (respective mean values of response score were 3.84, 3.79 and 3.70). In course of the survey we had discussions with the adopters regarding the technology that was being used in MI installations. We had the impression that the farmer were quite familiar with the technology and had no complaint regarding availability of such information that were being imparted by the grass root technical personnel of the Department of Horticulture in respective areas. However, when the question boiled down to sufficiency of water supple we found a mixed reaction. Out of 96 adopters 54.2 per cent was of the agreed that the water supply was sufficient while the other 45.8 per cent was not in such confirmatory opinion.

Here again the question of finance on part of beneficiaries did not arise. Moreover, as we have said earlier that the whole micro irrigation system in Sikkim depended on flow of water from upper reaches of the hill to the lower stretches to the fields taking advantage of the gravitational force. Hence, no electricity is required by the adopters for installation of MI at field level.

On the supply side of MI, there were fewer complaints as regards to the quality of the instruments that were being provided. Out of the total adopters 82.3 per cent was in agreement that the kits being provided were good and reliable and 3.1 per cent was in strong agreement with the proposition. However, 14.6 per cent seemed indecisive. On the contrary, presence of large number of companies that are suppliers of MI equipment was denied (in disagreement) by over 79 per cent of the total respondents (mean response score being only 1.59).

The distribution aspect of MI revealed more or less similar scenario where all respondents denied existence of numbers of MI dealers located nearby (27.1 per cent in agreement and 72.9 per cent in strong agreement). It was also noted that the suppliers provided equipment of good quality and respondents seemed to have trust. We came to know that there were few dealers affiliated by the Sikkim Micro Irrigation Council that are

entrusted to supply the MI equipments. As regards to post installation services made available to the farmers by dealers of MI there was clear dissatisfaction among the adopters. None of the adopters was of the opinion that the dealers provided after-installation services. As regards to the quality they had been happy, nonetheless, there were grumbles about further services and support provided by the dealers of MI.

9.2 PERCEIVED ADVANTAGES AND DISADVANTAGES OF MICRO-IRRIGATION

In course of the present study the adopters were questioned as regards to their perception as to the advantages and disadvantages of MI. Again, a five point scale was constructed, having strong advantage at one end to strong disadvantage at the other, to capture their responses. It was observed that the strongest advantage had been lesser usage of labour in MI. About 19 per cent of total adopters opined this to be strong advantage while to rest 81.3 per cent it was an advantage. Similarly, reduction in water usage had been advantageous for all the respondents. Mean response score was 4.19 in case of lowering the use of labour while the corresponding score was 4.00 for reduction in use of water for irrigation (Table 9.2). Resultant was reduction in the input cost.

Table 9.2 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	3.1	68.8	28.1	-	-	3.75	96
2. Better Quality	-	54.2	45.8	-	-	3.54	96
3. High output price	-	4.2	95.8	-	-	3.04	96
4. Lower input cost	-	46.9	53.1	-	-	3.47	96
5. Less water need	-	100.0	-	-	-	4.00	96
6. Less labour need	18.8	81.3	-	-	-	4.19	96
7. Less weed problem	-	28.1	71.9	-	-	3.28	96
8. Less pest problem	-	46.9	53.1	-	-	3.47	96
9. Less fertilizers need	NA	NA	NA	NA	NA	-	96
10. Easy marketing of output	-	1.0	93.8	5.2	-	2.96	96
11. Higher Profit	-	68.8	31.3	-	-	3.69	96
12. Less risk	-	50.0	50.0	-	-	3.50	96
13. Employment for youth	-	-	100.0	-	-	3.00	96
14. OVERALL	-	90.6	9.4	-	-	3.91	96

Source: Field Survey 2019-20; NA= NOT APPLICABLE, NI=NO ISSUES

Diagram 9.2
Perceived Advantages of MI based on Mean Response Score

Generally, in accordance with the farmers' perception higher yield, higher profit, better quality of output along with lower risk of paste infestation had been major issues of advantage from MI. However, it was interesting to observe that in question of employment of youth the adopters had unanimous opinion that MI had brought about no difference in the participation of youth and their employment in the agrarian sector. In fact, this was a common criticism against the youth for not taking interest in agricultural activities that was foregrounded time and again in course of our discussions with the farmers. There were, however, no other issues in connection with MI. On the whole implementation of MI had been advantageous to 90.6 per cent of total adopters (while mean response score been 3.91).

10

LARGER IMPACTS AND PROBLEMS OF MICRO-IRRIGATION

10.1: LARGER IMPACTS OF MICRO IRRIGATION

Assemblage or cluster approach of any assistance programme in agrarian economy is supposed to have a widespread impact in the socio-economic contour of village society. In Sikkim implementation of micro irrigation project was conceived in a manner as to include as many number of farmers as possible in a village within its reach. It was thus thought to have had a broader impact on the village as a whole. Perception of adopters in view of this impact was collected with the help of enlisting their response on a five point attribute scale.

It appeared from the perception responses of adopters that MI has had an impact in improving the condition of the village as a whole (62.5 per cent of the respondents confirmed the outcome as positive, Table 10.1). However, the rest 37.5 per cent had an opinion that MI had no impact on the village (mean response score was 3.63).

Apart from general impression of the beneficiaries there were several other aspects on which the farmers foregrounded their opinion. It was observed that around half of the adopters had positive response towards water conservation and environment (proportion of farmers was 59.4 and 51.0 per cent and mean response score 3.59 and 3.51 respectively).

Despite the fact that general response of adopters was positive, the opinions as regards to locational advantage of land varied considerably. Impact of MI was significantly higher among the lowland farmers, as perceived by the respondents, than their upland counterpart (where mean response index was 3.60 and 3.28 respectively). This might have been due to the method of MI being pursued in Sikkim's hilly region where the flow of water depended on the gravitational force (as the water went down the terrain the pressure increased).

It was rather interesting to find that there was a general positive impact of MI on upper or lower caste and poor or tribal people. We had a detailed discussion with the villagers in course of our survey regarding their responses. We never found an occasion where any of the farmers complaining against discriminatory nature of programme implementation in view of caste or economic position of the family. In a cluster command method generally the farmers in the close proximity with the water outlet were roped up as MI beneficiaries. As for

the young people the general opinion, as we discussed earlier, was rather disappointing in view of their participation in agriculture.

Table 10.1: Larger Impacts of Micro Irrigation

Impact on	Substantially positive (%) 5	Positive (%) 4	No Impact (%) 3	Negative (%) 2	Substantially Negative (%) 1	Mean	No. Reporting
1. Village as a whole	-	62.5	37.5	-	-	3.63	96
2. Water conservation/availability	-	59.4	40.6	-	-	3.59	96
3. Women	-	14.6	85.4	-	-	3.15	96
4. Upper Caste	-	100.0	-	-	-	3.00	96
5. Lower Caste	-	100.0	-	-	-	3.00	96
6. Labour/Poor	-	100.0	-	-	-	3.00	96
7. Tribals	-	100.0	-	-	-	3.00	96
8. Young farmers/Youth	-	-	100.0	-	-	3.00	96
9. Upland farmers	-	28.1	71.9	-	-	3.28	96
10. Lowland farmers	-	60.4	39.6	-	-	3.60	96
11. Environment	-	51.0	49.0	-	-	3.51	96
12. Any other (specify)	NI	NI	NI	NI	NI	-	96

Source: Field Survey 2019-20; NI=NO ISSUES

10.2: MAJOR PROBLEMS FACED BY FARMERS IN RELATION TO MICRO-IRRIGATION

Questions were asked to get an assessment of the problems as perceived by the adopters in connection with MI installation. Adopters, however, seemed to have little problem with quality of the equipment that had been supplied to them. Only 7.3 per cent of the total respondents were in partial agreement that the MI equipment were of poor quality. Proportion of beneficiary farmers with disagreement with the proposition was 89.6 per cent and 3.1 per cent had a strong disagreement (Table 10.2). Mean value of perception score was 2.04.

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	No. of reporting
1. Poor quality of micro irrigation equipment	-	-	7.3	89.6	3.1	2.04	96
2. High need/cost of maintenance in micro irrigation	-	-	3.1	89.6	7.3	1.96	96
3. Inadequate water	-	-	30.2	69.8	-	2.30	96
4. Poor water quality	-	-	17.7	81.3	1.0	2.17	96
5. Difficulty in obtaining government subsidy & support	-	-	3.1	94.8	2.1	2.01	96
6. Unreliable electricity supply	NA	NA	NA	NA	NA	-	96
7. Lack of credit	NA	NA	NA	NA	NA	-	96
8. Lack of own wells/tube wells	NA	NA	NA	NA	NA	-	96
9. High cost of wells/tube-wells	NA	NA	NA	NA	NA	-	96
10. Water table going down fast	NA	NA	NA	NA	NA	-	96
11. Lack of knowledge/training for micro irrigation	-	-	26.0	74.0	-	2.26	96
12. Lack of government support	-	-	10.4	75.0	14.6	1.96	96
13. Difficulty in getting government support	-	-	10.4	74.0	15.6	1.95	96
14. Lack of micro irrigation dealers in area	7.3	66.7	16.7	9.4	-	3.72	96
15. Poor after sales service	12.5	62.5	20.8	4.2	-	3.83	96
16. Low output price/profitability	-	3.1	31.3	65.6	-	2.38	96
17. Poor marketing arrangements	-	4.2	79.2	16.7	-	2.88	96
18. Land fragmentation	-	-	96.9	3.1	-	2.97	96
19. Damage by animals	-	26.0	67.7	6.3	-	3.20	96
20. Lack of fencing	-	20.8	68.8	10.4	-	3.10	96
21. Other (Specify)	NI	NI	NI	NI	NI	-	96

Source: Field Survey 2019-20; NA=NOT APPLICABLE, NI=NO ISSUES

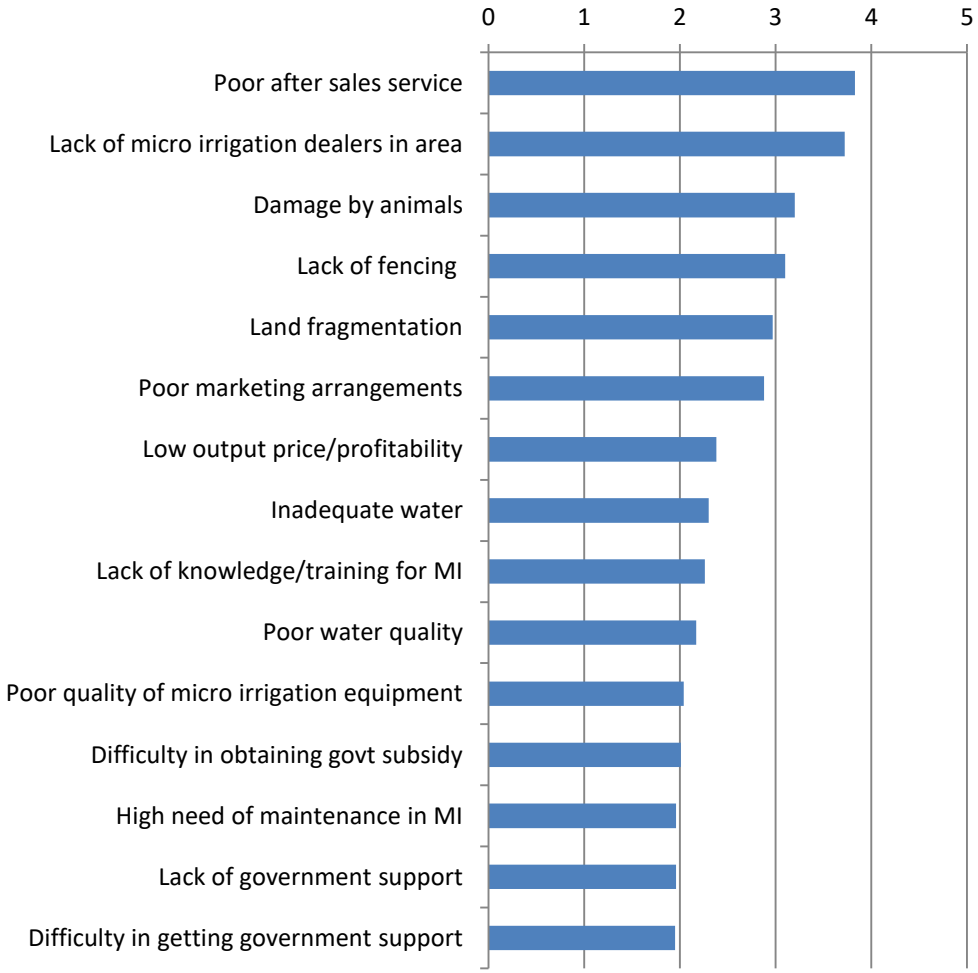
At the same time the adopters rejected the suggestion that operation of MI needed high maintenance cost (mean value of response being 1.96). Only 3.1 per cent were in partial

agreement that required maintenance cost for MI was high while 96.9 per cent negated such necessity.

Now coming to the question of quantity and quality of water for irrigation, about a third of the total respondents felt and partially agreed that the quantum of water had been inadequate. However, the respondents seemed to be more or less satisfied about the quality of water.

There was lack of agreement in connection with the questions regarding difficulty in obtaining or deficiency in government support or provision of subsidy but respondents opined very strongly that there were lack of MI dealers and affirmed very poor after sales services provided by them (mean score values being 3.72 and 3.83 respectively).

Diagram 10.2
Major Problems Faced by Farmers in relation to MI based on Mean Response Score



Lack of farm fencing and damage of crop caused by wild animals was perceived by about a fifth of the respondents to be major problems. In Sikkim, however, in the extensive forest area there is presence of wild boars and deer in a large number. At times these wild animals intrude in the cropping field in search of food and damage standing crops. In the upper reaches it is rather frequent as compared to the cropping fields situated in the lower reaches.

Questions concerning unreliable electric supply, lack of own tube-wells and cost therein or depleting water table had no connection with the MI practice in Sikkim.

It was rather pleasing to observe that most of the respondents had knowledge or training for running micro irrigation with mean score at 2.26.

Figure 10.2: Cultivation in the Slopes of Himalayas

11

OVERALL ASSESSMENT OF THE PERFORMANCE OF MICRO-IRRIGATION

11.1: OVERALL ASSESSMENT OF MICRO-IRRIGATION BY THE FARMERS

In view of the overall performance of micro irrigation, adopters' responses were generally optimistic in the sense that had been benefitted from such assistance. The installations were provided to the farmers, as said earlier, free of cost. We had questions as regards to improvement in water use efficiency, reduction in input cost, increase in income and over and above all the general overall performance of MI as considered by the adopters. We found that the general opinion as regards to micro irrigation to be affirmative with 83.3 per cent out of 96 adopters' response was 'good' (mean response score was 3.83, Table 11.1). And 16.7 per cent seemed to be satisfied with the MI programme.

In connection with the performance of MI on improving the water use efficiency the observed mean score was 3.75. Proportion of farmers who seemed to be satisfied in this respect was to the tune of 25 per cent while to the rest 75 per cent improvement in water use efficiency was good. More or less a similar representation is observed when the question boiled down to reduction in the input cost as an effect of MI installation. When probed, the farmers endorsed that such reduction was the resultant of lower labour usage and reduction in pest infestation.

However, as regards to increase in income and profit the respondents answered in positive but with a little reservation (mean score accounting for 3.46). At times adopters were critical about the transport and marketing system of the produce. The usual system of transportation was to carry the produce on head-load from the field up to the vehicle hired by few farmers and move for the market. And there are times, particularly during the harvesting season, when scarcity of vehicles poses hindrance in view of marketing the product of the farmers. Some of them were of the opinion that had the government intervened it would have been easier for them to reap more profits from their produce.

The adopters, despite their difficulties in marketing, were eager to continue with the micro irrigation with 8.3 per cent were in strong agreement while 86.5 per cent agreed to

continue with this particular system of irrigation. But in view of small land holding of the farmers and fragmentation of plots in the hilly tract there were little scope for extension or expansion of micro irrigation among the already benefitted farmers.

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	No. Reporting
Overall performance of micro irrigation	-	83.3	16.7	-	-	3.83	96
Performance on Improving Water Use Efficiency	-	75.0	25.0	-	-	3.75	96
Performance on reducing input cost (such as Fertilizers, Pesticides, Labour, Electricity)	-	78.1	21.9	-	-	3.78	96
Performance on increasing incomes/Profits	-	45.8	54.2	-	-	3.46	96
Item	**Strongly Agree (%) 5**	**Agree (%) 4**	**Partially Agree/Disagree (%) 3**	**Disagree (%) 2**	**Strongly Disagree (%) 1**	**Mean**	**No. Reporting**
Will you adopt/continue to use micro irrigation?	8.3	86.5	5.2	-	-	4.03	96
Will you expand micro irrigation use?	-	45.8	54.2	-	-	3.46	96

Source: Field Survey 2019-20

11.2: SUGGESTIONS FOR INCREASING THE ADOPTION AND IMPACT OF MICRO-IRRIGATION

In course of the field survey the adopters were enquired in detail as to their suggestions for increasing the adoption of MI and its impact. It turned out that provision of better marketing arrangement and better training for micro irrigation would be beneficial for earning more profit from MI and increasing annual income. Of the total adopters 8.3 per cent strongly agreed that better marketing arrangements was need of the hour. Imparting better training with regard to micro irrigation was another requirement posed by the beneficiaries. Improvement in water availability was, however, pleaded by a section (43.8 per cent) of recipients of MI. As to technological aspect of the MI installations, over 14 per cent voted against such requirement while 54.2 per cent was in two minds regarding such need.

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	No. Reporting
1. Better micro irrigation technology/equipment	-	31.3	54.2	14.6	-	3.17	96
2. Lower price of micro irrigation	NA	NA	NA	NA	NA	-	96
3. More subsidy/ government assistance	NA	NA	NA	NA	NA	-	96
4. Easier process for getting subsidy/government assistance	NA	NA	NA	NA	NA	-	96
5. More loans/ credit	NA	NA	NA	NA	NA	-	96
6. Improve water availability	2.1	41.7	56.3	-	-	3.46	96
7. Better training for micro irrigation	-	55.2	44.8	-	-	3.55	96
8. Provision/support for farm fencing	-	16.7	83.3	-	-	3.17	96
9. Better marketing arrangements	8.3	51.0	40.6	-	-	3.68	96
10. Others	NI	NI	NI	NI	NI	-	96

Source: Field Survey 2019-20; NA= N0T APPLICABLE, NI= NO ISSUES

As fully subsidized kits were made available by the Government after an exhaustive survey of the local region issues relating to price of kit, more credit etc. did not receive any concern by the adopters. Moreover, there were no other issues on which the farmers had further suggestions.

12

NON-ADOPTERS OF MICRO-IRRIGATION: PROFILE & ISSUES

12.1: SAMPLE COVERAGE OF NON-ADOPTERS

As has been mentioned earlier in study methodology, the primary sample survey for the present study has been done following a multistage stratified random sampling, where the stratification has been done based upon the criteria of whether the sample farmers have adopted micro irrigation or not. As such, along with the 96 adopter farmers of micro irrigation, this study has also covered 24 non-adopter farmers. Here, an analysis of the farm economics of the sample non-adopter farmers, in turn, allows us to compare performances of the adopters of micro irrigation in sharp contrast to their counterparts, viz. the non-adopters.

The sample pool of non-adopter farmers of micro irrigation consists of 24 farmers, 12 from each of the two selected districts of Sikkim (refer table 121). Whereas the 12 non-adopter farmers from East district are selected from 3 different villages, the rest 12 non-adopter farmers are selected from 4 villages from the South district. It should be noted here that out of the total number of 24 sample non-adopter farmers, as much as 20 non-adopter farmers (83.33%) have either partial or complete access to irrigation for their farmlands.

Table 12.1: Sample Coverage of Non-Adopters

Sr. No.	District Name	No. of Village	No. of Farmers surveyed	With irrigation	Without irrigation
1.	East	3	12	8	4
2.	South	4	12	12	0

Source: Field Survey 2019-20

12.2: AGE PROFILE OF NON-ADOPTERS

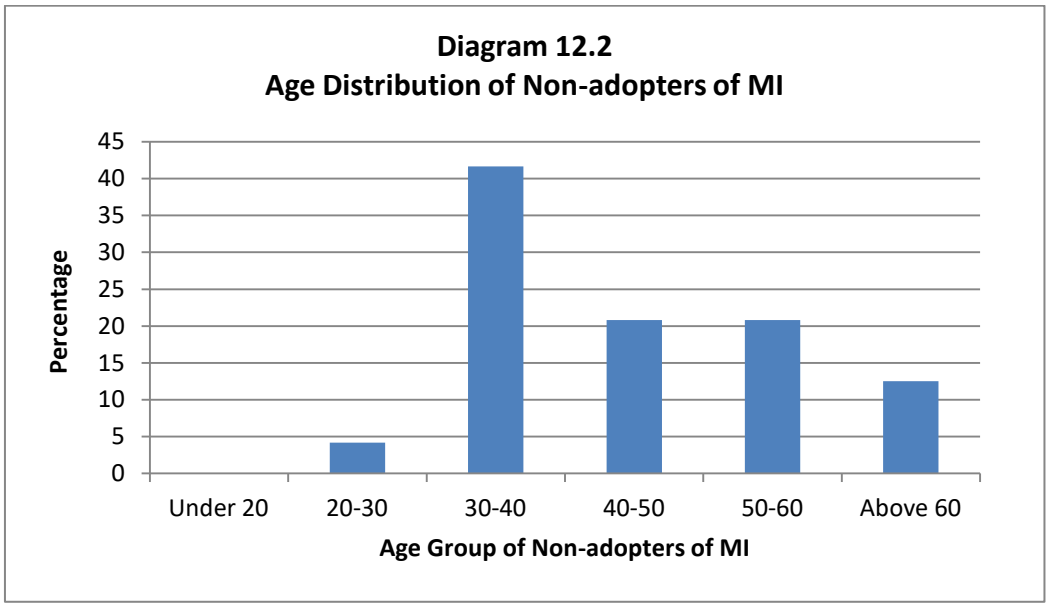
A tabular analysis of the sample pool of non-adopter farmers according to age group of respondents (refer table 12.2) reveals that majority (41.67%) of the non-adopter farmers falls under the age-group of 30-40 years, while age-groups 40-50 years and 50-60 years both represent 20.83% of non-adopter farmers. Thus in total, more than 82% of farmers are from the age range of 30 years to 60 years, which indicates dominance of middle aged farmers in

the sample pool. In comparison, younger farmers aged less than 30 years only form 4.17% of the sample size, which is less than proportion of non-adopter farmers aged 60 years or more (12.50%). If we compare the age distribution of adopters vis-à-vis non-adopters, we observe that while adopter farmers are more or less evenly distributed over the middle aged groups, the non-adopter farmers are concentrated in the 30-40 years age-group.

Table 12.2: Age Profile of Non-Adopters

	Number	Percent
Under 20	0	0.0
20-30	1	4.17
30-40	10	41.67
40-50	5	20.83
50-60	5	20.83
Above 60	3	12.50

Source: Field Survey 2019-20



12.3: EDUCATION PROFILE OF NON-ADOPTERS

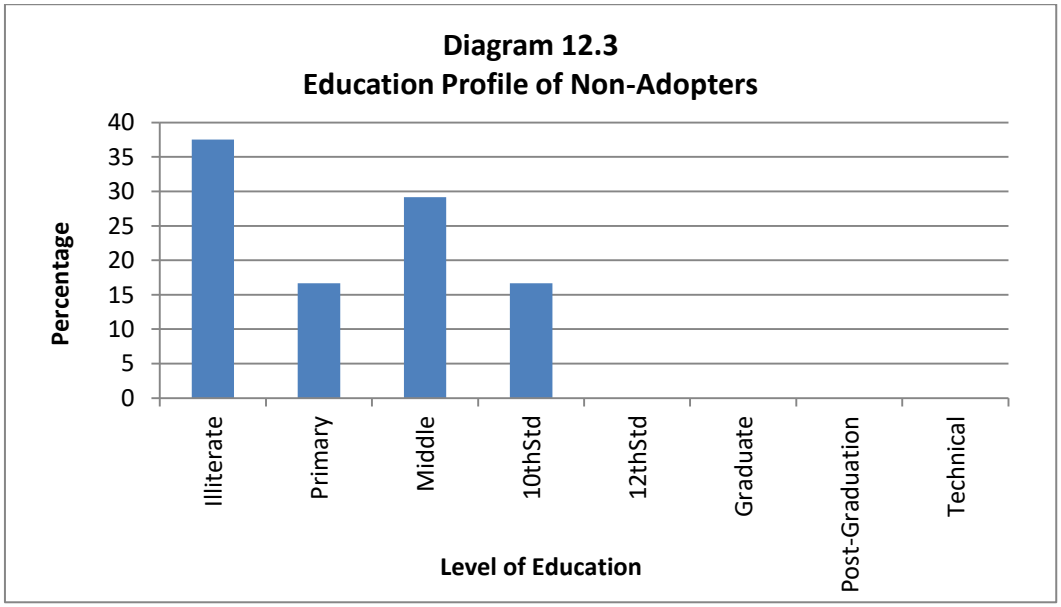
As it has been widely debated in the academic arena that education plays a pivotal role in adoption of technology, here we have taken account of the education profile of the sample non-adopter farmers (refer table 12.3). It is quite evident from a categorization of non-adopter farmers according to their educational achievement that the non-adopter sample pool is poorly educated as none of the 24 sample non-adopter farmers have cleared 12th standard or

more. In fact, as much as 37.50% of non-adopter farmers are found to be illiterate. Among the 15 literate non-adopter farms, more than 73% are unable clear even the 10th standard. However, among the literate non-adopters, about 47% studied up to the middle standards of schooling. Overall, the education profile of the sample non-adopter farmers remains quite poor. In fact, there is little difference in the educational attainment of the adopters vis-à-vis non-adopters, except that none of the non-adopters attained 12th standard as compared to the adopters (3.1 percent attained 12th standard).

Table 12.3: Education Profile of Non-Adopters

	Number	Percent
Illiterate	9	37.50
Primary	4	16.67
Middle	7	29.17
10thStd	4	16.67
12thStd	0	0.0
Graduate	0	0.0
Post-Graduation	0	0.0
Technical	0	0.0

Source: Field Survey 2019-20



12.4: LAND PROFILE OF NON-ADOPTERS

In case of pattern of landholding across the sample non-adopter farmers, it should be noted at the outset that there exists no landless/tenant farmers in our sample pool (refer table 12.4). Such a phenomenon is quite obvious as the sample population only covers the farmers with land holding, and not the landless farmers. However, it can be observed that an overwhelming majority (more than 79%) of non-adopter sample farmers are marginal farmers with an average land holding size of .50 hectares. The proportion of small and medium non-adopter farmers are 12.50% and 8.33% respectively.

However, in case of irrigation availability, it is interesting to observe that irrigated land as proportion to total operated area decreases steadily with increase in farm size, which indicates that the smaller farms are better endowed with irrigation availability as compared to the larger farms. On the whole, the landholding pattern of the non-adopter farmers represents a highly marginalized farm economy with an overall irrigation availability of less than 30%.

Table 12.4: Land Profile of Non-Adopters

	Number	Percent	Total Area Average (ha.)	Area irrigated Average (ha.)	Area unirrigated Average (ha.)
Landless/Tenant	0	0.00	0.00	0.00	0.00
Marginal (<1)	19	79.17	0.50	0.21	0.30
Small (1-2)	3	12.50	1.23	0.43	0.80
Medium (2-10)	2	8.33	3.10	0.25	2.85
Large (>10)	0	0.00	0.00	0.00	0.00
Total	24	100.00	0.81	0.24	0.57

Source: Field Survey 2019-20

If we compare the average size of land holding between the adopters and non-adopters of MI (refer diagram 12.4.1), we observe that average size of land-holding is slightly higher for the non-adopter farms. However, average irrigation availability remains much higher for the adopters of MI (refer diagram 12.4.2), which appears to be a clear reflection of the benefits of MI.

Diagram 12.4.1
Average Size of Land Holding for Adopers and Non-adopters of MI

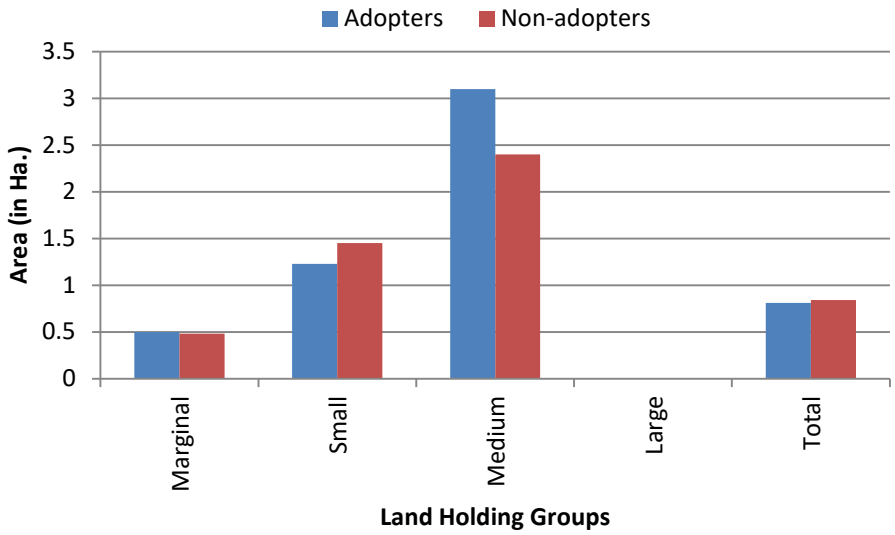
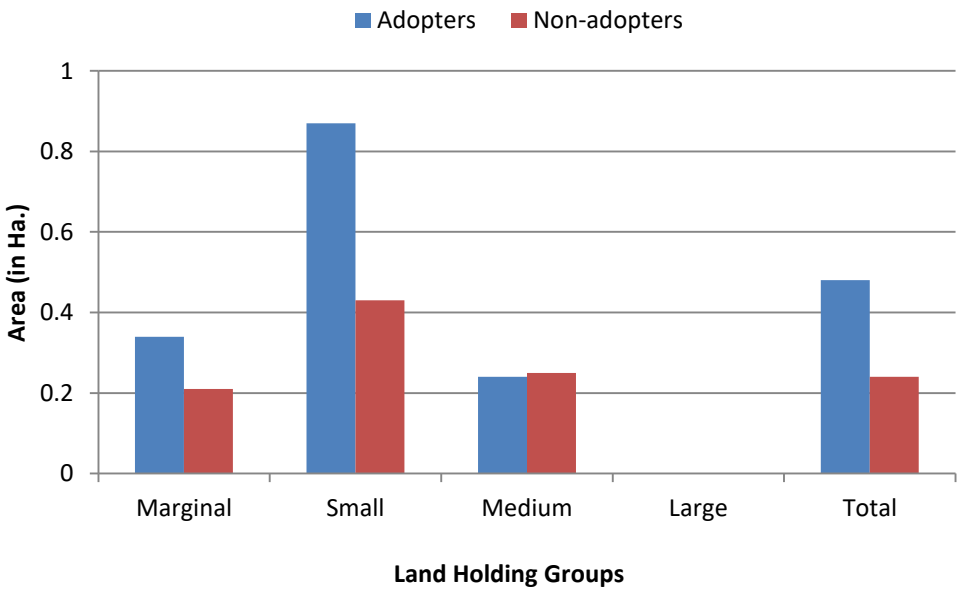


Diagram 12.4.2
Average Irrigated Area for Adopers and Non-adopters of MI



12.5: WATER SOURCES AND SITUATION

As the state of Sikkim is entire a Himalayan hilly region, the sources of water for irrigation differ completely from that in plain lands or plateaus. As such, irrigation sources like canals, lift irrigation from various sources, tanks, ponds, check/percolation dams, etc. are completely absent in Sikkim. The only major source of irrigation is small streamlets. Irrigation activities are carried out entirely depending upon these streamlets (refer table 12.5). It has been observed during the field survey that pipelines connect these streamlets to small concrete reservoirs at the farm site, from which irrigation is carried out with pipes using gravity flow. Even in some instances, it has been observed that simple tools like buckets are used to irrigate farmland from these streamlets. In the absence of micro irrigation, all the non-adopter farmers who receive irrigation (83.33%) are completely dependent on these sources. In fact, irrespective of the newly introduced MI technology, the water sources and availability for the adopters and non-adopters are more or less similar.

Table 12.5: Water Sources and Situation

	Number	Percent
Water source		
Canal	0	0.0
Canal-Lift	0	0.0
River-Lift	0	0.0
Tubewell	0	0.0
Well	0	0.0
Tank	0	0.0
Pond	0	0.0
Farm Pond	0	0.0
Check dam	0	0.0
Percolation Tank	0	0.0
Others (Streamlets)	20	83.33
Water situation		
Excess water	0	0.0
No scarcity	0	0.0
Occasional scarcity	0	0.0
Scarcity	20	83.33
Acute scarcity	4	16.67

Source: Field Survey 2019-20

However, as these streamlets are natural flows of water, they are subject to seasonal variations throughout the year, and thus, scarcity of water is a common phenomenon for all those who depend upon these streamlets (all 83.33% of non-adopter farmers). For those who do not even have the opportunity to irrigate their farmland from these streamlets face acute water scarcity throughout the year. Naturally, choice of crops in these hilly regions greatly depends upon availability of irrigation as well as the degree of scarcity of irrigation water.

12.6: CROPPING PROFILE OF NON-ADOPTERS

Depending upon the availability of water for irrigation, land terrain, weather, soil type and other factors, cropping pattern varies greatly across geographical areas. In Sikkim, the cropping pattern of non-adopters of micro-irrigation appears largely dominated by vegetable cultivation (refer table 12.6). In Kharif season, crops like buckwheat, maize and paddy are cultivated mostly in un-irrigated tracts, where the average cultivated area is higher than that for Rabi crops. In Rabi season, a number of roots and vegetables are cultivated in smaller plots of land, like cauliflower, broccoli and cabbage. Other important Rabi crops include crops like beans, peas, tomato, ginger and turmeric. Among these Rabi crops, the roots like ginger and turmeric do not require irrigation and these crops are cultivated in un-irrigated tracts. Rarely, intercropping practices were observed involving crops like broccoli and cauliflower. In Sikkim, though there is a complete absence of summer crops, we observed a number of orchards of perennial crops like guava and mandarin orange. These orchards require little irrigation and are primarily cultivated in the un-irrigated slopes of the hills.

A comparison of cropping profile between the adopters and non-adopters of MI reveals that both the groups follow a similar cropping pattern, where cultivation of vegetables and roots remains predominant. Also, as the agro-climatic condition suits crops like mandarin oranges, both the adopters and non-adopters can be seen maintaining orange orchards.

Table 12.6: Cropping Profile of Non-Adopters

Sr. No.	Crop name	Season	No. of farmers reporting	Average total area	Average irrigated area	Average un-irrigated area
1	Buckwheat	Kharif	9	0.24	0.00	0.24
2	Maize	Kharif	7	0.51	0.00	0.51
3	Paddy	Kharif	11	0.35	0.00	0.35
4	Beans, Peas	Rabi	3	0.13	0.13	0.00
5	Beans	Rabi	7	0.09	0.09	0.00
6	Broccoli, Cauliflower	Rabi	1	0.20	0.20	0.00
7	Broccoli	Rabi	13	0.10	0.10	0.00
8	Cabbage	Rabi	9	0.09	0.09	0.00
9	Cauliflower	Rabi	13	0.10	0.10	0.00
10	Ginger	Rabi	5	0.10	0.00	0.10
11	Peas	Rabi	7	0.09	0.09	0.00
12	Radish	Rabi	1	0.05	0.05	0.00
13	Spinach	Rabi	1	0.05	0.05	0.00
14	Tomato	Rabi	4	0.06	0.06	0.00
15	Turmeric	Rabi	5	0.08	0.00	0.08
16	Guava	Perennial	1	0.40	0.00	0.40
17	Orange	Perennial	2	1.40	0.00	1.40

Source: Field Survey 2019-20

Table 12.6 (a): Cropping Profile of Non-Adopters (Percentages)

Sr. No.	Crop name	Area - in hectares (percentages)		
		Total Area	Irrigated Area	Un-irrigated Area
1	Buckwheat	2.15 (100.00)	0.00 (0.00)	2.15 (100.00)
2	Maize	3.60 (100.00)	0.00 (0.00)	3.60 (100.00)
3	Paddy	3.80 (100.00)	0.00 (0.00)	3.80 (100.00)
4	Beans, Peas	0.40 (100.00)	0.40 (100.00)	0.00 (0.00)
5	Beans	0.65 (100.00)	0.65 (100.00)	0.00 (0.00)
6	Broccoli, Cauliflower	0.20 (100.00)	0.20 (100.00)	0.00 (0.00)
7	Broccoli	1.30 (100.00)	1.30 (100.00)	0.00 (0.00)
8	Cabbage	0.85 (100.00)	0.85 (100.00)	0.00 (0.00)
9	Cauliflower	1.30 (100.00)	1.30 (100.00)	0.00 (0.00)
10	Ginger	0.50 (100.00)	0.00 (0.00)	0.50 (100.00)
11	Peas	0.65 (100.00)	0.65 (100.00)	0.00 (0.00)
12	Radish	0.05 (100.00)	0.05 (100.00)	0.00 (0.00)
13	Spinach	0.05 (100.00)	0.05 (100.00)	0.00 (0.00)
14	Tomato	0.25 (100.00)	0.25 (100.00)	0.00 (0.00)
15	Turmeric	0.40 (100.00)	0.00 (0.00)	0.40 (100.00)
16	Guava	0.40 (100.00)	0.00 (0.00)	0.40 (100.00)
17	Orange	2.80 (100.00)	0.00 (0.00)	2.80 (100.00)
18	All Crops	19.35 (100.00)	5.70 (29.46)	13.65 (70.54)

Source: Field Survey 2019-20

12.7: REASONS FOR NON-ADOPTION

While analysing the farm economics of non-adopters of micro-irrigation, it is extremely important to address the reasons behind non-adoption of micro-irrigation for these farmers. Thus, in the present study we have asked several questions regarding the reason(s) for non-adoption of micro-irrigation to these non-adopter farmers (refer table 12.7).

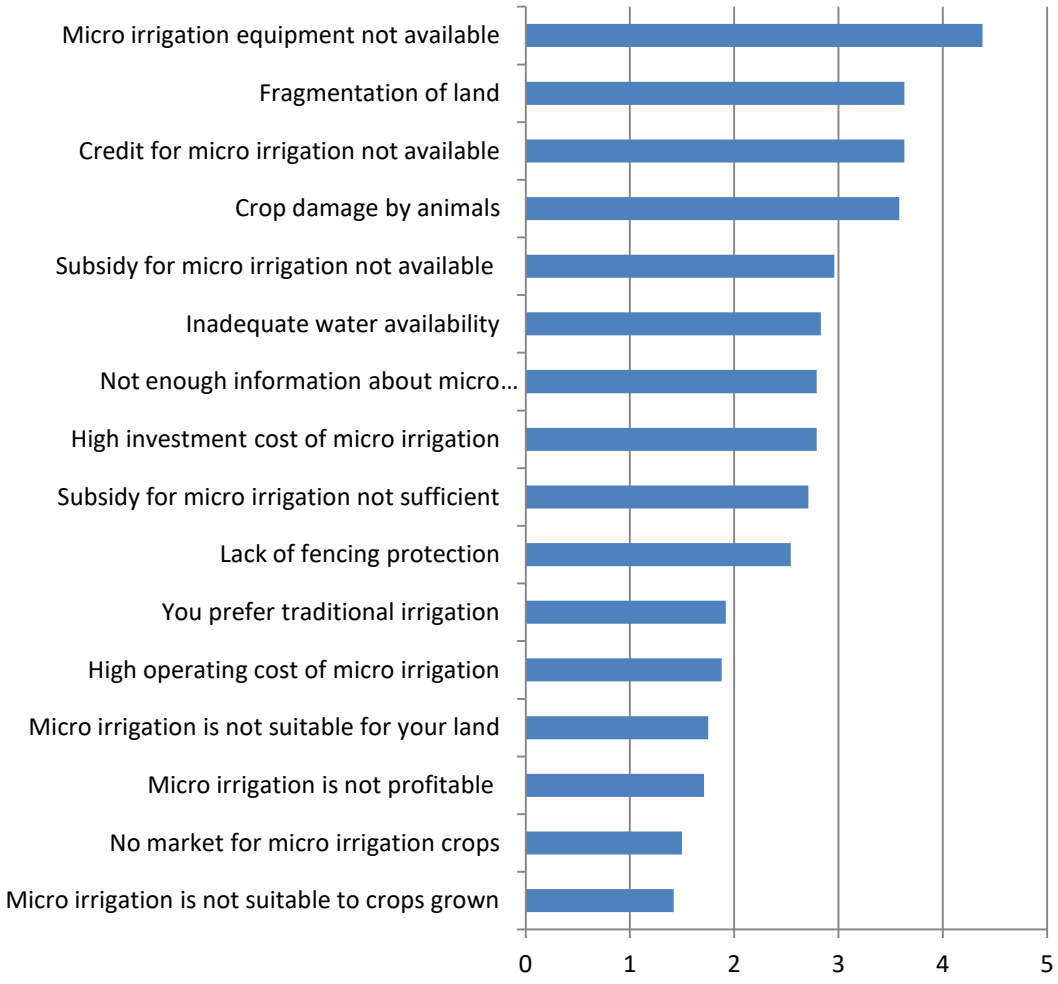
Table 12.7: Reasons for Non-Adoption

Item	Strongly Agree (%) 5	Agree (%) 4	Partially Agree/ Disagree (%) 3	Disagree (%) 2	Strongly Disagree (%) 1	Mean	No. reporting
1. Micro irrigation equipment not available	45.83	45.83	8.33	0.00	0.00	4.38	24
2. High investment cost of micro irrigation	0.00	12.50	54.17	33.33	0.00	2.79	24
3. High operating cost of micro irrigation	0.00	0.00	8.33	70.83	20.83	1.88	24
4. Subsidy for micro irrigation not available	0.00	37.50	29.17	25.00	8.33	2.96	24
5. Subsidy for micro irrigation not sufficient	0.00	0.00	70.83	29.17	0.00	2.71	24
6. Credit for micro irrigation not available	20.83	37.50	25.00	16.67	0.00	3.63	24
7. Not enough information about micro irrigation not available	0.00	16.67	54.17	20.83	8.33	2.79	24
8. Micro irrigation is not profitable	0.00	0.00	0.00	70.83	29.17	1.71	24
9. No market for micro irrigation crops	0.00	0.00	0.00	50.00	50.00	1.50	24
10. Micro irrigation is not suitable to crops grown	0.00	0.00	8.33	25.00	66.67	1.42	24
11. Micro irrigation is not suitable for your land	0.00	4.17	8.33	45.83	41.67	1.75	24
12. You prefer traditional irrigation	0.00	0.00	29.17	33.33	37.50	1.92	24
13. Inadequate water availability	0.00	12.50	58.33	29.17	0.00	2.83	24
14. Fragmentation of land	8.33	45.83	45.83	0.00	0.00	3.63	24
15. Crop damage by animals	0.00	58.33	41.67	0.00	0.00	3.58	24
16. Lack of fencing protection	0.00	0.00	54.17	45.83	0.00	2.54	24
17. Other	-	-	-	-	-	.00	24

Source: Field Survey 2019-20

It has been observed that the major causes of non-adoption of micro-irrigation, as evident from the mean response score in table 12.7, appeared to be the non-availability of micro-irrigation equipments, followed by other causes like non-availability of credit for micro-irrigation and fragmentation of land. Other important causes of non-adoption of micro-irrigation included crop damage by animals, non-availability of government subsidy for micro-irrigation, inadequate water availability, lack of knowledge regarding micro-irrigation and high investment costs of micro-irrigation.

Diagram 12.7
Reasons for Non-Adoption of MI



On the other hand, the non-adopter farmers disagree to treat reason like non-suitability of micro-irrigation to the crops grown or to the type of land they own as reasons behind non-adoption of micro-irrigation. In turn the farmers' response reveals that they do not consider micro-irrigation as non-profitable, or that micro-irrigation involves a high operating cost. They also do not consider that there is no market for micro-irrigation crops.

On the whole, the farmers' response regarding non-adoption of micro-irrigation indicates that though they consider micro-irrigation as a suitable, profitable technique involving low operating cost and a ready market for output; the non-availability of micro-irrigation equipments, credit for installation of MI and lack of government subsidy are the prominent reasons behind non-adoption on micro-irrigation.

13

SPECIFIC MAJOR PROBLEMS, NEEDS, INNOVATIONS AND SUGGESTIONS

13.1: SPECIFIC MAJOR PROBLEMS, NEEDS, INNOVATIONS AND SUGGESTIONS

In this section we have taken up the views of adopters regarding major problems being faced by them in connection with MI, their needs, innovations and suggestions for its improvement. This part of the questionnaire was an open ended one and we have had free discussion with the respondents as regards to his/her recommendations.

Main problem, as it appeared, was water scarcity in dry seasons or in occasions of low rainfall. As the whole micro irrigation system in Sikkim depended on water from streams in the mountain, the volume of flow depended naturally on the quantum of annual rainfall and various other factors including the length of the dry period every year. To over 58 per cent adopters (56 responses) scarcity of water flow had been the major problem. However, 11 respondents grumbled about crop damage by wild animals while 9 of them complained about clogging of feeder pipes.

The adopters had been looking for more coverage of micro irrigation within a village for 31 beneficiary households had placed such demand to us as major need. However, in course of the discussion they also appreciated the fact that the water supply from higher reaches depended on several climatic and other factors all of which could not be taken care of without an exhaustive planning considering the ecology and the environmental issues. Some of the respondents (14) were inclined towards expansion of MI clusters across the villages. To them it was necessary to look for new avenues of water source so that MI could be expanded further. There was also proposed requirement (13 in number) for constructing more storage tank in the upper reaches for a perennial and adequate flow of water for irrigation.

In our study area there were not many new practices as regards to the micro irrigation installations. It was found that some of the farmers (22) have had the practice of extending the feeder pipes with additional flexible pipes and attach the sprinkler kits to extend the command area under sprinkler MI. As the sprinkler sets were very handy it could be carried

to different plots of land just by extending the length of the feeder pipes. But with drip sets been dug under the ground it was difficult to shift those from one field to another. This has been one of the reason for which farmers preferred sprinkler sets to drip ones. Moreover, for the field crops like vegetables sprinkler had been more useful for covering larger area under its command. For cardamom plantation also sprinklers were more in use. Drip irrigation system had been used in orange or guava orchards.

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

Top 3	**Major Problems faced in Micro Irrigation**	Number reporting (percentage)
1	Water scarcity in dry season + Occasional water scarcity	31+25=56 (58.3)
2	Damage by animals	11(11.5)
3	Clogging of pipes	9 (9.4)
Top 3	**Major Needs/ Requirements**	Number reporting
1	More micro irrigation needed + Increasing the number of beneficiaries	17+14=31 (32.3)
2	Expansion of coverage across the villages	14 (14.6)
3	More storage tanks needed	13 (13.5)
Top 3	**New Practices and Innovations**	Number reporting
1	Relocating flexi-pipes & extension of command area of sprinklers+ Shifting MI kits to other plots	15+7=22 (22.9)
2	No further innovations	
Top 3	**Recommendations**	Number reporting
1	Coverage of MI should be increased + Should provide more MI kits to individual farmer	33+11=44 (45.8)
2	Forming SHG among MI beneficiaries for better water usage	4 (4.2)
3	More MI clusters should be identified in the district	4 (4.2)
Top 3	**Suggestions**	Number reporting
1	Government should provide MI kits to all farmers	21 (21.9)
2	More MI kits should be provided to farmers who are interested in MI	8 (8.3)
3	Formation of self hep group/co-operative among the beneficiaries within the cluster can be organized for efficient water usage	8 (8.3)

Source: Field Survey 2019-20

There were few recommendations and suggestions from the adopters in view of MI. Most common response was towards making provision for more MI clusters and setting up of micro irrigation at a larger scale within the village cluster itself and also across the district as a whole. Suggestions were there for formation of self help groups or some sort of co-

operatives among the beneficiary farmers for increasing the water use efficiency. However, some were of the opinion that farmers who were really interested should be identified and provided with more MI kits leaving aside the ones who did not seem to be interested in farming activity. In their view there were landholders in the village who cared a little for farming and bestowing them with such assistance would be abuse of funds. Overall, in course of this study, the farmers in general seemed to be quite satisfied with the assistance been provided by the Government in the form of MI installations.

14

CONCLUSION AND POLICY RECOMMENDATION

14.1: CONCLUSION

In the face of inefficient use and concerns of growing water scarcity, the present day irrigation in Indian agriculture generally emphasizes and focuses on technological solutions. In this context, micro-irrigation technology such as those based on drip and sprinkler systems are being increasingly used as an ideal technological solution. The micro-irrigation technology is reported to have a number of positive impacts on water-use efficiency, crop productivity, and efficiency in input use like fertilizers, pesticides, labour power, etc. as well as water conservation, environmental issues, income generation, poverty alleviation and farm economy as a whole. Despite the significant economic advantages micro-irrigation in India remains an insignificant proportion of its potential, which is often attributed to number of factors such as high cost, complexity of the technology and other socio-economic issues such as a lack of access to credit facilities, fragmented landholdings, localised crop pattern, etc.

It is here that the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is conceived in the year 2015 by the Government of India as an umbrella scheme for coverage of more and more area under assured irrigation as early as possible. Among the components of the PMKSY scheme, the component PDMC is aimed at increasing on-farm water-use efficiency by using suitable water conveyance and precision water application devices like drips, and sprinklers in the agricultural farms. Like all states in India, the PDMC component of PMKSY scheme has also been implemented in hilly states like Sikkim. The cultivation practices in hill slopes are done in terraces for which no major pumping of water through electric pumps is required. Since, only minor irrigation schemes are implemented in Sikkim due to topographical limitation, the micro-irrigation system may well suffice the irrigations requirements of the state of Sikkim and expected exert positive impact on the farm economy and agronomics.

In this background, the present study attempts to analyze the various benefits of micro irrigation in the state of Sikkim, adopted through implementation of PDMC component under PMKSY. In particular, the study attempts to examine benefits to the farmers in terms of input use, costs and returns, savings of various inputs, enhancement of productivity, and overall

impact on farmer incomes. The study also aims at examining the need/ importance of subsidy, capital cost, maintenance cost and the distribution of subsidy and tries to identify problems in the benefit transfer work flow and monitoring by the implementing agency, emphasizing on control and treatment farmers. The study also aims at examining the adoption of MI including some of its determinants such as need/ importance of subsidy, capital cost, maintenance cost and the distribution of subsidy and tries to identify problems in the benefit transfer work flow and monitoring by the implementing agency.

After a detailed analysis of various aspects of adoption of micro-irrigation system in the state of Sikkim, as described in the present study, some important concluding observations come out, which may be outlined as follows-

Cropping Profile and Changes

- With the introduction of micro-irrigation, there has been a marked shift in the cropping pattern in favour of major vegetable crops like cauliflower, broccoli, cabbage, peas and beans by bringing in new land under cultivation, irrigated through sprinkler irrigation method.
- Along with increase in area under cultivation, the major vegetable crops in the Rabi season has also witnessed an increase in their yields due to the introduction of micro-irrigation techniques.

Changes in Incomes and Farm Economics with Micro Irrigation

- In case of production of major vegetable crops, viz, cauliflower, broccoli and cabbage, it has been observed that while production of broccoli increased by 46.23 per cent, that of cauliflower and cabbage comes out to be 36.26 percent and 36.75 per cent respectively, which in turn led to an increase in the sales revenue in the tune of 56.28 per cent, 55.16 per cent, and 58.92 per cent for broccoli, cauliflower and cabbage respectively. Considering the changes that took place in the sales price of the crops vis-à-vis changes in production, it comes out that the increase in sales revenue for the crops considered is driven more by changes in area, production (and yield), rather than increase in their respective sales prices.
- As the state of Sikkim strictly follows an organic cultivation technique, we do not observe any cost on account of fertigation or in the application of fertilizers and pesticides at all.

- As Sikkim largely follows a gravity flow technique in irrigation where water flows naturally due to gravitational pull, use of electric/diesel pumps has limited use in drip/sprinkler irrigation systems, and there has been no cost on account of irrigation.
- Increase in the cost of farmyard manure with the adoption of micro-irrigation has been the highest for broccoli (74.60 percent), followed by cauliflower (64.53 per cent) and cabbage (57.88 per cent). It comes out that increase in expenditure on account of farmyard manure for broccoli and cauliflower exceeded their respective increase in sales revenues, indicating that use of farmyard manure assumed higher importance with the adoption of micro-irrigation.
- While the average number of man-days employed increased by 17.60 per cent for cabbage, that for cauliflower and broccoli stands at 7.45 per cent and 4.19 per cent respectively. If we compare the increase in the average area under cultivation with the increase in average man-days employed, it comes out that the increase in labour-days remains far less than the increase in area under cultivation. This implies that with the adoption on micro-irrigation, the rate of labour application decreased, while there has been an increase in area under cultivation.
- Though total costs of cultivation for cabbage, broccoli and cauliflower increased by 54.96 per cent, 53.26 per cent and 49.75 per cent respectively, the corresponding increase in profit stands much higher at 71.01 per cent, 67.48 per cent and 63.01 per cent respectively.
- Profit as percentage of total cost increased by 5.20 per cent for cauliflower, 2.86 per cent for broccoli, and 3.39 per cent for cabbage.
- Similarly, decrease in labour cost as proportion of total cost comes out to be 6.14 per cent for cauliflower, 7.99 per cent for broccoli and 2.25 per cent for cabbage. For the farm as a whole, the relative increase in profit as proportion of total cost stands at 2.61 per cent, while cost of labour as proportion to total cost decreased by 5.97 per cent.
- Findings relating to farm-economics before and after the introduction of micro-irrigation thus indicate that, adoption of micro-irrigation comes out to be a profitable notion, which in turn induced an increase in the area under cultivation, higher yield and lower costs of account of labour power in particular. Micro-irrigation here comes out to be a high-yielding, labour-saving and cost-efficient technology with positive acreage effect.

Capital and Maintenance Cost of Micro Irrigation

- In the state of Sikkim that these concerns regarding initial capital costs/investments remain largely invalid, as there has been 100% subsidy assistance for adopting micro-irrigation for the adopter farmers, and they did not have to pay any money or take any loan for installation of micro-irrigation. While the maintenance costs depend upon the beneficiary farmers themselves, the only cost that the adopter farmers (less than 30% of adopters) had to bear is the cost of replacement or addition of pipes.

Factors and Determinants Affecting Micro-Irrigation Adoption

- In case of agronomic potential as a determinant of adoption of micro-irrigation, a large section of adopters agreed on the point that MI had a positive impact in reduction of labour, water usage, and yield as well. Overall, agronomic potential centred on reduction in labour and water usage where over 95 per cent of the adopters were in agreement of its impact with mean responses scores of 4.07 and 3.97 respectively.
- In view of agro-economic potential of micro irrigation, a sizeable proportion (over 97 per cent) of MI adopters were of the opinion that subsidy on micro irrigation played the most important role in adoption of MI, apart from factors like increasing income, reducing input cost and augmenting output quality as agro-economic contribution of MI.
- On the effective demand side, we observed that the easy technology, available subsidy and availability of information regarding MI got priority in the responses (respective mean values of response score were 3.84, 3.79 and 3.70) as determining factors of MI adoption.
- On the supply side, there were fewer complaints as regards to the quality of the instruments that were being provided as 82.3 per cent was in agreement that the kits being provided were good and reliable. On the contrary, 79 per cent of respondents disagree to the presence of large number of companies supplying MI equipment as a determinant factor of MI adoption.
- The distribution aspect of MI revealed more or less similar scenario where all respondents denied existence of numbers of MI dealers located nearby. It was also noted that the suppliers provided equipment of good quality and respondents seemed to have trust.
- The strongest advantage of MI, as perceived by the adopters, had been lesser usage of labour in MI and reduction in water usage, with mean response scores of 4.19 and 4.00 respectively.

- In the question of employment of youth, the adopters had unanimous opinion that MI had brought about no difference in the participation of youth and their employment in the agrarian sector.
- On the whole, implementation of MI had been advantageous to 90.6 per cent of total adopters (with a mean response score of 3.91).

Larger Impact and Problems of Micro-Irrigation

- It is found that MI has had a positive impact in improving the condition of the village as a whole as confirmed by 62.5 per cent of the respondents, while the rest had an opinion that MI had no impact on the village (mean response score was 3.63).
- Around half of the adopters had positive response towards water conservation and environment (proportion of farmers was 59.4 and 51.0 per cent and mean response score 3.59 and 3.51 respectively).
- Impact of MI was significantly higher among the lowland farmers, as perceived by the respondents, than their upland counterpart, which might have been due to an increase in water pressure by gravity pull as water went down the hilly terrain in Sikkim.
- Apart from young people, the MI has been observed to have a positive impact across caste and gender of the respondents. After a detailed discussion with the villagers no discriminatory nature of programme implementation in view of caste/age/gender/economic position of the family is observed.
- There seemed to have little problem with quality of the MI equipments or high maintenance cost, and in case of quantity and quality of water for irrigation, the respondents seemed to be more or less satisfied. However, there have been a very poor after sales services provided by the MI dealers. As also, lack of farm fencing and damage of crop caused by wild animals were perceived as other major problems.

Overall Assessment of the Performance of Micro-Irrigation

- The general opinion regarding the overall performance of micro irrigation and its role in improving water use efficiency were considered to be ‘good’ by a majority of adopters (83.3 per cent and 75 per cent respectively), as also reduction in the input cost due to MI installation.

- As regards to increase in income and profit the respondents answered in positive but with a little reservation (mean score accounting for 3.46). However, an overwhelming majority of the adopters (more than 92 per cent) agreed to continue with MI, though there was little scope for expansion of micro irrigation for them.
- It turned out that provision of better marketing arrangement and better training for micro irrigation is considered to be beneficial for earning more profit from MI and increasing annual income. Improvement in water availability was, however, pleaded by a section (43.8 per cent) of recipients of MI. As to technological aspect of the MI installations, 54.2 per cent of adopters was in two minds regarding such need.

Non-Adopters of Micro-Irrigation: Profile and Issues

- There has not been much difference between socio-economic profiles and cropping profile of the sample pool of adopters vis-à-vis non-adopters, except for the fact that average availability of irrigation is far less for the non-adopters as compared to the adopters of MI.
- The non-adopter farmers' response regarding non-adoption of micro-irrigation indicates that though they consider micro-irrigation as a suitable, profitable technique involving low operating cost and a ready market for output; the non-availability of micro-irrigation equipments, credit for installation of MI and lack of government subsidy are the prominent reasons behind non-adoption on micro-irrigation.

Specific Major Problem, Needs, Innovations and Suggestions

- The major problem in the adoption of MI as perceived by the adopter farmers relates to scarcity of water flow, followed by crop damage by wild animals and clogging of feeder pipes.
- Not many innovative practices relating to MI was observed. Only in a few cases, the practice of extending the feeder pipes with additional flexible pipes and attach the sprinkler kits to extend the command area was observed, which has been the reason for which farmers preferred sprinkler sets to drip ones.
- The most common recommendation/suggestion was towards making provision for more MI clusters and setting up of micro irrigation at a larger scale within the village cluster itself. Suggestions were there for formation of self help groups or some sort of co-operatives among the beneficiary farmers for increasing the water use efficiency. Also, it

was suggested that farmers who were really interested should be identified and provided with more MI kits leaving aside the ones who did not seem to be interested in farming activity.

Work Flow and Monitoring by the Implementing Agency

- The implementation of PDMC-MI, PMSKY is executed through Horticulture Department, Govt. of Sikkim.
- The PDMC-OI, PMSKY Programme is executed by Agriculture Department whose main objective is to create adequate water reservoirs/bodies to feed the MI System.

14.2: POLICY RECOMMENDATIONS

Based on the concluding observations stated earlier, a few policy recommendations may be sketched out as follows-

- As MI system has come out to be very effective in hilly slopes of a state like Sikkim, which is quite energy efficient as it requires little expenditure on account of electric/diesel for pumping water, policies like PDMC should be implemented proactively in hilly states like Sikkim to reap out the benefits of MI.
- The agro-climatic condition of hilly state like Sikkim comes out to suit horticulture, particularly vegetables, where MI system comes out to enhance productivity and reduce costs with a positive impact on area expansion. As such, policies on MI system should target expansion of area along with irrigation coverage in states like Sikkim.
- The provision of 100 per cent subsidy comes out to have a significant and determining role in the adoption of MI. As such, while promoting MI system, the State and the Central Government should continue subsidizing the initial costs of installation of MI system in farmers' fields.
- In the absence of after-sales service by the MI equipment suppliers, as is observed in our study, there should be training camps for MI adopter farmers to impart basic knowledge on maintenance of the MI kits provided.
- The adopters of MI were sometimes found to face difficulties in transportation of their MI crop from field to road and from road to market. Here, the government should step-in and form SHGs/ FPOs to facilitate easy transportation. The SHGs/FPOs should also arrange for marketing of the crop output to ensure reasonable price.

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Table 1: Central Assistance released under PMKSY-PDMC (2015-16 to 2019-20)

(Rs. in crore)

Name of States	2015-16	2016-17	2017-18	2018-19	2019-20
Sikkim	4.86	5.4	4	55.19	31.80

Source: Department of Agriculture, Cooperation & Farmers Welfare, Govt. of India

Table 2: Sub Component Wise Specifications and Cost for Micro Irrigation (Mini Sprinkler Irrigation system in open condition)

Sl. No.	Component Lateral to lateral x Dripper spacing (mxm)	Unit	quantity	Remarks
1	PVC Tank 500lts capacity	No.	1	For 0.22 Hectare Unit Crop spacing =8.0x8.0 m Crops: Vegetables, Peas and beans, Cherry Pepper, Buckwheat, Mustard etc. Max. Cost: Rs.29578 /- per unit
2	HDPE Pipe 75mmClass II; 3 Kgs/cm2	m	15	
3	HDPE Pipe 63mm; Class II; 6 Kg/cm2	m	33	
4	32 mm LLDPE plain laterals 4 kgs/cm2 class II	m	250	
5	Micro sprinkler head/nozzle	No.	31	
6	M S Riser rod 8mm and assembly	No.	31	
7	Control valve 63 mm.	No.	1	
8	Flush valve 63 mm	No.	1	
9	Air Release valve 1"	No.	1	
10	Non Return Valve 2"	No.	1	
11	Throttle Valve 2"	No.	1	
12	Screen filter 20/25 m3/hr	No.	1	
13	By Pass Assembly 1.5 "x1.5"	No.	1	
14	Venturi& Manifold 2"	No.	1	
15	Fittings and Accessories	5%		

Source: Department of Horticulture, Govt. of Sikkim

Table 3: Sub Component Wise Specifications and Cost for Micro Irrigation (Mini Sprinkler Irrigation system in open condition)

Sl. No	Component	Unit	Quantity	Remarks
1	PVC Tank 500lts capacity	No.	1	
2	HDPE Pipe 75 mmClass II; 3Kgs/cm2	m	30	
3	HDPE Pipe 63mmClass II; 3 Kgs/cm2	m	55	
4	32mm LLDPE Plain Laterals, 4 kg/cm2	m	625	
5	Mini Sprinkler Haed, Nozzle	No.	78	
6	M/s Riser Rod & Assembly	No.	78	
7	Control valve 75 mm.	No.	1	For 0.55 Hectare Unit
8	Control valve 32 mm.	No.	16	
9	Flush valve 75 mm	No.	1	Crop spacing =8.0x8.0 m
10	Air Release valve 1"	No.	1	
11	Non Return Valve 2.5"	No.	1	Crop :CARDAMOM FIELD
12	Throttle Valve 2.5"	No.	1	
13	Screen filter 20/25 m3/hr	No.	1	
14	By Pass Assembly 1.5 "x1.5"	No.	1	
15	Venturi& Manifold 2"	No.	1	Max. Cost: Rs.64644/- per unit
16	Fittings and Accessories	5%		

Source: Department of Horticulture, Govt. of Sikkim

Table 4: Sub Component Wise Specifications and Cost for Micro Irrigation (Micro Sprinkler Irrigation system in Cardamom nursery)

Sl. No.	Items	Unit	Quantity	Remarks
1	PVC Tank 500lts capacity	No.	1	
2	HDPE Pipe 75mmClass II; 3 Kgs/cm2	m	15	
3	HDPE Pipe 63mm; Class II; 3 Kg/cm2	m	33	
4	Lateral 16 mm Class I 2.5/cm2	m	668	
5	Micro sprinkler set	No.	222	
6	Control valve 75 mm	No.	1	For 0.22 Hectare Unit
7	Control valve 63 mm	No.	1	
8	Flush valve 63 mm	No.	1	Crop spacing : 3.0x3.0 m
9	Air Release valve 1"	No.	1	
10	Non Return Valve 2"	No.	1	Crop : CARDAMOM Nursery
11	Throttle Valve 2"	No.	1	
12	Screen filter 20/25 m3/hr	No.	1	
13	By Pass Assembly 2"x1.5"	No.	1	
14	Venturi& Manifold 2"	No.	1	Max. Cost: Rs.23813/- per unit
15	Fittings and Accessories	5%		

Source: Department of Horticulture, Govt. of Sikkim

Table 5: Sub Component Wise Specifications and Cost for Micro Irrigation (Drip Irrigation system in open condition)

Sl. No.	Component	Unit	Quantity	Remarks
1	PVC Tank 500lts capacity	No.	1	
2	HDPE Pipe 50mm; Class II; 3 Kg/cm2	m	52	
3	Lateral 12 MM Class II 2.5/cm2	m	675	For 0.22 Hectare Unit
4	Emitter 2/4/8 lph	No.	453	
5	Control valve 63 mm	No.	2	Crop spacing =3.0x3.0 m
6	Flush valve 63 mm	No.	1	
7	Air Release valve 1"	No.	1	
8	Non Return Valve 1.5"	No.	0	Crop : ORCHARDS
9	Throttle Valve 1.5"	No.	1	
10	Screen filter 10 m3/hr	No.	1	
11	By Pass Assembly 1.5"	No.	1	Max. Cost: Rs.16068/- per unit
12	Venturi& Manifold 1.5"	No.	1	
13	Fittings and Accessories			

Source: Department of Horticulture, Govt. of Sikkim

Table 6: Sub Component Wise Specifications and Cost for Micro Irrigation (Drip Irrigation system in green houses and protected conditions)

Sl No.	Component (1.5 x 1.5)	Unit	quantity	Remarks
1	PVC Tank 500lts capacity	No.	1	
2	HDPE Pipe 63mmClass II; 3 Kgs/cm2	m	15	
3	HDPE Pipe 50mm; Class II; 3 Kg/cm2	m	52	
4	Lateral 16 MM Class II 2.5/CM2	m	1346	
5	Emitter 2/4/8 lph.	No.	900	
6	Control valve 63 mm.	No.	2	For 0.22 Hectare Unit
7	Control valve 63 mm.	No.	1	
8	Flush valve 63 mm	No.	1	Crop spacing: 1.5x1.5 m
9	Air Release valve 1"	No.	1	
10	Non Return Valve 1.5"	No.	1	Crop : CYMBIDIUM (FLOWERS)
11	Throttle Valve 1.5"	No.	1	
12	Screen filter 10 m3/hr	No.	1	
13	By Pass Assembly 1.5"	No.	1	
14	Venturi& Manifold 1.5"	No.	1	Max. Cost: Rs.28985/- per unit
15	Fittings and Accessories	5%		

Source: Department of Horticulture, Govt. of Sikkim

Table1: Educational Attainment of Adopters with age-group

Education	No. of respondents in Age Group					
	20-30 yrs.	30-40 yrs.	40-50 yrs.	50-60 yrs.	>60 yrs.	Total
Illiterate	0 (0.0%)	4 (12.9%)	3 (9.7%)	18 (58.1%)	6 (19.4%)	31 (100.0%)
Educated	3 (4.6%)	26 (40.0%)	21 (32.3%)	12 (18.5%)	3 (4.6%)	65 (100.0%)
Total	3	30	24	30	9	96
Educational Level						
Primary	0 (0.0%)	9 (40.9%)	6 (27.3%)	5 (22.7%)	2 (9.1%)	22 (100.0%)
Middle	1 (3.6%)	10 (35.7%)	12 (42.9%)	4 (14.3%)	1 (3.6%)	28 (100.0%)
Xth. Standard	2 (16.7%)	5 (41.7%)	3 (25.0%)	2 (16.7%)	0 (0.0%)	12 (100.0%)
XIIth. Standard	0 (0.0%)	2 (66.7%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	3 (100.0%)

Source: Field Survey 2019-20

Table 2 : Total Land Area

Farm_Size	Area Operated Total (Ha)	Area MI Total (Ha)	Area Drip Irrigation (Ha)	Area Sprinkler Irrigation (Ha)	Area Non-Micro Irrigation (Ha)	Area Un-irrigated (Ha)
Marginal	31.05 (38.5%)	21.90	.50	21.40	3.10	5.95
Small	37.70 (46.7%)	21.10	5.70	15.40	3.00	11.20
Medium	12.00 (14.9%)	1.30	.80	.50	.80	9.90
Total	80.75 (100.0%)	44.30	7.00	37.30	6.90	27.05

Source: Field Survey 2019-20

Table 3: Area under Irrigation by types and districts

District	Area Total MI (Ha)	Area Drip (Ha)	Area Sprinkler (Ha)
East	30.90	6.20	24.70
South	13.40	.80	12.60
Total	44.30	7.00	37.30

Source: Field Survey 2019-20

Table 4: Monthly Rainfall (in mm) 2018

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
East	0.6	24.9	113	268.5	302.7	456	408.9	442.6	279.5	44.5	11.4	23.7	2376.3
South	2.9	14.5	78.5	153.4	224.7	372.6	400.3	416.2	363.5	34.1	0	26.2	2086.9

Source: Hydrome Division, India Meteorological Department, New Delhi

Comments on the Draft Report from the Coordinator

Review of the Report

(I) Title of the Draft Study Report Examined:
Impact Evaluation Study on Per Drop More Crop Component of Pradhan Mantri Krishi Sinchyayee Yojana (PMKSY) in Sikkim
by Dr. Debajit Roy and Mr. Debanshu Majumder

(II) Date of Receipt of the Draft Report: 31-07-2020
(III) Date of Dispatch of Comments: 18-9-2020

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

(IV)

A. General Comments

1. Given its topic and objectives, this is a very important study for India's agriculture, the government, 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. Micro irrigation is a very promising and highly efficient water saving technology. With the need and the government objective of substantially increasing its use, it is very important to understand the factors affecting its adoption, the impact, and the performance of the PMKSY-PDMC scheme for its promotion in helping the adoption of micro irrigation in the state of Sikkim.
2. The title of report may be brought in line with the overall project as given in the proposal: Improving Water Use Efficiency in India's Agriculture: The Impact, Benefits and Challenges of Micro-Irrigation under the Pradhan Mantri Krishi Sichai Yojana: Per Drop More Crop (PMKSY-PDMC) in Sikkim.
3. The study objectives are appropriate and sound. They include examining the level of adoption of micro irrigation and its efficiency is saving the water. They also include examining the impact of micro irrigation on crop productivity and incomes.
4. The objective of the study is to examine the impact of micro irrigation and its various adoption factors in Sikkim. The study has examined the impact of micro irrigation on crop productivity and incomes in Sikkim, also touching upon the constraints faced by the non-adopters of micro irrigation.

B. Comments on the Methodology and Analysis

1. Page 1: You can use "agricultural production" instead of "food production"
2. P1: You can use "should have" instead of "requires', "water" not "irrigation"
3. You may try to have a picture or pictures on the cover and elsewhere
4. Page 17 – irrigation – give percentages
5. Page 18 – instead of in "other" – put it under "river-lift" – with a footnote explaining.
6. Page 20, 22 – There is singular lack of variation – there would be some variation in some aspects – please check & see in the data/ observations – and try to reflect in Tables
7. Tables on pages 26-30 – please give results in terms of percentage of the row totals – with one decimal place – instead of average area.
8. Page 33 Table 7.1 is very important – you can break it into parts – give some percentages/differences – in columns and rows – to bring out the results better.
9. Page 33: The Table should preferably be at the end of the discussion
10. Page 38: – please see if some results/data can be shown – it is blank. What is the cost – even if it is subsidized.

11. Page 40 – the Table is blank – please try to find and put in some information – some company or some agency must be doing it?
12. Page 43 – The Table is important. Please improve presentation of Table – break it into 2-3 parts. NA appears too large, numerous – change it to nr=not reported.
13. Page 46 – This Table is important. Break into 2-3 parts –and discuss
14. Page 48 – Again this is important – try to bring some distribution – eg. in castes, poor/ labour – and others. There has to be some impact on someone?
15. Page 50 – again very important – break it into 2 parts – highlight important aspects better
16. Page 54 – Table - please see if you can improve the reporting. Many NAs
17. Page 56-64 – some aspects of non-adopters and adopters must be compared
18. Page 67 – please give in percentages
19. Page 68-77 – please see that the different objectives/questions of the study given earlier are addressed. Some response should be there for each objective/question– from the findings of the study.

Other Comments

20. Chapter II-(2.1- Background of the Study): Some important work in the form of papers/reported are cited in the footnotes, e.g. Page No. 6. Kindly add the citations inside the text and include the same in the references.
21. Chapter III- The chapter discusses the trends and growth of micro irrigation in the state. It would be interesting to make some charts and graphs. Figures can be created by taking the overall data from the Table. It will be useful to show the change across years in some graph or figure form. Pie chart can be used to show the share of micro irrigation in the state district-wise.
22. Chapter IV- Table 4.2 and 4.3: Pie Chart and Bar Chart can be added
23. Chapter V- Table 5.2- Instead of others, this can be under river-lift with a footnote
24. A chart can be made using data from Tables 6.1 and 6.2. This can show the change in cropping before and after adoption. Perhaps, a bar chart showing the change in area of few major crops would be useful.
25. Chapter VII: Table 8.1 – please bring some data here. What is the value even if it is subsidized.
26. Chapter IX- In Table 9.1: It is an interesting table which shows the various factors affecting the adoption of micro irrigation. Bar charts from Table 9.1, showing some important findings.

(V) Comments on the Presentation & Get up

A. Comments on presentation:

1. *Please add Executive Summary. It is necessary and useful for the readers to get a quick picture.*
2. *Kindly add the References and Appendix in the Table of Contents.*
3. *Kindly add list of acronyms.*
4. *Page-3 - Objectives can be numbered (1,2,3,4).*

B. Other Comments:

Typographic issues are listed below:

1. *In the Preface- 1st Paragraph- 6th Line- Replace centre"s with center's. Similar issues are seen in the subsequent chapters. Kindly check for errors.*
2. *Page 4- 1st Paragraph- 9th Line-Replace over-view with overview.*
3. *Page No. 26- 6.2- 2nd Paragraph and 3rd Paragraph- Typo errors. Please correct.*
4. *Have consistencies in using quotation marks and apostrophes. Some are missing or are used unnecessarily e.g. Page No. 42.*

(VI) Overall View on Acceptability of the Report

The report provides many insights and it is valuable and useful and acceptable. If the suggestions and comments given above can be addressed, it will help to make it a better report.

Action Taken Report

I. **Title of the Study Report Finalized:**
Improving Water Use Efficiency in India's Agriculture: The Impact, Benefits and Challenges of Micro-Irrigation under the Pradhan Mantri Krishi Sichai Yojana: Per Drop More Crop (PMKSY-PDMC) in Sikkim
by Dr. Debajit Roy and Mr. Debanshu Majumder

II. **Date of Dispatch of the Draft Report:** 31-07-2020

III. **Date of Receipt of Comments:** 18-9-2020

IV. **Date of Dispatch of Final Report:** 30-09-2020

V. **Action Taken Report on the Comments on Draft Report:**

A. General Comments

1. Action not required.
2. The title of report has been brought in line with the overall project.
3. Action not required.
4. Action not required.

B. Comments on the Methodology and Analysis

1. The comment has been addressed.
2. The comment has been addressed.
3. The comment has been addressed. Ten (10) images in body and cover have been included.
4. The comment has been addressed and subsequent changes made.
5. The comment has been addressed and subsequent changes made.
6. Data has been checked and no changes made. Absence of variation has been due to the fact that the agro-climatic and geomorphological specificities are similar across the survey area in Sikkim.
7. Though table 6.1 and 6.2 followed the original table structure provided by the coordinating centre, however the comments have been addressed by creating additional tables and diagram (Diagram 6.2, Table 6.1(a) and 6.2(a)).
8. Though table 7.1 followed the original table structure provided by the coordinating centre, however the comments have been addressed by creating additional diagram (Diagram 7.1).
9. The comment on table 7.1 has been addressed and subsequent changes made.
10. Data pertaining to table 8.1 is left blank as the entire cost is subsidized by the State Government for installation of micro-irrigation equipments in farmers' plots. However, per unit installation cost of MI has been annexed in appendix.
11. The comment on table 8.3 has been addressed and subsequent changes made.
12. The table 9.1 has followed the original table structure provided by the coordinator.
13. The table 9.2 has followed the original table structure provided by the coordinator.
14. The comment on table 10.1 has been addressed and subsequent changes made.
15. Though table 10.2 followed the original table structure provided by the coordinating centre. To highlight important aspects additional diagram (Diagram 10.2) has been included.
16. Comments on table 11.2 cannot be addressed as points 2 to 5 in the table is not applicable in case of MI adoption in Sikkim (as it is fully subsidized by the Govt. of Sikkim).
17. The comments on tables of chapter 12 have been addressed and subsequent changes made. Diagrams have been incorporated as necessitated.
18. The comment on table 13.1 has been addressed and subsequent changes made.
19. The comments on chapter 14 have been addressed and subsequent changes made.

C. Other Comments

1. The comments on chapter 2 have been addressed and subsequent changes made.
2. Charts and graphs have been included in chapter 3.
3. Charts and graphs included in chapter 4.
4. The comments on chapter 5 have been addressed and subsequent changes made
5. A chart using data from Tables 6.1 and 6.2 has been incorporated.
6. The comments on chapter 8 have been addressed.
7. Bar charts from Table 9.1 showing some important findings has been incorporated.

D. Comments on the Presentation & Get up

a. Comments on presentation:

1. Executive Summary has been attached.
2. References and Appendix included in Table of Contents.
3. List of acronyms has been added.
4. Objectives have been numbered.

b. Other Comments:

Typographic issues are listed below:

1. The comments on preface have been addressed.
2. The comments on page 4 have been addressed.
3. The comments on page 26 have been addressed.
4. The comments on page 42 have been addressed.

E. Overall View on Acceptability of the Report

Suggestions and comments from the coordinator on draft report have been addressed to the extent possible to make it a better report.