EXECUTIVE SUMMARY

Water is fundamental for sustaining a quality life, as well as economic and social development of human society. Efficient water use and food production are flagged as the two most important issues for world peace and social security in the 21st century and water scarcity poses serious threats to rural livelihoods and food security. It has been estimated that by 2025, 1/3rd of the world population will face absolute water scarcity and whereas, in India 54 percent area faces high to extremely high-water stress (Seckler, et. al., 1999 and Vibha Dhavan, 2017). Agriculture accounts for a majority of global freshwater and In India approximately 90 percent of annual freshwater withdrawals for agriculture, including ground water, which expanded rapidly in the last few decades.

In India, out of 142 M ha of arable lands, 60 percent (85.2 M ha) is rainfed. Karnataka has the second largest area under rainfed agriculture characterized by highest concentration of drought prone area after Rajasthan in the country. With 10.10 M ha of cropped area in Karnataka state, only 35.8 percent is irrigated and the rest 64.2 percent is rainfed. This indicates 2/3rd cropped area is still under dry land agriculture and relying on monsoon and suffering frequent droughts (< 750 mm of rainfall) KMIP, 2017 and KJA, 2019. Thus, the demand for irrigation water is increasing, as irrigation is very critical input for enhancing agricultural productivity and farmer's income. Meanwhile, groundwater exploitation in the state is highly skewed, exploiting more intensively in semi-arid districts of North and South interior Karnataka. The stage of groundwater development in the state is around 65 percent. However, in over exploited area it is around 125 percent as against 87 percent in critical areas implying distorted development. Currently, more than half of the state's cultivated area is under critical to over-exploited category (Suresh Kumar 2019). Overall, 44 of the 176 talukas in the state have been declared as 'over exploited', 14 are in the 'critical' category and 21 are in the 'semi-critical1' category with regard to groundwater exploitation (KJA, 2019). Though the trend in the growth of number of borewells as well as area irrigated by borewells is increasing, the area irrigated per bore-well is increased from 0.9 to

1 Ground water status categorized based on ground water development- a) stage of ground water development, and b) long-term of pre and post monsoon water levels.1. 'Safe' areas which have ground water potential for development (>70% and <=90%); 2. 'Semi-critical/critical' areas where cautious groundwater development is recommended >90% and <=100%; 3. Over-exploited' areas, where there should be intensive monitoring and evaluation and future ground development be linke (>100%)

1.47 ha. The increasing probability of borewell failure to the tune of 0.4 and the unsustainable groundwater use necessitates demand management and supply augmentation measures for improved Water Use Efficiency (WUE) in agriculture sector. Thus, given the climate change scenario and increased demand for water from competing sectors and absolute scarcity & variability in water availability necessitate technological, institutional and policy interventions for equitable and sustainable use of water for agriculture.

Thus, Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW) has launched a centrally sponsored scheme on Micro Irrigation in 2005-06 which was subsequently converted as National Mission on Micro Irrigation (NMMI) in 2010-11. During 2014-15, the scheme was subsumed as On Farm Water Management (FWM) component of National Mission for Sustainable Agriculture (NMSA) and further subsumed under Per Drop More Crop (PDMC) Component of The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) during 2015-16 with the objective to provide end-to-end solutions in irrigation supply chain in India. Recently, the Task Force on Micro Irrigation 2004, had estimated a potential of 69.5 m ha under micro irrigation, whereas the area covered by 2018-19 is only about 11.58 m ha (16.6 percent), Whereas Karnataka achieved yearly 11 percent, 17 percent, 23 percent and 20 percent during 2015 to 2019 covering 30 districts through line Departments like Horticulture, Agriculture and Sericulture by providing varying levels of subsidy extending up to 90 percent of the cost of irrigation system.

However, there is a new debate concerning the impact of MI systems at various levels of water use for consideration of "water-saving" and also on the status of the resource and there might be increase in crop output but no net water saving may result. Thus, PMKSY-PDMC scheme requires evaluation to find out impact of the scheme at the ground level of MI Technology vis-a-vis resource conservation through strengthening the state Micro Irrigation Policy/ guideline, other claimed benefits and also to suggest the activities requiring more focus and attention to ensure that more benefits accrue to farmers in the next phase of implementation of the scheme. In this context TERI took an impact evaluation of PMKSY-PDMC scheme implemented during 2016-17 to 2018-19 in Karnataka with an aim of determining the potential benefits from the use of MI systems in sample study area

Specific objectives of the study

1. To review the scheme implementation as per the guidelines.
2. To assess the impact of the scheme on: crop diversification, crop production, productivity, energy saving, water saving and income of the farmers across the regions and categories
3. To assess promotion of MI technologies in water scarce, water stressed and critical ground water districts (over exploitation, critical, semi critical and safe zone).
4. To examine quality and functional status of the MI system.
5. To gauge the extent of awareness and knowledge on water management, its technology and adaptation.
6. To assess training needs and training impact in maintenance of maintenance of MI system.

Present study is a multi-dimensional impact assessment which involved typology, spatio-temporal, social and farm size, institutional and economic, techno-feasibility of MI system towards meeting the objectives of the scheme. A multi-stage- proportionate random sampling design was adopted for selection of taluks and beneficiaries. With the pre-identified 10 districts viz., Belagavi, Bidar, C. R Nagar, Haveri, Kalaburgi, Kolar, Mysuru, Shivamogga, Tumakuru and Uttara Kannada, representing 10 agro-climatic zones, further taluks were selected by classified into high, moderate and low groups of beneficiaries considering ground water exploitation status Viz., safe, semi critical/ critical and over exploitation. From each sample taluk 5 to 6 gram panchayaths (GP) were classified into best, moderate and average level of MI installation.

The selection of the sample beneficiaries has been made randomly representing various category (marginal, small, medium and large farmer), social group (General, OBC, SC and ST) and gender (male and female). Besides this, non-beneficiaries were also selected to identify reasons for their non-participation in the programmes and also to compare with MI beneficiaries. Total number samples are 3730 selected who benefited during 2016-17 to 2018-19. Out of which, 3690 beneficiaries and 40 were non-beneficiaries. Based on proportionate sample distribution further, highest (70%) sample beneficiaries were drawn from agriculture and medium (27%) from horticulture and minimum (3%) from sericulture. Additionally, 20 FGDs (10 drip and 10 sprinkler) and 20 (10 drip and 10 sprinkler) case studies were conducted to capture success or failure of the program across drip and sprinkler

beneficiaries. Both qualitative and quantitative data was collected through primary and secondary information. Secondary information was collected from Department of Agriculture, horticulture, sericulture and supportive literature review through extensive desk. Primary data collection was majorly through participatory tools such as questionnaire survey, FGDs and key stakeholders' consultative interactions were adopted.

All the primarily processed quantitative data was analyzed for assessing interrelationships by using relevant statistical approach like comparative, average, mean, range, percentage, grading and correlation. Impact of micro irrigation was estimated by using opinion survey data captured before and after the scheme implementation for beneficiaries, and after adoption of MI by the beneficiaries (adopters) Vs non-beneficiaries(non-adopters) of the MI system. The important variables evaluate are changes in land use, cropping pattern, crop diversity and cropping intensity production /unit area. Further change with respect, water (acre inches), energy, labour saving, employment generation and income were worked out for beneficiary and non-beneficiary, various crops, district and farmer category. Further analyzed impact of training on adoption, functioning status and productivity of different forming community. Key findings and observations are highlighted under the following sub heads:

Process and Implementation of Micro Irrigation

- Funds are allocated in the proportion of 50: 40 between center and state for MI scheme under PMKSY-PDMC program. However, state extended his share through convergent of other scheme and provide up to 90% subsidy for 0.1-2 ha micro irrigation for all community.
- The selection of beneficiaries is done on the principle of "first come first serve", social group norms and ground water exploitation status (Over exploitation-I, Critical/Semi critical-II and Safe zone-III beneficiaries).
- Application of farmer friendly ICT technology is required to be developed for real time tracking of the status and its monitoring. The currently adopted HASIRU IT application initiated by the nodal department (DOH) needs to be extensively popularized.
- The inadequacies and deviation of the PMKSY-PDMC GOI guidelines during the execution of MI especially with respect to planning (DIP & DAP), implementation (scheme convergence, post installation service, training) and technologies (designing,

solar pump, quality inspection) to be addressed at various levels for effective promotion of the scheme.

- It was noticed that there lies a weak linkage between dealers and farmers and also between field assistant and farmer after installation of MI and financial commitment
- KAMIC structuring appears to be in line with the GGRC model to function as the nodal agency for all matters related to micro irrigation promotion in Karnataka. The pros and cons of the proposed mechanism yet to be realized at field for any further refinements. The inclusion and updating are based on the analysis of similar institutional mechanisms operative in other governmental system.

Physical and Financial Performance of MI Scheme

Physical performance of MI scheme

- As on 2020, the 5 years of cumulative area covered under PMKSY-PDMC is 43.12 Lakh ha at national level and in Karnataka 8.12 Lakh ha which accounts for 18 percent of the national achievement (Anon, 2020).
- MI area coverage between the years 2016-17 to 2017-18 was remarkable both at national and state level, as this coverage represents increase of 24.8 percent and 69.3 percent in state, respectively. While marginally increased to the tune of 10.4 percent (10, 48,934 to 11, 58,519 ha) at national level while in Karnataka it was reduced to percent of 0.5 (236107 to 234853 ha) in Karnataka between 2017- 18 to 2018-19.
- Growth of both drip and sprinkler irrigation area coverage between the years 2016-17 to 2017-18 was remarkable, as this coverage represents 44.2 percent (0.46 to 0.67 lakh ha) and 82.1 percent (0.92 to 1.68 lakh ha). However, during 2017- 18 to 2018-19, a marginal (0.67 to 0.76 lakh ha) increase up to 14.3 percent in drip and reduced 6.4 percent (1.68 to 1.58 lakh ha) in sprinkler. The variation in area coverage of MI (drip and sprinkler) in both national and state level during 3 consecutive years may be due to variation in allocation of matching fund, awareness and market value of product. Thus, a stronger push and appropriate fund allocation and monitoring system is needed to meet the target and achievement.
- With respect to district wise, the percentage to the total area of MI, maximum 7.8 percent (0.51 lakh ha) MI area was found in Belagavi followed by Kalaburgi district 7.4 percent (0.50 lakh ha) and minimum of 0.2 percent (0.015 lakh ha) area noticed under Dakshina Kannada which is still 23.23 lakh ha area is under potential to expand

micro irrigation system in the state. The growth rate of MI in north west and north eastern transitional zone evident that MI is adopted extensively in areas of water intensive crop and acute water scarcity. Thus, programme is implemented efficiently and meeting the guideline (priority given to water intensive crop and water scarcity/dry land area) and objectives.

- Cumulatively a maximum of 16336.2 ha drip irrigated area coverage is noticed in Belagavi district followed by Vijayapura 13863.9 ha, Kolar 13303.1 ha, Davanagere 12262.7 ha and Tumakuru 10905.9 ha. The lowest area coverage is observed in Kodagu 200.4 ha. With respect to sprinkler system among the different districts, the maximum area under sprinkler irrigation is seen in Kalaburgi (39263 ha), Mysuru (29850.6 ha), Belagavi (28479.4 ha) and Shivamogga (22954.2 ha) districts. The lowest area coverage was observed in Bengaluru urban (833.2 ha).

Financial performance of MI Scheme

- Public investment and area covered with micro irrigation has shown a consistent increase was observed with 19.3 percent increased (1489 crores to 1777 crores) between 2016-17 to 2018-19 at national level and 60% percent (227 to 376 crores) at the state level.
- It is seen that the allocations as well as the expenditure recorded a consistent increase during the period 2016-17 to 2018-19 period. The average annual growth of allocation of grants was 77.6 percent Rs 48578.8 lakh to Rs 86263.3 lakh) 2017-18 and 14.2 percent Rs 98485.0 lakhs during 2018-19, while the expenditure grew by 38.6 percent (Rs 51349.9 lakhs to Rs 71154.9 lakhs) and 18.4 percent (Rs 71154.9 lakhs to Rs 84220.0 lakhs), respectively.

Performance of MI scheme (Micro analysis)

- Out of the total 3690 beneficiaries, the beneficiary covered under drip and sprinkler irrigation is 44.7 percent and 55.3 percent, respectively. The percentage of MI area coverage during sample survey to the total area (6515.3 acre) covered under MI in sample district is about 43.0 percent drip and 57.0 percent sprinkler. In the overall scenario it is observed that the percentage of drip irrigation installation gradually improved from 2016-17 to 2018-19 compared to sprinklers. year wise increment was noticed 20 percent from 2016-17 to 2017-18 and 18.3 percent from 2017-18 to 2018-

19 in drip installation. However, it was declined to 28 percent in sprinkler from 2016-17 to 2017-18 and escalated to 36 percent from 2017-18 to 2018-19.

- On cross sectional analysis of total MI Installation, it is observed that a maximum beneficiary with drip irrigation was recorded in Belagavi and Chamarajanagar and with less installation in among Mysuru and Shivamogga beneficiaries. However, under, sprinkler irrigation maximum coverage was noticed in Mysuru and Shivamogga and least in Chamarajanagar and Belagavi.
- In the overall sample, more than 50 percent of the beneficiaries were from the general category, 29.6 percent of the beneficiary from OBC category, 7.5 percent and 6.3 percent of the beneficiaries represented SC and ST categories. The study shown the dominance of male farmer beneficiaries (84.9%) compared to female beneficiaries. Overall, nearly two thirds of the beneficiaries were exposed to education while one third are yet to be educated. The predominance of agriculture-based occupation (88.5%) found to be the lead adopters of MI systems compared to other occupations. The proportions of milch animals are dominant as compared to drought animals and small ruminants among both beneficiaries and non-beneficiaries.
- In the sample size (out of 3690) it was observed that, medium category of farmer accounted maximum 67.8 percent, whereas 23.2 percent farmers are reported to be under small, 6.5 percent marginal and 2.4 percent under large farmer category.
- The assessment study covered more than 40 crops with the classification of 12 major crop categories. Drip irrigation, prominently used for horticulture, fibre, cash crops and mulberry. Whereas, the sprinkler irrigation system is widely used in field crops (cereals, pulses, millets and oil seeds).
- This impact assessment study in different districts has properly covered with principal crops which were predominant to agro-climatic zone coupled with ground water status. With respect to spread of crops, it could be noted that cereals (Paddy) in Uttara Kannada, pulses in Kalaburgi, oil seeds in Haveri, millets in Kolar and Mysuru, cash crops (Sugarcane) in Belagavi, fibre crops (Cotton) in Haveri, fruit crops in Chamarajanagar, plantation crops in Shivamogga, spices in Mysuru and Chamarajanagar, flower crops in Belagavi, vegetables in Kolar and mulberry in Kolar are dominated and found to be potential for promoting MI irrigation.
- Awareness on PMKSY-PDMC among beneficiaries and non-beneficiaries, on an average 85.5 percent (out of 3690) farmer are aware about PMKSY-PDMC scheme among beneficiaries and 75.5 percent (out of 40) among non-beneficiaries. With

respect to district-wise awareness levels among beneficiaries, Kalaburgi district farmers have well aware of the scheme and least awareness about PMKSY PDMC program was noticed in Belagavi district farmers.

- Awareness on PMKSY-PDMC among the gender found male is 85 percent and in female it was only 15 percent. Further information access and knowledge about PMKSY-PDMC among farmers category was medium sized farmers (66.7%), and least was observed with large farmers (2.4%). Among various social groups, general/other category beneficiaries have better knowledge and well aware of the scheme which account to 57.2 percent, followed by OBC and least was noticed among with SC and ST beneficiaries which accounts only 6 and 7 percent, respectively. Thus, a special drive is needed on wider publicity to make them aware about the benefits and operation of the scheme. From this study it could be inferred that the overall trend of generating awareness through all the lead sources must need to be enhanced significantly to ensure greater influence for MI adoption.
- The major (15.9%) sources and awareness is through neighbouring farmer. Towards the shortlisted 13 reasons for non-adoption of MI system, primarily the reasons are pertaining to lack of clarification in subsidy issues (12%), followed by lack of technical guidance and labour scarcity (9.7% each). However, average willingness to adopt MI system was 65 percent.
- A majority of 86.3% of the MI systems (both drip and sprinkler) supported under the scheme are functional enough to enable crop production as a sustainable technological investment. Maximum functioning of the MI installation was observed in Uttara Kannada (97.1%) and minimum functioning of MI system was noticed in Haveri (59.7%). The non-functionality of the MI units is mainly due to beneficiaries have sold the units to others due to drying of water sources and damage of the units chocking of the system.
- In the current study it is observed that 64.5 percent of the beneficiaries have invariably installed the various types of filters, whereas 35.5 percent of the beneficiaries have failed to install the filters. Owing to the economic cost, accessibility and easy maintenance many of the beneficiaries have adopted screen filter (69%) followed by sand filter (15%) and hydro cyclone filter (10%).
- In the present study it is observed that maximum proportion of farmers have expressed the lifespan of MI is between 3-5 years (36.3%), followed by 2-3 years (32.8%). This variation in the lifespan of the MI system largely depends on quality of the material,

maintenance and designing of the system. Among various district it is noted that the beneficiaries in Uttara Kannada (71.1%) have expressed lifespan of the system is 3-5 years compared to other districts. This particular issue calls for review of the policy to re extend the benefits after a set standard of lifespan. Few interactions and discussion with micro irrigation system manufactures and agencies the average life span of the micro irrigation system may last for about 8 years subjected to quality and maintenance of the system. It is also noticed that on a conservative estimate the life span of MI equipment in general is about 5 years.

- It is a noteworthy observation that, the average participation of the beneficiary in PMKSY-PDMC-Scheme was higher up to 71.7 percent across all districts and being maximum in Shivamogga (90.7%) and Kolar (90.1%) and least was in Belagavi (41%).
- On an average, cost of MI installation is about Rs 24291/acre of which drip irrigation is about Rs.31161/-acre and sprinkler is about Rs. 17421/- acre. The investment for drip irrigation is found be to be 78.8 percent more compared to sprinkler irrigation. In field observation it is noted that the MI investment is maximum (Rs 40832/acre) of drip irrigation in kolar and Rs 23298/acre for sprinkler in Belagavi. whereas, in mulberry crop it was Rs 82920/ acre which is higher than other agriculture and horticultural crops. With respect to subsidy availed by various beneficiaries, maximum subsidy availed by medium size farmers (47.5%) followed by large farmers (23.6%) and small farmers (19.4%) and minimum was observed among marginal farmers (9.6%). Maximum (55%) beneficiaries have availed their subsidy between 6-12 months which is a long duration, total deviating the specified norms and thus it is a demotivating factor which needs to be addressed at all levels of scheme implementation. Only 31.2 percent of the beneficiaries the DBT system is functioning while 69.3 percent gets streamed through other non-considerate modes of disbursements and 59 percent of the subsidy disbursement channelized through MI agency.
- Convergence of PMKSY-PDMC with MGNREGA, NHM, Krishi Bhagya, Ganga Kalyan, NFSM, and ISOPHOM, found very marginal (only 31%). Among all scheme, maximum (62.9%) convergence was found with NSFM scheme which provides several crop productions inputs along with demonstration and training and minimum with ISOPHOM (1.7%) scheme. An average maximum convergence of the scheme noticed with NFSM programme in Kalaburgi district (91.1%), Bidar (82.6%) and

Kolar (77.6%), while the other scheme enabled included NMH Ganga Kalyan and Krishi Bhagya scheme intermediately.

- Popular programs like soil health testing have enabled a maximum number of farmers to test their soils to supplement benefit of micro-irrigation to the extent of 62.3 percent, while 37.7 percent requires guidance to reap better out come out of MI investment.
- It can be clearly observed that medium size farmers have adopted maximum (47.2%) MI system followed by small farmer (24.4%) and marginal farmer (19.2%). Whereas least MI adoption was observed with large farmers that is only 9.1 percent.
- Medium size farmer category in Uttara Kannada district beneficiaries have highest adoption rate (53.8%) followed by Chamarajanagar and Shivamogga district beneficiaries. However, least (37.5%) adoption rate was noticed with Bidar district beneficiaries. Under small farmer category, farmers belong to Tumakuru district have maximum adaptation of MI followed by Bidar which is accounted 34.5 and 31.5 percent respectively whereas, least adoption rate was noticed with Kalaburgi district farmers (16.3%). In marginal and large farmers category, Shivamogga and Uttara Kannada beneficiaries have accounted maximum of 28.2 and 17.6 percent respectively and minimum adoption rate was observed in Kalaburgi district (14.7%) and Mysuru district (3.2%)
- The study also revealed that training significantly influenced on their knowledge and interest towards technology which leads to increase in adoption of MI system among medium and small farmer as compared to other farming community.
- Greater interest in the MI adoptability to the extent of 42,2 percent, 26.8 percent, 16.5 percent and 14.2 percent respectively found with general/ OBC, SC and ST category. The proportion of MI adoption with respect to gender, the ratio between the genders is almost 1/3rd. Male gender representation is recorded at 72.6 percent, and female gender representation is only 27.4 percent.
- One of the prime reasons for adoption of MI system by beneficiaries is quite acceptable due to the fact that MI is water saving technology and found on an average 14.6%. Among various districts Tumakuru, Chamarajanagar and Mysuru district beneficiaries expressed MI adoption is mainly due to its purpose as a water saving technology.
- PMKSY PDMC scheme although envisages effective implementation of the scheme by gathering decadal experiences still not able to minimize/reduce certain critical

constrains which calls for a careful review of the implementation norms and procedures. Around, 63.7% beneficiaries, expressed that an inadequate power supply has found to have affected the MI installation. Further, administrative procedural anomalies have also affected the subsidy claims to the extent of 52.2 percent beneficiaries which is alarming to note and calls for drastic measures in the system and to comfort the claiming procedure. The other reflections factors area delay in system installation (43.7%), differences in quality material supply by (43.10%), cumbersome procedures (42.4%), difficulty during inter-cultivation (41.5%), quality issues of MI components (34.8%), lack of guidance in utilizing and managing the system (34.1%), difficulty in maintaining proper pressure (31.3%) and clogging of emitters and laterals (25.70%). For all the above constraints, appropriate orientation and training has to be done among various beneficiaries.

- M I irrigation Systems supported under the scheme are functional enough to the extent 86.3 percent both under drip and sprinkler. Maximum functioning of the MI installation is observed in Shivamogga and Uttara kannada (97.1%) followed by Tumakuru and Kalaburgi. The coefficients of the independent variables (training) is positive and significant influenced among medium farmers in improving functioning status than other category of farmers.
- Failure to extent post installation services by MI agencies up to an extent of 79 percent is quite alarming and warranting on the part of the public sector to insist for a conditional post installation service support system. Among the district in study area, Uttara kannada district beneficiaries suffered heavily without the maintenance support to an extent of 96.9 percent followed by Belagavi (88.3%). With respect maintenance support for drip and sprinkler irrigation it is observed up to 72.9 and 83.3 percent, respectively due to lack of post installation services by MI agency was common in Uttara kannada district.
- Bneficiaries farmers have been experienced the post installation services with in time span of 3 to 5 months (45%) and the major districts are like Shivamogga, Chamarajanagar, and Belagavi. Further it was noticed that 41 percent beneficiaries received services within two months, and 13 percent beneficiaries within 6 months.
- Borewells are the predominant source of water by beneficiaries as well as non-beneficiaries in all the districts which accounts to 94.0 and 97.5 percent respectively, followed by open well. However, least was noticed with farm ponds. Among districts, under MI beneficiaries, C.R. Nagar, Mysuru and Shivamogga district beneficiary

have completely relied on borewell sources of water. Use of open well as water source for irrigation was found to be limited to only 30 percent and that to majority of them are belongs to Bidar district. In all district farmers are heavily dependent deep ground water for their agriculture which leads ground water depletion in future and it requires urgent attention to rejuvenate at individual level by promoting rainwater harvesting structure around borewells.

- A maximum (85%) depth of open well found between 25 to 50 ft. With respect borewells, more than 500 to 750 ft depth were most common with 48% beneficiaries followed by 250 to 500 ft depth which accounts with 34 percent of beneficiaries and only 2 percent farmers have borewell depth of more than 100ft. Similar trend was also observed with non-beneficiaries.
- The average depth (460.8 ft) of water table can be seen under MI beneficiaries land and 520 ft under non-beneficiaries. Among various district, maximum (604.8 ft) deep borewells are observed in the Kolar district beneficiaries land, followed Shivamogga (547.7ft) and minimum depth of water table borewell (361 ft) noticed in Mysuru. Average water yield of borewell is 2.1 inch under beneficiary land and 2.0 inch in non-beneficiaries. The study results showed that on an average grass irrigated area per borewell is 9.5 acre in MI beneficiaries and 9.5 5.96 acre under non-beneficiaries. This indicates maximum cultivable area was facilitated by borewell found among MI beneficiaries compared to non-beneficiaries. Among various district under MI beneficiaries, gross irrigated area per borewell found maximum (13.2 acre) in Kolar followed by Mysuru (12.8 acre) and minimum (6.4 acre) gross irrigated per borewell noticed under Haveri district. While among non-beneficiaries, maximum (7.02 acre) gross irrigated per borewell found in Kolar and Haveri MI beneficiaries and minimum of 4.35 acre per borewell in Bidar district beneficiaries land. Overall study results indicates that deeper bore wells implies declining dependency of farmers on surface water schemes and increasing dependency on ground water schemes for meeting their minor irrigation needs. So, in order to decrease the dependency of farmers on ground water and to reduce the further depletion of ground water, surface water sources need to be restored through convergence of various scheme in order to continue to derive irrigation benefits from them.

Impact Evaluation

Land use change

Micro irrigation is being practiced in different parts of the sample districts which leads to change in land use system. Out of 6515.3 acres surveyed in the sample districts, it was noticed that a maximum 76% (4920.0 acres) of rain fed and 24% (1594.0 acre) flood irrigated area has been converted to MI. Among districts, conversion MI from rain fed area was noticed is maximum (99% out 641 acres) in Kolar, moderate range of enhanced MI area was observed in Belagavi (63% out of 786.8 acres) and least in Uttara kannada (13% out of 810.4 acres) as these areas are generally rainfall predominant districts. Likewise, the conversion of MI from flood irrigation practices in the survey district changed up to 24% on an average, wherein maximum conversion was observed in Uttara kannada (87% out of 810.4 acres), moderate in Shivamogga (49% out of 699.2 acre) and least was in Kolar (2%, out of 641.6 acres).

Crop diversification

It is found that the tendency of retention of the crop as per the approval was found to be at an average of 61.5% (out of 3690 beneficiaries), being maximum (90.9%) in Uttara kannada and lowest in Mysuru (35.6%). During the course field survey, it was observed that the beneficiaries have switched over to new crops mostly high value crops with the adoption of MI which might be due to subsequent decision of the beneficiary from the production and profit point of view.

With respect to introduction of new crop, average 1.3 percent (out of 370) of beneficiaries with an area of 78.2 acres being maximum (4.3 percent) in Belagavi district, followed by an area expansion of up to 35.6 acres in Kalaburgi distric (9% out of 370 beneficiaries).

Cropping intensity

The average increase in cropping intensity was observed in 34.0 percent of beneficiaries. Maximum extent of cropping intensity was noticed with medium farmers (38%), followed by small farmers (28.1%) and minimum was with large farmers (22.7%). It is also found that the tendency of kharif farmers adopting the practice was found to be at 36.1% (1063 to 1514), being maximum among medium farmers (42.9%) and lowest (23.1%) in small farmers (39 to 48 farmers).

Productivity enhancement

Introduction of micro irrigation has generated benefits in terms of enhancement of the average productivity in agriculture, horticulture and sericulture crops as compared to before installation of MI, and similarly between beneficiaries and non-beneficiaries. Commonly 12 agricultural crops have been identified for assessing the changes. Among various crop, cotton has recorded a greater to an extent of 44.8 percent (14.5 qt/acre to 21.0 qt/acre) followed by sugarcane with 44.4 percent (450 qt/acre to 650 qt/acre) increase and least of 161.8 percent with ragi (9.5 qt/acre to 11.1 qt/acre) as compared to before installation of MI.

Subsequently, beneficiaries have recorded for highest productivity in ground nut crops 78.6 percent (7qt/acre to 12.5 qt/acre) compared and non-beneficiaries and least increase in productivity found with sunflower (5.9%, from 18qt/acre to 17 qt/acre). Among the various districts, in Bidar district highest productivity (72.4%) under sugarcane and minimum increase in productivity was noticed with cotton crop in C. R. Nagar which about only 8.0 percent. The differential response of expressing the productivity enhancement with MI adopters before and after and also compared to non-beneficiaries is obviously due to application of water through drip irrigation and sprinkler enabled optimum moisture nearby root system which enhanced the healthy crop growth and development leading to higher productivity per acre.

In horticulture crop, productivity level in turmeric crops was raised to 52.0 percent as compared to before adoption of MI. However, among MI adopter and non-adopters, a higher positive growth rate of productivity is observed in the case of arecanut (56.7%) under MIS adopters as compared to the non-adopters. Average productivity of the turmeric has increased by 69.0 percent in C. R Nagar, followed by banana 64.7 percent in Kalaburgi due to MI installation. This may be due to drip irrigation technique ensures optimum moisture around the root system and this enables healthy growth of crop and yield.

Mulberry is a perennial commercial crop, where the leaf biomass is the principal source of food to silkworms. The mulberry plant growth and leaf yield was responded significantly well, both spatially, temporally, among beneficiaries and non-beneficiaries. By adopting MI, the percent of biomass productivity found highest up to 40.0 percent as compared to conventional practices, and 43.8 percent increment in productivity among MI adopters as compared to non-adopters. Among various district, after adoption of MI, the percentage of

increase in average productivity of leafy biomass was maximum (59.1%) in Mysuru district followed by Uttara kannada district and C. R Nagar as compared to before MI adoption with a minimum productivity increase in leafy biomass was seen in Haveri district (24.6%). It may be concluded that MI adopters are getting adequately compensated for the investments that they make to adopt the MI and many of the crops grown under MI have resulted in higher productivity than those crops grown with conventional method. Performance in term of productivity varies from district to district even for the same crop due to varied reasons like agro-climatic conditions, planting material, cultivation practices, soil productivity, irrigation system adopted and etc.

Among farm holding category, adoption of micro irrigation was benefited more with medium category farmers in agriculture and horticulture crops while, marginal category farmers benefited with sericulture crop as compared other category of farmers. In agriculture crops, maximum (66.7%, 7.5 to 12.5 qt/acre) productivity was observed in medium category farmers with black gram, and horticulture crops. A maximum of 66.2 percent (23.1 qt/acre to 38.4 qt/acre) crop productivity with turmeric in medium category farmers, and in mulberry 50.0 percent (114 qt/acre to 171 qt/acre) was observed with marginal farmers. Thus the adoption of micro irrigation system found more effective in enhancing the productivity among marginal, small and medium farmers than large farmers.

Net water saving

The focus PMKSY-PDMC scheme is to ensure provide end-to-end solutions in the irrigation supply chain, from source to field application with the vision of “Prathi Jaminige Neeru (Har Khet Ko Pani) and “More crop per drop (Parthi Hanigu Hechina Bele).

Micro irrigation intervention, average net water saving was observed in the study area is 4.2-acre inches after installation of MI as compared to before under beneficiaries and 0.9-acre inches among beneficiaries and non-beneficiaries. With respect to ground water zone, with the installation of MI system showed a maximum (39%; 10.8 to 6.5 acre inches) water saving in over exploitation zone followed semi critical/critical zone (33.3%; 12.3 to 8.2 acre inches) and under safe zone (31%; 14.2 to 9.8 acre inches) after installation of MI as compared to before installation of MI system under beneficiaries. Water saving interventions through micro irrigation appears to be productive in over exploitation (18% saving 7.9 to 6.5 acre inches) zone, followed by safe ground water zone (10% saving 10.9 to 9.8 acre inches) and it is quite marginal in the semi critical zone (only 5% saving -8.6 to

8.2 acre inches) among beneficiaries compared to non-beneficiaries.

With agricultural crops, both sprinkler and drip irrigation system are supported under the scheme. Predominantly three major crops Viz. sugarcane, paddy and cotton are supported with drip irrigation system, while rest of the crops- mainly the mulberry and horticultural crops are mainly supported with sprinkler irrigation system.

In general, beneficiaries with the installation of MI it was found that a maximum water saving was observed in paddy (72.0%; 61.8 to 17.2 acre inches) followed by sugarcane (62.0%; 32.1 to 12.2 acre inches), and least water saving was noticed in maize (10.0%; 1 to 0.9 acre inches) crop as compared to before installation of MI. Similar trend of observation was noticed among beneficiaries and non-beneficiaries. Maximum percentage of water saving noticed in paddy (66.8% 51.8 to 17.2 acre inches), followed by sugarcane and minimum of 18.2 percent (1.1 to 0.9 acre inches) water saving found with black gram. It is observed that the range of percent of water saving varies from 10 percent (1 to 0.9 acre inches) to 73.8 percent (66.1 to 17.3 acre inches) which is noticed with maize and paddy in Haveri district. Higher percent of water saving in various crops is due to efficient use of both sprinkler and drip irrigation and proved the fact that micro irrigation adoption as the best water saving approach than conventional irrigation practices.

Common 10 horticulture crops were classified in to 4 groups viz. fruits, plantation crops, spices and vegetables. Drip installation is a common practice under horticulture crops which is well suited and this is mainly due to this nature of crop density and spacing of crops.

The comparative water saving before and after the installation of drip within beneficiaries as well as among beneficiaries and non-beneficiaries showed a positive growth under almost all the crops as compared to the conventional irrigation method. It is important to note that the installation of drip system resulted in a maximum (55.3%; 28.4 to 12.7 acre inches) water saving under banana crop followed by 55.1 percent (28.3 to 12.7 acre inches) in arecanut and minimum (35.6%; 21.6 to 13.9 acre inches) water saving was noticed under mango as compared to before installation of drip system of irrigation. However, among beneficiaries and non-beneficiaries, a maximum (50%; 3.2 to 1.6 acre inches) percent of water saving was noticed in beans crop and minimum (16%; 16.6 to 13.9 acre inches) water saving found in mango under beneficiaries as compared to the non beneficiaries.

Survey results describes that average maximum (68.9%; 4.5 to 1.4 acre inches) water saving was noticed in Kolar with onion followed by arecanut (62.2%) in Shivamogga and minimum water saving (17%; 4.1 to 3.4 acre inches) was noticed in Kalaburgi district farmers. Performance in terms of water saving varies from district to district, even for the same crop due to varied reasons like agro-climatic conditions, planting material, cultivation practices, soil productivity, irrigation system adopted, etc.

Field study results indicated that the percent of water saving in mulberry was found to be maximum up to 42.6 percent (14.8 to 8.5 acre inches) as compared to conventional practices, and only 4.9 percent (8.9 to 8.4 acre inches) increment in water saving among MI adopters as compared to non-adopters. Among districts, the percentage of water saving was maximum (50% each; 16.0 to 15.2 and 8.0 to 7.6 acre inches) in Mysuru and Shivamogga followed by Tumakuru and Uttara kannada as compared to before installation of MI, with a minimum water saving was seen in Haveri district (21.4%; 11.2 to 8.8 acre inches).

Differential water saving among various group of farmers under agriculture, a maximum water saving up to 77.9 percent (59.5 to13.5 acre inch) was observed under paddy with small farmers and minimum of 8.3 percent (1.2 to 1.1 acre inches) in maize with large farmer category. With respect to horticulture crops, a maximum 72 percent (25 to 7 acre inches) water saving was observed with arecanut in medium farmers, and minimum of 17.0 percent (4.1 to 3.4 acre inches) in onion with small farmers. In mulberry, maximum changes in productivity of 57.05 percent (15.6 to 6.7 acre inches) with medium farmers 20.91 percent (11 to 8.7 percent) with marginal farmers was observed.

Fertilizer saving

As a production input, fertilizer application (FYM+ NPK) is a critical activity. The average reduction/saving of fertilizer usage was 23.3 percent after installation of MI. Maximum saving was noticed among beneficiaries in Belagavi (30.5%: 13.2 to 9.1 qt/acre), followed by Mysuru (29.5%: 9.8 to 6.9) and least in Uttara Kannada (17.6%: 10.5 to 8.7 qt/acre). Among beneficiaries and non-beneficiaries an average of 16.3 percent (with a range of 13.4 to 22.2 %) saving was observed with Uttara Kannada recording the highest savings (22.2%: 11.2 to 8.7 qt/acre) followed by Belagavi (19.2%: 11.4 to 9.1 qt/acre) and Shivamogga for the lowest of (13.4%: 11.3 to 9.7 qt/acre) after installation of MI.

Crop category wise fertilizer saving observed maximum under jowar (33.3%), followed by

cotton (30.0%) while black gram and ragi recorded minimum (11.1% each) as compared to before installation of MI. Among beneficiaries and non-beneficiaries, maximum percent of fertilizer saving was noticed in cotton (53 %) cultivation, followed by Bengal gram (44%) and minimum saving of 24 % was recorded in maize. The district-wise and crop-wise fertilizer saving were recorded between 4.5 to 57.5 percent, with the lowest in green gram in Tumakuru and highest with jowar at Belagavi district beneficiaries.

Comparative analysis of fertilizer savings before and after the installation of drip system within beneficiaries, as well as among beneficiaries and non-beneficiaries shown a reduction in all horticulture crops. Installation of drip irrigation system resulted in maximum fertilizer savings of 32.4 percent (3.7 to 2.5 qt/acre) for beans, followed by Banana (31.3%: 16 to 11 qt/acre) and least being 15.9 percent 22 to 18 qt/acre) in arecanut. Among beneficiaries and non-beneficiaries, a maximum of 63.3 percent (5.5 to 2.0 qt/acre) of fertilizer saving was recorded under tomato cultivation and a minimum of 21.9 percent (3.2 to 2.5 qt/acre) for onion crop with beneficiaries.

Survey results have described the fact that average maximum (52%: 2.5 to 1.2 qt/acre) fertilizer saving under tomato cultivation in Belagavi and followed by 50.0 percent (4.0 to 2.0 qt/acre) in beans at Tumakuru and a minimum of 5 percent (20.0 to 19.0 qt/acre) for arecanut at Shivamogga in comparison to the conventional practice.

Under mulberry crop, after installation of the MI system, an average fertilizer savings of 11.1 percent (9.0 to 8.0 qt/acre) as compared to before installation under beneficiaries and 33.3 percent saving among beneficiaries and non-beneficiaries. Among various districts, beneficiaries belongs to Tumakuru showed maximum (36.8%: 9.5 to 6.0 qt/acre) savings of fertilizers as compared before installation of MI and least (4.5% 11.0 to 10.5 qt/acre) was noticed in Belagavi.

With respect to various group of farmers a maximum (57.1%: 14 to 6 qt/acre) fertilizer saving was observed under medium category farmers with jowar crop before adoption of MI, while it was minimum (4.5%: 5.5 to 5.25 qt/acre) with groundnut with large farmers. Among horticulture crops, maximum fertilizer saving 42.8 percent (14 to 8 qt/acre) with banana under medium category farmers and minimum of 13.3 percent (3 to 2.6 qt/acre) reduction in fertilizer usage with onion under large category of farmers. In mulberry, a maximum fertilizer (only FYM) saving of 22.2 percent (9 qt/acre to 7 qt/acre) was observed with marginal farmers, and a minimum of 4.5 percent (11 to 10.5 qt/acre) with large

category farmers.

Micro irrigation as technology has been popularly known for reduced consumption of fertilizer, however, its potential to reduce fertilizer consumption is really a boon to soil health. Supply of excessive fertilizers mostly followed during conventional cultivation practice which leads to pollutes the farming land hence adoption of MI technology holds greater scope in checking the excessive supply of chemicals to the soil.

Labour saving

The average labour saving before and after installation of MI is about 23 percent, whereas among beneficiaries and non-beneficiaries it is 4.0 percent. A maximum of 25 percent each labour savings was recorded in C. R Nagar, Kolar and Uttara kannada and least Kalaburgi district beneficiaries (21%; 37 to 30) with MI installation. Among beneficiaries and non-beneficiaries maximum (7%; 28 to 26) labour saving was noticed in Bidar district followed by Uttara Kannada and least of 2 percent (31 to 30) in Kalaburgi district beneficiaries.

Crop-wise labour reduction shown a maximum 26 percent (55 to 41) in paddy followed by bengal gram and soybean, with 25 percent (24 to 18 and 28 to 21) savings each and ragi with a minimum 13 percent (31 to 27) of labour reduction after installation of MI. While under beneficiaries and non-beneficiaries maximum labour saving of 38 percent (29 to 18) each in tomato and bengal gram was observed, with minimum 12 percent (17 to 15) in green gram. Labour savings following the implementation of MI practice was observed maximum in soyabean (38.8 %) cultivation in C R Nagar, followed by sunflower (38.5 %) in Kalburgi and minimum in green gram (5.6 %) at C. R Nagar districts.

Efficient use of water management is key to efficient agricultural practices but involves substantial labour work. MI technology is a planned motorized system of water monitoring system built with due consideration of crop tillage and cultivation mechanism. Hence, possess great potential to reduce labour work compared to conventional system of operation.

Under horticulture crops, a maximum of 36.4 percent labour (55 to 35) saving was noticed under tomato, followed by arecanut (35%; 55 to 36), onion (33%; 57 to 38) and least was in grapes (12% 33 to 29) within beneficiaries (before and after). While under beneficiaries and non-beneficiaries, maximum labour saving (40%; 55 to 33) was noticed in beans, followed by 38 percent (56 to 35 and 58 to 36) each in tomato and areacnut with a minimum

labour savings of 21percent (42 to 33) in banana. Installation of drip irrigation helped a maximum (57.8%: 65 to 41.2 No/acre) labour saving under tomato in Mysuru district, followed 47.2% percent (53.0 to 28.0 no/acre) labour saving under turmeric in Shivamogga, and minimum (7.5%; 40.0 to 37.0) labour saving under banana in C. R. Nagar.

Horticultural practices are known to be labour intensive, requires regulation of water distribution manually under conventional irrigation system which demands greater labour work. With installation of drip irrigation, direct supply of water to root coverage area without any excess flow as it could be in the case of conventional flood irrigation method is greatly avoided. Furthermore, automatized system of water supply with well controlled water monitoring system have regulated optimum supply of water for cultivation.

In mulberry crop the range of labour saving was noticed from 17 percent (48 to 40) with the installation of MI (before and after) and the percent labour saving up to 23 percent (52 to 40) between beneficiaries and non-beneficiaries was recorded. In Mysore and Tumakuru districts it is noticed that a highest labour savings in mulberry cultivation was 23.6 and 23.5 percent respectively while in Belagavi district it is noticed for a minimum labour savings of 3.6 percent. As in the case of horticulture crops, mulberry also requires regular distribution of water through manually created channels, however with drip irrigation system these routine work is avoided minimizing the labour requirement.

With respect to farmers category, under agriculture crops, a maximum (57.1%: 14 to 6 qt/acre) labour saving was observed under medium category farmers with bengal gram, while it was minimum (6.6%: 30 to 28 No/acre/year) with jowar with large farmers. Under horticulture crops, a maximum 47.1 percent (53 to 28 No/acre/year) labour saving was with tomato under medium category farmers and minimum of 7.5 percent (40 to 37 No/acre/year) reduction in labour usage with banana under large category of farmers. In mulberry, labour saving of 30.9 percent (55 to 38 No/acre/annual) was observed with marginal farmers and minimum of 5.7 percent (42 to39.6 No./acre/year) with small category farmers.

Energy saving

Beneficiaries who have installed MI have indicated the adequacy of power supply up to 33.6 percent (out of 3690), whereas, with non-beneficiaries it was 57.5 percent (out of 40). Among different districts, Belagavi (71.8%) and Kolar (71.5) beneficiaries expressed their suffering highest power shortage. Whereas, under non-beneficiaries, Shivamogga farmers

facing a maximum (75%) shortage of power followed by Belagavi, Bidar, Kalaburgi, Mysuru, and Tumakuru (50% each). Thus, there is urgent need to take step towards sufficient power supply for effective utilization of MI system and on other side it was also found that there is potential scope to promote renewable energy (solar) among beneficiaries and non-beneficiaries, by integrating energy conservation schemes.

There are 10187 bore wells found in the study area and majority (48.4%) of the beneficiaries are using pump sets of capacity ranging between 5-10 hp for their irrigation purpose. Among various districts, Shivamogga district has maximum (71.4%) beneficiaries installed with 5.5-10 hp pump sets followed by Tumakuru district beneficiaries (57.1%) and minimum 12.5 percent in Bidar. The variations in the capacities of installed pump sets as attributed to the depth of water, extent of land irrigated, type of MI system installed and cropping pattern.

Savings of electricity with the installation of MI was significantly high ranging from 24 to 28 percent with an average saving of 26 percent before and after installation of MI within beneficiaries. Whereas among beneficiaries and non-beneficiary energy consumption range from 7 to 10.2 percent. The maximum percent of saving in energy consumption was observed in Bidar (10.2%; 23.6 to 21.2 Kw/h/acre) followed by Kalaburgi (9.3%; 24.9 to 22.6 Kw/h/acre) and minimum energy saving was expressed by Tumakuru beneficiaries which is accounted to only 7.0 percent (30.5 to 28.4 Kw/h/acre).

The results of the comparative energy saving before and after the installation of MI with beneficiaries, as well as among beneficiaries and non-beneficiaries showed positive growth under almost all the crops (agriculture, horticulture, and sericulture) as compared to the conventional irrigation method.

Energy savings following to the implementation of MI practice was observed to be maximum in sugarcane (35.3%; 110.5 to 71.5 Kw/h/acre) cultivation, followed by ground nut (31.4%; 17.5 to12.0 Kw/h/acre) and minimum in black gram (11.1%; 9.0 to 8.0 Kw/h/acre). Subsequently, among beneficiaries and non-beneficiaries a maximum energy savings was noticed in sugarcane and soyabean (36.4% each 112.5 to 71.5 and 30 to 7Kw/h/acre) cultivation and minimum of 17.5 percent (57 to 47.0 Kw/h/acre) in maize cultivation. Sugarcane is known to be water intense crop and excessive water supply through flood irrigation is the common practice among non-adopters, reduction in energy consumption under sugar cane cultivation is mainly due to adoption of drip irrigation system.

With respect to crop and district wise maximum energy savings of 53.1 percent (25.6 to 12 Kw/h/acre) under soyabean cultivation in Tumakuru and followed by 50 percent (8 to 4 Kw/h/acre) under ragi cultivation and lowest of 4.8 percent (8.3 to 8.7 Kw/h/acre) for paddy cultivation at Shivamogga district. Sprinkler technology enables a greater area of distribution optimal supply of water in short duration of pumping time, in contrast to flood irrigation. Thus, MI technology has contributed for greater energy savings in the crop production.

The results of the comparative energy saving before and after the installation of drip within beneficiaries, as well as among adopters and non-adopters showed increasing trend under almost all the crops as compared to the conventional irrigation method. Installation of drip resulted maximum (33.3% each 12.0 to 8.0 and 52.5 to 35.0 Kw/h/acre) energy saving under arecanut and coconut followed in chilly 28.0 percent (25.0 to 18.0 Kw/h/acre) and minimum (18.2%; 11.0 to 9.0 Kw/h/acre) energy saving under onion as compared to conventional method. Similar trend was seen among adopter and non-adopters. Survey results describes that average maximum (71.7%: 12 to 3) energy saving was noticed in Shivamogga district under sugarcane cultivation followed by chilly (58.7%) in Kolar and minimum energy saving (5.9%) was noticed in Belagavi under grapes cultivation.

Energy saving in mulberry was found up to be 27.3 percent (16.5 to 12.0 Kw/h/acre) as compared to conventional practices within beneficiaries (before and after MI adoption) and 29.3 percent (17 to 12 Kw/h/acre) increment in energy saving among MI adopters as compared to non-adopters. With respect to district wise, the percentage of energy saving noticed to be highest in Kolar (44.9%: 18.3 to 10.2 Kw/h/acre) followed by Uttara kannada (39.5%: 19 to 11.5 Kw/h/acre) with a minimum energy savings of 12.8 percent (21.8 to 19 Kw/h/acre) in C. R Nagar district as compared to before installation of MI as compared to before installation of MI.

Among various farmer category, under agriculture crops, a maximum (49%: 98 to 50 Kw/h/acre) energy saving was observed under medium category farmers with sugarcane while it was minimum (8.6%: 52 to 47.5 Kw/h/acre) with maize with small farmers. Under horticulture crop, maximum energy saving ranged from 44.7 percent (55.2 to 30.5 Kw/h/acre) with coconut under medium category and minimum of 12.0 percent (58 to 51 Kw/h/acre) reduction in energy usage with tomato under large category of farmers. In mulberry, labour saving of 28.4 percent (15 to 8 Kw/h/acre) was observed with medium

farmers and minimum of 18.1 percent (15.4 to 12.6 Kw/h/acre) with small category farmers.

Performance in terms of energy saving varies from district to district, even for the same crop due to varied reasons like agro-climatic conditions, planting material, cultivation practices, soil productivity, irrigation system adopted, etc. have rendered water usage efficient implementation of MI technology and hence, reduction in energy consumption.

Employment generation

Changes in the man days or labour utilization before and after MI intervention at pre-harvest and post-harvest stages were studied. Study results reveals that during pre-harvest stage on an average increased man day was 10.8 percent being maximum in Kalaburgi (16.9%), followed by Tumakuru (14.8 %) and least was in Chamarajanagar (5.5%). Likewise, with respect to post-harvest activities the average percent increase of man days was 26.3% in the study area, maximum (36.1%) being in Haveri and followed by Tumakuru and Belagavi (31.3% and 31.1% respectively) and least in Mysuru (15.4%).

Increase in farm income

Adoption of MI is quite prominently noticed in increasing of farm income (gross income) before and after adoption of MI within beneficiaries. The average increase in gross income/acre was 30 percent under beneficiaries as compared to before adoption of MI. The maximum 42.9 percent (Rs 83245 to Rs 118942 per acre) gross increase in farm income has been reported in Belagavi and minimum increase in gross income/acre by 17.8 percent (Rs 61847 to Rs 72833 per acre) in Mysuru. Similar trend of increasing in farm level income per acre was found among beneficiaries as compared to non-beneficiaries. The average enhancement of gross income among beneficiaries as compared to non-beneficiaries is 26.1%. The maximum increase in gross income has been reported in Bidar 46.6% (Rs 84000/acre to Rs 118942/acre) followed by Belagavi (Rs 49600/acre to Rs 72692/acre).

Adoption of MI is quite prominently noticed in increasing of farm income of various farmers category. By adoption of MI showed average increase in gross income/acre, ranging from 6.1% to 39.7 percent (Rs 71245 to RS 115838/ acre) as compared to before adoption of MI. The average maximum gross increase in farm income has been reported among medium farmers (Rs 82945 to 115838/acre) followed by small (Rs 50708 to Rs 6641/ acre) and marginal farmers, however least was noticed in large farming (Rs 67146 to Rs 71245/acre).

The participation in training on MI technology really helps in enhancing the net household income among small, medium and marginal farmers however not much directly influenced on net income of large farmers.

Social and Environmental benefits of MI installation

- Micro-irrigation scheme implementation has resulted in inclusive development of beneficiary contributing for their infrastructure, livestock, household assets and education enhancement, sequentially. From the field study it was noticed the infrastructure improvement (47%) was observed to be a most significant social impact followed by livestock (20%), household assets (19%) and education (14%) support as general phenomena by adoption of MI.
- Among various district beneficiaries in Haveri, Shivamogga and Belagavi beneficiaries have registered higher percent of social benefits than other districts in terms of infrastructure and minimum was noticed in Bidar. However, livestock support was obtained maximum in Bidar, Mysuru and Chamarajanagar by adopting MI. Were expressed positive response towards gaining household assets benefit by adopting MI in Kalaburgi and Uttara Kannada and least among Tumakuru and Haveri beneficiaries. Similarly, the family members like children getting into the academics through MI support in education front to the extent of 35 percent in Kolar and 33 percent Bidar beneficiaries.
- Overall average 68.6% labour migration was reduced by adoption of MI. Among various district, maximum reduction in labour migration was observed in Shivamogga (98.4%) district followed by followed by Uttara Kannada (90.3%). However, no changes have been noticed in Kalaburgi district.
- Agricultural water management tend to possess several heavy and hard activities causing stress and strain to human labour, which is very predominant with irrigation practice. A transition from traditional flood irrigation towards MI irrigation resulted in the reduction of labour drudgery especially in water management which sustained human energy for productive activities. In the present analysis, it was found that the average reduction of labour drudgery of 57.9 percent by adopting MI. With respect individual component, drip adoption reduced labour drudgery by 64.5 percent and 52.5 percent by sprinkler adoption. Among the districts maximum reduction in labour drudgery was noticed in Chamarajanagar, Kalburgi and Belagavi districts, owing to

the dependence of higher population on agricultural labour. The shifting, shuffling and insertion of sprinkler jets calls for additional drudgery, hence which is not so in-case of drip system.

- It is heartening to note that the 75.4 percent beneficiaries have expressed installation of MI system as a practice to overcome water scarcity. However, still 24.6 percent of beneficiaries substituting water through purchasing or shared by neighbour. Among various district Mysuru and C. R. Nagar beneficiaries expressed that installation of MI helped maximum (94.3% each) to overcome water scarcity during critical period and minimum was in Bidar (45.9%).
- In this study it is noted that the 72.1 percent farmers have experienced the incremental population of earth worms and 77.5 percent reduced soil cracking with MI adoption.

Training and Capacity Building

- The training and capacity building is an integral component of the PMKSY-PDMC initiatives. In the present study the level of beneficiary participation, stakeholder engagement, frequency, seasonality, topic covered, usefulness in building the knowledge and skill in MI system management. The study results highlighted that a majority around 87.4 percent of beneficiaries across all districts not had training program, thus highlighting the need for interventions to strengthen the training and capacity building component of the program.
- As business traders, the MI agencies have taken maximum initiative to the extent of 41 percent which is a dominant approach in organising the training program. Followed by the involvement of governmental staff to an extent 25 percent, RSK with 17 percent share, SAUs/KVKs with 12 per cent share and NGOs/CBOs with 5 per cent.
- The dominant mode of training was through demonstrations (71) and one day training program was most popular and only 31 percent expressed timing as convenient.
- 72 percent farmers expressed principal topic covered in the training is irrigation practices. In terms of gaining knowledge and skill enhancement, 33 per cent of respondents rated the training program to be very good, 47 per cent rated it to be good and 20 per cent rated it as medium/average. Since the program is a more technically oriented one, any improvement in the wisdom and skill matters the sustainable outcome from the program and investment. Among participated beneficiaries more

than 82 percent of the farmer beneficiaries have expressed their enhanced knowledge and skill due to training,

Focus Group Discussion (FGD)

MI a uniform water distribution technology has become an agricultural practice through the MI system to support crop production and area expansion dimensions in both flat and uniform terrains like in northern Karnataka and with undulating terrains in coastal southern Karnataka districts also. Irrespective of soil types and texture, the MI practices are found to be an adoptive one in all parts of the state- [Hunsaghatta, Tumakuru and Mudapali, Uttara Kannada]

Cereal crops like paddy, maize, groundnut, soybean, pluses, and closely spaced vegetables have been the choicest crops for sprinkler adaption, while perennial crops including widely spaced row crops like various fruits, plantation crops, spices and row crops like vegetables and flower crops are with the drip system, which is being very well acclimatized as a most viable irrigation practice by the farming communities across the land holding size. [Morkandi, Bidar and Hulidevanhalli, Kolar]

A common voice of adoption of MI system enabling the farmers in stabilizing their crops and yield was observed in most of the districts of study. Simultaneously, the financial improvements are received as MI scheme compensated the initial investment. Owing to soil physiography in district like Chamarajanagar has been observed to be a marginal exception: [Maddur, Chamarajanagar and Hulidevanhalli, Kolar]

Prevalent of seasonal drought in districts like Tumakuru and Kolar during 2018-2019, and with unsettled rainfall pattern decreasing up to 30-40% of the total rainfall in North Karnataka region, the MI system sustained as a boon for crop production. [Morkandi Bidar and Hulidevanhalli, Kolar]

Borewell has been the major source of irrigation across the state and the number of bore-wells would vary with land size. Cultivators with up to 2-3 acres would own one bore-well while in land holding of 10-12 acres up to six bore-wells. [karadaggi, Haveri and B Matagere Mysuru]

Affluence of revenue out come with MI practice has been well relished by the farmers and it tempted them dug borewells up to a maximum depth 800-1400 above at Kolar/Tumakuru

and minimum record of 600-1200 ft at Shivamogga/ Uttar Kannada: [Mydholalu, Shivamogga and Hunsaghatta, Tumakuru]

In general, during summer season and in dry regions crops face shortage of water and farmers would like to avoid cultivation of crops which yield on lesser water. In case scarcity of water, farmers would request and trade the water from the neighbouring land holder in return of sharing some produce, out of gratitude. [Tengli, Kalaburgi and Adahalli, Belagavi]

It has been a conscious suggestion by farmers for joint inspection by field implementing officials of Revenue, Irrigation and Electricity Departments towards confirming the water source, water Output, power supply before launching the program for efficient utilization of Government subsidy. [Morkandi, Bidar]

Irregular time of power-supply has forced farmers to accommodate unconventional irrigation timings and this has also led to the use of condenser for power extraction as an illegally compromised plan. [Maddur, Chamarajanagar and Hunsaghatta, Tumakuru]

Farmers reported to have not provided with any organized training apart from providing one onsite demo at few places of study area. Lack of training has been the major bottle neck. [Matagere, Mysuru and Mudapali, Uttara Kannada]

Recommendations

Short term

1. To trace the entire process from the stage of application to installation till subsidy transfer, IT applications like Geo-tagging and referencing for real-time monitoring are to intensified for clarity and transparency.
2. Proper verification mechanism of field documents verification for ownership, water sufficiency, electricity connection and any parallel installations to avoid duplication of scheme benefits.
3. Seasonal and year-round crop planning advisories to be formulated and trained the farmers for the best and efficient utilization of MI installation during peak and other follow-on seasons.
4. Focused training to farmers on the maintenance and post-installation services of micro-irrigation system and to instill confidence of the technology through regional institutional training-cum- services centers are to be arranged.

5. Innovative low-cost micro irrigation systems having a longer lifespan are to be promoted for enhancing the technology adoption with suitable quality control regulations on materials.
6. Direct Benefit Transfer (DBT) model to be rationalized (instead of Direct Beneficiary Transfer) and uniformly adopted in all the major implementing departments to enhance transparency.
7. Mandating the MI system for heavy water-consuming crops like sugarcane, banana, and vegetables with special subsidy incentives.
8. Enforcing regulatory measures to the unapproved agencies, distributors and dealers to avoid supply of sub-standard components through exclusive autonomous institutions like KAMIC.
9. The officials who are involved in promoting micro-irrigation technology have inadequate knowledge and skills about the technical and related details. Therefore, the state government extension staffs need to undergo refresher courses and exposure visits to have basics and advances in micro-irrigation.
10. MI system manufacturers should be involved intensively in promoting micro-irrigation technology through demonstrations at farmers' fields and strategic locations and provide advisories on agronomic packages for large scale adoption.
11. Designing the subsidy provisions ranging from 45 % to 90% to vulnerable categories to enhance the adoption of micro-irrigation with marginal and small land holders.
12. In order to encourage adoption of micro irrigation and its promotion among the poor and marginal farmers, a special scheme could be introduced that links the bank loan facility for digging wells with electricity connection for pump sets.
13. Operationalizing the KAMIC institutional mechanism on a priority basis for improved expansion of micro irrigation schemes.

Medium term

1. The system suppliers should make supply provisions for acid treatment to the growers as part of their after-sales service obligation.
2. Dovetailing other schemes such as Raita Surya, Krishi Bhagya and Ganga Kalyan Yojane and ISOPHOM, NFMS for MI to enhance the socio-economic benefits.
3. The inclusion of insurance to be mandated that it can be a useful tool to absorb some adoption risks for the farmers to some extent.

4. Institutionalization of external (third-party) concurrent monitoring and evaluation as an integral part of scheme implementation.
5. To install more vigilant, follow up by MI supply agencies on warranty and after-sales services it is proposed that 10 percent of the subsidy may be released after one year subject to satisfactory performance of the system as certified by the beneficiary.
6. Establishment of a comprehensive testing of all types of equipment, devices, machines used in micro irrigation systems using state-of art technology in a Central Testing Facility Laboratory (CTFL).
7. Relaxation of the land ceiling to 10 ha in a faced and seniority method for availing renewed subsidy to expand coverage under micro irrigation.
8. Integration of credit assistance as a component to the ongoing scheme system to be developed to enhance the investment support.

Long term

1. Formulation of a revised State Irrigation Act (aquifer and recharge status) for achieving water use efficiency and to address SDG 6 objective.
2. Awarding an industry infrastructure status to micro-irrigation sector for larger benefits of the multiple stakeholders and promotion of agrarian sector in the state.
3. Public Private Partnership mode for water harvesting and utilization plan on a comprehensive and block basis to be developed with farming communities.
4. Integrated watershed development and Krishi Bhagya with Per Drop More Crop scheme are critical in transforming rained agriculture and also in facilitating adoption of diversified livelihood options among smallholder, marginal holders and rural youth.
5. MI technology enhancement towards its adoption for cultivation of water intensive crops
6. Establishment MI technology skill development centre in PPP model for farmers.
7. Incentivisation of a farm rainwater harvesting for MI practitioners.
8. Identification of and promotion MI technology among canal bank farm lands
9. Water conservation to be promoted based on collective community investments for judicious use of resources.