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Working of Pressurized Irrigation Network Systems (PINS) in India

(Consolidated Report)

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Foreword

Micro irrigation technologies were first introduced in India during the 1980s. After a long period of tepid growth, the area under micro irrigation has rapidly increased during the past decade. Even so, the area actually covered by this technology is still less than 5 per cent of the potential. The market for drip and sprinkler irrigation has so far been confined to land owned by farmers who own irrigation tubewells. Operation of drip and sprinkler irrigation system requires that water can be delivered with a certain minimum pressure. Therefore, drip and sprinkler technologies have not been adapted to canal irrigation where water is delivered by gravity flow.

In recent years, however, there is a surge in interest in applying micro irrigation technologies on heavy duty public tubewells which serve dozens of farms as well as to canal water delivery. These are fancily called Pressurized Irrigation Network Systems (PINS). Massive investment programme have been planned to install PINS in large public canal command in Rajasthan, Karnataka, Andhra Pradesh, Telangana and Gujarat. However, in the absence of reliable water supply and power supply, doubts have been raised about whether expensive PINS can improve the productivity of canal irrigation. India's canal irrigation systems are notoriously unreliable, and so, in most states, is agricultural power supply. In absence of these two pre-requisites, PINS in canal command is like a diamond necklace adorning the neck of a donkey!

It is in this context that the present study by the Agro-Economic Research Centre, Vallabh Vidyanagar acquires value. Government of India which entrusted this study is naturally interested to find out if investments in PINS would be worthwhile without improving the reliability of agricultural water and power supply.

The study is based on primary and secondary data. It was planned as an all India coordinated study covering Gujarat, Rajasthan, Maharashtra and Telangana. The study finds beneficial impact of PINS investment on cropped area, irrigation area, farm production as well as water and energy savings. However, it makes no assessment of whether the extent of benefits generated justifies large capital investments per hectare that PINS programmes entail. Without such analysis, it is difficult to make valid recommendation. A thorough cost benefits analysis of PINS investment is required, especially because these investments are fully financed by government subsidies with only token contribution from farmers.

I compliment the authors, research team members and the three AERCs at Pune, Waltair and Vallabh Vidyanagar for completing this important piece of work.

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The study would not have reached to this stage without the active co-operation of the sample households, who provided all the required data for the study without any hesitation and expectation. We thank each one of them for their invaluable support.

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List of Abbreviations

ACZ	Agro-Climatic Zones
AIMO	Area Irrigated More Than Once
ASMO	Area Sown More Than Once
Av.	Average
BCM	Billion Cubic Meter
BF	Beneficiary farmers
Bgl	Below Ground Level
BH	Beneficiary households
BIS	Bureau of Indian Standard
CAGR	Compound Annual Growth Rate
CCA	Culturable Command Area
CIPET	Central Institute of Plastics Engineering & Technology
CN	Command Network
CU	Coefficient of Uniformity
Cum	Cubic meters
DWs	Diversion Weirs
EU	Emission Uniformity
FMI	Flood Method Of Irrigation
GCA	Gross Cropped Area
GGRC	Gujarat Green Revolution Company
GGWA	Gujarat Ground Water Authority
GIA	Gross Irrigated Area
GOG	Government Of Gujarat
GOI	Government Of India
GoI	Government of India
GoM	Government of Maharashtra
GR	Govt. Resolution
GWRDC	Gujarat Water Resources Development Corporation
ha	Hectare
HHs	Households

HP	Hours Power
HVDS	High Voltage Distribution System
ICA	Irrigable Command Area
kg	Kilograms
KTWs	Kolhapur Type Weir s
LS	Large Size
MDIS	Micro Drip irrigation System
mha	Million Hectares
MI	Micro-irrigation
MIS	Micro Irrigation System
MITs	Minor Irrigation Tanks
MOM	Management Operation and Maintenance
MS	Medium Size
mt	Metric Tonnes
MWRRA	Maharashtra Water Resources Regulatory Authority
NBF	Non-beneficiary Farmers
NBH	Non-beneficiary households
NIA	Net Irrigated Area
NMMI	National Mission on Micro Irrigation
NSA	Net Sown Area
NWDA	National Water Development Agency
O&M	Operation And Maintenance
OBCs	Other Backward Classes
PIM	Participatory Irrigation Management
PINS	Pressurized Irrigation Network Systems
PTs	Pazar/Percolation Tanks
PVC	Polyvinyl Chloride
R&D	Research And Development
Sq. Km.	Square Kilometre
SS	Small Size
SSNNL	Sardar Sarovar Narmada Nigam Limited
SSNP	Sardar Sarovar Narmada Project

SSY	Sujalam Suphalam Yojana
STs	Storage Tank s
TMIP	Telangana Micro Irrigation Project
TRA	Total Reporting Area
TUA	Tubewell Users Association
UGPL	Underground Pipeline System
VSA	Village Service Area
WUA	Water User Associations

Executive Summary

Background

Water scarcity for agriculture has been growing year after year due to various reasons, for which the government has been very keen to increase the water use efficiency with its new slogan 'more crops per drop'. The government has envisaged promoting MIS and increasing the area under these water saving technologies. The Pressurised Irrigation Network System (PINS) is one such new innovative concept that acts as interface between water source and MIS in farm plots and increases the area under irrigation through adoption of MIS. It comprises of pipe network with controls, pumping installations, power supply, filtration, intake well/diggy. It is a common and shared infrastructure (by group of farmers) facilitating individual beneficiary for installing and operating MIS.

The present study was undertaken with major objectives as (i) to undertake a broad situation analysis of various PINS programs implemented in select states of India; (ii) to assess the extent of adoption and performance of PINS in different scenarios in the country; (iii) to analyse the institutional arrangements for management, operation and maintenance of PINS in the country; and (iv) to identify the major constraints in adoption, management, operation and maintenance of PINS in the country. The study covers four major states (Rajasthan, Gujarat, Maharashtra and Telangana) of the country promoting PINS with MIS. The data were collected from sample households as well as PINS-WUAs of selected states as per the distribution presented in Table 1.

Table 1: PINS Sample Size Distribution in Selected States

States	*No. of Beneficiary Households*	*No. of Non-Beneficiary Households*	*Total Households*	*No. of PINS-WUAs*
Gujarat	*200*	*100*	*300*	*27*
Rajasthan	*200*	*100*	*300*	*26*
Maharashtra	*250*	*105*	*355*	*75*
Telangana	*200*	*100*	*300*	*32*
Grand Total	*850*	*405*	*1255*	*160*

In Gujarat and Telangana, all the selected PINS were tube well PINS where as in Rajasthan, all the selected PINS were canal PINS. In Maharashtra, three types of PINS were observed: Government PINS (100% government funded), Cooperatives PINS (partially funded by government and managed by group of farmers) and private PINS (owned and managed by individual farmers).

Overview of PINS Programme in India

During the last six decades period, the land area under irrigation in India has expanded from 22.6 million hectares in 1950 to about 91.53 million hectares in 2011-12, with 52 per cent area being irrigated by surface irrigation through canal network. Unfortunately, the overall efficiency of canal irrigation system is very low which leads to poor utilization of irrigation potential, created at huge cost. On the other hand, the demand for increasing irrigation coverage has been growing. For enhancing the irrigation efficiency, the MIS is being promoted through many programmes. The concept of Pressurized Irrigation Network System (PINS) is one such programmes which was developed at Design Office of Sardar Sarovar Narmada Nigam Limited (SSNNL) as a necessity step to introduce MIS in the command area of Sardar Sarovar Narmada Project (SSP). Later on, the concept has been used in various other states. Since it is a new concept got popularised in last ten years, the literature and statistics on the same is mostly unavailable. Therefore, only aforesaid four front runner states were included in the study for the detailed study.

Gujarat: *Government of Gujarat has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The pilot project on Pressurized Irrigation Network System (PINS) is one such effort started in 2007-08 in the command area of SSP. Accordingly, about 25 pilot projects were initiated in the state covering 1029 farmers with 1491.6 ha of CCA and estimated budget of Rs 1306.3 lakh. The average spending incurred per PINS was Rs 35.4 lakhs against the estimated Rs 52.3 lakhs. The estimated per hectare expenditure on PINS at Chak level was Rs 20340/-. Because of PINS, the per hectare water savings was estimated to be to the tune of Rs 15000/- for Bhal and Bara areas (mainly saline areas) and Rs 19560/- for other zones, respectively. The project work was carried out by three agencies, viz. Jain Irrigation Ltd (56%), Parikhit Industries (32.0%) and EPC Industries (8.0%) etc.*

Though the Government of Gujarat followed a proactive approach to increase the adoption of PINS by the water users, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to various reasons. The farmers did not prefer to change the cropping pattern which was highly water intensive. They did not want to spend anything on installation of MIS since canal water was available to them plentily almost free of cost. There are not much strict rules and regulations enforced to check the illegal use of canal water and water theft.

Looking at the unsatisfactory experience of Canal PINS in the state, an attempt was made by the Irrigation Department in devising a suitable solution to address various issues. The main features included promotion of Under Ground Line System (UGPL) Network for micro canals such as Minors. The combination of UGPLs and PINS replacing Minors, Sub-Minors and FCs has also been put in some places in the state.

However, the tube well PINS have been operating in the state since a long ego as a viable method of irrigation in the state. The Government of Gujarat introduced a policy of pressurized irrigation system in the command area of public tube wells under Gujarat Water Resources Development Corporation (GWRDC). As per the Government norms, Micro Irrigation System (MIS) is provided in the command area of 309 tube wells covering 1452 Ha in five districts of the state i.e. Banaskantha, Mehsana, Patan, Gandhinagar and Sabarkantha. The State Government has decided in March 2013 to provide MIS in Government tube wells at 100 per cent Government cost in total nine districts. Accordingly, State Government provided MIS system in 162 tube wells in 2013-14 covering 1531 ha and 1037 farmers. The MIS works covering 2984 ha of 3780 farmers were in progress in 208 tube wells which was likely to be completed in 2014-15. Till January 2016, a total of 674 tube wells have been covered by GWRDC out of which 54.0 per cent was through government subsidy and remaining 44 per cent were given partial assistance.

Rajasthan: *The Government of Rajasthan has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The Pressurised Irrigation Network System (PINS) Programme in Rajasthan is mainly concentrated in two major irrigation projects, i.e., Indira Gandhi Neher Project in Bikaner district and Narmada Irrigation Project in Jalore and Barmer districts. Thus, the main feeder source for PINS programme was canal. No other kinds of PINS such as tube well PINS or private PINS were not available in the selected areas of Rajasthan.*

Under IGNP, the PINS project was started on pilot basis in Bikaner district from 2012-13 and initially only 33000 hectare area was covered. Recently, the Centre has approved around Rs 1,659 crore for PINS projects in the state. With these new irrigation projects, around 347.66 lakh hectares of area can be irrigated with sprinkler system in Bikaner, Churu, Hanumangarh, etc. Under these projects, sprinkler irrigation systems are proposed for optimum utilisation of available water. Total culturable command area (CCA) of these projects is 3,47,566 hectares, out of which sprinkler irrigation system has already been established in 27,449 hectares under the pilot project.

The PINS projects under IGNP are being operated in bigger area around 200 to 600 ha in one diggy, whereas the size of PINS project in Narmada Project at Jalore and Barmer are of smaller size of with 90 to 100 hectares. Under Narmada canal, about 2,35000 hectares area has been irrigated in Sanchore and Chittalwana (Jalore), Gudha malani and Dhorimanna (Barmer) districts. All areas of Jalore and Barmer districts have been benefitted through Narmada Canal where all irrigated areas are with PINS only. There is no flood irrigation allowed in the region which is main reason for successful working of PINS project in these regions. Another reason for success of PINS project in Sanchore area is that the groundwater level is very high and groundwater is salty. Thus, the farmers failed through tubewell irrigation in their field. As the only option, the farmers adopted canal PINS and succeeded in making agricultural prosperity.

Maharashtra: *In Maharashtra state, the types of PINS projects are of three types - government PINS (100% government funded), cooperatives PINS (partially funded by government and managed by group of farmers) and private PINS (owned by individual farmers). There are government PINS (govt PINS) and cooperative PINS (coop PINS) in Buldhana, Kolhapur, Sangli and Yavatmal districts, while private PINS (pvt PINS) are spread across many districts, with high penetration in districts like Nashik and Ahmednagar. In the state, and the sources of water for PINS are river, tube well, dug well, and storages by weirs, dams etc.*

There are large number of lift irrigation schemes in co-operative sector, particularly in southern part of Western Maharashtra (101205 ha) in Krishna basin (i.e. on Krishna river and its tributaries). These lifts can be considered as PINS with flood irrigation. However, over the years, the lands under them are becoming saline/water logged. For this reason, as well to save labour, fertilizers and water, initiatives have been taken through some schemes for converting the flood distribution systems into MIS. The list of 15 such schemes (from the micro irrigation manufacturing companies) were obtained and some of them were included in this project survey.

There are other 11 irrigation projects, under which flow/canal irrigation systems are not economical, as these projects have command mainly located in hilly region. The total area under these 11 projects is 54100 ha. With the area under lifts on Krishna etc., the total ICA works out to (54100+ 101205) 155305 ha. Therefore, it is advised that if the financial assistance is made available to these lifts, they would get converted from PINS + Flow into PINS + MIS rapidly, as the trend is already set by 15 schemes converted.

Telangana: *It is newly constituted state where there are no government PINS projects with MIS available in the state, alternatively the projects with MIS scheme are installed connected to the irrigation source of tube-wells/bore-wells in the state. From 2014 onwards, the MIP scheme (NMMI) was subsumed into National Mission for Sustainable Agriculture (NMSA) as one of the component as On-Farm Water Management (OFWM). Out of 17.12 lakh hectares of net irrigated area (irrigated with ground water), only 5.73 lakh hectares are covered under micro-irrigation, leaving a balance potential of 11.39 lakh hectares for micro-irrigation under PINS. In all the districts, the MIP project through MIS scheme connecting to tube-well irrigation is implemented. About 550212 numbers of micro-irrigation systems were installed with coverage of area of 550212 hectares with the total number of beneficiaries being 296436.*

The drip system of MIS is provided for cotton crop with a total initial fixed cost of Rs. 106120 of which 10.612 is given as subsidy for BCs small/marginal farmers and for others the subsidy is given to a maximum of Rs. 21,224. Moreover, the sprinkler irrigation system of MIS is provided for groundnut crop with a total fixed cost of Rs. 17880 of which Rs. 4,470 is given as subsidy for SC/ST, BCs small/marginal and for others. MI project in Telangana is mainly based on well and tube-well irrigated areas.

Performance of PINS Programmes in Gujarat

It is observed that the tubewell PINS are popular in several districts in Gujarat whereas the canal PINS are not well adopted by the farmers. The majority of farmers (68.7%) had less than 1 ha area under tubewell PINS. About 95.3 per cent of sample beneficiary farmers have adopted drip whereas the 10 per cent of them adopted sprinkler. The total cost of drip and sprinkler systems was estimated to be Rs. 42950 and Rs. 30133 per household (hh) in the study areas. The major motivating factors for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation (79.3%), better and stable crop yield and farm income (78.0%), saving more water and to cover more area under irrigation (67.3%), facilitating judicious or efficient distribution of water among the water users (54.7%) and avoiding unnecessary conflicts with other farmers (28.7%).

The water saving due to judicious use of water (94.0%), increase in agricultural income (86.7%), getting water in right time (88.0%), proper distribution of water among farmers (62.7%), getting more information on how to use water judiciously (56.7%), electricity saving (54.0%) and improved maintenance of the system (26.7%) were the major benefits accrued by the beneficiary water users/farmers.

The proportion of area under more remunerative Rabi crops was also found to be higher (28.7% of GCA) in case of beneficiary farmers as compared to non-beneficiary farmers. It was observed that, except few crops like groundnut, mung and cumin, beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers. The percentage change in yield under drip over flood and change in yield under sprinkler over flood has been spectacular with respect to some crops like castor (117.6% and 102.1%, respectively) and cotton (83.1%). Among Rabi crops, major benefits were observed in the case of wheat (by 83.3% and 108.4%, respectively), fennel (55.1%), rapeseed-mustard (59.9%), and tobacco (by 84.6%).

Some of the factors those helped in generating some benefits were better water management by WUA members (58.0%), better education and awareness of the farmer (43.3%), more area under PINS-MIS (34.0%) and more area during Rabi (37.3%) were the major ones. The results of Probit model indicated that, more area under PINS-MIS, uninterrupted power regular supply, more depth of tubewell, sufficiency of water in PINS and group membership helped in realising the benefits like increase in yield and income, water and energy saving by the beneficiary farmers.

Among the major activities undertaken by different types of PINS TUAs, operation and maintenance of PINS project, deciding the timing of water release, judicious water distribution, collection of water rates, collection of per capita operation and maintenance cost were the major activities of Govt. TUAs.

The main source of income for these TUAs were annual maintenance fees collected whereas the major heads of expenditures were the expenditure on electricity bill, repairing expenses, salary expenses. Besides, in case of PINS, the charges to Irrigation Department and some miscellaneous expenses were incurred by the WUA/TUAs.

The major benefits provided by the WUAs to its members were arrival of water in time, proper distribution of water among farmers, more information on how to use water judiciously, saving of water, electricity and labour cost, improved maintenance of the system and less conflicts around water.

WUAs/TUAs also faced some constraints in management of their associations. Among these constraints, the funds constraints, unavailability of required quantity of water, unavailability of proper maintenance and repairing services and electricity problems are the major ones.

Performance of PINS Programme in Rajasthan

Since the sprinkler system is very useful on sandy topography in Rajasthan, it is very popular in the state. The average area covered by the farmers under sprinkler and drip method of irrigation was 3.63 ha and 0.02 ha respectively per households having access to those systems. The total cost of sprinkler and drip systems was estimated to be Rs 265000 and Rs 60820 per household in the study areas. It was found the average subsidy amount received by the farmers was only 15 per cent on sprinkler and 70 per cent on drip. Jain Irrigation was the main agency in Rajasthan who had supplied MIS to the farmers under various subsidy norms.

The major motivating factor for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation. Other factors like better and stable crop yield and farm income, saving more water and to cover more area under irrigation, facilitating judicious or efficient distribution of water among the water users and avoiding unnecessary conflicts with other farmers were considered as important factor (though not most important factors) by the farmers.

Impacts of Adoption of PINS-MIS on Water Saving, Irrigated Area and Crop Yield and Farmers' Income

Among different benefits accrued by the beneficiary farmers by participating in WUA, the increase in area under irrigation (100%), increase in agricultural income (99.0%), water saving due to judicious use of water (97.5%), getting water in right time (88.0%), timely information on release of water from canal (82.5%), proper distribution of water among farmers (68.0%), getting more information on how to use water judiciously (56.7%) and electricity saving due to use of shared pump sets attached with PINS (58.0%) were the major ones. The extent of water saving, electricity saving, increase in irrigated area and increase in farmers income due to adoption of PINS-MIS was 39.2 per cent, 39.4 per cent, 58.5 per cent and 44.7 per cent, respectively.

About 55.5 per cent farmers complained about not getting sufficient water throughout the year. Inadequate water availability in canal, water theft by other farmers, less rainfall and land located in tail region were found to be some of the major reasons for inadequate water availability. Among water users, about 72.5 per cent were used to pay the operation and maintenance cost of PINS project and water rates regularly, out of which the majority (43.5%) pay these fees annually to the office bearers of WUA.

As far as area and yield impacts are concerned, it was found that the average yields as well as area under majority of crops were higher in case of

beneficiary compared to non-beneficiary households. Overall, 12.3 per cent more area was cultivated by the beneficiary households. Among Rabi crops, the beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers in case of crops like gram, isabgul and cumin. Among summer crops, the beneficiary farmers got better crop yields as compared to non-beneficiary farmers (in case of crops like bajra and fodder crop).

The major problems faced by the farmers were insufficient electricity for operation of PINS (60%), inadequate water availability (37.5%), difficulty in getting subsidy for MIS system (26%) and the problems related to operation and maintenance of the PINS-MIS system. The performance of promoting companies was found to be very poor in terms of supplying good quality components of MIS and timely services. The farmers suggested that the subsidy may be provided to set up solar unit with PINS so that water can be provided to farmers when electricity is not available for irrigation. Farmers also emphasized that they should be given more subsidy on MIS, especially sprinkler systems since they purchase pipe and nozzle from local market with fairly high price. The performance of promoting companies should be monitored with suitable Incentives/disincentives.

As regards performance of WUAs is concerned, all the PINS systems were constructed on minor or sub-minor of Indira Gandhi Canal in Bikaner or Narmada Canal project in Jalore and Barmer. The average area covered under each PINS WUA was 246.8 ha per PINS and the average number of beneficiaries covered was 84. The size of PINS was much larger in Bikaner, followed by Barmer and Jalore. The entire cost on PINS equipments and installations was borne by the state Govt. The beneficiary farmers only had to pay the operation and maintenance cost.

The major component of operation and maintenance cost on PINS was electricity charges and repairing/maintenance of canal PINS, accounting for about 46.24 per cent and 35.8 per cent of total operation and maintenance cost, respectively. The number of members of WUA was 84, out of which 39 members (46%) did not join the WUA. Those who did not join the WUA expressed various reasons for not joining the WUA. About 28.2 per cent of them expressed that they are not able to put pipelines due to not getting loan, since they don't have land. About 33.3 per cent of them expressed that they stay in other chaks and they don't want to cultivate their land due to long distance (average 70-75 km).

Among the major activities of WUA, operation & maintenance of PINS Project, deciding the timing of water release, judicious water distribution, collection of water rates, collection of per capita operation and maintenance cost and dispute settlements were the major activities of WUAs. The main sources of income for these WUAs were annual maintenance fees and annual

electricity fees collected whereas the major heads of expenditures were the expenditure on electricity bill, repairing expenses, salary expenses.

The major benefits provided by the WUAs to its members were arrival of water in time, proper distribution of water among farmers, more information on how to use water judiciously, saving of water, electricity and labour cost, improved maintenance of the system and less conflicts around water. The crop yield has improved significantly during post-WUA situation with about 81 per cent WUAs reporting higher yield compared with pre-WUA situation. The average irrigated area has increased from 36.9 ha per WUA during pre-WUA situation to 228.2 ha during post-WUA situation, by more than 06 times, while the returns from agricultural production has increased by more 04 times during post WUA situation compared with pre-WUA situation.

As far as the sufficiency of irrigation water is concerned, only 23 per cent of WUAs agreed that they are getting sufficient water throughout the year after formation of WUA. Normally they get the canal water for about 5 months during Rabi while, during Kharif, they depend on rainfall. Some of them could be able to provide life saving irrigation during Kharif as well.

Performance of PINS Programmes in Maharashtra

The source of irrigation for all govt PINS was tanks/storages, for cooperative PINS sources were river and storages/tanks and for pvt PINS the sources were well and river in Maharashtra. Since, the govt PINS projects were around 100% funded by the government, there was no cost for the farmers. Regarding the coop PINS farmers, average expenditure was Rs. 47,200 on PINS project, and there was no considerable variation on the expenditure on PINS across the landholding class of farmers. About pvt PINS farmer, the expenditure on PINS project was Rs. 87325 and there was not much variation across the farmers' landholding class. These findings suggest that being a part of cooperative system could save PINS project cost by around 50%.

The reasons to adopt PINS were to get assured water, better yield and increase in area under irrigation. The pvt PINS adopter farmers were interested in personal benefits in comparison with the govt and coop PINS adopter. The main benefits of coop and govt PINS were an increase in area under irrigation by around 60%, farm income and water saving by more than 35%, and 35% saving in electricity.

The majority (80-96%) of the members of the coop PINS WUA were aware about the functioning, while the awareness among the govt PINS was comparatively very poor. All the coop PINS WUA members had paid O&M cost regularly. The important reasons for inadequate supply of water were the

inadequate water availability and poor rainfall, moreover, for govt PINS inefficient functioning of the PINS system was also an additional reason.

The findings suggest that PINS helps to increase the area under cultivation during the summer season or under the perennial crops. It is also reported that the most preferred method of irrigation under PINS was drip irrigation over sprinkler and flood method. For most of the crops the production was reported higher under the PINS farm than for the non PINS farm, this indicates that the PINS improves the productivity of most of the crops. The MIS increased yield for soybean, tur, cotton, groundnut, jowar, onion and sugarcane crops, while yield was decreased for udid, mung and wheat under MIS. For majority of crops the yield under MIS was higher than the flood method, while there was not much difference between sprinkler and drip methods. Regarding the water saving under MIS, in principal there is water saving under MIS than flood. Apart from water saving the major benefits of PINS with MIS were, saving of land by avoiding field channels, reduction in frequency and maintenance cost of irrigation system, weeding cost, water logging and labor cost.

There is a lack of awareness about ISO standards, training and testing facility for PINS and MIS. Therefore, there is a scope for providing these facilities for farmers at the block level. The main problems faced by the farmers were planning and installation of PINS with MIS, delay in receiving subsidy for MIS, power to run PINS and MIS, quality of components and damage of MIS in field from rodents.

Performance of PINS Programmes in Telangana

On an average the area under PINS -MIS was 1.11 hectares per hh. All the 200 sample farmers were having drip system and only five farmers had sprinkler system. On the whole, amount spent on MIS was Rs. 8,443 per hh.

There are three main reasons behind the adoption of PINS (MIS) programme. They are: (i) to get assured amount of water for irrigation; (ii) to get better and stable crop yield and farm income and (iii) to save more water and to cover more area under irrigation. On an average, 40 farmers participated in a TUA. The percentage change in production realised by the beneficiaries over non-beneficiaries ranged from 30 per cent in case of paddy to 100 per cent in case of Redgram. All the crops under drip irrigation have achieved more per hectare production than the yield achieved under the other sources of irrigation.

The output from probit model reveals that among the explanatory variables the marginal effect of operated area is positively associated with increase in agricultural yield, income, water and energy saving but negatively associated with fertilizer and pesticide use. The positive

association implies that due to the marginal effect of operated area, the yield, income, water and energies are saved to a significant level. On the other hand, the negative association signifies that the fertilizers and pesticides are being used more than the required doses.

Majority of the beneficiaries expressed the problem of power supply to MIS and a few farmers reported the problem of operation and maintenance. Majority of the farmers suggested that the MIS subsidy should be extended from 1 hectare limit to 3 hectares limit and reduction in input price also. Almost all farmers suggested the need of regular power supply.

The average life span of PINS was about 7-8 years. On an average, the total annual operation and maintenance cost of PINS per TUA accounts for Rs. 8,000 of which 87.50 per cent towards repairing and maintenance of tube-wells and 12.50 per cent towards electrical charges. The inflow of income is due to collection of annual maintenance fees, while the outflow of income is through expenditure on electricity bill and repairing expenses.

Due to formation of TUAs the farmers could realise three major benefits viz., (i) timely release of water to their fields and Judicious use of water, (ii) improved maintenance of the system and (iii) more information on crops and technologies and thereby improved quality of ground water due to less extraction compared to pre-TUA periods. About 66.67 per cent of TUA members reported to have received sufficient water throughout the year. Nearly 33.33 per cent of water users reported that the PINS system is not functioning properly and also due to improper management of PINS system, they received inadequate water to their farm plots.

Policy Implications: Gujarat

The water resources for irrigating more area have been a challenge for the country. It is desirable to utilize the available water resources more judiciously, so that the 'more crops per drop' slogan of the Govt can be realized and farmers income can be doubled within the stipulated time period. Thus, PINS infrastructure with MIS is inevitable for the farmers since it saves the water and the collected water can be used for further increase in area under irrigation. The present study has examined some aspects of working of PINS at different levels. During the survey, the sample farmers have also given some useful feedbacks which have been discussed earlier. Besides, some additional suggestions on different types of PINS those are drawn from the study are presented below.

Suggestions on Canal PINS

- *Though the State Government has followed an innovative approach by developing and implementing the concept of PINS, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to some specific reasons. The farmers did not want to change the cropping pattern which was highly water intensive. Thus, it is necessary to discourage more water consuming cropping pattern, by encouraging suitable cropping pattern through some incentive structure.*
- *It was found that the farmers did not want to spend any amount on MIS since canal water was available to them almost free of cost. Thus, it is suggested to revise the water rates which are very less and strict rules and regulations should be enforced to check the illegal use of canal water and water theft.*
- *Farmers having land at favourable locations (canal vicinity) do not find it to be a lucrative proposition. One of the major factors that contributed to less adoption of canal PINS in the state was that, PINS Projects were located very close to minors or sub minors, from where farmers are able to get water in alternative ways. Thus, it is suggested to re-lunch this canal PINS programme with required amendments by locating these projects at far off places where farmers are struggling to get irrigation water. Though it involves little more investments in term of infrastructure expenditure, the adaptation and long-term sustainability would be surely achieved just like the success of PINS projects in Sanchore region in Rajasthan.*
- *The areas where PINS+MIS is techno-economically not feasible, normal/conventional flow irrigation as per present SSNNL policy may be allowed to continue.*
- *Majority of sample farmers were marginal with small land holdings who faced difficulties in getting bank loans due to incomplete land documents and other outstanding debts. The measures may be taken to provide affordable credit facilities to small and marginal farmers.*

Suggestions on Tube well PINS:

- *The study finds that maintenance and electricity cost for beneficiaries of tube well PINS is a major part of their expenses which is reasonably high, thus the subsidy may be given on electricity provided to farm plots.*
- *Drip system is damaged at some cases due to animal attack (pig, rat, squirrel, rabbit, blue bulls) and sometimes due to poor awareness of agricultural workers. Thus better quality systems should be provided. The fencing subsidy may be provided to encourage fencing by farmers.*

- *The quality of MIS components and services provided by some promoting companies were unsatisfactory; frequency of their visits was insufficient. Thus there is a need to take measures to regulate these promoting agencies supplying MIS to the farmers and check their adherence of standard norms on maintaining quality and providing proper and regular services for the repairing of the PINS-MIS within reasonable time limits. There is also a need to have more testing facilities for quality checking of equipments.*
- *Farmers are unaware, uneducated about use of PINS and MIS. So the required extension advisory services should be provided to the farmers, especially on maintenance and applicability of PINS-MIS for different crops. The training and awareness programmes should be regularly conducted to impart training to farmers on need, importance and use of MIS with PINS and also to promote fertigation and chemigation.*

Suggestions on UGPL with PINS:

- *Since underground pipeline system (UGPL) is used as PINS as well as for conventional irrigation, the new scheme has been well adopted by some farmers in Gujarat. However, there are some issues in implementation of UGPL in Sub-Minors. Farmers were not willing to pay 10 per cent, their contribution, which was later on reduced to 2.5 per cent. Farmers are continuously growing some crops and hence not willing to allow laying of UGPL. There is a need of strict adherence of Government guidelines so as to complete the implementation work in a time bound manner. Provisions should be made to pay required compensation for crop loss for laying of UGPL.*
- *Due to poor maintenance of field channels, the nearby lands are affected by water logging. Thus, it is suggested to arrange regular repairing and maintenance of minors and field channels, which are used by UGPL.*
- *Due to poor management culture in WUAs, the maintenance and distribution of water was badly affected in some cases. In so many cases, WUAs were not formed that affected to regulate the proper supply of water among water users. Thus, there is need to strengthen existing WUAs and to form WUAs in a time bound manner, where they are not available.*
- *The combination of UGPLs and PINS replacing Minors, Sub-Minors and FCs need to be systematically promoted to help saving land as well as water. The UGPL system with PINS should gradually focus on more adoption of MIS with appropriate financial incentives for effective management of irrigation water while taking care of farmers' preferences for different cropping pattern. The services of NGOs and*

model WUAs may be taken as motivators for more adoption of water saving technologies under UGPL with PINS.

Policy Implications: Rajasthan

The ever-increasing difference between water availability and consumption is causing severe shortage of water in many fields. This is a growing concern all over the world but India is most vulnerable because of the growing demand and in-disciplined lifestyle. The water resources for irrigating more area have been a challenge for the country. It is desirable to utilize the available water resources more judiciously, so that the 'more crops per drop' slogan of the Govt can be realized and farmers' income can be doubled within the stipulated time period. Thus, PINS infrastructure with MIS is inevitable for the farmers since it saves the water and the collected water can be utilised for further increase in irrigation and farmers' income.

The study finds that PINS with MIS has been highly successful in Narmada Project in Sanchore and Indira Gandhi Nahar Project (IGNP) in Bikaner district. The impact of these PINS projects on water saving, irrigated area expansion, crop yield and farmers' income has been praiseworthy. On the same time, it is necessary to strengthen these projects further by considering the inputs provided by the different stakeholders so as to enhance the irrigation benefits. Some of the observations were made during the study which are summarised below.

- *The average size of WUA in Rajasthan is usually high, sometimes covered about 900 ha under one PINS project with more than 200 beneficiary farmers. Very large size of WUA becomes very difficult to manage. Among these large number of water users, the equitable distribution of water also becomes very difficult. As a result, the tail end beneficiaries turned out to be non-beneficiaries in real sense, since they don't get irrigation water. Thus, it is suggested to install more number of PINS and reduce the number of farmers per PINS-WUA, which would help in proper distribution of water among the farmers irrespective of location of plots in the command area of PINS.*
- *It was recommended to provide 15 sprinkler points to each outlet provided at farmer's field. However, due to larger size of PINS command area and large number of beneficiaries, the number of outlets has not been provided in proportion to size of plots. A large size of plot with less number of outlets fails to discharge required amount of water to the crops in the entire plot. Moreover, sometimes, more number of sprinkler points were found in a smaller plot, while less number of sprinkler points in large plot size affected the irrigation*

provision. Thus, it is suggested to provide more outlet points in larger size plots, so that required number of sprinklers can be used.

- *Moreover, same time is allotted to all plots irrespective of their location. However, due to lower pressure at tail end region, the tail end farmers did not get enough water compared to head region farmers.*
- *Due to scarcity of irrigation water, some of the non-beneficiary farmers depend only on rain water. Thus they demand to expand the coverage of PINS to their area. Thus, it is necessary to expand PINS coverage so as to ensure proper water distribution among the farmers.*
- *In some cases, due to close vicinity to canal, some farmers didn't install MIS in their farm plot, and they used to irrigate by flood method. Thus, the measures need to be taken to check water theft. More stringent policy should be implemented to check the same.*
- *In case of IGNP, it was observed that, on side of canal, PINS systems have been promoted, while on the other side, farmers are irrigating using flow method. It is necessary to discourage the flow irrigation and encourage the MIS with suitable incentives, so that more water scarce areas can be irrigated in Rajasthan.*
- *In some cases, the condition of minor canal was not in proper state. It is suggested to cement/renovate the minors/sub-minors regularly for supplying water to PINS in better way which would expand their irrigation efficiency.*
- *It was observed that some promoting companies supplying the irrigation infrastructures and servicing are not functioning genuinely. As a result, the farmers are facing repeated troubles. Due to low quality of materials, frequent repair happens to be inevitable. On the other hand, much more time is being consumed for repairing and high charge is being imposed since the technician covers a long distance to reach the farmer's village.*
- *There is urgent need to provide more number of servicing centres, at least one at taluka level. On the other hand, local people should be trained to cater the need of the farmers.*
- *Some instances were found, where there were a large number of incomplete diggies (mainly in Gudha malani, Barmer district) since the promoting agency left the scene in between without completing the work. Thus, it is suggested to examine the performance of these promoting companies and treat them with appropriate incentives/ disincentives.*
- *The farmers have expressed concern over less subsidy on sprinkler as it is evident that only about 15 per cent subsidy has been realised by the*

farmers. It is suggested to relook at the subsidy policy of the government on MIS, particularly on sprinklers.

- *As suggested by some promoting companies, submersible pump sets should be promoted, which can reduce the requirement of separate pump house, reduce the maintenance requirement and are convenient to use.*
- *PINS programme in the command area of IGNP was started on pilot basis in Bikaner district since 2012-13. This project area was not covered fully in many areas due to some reasons, may be, the financial constraints. As a result, some diggies could not be made functional properly. Moreover, IGNP system is operating since last 20 years and farmers were habituated and benefited through flood irrigation till then. With the changed situation, farmers were worried about the technical problems related to PINS. Thus it is necessary to provide training and counselling to the needy farmers.*
- *During first two years of installation of PINS and formation WUA, the WUA members and implementing agency/promoting companies work together. During this period, all maintenance cost are borne by the implementing agency/promoting companies. There is provision to provide proper training to WUAs to manage the PINS system. However, the quality of such training programme needs improvement. The promoting companies that work closely with the PINS system and the water users should be allowed to take part in training provided to the farmers.*
- *The cost of electricity has been a major share of total cost of crop cultivation. Farmers often requested to provide more subsidy on electricity or to provide solar pump sets to lift the water. At some places, electricity infrastructures have been damaged since a long time, for which more than 500 hectares of land failed to be irrigated. In spite of repeated requests of the farmers, the electricity facilities could not be restored. Thus, it is suggested to take up the farmers' concern in a time bound manner. On the other hand, fully automated solar systems need to be promoted in order to meet the farmers need. At some places, the outlets were kept open, when not in use. This resulted in choking of outlet pipes during regular storms/ sand dunes in the state. Thus, it is suggested to provide outlet covers to keep it closed while not in use.*

Policy Implications: Maharashtra

- *It is realised that, if the financial assistance is made available to the lifts Schemes, they would get converted from PINS + Flow into*

PINS+MIS rapidly, as the trend is already set by 15 schemes in the state.

- *The distribution systems of lift projects will also be converted into PINS+MIS, though not envisaged at the conceptual stages. There is an advantage for lifts, that on the way from pumps to the delivery point, there can be sufficient head available to use MIS by directly hooking up to the rising/pumping main.*
- *There is a large scope for PINS+MINS for (i)Co-operative lifts, (ii)lifts on Other Govt Projects with lift as distribution System, (iii)Govt. Lift irrigation projects themselves, (iv)individual lifts including lifts on Minor Irrigation Schemes, and in the long run of pipe distribution systems in place of flow irrigations.*
- *The costs of the drip systems were higher under coop and pvt PINS than the govt norms. Therefore it is suggested that the cost norms for drip irrigation system may be revised so that the farmers can afford the drip irrigation system.*
- *Extension activities for increasing the awareness about efficient use of water under the MIS, water requirement of the crops as per the crops critical growth stages and season wise are recommended.*
- *There is a lack of awareness about ISO standards, training and testing facility for PINS and MIS. Therefore, there is a scope for providing these facilities for farmers at the block level.*
- *We observe that some sort of refreshers training etc. need to be arranged at different levels for WUA office-bearers, member farmers etc. Such training should been co-operative, new technologies in irrigation and agriculture-cultivation, processing, post harvesting issues. There is also a need of a body such as federation, which can put forth the issues faced by these WUAs.*
- *We feel that for Maharashtra, being a leading state in MIS, comprehensive testing facilities for MIS components need to be developed in the state Agricultural Universities.*

Policy Implications: Telangana

- *Though the PINS-MIS scheme is being implemented by private agencies, the subsidy is being provided by Telangana State Micro-Irrigation Project (TSMIP). Due to delay in release of funds from Central Government the release of subsidy to farmers is accordingly delayed. As a result the farmer could not receive the benefit in time and could not proceed further. Thus, it is requested to release the funds by Central Government in time.*

- *In recent years, the tanks in Telangana are being renovated through the programme of Mission Kakatiya. This renovation should be extended to all other tanks which in turn will be useful to irrigate more land in various parts of Telangana. Thus, the PINS-MIS programme be initiated through tank irrigation also.*
- *The amount of subsidy for all inputs and also to the machinery should be enhanced as the input prices has increase many fold.*
- *Awareness generation programme on PINS-MIS should be carried out more frequently with larger scale and such programmes being carried out by NGOs should be encouraged through incentives. More training programmes should be conducted and more frequently such training programmes (i.e., once in a month in every mandal head-quarters) should be carried out.*
- *Training programmes to farmers to create awareness about fertigation and chemigation must be conducted.*
- *The implementing agencies and department officials (TS-MIP) should ensure thorough checking of MIS systems before installations and should provide timey services for any maintenance related problems.*

Chapter I

Introduction

1.1 Background:

India is an agriculture economy where land and water are two key natural resources upon which farmers depend for their livelihoods and development. Farmers' development depends upon interactions of these and other resources, institutions, actions and policies and their ultimate outcomes. It would be naive to perceive that all rural poverty problems could be solved through improving the poor's access to water alone through development of irrigated area in rainfed conditions. However, though water is only a single element in the poverty equation, it plays a disproportionately powerful role through its wider impacts on such factors as food and other essential agricultural production. Though water is one of the most critical inputs for agriculture and availability of adequate water for irrigation is a key factor in achieving higher productivity, the poor efficiency of conventional irrigation systems has not only reduced the anticipated outcome of investments towards water resource development, but has also resulted in environmental problems like water logging and soil salinity, thereby adversely affecting crop yields.

Irrigation has been a high priority area in economic development of India with more than 50 per cent of all public expenditure on agriculture having been spent on irrigation alone. The land area under irrigation has expanded from 22.6 million hectares in 1950 to about 89.4 million hectares in 2010-11, with 52 per cent area being irrigated by surface water through canal network. Unfortunately, the overall efficiency of canal irrigation system worldwide is very low which leads to poor utilization of irrigation potential, created at huge cost. Recognizing the fast decline of irrigation water potential and increasing demand for water from different sectors, a number of demand management strategies and programmes have been introduced to save water and increase the existing water use efficiency in Indian agriculture.

Adoption of new irrigation scheduling practices is a dynamic process that is potentially determined by various factors, including farmers' perceptions of the relative advantage and disadvantage of new technology vis-a-vis that of existing technologies and the efforts made by extension and changed agents to disseminate these technologies. Other factors, which influence in respect of new irrigation practices, are resource endowments, socio economic status, nature of crop production and from their profitability etc. Due to scarcity of irrigation water and improved agronomical practices recommended for scheduling irrigation for commercial crops, farmers showed reasonable attraction and awareness of irrigation technologies that could help them irrigate crop more accurately with water saving technique.

The water use efficiency under conventional flood method of irrigation, which is predominantly practised in Indian agriculture, is very low due to substantial conveyance and distribution losses. In India, most of the irrigation networks are unlined and huge amount of the irrigation water is lost in main canal, distributaries, minors and field channels. Navalawala (1991) found that about 71 per cent of the irrigation water is lost in the whole process of its conveyance from head works and application in the field. The breakup of the losses is as main and branch canal (15%), distributaries (7%), water courses (22%) and field losses of 27 per cent. The situation is particularly bad in minor irrigation systems of plateau areas of eastern India, where the overall irrigation efficiency varies between 20 per cent and 35 per cent. These systems are located in coarse soil area and have rolling topography. Due to this, the conveyance losses are high and the system suffers from inadequate supply and poor water availability especially during lean season. Therefore, the need of the hour is to increase irrigation efficiency of existing projects and use saved water for irrigating new areas or reducing the gap between potential and actual irrigated areas. Shifting to pressurized irrigation can be an option for increasing this irrigation coverage and efficiency.

Much of the water scarcity in India is due to spatial variation in demand and supply of water and inefficient use of water. Irrigation is the largest water consuming sector, accounting for more than 80 per cent of the total withdrawals. Yet, irrigation so far has covered only about 40 per cent of

the gross cropped area, even though India has the largest irrigated area in the world. Given the increasing scarcity and also non-agricultural water demand, demand management is receiving special attention. In India, although a number of demand management strategies in the irrigation sector have been introduced with a view to increasing the water use efficiency (Vaidyanathan 1998; Dhawan 2002), the net impact of these strategies in increasing the water use efficiency so far has not been very impressive. One of the demand management strategies introduced relatively recently to manage water consumption in Indian agriculture is micro-irrigation systems (MIS). Unlike flood method of irrigation (FMI), micro-irrigation supplies water at the required interval and in desired quantity at the location where water is demanded using a pipe network, emitters and nozzles. Therefore, MI in principle results in low conveyance and distribution losses and leads to higher water use efficiency.

1.2 Importance and Concept of Pressurized Irrigation Network Systems:

A Pressurized Irrigation System is a network installation consisting of pipes, fittings and other devices properly designed and installed to supply water under pressure from the source of the water to the irrigable area (FAO, 2000). In this system of irrigation, water is pressurized, supplied to farm plots that uses MIS such as drip and sprinkler and thus precisely applied to the plants under pressure through a system of pipes. Pressurized irrigation systems, as opposed to the surface irrigation systems, are more effective in water saving and in increasing area under irrigation. They provide improved farm distribution, improved control over timing, reduced wastage of land in laying field distribution network, reduced demand for labour and better use of limited water resources.

The Pressurized Irrigation Network System (PINS) is an innovative concept which facilitates all the basic requirements of MIS viz. (a) Daily application of water and (b) Pressurized flow using Surface water resource (Canals) and acts as an interface between Canal waters and MIS. It comprises of pipe network with controls, pumping installations, power supply, filtration, intake well/diggy (Figures 1.1 and 1.2). It is a common and shared

infrastructure (by Group of farmers) facilitating individual beneficiary for installing and operating MIS.

As per the requirement, the pressure is given at different levels depending on the size of PINS. As stated in Table 1.1, the pressure can be exerted at village service area (VSA) level (300 to 500 ha), Chak level (40 to 60 ha) and Sub- Chak level (5 to 8 ha). Obviously pressurization at terminal point i.e. Sub-Chak level would be the most economical option but would also require more number of power connections. Evidently to take the advantage of Cost and feasibility aspects of power connections Sub-Chaks are re-oriented radially from the centre of a Chak and pressurized flow is resorted to only at the head of sub-Chaks.

Figure1.1: Concept of PINS- Network Bridge between Canal and MIS in the Field

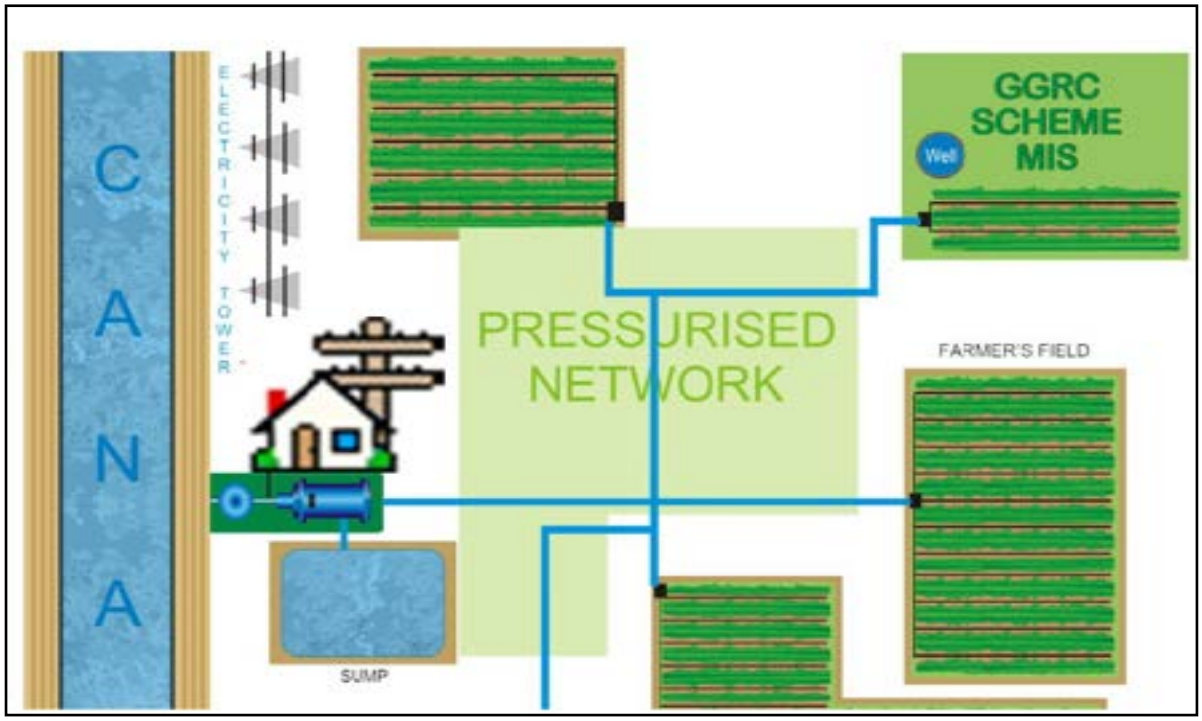


Figure 1.2: Components of PINS in Gujarat

Table 1.1: Levels of Pressurization (canal command)

Sr. No	Level of Pressurization (Command Block)	Capital & Operational Cost	Power connections Per VSA
1	VSA (300 to 500 Ha)	Very High	1 connection
2	Chak (40 to 60 Ha)	High	5-6 connections
3	Sub- Chak (5 to 8 Ha)	Low	About 50 connections

Source: Ganpatye (2011).

The PINS-MIS enjoys many advantages over conventional flow irrigation as presented in Table 1.2. The PINS-MIS helps in ensuring more crops per drop of water by enhancing water use efficiency and covering more area under irrigation with saved water from switching over from flow irrigation.

Table 1.2: Advantages of PINS-MIS over Conventional Flow Irrigation

Sl	Particulars	Flow	PINS+MIS
1	Distribution	Gravity	Pressure
2	Water losses a. Conveyance losses b. Application losses	 7 to 9 % 25%	Nil Drip- 2- 3%; Sprinkler -10 -15%
3	Water availability	Not enough for optimum irrigation and yield	Availability can be increased
4	Water productivity	Low	High
5	Conjunctive use necessity	More	Less
6	Poor quality of water	Use will deteriorate soil and crop productivities	Reasonably poor quality of water can be used without affecting soil productivity
7	Land requirement/Ha	170 m2 required for sub minor and FC	24 m2 required for storage (8 hrs supply)
8	Land topography restriction	Restriction	No restriction
9	Maintenance of water courses	Recurring maintenance expenditure	No maintenance problems
10	Drainage	Is a must. In long run problems may arise	Drainage related problems minimal
11	Soil health	Prone to deteriorate	Health maintained.
12	Poor irrigable soils	Cannot be irrigated	Can be irrigated
13	Other than command areas	Cannot be irrigated	Can be brought under irrigation
14	Incidences of pests, Diseases, weeds	More	less
15	Cost of cultivation	More	About 20 % lesser than flow
16	Watch and Ward	More	less
17	Ground Water pollution	Highly prone	Nil
18	Double cropping	Not possible	Enough scope
19	Crop Quality	Normal	Improved
20	Employment generation	Labour/unskilled	Skilled manpower
21	Energy requirement	No	Yes

Source: Ganpatye (2011).

1.3 Review of Literature:

Rich level of scholarly work is available at global as well as national level on the issues related to the irrigation water management and specifically on the drip irrigation, sprinkler irrigation and participatory irrigation management. The study under investigation is on PINS concept, which was developed not more than ten years ago in the Gujarat state of India. Since the PINS concept is new, few studies are available on this issue (Uphoff, 1986; Gandhi, and Namboodiri, 2011: 2002: Singh, 1991; Chavan, 2016; Viswanathan and Bahinipati, 2015).

A large number of studies have been undertaken that have established that benefits of micro irrigation in terms of water saving and productivity gains are substantial in comparison to the same crops cultivated under flood method of irrigation (Narayanamoorty, 1997, 2003; Raju, 2010; Palanisami et al 2011). Micro irrigation technologies such as drip and sprinkler are proved to be efficient method in saving water and increasing water use efficiency as compared to the conventional surface method of irrigation, where water use efficiency is only about 35-40 per cent (Narayanamoorthy, 1997). The benefits of micro irrigation in terms of water saving and productivity gains are substantial in comparison to the same crops cultivated under flood method of irrigation. Micro-irrigation is also found to be reducing energy (electricity) requirement, weed problems, soil erosion and cost of cultivation. Investment in micro irrigation also appears to be economically viable, even without availing State subsidy. Despite this, the total potential of micro irrigation in India is estimated at around 69 Mha. However, currently the coverage of micro irrigation is only 7.7 Mha (2015). With the current target of achieving 0.5 mn hectare/ annum coverage, it would take a very long time to realise the potential estimates of micro irrigation in India.

Micro irrigation has seen a steady growth over the years. Since 2005, area covered under micro irrigation systems has grown at a CAGR of 9.6 percent. Geographically, states with the largest area under micro-irrigation include: Rajasthan (1.68 mh), Maharashtra (1.27 mh), Andhra Pradesh (1.16 mh), Karnataka (0.85 mh), Gujarat (0.83 mh) and Haryana (0.57 mh). Majority of the area covered under micro irrigation systems comes under

sprinkler irrigation with 56.4 percent, while 43.6 percent comes under drip irrigation. Area under drip irrigation has shown stronger growth in recent years, growing at a CAGR of 9.85 percent in the 2012-2015 periods while sprinkler irrigation has grown at a pace of 6.60 percent in the same time period. Overall, the area under micro-irrigation has grown at a CAGR of 7.97 percent in this time frame. A centrally sponsored scheme on Micro irrigation was launched in Jan 2006 to increase the area under improved methods of irrigation for better water use efficiency to provide stimulus agricultural growth. The term micro irrigation describes a family of irrigation systems that deliver water through small devices on the soil surface very near the plant or below the soil surface directly into the plant root zone. Micro-irrigation technologies commonly use of water in scarce areas, constitute one such intervention with the ability to use water more efficiently in irrigated agriculture. These technologies can improve productivity; raise incomes through crop yields and outputs; and enhance food security of households. Though India has the largest irrigated area in the World, the coverage of irrigation is only about 40 percent of the gross cropped area. One of the main reasons for the low coverage of irrigation is the predominant use of flood (conventional) method of irrigation, where water use efficiency is very low due to various reasons. Available estimates indicate that water use efficiency under flood method of irrigation is only about 35 to 40 percent because of huge conveyance and distribution losses Rosegrant (1997).

Dhawan and Datta (1992) reported that irrigation enables the poor and smallholders to achieve higher yields. The productivity of crops grown under irrigated conditions is often substantially higher than that of the same crops under unirrigated/rainfed conditions. Higher productivity helps to increase returns to farmers' endowments of land and labour resources. Apart from yield improvements, higher productivity partly stems from higher land use intensity and cropping intensity. Irrigation affects cropping intensity positively. Sivanappan (1994) reported that micro-irrigation can also be adopted in all kind of lands, which is not generally possible through flood irrigation method. Research suggests that Drip Irrigation Management (DIM) is not only suitable for those areas that are presently under cultivation, but it

can also be operated efficiently in undulating terrain, rolling topography, hilly areas, barren land and areas which have shallow soils.

Narayanamoorthy (1997) reported that micro-irrigation is introduced primarily to save water and increase the water use efficiency in agriculture. However, it also delivers many other economic and social benefits to the society. Reduction in water consumption due to drip method of irrigation over the surface method of irrigation varies from 30 to 70 per cent for different crops. Shah et al (2000) reported that the distribution of irrigation benefits tends to be more or less equal in every size of land holding. Study showed that micro-irrigation technologies such as sprinkler, drip irrigation and trickle irrigation, self-target the poor, and empower them by enabling them to raise their incomes permanently. A study by Jiterwal (2008) evaluated the adoption rate of drip irrigation system and found that 48.33 per cent of the respondents were found to be medium adopters. While, 26.66 per cent and 25.00 per cent of them were low and high adopters of drip irrigation technology, respectively in Rajasthan state. Devasirvatham (2009) has discussed the advantages of sub-surface drip irrigation (SDI) over surface drip. The study concludes that SDI improves the water use efficiency, and reduces environmental impact more than surface drip. It may also overcome two important demerits of drip irrigation, i.e., high ongoing cost and disruption to normal cultivation practices.

Postal (2001) found that water saving due to adoption of drip over the surface method varied from 30 to 70 percent for different crops. Siag et. al (2009) also finds that the average increase in yield in drip irrigated plot was 21% with a maximum yield of 2812 as compared to 2036 kg/ha under flooding and the water savings under drip was by 30%. Their economic analysis showed that using drip irrigation in cotton resulted a benefit cost ratio of 2.03:1, as compared to that of 1.88:1 in case of flooding. Sahu and Rao (2005) conducted a study of the Micro Drip irrigation System (MDIS) is now being identified as an additional income generating technology while looking at the evolution of the market driven approach to reach small farmers. The hydraulic performance of the system was evaluated by measuring discharge variation among the different emitters, estimating friction head losses in different components. The correlation was developed

between average discharge of emitters and pressure head. The Coefficient of Uniformity (CU) and Emission Uniformity coefficient (EU) were also estimated. The CU was found to be excellent (>95%) and EU was also found to be reasonably good (>90%). The economics of MDIS was worked out. The system cost was Rs.78000 per ha. On an average the use of low cost MDIS produce 25-35% higher cop yield and saved 45-48% water, 45% of labour cost and 50% of fertilizer cost. The Benefit-Cost ratio was higher in case of MDIS (5.34) as compared to basin irrigation (4.14). Thus in one season (1/3rd year) additional cost of MDIS can easily be recovered.

Srivastava et al. (2010) evaluated feasibility of pressurized irrigation system on one outlet of a minor irrigation command at Water Technology Centre for Eastern Region, Bhubaneswar. They reported that the system can be used with the canal irrigation system because it reduced the turbidity of the water and provided continuous supply of water. The system is also capable of providing irrigation through drip to part of a command during summer, by using water stored in service reservoir after the canal is closed in first week of April. To take care of sediment in the canal water, there are three stages of filtration: first by hydro cyclone filter which filters heavy suspended materials viz. sand, silt, etc., then by the sand filter and finally by the screen filter. The filtration at three stages reduces the turbidity to the desired level. The benefit-cost ratio of the system was found to be 1.126.

Narayanamoorthy (2010) reported that the benefits of micro-irrigation in terms of water saving and productivity gains are substantial in comparison to the same crops cultivated under flood method of irrigation. Micro-irrigation is also found to be reducing energy (electricity) requirement, weed problems, soil erosion and cost of cultivation. Investment in micro irrigation also appears to be economically viable, even without availing State subsidy. Despite this, as of today, the coverage of drip (2.13%) and sprinkler (3.30%) method of irrigation is very meager to its total potential, which is estimated to be 21.01 million hectares for drip and 50.22 million hectares of sprinkler irrigation method. It is identified that slow spread of MI is not mainly due to economic reasons, but due to less awareness among the farmers about the real economic and revenue-related benefits of it. Therefore, apart from

promotional schemes, study suggests various technical and policy interventions for increasing the adoption of two water saving technologies.

Performance of the WUAs was carried out for three states in Gujarat, Maharashtra and Andhra Pradesh. The study reports that there is considerable progress in farmers' participation and decentralization of power for irrigation management, which helped to increase the performance related to water resource management. The study also focuses on (i)the issues which need to be addressed; (ii)inputs in institutional design, institution building, trainings, (iii)greater accountability through proper audit, performance evaluation, social audit, financial viability and sustainability of WUAs (Gandhi and Namboodiri, 2011). Despite the considerable success of the PIM in the country, the ministry of water resources status report on PIM reports that there are few constrains in adoption of the PIM. The issues pointed out in the report are such as (a)lack of legal back up and policy changes in many states, (b)system deficiency in older projects, (c)uncertainty of water availability, (d)fear of financial viability, (e)lack of technical knowledge, (f)lack of leadership, (g)lack of publicity and training, (h)demographic diversity, (i)complexity of mega irrigation projects, (j) WUAs v/s Panchayats & PIM in efficient systems (MWR, 2014). It is clear from the experience of PIM in India that it has helped the nation to improve irrigation management at certain level but still there is wider scope.

It is worth-mentioning that promoting water saving technologies requires supplying water at required pressure. Supplying water from canal to farmers' field with the required pressure is an essential feature of PINS system. Converting the area under flood method in the canal command to that under micro irrigation technologies and increasing area under irrigation with the saved water is the main objective of promoting PINS.

Since the concept of PINS is very new one, there is dearth in research in this field. It is pertinent to examine how the PINS systems are performing and what are the major constraints and prospects of their future growth in various parts of the country. Thus, the present study attempts to examine various aspects of PINS performance in some selected states of India.

1.4 Need and Scope of the Study:

Performance evaluation of irrigation has been an important area of research for better management of water resources. Pressurized Irrigation Network Systems (PINS) with MIS have the potential to avoid the water loss compared to surface irrigation, increasing the irrigation efficiency from 45 - 60 per cent in open canal to the range of 75- 95 per cent with pressurized irrigation (Narayanamoorthy, 2010). While open canals systems have high labour requirement for maintenance, the pressurised systems require skilled labour. The benefits of micro-irrigation in terms of water saving and productivity gains are substantial in comparison to the same crops cultivated under flood method of irrigation. Micro-irrigation system (MIS) is also found to be reducing energy (electricity) requirement, weed problems, fertiliser and pesticides requirement and cost of cultivation (Viswanathan and Bahinipati, 2015).

Given the high capital investment requirement in PINS, the present study has evaluated the functioning, economic benefits and costs of PINS. For PINS established on canal systems and on community tube wells, there is need for effective institutional arrangement for orderly Management, Operation and Maintenance (MOM) of water releases and distribution. In the present study, we have defined PINS as "a common and shared infrastructure (micro water resource (such as farm pond/diggy/tube well), pump sets, filtration unit and pipelines upto farmers field facilitating individual beneficiary for installing and operating MIS". The source of water could be canal, tube well or tanks.

The present study intended to assess functioning of WUAs in PINS command area, the experiences of beneficiary farmers in the command area using MIS in their lands and non-beneficiary farmers around the PINS command area. It sought to assess the effectiveness of institutional arrangements for management of PINS projects and the bottlenecks for their smooth functioning. Accordingly, different kinds of irrigation commands such as canals and public tube wells were covered under the study to capture the dynamics of community based irrigation management. Under different command areas, the study analysed system performance of PINS

Project with MIS such as sprinklers and drip in terms of their functioning, costs and benefits, adoptability for different soils and field crops.

1.5 Objectives of the study:

The major objectives of the study are:

a) To undertake a broad situation analysis of various PINS programs implemented in select states of India;
b) To assess the extent of adoption and performance of PINS in different scenarios in the country;
c) To analyse the institutional arrangements for management, operation and maintenance of PINS in the country;
d) To identify the major constraints in adoption, management, operation and maintenance of PINS in the country;
e) To recommend suitable policy measures to enhance the effectiveness and techno-economic performance of PINS in the country.

1.6 Coverage, Data and Methodology:

The study covers four major states (Rajasthan, Gujarat, Maharashtra and Telengana) of the country promoting PINS with MIS in their states.

Sample Selection

The data were collected from selected states from sample households and PINS-WUAs as per the distribution stated in Tables 1.3. The state-wise distribution of sample households and PINS-WUAs has been stated in Tables 1.4 to 1.9. The PINS were selected from both surface irrigation command areas (mainly canal) and groundwater irrigation command areas (mainly tube well), depending on availability in various states. The beneficiary households (households having access to irrigation water in PINS command area were selected. To facilitate comparison, non-beneficiary households in adjacent areas of PINS Projects and households having installed PINS with some private contribution were covered as per the stated distribution. Data were collected from (i) PINS Project operators and the associated Water User Association (WUAs), (ii) beneficiary farmers/water users with PINS-MIS or PINS with flood irrigation, (iii) non-beneficiary households having no access

to PINS-MIS but having the access to surface/flood irrigation around the PINS project area, (iv) implementing agencies/promoting companies and (v) concerned government departments.

It may be seen from Table 1.3 that the total number of sample beneficiary households in four states taken together was 850 and the total number of non-beneficiary households was 405. About 160 PINS-WUAs were covered the survey.

Table 1.3: PINS Sample Size Distribution for India (Beneficiary and Non-beneficiary Farmers)

States	No. of Beneficiary Households	No. of Non-Beneficiary Households	No. of PINS-WUAs
Gujarat	200	100	27
Rajasthan	200	100	26
Maharashtra	250	105	75
Telengana	200	100	32
Grand Total	850	405	160

Table 1.4: PINS Sample Size Distribution for Gujarat
(Beneficiary and Non-beneficiary Farmers)

Districts	Govt-PINS with MIS		Underground Pipeline (UGPL)		Pvt. PINS with MIS*(BH)	Govt-PINS without any irrigation (defunct/not used)*(NBH)	Total No. of Households	
	BH	NBH	BH	NBH			BH	NBH
Mehesana	57	15	14	04	09	-	80	19
Patan	76	50	-	-	05	10	81	60
Gandhinagar	17	10	-	-	06	-	23	10
Ahmedabad	-	-	16	11	-	-	16	11
State total	150	75	30	15	20	10	200	100

Notes: BH: Beneficiary households, NBH: Non-beneficiary households.

Table 1.5: Distribution of Sample PINS Projects across study districts in Gujarat

Districts	Govt-PINS With MIS	Underground Pipeline (UGPL)	Pvt. PINS With MIS	Govt-PINS without any irrigation (without WUA)	Total No. of PINS Projects
Mehesana	06	01	01	-	08
Patan	12	-	01	02	15
Gandhinagar	02	-	01	-	03
Ahmedabad	-	01		-	01
State Total	20	02	03	02	27

Source: Field survey.

Table 1.6: Distribution of PINS Projects and the Sample Size in Rajasthan (Beneficiary, Non-beneficiary Farmers and WUAs)

Districts	Canal-PINS with MIS			Total No. of PINS-WUAs
	BH	NBH	Total	
Bikaner	40	15	56	5
Jalore	112	36	148	17
Barmer	48	49	96	4
State total	200	100	300	26

Notes: (1) BH: Beneficiary households, NBH: Non-beneficiary households.
(2). No other kinds of PINS with WUA such as Tubewell PINS, Pvt PINS etc. were found in Rajasthan
Source: Field survey

Table 1.7: PINS Sample Size Distribution in Maharashtra

Sr. No	Districts	Govt PINS With MIS		Coop PINS with MIS		Coop PINS with Flood Irrigation		Pvt PINS With MIS		Govt PINS without any irrigation (defunct)	Total[1]	
		BH	NBH	BH	NBH	BH	NBH	BH	NBH	NBH	BH	NBH
1	Buldhana	-	-	31	6	35	15	-	-	-	66	21
2	Kolhapur	-	-	17	6	-	-	-	-	-	17	6
3	Pune	-	-	-	-	-	-	3	-	9	3	9
4	Sangli	-	-	70	17	2	-	-	-	-	72	17
5	Yavatmal	39	43	-	-	-	-	-	-	-	39	43
6	Nasik	-	-	-	-	-	-	26	4	-	26	4
7	Ahmednagar	-	-	-	-	-	-	27	5	-	27	5
	State Total	39	43	118	29	37	15	56	9	9	250	105

Notes: BH: Beneficiary households; BF:Beneficiary farmers (BH and BF are synonyms) NBH: Non-beneficiary households; NBF: Non-beneficiary farmers (NBH and NBF aresynonyms)

[1]For possible non-availability of particular type of PIN+MIS scheme in a state, a freedom was given to adjust/make up the short-fall of sample in similar other category/ies. The actual sample size covered under the survey is given in Table 1.2 below. From the same, it can be noted that we have covered more sample size than that works out.

Table 1.8: Distribution of Sample PINS Projects in study districts in Maharashtra

Sr. No.	Districts	Govt-PINS With MIS*	Coop - PINS With MIS	Coop -PINS with Flood Irrigation	Pvt. PINS With MIS	Govt-PINS without any irrigation	Overall
1	Buldhana		2	2			4
2	Kolhapur		3				3
3	Pune				3	1	4
4	Sangli		9	1			10
5	Yavtmal	1					1
6	Nasik				26		26
7	Ahmednagar				27		27
	State Total	1	14	3	56	1	75

Notes: *The scheme was erected with the funds from Govt , while WUAs will form as cooperative act

Table 1.9: PINS Sample Size Distribution in Telengana State

Districts Selected	Models*	Govt-PINS With MIS		Govt-PINS with Flood Irrigation		Pvt. PINS With MIS**(BH)	Defunct-PINS without any irrigation **(NBH)
		BH	NBH	BH	NBH		
Mahabobnagar	1,2, 3, 5	50	25	10	5	10	
Madak	1,3, 4	50	25	10	5	10	
Rangareddy	1, 2	25	13	10	5	-	
Nalgonda	1,3	25	12	-	-	-	
Telengana state		150	75	30	15	20	10

Notes: (1) BH: Beneficiary households, NBH: Non-beneficiary households, HHs: Households

(2) *Codes for Models: WASSAN (Bore wells GW -1, Community based Tank Management-2, Lift irrigation-(River PINS)-3, Borewell PINS-4, Telengana Well Irrigation Project-5

(3) ** Survey Schedule meant for Beneficiary households are also to be administered for private PINS and Survey Schedule meant for Non-Beneficiary households are also to be administered for defunct PINS not able to provide irrigation water to intended beneficiaries.

4) Where the sufficient number of sample households were not available in one category, the same were taken from other category to complete the target (i.e., total beneficiary HHs-200, non-beneficiary HHs-100, WUA-20)

Out of a total of 27 PINS projects in Gujarat, 25 PINS projects were having associated water user associations (WUA), while other two were defunct PINS project without providing any irrigation water and without having any WUA. There were also three private PINS projects covered under the survey in Gujarat. The Private PINS was defined as the PINS established with some private investment. For example, if WUA contributed some part of

PINS expenditure, it was covered under private PINS. Where the private PINS installed with cent per cent private investment, they were given priority under this category. In Gujarat and Telengana, all the working PINS were tube well PINS where as in Rajasthan, all the selected PINS were canal PINS. In Maharashtra, three types of PINS were selected: government PINS (100% government funded), cooperatives PINS (partially funded by government and managed by group of farmers) and private PINS (owned and managed by individual farmers).

The care was taken to select PINS projects from various types of command areas such as canal, tube wells and rivers, so as to assess the institutional dynamics in operation and maintenance of the irrigation systems. Non-beneficiary households were selected from the irrigation command area around the PINS project. The care was also taken to include both good performing PINS and unsatisfactory performing PINS, so as to differentiate the different kinds of management culture practiced in different PINS-WUAs.

Data Collection Methods and Tools

The pre-decided PINS sample size distribution was slightly modified as per local condition and availability. The major type of MIS was drip in all selected states except Rajasthan where the major type of MIS was sprinkler due to sandy topography. No other kind of MIS found popular in the selected states.

Four kinds of survey schedules were administered on the major stakeholders such as (i) Implementing Agencies/ Promoting Companies, (ii) PINS Water User Association (WUAs), (iii) Beneficiary Households and (iv) Non-Beneficiary Households. Additionally, the survey schedule meant for beneficiary households was administered for private PINS and the survey schedule meant for non-beneficiary households were administered for defunct Govt PINS which was not able to provide irrigation water to intended beneficiaries.

In addition to survey method, the Focused Group Discussion and Key Informant Interviews were conducted to capture institutional dynamics in

operation and maintenance in various command areas of the country. PINS operators, WUA management committee members and farmers were interviewed for understanding the effectiveness of institutional arrangements for operation and management of irrigation systems and distribution of irrigation water and the difficulties they face.

Data Analysis Methods and Tools

Simple statistical tools were used for data analysis and interpretation of results. The performance of PINS-MIS was evaluated with respect to water saving, irrigation productivity, costs and benefits of the systems. Case studies were undertaken on three selected PINS projects: (a) successful canal PINS, (2) unsuccessful canal PINS and (c) PINS with underground pipeline (UGPL).

Besides, **Probit model** was fitted so as to ascertain the significance of various determinants of benefits accrued from tubewell PINS. The benefits such as Increase in agricultural yield and income, Water saving, Energy saving and Reduction in fertilizer and pesticide use were considered as the binary response variables whereas the determinants of benefits such as Age of HH head, Years of schooling of HH head, years of farming experiences, amount of loan taken for investment on PINS-MIS, group membership, Land location in the command area of the PINS, Sufficiency of water in PINS project, Area under PINS-MIS, total operational area, horsepower of pumpset, total area under rabi, total area under horticultural crops, depth of tubewell, No interruption in regular supply of power, Better water management by WUA etc. were considered as the explanatory variables in the Probit model. The model was administered on the members of tubewell users association (TUA) in the state.

1.7 Limitations of the study:

The study is basically about assessing the performance of PINS in selected states of India on which not many studies have been done. Unavailability of sufficient data and literature on its implementation and performance affected the depth of the study. Prevalence of very divergent conditions related to PINS projects in various states posed great difficulty in making uniform pattern of study designs for all states. In some states like Gujarat all canal PINS were defunct and were not adopted by the intended farmers. As a result, the study on main issues around Canal PINS could not be done properly, though the same has been done nicely for tubewell PINS in the state. Some aspects of the study such as costs and benefits of PINS before and after installation of PINS were based on the recall method. Where the installations were carried out a long ago, the data provided by the farmers on the same may not be accurate.

1.8 Organization of the Report:

The present report is organized in seven chapters. The first chapter discusses the background, importance and concept of PINS, review of literature, objectives, coverage, data and methodology and limitations of the study.

The second chapter discusses about irrigation development and management in India with some illustrations and discussions on state wise and source wise irrigation provisions. The ground water resource availability in the state, progress in water conservation and micro irrigation, progress in participatory irrigation management (PIM), other initiatives for irrigation development and management along with some strategic options have been discussed in this chapter.

The next four chapters discussed state specific study outcomes related to study objectives for four selected states (Gujarat, Rajasthan, Maharashtra and Telengana). In each of these chapters, the overview of PINS programmes in respective states covering progress in implementation and cost pattern on PINS, the adoption, performance and management of PINS by farmers and

the adoption, performance and management of PINS by WUAs in each of the selected states have been discussed in detail.

The last chapter, i.e., Chapter VII presents the summary of findings of the study with policy implications.

Chapter II

Irrigation Development and Management in India

2.1 Introduction:

Irrigation water is always considered as an engine of agricultural growth. Irrigation development increases the cropping intensity, alters the cropping pattern in favour of high value crops, encourages the adoption of technological inputs (HYV seeds, fertilisers, pesticides, etc) as well as machineries, all of which one way or the other help to augment the crop output. Besides providing direct benefits to the farming community, it also indirectly benefits the non-farming community substantially. While benefiting the landless agricultural labourers in terms of increased employment opportunities and wage rate, irrigation helps to reduce the rural poverty in a sustained manner (Hussain and Hanjra, 2003). Increased production of foodgrains and other commodities that takes place mainly because of irrigation development also makes dent in the prices of agricultural commodities, which indirectly benefits millions of non-agricultural rural and urban consumers.

Over the time irrigation methods have been developed across the world. Current irrigation methods can be divided into main four types, surface irrigation, drip/micro irrigation, sprinkler and subirrigation. In surface irrigation, water flows over the soil by gravity; in sprinkler method water is applied by sprinkling droplet (creating artificial rain) from moving or fixed pipes. Water in the form of small droplets is frequently applied to the root zones of the crops in the drip/micro irrigation. Sub surface drains or ditches are used to raise water table near the root zones in the subirrigation method (Bjorneberg, 2013).

At global level, it is reported that about 85% of the crop productions is from irrigated land (ICID, 2016). China and India irrigate around 60 Mha (Million hectares) area each, in the United States and Pakistan area under irrigation is around 20 Mha area each (Bjorneberg, 2013), majority of land in India and China is irrigated by using surface irrigation. The US stands first

for the use of micro irrigation and sprinkler. In the US, around 54% of the irrigated land is under sprinkler irrigation and 7% under is the micro irrigation (Bjorneberg, 2013; USDA, 2013). It is evident that there has been great development in the irrigation systems, where various cutting age technologies are used, which resulted in the considerable level of application efficiency, as shown in the Table 2.1.

Table 2.1 Typical application efficiencies for irrigation systems

Sr. No.	System type	Application efficiency
1	Surface irrigation	
	a) Furrow	50-70%
	b) Level basin	60-80%
	c) Border	60-75%
2	Sprinkler irrigation	
	a) Solid set	60-85%
	b) Set move	60-75%
	c) Moving	75-95%
	d) Travelling gun	55-65%
3	Micro irrigation	80-95%
4	Sub irrigation	50-80%

Source: Bjorneberg, 2013.

2.2 Irrigation Development in India:

The total geographic area of India is 328.7 Mha, of which net sown area is 43% (139.9 Mha) and gross cropped area is 194.4 Mha, while around 66 Mha area is under irrigation (DAC&FW, 2016).Agriculture sector plays crucial role directly and indirectly in Indian economy, since there is great variation in the climate across India, the development of this sector is vastly depend on the availability and development of irrigation facilities. In India, FruzTughlug (1351-86) was the first who built canal for irrigation, in 15th century. Moreover it is argued that the presence of irrigation facilities was one of the reasons for the expansion of the Vijayanagar Empire in the southern part of India (Manivanan, 2006). The first systematic attempt for the irrigation development was done in 1850 by British rule through private companies, which was an abortive effort, therefore in 1866, the policy was developed for irrigation, which states that the projects will be funded by the states through public loans, while the barrier of states political boundaries were kept away to provide the best solutions (Mohile, 2007).

Between the period from 1836 to 1866, the British rule completed first four major projects: the Upper Ganga Canal, the Upper Bari Doab Canal, the Krishna, and the Godavari Delta Systems, followed by Lower the Ganga, the Sirhind, the Mutha and the Agra canal and the Periyar Dam (Manivanan, 2006). This kind of man made works brought 7.5 Mha area under irrigation at the end of 19th century. At the time of partition, net irrigated area was 28.2 Mha, of which 8.8 Mha went to Pakistan and 19.4 Mha area remained in India (Manivanan, 2006).

The irrigation projects are mainly classified into three types: major, medium and minor irrigation projects. Major irrigation projects which envisage culturable command area (CCA) more than 10,000 ha, medium irrigation projects envisage CCA 2000–10,000 ha, and minor irrigation projects envisage CCA less than 2000 ha. Table 2.2 shows the list of 12 major irrigation projects were completed before the independence of India.

Table 2.2: Irrigation Projects Completed before Independence

Sr. No.	Important irrigation works	Year of completion	Irrigation benefits (lakh ha)
	Andhra Pradesh		
1	Godavari delta system	1890	5.58
2	Krishna delta system	1898	4.42
	Bihar		
3	Sone canal system	1874	3.47
	Haryana		
4	Western Yamuna canal system	1820	4.31
	Punjab		
5	Upper Bari Doab canal	1859	3.35
6	Sirhind canal	1873	6.00
	Rajasthan		
7	Gang canal	1927	3.04
	Tamil Nadu		
8	Cauvery delta system	1889	5.05
	Uttar Pradesh		
9	Upper Gang canal system	1856	6.99
10	Lower Gang canal system	1880	6.28
11	Eastern Yamuna canal system	1830	1.91
12	Sarda canal system	1926	6.12

Source: Sen (2016).

The Central Water Commission (CWC) of India divided the country in to 20 river basin (river basin is the basic hydrological unit for water resources planning and management). Table 2.3 presents the major river basins in India with catchment area, water resource potential and utilizable surface water resource for each river basin.

Table 2.3: Major River Basins

Sr. No.	River Basin	Catchment Area (sq km)	Average Water Resources Potential (Bcum)	Utilizable Surface Water Resources (Bcum)
1	Indus (up to Border)	321,289	73.31	46.0
2	Ganga- Brahmaputra- Meghna			
	a) Ganga	861,452	525.02	250.0
	b) Brahmaputra	194,413	537.24	24.0
	c) Barak & Others	41,723	48.36	
3	Godavari	312,812	110.54	76.3
4	Krishna	258,948	78.12	58.0
5	Cauvery	81,155	21.36	19.0
6	Subernarekha	29,196	12.37	6.8
7	Brahamani & Baitarni	51,822	28.48	18.3
8	Mahanadi	141,589	66.88	50.0
9	Pennar	55,213	6.32	6.9
10	Mahi	34,842	11.02	3.1
11	Sabarmati	21,674	3.81	1.9
12	Narmada	98,796	45.64	34.5
13	Tapi	65,145	14.88	14.5
14	West Flowing Rivers From Tapi to Tadri	55,940	87.41	11.9
15	West Flowing Rivers From Tadri to Kanyakumari	56,177	113.53	24.3
16	East Flowing Rivers Between Mahanadi & Pennar	86,643	22.52	13.1
17	East Flowing Rivers Between Pennar and Kanyakumari	100,139	16.46	16.5
18	West Flowing Rivers Of Kutch and Saurashtra including Luni	321,851	15.10	15.0
19	Area of Inland drainage in Rajasthan	-	Negligible	-
20	Minor River Draining into Myanmar (Burma) & Bangladesh	36,302	31.00	-
	Total		**1,869.37**	**690.1**

Source: Central Water Commission, Ministry of Water Resources, Govt. of India.

According to the CWC, the water resources potential, which is the natural run off in the rivers in the country is about 1,869 Billion Cubic Meters (Bcum), from this around 690 Bcum is utilizable. The completed major & medium irrigation projects created 253.4 Bcum storage capacities and the projects under construction will create additional 51 Bcum, hence the total storage capacity will be around 304.3 Bcum. The Ganga-Brahmaputra-Meghna (GBM Delta) river basin is the biggest river basin in India with water resource potential of 1,111 Bcum, which is 60% of the total water resource potential of India. In India the total length of the rivers and canals is about 2 lakh km.

After independence, governments focus was on creation of irrigation infrastructure, which was reflected in the first five year plan (1951-56), the expenditure on irrigation sector was Rs. 441 Crores, which was 23% of the total plan expenditure. The plan wise expenditure on irrigation and flood control sector is shown in the table 2.4. After the first plan the share of the expenditure on irrigation has been considerably decreased.

Table 2.4: Plan wise expenditure incurred on Irrigation and Flood Control Sectors

(Rs in Crores)

Sr. No.	Plan Period	Major & Medium Irrigation	MI/MI & CAD	Total Irrigation	Flood Control	Total Plan Expenditure All Sectors	Percentage expenditure on Irrigation
1	First (1951-56)	376.2	65.6	441.8	13.2	1960	22.54
2	Second (1956-61)	380.0	161.6	541.6	48.1	4672	11.59
3	Third (1961-66)	576.0	443.1	1019.1	82.1	8577	11.89
4	Annual (1966-69)	429.8	560.9	990.7	42	6625	15.04
5	Fourth (1969-74)	1242.3	1173.4	2415.7	162	15779	15.31
6	Fifth(1974-78)	2516.2	1409.6	3925.8	298.6	28653	14.22
7	Annual (1978-80)	2078.6	1344.9	3423.5	330	22950	14.27
8	Sixth (1980-85)	7368.8	4159.9	11528.7	787	109292	10.55
9	Seventh (1985-90)	11107.3	7626.8	18734.1	941.6	218730	8.56
10	Annual (1990-92)	5459.2	3649.5	9108.7	460.6	123120	7.4
11	Eighth (1992-97)	21071.9	13885.3	34957.2	1691.7	483060	7.59
12	IX Plan(1997-02)	49289.0	13760	83049.0	3038	941041	6.7
13	X Plan (2002-07)	83647.0	16458.9	100105.9	4344.18	1618460	6.19
14	XI Plan (2007-12) Outlay(Projection)	165350	46350	211700	20100	3644718	5.81

Source: Central Water Commission, Ministry of Water Resources govt. India

The state wise list of the large dams completed and under construction is shown in Table 2.5. We can say that the output of the governments' expenditure on the irrigation sector is that 4877 large dam are ready for water storage and 313 dams are under construction. While there are 198 dams in India whose construction year is unknown. Highest numbers of dams are in Maharashtra 1845, followed by Madhya Pradesh (906) and Gujarat (632).

Table 2.5: State wise abstract of large dams

Sr. No.	State	Total completed dams with known construction year(no.)	Under Construction (no.)	Year of construction not available (no.)	Total
1	Andaman & Nicobar Islands	2			2
2	Andhra Pradesh	142	25	46	167
3	Arunachal Pradesh	1	3		4
4	Assam	3	1		4
5	Bihar	24	2		26
6	Chhattisgarh	248	10	1	258
7	Goa	5			5
8	Gujarat	619	13	5	632
9	Himachal Pradesh	19	1	2	20
10	Haryana	1			1
11	Jammu & Kashmir	14	3	3	17
12	Jharkhand	50	29	3	79
13	Karnataka	230	1	16	231
14	Kerala	61	1	0	62
15	Madhya Pradesh	898	8	28	906
16	Maharashtra	1693	152	3	1845
17	Manipur	3	1		4
18	Meghalaya	8			8
19	Mizoram		1		1
20	Nagaland	1			1
21	Odisha	199	5	4	204
22	Punjab	14	2		16
23	Rajasthan	201	10	8	211
24	Sikkim	2			2
25	Tamil Nadu	116	0		116
26	Telangana	162	20	79	182
27	Tripura	1			1
28	Uttar Pradesh	115	15		130
29	Uttarakhand	16	9		25
30	West Bengal	29	1		30
	Grand Total	4877	313	198	5190

Source: Central Water Commission, http://www.cwc.nic.in/main/downloads/new%20nrld.pdf.

The minor irrigation schemes (MnrIS) are the structures either in ground water or in surface water having culturable command area (CCA) up to 2,000 ha. The ground water schemes include dug well, shallow tube well, deep tube well and the surface water schemes include surface flow and surface lift schemes.

Minor irrigation accounts for 65% of the total irrigation potential utilised, in the country. Currently there are around 2.1 crores MnrIS spread across 609 districts and 6.4 lakh villages. Around 97% of the MnrIS are owned privately while only 3% are owned by the public sector. In 1970, The National Commission on Agriculture had recommended that the census of source of minor irrigation may be carried out once in five years, on this recommendation first minor irrigation census was carried out in 1986-87, and followed by three censuses in the years 1993-94, 2000-01 and 2006-07. Table 2.6 summarizes the census of minor irrigation schemes (MnrIS).

Table 2.6: Census of Minor Irrigation schemes

Census	No of schemes (in Millions)	Ground water (in Mha)		Surface water (in Mha)	
		Irrigation potential created	Irrigation potential utilized	Irrigation potential created	Irrigation potential utilized
Census I (1986-87)	8.24	24.02	21.24	6.04	4.6
Census II (1993-94)	9.3	33.3	26.63	8.01	5.15
Census III (2000-01)	19.76	62.4	44.96	11.9	6.97
Census IV (2006-07)	21.4	72.5	57.3	13.2	7.8

Source: Minor Irrigation Census, Govt. India, (2006-2007). http://micensus.gov.in/

State wise status of the minor irrigation schemes is shown in the Table 2.7. Maximum numbers of schemes are in Uttar Pradesh 42.7 lakhs, followed by Andhra Pradesh 23 lakhs, Maharashtra 22.7 lakhs, Tamil Nadu 19 lakhs, and Madhya Pradesh 19 lakhs. The spread of minor irrigation is highest in Uttar Pradesh around 1 lakhs villages, followed by Madhya Pradesh 0.56 thousand villages, Odisha 50 thousand villages, Bihar 45 thousand villages

and Maharashtra 44 thousand villages. The numbers of schemes per village are recorded highest in Kerala183, followed by Tamil Nadu111, Punjab 91, Andhra Pradesh 82, Haryana 66, Gujarat 62, Delhi 52 and Maharashtra 51.

Table 2.7: State wise minor irrigation schemes in India

Sr. No.	States	Ground Water (Dug well /shallow and deep tube well/) (no.)	Surface Water (Surface flow and lift schemes)(no.)	Total (no.)	No of Village Schedules (no.)
1	Andhra Pradesh	21,99,551	1,05,816	23,05,367	28,162
2	Arunachal Pradesh	35	4,983	5,018	3,865
3	Assam	1,04,312	6,442	1,10,754	26,062
4	Bihar	6,51,242	12,127	6,63,369	45,421
5	Chhattisgarh	3,32,290	84,318	4,16,608	20,324
6	Goa	4,423	2,651	7,074	389
7	Gujarat	11,18,335	33,304	11,51,639	18,511
8	Haryana	4,67,846	494	4,68,340	7,083
9	Himachal Pradesh	5,081	12,293	17,374	20,723
10	Jammu & Kashmir	3,157	4,888	8,045	6,422
11	Jharkhand	1,42,547	53,079	1,95,626	31,853
12	Karnataka	9,77,702	1,20,776	10,98,478	29,336
13	Kerala	1,69,789	23,607	1,93,396	1,057
14	Madhya Pradesh	16,66,349	2,39,802	19,06,151	56,324
15	Maharashtra	20,54,025	2,19,160	22,73,185	44,253
16	Manipur	0	588	588	2,390
17	Meghalaya	222	8,269	8,491	6,200
18	Mizoram	0	5,371	5,371	757
19	Nagaland	103	20,792	20,895	1,149
20	Odisha	4,72,443	88,710	5,61,153	50,141
21	Punjab	11,78,272	2,834	11,81,106	12,948
22	Rajasthan	14,99,446	9,393	15,08,839	42,760
23	Sikkim	0	1,485	1,485	905
24	Tamil Nadu	18,66,302	45,968	19,12,270	17,271
25	Tripura	2,091	2,780	4,871	1,040
26	Uttar Pradesh	42,53,255	25,459	42,78,714	106,879
27	Uttarakhand	53,498	31,820	85,318	16,359
28	West Bengal	5,19,439	78,622	5,98,061	41,825
29	Andaman &Nicobars	1,372	1,886	3,258	253
30	Chandigarh	91	0	91	13
31	Dadra & Nagar Haveli	645	557	1,202	72
32	Daman & Diu	0	0	0	0
33	Delhi	9,824	134	9,958	192
34	Lakshadweep	0	0	0	0
35	Puducherry	4,133	445	4,578	123
	Total	1,97,57,820	12,48,853	2,10,06,673	6,41,062

Source: Minor Irrigation Census, Govt. India, (2006-2007). http://micensus.gov.in/.

The total annual flow from all the river basins in India is 1,869.4 Bcum, from this the total utilizable surface water is 690 Bcum, out of this the created storage capacity can store 253 Bcum water and under construction project will add around 51 Bcum storage capacity which will lead to total live storage capacity of 304 Bcum. The basin wise live storage capacity is shown

in the table 2.8, which shows that highest live storage capacity is in Ganga river basin 56.3 Bcum, followed by Krishna river basin 54.8 Bcum, Godavari river basin 43.4 Bcum and Narmada river basin 24.4 Bcum. Only 16% of the average annual flow in the all basin can be stored in all the water storage projects. Overall, this indicates that there is considerable scope for increasing the live storage capacity.

Table 2.8: Basin Wise live Storage in India

Basin Code as per WRIS	Basin Name	Average annual flow (BCM)	Total Live Storage Capacity (BCM)			
			Completed Projects	Under Construction Projects	Total	% of average Annual flow
1	Indus	73.3	16.223	0.1002	16.323	22.3
2a	Ganga	525.0	48.677	7.649	56.326	10.7
2b	Brahmaputra	537.2	1.718	0.795	2.513	0.5
2c	Barak & Others	48.4	0.719	9.172	9.891	20.4
3	Godavari	110.5	35.033	8.412	43.444	39.3
4	Krishna	78.1	50.651	4.156	54.807	70.2
5	Cauvery	21.4	9.083	0.015	9.098	42.5
6	Subernarekha	12.4	0.309	2.150	2.459	19.8
7	Brahmani&Baitarni	28.5	5.515	0.703	6.218	21.8
8	Mahanadi	66.9	13.006	1.461	14.467	21.6
9	Pennar	6.3	2.938	2.141	5.079	80.6
10	Mahi	11.0	5.017	0.150	5.167	47.0
11	Sabarmati	3.8	1.577	0.109	1.686	44.4
12	Narmada	45.6	17.622	6.835	24.457	53.6
13	Tapi	14.9	9.137	1.558	10.695	71.8
14	WFR from Tapi to Tadri	87.4	14.668	2.430	17.098	19.6
15	WFR fomTadri to Kanyakumari	113.5	11.023	1.416	12.439	11.0
16	EFR between Mahanandi and Pennar	22.5	2.676	1.181	3.857	17.1
17	EFR between Pennar and Kanyakumari	16.5	1.441	0.015	1.456	8.8
18	WFR of Saurashtra and Kutchh including Luni	15.1	6.336	0.511	6.847	45.3
19	Area of Inland Drainage of Rajasthan	-	0.000	0.000	0.000	--
20	Minor River Draining into Myanmar and Bangladesh	31.0	0.019	0.000	0.019	0.1
20a	Area of North Ladakh not draining into Indus	0.00	0.000	0.000	0.000	--
	Total in BCM	1869.4	253.388	50.959	304.348	16.3

Source: Central Water Commission (WM Directorate), as on 31.03.2013.

Table 2.9 shows state wise live storage capacity of reservoirs in India. Highest water storage capacity is created in Maharashtra state 48 Bcum,

followed by Andhra Pradesh 35.7 Bcum, Madhya Pradesh 34.7 Bcum and Karnataka 32.6 Bcum. While in future, the live storage capacity will be added in the states Maharashtra, Manipur, Gujarat, Jharkhand and Andhra Pradesh, from the under construction projects.

Table 2.9: State wise Live Storage Capacity of Reservoirs in India

Sr. No.	Name of State	Total Storage Capacity (Bcum)		
		Completed Projects	Under Construction Projects	Total
1	Andhra Pradesh	28.716	7.062	35.778
2	Assam	0.012	0.547	0.559
3	Arunachal Pradesh	0.000	0.241	0.241
4	Bihar	2.613	0.436	3.049
5	Chhattisgarh	6.736	0.877	7.613
6	Goa	0.290	0.000	0.290
7	Gujarat	18.359	8.175	26.534
8	Himachal Pradesh	13.792	0.100	13.891
9	Jammu and Kashmir	0.029	.000	0.029
10	Jharkhand	2.436	6.039	8.475
11	Karnataka	31.896	0.736	32.632
12	Kerala	9.768	1.264	11.032
13	Madhya Pradesh	33.075	1.695	34.770
14	Maharashtra	37.358	10.736	48.094
15	Manipur	0.407	8.509	8.916
16	Meghalaya	0.479	0.007	0.486
17	Mizoram	0.000	0.663	0.663
18	Nagaland	1.220	0.000	1.220
19	Orissa	23.934	0.896	24.830
20	Punjab	2.402	0.00002	2.402
21	Rajasthan	9.708	0.443	10.152
22	Sikkim	0.007	0.000	0.007
23	Tamil Nadu	7.859	0.013	7.872
24	Tripura	0.312	0.000	0.312
25	Uttarakhand	5.670	1.613	7.283
26	Uttar Pardesh	14.263	0.724	14.987
27	West Bengal	2.027	0.184	2.212
28	Andaman Nicobar island	0.019	0.000	0.019
	Total in BCM	253.388	50.959	304.348

Source : Central Water Commission (WM Directorate).

The output of the huge investment in the irrigation sector is the irrigation potential of around 107 Mha area is created, while 86.9 Mha potential is utilized and ultimately gross area under irrigation is 86.4 Mha.

Table 2.10: Irrigation Potential Created, Utilised & Gross Irrigated Area by State

Sr. No.	Name of the State/UTs.	Potential Created Up to 2009-10 (000 ha)			Potential Utilized* Up to 2009-10 (000 ha)			Gross Irrigated Area* 2009-10(000 ha)
		Major & Medium	Minor	Total	Major& Medium	Minor	Total	
1	Andhra Pradesh	3967	3245	7211	3245	2844	6089	5764
2	Arunachal Pradesh	1	127	128	1	87	87	56
3	Assam	349	715	1064	211	509	720	225
4	Bihar	2896	5125	8021	1815	3793	5608	4625
5	Chhattisgarh	1199	642	1842	948	378	1326	1487
6	Goa	46	25	71	24	22	46	38
7	Gujarat	3095	2047	5142	1843	1900	3743	4933
8	Haryana	2206	1638	3843	1893	1584	3477	5545
9	Himachal Pradesh	23	180	203	8	145	153	188
10	Jharkhand	411	705	1115	246	501	747	155
11	Jammu & Kashmir	205	445	650	181	392	573	480
12	Karnataka	2809	1684	4494	2225	1635	3859	4096
13	Kerala	693	742	1434	591	629	1221	455
14	Madhya Pradesh	2197	2442	4638	1173	2217	3391	7162
15	Maharashtra	3780	3099	6878	2313	2648	4961	4352
16	Manipur	123	100	224	81	73	155	52
17	Meghalaya	0	69	69	0	54	54	74
18	Mizoram	0	43	43	0	17	17	10
19	Nagaland	0	107	107	0	72	72	85
20	Orissa	2046	1771	3817	1879	1442	3321	3197
21	Punjab	2647	3475	6122	2511	3368	5879	7714
22	Rajasthan	3100	2482	5582	2526	2374	4901	7309
23	Sikkim	0	38	38	0	26	26	18
24	Tamil Nadu	1574	2264	3838	1557	2128	3685	3238
25	Tripura	20	141	161	10	116	127	106
26	Uttar Pradesh	8946	24808	33754	7324	19798	27123	18896
27	Uttarakhand	289	559	848	191	409	600	567
28	West Bengal	1765	4070	5835	1574	3320	4894	5525
	Total States	44388	62752	107174	34370	52482	86852	85353
	Total U.Ts.	7	58	64	4	38	42	70
	Grand Total	**44394**	**62810**	**107238**	**34374**	**52520**	**86894**	**86423**

Source: Ministry of Agriculture (DE & S), Planning Commission. Govt. of India.
Note: * Provisional.

State wise irrigation potential created, utilised and gross irrigated area by the major and medium projects and minor projects is shown in Table 2.10. Highest irrigation potential is created in Uttar Pradesh 33.7 Mha, followed by Bihar 8 Mha, Andhra Pradesh 7.2 Mha, Maharashtra 6.8 Mha and Punjab 6 Mha. The maximum irrigation potential is utilized in Uttar Pradesh

27 Mha followed by Andhra Pradesh 6 Mha, Punjab 5.8 Mha, Bihar 5.6 Mha and Maharashtra 5 Mha. Overall it is clear from the irrigation development in India that good amount of irrigation potential is created in last century, there is need for efficient utilization of this created potential to bring more area under irrigation.

2.3 Policies & Programmes on Irrigation Development in India:

Historically, irrigation was the subject under the Public Works Department (PWD) which was created in 1855, while this subject got more attention only after the famine in 1858, by appointing an inspector general of canals. Further, this subject was taken much seriously and an irrigation expert was appointed as an Inspector General of Irrigation, under the Government of India Act 1919. Irrigation is provincial subject and the Centre's role is to advice, co-ordinate and settle the water related dispute between the states (MWR, 2016). Only in 1952, a separate ministry for water was created, namely Ministry of Irrigation and Power. In 1969, Irrigation Commission was established to look after the irrigation development programme in the comprehensive manner, while in 1980, separate ministry of irrigation was established from the Ministry of Irrigation and Power. In January 1985, again the irrigation ministry was combined with power as Ministry of Irrigation and Power. Further in September 1985 it was bifurcated, and irrigation ministry was renamed as Ministry of Water Resources, which was renamed in July 2014, as the Ministry of Water Resources, River Development & Ganga Rejuvenation (MWR, 2016).

It is noted that during the early British rule in India, the irrigation development works were divided in to commercial and social works and it was expected that commercial projects will get completed in ten years and return from projects were expected with 6% rate of return on capital invested for canal irrigation. While after the independence, they fall under the public sector as the part of essential infrastructure for agriculture sector, with the reduction of rate of return from 6% to 3.75 % (Mohile, 2007; Gulati.et., al. 2005). Mohile (2007) argues that documented evidences related water policy were not available prior to 1987, while documents such as reports of the

second water commission and documents related to discussion on flood control in the parliament, provides few guidelines.

In 1980, under the chairmanship of the Prime Minister of India, the National Water Resource Council (NWRC) was formed, which was represented by the ministers in central government and also state governments, they formalized the national water policy in September1987. In September 1990, National Water Body (NWB) was constituted to look after the progress of implementation of stipulations of National Water Policy (NWP), under the chairmanship of secretary, Ministry of Water Resources, which reports to the NWRC. The NWRC finalized the NWP, which covers mainly the policies related to irrigation management, asset management, operational and procedural changes (Mohile, 2007). The summary of important polices related to the water management is presented in the Table 2.11.

First time, the government of India has adopted a National Water policy in 1987, which was revised in 2002 and 2012. On June 2016, the Ministry of Water Resources, River Development & Ganga Rejuvenation released the draft of National Water Framework Bill, 2016. The new bill tries to provide a legal framework for water with respect toprotection, conservation, regulation and management. The new bills covers the main aspects as: (i)Right to water for life (ii)Basic principles as water as common heritage and resource, river rejuvenation, people centric water management and standards for water quality and water footprints (iii)Integrated river basin development and management (iv)Planning for water security and pricing, and water regulators (v) Urban, industrial and participatory irrigation management (vi)Access to and transparency of water data, promotion of innovation and knowledge management (vii)Inter-state river water conflicts prevention and resolution(MWRM, 2016). This bill suggest that water management should be done at the level of river basin and river basin authority (RBA) shall be established, the RBA shall prepare a master plan for a river basin and this shall remain in the public domain. Overall the new bill will bring more transparency and is having a more decentralize management approach.

Table 2.11: The important policies related to water-Government of India

Sr. No.	*Year*	Government of India- Water-Related Policies
1	1866	The government is given the main role in irrigation development
2	1935	Transferred 'irrigation' to the states
3	1950	Beginning of planned development
4	1972	Second irrigation commission report
5	1980	The RashtriyaBarhAyog (National Commission on Floods) submitted its report
6	1986	Formulation of National Water Resource Council (NWRC)
7	1987	National Water Policy (1987) finalized in the first meeting of NWRC
8	1994	Modified draft of National Policy for water allocation amongst states, circulated to the states
9	1998	Water sector review by GoI and World Bank(WB)
10	1999	Second meeting of NWRC considered water allocation and river basin authorities
11	1999	Report of the National Commission on Integrated Water Development
12	2000	Water vision by India water partnership
13	2002	National Water Policy (2002)
14	2004	Country Policy Support Program (CPSP) India studies by International Commission on Irrigation and Drainage-International Association of Hydrogeologists (ICID-IAH)
15	2008	launched National Action Plan on Climate Change (NAPCC)
16	2011	Approved a "Comprehensive National Water Mission (NWM) Document
17	2012	National Water Policy(2012)
18	2016	National Water Framework Bill, 2016

Sources: Mohile (2007), MWR (2016).

The government of India has launched various programmes for the irrigation water management. The most important programmes are Accelerated Irrigation Benefits Programme (AIBP), Command Area Development Programme (CADP) and Pradhan Mantri Krishi Sinchayee Yojana (PMKSY).

2.3.1 Accelerated Irrigation Benefits Programme (AIBP):

The irrigation related projects require huge capital investment. Since the irrigation is a state subject, planning, designing and implementation of the irrigation project is done by the state governments. It was observed that

many of the major and medium irrigation projects were incomplete because of the unavailability of capital at the state level. Hence, in 1996-97, the central government initiated the program, which was titled as "Accelerated Irrigation Benefits Programme(AIBP)" to provide Central Loan Assistance(CLA) for completion of the projects which were in advance stage of completion and those were beyond the resource capacity of the states. The priority was given for the tribal and drought prone area. From 1996-97 to 2014, Rs. 64,905.57 crores CLA was provided to states, and 143 major/medium projects and 12,083 surface MnrISs have been completed. In 2009, national important projects were attached to this scheme, for the AIBP and National Projects Rs. 55,200 crores are allocated in the XII plan (MWR, 2014).

2.3.2 Command Area Development Programme (CADP):

The Second Irrigation Commission (1972) suggested that there is a need for systematic development of command area of irrigation projects to fully utilize the created irrigation potential. In view of this, the Ministry of Irrigation and Power set up a committee of ministers, which recommended in 1973 for the formation of a broad based area development authority for each Major Irrigation Project should be set up to undertake the work of comprehensive command area area development(MWR, 2016). On the basis of this suggestion, in 1974, a central government funded programme titled "Command Area Development Programme (CADP)" was created to achieve speedy utilization of irrigation potential created and also to improve productivity in selected irrigated commands (MWR, 2016; Sekhar, 2007). The components of the CADP are (i)field channels and field drains, (ii)land leveling and shaping, (iii)realignment of field boundaries, (iv)consolidation of holdings, (v) enforcement of rotational water supply ("warabandi"), (vi) adaptive trials, demonstrations, & training, (vii) sprinkler, drip, (viii) groundwater development and (ix) incentives for farmers participation (Sekhar, 2007).

In the 10thPlan, the CADP was renamed as "Command Area Development and Water Management Programme (CADWM Programme)" to make it more farmer centric and comprehensive. In the initial phase, around 60 medium and major projects covering around 15 million ha (Mha) CCA

were taken up under this programme. Currently 150 projects covering 16.3 Mha CCA is under this project, the total outlay under the XII Plan was Rs. 15,000 Crores.

2.3.3 Pradhan Mantri Krishi SinchayeeYojana (PMKSY):

To ensure access to some means of protective irrigation to farms to bring rural prosperity, the central government started *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) programme in 2015. This programme is the combination of the various schemes such as [i]Accelerated Irrigation Benefit Programme (AIBP) of Ministry of Water Resources, River Development & Ganga Rejuvenation, [ii]Integrated Watershed Management Programme (IWMP) of Department of Land Resources; and [iii]On Farm Water Management(OFWM) component of National Mission on Sustainable Agriculture (NMSA) of Department of Agriculture and Cooperation.

The PMKSY is adopting decentralized State level planning and projectised execution, states have to prepare District Irrigation Plan(DIP), which is the starting point of the PMKSY and State Irrigation Plan(SIP). The main components of PMKSY are [a] Accelerated Irrigation Benefit Programme (AIBP), [b]PMKSY- *Har Khet ko Pani*, PMKSY - Per Drop More Crop and [c]PMKSY -Watershed Development. The outlay of Rs. 50,000 Crores is provided for PMKSY for a period of 5 years from 2015-16 (PMKSY-2016).The results of the three programmes [i.e. AIBP, CADP & PMKSY] is very positive, despite this success there is need to focus on the efficient use of water for irrigation at field level.

2.4 Progress in Participatory Irrigation Management in India:

The Participatory Irrigation Management (PIM) is the participation of the farmer in the management of the irrigation systems at all levels of system (-full physical limits of the system-) and with respect to all aspects (i.e. from design and planning to the evaluation) (Groenfeldt & Sun, 1997). It is found that in developing countries, governments incur high cost when they are involved in the irrigation management functions which otherwise farmers could handle. Farmers have solid incentives to manage water

productivity than a government administration, and decentralized irrigation management to farmers will result in quick response to the various problems of the irrigation systems (Groenfeldt & Svendsen, 2000; Brewer et al., 1999). Therefore, we can say that PIM is benefiting to both governments and farmers.

In 1987, Farmers' participation in the irrigation water management has been accepted as the policy of the central government in the National Water Policy (NWP). The NWP says "Efforts should be made to involve farmers progressively in various aspects of management of irrigation systems, particularly in water distribution and collection of water rates. Assistance of voluntary agencies (Non-Government Organisation - NGOs) should be enlisted in educating the farmers in efficient water-use and water management." The PIM should not only include farmers, but also other stakeholder as well government agencies (including local bodies).

The Ministry of water resources set up broad objectives for the PIM policy as follow:

a) To create a sense of ownership of water resources and the irrigation system among the users, so as to promote economy in water use and preservation of the system.
b) To improve service deliveries through better operation and maintenance.
c) To achieve optimum utilization of available resources through sophisticated deliveries, precisely as per crop needs.
d) To achieve equity in water distribution.
e) To increase production per unit of water, where water is scarce and to increase production per unit of land where water is adequate.
f) To make best use of natural precipitation and ground water in conjunction with flow irrigation for increasing irrigation and cropping intensity.
g) To facilitate the users to have a choice of crops, cropping sequence, timing of water supply, period of supply and also frequency of supply, depending on soils, climate and other infrastructure facilities available

in the commands such as roads, markets cold storages, etc., so as to maximize the incomes and returns.

h) To encourage collective and community responsibility on the farmers to collect water charges and payment to Irrigation Agency.

i) To create healthy atmosphere between the Irrigation Agency personnel and the users.

The Ministry of Water Resources (MWR) set up a model act for the PIM policy, which is to be adopted by state government for facilitating the PIM in the states, the PIM model act was enacted by 15 states (MWR, 2014). The list of states including their positions on the act is shown in Table 2.12. The model act provides legal framework for formation of water users' organization at three levels, The Water Users Association/s (WUAs), which is a formal group of farmers at a minor or group of outlets or a minor, the Distributary Committee, which is represent five or more WUAs, and the Project Committee, which is an apex committee of the irrigation system (MWR, 2014).

Most of the states are supporting the formation of WUAs for the management irrigation water, nationwide around 63 thousand WUAs are formed, which covers around 14.62 Mha area (MWR, 2014). State wise status of the WUAs is shown in the Table 2.13.

Table 2.12: State-wise Position of Enactment of New Act/Amendment of existing Irrigation Act

Sr. No.	Name of State	Position of issue / amendment of Irrigation Act
1	Andhra Pradesh	Enacted "Andhra Pradesh Farmers' Management of Irrigation Systems Act, March, 1997"
2	Assam	The Assam Irrigation Water Users Act 2004
3	Bihar	"The Bihar Irrigation, Flood Management and Drainage Rules, 2003" under the Bihar irrigation Act, 1997
4	Chhattisgarh	Enacted "Chhattisgarh SinchaiPrabandhan Me Krishkon Ki BhagidariAdhiniyam, 2006".
5	Goa	Enacted "Goa Command Area Development Act 1997 (Goa Act27 of 1997)"
6	Gujarat	Gujarat Water Users Participation Management Act, 2007
7	Karnataka	Promulgated an Ordinance on 7th June 2000 for amendment ofthe existing Karnataka Irrigation Act 1957.
8	Kerala	Enacted "The Kerala Irrigation and Water Conservation Act2003".
9	Madhya Pradesh	Enacted "Madhya Pradesh Sinchai Prabandhan Me Krishkon Ki Bhagidari Adhiniyam, 1999" during September 1999.
10	Maharashtra	"The Maharashtra Management of Irrigation Systems by Farmers Act,2005"
11	Orissa	Enacted "The Orissa Pani Panchayat Act, 2002".
12	Rajasthan	Passed the "Rajasthan Sinchai Pranali Ke Prabandh Me Krishkon Ki Sahabhagita Adhiniyam, 2000".
13	Sikkim	"Sikkim Irrigation Water Tax 2002" and "Sikkim Irrigation Water Tax (Amendment) Act 2008"
14	Tamil Nadu	Enacted the "Tamil Nadu Farmers' Management of Irrigation Systems Act, 2000".
15	Uttar Pradesh	Enacted the "Uttar Pradesh Irrigation Management Act, 2009"

Source: Ministry of Water Resources (2014), Status of Participatory Irrigation management http://wrmin.nic.in/writereaddata/CAD-WUA-20140331.pdf.

Table 2.13: State-wise number of WUAs formed and irrigated area covered up to 2011

Sr. No.	Name of State	Number of WUAs Formed		Area Covered (Thousand Hectare)	
1	Andhra Pradesh	10790	(19.4)	4800	(46.9)
2	Arunachal Pradesh	2	(0.0)	1.47	(0.0)
3	Assam	37	(0.1)	24.09	(0.2)
4	Bihar	37	(0.1)	105.8	(1.0)
5	Chhattisgarh	945	(1.7)	NA	NA
6	Goa	42	(0.1)	5	(0.0)
7	Gujarat	576	(1.0)	96.68	(0.9)
8	Haryana	2800	(5.0)	200	(2.0)
9	Himachal Pradesh	875	(1.6)	35	(0.3)
10	Jammu and Kashmir	1	(0.0)	1	(0.0)
11	Karnataka	2279	(4.1)	1052.41	(10.3)
12	Kerala	3930	(7.1)	148.48	(1.5)
13	Madhya Pradesh	1470	(2.6)	1501.45	(14.7)
14	Maharashtra	1299	(2.3)	444	(4.3)
15	Manipur	62	(0.1)	49.27	(0.5)
16	Meghalaya	99	(0.2)	NA	NA
17	Nagaland	25	(0.0)	NA	NA
18	Odisha	11020	(19.9)	907	(8.9)
19	Punjab	957	(1.7)	116.95	(1.1)
20	Rajasthan	506	(0.9)	219.65	(2.1)
21	Tamil Nadu	7725	(13.9)	474.28	(4.6)
22	Uttar Pradesh	24	(0.0)	10.55	(0.1)
23	West Bengal	10000	(18.0)	37	(0.4)
	Total	55501	(100.0)	10230.1	(100.0)

Note: Figures in parentheses are the percentages of total.

Ref: http://planningcommission.nic.in/plans/planrel/fiveyr/11th/11_v3/11v3_ch2.pdf

2.5 Progress in MIS Programme in India:

It has been assessed that there is the potential of bringing around 42 million ha under drip and sprinkler in the country (Raman 2010). Out of this, about 30 million ha are suitable for sprinkler irrigation for crops like cereals, pulses and oilseeds in addition to fodder crops. This is followed by drip with a potential of around 12 million ha under cotton, sugar cane, fruits and vegetables, spices and condiments; and some pulse crops like red gram, etc. The percentage of actual area against the potential estimated

under drip irrigation in different states varied between nil in Nagaland to as much as 49.74% in Andhra Pradesh, followed by Maharashtra (43.22%) and Tamil Nadu with 24.14%. In case of sprinkler irrigation, the percentage of actual area against the potential estimated was as much low as 0.01% (Bihar) and the highest of 51.93% (Andhra Pradesh). Compared to the potential of 42.23 million ha in the country, the present area under MI accounts for 3.87 million ha (1.42 million ha under drip and 2.44 million ha under sprinkler) which is about 9.16% . The present figures thus reflect the extent of MIS covered under different government programmes as well as own investment by the farmers. However, the actual area under MI may vary according to the extent of use by the farmers.

So far, the area covered under Micro Irrigation in various states in the country is far from potential (Table 2.14). About 77.28 lakh hectares area has been covered under MIS in India out of which, 1684.55thosand hectares have been covered in Rajasthan, which provided the status to the state as a number one state in coverage of MIS.

Among other states in the country, Maharashtra, Andhra Pradesh, Gujarat, Karnataka, Tamil Nadu, Madhya Pradesh and Tamil Nadu are the other leading states. The Rajasthan state ranks 1st in the country in terms of coverage of area under both drip and Sprinkler irrigation system. The Rajasthan state ranks 6th in terms of coverage of area under drip irrigation system. It has covers an area of about 170.10 thousand hectares under drip irrigation after Maharashtra (896.35 thousand ha), Andhra Pradesh (834.86 thousand ha), Karnataka (429.90 thousand ha), Gujarat (411.21 thousand ha) and Tamil Nadu (290.01 thousand ha).

Table 2.14: Area covered under Micro Irrigation Systems in India

(Data as on 31-3-2015; Area in hectares)

S. No.	State	Drip		Sprinkler		Total	
1	Andhra Pradesh	834865	(24.8)	328441	(7.5)	1163306	(15.1)
2	Arunachal Pradesh	613	(0.0)	0	(0.0)	613	(0.0)
3	Assam	310	(0.0)	129	(0.0)	439	(0.0)
4	Bihar	4610	(0.1)	97440	(2.2)	102050	(1.3)
5	Chhattisgarh	15553	(0.5)	241420	(5.5)	256973	(3.3)
6	Goa	965	(0.0)	899	(0.0)	1864	(0.0)
7	Gujarat	411208	(12.2)	418165	(9.6)	829373	(10.7)
8	Haryana	22682	(0.7)	550458	(12.6)	573140	(7.4)
9	HP	291	(0.0)	684	(0.0)	975	(0.0)
10	Jharkhand	6303	(0.2)	9919	(0.2)	16222	(0.2)
11	Karnataka	429903	(12.8)	417005	(9.6)	846907	(11.0)
12	Kerala	22516	(0.7)	6948	(0.2)	29464	(0.4)
13	Madhya Pradesh	166358	(4.9)	185759	(4.3)	352117	(4.6)
14	Maharashtra	896343	(26.6)	374783	(8.6)	1271125	(16.4)
15	Manipur	47	(0.0)	30	(0.0)	77	(0.0)
16	Mizoram	1727	(0.1)	425	(0.0)	2152	(0.0)
17	Nagaland	200	(0.0)	5005	(0.1)	5205	(0.1)
18	Odisha	18431	(0.5)	82147	(1.9)	100579	(1.3)
19	Punjab	30805	(0.9)	12161	(0.3)	42966	(0.6)
20	Rajasthan	170098	(5.0)	1514451	(34.8)	1684549	(21.8)
21	Sikkim	5544	(0.2)	2769	(0.1)	8312	(0.1)
22	Tamil Nadu	290009	(8.6)	30436	(0.7)	320445	(4.1)
23	Telangana	25299	(0.8)	5293	(0.1)	30592	(0.4)
24	Tripura	100	(0.0)	392	(0.0)	492	(0.0)
25	UP	15519	(0.5)	21164	(0.5)	36682	(0.5)
26	Uttarakhand	696	(0.0)	316	(0.0)	1012	(0.0)
27	West Bengal	604	(0.0)	50576	(1.2)	51180	(0.7)
28	Others	15500	(0.5)	31000	(0.7)	46500	(0.6)
	Grand Total	3371597	(100.0)	4357215	(100.0)	7728812	(100.0)

Note: Figures in parentheses are the percentages of total

Source: Lok Sabha Unstarred Question No. 4528, dated on 21.04.2015., Indiastat.com

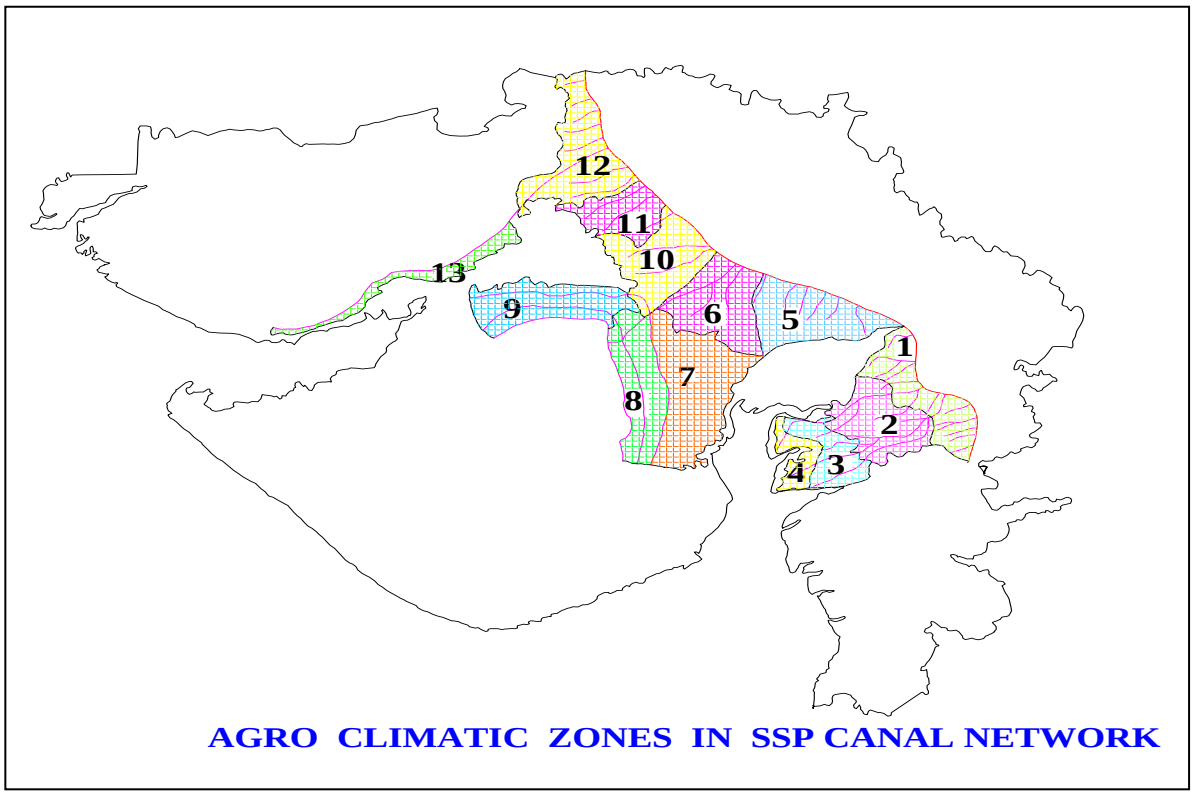
Chapter III

Performance of PINS Programme in Gujarat

3.1 Overview of PINS Programmes in Gujarat:

Gujarat State has been one of the front runners among states in India in promoting PINS. In fact, the concept of Pressurized Irrigation Network System (PINS) was developed at Design Office of Sardar Sarovar Narmada Nigam Limited (SSNNL) as a necessity step to introduce MIS in the command area of Sardar Sarovar Narmada Project (SSP). The details of coverage of SSP across various agro-climatic zones have been depicted in Table 3.1, Figures 3.1 and 3.2.

Figure 3.1: Coverage of Sardar Sarovar Narmada Project (SSNP)



AGRO CLIMATIC ZONES IN SSP CANAL NETWORK

The culturable command area (CCA) of SSP covers about 21.24 lakh hectares with gross cropped area of 34.29 lakh hectares. Though the SSP has good coverage in Gujarat and neighbouring states, there are certain issues which are affecting its further growth such as its limited delta, adverse soil conditions including soil salinity and soil degradation in some parts of its command area and inadequate irrigation infrastructure. Furthermore, there have been competing/increasing demands of other sectors like Municipal and Industrial supplies. Thus there is a strong need for efficient and cost effective use of limited delta to cover the entire command area which is not possible to irrigate through conventional flow irrigation.

Table 3.1. Area, physical characteristics and water allowance of agro-climatic zones (ACZ) in SSP command network

ACZ no.	GCA ('00 ha)	CCA ('00 ha)	No. of talukas	No. of villages	Annual rainfall (cm)	Drought proneness	Depth to water table (m)	Salinity range
1A	1001	618	5	339	118	Nil	< 10	Low
1B	1530	1001	6	278	118	Nil	< 10	Low
2A	1537	1089	3	237	113	Nil	Oct-35	Low
2B	1194	787	2	194	113	Nil	Oct-35	Low
3A	1153	736	3	168	93	Once in 10 year	< 15	Moderate
3B	379	113	1	35	93	Once in 10 year	< 15	Moderate
4A	641	227	2	52	85	Once in 6 year	< 10	High
4B	472	141	1	46	4	Once in 6 year	< 10	High
5	2957	1923	9	335	88	Once in 10 year	Oct-35	Low to Moderate
6	1817	1257	4	183	79	Once in 6 year	May-20	Low to Moderate
7A	2754	1865	3	142	71	Once in 6 year	05-Oct	Moderate to high
7B	2006	778	3	127	71	Once in 6 year	< 5	High
8	2940	1826	8	205	71	Once in 6 year	< 15	Moderate
9	2684	1680	4	151	61	Once in 6 year	< 10	Moderate
10	3446	2421	4	266	64	Once in 3 year	< 15	High
11	1917	1152	2	133	55	Once in 3 year	< 5	High
12	4628	3197	6	392	61	Once in 3 year	< 10	High
13	1229	428	4	82	40	Once in 3 year	Oct-25	Low to high
State Total	34285	21239	70	3365	1398			

Notes: GCA: Gross cropped area; CCA: Culturable command area
Source: SSNNL, Gandhinagar

Government of Gujarat has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The pilot project on Pressurized Irrigation Network System (PINS) is one such effort started in 2007-08. The details of coverage of this programme are presented in Table 3.2. About 25 pilot projects were initiated in the state covering 1029 farmers with 1491.6 ha of CCA and estimated budget of Rs 1306.3 lakh. The project work was carried out by Jain Irrigation Ltd (56%), Parikhit Industries (32.0%), EPC Industries (8.0%) etc (Figure 3.3).

The idea was to promote micro irrigation through water users association (WUA) by providing the basic irrigation infrastructure at the farmers' field. With the PINS programme, a common facility was provided to draw water from the canal and distribute it at farmers' field by imparting necessary pressure required for operating MIS. For encouraging the adoption of MIS, about 75 per cent subsidy was provided to the farmers and necessary credit facilities were also provided to the farmers for purchasing the MIS.

Figure 3.3: Distribution of Agencies Carried Out the Canal PINS in Gujarat

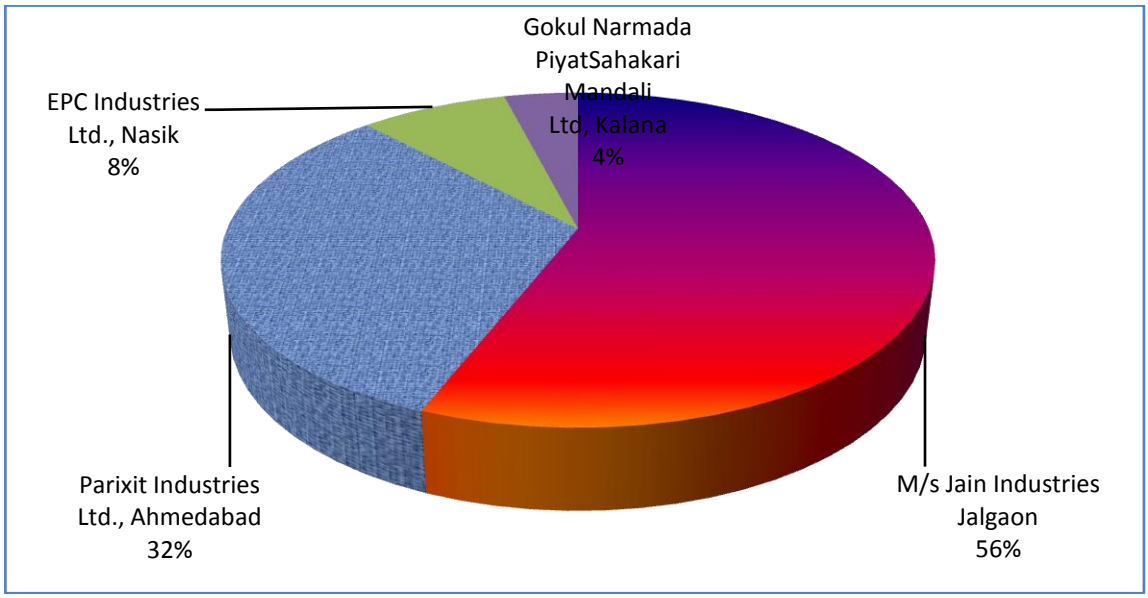


Table 3.2: Status of Implementation of PINS Pilot projects in Gujarat (As on January 2014)

Sr. No	Name of Pilot Project	District	Culturable Command Area in Ha.	Total no. Of farmers	Tendered Cost (Rs. Lakh)	Actual Expenditure (Rs. Lakh)	Status
1	Sutrel	Bharuch	81.3	48.0	71.2	41.6	completed
2	Hinglot-Desan	Bharuch	61.3	36.0	71.2	41.6	completed
3	Tandlaja	Vadodara	41.1	37.0	71.2	41.6	completed
4	Segwa	Vadodara	60.8	45.0	71.2	41.6	completed
5	Moti Mamekpur	Vadodara	43.7	22.0	73.0	45.9	completed
6	Kaliari	Bharuch	36.7	21.0	73.0	45.9	completed
7	Gutal	Vadodara	44.4	20.0	73.0	45.9	completed
8	Chandanpura	Vadodara	46.9	17.0	73.0	45.9	completed
9	KK Direct minor	Gandhinagar	34.9	21.0	35.4	19.9	Withdrawan
10	Bhatera	Kheda	52.9	72.0	35.4	19.9	completed
11	Torna	Kheda	33.0	47.0	35.4	19.9	completed
12	Badarpur	Kheda	56.2	60.0	33.8	26.7	completed
13	Saiyat	Kheda	51.1	24.0	33.8	26.7	completed
14	Andej	Ahmedabad	35.4	18.0	71.8	59.9	completed
15	Keliya-Vasana	Ahmedabad	43.1	66.0	71.8	60.9	completed
16	Rampur	Ahmedabad	60.7	27.0	71.8	61.9	completed
17	Pisawada	Ahmedabad	106.5	75.0	71.8	62.9	completed
18	Deusana	Ahmedabad	52.1	85.0	26.5	21.5	completed
19	Jadavpura	Ahmedabad	55.1	65.0	26.5	21.5	completed
20	Govana	Patan	37.4	33.0	12.2	9.4	completed
21	Dediwada	Mehsana	51.8	63.0	14.2	14.1	completed
22	Kalana	Patan	103.0	NA	98.6	NA*	completed
23	Zanzarkha	Ahmedabad	57.5	10.0	20.1	18.1	completed
24	Khambhalav	Surendranagar	178.5	82.0	52.6	41.2	completed
25	Bharada	Surendranagar	66.2	35.0	17.7	14.9	completed
26	Average	-	59.7	42.9	52.3	35.4	-
27	State Total	-	1491.6	1029.0	1306.3	849.3	-

Source: SSNNL, Gandhinagar

3.2 Estimated Expenditure and Pay Back period on PINS:

It may be noted from Table 3.2 that the average spending on an individual canal PINS in Gujarat varied from Rs 9.4 lakhs to 63.0 lakhs depending on the size of PINS and the pump set installed and length of pipelines used for PINS project. The average spending incurred per PINS was Rs 35.4 lakhs against the estimated Rs 52.3 lakhs. The estimated per hectare expenditure on PINS at Chak level was Rs 20340 (Table 3.3). It may be noted that the case of 24 hrs electric, high voltage distribution system (HVDS)/ express feeder is very cost effective and attractive option. However, 24 hours electricity is to be made available at Chak level i.e. 6 connections per VSA. This can be made possible through HVDS and express feeders. However, the option 2 with power availability of 8 hrs through agri-feeder is highly desirable and cost effective alternative as it is in tune with GOG's policy of power distribution for agriculture in the state and the estimated per hectare expenditure on PINS as per the option 2 was Rs 28740.

Taking the Rs 20340, being the lower, as the average capital cost per hectare on PINS, the payback period on investments made by the farmers on cotton cultivation with adoption of PINS and drip systems varies from 1.7 years to 2.8 years depending on location specific factors in the state (Table 3.4). It may be noted that both farmers and Government were expected to benefit in terms of lower expenses on land and construction and energy consumption. Suppose that the PINS not constructed, the Government and farmers had to spend more amount on minor, sub-minors and field channels to the tune of Rs 13565 and Rs 6220 per hectare, respectively. Because of PINS, the per hectare water savings was estimated to be to the tune of Rs 15000 for *Bhal* and *Bara* areas (mainly saline areas) and Rs 19560 for other zones, respectively. Similarly, considering the wheat crop cultivation, the per hectare savings on account of water savings was estimated to be Rs 8000 for *Bhal* and *Bara* areas and Rs 10480 for other zones, respectively (Table 3.5). The estimates savings for the Irrigation Department has been more than that for farmers because of larger coverage by the Department.

Table 3.3: Cost Effective and Feasible Estimates on PINS at Chak Level

(Rs/ha)

Options	Power Availability	Water sources	Storage With lining	Pipes		Pump House	Pumps Electric	Total capital cost	
				PVC	HDPE			PVC	HDPE
1	24 hrs Electric, HVDS/ Express Feeder	Minors operated at half design discharge for all days	0	10275	14700	3240	2400	15915	20340
2	8 hrs. through Agri. Feeder	Direct lifting from Perennial Canal (MC/BC/ Distry) all along both the banks	0	10275	14700	2000	4800	17075	21500
3	8 hrs. through Agri. Feeder	Pond of 1 day storage and minors operated at half design discharge	6000	10275	14700	3240	4800	24315	28740

Source: Ganapatye (2011).

Table 3.4. Estimates on Expenditure and Pay Back Period on Canal PINS in Gujarat
(Case of Cotton with drip system)

(Rs/Ha)

Particulars	Government		Farmers	
	Bhal and Bara	Other Zones	Bhal and Bara	Other Zones
PINS Cost	20340	20340	0	0
Land & Construction	-13565	-13565	-6220	-6220
Net PINS cost	6775	6775	-6220	-6220
MIS System cost	42000	42000	42000	42000
Energy cost	1659	1659	387	387
Total cost	57209	57209	29947	29947
Water Savings	15000	19560	1700	1700
Yield increase	-	-	10000	18000
Fertilizer Savings			1080	1080
Total Savings	15000	19560	12780	20780
Payback period (Crop seasons)	3.3	2.7	2.8	1.7

Source: Ganapatye (2011).

Table 3.5. Estimates on Expenditure and Pay Back Period on Canal PINS in Gujarat

(Rs/Ha)

Particulars	Government		Farmers	
	Bhal and Bara	Other Zones	Bhal and	Other
PINS Cost	20340	20340	-	-
Land & Construction	-13565	-13565	-6220	-6220
Net PINS cost	6775	6775	-6220	-6220
MIS System cost	9000	9000	9000	9000
Energy cost	1878	1878	438	438
Total cost	17653	17653	3218	3218
Water Savings	8000	10480	900	900
Yield increase	-	-	470	4800
Fertilizer Savings	-	-	-	-
Total Savings	8000	10480	1370	5700
Payback period	2	1.6	2.3	0.5

Source: Ganapatye (2011)

Table 3.6: Estimates of Water & Energy Savings for Cotton with different irrigation set up in Gujarat

Sr No.	Particulars	Tube well-flood	Tube well-drip	Surface flood	Surface drip Vs Tube well-flood	Surface drip Vs Surface flood
1	Water Requirement (cum/ha/annum)	6000	3000	6000	3000	3000
2	No. of Irrigation Days	180	180	180	180	180
3	No. of Irrigation Hours in a year @ 8 Hours per day	1440	1440	1440	1440	1440
4	Average flow per Ha. lps	1.16	0.58	1.16	0.58	0.58
5	Average pumping head	100	140	0	40	40 (addl.)
6	Average HP per Ha.	2.41	1.80	0	0.51	0.48 (addl.)
7	KW	1.79	1.34	0	0.38	0.38 (addl.)
8	Total Energy KWH	2578	1934	0	553	553 (addl.)
9	Energy savings %		25		79	Negative
10	Water savings %		50		50	75% *

Note: Including reduction in conveyance losses.
Source: Ganapatye (2011)

3.3 Bottlenecks in Adoptability of Canal PINS:

The discussions with different stake holders reveal that, though the Government of Gujarat followed a proactive approach to increase the adoption of PINS by the water users, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to various reasons. The farmers did not want to change the cropping pattern which was highly water intensive. They did not want to spend anything on installation of MIS since canal water was available to them plentily almost free of cost. There are no much strict rules and regulations enforced to check the illegal use of canal water and water theft. Unavailability of necessary power network, insufficient power availability in agri-mains and higher costs estimated provided by the MIS suppliers were some of the reasons.

Majority of sample farmers were are marginal with small land holdings who faced difficulties in getting bank loans due to incomplete land documents and other outstanding debts. Farmers having land at favourable locations (canal vicinity) do not find it to be a lucrative proposition.

Besides, there were some constraints from planning, technical and administrative aspects. For some reasons, progress in PINS Pilot Projects was too slow. Diversified nature of work (Civil, Elect., Mech.) and isolated work sites also posed some difficulties in carrying out the implementation work. Most difficult part in the part of Irrigation Department during implementation phase was to convince the farmers to form water users association (WUA) and adopt the MIS in spite of the reluctance of the majority.

Drawback in planning and conflicting policies also contributed to low level of adoption of Canal PINS in the state. The unit of implementation is considered a chak having 50 ha considering 30-50 farmers and the design was carried out assuming that all the farmers under the selected chak will adopt MIS from very beginning which was too optimistic. Some of the assumptions and guidelines were not realistic. For example, it was assumed that, all the farmers under the selected chaks shall compulsorily adopt MIS. However, the partial adoption increased share of beginners that discouraged them to adopt the PINS. Many of the land owners were migrated and have

entrusted agriculture to the Bhagias those don't have financial capability to make such investments. Furthermore, since it was an innovative concept and the implementing agency had no prior experience, the adoption level could not reach to the desirable level.

As far as the conflicting policies are concerned, it may be pointed out that water rates charged by the Govt found to be very meagre. Farmers do not incline to adopt MIS for the water saving. When farmer under the command area is getting ample water [without any restrictions] and that too at the token rates, there is no point to convince him to make investment for saving water. Similarly, the other input, i.e. power supply has been subsidised (based on the Horse Power of connection) and hence farmer cannot be convinced to save either power or electricity.

However, to achieve an optimum level of SSP water distribution, it is imperative to put in place PINS with MIS at Chak level or at sub VSA level of about 100 hectares. The best options to do so are as follows:

i. Direct pumping from perennial canals with 8/24 hrs power supply.
ii. Running the minor at half flow for all days with
iii. One day storage facility and 8/24 hrs power.
iv. To have High Voltage Differential Signaling (HVDS) supply for PINS+MIS at reasonable tariff.

The areas where PINS+MIS is techno-economically not feasible, normal/conventional flow irrigation as per present SSNNL policy may be allowed to continue.

Looking at the unsatisfactory experience of Canal PINS in the state, an attempt was made by the Irrigation Department in devising a suitable solution to address various issues. The main features included promotion of Under Ground Line System (UGPL) Network for micro canals such as Minors, which has been discussed in next section. The combination of UGPLs and PINS replacing Minors, Sub-Minors and FCs has also been put in some places in the state.

Some snapshots on Canal PINS structures on Narmada Canal command area may be seen from Figures 3.4 to 3.9.

Figure 3.4: Intake Well Cum Pump House at Badarpur Minor, Laxmipura

Figure 3.5: Deusana PINS Pilot Project

Figure 3.6: Inlet Arrangement for Canal PINS

Figure 3.7: Intake Arrangement through Tank

Figure3.8: Inside Arrangements and Filtration units for PINS

Figure3.9. Inspection of PINS by the officials

3.4 Under Ground Pipe Line (UGPL) System in Gujarat:

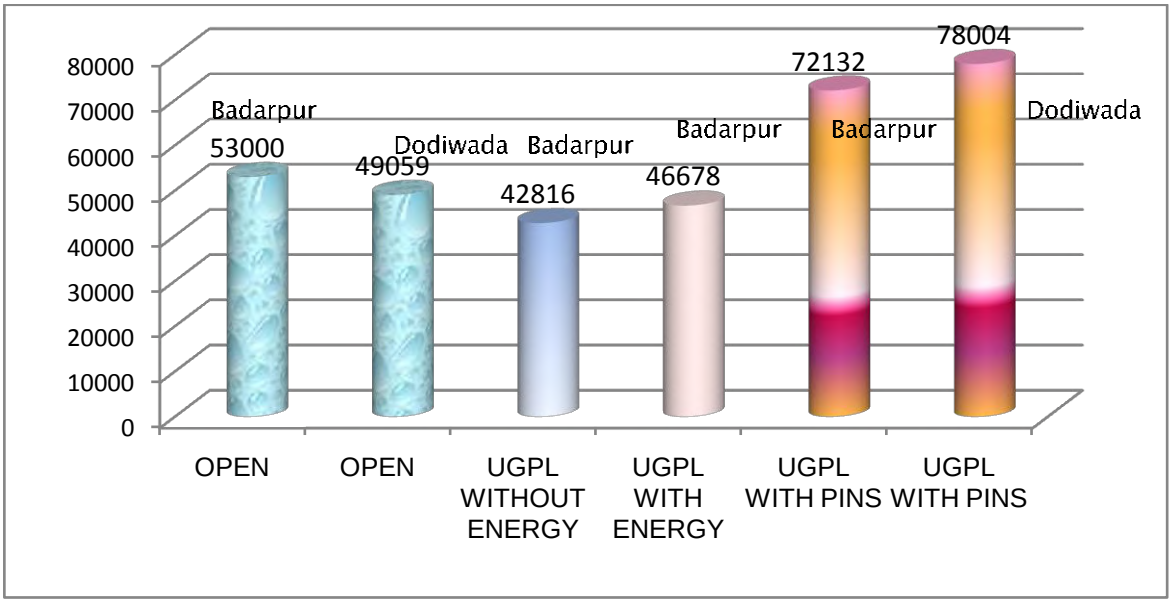
The underground pipeline system (UGPL) facilitates the supply of water through underground pipelines from the minor or sub-minors upto the centre of Chak or sub-Chak from where water distributed to farmers field who can use flood method of irrigation or micro irrigation (Figure 3.10). Since water is flown in pipelines, more pressure than gravity is automatically generated which helps in operation MIS also. Since there is flexibility in using flood method or MIS, the new scheme has been well adopted by some farmers in Gujarat. A UGPL network has a capacity to carry the cumulative requirement of the Chaks served by it. UGPL pipeline infrastructure is used as PINS as well as for conventional irrigation. At the centre of the Sub-Chaks, there is a stand post that facilitates surface irrigation through flexible hose pipes. Wells facilitate housing of pumping machinery for PINS which provides option to the farmers to choose Surface or MIS.

Figure 3.10: Layout of UGPL in Gujarat

Thus, the UGPL system can be combined with PINS for effective management of irrigation water while taking care of farmers' preferences for different cropping pattern. As per a case study conducted by SSNNL,

Government of Gujarat, the estimated per hectare cost for different combinations of UGPL and PINS is presented in Figure 3.11. It may be observed that the per hectare cost for of UGPL and PINS is maximum of Rs 78004 compared to all other combinations. However, it has potential to generate better results too.

Figure 3.11: Estimated per hectare cost for different combinations of UGPL and PINS (Rs/ha)



Source: Ganpatye, 2011.

The progress in UGPL in Gujarat has been presented in Table 3.7. So far, the UGPL work has been completed in 2.58 lakh ha of 5441 Chaks in 61 talukas of the state. Additionally, the UGPL work is in progress in about 3.06 lakh ha covering a total length of pipelines of 88.84 lakh metres in 7164 Chaks which is a record in the history of irrigation infrastructure development in India.

Table 3.7 : Progress in UGPL in Gujarat

Sr. No	Particulars	Unit	Progress made
	Nos. of Taluka	No.	61
1	Preparation of plan and Estimate after consulting farmers at the unit rates of implementing agency	Nos of chak	11580
		Hectare	551253
2	Technical approval of estimate of chaks	Nos of chak	11312
		Hectare	532434
3	Tri party agreement/work order	Nos of chak	8977
		Hectare	422204
	Ongoing works	Nos of chak	8202
		Hectare	344514
4	Detail of Pipes for ongoing works		
	Supplied at site	Nos. of Chaks	7164
		Length(m)	8884117
	Laid (Fix)	Nos. of Chaks	6472
		Hectare	306148*
5	Completion of work	Nos of chak	5441
		Hectare	257701

Note: * A record in the history of Irrigation Infrastructure Development in India
Source: SSNNL, Gandhinagar, Gujarat

The major benefits of UGPL system are the land saving and water saving (up to 10-20%), less implementation period, feasibility even in flood zone/ undulating area, avoidance of land fragmentation, integrating field channels with the sub-minors and less operation and maintenance (O & M) expenditure. However, it has some limitations. It requires energy for lifting operation in some patches. It is suitable mainly for falling topography. It may save the water to the desirable extent since majority of farmers still use flood irrigation.

Moreover, there are some issues in implementation of UGPL in Sub-Minors. Farmers were not willing to pay 10 per cent, their contribution, which was later on reduced to 2.5 per cent. Farmers are continuously growing some crops and hence not willing to allow laying of UGPL. The farmers are demanding for some provision of crop compensation in that case. Pipe suppliers are also unable / not willing to supply in sufficient quantity at reasonable rates. It is becoming difficult to persuade them to maintain regular supply.

According to UGPL Policy 2014 of Government of Gujarat, no restriction of technical options selected for the scheme. The group of

farmers have to decide the alignment of sub minor which is underground and therefore there is no question of land acquisition. However, if open channel is selected by farmers, farmers will be expected to contribute their land. The SSNNL will pay 97.5 per cent of the total cost. The group of farmers is expected to pay 2.5 per cent of the cost as a labour component to the cost of scheme. The purpose is to inculcate a sense of ownership in farmers. The O&M of sub minor will be responsibility of beneficiary farmers of the Chak. Alignment of UGPL and locations of turn-outs is to be decided in consultation with farmers. Tri-partite agreement (beneficiary farmers, implementing agency and SSNNL) has to be signed for each Chak.

3.5. Progress and Expenditure Pattern on Tube well PINS:

Among three types of water sources, tube well is the major source of water for successful PINS operation in the Gujarat state. Tube well PINS have been operating in the state since a long ego as a viable method of irrigation in the state. The Government of Gujarat introduced the policy of pressurized irrigation system in the command area of public tube wells under Gujarat Water Resources Development Corporation (GWRDC). As per the Government norms, Micro Irrigation System (MIS) provided in the command area of 309 tube wells covering 1452 Ha in five districts of the state i.e. Banaskantha, Mehsana, Patan, Gandhinagar and Sabarkantha. The State Government has decided in March 2013 to provide MIS in Government tube wells at 100% Government cost in total nine districts including above five of North Gujarat and Ahmedabad, Surendranagar, Rajkot and Kutch. Accordingly the State Government provided MIS system in 162 tube wells in 2013-14 covering 1531 Ha and 1037 farmers. The MIS works covering 2984 ha of 3780 farmers were in progress in 208 tube wells which was likely to be completed in 2014-15. It was planned to take up and complete MIS in 542 tube wells in 2015-16. Thus, overall 1221 tube wells of nine districts were planned to be provided MIS covering 13982 ha. The latest progress in Tube well PINS Programme is presented in Table 3.8. Till January 2016, a total of 674 tube wells have been covered by GWRDC out of which 54.0 per cent was through government subsidy and remaining 44 per cent were given partial

assistance. Besides, some open wells were adopted by GWRDC for providing irrigation facilities to the farmers, the details of which is presented in Table3.9. Around 907 open wells were also adopted by the GWRDC for utilising for irrigation purposes, out of which 66.7 per cent wells were with PDC.

Table 3.8: Details of Tube well PINS with MIS in Gujarat
(Upto January 2016)

Sr. No.	District	Number of Tube well	Number of farmers	Area Covered (In Ha.)
1	Kutch			
	Through to Partial Assistance	0	0	0
	100% Gov. Subsidy	60	167	395.63
	Total	60	167	395.63
2	Banaskantha			
	Through to Partial Assistance	179	712	717.99
	100% Gov. Subsidy	49	287	488.99
	Total	228	999	1206.98
3	Mehsana			
	Through to Partial Assistance	34	257	221.75
	100% Gov. Subsidy	76	1092	1172.1
	Total	110	1349	1393.85
4	Patan			
	Through to Partial Assistance	57	314	240.42
	100% Gov. Subsidy	76	763	1034.38
	Total	133	1077	1274.8
5	Ahmedabad			
	Through to Partial Assistance	5	20	64.04
	100% Gov. Subsidy	0	0	0
	Total	5	20	64.04
6	Gandhinagar			
	Through to Partial Assistance	25	140	137.87
	100% Gov. Subsidy	68	692	698.95
	Total	93	832	836.82
7	Sabarkantha			
	Through to Partial Assistance	10	69	95.14
	100% Gov. Subsidy	18	126	152.91
	Total	28	195	248.05
8	Surendranagar			
	Through to Partial Assistance	0	0	0
	100% Gov. Subsidy	17	130	298.35
	Total	17	130	298.35
9	Gujarat State			
	Through to Partial Assistance	310	1512	1477.48
	100% Gov. Subsidy	364	3257	4241.31
	Total	674	4769	5718.79

Source: Gujarat Water Resources Development Corporation (GWRDC), Government of Gujarat, Gandhinagar.

Table 3.9: District –wise Distribution of Open wells under GWRDC in Gujarat(up to June 2015)

Sr. No.	District	No. of working open wells	No of open wells with PDC	Total No. of Open wells
1	Ahmedabad	146	238	384
2	Surendranagra	14	90	104
3	Bhavnagar	0	2	2
4	Botad	0	2	2
5	Rajkot	0	1	1
6	Morabi	3	22	25
7	Junagadh	0	2	2
8	Amreli	0	7	7
9	Gandhinagar	101	169	270
10	Sabarkantha	27	76	103
11	Aravalli	1	6	7
	Total Open well of GWRDC	292	615	907

Note: PDC : Polycrystalline diamond compact drill
Source: GWRDC, Government of Gujarat, Gandhinagar

Among different agencies associated with supplying MIS and components of PINS, Jain Irrigation was the major one. It covered about 197 tube wells covering 1388 beneficiaries with 1904 ha of land (Table 3.10). On an average, 09 farmers were covered beneficiaries were covered under each Tube well Water Users Association (TUA) with average area of 11 ha per TUA. The expenditure on Tube well PINS has been presented in Table 3.11. The total expenditure on Tubewell PINS was Rs 2.64 lakhs whereas the expenditure on MIS component was Rs 9.87 for all beneficiaries under a single TUA. The per beneficiary expenses on MIS in a TUA was Rs 1.3 lakh on an average, which includes all components of MIS such as drip, sprinkler and all necessary accessories and pipes.

Table 3.10 : Tube well PINS covered by Jain Irrigation in Gujarat

District name	No of Tubewell (TW) PINS	Total no. of beneficiaries covered	No. of beneficiaries per TW PINS	Total area (In Ha.)	Average area per TW PINS (Ha)
Gandhinagar	25	199	8	201.69	8.1
Sabarkantha	16	121	8	145.89	9.1
Surendranagar	19	151	8	338.82	17.8
Banaskantha	44	241	5	406.21	9.2
Patan	13	188	14	160.63	12.4
Kutch	61	164	3	384.58	6.3
Mehsana	19	324	17	266.22	14.0
Gujarat total	197	1388	09	1904.04	11.0

Source: Jain Irrigation, Vadodara

Table 3.11: Details of Expenses on Tube well PINS in Gujarat

(Rs in Lakh)

District name	Total Expenses per Tube well PINS						
	PINS		MIS		Total		MIS Expenses per beneficiary
Gandhinagar	2.40	(24.4)	7.43	(75.6)	9.83	(100.0)	0.93
Sabarkantha	1.69	(17.2)	8.16	(82.8)	9.86	(100.0)	1.08
Surendranagar	3.78	(19.0)	16.09	(81.0)	19.87	(100.0)	2.02
Banaskantha	1.70	(17.4)	8.06	(82.6)	9.76	(100.0)	1.47
Patan	3.56	(24.4)	11.06	(75.6)	14.63	(100.0)	0.76
Kutch	1.51	(21.3)	5.58	(78.7)	7.09	(100.0)	2.08
Mehsana	3.84	(23.2)	12.71	(76.8)	16.54	(100.0)	0.75
Gujarat total	2.64	(21.1)	9.87	(78.9)	12.51	(100.0)	1.30

Source: Jain Irrigation, Vadodara

3.6 Adoption, Performance and Management of Tubewell PINS by Farmers:

As discussed earlier, the tubewell PINS was popular in several districts in Gujarat whereas the canal PINS was not well adopted by the farmers. It may be seen from Table 3.12 that the majority of farmers (68.7%) had less than 1 ha area under PINS. About 23.3% farmers had the PINS area of 1 to 2 ha, whereas only 1.3 per cent farmers had PINS area more than 4 ha. On the other hand, the marginal farmers had 0.49 ha area under PINS, on an average. The small, medium and large farmers had 1.44 ha, 2.63 ha and 6.0 ha area under PINS, respectively.

Table 3.12: Distribution of farmers according to area under PINS

(Area in Ha.)

Area under PINS	No. of farmers	% farmers	Area under PINS (Ha/hh)
Up to 1 .0 ha.	103	68.7	0.491
1.01-2.0 ha.	35	23.3	1.441
2.01 to 4.00 ha.	10	6.7	2.626
4.01 to more	02	1.3	5.995
Total	150	100.0	0.928

Source: Field Survey.

3.6.1 Details of Adoption of Tubewell PINS with MIS:

Promoting MIS was the main purpose of installing PINS in the selected water scarce districts of the Gujarat state. About 95.3 per cent of sample beneficiary farmers adopted drip whereas the 10 per cent of them adopted sprinkler in the state (Table 3.13). Since the sprinkler system is not very water saving MIS compared to drip system, the same has not been very popular in the state. The average area covered by the farmers under drip and sprinkler was 0.73 ha and 0.46 has per households having access to those systems. The total cost of drip and sprinkler systems was Rs42950 and Rs30133 per household (hh) in the study areas. About 68.7 per cent of beneficiary farmers receiving subsidy with an average amount of Rs 1842 per hh were from marginal farmer category (Table 3.14). On the other hand, only 1.3 per cent of large farmers received the subsidy with an average of Rs 21230 per hh.

Table 3.13: Adoption of Micro Irrigation Systems (MIS) under PINS Programmes

Type of MIS used	No. of farmers used	%.of farmers used	Average area under MIS (Ha./hh)	Total cost of the system (Rs/hh)	Amount paid the farmers (Rs/hh)	Subsidy (%)	Received subsidy from State Government (%)	Agency for the subsidy programme
Drip	143	95.33	0.73	42950	3153.2	92.77	95.3	GGRC
Sprinkler	15	10.00	0.46	30133	2233.3	91.33	10	GGRC

Source: Field Survey.

Table 3.14: Distribution of Farmers according to Subsidy Received on MIS

subsidy received on MIS	Amount paid by farmers (Rs.)	No. of farmers	% farmers
Marginal (Up to 1.0 ha.)	1842	103	68.7
Small (1.01 to 2.0 ha.)	3924	35	23.3
Medium (2.01 to 4.0 ha.)	6875	10	6.7
Large (4.0 to more)	21250	2	1.3
Total	2922	150	100.0

Source: Field Survey.

As revealed from Table 3.15, the major motivating factors for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation (79.3%), better and stable crop yield and farm income (78.0%), saving more water and to cover more area under irrigation (67.3%), facilitating judicious or efficient distribution of water among the water users (54.7%) and avoiding unnecessary conflicts with other farmers (28.7%).

Table 3.15: Factors influencing the adoption of PINS-MIS

(% of total farmers)

Reasons	Most Important	Important	Least Important	Total
To get assured amount of water for irrigation	60.7	18.0	0.7	79.3
To get better and stable crop yield and farm income	46.0	32.0	0.0	78.0
To save more water and to cover more area under irrigation thereby	43.3	22.0	2.0	67.3
To avoid unnecessary conflicts with other farmers	0.7	12.0	16.0	28.7
To facilitate judicious or efficient distribution of water among the water users	14.0	22.0	18.7	54.7
Any other (Free of Cost, Use of less water, Reduce labour cost)	24.7	4.7	3.3	32.7

Source: Field Survey

3.6.2. Impacts of Tubewell PINS on Crop Production, Water Saving and Energy Saving:

The water saving due to judicious use of water (94.0%), increase in agricultural income (86.7%), getting water in right time (88.0%), proper distribution of water among farmers (62.7%), getting more information on how to use water judiciously (56.7%), electricity saving (54.0%) and improved maintenance of the system (26.7%) were the major benefits accrued by the beneficiary water users/farmers (Table 3.16).

The proportion of area under more remunerative Rabi crops was also found to be higher (28.7% of GCA) in case of beneficiary farmers as compared to non-beneficiary farmers. It was observed that, except few crops like groundnut, mung and cumin, beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers. The percentage change in yield under drip over flood and change in yield under sprinkler over flood has been spectacular with respect to some crops like castor

(117.6% and 102.1%, respectively) and cotton (83.1%). Among Rabi crops, major benefits were observed in the case of wheat (by 83.3% and 108.4%, respectively), fennel (55.1%), rapeseed-mustard (59.9%), and tobacco (by 84.6%).

Table 3.16. Benefits accrued from Tubewell PINS

Benefits accrued	No. of farmers agreed	% farmers benefited	Extent of benefit (% increase)
Area under irrigation has increased	78	52.00	21.53
Agricultural income has increased	130	86.67	21.63
Water saving due to judicious use of water	141	94.00	31.65
Electricity saving	81	54.00	28.52
Water arrives in time	132	88.00	
Timely information on release of water from canal	66	44.00	
More information on how to use water judiciously	85	56.67	
proper distribution of water among farmers	94	62.67	
Less conflicts around water or less water theft	33	22.00	
More information on crops and technologies	39	26.00	
Improved maintenance of the system	40	26.67	
Any other (Crop production increased)	2	1.33	

Source: Field Survey.

Among various other benefits, reduction in fertiliser use (84.7%), reduction in weeding cost (88.0%), reduction in labour use (89.3%), cultivated land saved due to less need to construct field channels (42.7%), Less water logging or water salinity (59.3%) and Less pest attack/Reduced use of pesticides (52.7%) were the major socio-economic and environmental benefits accrued by the farmers due to adoption of PINS-MIS.

Some of the factors those helped in generating some benefits were better water management by WUA members (58.0%), better education and awareness of the farmer (43.3%), more area under PINS-MIS (34.0%) and more area during Rabi (37.3%) were the major ones. The results of Probit model indicated that, more area under PINS-MIS, uninterrupted power regular supply, more depth of tubewell, sufficiency of water in PINS and

group membership helped in realising the benefits like increase in yield and income, water saving and energy saving by the beneficiary farmers(Table 3.17).

Table 3.17. Probit Odds ratio of determinants of benefits of PINS with MIS

Explanatory variables	Dependant variables							
	Increase in agricultural yield and income		Water saving		Energy saving		Reduction in fertilizer and pesticide use	
Intercept	-5.89***	(1.935)	-0.741	(1799.000)	0.651	(1.218)	1.147	(1.301)
Age of HH head (Yrs)	0.034	(0.022)	0.094*	(0.049)	-0.010	(0.016)	-0.002	(0.017)
Years of schooling of HH head (Yrs)	0.049	(0.050)	0.144	(0.107)	0.015	(0.038)	-0.005	(0.042)
HH Head's experience in farming (Yrs)	0.006	(0.019)	0.057*	(0.034)	0.002	(0.014)	-0.010	(0.015)
Amount of loan taken (in Rs.)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Group membership other than TUA/ WUA	0.070	(0.403)	0.654	(0.899)	0.699**	(0.277)	0.578*	(0.327)
Land location in the command area of the PINS	-0.292	(0.369)	0.102	(0.647)	0.386	(0.271)	-0.623**	(0.296)
Sufficiency of water	0.668	(0.598)	-6.813	(1799.000)	-0.886*	(0.533)	0.673	(0.495)
Operational area (ha)	0.526*	(0.284)	0.320	(0.598)	0.131	(0.091)	-0.079	(0.104)
Area under PINS-MIS (ha)	0.552	(0.403)	0.175**	(1.088)	0.199	(0.194)	0.174	(0.222)
Horsepower of pumpset	0.029**	(0.013)	-0.018	(0.030)	-0.007	(0.008)	-0.003	(0.009)
Total area under Rabi (ha)	0.590*	(0.316)	-1.95**	(0.881)	-0.056	(0.209)	0.211	(0.266)
Total area under horticultural crops (ha)	-0.351	(0.600)	5.973	(3.733)	-0.517	(0.377)	0.093	(0.427)
More depth of tube well	0.207	(0.495)	0.502	(1.379)	-0.815**	(0.362)	0.433	(0.403)
No interruption in regular supply of power	1.346***	(0.379)	11.690	(505.900)	1.523***	(0.267)	-0.299	(0.291)
Better water management by WUA	0.203	(0.448)	0.075	(1.415)	-0.363	(0.316)	0.288	(0.331)
Number of Observations	150		150		150		150	
Pseudo R^2	0.107		0.145		0.0833		0.064	

Note: Figures in the parentheses indicate standard errors; Signif. codes: *p<0.1, **p<0.5, ***p<0.01
Source: Computed from primary data

The major suggestions provided by the farmers were to impart training to farmers on need, importance and use of MIS with PINS, provide better quality components of MIS so as to reduce the damages caused by rodents (squirrels, rats etc) and insects etc., need to promote fertigation and chemigation, need to take measures to regulate agencies supplying MIS to the farmers and adhering to standard norms on maintaining quality and providing proper and regular services for the repairing of the MIS subsystem within reasonable time limits, need to have more testing facilities for quality

checking of equipments, need to provide the required extension advisory services to the farmers, especially on maintenance and applicability of PINS-MIS for different crops.

Some of the major concerns and suggestions expressed by the non-beneficiary farmers have been also been analysed. Some of their agricultural areas are located very far from command area. Due to scarcity of irrigation water, they depend only on rain water. Thus they demand to increase coverage of PINS to their area. In some cases, due to less land and monetary problems, they didn't want to install drip in their farm, and they used to irrigate by flood method.

3.7 Adoption, Performance and Management of PINS by WUAs:

Among three types of PINS, the average life span UGPL system is highest of about 50 years followed by Pvt tube well (TW) PINS of 20 years and Govt TW PINS of about 19 years. Though there was 25 canal PINS implemented in Gujarat state, none of them were found functional. The feeder irrigation source is mainly tube well for all TW PINS and canal for UGPL. The average area covered under each PINS WUA was 19.2 ha per Pvt TW PINS, 22.2 ha under Govt. TW PINS and 34.6 ha per UGPL (Table 3.18).

As discussed earlier, the total expenditure on Tubewell PINS was Rs 2.64 lakhs whereas the expenditure on MIS component was Rs 9.87 for all beneficiaries under a single TUA. The per beneficiary expenses on MIS in a TUA was Rs 1.3 lakh on an average, which includes all components of MIS such as drip, sprinkler and all necessary accessories and pipes. As far as annual operation and maintenance cost is concerned, the major component of operation and maintenance cost on PINS was electricity charges and repairing/maintenance of tube well/canal pins, accounting for about 54 per cent and 45 per cent of total operation and maintenance cost, respectively (Table 3.19).

Table 3.18. Details of Associated PINS Projects managed by WUAs in Gujarat

Particulars	Govt TW PINS	UGPL	Pvt TW PINS
Average Life Span of the PINS (years)	19.18	50.00	20.00
Feeder irrigation source (% distribution):			
Canal	0.00	100.0	0.00
Tube well	100.0	0.00	100.0
Tank	0.00	0.00	0.00
River	0.00	0.00	0.00
Total Area covered under the PINS Project WUA (Ha./WUA)	22.23	34.6	19.18
Total number of beneficiaries of the Project/WUA (Average)	25.86	47.00	50.00
Nature of the land in the command area of PINS Project(% distribution):			
Very fertile	86.36	50.00	0.00
Moderately fertile	13.64	50.00	100.00
Less fertile due to salinity	0.00	0.00	0.00
Less fertile due to water logging	0.00	0.00	0.00
Less fertile since exposed to erosion/or for any other reason	0.00	0.00	0.00
Type of cultivation practice (%):			
Plots periodically left fallow	0.00	0.00	0.00
Zero or minimum tillage practiced on it	88.00	8.00	4.00
Crops grown during Kharif (2015)(% of WUAs):			
Cotton	91.67	4.17	4.17
Castor	90.48	4.76	4.76
Bajra	83.33	16.7	0.00
Crops grown during Rabi (2015-16) (% of WUAs):			
Wheat	85.71	9.52	4.76
Rapeseed & Mustard	88.24	5.88	5.88
Tobacco	75.00	12.5	12.50

Source: Field survey

Table 3.19 Annual Operation and Maintenance Cost on PINS

(Expenses in Rs)

Heads of expenses	Govt TW PINS		Pvt TW PINS		UGPL	
Electricity Charges	80500	(54.5)	90000	(54.1)	0	(0.0)
Repairing/Maintenance of tube well/canal PINS	64986	(44.0)	75000	(45.1)	5000	(100.0)
Other Expenses	2255	(1.5)	1450	(0.9)	0	(0.0)
Total annual Operation and Maintenance Cost on PINS (Rs):	147741	(100.0)	166450	(100.0)	5000	(100.0)
Frequency of maintenance works undertaken (No/Year):	2		2		0	

Note: The figures in parentheses are the percentages of total.

Source: Field survey

The Irrigation Department or Other related Government departments like Gujarat Water Resources Development Corporation (GWRDC) or Sardar Sarovar Narmada Nigam Ltd (SSNNL) mainly acted as facilitator/catalyst for formation of WUA/TUA in the command areas. It may be noticed that about 95.0 per cent of WUA/TUAs were formed directly by the Government department while remaining 5.0 per cent of WUA/TUAs were formed by the community organisers (Table 3.20). The majority of the water users were satisfied over the facilitators in forming WUA/TUA in case of Govt TW PINS and Pvt PINS.

Table 3.20: Details of PINS-Water Users Association (WUA)/Tube-well Users Association (TUA)

(% TUA/WUA agreed)

Particulars	Govt TW PINS (n=22)	Pvt TW PINS (n=03)	UGPL (n=02)
(a) Who acted as facilitator/catalyst for formation of WUA/TUA:			
Government Department Official	95.5	0.0	100.0
NGO	0.0	0.0	0.0
Community Organizer	4.5	100.0	0.0
Any Other	0.0	0.0	0.0
(b)Satisfaction over the facilitator:			
Good	77.3	66.7	0.0
Average	13.6	33.3	0.0
Poor	9.1	0.0	100.0
(c) Average number of members of WUA/TUA (No/WUA)	11.8	16.7	27.5
(d) Average number of farmers having land in the PINS Command area but did not become the member of WUA (No/WUA):	3.7	0.0	5.0
(e) Number of non-members of WUA/TUA who avails the facilities of PINS Project	13.5	0.0	19.5

Source: Field survey.

Some of the specific activities undertaken by different types of PINS WUA/TUAs have been presented in Table 3.21. Among the major activities, Operation & Maintenance of PINS Project, Deciding the timing of water release, judicious water distribution, Collection of water rates, Collection of per capita operation and maintenance cost were the major activities of Govt. TUAs. However, in case of pvt TUAs, the operation & maintenance of PINS project and dispute settlements were found to be the major activities. In the case of UGPL, operation and maintenance of PINS project and collection of water rates were found to be the major activities.

Table 3.21 Major activities of Govt Tubewell PINS

(% farmers agreed)

Major activities	Most Important	Important	Least Important
Operation & Maintenance of PINS Project	40.9	59.1	0.0
Deciding the timing of water release	18.2	72.7	9.1
Judicious water distribution	86.4	13.6	0.0
Collection of water rates	54.5	31.8	0.0
Collection of per capita operation and maintenance cost	59.1	22.7	0.0
Dispute settlements	0.0	0.0	13.6
Seed or Fertiliser distribution	0.0	0.0	0.0
Produce collection	0.0	0.0	0.0
Money lending to members	0.0	0.0	0.0
Any other	0.0	0.0	0.0

Source: Field survey

The main source of income for these TUAs were annual maintenance fees collected whereas the major heads of expenditures were the Expenditure on electricity bill, repairing expenses, salary expenses. Besides, in case of PINS, the chakrges to Irrigation Department and some miscellaneous expenses were incurred by the WUA/TUAs. The major benefits provided by the WUAs to its members were arrival of water in time, proper distribution of water among farmers, more information on how to use water judiciously, saving of water, electricity and labour cost, improved maintenance of the system and less conflicts around water.

WUAs/TUAs also faced some constraints in management of their associations. Among these constraints, the funds constraints, unavailability of required quantity of water, unavailability of proper maintenance and repairing services and electricity problems are the major ones.

The analysis of the problems faced by the WUAs under different set up has been studied. It was found that the situation has improved a lot in case of Govt- Tube wells PINS such as Inter and Intra village conflicts, labour shortage issues and salinity problem. In case of Pvt-Tube well PINS, the crop yield has improved a lot. In case of UGPL, crop yield has improved but water logging problems have increased.

Chapter IV

Performance of PINS Programme in Rajasthan

4.1 Introduction:

Rajasthan is the largest state of India with high population growth and has agrarian economy with greater drought vulnerability. The status of water in the state is most critical. With more than 10.4 per cent of the country's geographical area, supporting more than 5.5 per cent of the human population and 18.70 per cent of the livestock, the state has only 1.16 per cent of the total surface water available in the country. The 2/3rd of the State constitutes the great Thar desert which is bigger than most of the states except Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Maharashtra. This further aggravates the water crisis. The rural communities in Rajasthan are mainly dependent on rainfed agriculture. Rajasthan has cultivated area of almost 20 million hectares but due to some unavoidable circumstances only about 20 per cent of the total cultivated area is irrigated. The dismal scenario of water availability in the state is compounded further by the following factors:

1. Monsoon period is short with late onset and early withdrawal
2. Average rainfall is 575 mm while 61 percent of the area lies in arid and semi-arid tract. Soil in the area has poor fertility, low water holding capacity and high infiltration rate.
3. A large tract of land is saline and alkaline soil. The south east and eastern part of Aravali range is productive for agriculture purposes having clay loam soil type.

The crops are grown under high risk. The land resources of Rajasthan are peculiar on two counts. Firstly, it has a large desert cover compared to other states in the country. Secondly, the Aravali range of hills make a large part of land barren and it divides the state into two distinct regions. The west of Aravali is arid and semi-arid and the east of Aravali is humid and sub-humid in nature. Out of the total geographical area in the State, even 50 percent is not cultivable and within cultivable land, soil fertility varies considerably across districts. The wide differences in land productivity

indicate the variation in soil health across districts in the State. A relatively large average size of holdings of 3.07 hectare of land is again a manifestation of the less fertile land and soil structure in most of the arid and semi-arid zones in the state. Small and marginal farmers in the state constituted more than 58.4 percent share in total area. On the other hand, farmers with holding size of 10 hectares held 33.33 percent of the total area. This highly skewed distribution of land itself is a major barrier to make effective intervention in the advancement of agriculture.

The ground water condition in the state is quite alarming. The condition has deteriorated in last two decades. The stage of ground water exploitation, which was just 35 per cent in the year 1984, has reached a level of 138 per cent in 2008. Out of 237 blocks in the state, only 30 blocks are in safe category. This calls for immediate remedial measures to address the critical water resources situation in the State. Rajasthan has always been a water deficit area.

4.2 Irrigation Development and Management in Rajasthan:

At present, less than one fourth of the State's area is under irrigation. At the time of independence there was only 1 major irrigation project, 43 medium and 2272 minor projects and the irrigation potential was only 4 lakh ha. By now, there has been healthy growth in irrigation development in the state. There are 104 major and medium irrigation projects and 4786 minor irrigation projects in the State and the irrigation potential created has increased to 28.12 lakh ha. Thus, substantial development in water resources sector, considering the financial, geographical and hydrological constraints, has been made and the irrigation potential created has increased by more than 7 times to 5.64 per cent of the country's total potential as against 2.46 per cent at the time of independence. Still, Rajasthan is the driest state in the country and is water scarce (having per capita water availability below 1000 m3/year) since 1991. With prevailing high growth rate of population, the per capita water availability is going to further reduce to alarmingly low levels implying that the challenges for water sector are much more and severe in the State.

There are 14 defined river basins in the State but Chambal and Mahi are the only perennial rivers. 'Aravali' mountain range divides the state into two distinct physiographies i.e. Eastern & Western Rajasthan. The West of Aravali, mainly forms part of the Great Thar Desert" with average rainfall of 318.7 mm. The Eastern part is comparatively humid and rainfall ranges between 400 to 1000 mm (average 688.7 mm). The average rainfall for the State is about 570 mm. According to the simulation studies carried out for each basin the total internal surface water resources in the State have been estimated as 21.71 BCM (17.6 MAF) at 50per cent dependability as against 19.56 BCM (15.86 MAF) estimated earlier. Apart from this, the total external surface water resources from other States, under various inter-state agreements, are 17.88 BCM (14.5 MAF). It has been assessed that mean annual natural replenishable ground water is 7.413 BCM (6.01 MAF) and total 10.09 BCM (8.18 MAF) of ground water including return flows from irrigated areas, urban and other water utilisation sectors is available in the State.

The main sources of irrigation in Rajasthan are canals, tanks, tube-wells and wells. The net area irrigated by all sources during 2011-14 was 7232.76 thousand hectares as against 6265.74 thousand hectare in 2006-10 showing an increase of 15.43 percent. The following table shows the Net area irrigated with percentage change over the year from 1986-90 to 2011-14 by various sources Wells, Tube-wells and canals are the major sources of irrigation in state. The net area irrigated by open wells, tube-wells and canals together account for 74.20 lakh hectare (about 97.42 percent of the total net area irrigated) in 2011-14.

It can be seen from Table 4.1 that irrigation from canal and open wells has drastically declined from 34.77 per cent and 52.24 per cent in 1986-90 to 25 per cent and 30 per cent respectively in 201-14. On the other hand, the net irrigated area under tube wells has sharply increased from 8.77 per cent in 1986-90 to 42.32 per cent in 2011-14. Thus, the pressure on groundwater exploitation has considerably increased in Rajasthan.

Table 4.1 Net Irrigated area by sources in Rajasthan (1985-86 to 2013-14)

('000 hectare)

Period	Canals	Tanks	Tube- Wells	Wells	Other Sources	Total
1986-1990	1180.48	102.47	297.62	1773.44	40.70	3394.73
	(34.77)	(3.02)	(8.77)	(52.24)	(1.20)	(100.00)
1991-1995	1401.43	194.10	485.76	2312.09	41.39	4434.79
	(31.60)	(4.38)	(10.95)	(52.14)	(0.93)	(100.00)
In 1991-95 Over 1986-90	18.71	89.42	63.21	30.37	1.69	30.63
1996-2000	1546.44	149.76	791.74	2932.08	50.61	5470.64
	(28.27)	(2.74)	(14.47)	(53.60)	(0.93)	(100.00)
In 1996-2000 over 1991-95	10.34	-22.84	62.98	26.81	22.27	23.35
2001-2005	1307.49	58.64	1315.97	2432.54	48.82	5163.48
	(25.32)	(1.14)	(25.49)	(47.11)	(0.95)	(100.00)
In 2001-2005 over 1996-2000	-15.45	-60.84	66.21	-17.04	-3.52	-5.61
2006-10	1620.76	71.28	2221.74	2273.52	78.42	6265.74
	(25.87)	(1.14)	(35.46)	(36.28)	(1.25)	(100.00)
In 2006-2010 over 2001-2005	23.96	21.56	68.83	-6.54	60.62	21.35
2011-2014	1808.07	70.90	3060.83	2177.08	115.85	7232.76
	(25.00)	(0.98)	(42.32)	(30.10)	(1.60)	(100.00)
In 2011-2014 over 2006-10	11.56	-0.55	37.77	-4.24	47.72	15.43
In 2011-14 over 1986-90	53.16	-30.81	928.42	22.76	184.64	113.06

Source: Department of Water Resources, Government of Rajasthan

4.3 Overview of PINS Programme in Rajasthan:

The Government of Rajasthan has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The Pressurised Irrigation Network System (PINS) Programme in Rajasthan is mainly concentrated in two major irrigation projects, i.e., Indira Gandhi Neher Project in Bikaner district and Narmada Irrigation Project in Jalore and Barmer districts. Thus, the main feeder source for PINS programme was canal. No other kinds of PINS such as tube well PINS or private PINS were not available in the selected areas of Rajasthan.

4.3.1 PINS Projects under IGNP:

Under IGNP, the PINS project was started on pilot basis in Bikaner district from 2012-13 and initially only 33000 hectare area was covered. Recently, the Centre has approved around Rs 1,659 crore for PINS projects in the state (TOI, 2016). With these new irrigation projects, around 347.66 lakh hectares of area can be irrigated with sprinkler system in Bikaner, Churu, Hanumangarh, etc. Under these projects under Indira Gandhi Nahar Project (stage-II), sprinkler irrigation systems are proposed for optimum utilisation of available water. Total culturable command area (CCA) of these projects is 3, 47,566 hectares, out of which sprinkler irrigation system has already been established in 27,449 hectares under the pilot project. The duration of these new projects will be from 2015-16 to 2017-18 and the total estimated cost of it is 1,659 crore. The Central government will share Rs 830 crore in the total cost.

The PINS projects under IGNP are being operated in bigger area around 200 to 600 ha in one diggy, whereas the size of PINS project in Narmada Project at Jalore and Barmer are of smaller size of with 90 to 100 hectares. Under Narmada canal, about 2, 35000 hectares area has been irrigated in Sanchore and Chittalwana (Jalore), Gudha malani and Dhorimanna (Barmer) districts. All areas of Jalore and Barmer districts have been benefitted through Narmda Canall where all irrigated areas are with PINS only. There is no flood irrigation allowed in the region which is main reason for successful working of PINS project in these regions. Another reason for success of PINS project in Sanchore area is that the groundwater level is very high and groundwater is salty. Thus, the farmers failed through tubewell irrigation in their field. As the only option, the farmers adopted canal PINS and succeeded in making agricultural prosperity.

4.3.2 PINS Projects under Narmada Canal Project:

The Narmada River Development comprises of multi-state programme for development of hydropower and irrigation through construction of dams and their associated canal network on India's largest river in western part of the country. Government of India constituted a Tribunal named Narmada Water Dispute Tribunal (NWDT) in 1969 to adjudicate the allocation of

Narmada Water amongst co-basin states of Gujarat, Madhya Pradesh, Maharashtra and Rajasthan. The Tribunal issued final award in 1979, as per award issued, the utilizable flow of Narmada Water at *Nava Gaon* village is being shared by 4 co-basin states as stated in Table 4.2.

Table 4.2: State wise Utilizable flow of Narmada Water

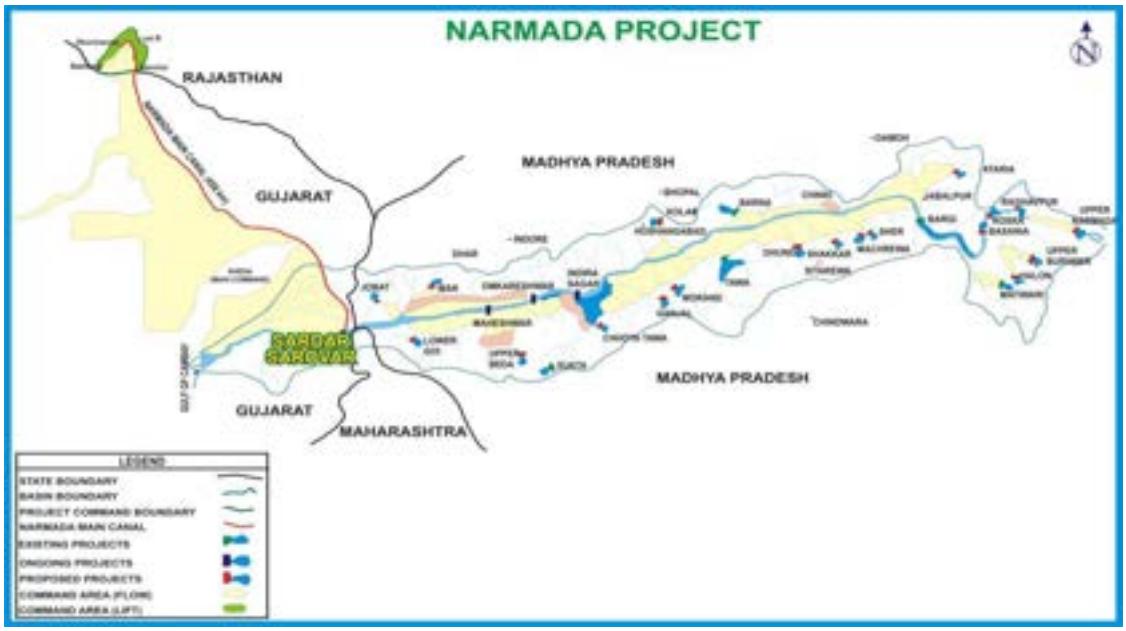
(Million Acre Feet per year)

Sr. No.	States Covered	Utilizable flow of Narmada Water (MAF)
1	Madhya Pradesh	18.25
2	Gujarat	9.00
3	Rajasthan	0.50
4	Maharashtra	0.25
Total		28.00

Source: Office of CE, Narmada Canal Project, Sanchore.

The storage reservoir known as Sardar Sarovar Dam is located in Gujarat, where the Narmada Canal starts, and after traversing 458 km in Gujarat enters Rajasthan near Silu village in Sanchore tehsil of Jalore district (Figure 4.1). The discharge capacity of the canal at the border of Rajasthan is 75 m3/sec. The total length of the main canal in Rajasthan is 74 km. There are 9 major distributaries, and the total length of the main canal, distributaries and secondary canal system totals 1,477 km.

Figure 4.1: Narmada Valley



At the initial stage of Narmada Canal Project, the gap between irrigation potential created in thousand hectares and its actual utilization over the plan period were high. Not only a gap exists between potential created and its utilization but the gap seems to be narrowing over successive plans (Table 4.3).

The share of Rajasthan from the Sardar Sarover Dam in Gujarat through Narmada Main Canal reaches Rajasthan after covering a distance of 458 km. Allowing for losses in transit, the net water availability at entry into Rajasthan is 0.48408 MAF. Out of available water, the amount of water allocated for drinking water and irrigation in the state is 0.1064 MAF and 0.3776 MAF, respectively. The project provides irrigation and drinking water to Jalore and Barmer districts of state, which is part of great Indian Thar desert and draught prone area. As per revised project proposal, the CCA has been enhanced to 2.46 lakh hectares against 1.35 lakh hectares proposed in original project report.

Table 4.3 Potential Created and Potential Utilized under Narmada Canal in Rajasthan

S. No	Year	Command area of project	Irrigable Command Area	Irrigation potential created in Ha.	Irrigation potential Utilized in Ha.	Remarks
1	2006-07	246000	151000	32628	18476.04	Before introduction of canal water
2	2007-08	246000	151000	88093	-	Water released for Rajasthan on 28.03.2008
3	2008-09	246000	151000	133093	10000	
4	2009-10	246000	151000	175093	15000	
5	2010-11	246000	151000	205093	30000	
6	2011-12	246000	151000	216093	80000	
7	2012-13	246000	151000	227093	100000	
8	2013-14	246000	151000	238093	154000	
9	2014-15	246000	151000	239593	214505	
10	2015-16	246000	151000	240193	235000	

Source: Department of Water Resources, Govt. of Rajasthan

About 125 villages of Jalore district and 108 villages of Barmer district were designed to be brought under irrigation with the help of Narmada water (Table 4.4). 874 villages of Tehsill Sanchore, Bhinmal, Jalore town of Jalore district and 667 villages of Barmer district were targeted to be benefited by drinking water supply. Thus, a total of 1541 villages and three towns are

being benefited by drinking water supply from Narmada project. The project is designed to supply irrigation water and drinking water to a target population of 1, 91,500 having an estimated demand of 0.47 Mm3/yr of water.

With Narmada Project in Rajasthan, a total of 2236 diggis/PINS projects were constructed in Jalore and Barmer districts, out of which about 1200 -1250 diggis are presently working. Some diggies are not working due to incomplete PINS project work by the promoting company in some area of Barmer district. On an average, 90-100 hectares area has been covered under each PINS project at Jalore and Barmer.

Table 4.4 Irrigation benefits of Narmada Canal Project

Districts covered	Flow		Lift		Total	
	No. of villages	CCA (in lakh ha)	No. of villages	CCA (in lakh ha)	No. of villages	CCA (in lakh ha)
Jalore	85	1.22	40	0.41	125	1.63
Barmer	11	0.04	97	0.79	108	0.83
Total	96	1.26	137	1.20	233	2.46

Source: Office of CE, Narmada Canal Project, Sanchore

4.3.3 Cost Structure on PINS:

The estimated cost on PINS project in Rajasthan is stated in Table 4.5. The total cost of a PINS project with the capacity to irrigate about 100 hectares including the charges of electricity connections is estimated to be about 37.0 lakhs. Out of the total cost incurred, about 40.4 per cent expenditure was incurred on civil work (Cost of diggy, pump, pump house and boundary wall) and 45 percent on mechanical works.

The Government of Rajasthan has taken an initiative to give subsidy to the farmers to an extent even upto 50 per cent in order to popularize the sprinkler method of water application. Earlier Aluminium was used as piping material. Now days HDPE and PVC pipes are extensively used due to its higher strength, low energy loss due to friction and lower cost. The simple sprinkler set in PINS Project costs around Rs 31498 per set by which the farmer can cover an area not less than 1 ha.

Table 4.5: Cost Pattern on Various Components of PINS

(For CCA of 100 ha; Rupees in lakh)

Sr. No.	Nature of work	Cost	% Share
(A)	Civil work		
	Cost of Diggy	6.18	16.70
	Cost of Sump	1.7	4.59
	Cost of Pump House & Boundary Wall	7.08	19.14
	Total of Civil Work	14.96	40.43
(B)	Mechanical work		
	Cost of 2 Nos. of Motor horizontal centrifugal pumping sets of discharge 12 LPS to 16 LPS including installation & commencement.	3	8.11
(C)	Supplying, laying, jointing, testing and commissioning of HDPE pipe network.	13.54	36.59
	Cost of 100 Ha.	31.50	85.13
(D)	Erection of 11 KV S/C line on 33 KV insulation for 1 km.	4.95	13.38
(E)	Security Deposit for electrification	0.55	1.49
(F)	Total	37.00	100.00

Source: Department of Water Resources, Govt. of Rajasthan

4.3.4 MIS Adoption in Rajasthan:

Sprinklers are the major types of micro irrigation system (MIS those have been able to perform in better way in the desert state. Sprinklers spray water uniformly over the field imitating a rainfall. Though less efficient than drip, its popularity can be attributed to the failure of surface irrigation on undulating land, which is abundant in Rajasthan. Sprinklers were the first irrigation system which had pipes to carry water over the crests and troughs thus doing away with the need for surface levelling. Since 1990-91, government programmes have patronised sprinkler irrigation. In 2005-06, the area under drip and sprinklers was 1614 ha and 54561 ha which has jumped to 28080 ha and 129522 ha in 2011-12 respectively (Table 4.6). No wonder Rajasthan has the highest area (15.14 lakh hectare) irrigated by sprinklers.

An analysis of past year data on source wise irrigation revealed that in 1973-74, tube wells and wells irrigated 53.09 percent area which shot up to 72.70 percent in 2013-14. In 1984, 100 percent blocks were in the "safe" category but by 2013-14, the figure tanked to less than 1 percent. Around

80 percent blocks are overexploited in the state today. In such a scenario, micro irrigation is a necessity as its water use efficiency is 70-90 percent as compared to 35-40 percent in conventional surface irrigation. Currently, drip irrigation is only practised in 2.85 percent of the total irrigated area in the country. In Rajasthan, it is slowly taking root riding piggyback on solar water pumps which are increasingly being used as an energy source for irrigation.

Table 4.6: Physical and Financial Progress for Drip and Sprinkler under Micro Irrigation Scheme in Rajasthan

(Rs. in Crore; Area in Hectare)

Years	Drip (Area Covered)	Sprinkler (Area Covered)	Total Financial Progress for both Drip and Sprinkler*
2005-06	1614	54561	25.18
2006-07	2608	67627	34.71
2007-08	2690	70984	35.70
2008-09	5097	72632	50.97
2009-10	8743	86813	83.23
2010-11	13401	134211	161.60
2011-12	28080	129522	321.04

Note: *: Total financial progress includes central govt. share+ state govt. matching share for drip and sprinkler.
Source : INDIASTAT.com

4.3.5 Performance of PINS in Narmada Canal Command in Rajasthan:

Narmada Canal Project was designed to utilize 0.50 MAF of Narmada water. Initially the project was approved by Planning Commission for Rs.467.53 Crore (1989-90 price level) in 1996 with targeted completion of project up to March 2003. The revised cost of the project amounting to Rs. 1541.36 cr. (at price level 2005) was sanctioned by Planning Commission in 2007 with targeted date of completion up to March, 2013-14. Again cost of project was further re-revised at 2009 price level and sanction of Rs.2481.49 crore was accorded by Planning Commission in 2010 with the direction to complete the project up to March, 2013. Further, the time of completion was again extended up to March, 2015 by Planning Commission in July 2013. The proposal for time extension up to March, 2017 is under consideration with MoWR, New Delhi.

Table 4.7: Performance of Pressure Irrigation in Narmada Canal Project in Rajasthan

S.N	Component	Pressure Irrigation	Gravity Irrigation	Net Increase/Decrease (+/- arks)
(A)	Infrastructure Cost	1541.36 Cr.(2005 price level) and revised cost 2481.49 Cr. At (2009 price level)	467.58 Cr. (1989-90 price level) original cost and revised cost would be 1134 cr. on 2015 price level.	Cost increased 1347 cr. more in addition
1	CCA	2.46 lac Ha with 61% intensity of irrigation	1.35 lac Ha. With 54 % intensity of irrigation	1.11 lac Ha. CCA increased
2	Nos. of Villages benefited by irrigation	233	89	144 more villages additionally benefited
3	Village benefitted for drinking water	1541 villages & 3 Towns (874 villages,3Towns of Jalore &667 villages of Barmer district	124	By saving of water 1417 villages and 3 towns are additionally benefited for drinking water
4	Length of main canal	74 km.	74 KM	No Change
5	Length of distributaries	385 km.	1403km	Length decreased by 1018 km.
6	Provision of mono block	4472 Nos.(two mono block at each pump room)	Not Proposed	4472
7	Laying of HDPE pipe line	HDPE is laid in entire CCA i.e. 2.46 lac ha.	Not Proposed	2.46
8	Formation of WUA (For formers participation in irrigation and water management	2236 Nos.(at each diggi level)	Not Proposed	2236
(B)	Cropping	Area in Ha.	Area in Ha.	
1	Main crops in Ha:			
	Kharif	47669	Not Proposed	
	Rabi	103412	74190	
	Grand Total	151081	74190	
(C)	Area Benefitted	2.46 lakh ha	1.35 lakh ha	1.11 lakh ha(82.2%)
(D)	Gross Production	314306 tonnes	228555 tonnes	85751 tonnes (37.5%)
(E)	Value of food produced on market value for the year 2014	Rs 1480 Cr.	Rs 534 Cr.	Rs 946 Cr. (277%)
(F)	Quantity of water used	2.2cs/1000 acre	7.40cs/1000 acre	5.20cs/1000 acre
(G)	Intensity of Irrigation	1.Area submerged in monsoon(ned Area)40%, 2.Area under gravity canal 70%, 3.Area under Lift canals60%	55%(only Rabi)	

Source: Department of Water Resources, Government of Rajasthan

As stated in Table 4.7, the adoption of PINS with sprinkler irrigation system in place of conventional irrigation method in Narmada command area in Rajasthan has resulted in widespread benefits as discussed below:

- The CCA has increased from 1.35 lakh hectares to 2.46 lakh hectares i.e.an increase by 78 per cent.
- The number of villages benefitted for irrigation has increased from 89 to 233.
- Drinking water facility has been provided in 1541 villages and 3 towns which was not available before.
- 5.20 cusec of water is saved per 1000 acre in sprinkler Irrigation method as compared to Convention method.
- 2236 Water User Associations have been formed for promoting farmers' participation in irrigation and water management, which did not exist earlier.
- The value of food production has been assessed to increase from Rs 534 crore to Rs 1480 crore, i.e. by Rs 946 crore (277%) during the year 2013-14

Impact of PINS on Cropping Pattern

New cropping pattern was proposed for the beneficiaries keeping in view the nature of soil, groundwater conditions, climatic conditions and the existing crops under cultivation in the project area. Care was taken to select only those crops, which are resistant to salinity and less water consuming so as to restrict the recharge to the groundwater and to properly address the likely salinity problems upon application of irrigation water. In addition to the general crops being sown in the command area, certain new potential crops have also been introduced, which are suitable for the area and are also remunerative.

Crops already being grown under well-irrigated condition during Rabi with sprinkler/underflow system of irrigation are (i) wheat, (ii) cumin, (iii) mustard, (iv) gram and (v) isabgol. Barley/oats are being raised for green fodder purpose. In 'Ned' area, mostly wheat used to be grown after the recede of floods in some years. However, floods have not been experienced

in the 'Ned' area for the last one decade due to deficient rainfall and construction of number of dams in the upper reaches.

Table 4.8 Impact of PINS on Cropping Pattern in Sanchore Tehsil of Jalore district

(Area in ha)

Crops	2000-01				2010-11				% Change in 2010-11 over 2000-01		
	Irri Area	Unirri Area	Total Area	% to GCA	Irrigated Area	Unirrigated Area	Total Area	% to GCA	Irrigated area	Unirrigated area	Total area
Bajra	2810	141877	144686	59.8	2840	118021	120861	37.8	1.1	-16.8	-16.5
Jowar	83	411	494	0.2	21	2033	2054	0.6	-74.7	394.6	315.8
Maize	0	21	21	0.0	2	5	7	0.0	-	-76.2	-66.7
Wheat	4519	22	4541	1.9	5607	832	6439	2.0	24.1	3681.8	41.8
T Cereals	7579	142354	149933	62.0	8623	121298	129921	40.6	13.8	-14.8	-13.3
Gram	0	6	6	0.0	0	0	0	0.0	-	-100.0	-100.0
Moong	33	923	956	0.4	5	3232	3236	1.0	-84.8	250.2	238.5
Moth	165	7476	7641	3.2	80	21563	21642	6.8	-51.5	188.4	183.2
Total Pulses	255	8556	8811	3.6	258	24874	25132	7.9	1.2	190.7	185.2
R&M	3989	21	4010	1.7	10721	5296	16017	5.0	168.8	25119.0	299.4
Castor	6058	1734	7792	3.2	11008	484	11491	3.6	81.7	-72.1	47.5
Sesamum	45	36	81	0.0	2	111	112	0.0	-95.6	208.3	38.3
Niger-seeds				0.0	15610	1026	16635	5.2	-	-	-
Other oilseeds	3970	63	4033	1.7	511	40475	40985	12.8	-87.1	64146.0	916.2
Total Oilseeds	14066	1855	15921	6.6	38003	47404	85406	26.7	170.2	2455.5	436.4
Cumin	20227	105	20332	8.4	30074	136	30210	9.4	48.7	29.5	48.6
Total spices	20266	108	20374	8.4	32057	306	32363	10.1	58.2	183.3	58.8
Isabgol	23673	378	24052	9.9	18156	29	18186	5.7	-23.3	-92.3	-24.4
All veg	63	1470	1533	0.6	23	6033	6055	1.9	-63.5	310.4	295.0
Fodder and green manure crops	1049	20228	21277	8.8	833	21774	22608	7.1	-20.6	7.6	6.3
Guar	593	20144	20738	8.6	20	6027	6046	1.9	-96.6	-70.1	-70.8
All crops	67024	174951	241975	100.0	98120	221734	319854	100.0	46.4	26.7	32.2

Source: District Agriculture Officer, Jalore district, Rajasthan

In addition to aforesaid crops being grown under irrigated conditions, certain other crops were proposed which were not only agro-climatically suitable but also had high commercial and/or export values. The crops proposed were groundnut, castor, tomato, fruits (date palm, goose berry, pomegranate etc.) and bajra (fodder) in Kharif. Among Rabi crops were wheat, mustard, cumin, gram, isabgol, pea (green), oats (fodder). These crops have potentiality of giving high yield when recommended package of practices are adopted. Comparatively being more remunerative, these crops provide higher returns.

Majority of farmers in the region were benefitted by adopting new cropping pattern, even with increased cost of cultivation due to adoption of sprinkler system of irrigation. It may be noted from Table 4.8 that after PINS intervention, the share of cereal crops in the cropping pattern has declined by 13.3 per cent, whereas the share of pulses, oilseeds, spices and vegetables has increased significantly. The share of pulses, oilseeds, spices and vegetables has increased by 185.2 percent, 436.4 per cent, 58.8 per cent and 295.0 per cent, respectively. Overall, the GCA has increased by 32.2 per cent due to benefits of PINS projects in the Sanchore region of Jalore district.

Most of the new crops were tolerant/moderately tolerant to salinity. In case of 'Ned' area/salinity affected area, groundwater table has potential to rise in due course of time with the introduction of canal in the area. In that case, the saline groundwater would create serious problems of salinity, adversely affecting the production. Therefore, rise of groundwater need to be restricted by utilising groundwater for irrigation for certain salinity tolerant crops like rapeseed & mustard, *Kharchiya* variety of wheat etc. On the other hand, this area requires more canal irrigation water for cultivating other crops and get higher crop yields.

4.4 Adoption, Performance and Management of PINS by Farmers:

4.4.1 Average Area and Cost of PINS Project

It may be seen from Table 4.9 that only 16.0 per cent farmers had PINS area less than 1 ha. About 32.5 per cent medium and large farmers had area under PINS. On the other hand, the marginal farmers had 0.71 ha area under PINS, on an average. The medium and large farmers had 4.59 ha and 8.76 ha area under PINS respectively. The amount spent on PINS was very meagre (Rs 5515) by the sample households since the entire infrastructure was developed with government funding (Table 4.10). Only farmers had to spent on MIS. However, some farmers had to pay one time amount at the time of installation of PINS and formation of WUA.

Table 4.9: Distribution of farmers according to area under PINS

(Area in Ha.)

Area under PINS	No. of farmers	% farmers	Area under PINS (Ha/hh)
Up to 1 .0 ha.	32	16.0	0.71
1.01-2.0 ha	54	27.0	1.50
2.01 to 4.00 ha	49	24.5	2.79
4.01 to 6 ha	27	13.5	4.59
6.01 and more	38	19.0	8.76
Total	200	100.0	3.49

Source: Field Survey.

Table 4.10 Amount Spent on PINS Project

Farmer category	Amount spent in Rupees (per/hh)
Marginal (Up to 1 .0 ha)	569
Small (1-2)	771
Semi-medium (2-4)	4238
Medium (4-6)	10233
Large (> 6 ha)	14713
Total	5515

4.4.2 Details of Adoption of Canal PINS with MIS

Promoting MIS was the main purpose of installing PINS in the selected water scarce districts of the Rajasthan state. It may be noted from Table 4.11 that about all sample beneficiary farmers had adopted sprinkler whereas only 1.0 per cent of them had adopted drip system in the state. Since the sprinkler system is very useful on sandy topography in Rajasthan, the same has been very popular in the state. The average area covered by the farmers under sprinkler and drip was 3.63 ha and 0.02 ha per households having access to those systems. The total cost of sprinkler and drip systems was Rs 265000 and Rs 60820 per household in the study areas. It was found the average subsidy amount received by the farmers was only 15 per cent on sprinkler and 70 per cent on drip. Jain Irrigation was the main agency in Rajasthan who had supplied MIS to the farmers under various subsidy norms.

Table 4.11 Adoption of Micro Irrigation Systems (MIS) under PINS Programs

Type of MIS used	%.of farmers used	Average area under MIS (Ha/hh)	Total cost of the system (Rs/hh)	Amount paid the farmers (Rs/hh)	Subsidy (%)	Who gives the subsidy*
Drip system	1	0.02	265000	79500	70.0	State Govt
Sprinkler	100	3.63	60820	51683.5	15.0	State Govt
Others (specify)	-	-	-	-	-	-

Source: Field survey

As depicted from Table 4.12, the major motivating factor for the beneficiary farmers for adoption of PINS-MIS was to get assured amount of water for irrigation since a majority of farmers (57.0%) considered it as a most important motivating factor. The major factors such as better and stable crop yield and farm income, saving more water and to cover more area under irrigation, facilitating judicious or efficient distribution of water among the water users and avoiding unnecessary conflicts with other farmers were considered as important factor (though not most important factors) by the farmers.

Table 4.12 Factors influencing the adoption of PINS-MIS

(% of total)

Reasons	Most Important	Important	Least Important	Total
To get assured amount of water for irrigation	57.00	36.50	6.50	100.00
To get better and stable crop yield and farm income	36.50	63.00	0.50	100.00
To save more water and to cover more area under irrigation thereby	11.50	85.50	3.00	100.00
To avoid unnecessary conflicts with other farmers	9.50	50.50	40.00	100.00
To facilitate judicious or efficient distribution of water among the water users	12.50	66.50	21.00	100.00
Any other (please specify)	-	-	-	-

Source: Field survey

4.4.3 Impacts of Canal PINS on Crop Production, Water Saving & Energy Saving

Different benefits accrued by the beneficiary farmers by participating in WUA are presented in Table 4.13. The increase in area under irrigation (100%), increase in agricultural income (99.0%), water saving due to judicious

use of water (97.5%), getting water in right time (88.0%), timely information on release of water from canal (82.5%), proper distribution of water among farmers (68.0%), getting more information on how to use water judiciously (56.7%) and electricity saving due to use of shared pump sets attached with PINS (58.0%) were the major benefits accrued by the beneficiary water users/farmers. It may be noted that the extent of water saving, electricity saving, increase in irrigated area and increase in farmers income due to adoption of PINS-MIS was 39.2 per cent, 39.4 per cent, 58.5 per cent and 44.7 per cent, respectively.

It may be noted that proper distribution of water among farmers and less conflicts around water or less water theft were some of the major goals behind joining the WUA. However, there were some issues within the command area of WUA that did not allow equitable distribution of canal water among the water users. The location of plot in the command area of the PINS project was one such issue that led to insufficient supply of irrigation water to some water users. About 39.0 per cent of farmers were having the land in tail end region and about 55.5 per cent farmers complained about not getting sufficient water throughout the year. More than six months a year, farmers did not get any canal water for irrigation.

Table 4.13 Benefits Accrued from Adoption of PINS-MIS

Benefits accrue	% farmers benefited	Extent of benefit (% increase)
Area under irrigation has increased	100.0	58.53
Agricultural income has increased	99.0	44.67
Water saving due to judicious use of water	97.5	39.22
Electricity saving	58.0	39.44
Water arrives in time	80.5	NA
Timely information on release of water from canal	82.5	NA
More information on how to use water judiciously	61.0	NA
proper distribution of water among farmers	68.0	NA
Less conflicts around water or less water theft	45.5	NA
More information on crops and technologies	38.0	NA
Improved maintenance of the system	28.0	NA

Source: Field survey

The share of irrigation cost including the annual operation and maintenance costs incurred by farmers on PINS and MIS was found to vary from 1.6 per cent to 7.8 per cent of total cost of cultivation of major crops during Kharif and from 2.6 per cent 11.1 per cent during Rabi.

As far as area and yield impacts are concerned, it was found that the average yields as well as area under majority of crops are higher in case of beneficiary compared to non-beneficiary households. Overall, 12.3 per cent more area was cultivated by the beneficiary households. Among Rabi crops, the beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers in case of crops like gram, isabgul and cumin. Among summer crops, the beneficiary farmers got better crop yields as compared to non-beneficiary farmers in case of crops like bajra and fodder crops. However, in case of some cereals like wheat and other spices like coriander, non-beneficiary farmers got marginally better yield, on an average. This may be attributed to applying abundant amount of canal water by flow method by some of non-beneficiary farmers close to canal command compared to relatively less water supplied by a large number of beneficiary farmers through sprinklers.

So many other benefits have been accrued to the beneficiary farmers because of adoption of PINS-MIS. Some of them were cultivated land saved due to less need to construct field channels (64.0%), reduction in fertiliser use (84.7%), reduction in weeding cost (52.0%), reduction in labour use (57.0%), Less water logging or water salinity (59.3%) and less frequency of maintenance due to adoption of PINS-MIS compared to conventional flow irrigation (44.0%), reduction in migration of family members due to more availability in water (61.0%), and increase in social cohesion among the water users/villagers in managing the water (27.5%).

The major problems faced by the farmers were insufficient electricity for operation of PINS (60%), inadequate water availability (37.5%), difficulty in getting subsidy for MIS system (26%) and the problems related to operation and maintenance of the PINS-MIS system. Thus, the farmers suggested that the subsidy may be provided to set up solar unit with PINS so that water can be provided to farmers when electricity is not available for irrigation. Farmers also emphasized that they should be given more subsidy on MIS,

especially sprinkler systems since they purchase pipe and nozzle from local market with fairly high price.

Some of the major concerns and suggestions expressed by the non-beneficiary farmers have been also been analysed. Most of the non-beneficiaries are the tail end farmers where irrigation water don't reach. Thus, they have suggested to install more number of PINS and reduce the number of farmers per PINS-WUA, thus would help in proper distribution of water among the farmers irrespective of location of plots in the command area of PINS (51%).

4.5 Adoption, Performance and Management of PINS by WUAs:

The feeding source for all PINS in Rajasthan was canal. Other sources such as tubewells, rivers etc. were non-existent among sample WUAs. The average life span of the PINS system was highest of about 24.4 years. All the PINS systems were constructed on minor or sub-minor of Indira Gandhi Canal in Bikaner or Narmada Canal project in Jalore and Barmer. The average area covered under each PINS WUA was 246.8 ha per PINS and the average number of beneficiaries covered was 84 (Table 4.14). The size of PINS was much larger in Bikaner, followed by Barmer and Jalore.

As discussed earlier, the total expenditure on canal PINS was estimated to be Rs 37 lakhs. Among different components of PINS, the civil works including cost of diggi, sump, pump house and boundary wall constituted about 40.43 per cent of the total cost. The entire cost on PINS equipments and installations was borne by the state Govt. The beneficiary farmers only had to pay the operation and maintenance cost.

The major component of operation and maintenance cost on PINS was electricity charges and repairing/maintenance of canal PINS, accounting for about 46.24 per cent and 35.8 per cent of total operation and maintenance cost, respectively (Table 4.15). Among other expenses, salary, charges to Irrigation Dept, the travel expenses of office bearers and office stationeries etc accounting for about 18.0 per cent of total operation and maintenance cost. Some members of WUA could not pay regularly the operation and maintenance costs of PINS that posed difficulties for the WUA office bearers in managing the WUA. The major reasons of non-payment were insufficient

water that they got through the PINS and the dissatisfaction over the bad maintenance of the system resulting in more frequent number of repairing of PINS.

Table 4.14. Details of Canal PINS Projects managed by WUAs in Rajasthan

Particulars	Bikaner district	Jalore District	Barmer District	State Average
Average Life Span of the PINS (Years)	25	24.71	22.5	24.42
Feeder irrigation source (% distribution):				
Canal	100	100	100	100
Any other	–	–	–	–
Type of the irrigation project (% distribution):	–	–	–	–
Major	–	–	–	–
Medium	–	–	–	–
Minor	100	100	100	100
Total Area covered under the PINS Project WUA (Ha)	897.8	88.5	106.0	246.2
Total number of beneficiaries of the Project/WUA	207	45	99	84
Nature of the land in the command area of PINS Project(% distribution):				
Very fertile	40.0	11.8	25.0	19.2
Moderately fertile	60.0	41.2	50.0	46.2
Less fertile due to salinity	0.0	5.9	25.0	7.7
Less fertile due to water logging	0.0	17.6	0.0	11.5
Less fertile since exposed to erosion/or for any other reason	0.0	23.5	0.0	15.4
Crops grown during Kharif (2015):				
Kharif crop1	Guar	Bajra	Bajra	Bajra
Kharif crop 2	Moth	Guar	Guar	Guar
Kharif crop 3	Bajra	Castor seed/ Moong	Castor seed/Moong/ Moth	Castor /Moth
Crops grown during Rabi (2015-16)				
Rabi crop1	Gram	Cumin	Cumin	Cumin
Rabi crop 2	Wheat	Isabgol	Isabgol	Isabgol
Rabi crop 3	Rapeseed & Mustard/Isabgol	Wheat/Rapeseed & Mustard	Wheat/Rapeseed & Mustard	Wheat/Rapeseed & Mustard

Source: Field survey

Table 4.15 Annual Operation and Maintenance Cost on PINS

Heads of expenses	Rs per WUA	% to total
Electricity Charges	57221.2	46.2
Repairing/Maintenance of tube well/canal PINS	44420.0	35.8
Others (salary, charges to Irrigation Dept, miscellaneous)	22307.0	18.0
Total annual Operation and Maintenance Cost on PINS	123948.2	100.0
Frequency of maintenance works undertaken (Number/Year)	3.6	

Source: Field survey

The Irrigation Department mainly acted as facilitator/catalyst for formation of all WUAs in the command areas. The majority of the water users were satisfied over the facilitators in forming WUAs. The number of members of WUA was 84, out of which 39 members (46%) did not join the WUA. Those who did not join the WUA expressed various reasons for not joining the WUA. About 28.2 per cent of them expressed that they are not able to put pipelines due to not getting loan, since they don't have land. About 33.3 per cent of them expressed that they stay in other chaks they don't want to cultivate their land due to long distance (average 70-75 km).

Among the major activities of WUA, operation & maintenance of PINS Project, deciding the timing of water release, judicious water distribution, collection of water rates, collection of per capita operation, maintenance cost and dispute settlements were the major activities of WUAs (Table 4.16). The main sources of income for these WUAs were annual maintenance fees and annual electricity fees collected whereas the major heads of expenditures were the expenditure on electricity bill, repairing expenses, salary expenses. Since none of them got any assistance from Govt, about 96 per cent of the WUAs wanted to get assistance from Government for operation and maintenance of PINS project.

Table 4.16. Major activities of PINS WUA

(% farmers agreed)

Major activities	Most Important	Important	Least Important
Operation & Maintenance of PINS Project	92.31	7.69	0.00
Deciding the timing of water release	84.62	15.38	0.00
Judicious water distribution	80.77	19.23	0.00
Collection of water rates	80.77	19.23	0.00
Collection of per capita operation and maintenance cost	61.54	34.62	3.85
Dispute settlements	50.00	42.31	7.69
Seed or Fertiliser distribution	3.85	3.85	92.31

Source: Field survey

There were some members of WUA who could not pay their due in time. Some of the major reasons of the non-payment were found to be (i) not getting enough water, (ii) dissatisfaction with maintenance of the system and incomplete PINS construction work, (iii) crop failure due to pest attack and other reasons and (iv) poor financial position.

The major benefits provided by the WUAs to its members were arrival of water in time, proper distribution of water among farmers, more information on how to use water judiciously, saving of water, electricity and labour cost, improved maintenance of the system and less conflicts around water. The crop yield has improved significantly during post-WUA situation with about 81 per cent WUAs reporting higher yield compared with pre-WUA situation. The average irrigated area has increased from 36.9 ha per WUA during pre-WUA situation to 228.2 ha during post-WUA situation, by more than 06 times, while the returns from agricultural production has increased by more 04 times during post WUA situation compared with pre-WUA situation.

As far as the sufficiency of irrigation water is concerned, only 23 per cent of WUAs agreed that they are getting sufficient water throughout the year after formation of WUA. Normally they get the canal water for about 5 months during Rabi while, during Kharif, they depend on rainfall. Some of them could be able to provide life saving irrigation during Kharif as well.

Among the constraints faced by the WUAs, the funds constraints, unavailability of required quantity of water, unavailability of proper maintenance and repairing services, Poor participation of WUA members and incomplete PINS work are the major ones. The analysis of the problems faced by the WUAs reveals that that the situation has improved a lot during post WUA situation compared to pre-WUA situation with respect to crop yield, area irrigated and inter and intra village conflicts.

Chapter V

Performance of PINS Programme in Maharashtra

5.1 Introduction

In Maharashtra state, there are three types of PINS projects viz., - government supported (100% government funded), cooperatives (partially funded by government and managed by group of farmers) and private (owned by individual farmer). There are government PINS (govt PINS) and cooperative PINS (coop PINS) in Buldhana, Kolhapur, Sangli and Yavtmal districts, while private PINS (pvt PINS) are spread across many districts, with high penetration in districts like Nashik and Ahmednagar. There are defunct PINS in Pune and Ahmednagar districts. We have observed poly-house cultivation under the pvt PINS, hence these types of few schemes are also included in the sample. Therefore, for this study we have selected seven districts from these districts. The Maharashtra state has mostly distribution systems with flow/gravity canal irrigation, as such there are no PINS+MIS under canal irrigation. The state govt has recently decided to introduce pipe distribution system on all irrigation projects, which is expected to work on gravitational head (i.e. the head available at site, and not head under the pressurized system). However, gravitational pipe distribution may not be feasible everywhere and we feel that lifting of water (PINS) would be unavoidable in future.

In the state, the sources of water for PINS are river, tube well, dug well, and storages by weirs, dams etc. Hence, PINS project under study were selected from both surface irrigation command areas (tank and river) and groundwater irrigation command areas (tube well and dug well). Beneficiary households (households having access to irrigation water from govt PINS, Coop PINS and Pvt PINS) were selected from the sample districts. To facilitate comparison, non-beneficiary households from adjacent areas of PINS were covered. Data was collected from (i)PINS project operators and the associated Water User Associations (WUAs), (ii)farmers/water users with PINS-MIS or PINS with flood irrigation, non-beneficiary households having no access to PINS-MIS; but having access to surface/flood irrigation around the PINS

project area (iii)implementing agencies/companies and (iv)concerned government departments.

5.2 Irrigation Development and Management in Maharashtra:

The Maharashtra state is having history of use of one of the oldest (200-300 years old) community based method of irrigation *Phad irrigation*. In this method water is diverted in to the farm from the river, canal or *nala* by creating *bandharas* or wier in these water sources (Patil&Belsare, 2011).The state of Maharashtra was formed on 1st May 1960, before the formation of the state, the irrigation development was progressive in the state as compared with other states, this can be seen from the number of dams created before the state was formed, around 75 dams were created (WRIS, 2016). Before 1960, the water was the subject under the department of public works, which was divided in to irrigation department and building and communication department, the irrigation department was renamed as the water resource department in 2004 (WRD, 2016).The state of Maharashtra is having 22.5 Mha cultivable area, from this around 40% area is drought prone area and 7% is flood prone (MWRRA, 2016, WRD, 2016). The crated irrigation water potential in 1960 was 0.39 Mha, which is increased to 12.6 Mha, of which 4.1 Mha is based on ground water and 8.5 Mha is based on surface water (WRD, 2016).Maharashtra state is also one of the leading states in adoption of the drip and sprinkler irrigation methods.

The Maharashtra state has been divided into five river basins: Godawari, Tapi, Narmada, Krishna and west flowing rivers. The Table 5.1 summarizes the river basins in Maharashtra. The biggest river basin in the state is Godawari with geographic spread of 15.43 Mha, which is 50% of the geographic area of the state and 11.3 Mha culturable area. The total annual average availability of water in the state is 163820 million cubic meter (Mcm). The 75% dependable yield is 131562 Mcm. While the permissible use of water for the state is 125936 Mcm, as per the decisions of the various central govt appointed tribunals.

Table 5.1: River Basins in Maharashtra

Sr. No.	Name of Basin	Geographical area (Mha)/ Percent of Area w.r. to Maharashtra	Culturable area (Mha)	Annual Average Availability (Mcm)	75% Dependable yield (Mcm)/ Percentage with respect to state	Permissible use as per Tribunal award / committee report (Mcm)
1	Godawari	15.43/49.5%	11.25	50880	37300/28.35%	34185
2	Tapi	5.12 /16.7%	3.73	9118	6977/5.30%	5415
3	Narmada	0.16/0.5 %	0.06	580	315/0.24%	308
4	Krishna	7.01/22.6%	5.63	34032	28371/21.56%	16818
5	West Flowing	3.16/10.7%	1.86	69210	58599 /4.54%	69210
	Maharashtra	30.80/100.0%	22.53	163820	131562 /100%	125936

Source: Maharashtra Water Resources Regulatory Authority

The projects related to irrigation water in the state are mainly divided as projects under the water resource department and minor irrigation local sector and Zilla Parishad. Further the projects under water resource department are classified as major and medium projects and minor project under state sector. The projects under minor irrigation local sector are Kolhapur type weirs (K.T. weirs), percolation tanks, lift irrigation, minor irrigation tanks and others. The Table 5.2 summarizes number of irrigation projects, irrigation potential created and utilised in the Maharashtra state.

Table 5.2: Number of irrigation projects, irrigation potential created & utilised

Item	Projects of Water Resources Department			Minor Projects (local sector)					Total
	Major and Medium	Minor (State sector)	Total	K.T. Weirs	Percolation tanks	Lift irrigation	M.I. tanks	Others	
(A) No. of projects as on 30th June, 2015									
i. Completed	403*$	3,506*$	3,909 *$	11,006	21,317	2,652	2,608	37,714	75,297
ii. Ongoing	0	0	0	1,658	1,178	89	566	4,440	7,931
(B) Irrigation potential (lakh ha)									
i) Created up to June, 2014	34.30*@	14.36*@	48.66 *@	3.13	6.48	0.39	2.29	3.96	16.25
(ii)Area under irrigation by canal in 2014-15	15.53 ++	4.81++	20.34 ++	1.09	(-)	0.14	0.8	(-)	2.03
(iii)Area under irrigation by wells in command area during 2014-15	9.88	1.15	11.03	(-)	(-)	(-)	(-)	(-)	(-)
Total irrigation potential utilised	25.41*	5.96*	31.37 *	1.09	(-)	0.14	0.8		2.03

$ completed & ongoing components together * provisional

@ As per the recommendations of Chitale Committee, the data has been complied by MWRDC, based on information from all Chief Engineers of WRD.

++ Includes actual irrigation by project, canals, lift & water released in rivers and nallas

Source: Economic Survey of Maharashtra 2015-16

The net area irrigated by source wise in the Maharashtra state is shown in Table 5.3. The area under well irrigation has been increased from 5,95,000 ha to 21,59,000 ha from year 1960-61to 2009-10, 5,95,000 ha, while area under other sources(mainly canal irrigation) increased from 4,77,000 ha to 11,62,000 ha from year 1960-61to 2009-10, 5,95,000 ha. This shows that in Maharashtra the dominating source of irrigation is well with around 65% share in net irrigated area (33,21,000 ha).

Table 5.3: Area Irrigated by various Sources in Maharashtra

Area Irrigated (000 Ha)

Year	Wells	Other Sources	Net Area	Gross Area
1960-61	595	477	1072	1220
1965-66	711	496	1206	1388
1970-71	768	579	1347	1570
1975-76	1084	717	1802	2171
1980-81	1055	780	1835	2415
1985-86	1162	787	1949	2420
1990-91	1672	999	2671	3319
1993-94	1571	996	2567	3149
1994-95	1760	1017	2778	3377
1995-96	1870	1010	2880	3550
1996-97	2059	1028	3087	3769
1997-98	2090	1050	3140	3828
1998-99	1904	1042	2946	3630
1999-00	1400	1168	2568	3374
2000-01	1912	1047	2959	3647
2001-02	1922	1053	2975	3667
2002-03	1931	1040	2971	3668
2003-04	1914	1030	2944	3636
2004-05	1942	1001	2943	3665
2005-06	2077	1070	3147	3810
2006-07	2109	1137	3246	3958
2007-08	2151	1160	3311	4037
2008-09	2115	1140	3255	3970
2009-10	2159	1162	3321	4050

Sources: Indiastat. Directorate of Economics & Statistics, Planning Department, Govt. of Maharashtra

5.2.1 Growth in area covered under sprinkler and drip in Maharashtra

Maharashtra state is one of the leading states in adoption of the drip and sprinkler irrigation methods. The status of sprinkler and drip irrigation in the Maharashtra state is summarized in the Tables 5.4, 5.5 and 5.6. The total area under drip irrigation was 13,66,000 ha and under sprinkler was

5,21,038 ha, which sum up together 18,87,038 ha by March 2015. Around 50% area under drip and sprinkler irrigation was reported in the western Maharashtra region, followed by Marathwada (24.4%), Vidarbha (24.4%) and Konkan (0.7%) region. In the state highest area under drip was reported for cotton crop i.e. 3,76,944 ha(27%), followed by sugarcane 2,25,079 ha(16%), banana 1,49,382 ha(11%) and pomegranate 1,24,044 ha (9%). Table 2.22 presents year wise sprinkler and drip irrigation set distributed in the state and total government expenditure. Around 45,000 sprinkler sets per year were distributed, which added every year around 44,000 ha area under sprinkler irrigation. Around 90,000 drip sets per year were distributed in the state, which leads to per year increase in 88,000 ha area under drip irrigation. The state government provides 60% subsidy on drip for small and marginal farmers and 50% for others. In recent year (2014-16), the state expenditure on drip and sprinkler irrigation sets was Rs 688 crore. Despite the considerable level of adoption of drip and sprinkler in the state, there is a huge potential in the state as well as national level.

Table 5.4: Distribution of Sprinkler and Drip in Maharashtra

(by March 2015)

Sr. No. Division)	District	Area under Drip (ha)	Area under Sprinkler (ha)	Total (ha)	% to state Total
1	Thane	5355.98	127.32	5483.30	0.29
2	Raigad	1602.39	46.52	1648.91	0.09
3	Ratnagiri	3701.33	77.13	3778.46	0.20
4	Sindhudurg	2182.49	29.38	2211.87	0.12
	Kokan	**12842.19**	**280.35**	**13122.53**	**0.70**
5	Nashik	121947.98	11790.44	133738.42	7.09
6	Dhule	55516.01	3077.68	58593.69	3.11
7	Nandurbar	22473.09	1170.35	23643.45	1.25
8	Jalgaon	253505.18	10345.86	263851.04	13.98
9	A.nagar	86230.90	26553.28	112784.18	5.98
10	Pune	68141.42	5537.14	73678.56	3.90
11	Solapur	146765.71	7003.75	153769.45	8.15
12	Satara	24945.28	13530.05	38475.33	2.04
13	Sangli	60822.41	19025.56	79847.98	4.23
14	Kolhapur	11949.85	2033.43	13983.28	0.74
Western Maharashtra		**852297.85**	**100067.54**	**952365.39**	**50.47**
15	A.bad	76539.97	10830.65	87370.62	4.63
16	Jalana	54883.78	13874.06	68757.84	3.64
17	Beed	30509.85	9239.17	39749.02	2.11
18	Latur	30910.94	32444.21	63355.16	3.36
19	O.bad	32695.88	8088.41	40784.28	2.16
20	Nanded	45270.28	33286.47	78556.76	4.16
21	Parbhani	38688.72	8903.73	47592.45	2.52
22	Hingoli	15445.48	18912.94	34358.42	1.82
Marathwada		**324944.90**	**135579.64**	**460524.55**	**24.40**

Sr. No. Division)	District	Area under Drip (ha)	Area under Sprinkler (ha)	Total (ha)	% to state Total
23	Buldhana	65218.30	69253.99	134472.28	7.13
24	Akola	16256.93	29693.40	45950.33	2.44
25	Washim	5262.56	31759.88	37022.44	1.96
26	Amrawati	49409.06	47050.35	96459.41	5.11
27	Yeotmal	16578.61	51889.68	68468.30	3.63
28	Wardha	8248.85	31620.31	39869.16	2.11
29	Nagpur	10473.81	12909.37	23383.19	1.24
30	Bhandara	1198.47	1746.96	2945.43	0.16
31	Gondia	792.34	1367.45	2159.79	0.11
32	Chandrapur	2398.01	7135.96	9533.97	0.51
33	Gadchiroli	78.11	683.11	761.23	0.04
Vidarbha		**175915.06**	**285110.47**	**461025.53**	**24.43**
State total		**1366000.00**	**521038.00**	**1887038.00**	**100.00**

Source: Directorate of Horticulture, Maharashtra State, Pune

Table 5.5: Crop wise area covered under Drip Irrigation in Maharashtra 2015

Sr. No.	Crop	Area (ha)	% area
1	Cotton	376943.6	27.59
2	Sugarcane	225078.9	16.48
3	Banana	149381.8	10.94
4	Pomegranate	124044.3	9.08
5	Citrus group	117659.9	8.61
6	Grapes	108952.2	7.98
7	Vegetables	100563.9	7.36
8	Mango	19124.34	1.4
9	Papaya	13769.5	1.01
10	Flowers	10145.59	0.74
11	Ber	8223.87	0.6
12	Coconut	4538.96	0.33
13	Sapota	4113.85	0.3
14	Custard apple	3083.44	0.23
15	Guava	2710.54	0.2
16	Fig	1962.16	0.14
17	Amala	1581.99	0.12
18	Tamarind	871.4	0.06
19	Cashewnut	672.81	0.05
20	Arecanut	390.16	0.03
21	Others	92186.86	6.75
	Total Drip	**1366000.00**	**100.00**

Source: Directorate of Horticulture, Maharashtra State, Pune

Table 5.6: Year wise sprinkler & drip irrigation sets distributed and expenditure incurred

Year	Sprinkler		Drip		Expenditure incurred (Rs. crore)
	No. of sets	Area (ha)	No. of sets	Area (ha)	
2009-10	36,329	37,552	91,058	81,660	192.11
2010-11	38,030	38,029	1,40,764	1,27,967	407.88
2011-12	38,959	37,904	1,77,150	1,50,995	448.04
2012-13	79,630	79,630	1,78,310	1,62,100	574.85
2013-14	30,296	30,296	89,108	81,008	305.57
2014-15	52,180	43,098	2,00,496	1,70,719	688.41

Source: Economic Survey of Maharashtra 2014-15, 2015-16

5.2.2 Progress in Participatory Irrigation Management in Maharashtra

The Maharashtra state has a tradition of PIM, the *Phad*systems *and Malgujari tanks* are the traditional examples of PIM, in 1990, the first WUA was formed in the state in the Mula irrigation project (Patil &Belsare 2011). In the state, it was reported that under the irrigation development corporations (IDCs), substantial level of irrigation potential was created but the distribution network was incomplete, hence the potential was not utilized (World Bank, 2005). To address this problem the state government has taken various policy measures, one of the measures was that the state govt passed the Maharashtra Management of Irrigation Systems by Farmers (MMISF) Act 2005 (World Bank, 2005). Under this act the management of irrigation water was transferred to farmers and water charges were allowed to collect on volumetric basis from the WUAs. The status of WUAs in the state is summarized in the table 2.24. The WUAs in the state were formed as per MMISF and Cooperative societies Acts. In the state till 2016, around 5026 WUAs were formed covering area of 19, 92,038 ha area. While only 3102 WUAs were functioning covering area of 12,43,115 ha. In 1969, the state govt. established the Directorate of Irrigation Research and Development (DIRD) for drainage works and irrigation management (Patil&Belsare 2011).

Regarding the irrigation water management, several scholars have recommended that the government should focus on irrigation system at main level, while farmers should look after the operation and management (O&M) of the system (Meinzen-Dick and Mendoza 1996; Subramanian, 1997; Vaidyanathan, 1999). It is reported that PIM helps to increase the area under

cultivation, solid improvement in water use efficiency, resolving water related issues, solved soil related problems as water logging (Uphoff, 1986; Gandhi, and Namboodiri, 2011: 2002: Singh, 1991).

Table 5.7: Status of WUAs in the Maharashtra state

Name of regional office	As per MMISF Act 2005		As per cooperative Act 1960		As per MMISF Act 2005		As per cooperative Act 1960		As per cooperative Act 1960		Total Formed WUA on all stages & including both act	
	Functioning		Functioning		Registration agreement yet to be done		Registration agreement yet to be done		Agreement done Yet to be functioning			
	No	CCA (Ha)	No	CCA (Ha)	No	CCA (Ha)	No	CCA(Ha)	No	CCA(Ha)	No	CCA (Ha)
CEWRD Pune	274	137982	56	14236	1	411	0	0	8	1408	339	154037
CE(SP)WRD Pune	307	143034	292	73822	20	11341	166	49103	1	640	786	277940
CE CADA Aurangabad	49	19165	393	189699	27	11737	216	101228	36	13061	721	334890
CEWRD Aurangabad	71	42224	113	54985	56	27501	36	12871	23	9748	299	147329
CE(SP)WRD Amravati	175	63989	137	43813	45	18066	113	37526	0		470	163394
CE WRD Amravati	22	5607	95	29480	117	35788	282	107994	104	34028	620	212897
CEWRD Nagpur	371	154368	42	18026	88	37626	158	75308	79	34631	738	319959
CEGoshikhurdWRD Nagpur	0	0	0	0	75	29927	0	0	0	0	75	29927
CENMRWRD Nashik	349	127388	252	78146	11	5066	11	5473	0		623	216073
CE Tapi Jalgaon	79	35627	13	9615	76	31344	118	34987	7	4909	293	116482
CE WRD Konkan Mumbai	10	1028	2	881	50	17201			0		62	19110
Total	1707	730412	1395	512703	566	226008	1100	424490	258	98425	5026	1992038

Note: Total functioning WUA as per both act : 3102 (1243115 Ha)

Source: DIRD, Govt.of Maharashtra, http://www.dird-pune.gov.in/UntitledFrameset-6_.html As on 17thJune 2016

The Directorate of Irrigation Research & Development (DIRD) conducted a study on working of 439 WUAs in the Maharashtra state. The study reports that after the WUAs took over the water management, irrigation efficient was increased by 66%, 34% WUAs followed diversified cropping pattern and around 31% of WUAs reported balance in their accounts (Patil & Belsare 2011).

5.3 Overview of PINS Programmes in Maharashtra:

As mentioned earlier, there are three types of PINS projects in the state -government supported (these are around 100% government funded), cooperative and private (owned by individual farmer). After discussion with govt. officers and manufactures we decided to collect data from seven districts (Buldhana, Kolhapur, Sangli, Yavtmal Nashik, Pune and Ahmednagar), where the PINS projects were implemented. Data was collected from (i)PINS project operators and the associated Water User Associations (WUAs), (ii)farmers/water users with PINS-MIS or PINS with flood irrigation, non-beneficiary households having no access to PINS-MIS; but having access to surface/flood irrigation around the PINS project area (iii)implementing agencies/companies and (iv)concerned government departments. The total sample of 355 farmers was covered in the study, representing 250 beneficiaries (BH) and 105 non-beneficiary households (NBH). In this study, we have covered 75 PINS projects; among this 19 were govt and coop PINS, and 56 were pvt PINS projects.

In order to assess the progress and performance of PINS in Gujarat, it is imperative to shed some light on existing overall position of the irrigation in Maharashtra State, which is presented in Table 5.8. From the same it can be seen that (i) the ground water potential is half of that of surface irrigation potential; (ii) there are 403 major irrigation projects, 3,506 are medium and minor irrigation projects in state sectors. There are large numbers of minor irrigation schemes under the local sector.

Maharashtra State has mostly distribution systems with flow/gravity canal irrigation, as such there are no PINS+MIS under canal irrigation. The rotation of canal system (i.e. canal is "on" for about 3 weeks and "shutdown" for about the same period), creates a need to store water for use during "shutdown" period.

The GoM has recently decided to introduce pipe distribution system on all irrigation projects, which is expected to work on gravitational head (and not pressurised system). However, gravitational pipe distribution may not be feasible everywhere and we feel that lifting (PINS) would be unavoidable in no. of cases. The Maharashtra Water Resources Regulatory Authority (MWRRA) has also made it compulsory to use water by micro irrigation on all

perennial crops (12 monthly crops) under all flow irrigation system[2]. These both steps will see PINS in future.

Table 5.8 PINS Programmes in Maharashtra

Item	Particulars	
• Culturable Command Area(CCA):	225 lakhs ha	
• Ultimate Potential of Irrigation[3]:	o Surface Irrigation:	85 lakhs ha
	o Ground Water Irrigation:	41 lakhs ha
	o Total Potential:	126 lakhs ha
• Potential Developed[4]	o Major Irrigation Projects(more than 10,000 CCA):	403 no.
	o Medium & Minor(State Sector-251-2,500 ha) Projects:	3,506 no.
	o Minor Irrigation(Local Sector- below 250 ha)[5]:	More than 65,000 no.

Source: Maharashtra Water & Irrigation Commission Report 1999 & others

5.3.1 PINS in form of Co-op. Lifts Schemes in Maharashtra

However, there are large no. of lift irrigation schemes in co-operative sector, in southern part of western Maharashtra (1,01,205 ha) in Krishna basin (i.e. on Krishna river and its tributaries). These lifts can be considered as PINS with flood irrigation. However, over the years, the lands under them are becoming saline/water logged. For this reason, as well to save labour, fertilizers and water, initiatives have been taken through some schemes for converting the flow distribution systems into MIS. We obtained a list of 15 such schemes (from the micro irrigation manufacturing companies), and included some of them in our survey. The list of these schemes is presented in Annexure1. There could be more schemes (around15 schemes) under the proposals of conversion, but MIS companies observe secrecy, till such proposals actually get materialized.

There are other 11 irrigation projects, under which flow/canal irrigation systems are not economical, as these projects have command mainly located in hilly region. In such cases, the water is let down from the storages in the parent water sources, which is tapped in the course (of parent

[2] Maharashtra Water Resources Regulatory Authority's notification dt. 12.06.2015.
[3] Maharashtra Water & Irrigation Commission Report 1999
[4] Govt. Resolution (GR), Water Resources Dptt, dt. 04.10.2016
[5] Minor Irrigation Schemes include Minor Irrigation Tanks(MITs), Storage Tanks(STs), Kolhapur Type Weirs(KTWs), Pazar/Percolation Tanks(PTs), Diversion Weirs(DWs), small Lifts(LI).

water source) by weirs and lifted by farmers at various locations on the course/parent. This arrangement is similar to that for the lifts on Krishna and its tributaries, mentioned above. The total area under these 11 projects is 54,100 ha. With the area under lifts on Krishna etc., the total ICA works out to (54,100+ 101,205=) 1, 55,305 ha. We feel that, if the financial assistance is made available to these lifts, they would get converted from PINS+Flow into PINS+MIS rapidly, as the trend is already set by 15 schemes converted.

5.3.2 Govt. Lift irrigation Projects in Maharashtra

Besides, regular flow/canal irrigation projects, GoM has also taken up around 20 Lift Irrigation projects for 5.89 lakh ha, these are at various stages of development/completion. The CCA of individual projects ranges from 1,873 ha for AndhaliLift (Dist:Satara) to 2.240 lakhs ha for Krishna-Koyna Lift (Southern Western Maharashtra).

Under these projects, once water is lifted, further irrigation is under gravity/flow canal. As mentioned above, the GoM has recently decided to introduce pipe distribution system on all irrigation projects, which is expected to work on gravitational head (and not under additional head created similar to pressurised system). Thus, the distribution systems of these lift projects will also be converted into PINS+MIS, though not envisaged at the conceptual stages. There is an advantage for lifts, that on the way from pumps to the delivery point, there can be sufficient head available to use MIS by directly hooking up to the rising/pumping main.

Though the distribution of water is under gravity/flow under regular irrigation projects; in some projects, the lift irrigation is also adopted for water distribution, e.g. on two irrigation projects (i.e. along with the water distribution by gravity flow), they are [i]Dahini lift scheme on Bembala Project in Yavatmal District - 6,968 ha, [ii]Tajnapur Lift under Nathsagar(Godavari) Project in Aurangabad District: 6,960 ha, Dahini Lift is functioning partially so, we have covered it under the survey, other two projects are still at planning stage.

Under Minor Irrigation Schemes, except Minor Irrigation Tanks (MITs), there is no gravity flow system but lift irrigation on Storage Tanks (STs), Kolhapur-Type-Weirs (KTWs these are weir-cum-birdges), Storage Weirs

(SWs). Usually these lifts belong to small and individual farmers or to a small group of farmers. If financial assistance is made available to them, these can easily get converted into PIN+MIS. A group of four such schemes is functioning well on a Storage Tank at Janephal in Buldhana District. This was developed under a German KfW bank's assistance for participatory irrigation development[6]. We have covered these lifts under the survey.

5.3.3 PINS Project Implemented in the State (till 2015-16)

Only two companies have responded to provide this information, they are (i).Jain Irrigation Systems Ltd, Jalgaon and (ii). Netafim Irrigation India Pvt. Ltd, Pune. There appears two more players for PINS+MIS who indicated that they were undertaking similar assignments, but declined to disclose the assignments (probably in Kolhapur and Sangli Districts), as those assignments were under negotiation stages. These companies are [i]EPC Industrié limited(Mahindra Group), Nasik; [ii]FinolexPlastroPasson(India) Pune[7]. The information on the no. of PINS projects installed in the state is given below in Tables 5.9, 5.10 and 5.11. From these tables, it can be seen that 12 co-operative PINS-MIS(Drip based) are located in southern western Maharashtra, and while a sprinkler based unit is located in Vidarbha. One more drip based unit is partially completed in Govt sector and it is also located in Vidarbha.

[6] The programme was known as MIP-M (Minor Irrigation Programme-Maharashtra), 2001-2011.

[7] However, for these two companies (along with for two others companies), GoM has imposed the ban in the state, for 10 years in Jul 2016.
There are 104 companies registered with the GoM. The list of dealers for supply of drip as well sprinkler sets is also published by the GoM, in which 4,965 dealers are included from Western Maharashtra & Marathwada, and 1,497 from Vidarbha region.

Table 5.9: No of the PINS Project implemented in the State (till 2015-16)

Districts covered	Name of the implementing Agency/Company	Head Quarters and Address of implementing Agency/Company	No. of PINS Installed	Year of implementation of PINS Project
Sangli	Jain Irrigation System Limited,	Jain Hills, Jalgaon, 425 001	5 no. (268 ha)	2012- 2015
	Netafim Irrigation India Pvt. Ltd.	101 & 102, First floor, C-1 Building, Saudamini complex, Bhusari Colony, Kothrud, Pune. Pin.411 038	5 no. (730 ha)	2010—2014
	Jain Irrigation System Limited,	Jain Hills, Jalgaon, 425 001	1 no. (40 ha)	2015
Kolhapur	Netafim Irrigation India Pvt. Ltd.	101 & 102, First floor, C-1 -- as above --	1 no. (66 ha)	2014
Buldhana	Jain Irrigation System Limited,	Jain Hills, Jalgaon, 425 001	1 no. (295 ha)	2011
Yavatmal	Saisanket, Mumbai	Data not available	1 no.	Partly functioning

Source: Collected from implementing agencies.

Table 5.10: District-wise and irrigation project wise distribution of PINS Projects implemented (till 2015-16)

District	Irrigation basin/project	No. of PINS Installed	Year of Installations	Avg. Life span	Area covered (Ha)	Total number of beneficiaries
Kolhapur, Sangli&Satara [Co-op. Lift Schemes].	No. of projects in these districts(water is let down and lifted by Co-op. L I Schemes.)	12 PINS (are converted into PINS+MIS).	2010-2015	7	1098	1372
Yavatmal	Bembala irrigation Project	1 PINS Dahini Lift Scheme)	Partly completed.	7	4121	1948

Source: Collected from implementing agencies.

Table 5.11: Feeder Irrigation Source wise Distribution of PINS in the state

District	Irrigation basin/ Project	No. of PINS Installed	Total number of beneficiaries	Area covered (ha)
		River	River	River
Kolhapur, Sangli & Satara [Co-op. Lift Schemes].	No. of projects in these districts (water is let down and lifted by Co-op. L I Schemes.)	12	1372	1,098
Yavatmal	Bembala irrigation Project	1 PINS Dahini Lift Scheme)	1948	4121

Source: Collected from implementing agencies.

5.3.4 Irrigated Area & Crop Coverage under Drip & Sprinkler Irrigation in the State

The Table 5.12 presents the crop-wise area under MIS in the state, the major area is under cotton followed by the sugarcane. In horticulture, banana is the major crop followed by pomegranate and citrus.

Table 5.12: Crop wise area covered under Micro Irrigation in Maharashtra

(up to March 2015)

Sr. No.	Crop	Area	% area
1	Mango	19,124.34	1.40
2	Tamarind	871.40	0.06
3	Ber	8,223.87	0.60
4	Pomegranate	124,044.34	9.08
5	Sapota	4,113.85	0.30
6	Guava	2,710.54	0.20
7	Cashewnut	672.81	0.05
8	Arecanut	390.16	0.03
9	Papaya	13,769.50	1.01
10	Grapes	108,952.17	7.98
11	Banana	149,381.77	10.94
12	Citrus group	117,659.90	8.61
13	C, apple	3,083.44	0.23
14	Fig	1,962.16	0.14
15	Amala	1,581.99	0.12
16	Coconut	4,538.96	0.33
17	Vegetables	100,563.89	7.36
18	Flowers	10,145.59	0.74
19	Cotton	376,943.58	27.59
20	S,cane	225,078.88	16.48
21	Others	92,186.86	6.75
Sub Total A	Total Drip	1,366,000.00	100.00
Sub Total B	Area under Sprinkler	521,038.00	
	Grand Total	1,887,038.00	

Source: Directorate of Horticulture, Maharashtra State, Pune

5.3.5 Cost pattern on PINS

We have obtained latest cost-estimate for a 100 ac(40 ha) PINS scheme namely Shiva Rama PaniPuvathaSansthaShivaram Water Supply(Lift) Society Ltd, at Karbharwadi, Tal- Karveer, Dist- Kolhpur. This can be considered as a typical cost for a PINS, in which the cost of MIS can be added based on the norms of the individual states. From the Table 5.13, it can be seen that the installation cost is about 12% of the equipment cost. It needs to be noted that the cost of equipment will vary depending the head for the pumps and the length of the rising/pumping main.

Table 5.13: Initial capital cost on PINS equipment and installations at WUA level

(Rs/WUA)

Sr. No.	PINS-MIS Equipment	Equipment Cost (Rs)	Installation Cost (Rs)	Total Cost (Rs)
A	Water Supply System			
1	Pump Sets and power unit	2,25,000	25,000	2,50,000
2	Control Head/ control box	3,00,000	50,000	3,50,000
3	Storage Facility/ Wells	----	---	---
4	Filters/Filtration	6,50,000	35,000	6,85,000
B	System Layouts			
5	Main/ Sub-main PINS pipes/ PVC Pipes	33,50,000	5,25,000	38,75,000
6	Valves, Flush valves, Fittings and Bushings	3,50,000	25,000	3,75,000
C	Automated Water control System, if any			
7	Monitoring Storage	---	----	---
8	Float device and float switch			
9	Automation equipment	8,50,000	25,000	8,75,000
D	Total PINS System (Excluding MIS) for 100ac(40 ha)	57,25,000	6,85,000	64,10,000

Source: Field survey

5.4 Adoption, Performance and Management of PINS by Farmers in Maharashtra:

5.4.1 Details of Adoption of PINS with MIS

A total of 250 beneficiary and 105 non-beneficiary farmers were surveyed in Maharashtra. The average age of the respondent was 51 years. Respondents' average education was nine years of schooling. Most of the farmers' main occupation was the agriculture. For govt PINS, 47.6% of farmers were beneficiary farmers and 52.4% were non beneficiary farmers. The source of irrigation for all govt PINS was tanks/storages, for coop PINS

sources were river and storages/tanks[8] on the rivers, and for pvt PINS the sources were well and river in Maharashtra. It is seen that farmers prefer assured irrigation water source (tank, well and river) for installing PINS. The govt PINS farmers were small and marginal farmers, while coop PINS farmers were mostly small and medium, while majority of pvt PINS farmers were big medium and large farmers.

The main water sources of irrigation are canal, well, tank and river (Table 5.14). The source of irrigation for all govt PINS was tanks/storages, for coop PINS sources were river and storages/tanks[9] on the rivers, and for pvt PINS the sources were well and river. For NBF the sources of water were well, tank and river. Unfortunately not a single farmer in beneficiary or non-beneficiary group reported that they used canal as irrigation source. Since, most of the canals in Maharashtra were not providing water through out the years, most of the PINS sources of water were tank, river or well, and therefore the non PINS farmers were also not depending on the canal as a source of water for farming. Overall it indicated that farmers prefer assured irrigation water source for installing PINS.

Table 5.14: Sources of Irrigation

(% of net irrigated area)

Sr. No	Particulars	Govt PINS		Coop PINS		Pvt PINS	
		BF	NBF	BF	NBF	BF	NBF
1	Canal	0	0	0.0	0	0	0
2	Open/ dug well	0	91.2	0.0	67.5	67.3	100
3	Tube- well	0	2.7	0.0	18.8	0.0	0
4	Tank	100	0	47.3	0.7	0.0	0
5	River	0	6.1	52.7	13	32.7	0

Source: Field Survey

The distribution of farmers according to area under PINS is shown in Table 5.15. Around 90% of govt PINS farmers' area under PINS was between 2.5-5 acres, while 10% farmers' area under PINS was between 1-2.5 acres. About govt PINS farmers, around 40% of farmers' area under PINS was between 2.5-5 acres, 30 farmers between 1-2.5 acres, 17% farmers between 5-10 acres, 11% farmers less than 1 acre and 3% more than 10 acres. About

[8] These are the storages created by weirs on the rivers, these weirs are usually weir-cum-bridges types known in Maharashtra as Kolhapur-type-weirs (Kolhapur is the district, wherein these were first introduced in 1950s).

[9] These are the storages created by weirs on the rivers, these weirs are usually weir-cum-bridges types known in Maharashtra as Kolhapur-type-weirs(Kolhapur is the district, wherein these were first introduced in 1950s.

pvt PINS farmers' 50% farmers area under PINS was more than 5 acres, and around 20% farmers area under PINS was less than 2.5 acres, while 30 % farmers' area under PINS was between 2.5-5 acres. Overall it suggests that govt PINS farmers were small and marginal farmers, while coop PINS farmers were mostly small and medium, while majority of pvt PINS farmers were big medium and large farmers.

Table 5.15: Distribution of farmers according to area under PINS

Sr. No.	Area under PINS (Area in acre)	Govt PINS (% farmers)	Coop PINS (% farmers)	Pvt PINS (% farmers)
1	Up to 1 .0	0.0	11.0	1.8
2	1.01-2.50	10.3	31.0	21.4
3	2.51 to 5.00	89.7	38.1	28.6
4	5.01 to 10.00	0.0	16.8	17.9
5	10.01 or more	0.0	3.2	30.4

Source: Field Survey

Classification of average area under PINS project by farmer category is shown in Table 5.16. About the govt PINS farmers under marginal farmers class the average area was 2.5 acres and under small farmers 4.2 acres. Regarding the coop PINS farmer average area under the large farmer class was 14.6 acres, and under medium farmer class 7.2 acres. About the pvt PINS farmer under the large farmers class the average area was around 26 acres, under medium class around 7 acres, under small class 3.6 acres and under marginal class 2 acres.

Table 5.16: Average area under PINS Project by farmer category

(in acres)

Sr. No	Farmer category	Govt PINS	Coop PINS	Pvt PINS
1	Marginal (up to 2.50 ac)	2.5	1.7	2.0
2	Small (2.51 to 5.0 ac)	4.2	4.0	3.6
3	Medium (5.01 to 10.0)	0.0	7.2	7.3
4	Large (>10.0)	0.0	14.6	25.9

Source: Field survey

The cost of PINS is the most important factors for making decisions regarding adoption of PINS. Expenditure on PINS project is shown in Table 5.17. Since, the govt PINS projects were around 100% funded by the government, there was no cost for the farmers. Regarding the coop PINS farmers, average expenditure was Rs. 47,200 on PINS project, and there was

no considerable variation on the expenditure on PINS across the landholding class of farmers. About the pvt PINS farmer the expenditure on PINS project was Rs. 87,325 on PINS project and there was not much variation across the farmers' landholding class. These findings suggest that being a part of cooperative system could save PINS project cost by around 50%.

Table 5.17 Amount spent on PINS project

(Rs/acre)

Sr. No.	Farmer category	Govt PINS*	Coop PINS	Pvt PINS
1	Marginal (up to 2.50 acres)	0	45,616	87,495
2	Small (2.51 to 5.0 acres)	0	34,250	97,118
3	Medium (5.01 to 10.0 acres)	0	49,350	87,945
4	Large (>10.0 acres)	0	49,370	83,265
	All farmers	0	47,200	87,325

Note:* *Around 100% Subsidy for Govt PINS*
Source: Field Survey

The details of adoption of micro irrigation systems (MIS) under the PINS programs are presented in Table 5.18. From table it can be seen that all of govt PINS farmers adopted drip irrigation system because it was mandatory for them to have micro-irrigation. For coop PINS around 55% of the farmers adopted drip irrigation and 20% adopted sprinkler and remaining were using flood irrigation method. All of the pvt PINS farmers were using drip irrigation system. Average area under drip irrigation of the govt PINS farmers was 4.3 acres per household. Coop PINS farmers average area under drip irrigation was 3.5 acres and average area under sprinkler was 4.6 acres. Average area under drip irrigation of the pvt PINS farmer was 11 acres. The total cost of the drip under govt PINS was around Rs 20,000, which was very low, the reason was that in this case the manufacturers of the drip system provided the system at very low rates i.e. 20,000 Rs/acre. Moreover they received special subsides from govt from different department, whichcounted to total subsidy of 90% for the drip system. Hence, the final contribution of the farmers was around 2000 Rs/acre for drip irrigation system. Under the coop PINS the average cost of the drip irrigation system was around 50,000 Rs/acre and for sprinkler it was 8863 Rs/acre. The average cost of drip irrigation system under pvt PINS was 48,306 Rs/acre. For drip irrigation system farmers under coop PINS received 19% subsidy, while under pvt PINS they received 25% subsidy. For sprinkler the subsidy

received was 54% of the total cost of the system, which was higher because the installation was quite old, at that time the subsidy was at higher rate. The variation in subsidy was because the farmers were not getting the subsidy immediately after the installation of the system, hence, the farmers received subsidy only for some area under drip irrigation at the time of survey. Farmers reported that they were not getting subsidy on time, in some cases they have to wait for 2-3 years.

Table 5.18: Adoption of Micro Irrigation Systems (MIS) under PINS Programs

Sr. No.	Type of MIS used	Category Of PINS	%. of farmers used	Average area under MIS (Acre/hh)	Total cost of the system (Rs/hh)	Amount paid by the farmers	Subsidy (%)*	Total cost of the system (Rs/Acre)	Amount paid by the farmers	Who gives the subsidy	Name of the subsidy programme
1	Drip	govt	100	4.3	85,707	8,620	90	19,707	1,982	State govt	NMMI
		Coop	55.5	3.5	1,77,419	1,43,543	19	50,197	40,613	State govt	NMMI
		pvt	100	11.0	5,29,643	3,99,064	25	48,306	36,397	State govt	NMMI
2	Sprinkler	Coop	20.6	4.6	41,066	18,849	54	8,863	4,068	State govt	NMMI

Note:*The variation in subsidy received by the farmers was because they received subsidy only for some part of area under drip at the time of survey, while for remaining part they were waiting for subsidy to receive.
Source: Field survey

Table 5.19 presents distribution of farmers according to subsidy received on MIS. Since, the govt PINS scheme was funded by the state govt., all of the farmers received 90% subsidy on MIS. Regarding the coop PINS farmers, around 15% of drip adopter and 7% of sprinkler adopter have not received any subsidy. Around 50% of the drip adopter under coop PINS received subsidy between 25-50%, while around 30% received subsidy up to 25%. Around 75% of the sprinkler adopter under the coop PINS received subsidy between 25-30%. Regarding the drip adopter under the pvt PINS, 33% adopter were without any subsidy, 35% were with subsidy up to 25%, and around 30% were with 25-50% subsidy. Overall it shows that considerable numbers of farmers were without subsidy. Since, initially farmers have to bare entire cost, which is quiet high amount for them, and the farmers get subsidy after long period of installation of MIS. This might

be the major reason for farmers not to go for MIS. Hence, there should be some mechanism, so that farmers get subsidy on time.

Table 5.19: Distribution of farmers according to subsidy received on MIS

(% farmers)

Sr. No.	Subsidy Received on MIS	Govt PINS	Coop PINS		Pvt PINS
		Drip	Drip	Sprinkler	Drip
1	0 per cent	0	14.3	6.5	33.9
2	1 to 25 per cent	0.0	28.6	0.0	35.7
3	25- 50 per cent	0.0	46.8	74.2	28.6
4	50 -75 per cent	0.0	7.8	6.5	1.8
5	More than 75 per cent	100	2.6	12.9	0.0
	All farmers	100	100	100	100

Source: Field survey

5.4.2 Reasons behind Adoption of PINS-MIS

The major reasons to adopt PINS were to get assured water, better yield and increase in area under irrigation (Table 5.20). Around 30% respondents with Gvt PINS strongly agreed that they adopted PINS to avoid conflicts among farmers and efficient distribution of water among the farmers. The pvt PINS adopter farmers were interested in personal benefits in comparison with the govt and coop PINS adopter. The pvt PINS adopter farmers were interested in personal benefits rather than community based benefits.

Table 5.20 Reasons behind adoption of PINS MIS -Govt PINS

Sr. No.	Reasons	(1-5; strongly agree to strongly disagree), multiple responses possible. *(% of farmers agreed)*				
		1	**2**	**3**	**4**	**5**
1	To get assured amount of water for irrigation	43.6	28.2	23.1	2.6	0.0
2	To get better and stable crop yield and farm income	17.9	46.2	25.6	5.1	0.0
3	To save more water and to cover more area under irrigation thereby	28.2	30.8	12.8	2.6	2.6
4	To avoid unnecessary conflicts with other farmers	7.7	10.3	38.5	2.6	2.6
5	To facilitate judicious or efficient distribution of water among the water users	7.7	20.5	33.3	2.6	0.0

Source: Field survey

5.4.3: Benefits accrued by Adopting PINS-MIS

The benefits realizations of joining WUA are presented in Table 5.21. Around 60% of the farmers who joined WUA under the govt PINS reported that there was an increase in area under irrigation, farm income and water saving by more than 35%, further; only 30% responded that there was around 35% saving in electricity. Regarding the coop PINS farmers, majority of them agreed that there was an increase in area under irrigation, farm income, water saving and electricity saving. Because of joining WUA under the coop PINS, the area under irrigation increased by 64%, income increased by 40%, water saved by 32% and electricity saved by 21%. Around 20-35% of the farmers reported indirect benefits of joining of WUA under pvt PINS such as; timely information regarding water release, information on judicious use of water, information on crops and less conflict. More than 70% of the coop PINS WUA participant reported indirect benefits such as timely information regarding water release, information on judicious use of water, information on crops and less conflict. Overall it shows that joining the WUA under coop PINS benefits farmers more than the govt PINS farmers, may be because under coop PINS the management might be working better than under the govt PINS.

Table 5.21: Benefits Accrued by Adopting PINS- WUA

Sr. No	Benefits accrued	Govt PINS		Cooperative PINS	
		%farmers benefited	Extent of benefit (% increase)	% farmers benefited	Extent of benefit (% increase)
1	Area under irrigation has increased	69.2	63.7	95.5	64.29
2	Agricultural income has increased	61.5	34.6	96.8	40.51
3	Water saving due to judicious use of water	59.0	36.7	96.1	32.82
4	Electricity saving	30.8	37.9	72.9	21.32
5	Water arrives in time	23.1	--	91.6	--
6	Timely information on release of water from canal	23.1	--	87.7	--
7	More information on how to use water judiciously	28.2	--	89.7	--
8	proper distribution of water among farmers	23.1	--	91.6	--
9	Less conflicts around water or less water theft	25.6	--	76.1	--
10	More information on crops and technologies	30.8	--	81.3	--
11	Improved maintenance of the system	10	--	11.9	--

Source: Field survey

Locations of the plots in the command area of the PINS projects and sufficiency of irrigation water are shown in Table 5.22. Around 50% of the plots were in middle region, 30% plots were at the tail region and remaining were at the head region of both the govt and pvt PINS schemes. Around 93% of the farmers in govt PINS projects were getting water throughout the year; while only 32% of the farmers in coop PINS were getting water throughout the year. Moreover, it was also reported that for a period of three months farmers were not getting sufficient water. From these findings it looks like that the majority of farmers under govt PINS were getting sufficient water but very few farmers under the coop PINS were getting sufficient water. This might be because the govt PINS were on more assured source of water than the coop PINS. It was also reported that for one season both govt and Pvt PINS farmers were facing water problem.

Table 5.22: Location of plot in the command area of the PINS project and sufficiency of irrigation water

Sr. No.	Particulars	Govt PINS *(% farmers agreed)*	Coop PINS *(% farmers agreed)*
1	Location of plot under PINS:		
A	Head region	25.2	12.8
B	Middle region	46.5	56.4
C	Tail region	28.4	30.8
2	Do you get sufficient water throughout the year		
A	% farmers not getting sufficient water throughout the year	92.31	32.90
B	% of months not with sufficient water (months)	25.00 (around 3 months)	33.33 (around 3 months)

Source: Field survey.

The reasons for insufficient supply of water to farm plot are shown in table 4.15. Regarding the govt PINS farmers the most important reasons for the inadequate supply of water were inadequate water at the source of water for PINS (around 86% farmers reported this reason), followed by inefficient functioning of PINS system(66% farmers reported), water theft (58% farmers reported) and poor rainfall (43% farmers reported). Regarding the coop PINS, farmers reported that inadequate water at the sources (63% farmers

reported) and poor rainfall (41% farmers reported) were the main reasons for insufficient supply of water for PINS. Moreover, for govt PINS inefficient functioning of the PINS system was also an additional cause.

5.4.4 Impact of PINS and MIS on Cropping Pattern and Production

Cropping pattern of BF and NBF sample households under the govt PINS is shown in Table 5.23. The findings show that kharif season was the major season for the BFs and NBFs, only one crop; groundnut was grown in the summer season on 3% of the gross cropped area (GCA). The main crops were soybean, tur and cotton. Intercropping was the most common practice; tur was an intercrop in soybean and cotton. There was not much variation in the cropping pattern between BFs and NBFs under the govt PINS.

Table 5.24 summarizes the cropping pattern of the sample household under the coop PINS. We found that the crops were grown in three seasons; kharif, summer and rabi. In kharif season soybean and tur (intercropping) were the dominating crops. In rabi season wheat and gram were dominating crops. While only beneficiary farmers were growing crops in summer season i.e. groundnut and onion for seeds. Both the BFs and NBFs were growing perennial crops, while share of area under these crops in the GCA was comparatively higher under the beneficiary farmers than the non-beneficiary farmers. The share of the area under cultivation during the rabi, summer and perennial seasons in the GCA was comparatively higher for BFs than the NBFs. While the share of total area under cultivation in kharif season in the GCA was higher under the NBFs than BFs.

Table 5.25 summarizes the cropping pattern of the sample households under the Pvt PINS. In kharif season, soybean, maize, and vegetables were major crops grown by beneficiary farmers, and soybean and maize were grown by the non-beneficiary farmers. During rabi season onion, wheat and jowar crops were grown by the beneficiary farmer, and onion was the major crop grown by the non-beneficiary farmer. The perennial crops grown by the beneficiary farmers were sugarcane, grape, pomegranate and banana, while sugarcane, grape, pomegranate were grown by non-beneficiary farmers. The share of area under perennial crops in the CGA of beneficiary farmers was comparatively higher than the non-beneficiary farmers.

Table 5.23: Cropping Pattern of the Sample Households under the govt PINS

(Area in acre/hh)

Sr. No.	Season/ crop	Beneficiary Farmers (BF)		Non-beneficiary Farmers (NBF)		percentage change in area of BF over NBF
		Area	*% of GCA*	Area	% of GCA	
1	Soybean	1.23	24.96	0.9	14.8	41.38
2	Tur	0.23	4.63	0.0	0.0	
3	Soybean (Intercrop Tur)	1.51	30.67	3.6	60.5	-57.5
4	Cotton	1.44	29.10	1.3	21.3	
5	Cotton (Intercrop Tur)	0.32	6.39	0.1	1.6	239.0
6	Udid	0.00	0.00	0.1	1.8	-100.0
7	Vegetables	0.06	1.17	0.0	0.0	
A	Kharif Total	4.79	96.92	5.9	100.0	-18.7
1	Ground Nut	0.15	3.08			
B	Summer Total	0.15	3.08			
C	Gross cropped area	4.94	100.00	5.9	100.00	-16.1

Source: Field Survey

Table 5.24: Cropping Pattern of the Sample Households under the coop PINS

(Area in acre/hh,)

Sr. No.	Season/ crop	Beneficiary Farmers		Non-beneficiary Farmers		percentage change in area of BF over NBF
		Area	*% of GCA*	Area	*% of GCA*	
1	Rice	0.00	0.00	0.06	1.16	-100.0
2	Soybean	0.42	8.33	0.90	18.58	-53.5
3	Soybean (Intercrop Tur)	1.21	23.87	1.42	29.27	-15.3
4	Gr. Nut	0.04	0.83	0.11	2.28	-62.2
5	Mung	0.06	1.12	0.03	0.58	99.5
6	Udid	0.03	0.64	0.03	0.58	14.0
7	Cotton	0.10	1.91	0.00	0.00	
8	Turmeric	0.02	0.45	0.03	0.58	-20.2
9	Corn	0.01	0.19	0.00	0.00	
10	Vegetables	0.05	0.98	0.20	4.07	-75.0
A	Kharif Total	1.94	38.31	2.78	57.10	-30.3
1	Wheat	0.58	11.55	0.16	3.30	264.1
2	Gram	0.26	5.23	0.16	3.30	64.9
3	Jowar	0.13	2.49	0.15	3.10	-16.7
4	Onion	0.00	0.00	0.22	4.56	-100.0
B	Rabi Total	0.97	19.27	0.69	14.25	40.5
1	Ground Nut	0.20	3.89	0.00	0.00	
2	Onion seed	0.16	3.26	0.00	0.00	
C	Summer Total	0.36	7.15	0.00	0.00	
1	Sugarcane	1.47	29.09	1.28	26.32	14.8
2	Grape	0.30	6.01	0.11	2.33	168.5
3	Banana	0.01	0.16	0.00	0.00	
D	Perennial Total	1.78	35.26	1.39	28.65	27.8
E	Gross cropped area	5.05	100.00	4.87	100.00	3.9

Source: Field Survey

Table 5.25: Cropping Pattern of the Sample Households under the Pvt PINS

(Area in acre/hh)

Sr. No.	Season/ crop	Beneficiary Farmers		Non-beneficiary Farmers		percentage change in area of BF over NBF
		Area	% of GCA	Area	% of GCA	
1	Soybean	0.36	2.9	0.03	1.33	971.4
2	Maize	0.49	3.9	0.08	3.33	483.9
3	Fodder	0.09	0.7	0.00	0.00	
4	Vegetables	0.31	2.5	0.00	0.00	
A	Kharif Total	1.25	10.1	0.12	4.67	967.6
1	Bajara	0.00	0.0	0.11		-100.0
2	Wheat	0.64	5.2	0.03	1.33	1828.6
3	Jowar	0.09	0.7	0.00	0.00	
4	Gram	0.02	0.1	0.06	2.22	-67.9
5	Onion	0.99	8.0	0.42	16.89	134.7
B	Rabi Total	1.74	14.1	0.62	24.89	179.8
1	Sugarcane	1.46	11.8	0.89	35.56	63.7
2	Grape	4.23	34.2	0.08	3.33	4978.6
3	Pomegranate	2.86	23.1	0.79	31.56	262.0
4	Banana	0.30	2.5	0.00	0.00	
5	Other Horticulture	0.53	4.3	0.00	0.00	
C	Perennial Total	9.37	75.8	1.76	70.44	432.3
D	Gross cropped area	12.36	100.0	2.50	100.0	394.4

Source: Field Survey

Thus PINS helps to increases the area under cultivation during the summer season or under the perennial crops. It is also reported that the most preferred method of irrigation under PINS was drip irrigation over sprinkler and flood. For most of the crops the production was reported higher under the PINS farm than for the non PINS farm, this indicates that the PINS improves the productivity of most of the crops. The MIS increased yield for soybean, tur, cotton, groundnut, jowar, onion and sugarcane crops, while yield was decreased for udid, mung and wheat under MIS. For majority of crops the yield under MIS was higher than the flood method, while there was not much difference between sprinkler and drip methods. Regarding the water saving under MIS, in principal there is water saving under MIS than flood. We feel that though the farmers were aware that the water quantum will depend on the season, stage of the growth of plant/tree as well as crop/fruit, they don't have clear idea about the reduction of water quantum to be made applicable.

The production pattern of the sample household under the govt PINS is summarized in Table 5.26. Soybean reported production of 4.02 quintals/acre, which was 30% higher than the production under non PINS, while for soybean in intercropping the yield was 5.9 quintals/acre, which was around double of the yield under the non PINS. The production of tur intercrop was 2.9 quintals/acre, which was nearly double than the production under the non PINS. The production of cotton was 8.9 quintals/acre, which was 40% higher than the production of cotton under the non PINS, while the production of cotton intercrop was 3.3 quintals/acre, 60% higher than production of cotton under non PINS. The production of all crops under the PINS was higher than the non PINS.

Table 5.27 summarizes production pattern of various crops under the coop PINS. The production of various crops under the coop PINS was as soybean was 4.8 quintals/acre (66% higher than non PINS), soybean intercrop 6.5 quintals/acre (217% higher than non PINS), tur intercrop 2.7 quintals/acre (108% higher than non PINS), ground nut 9.8 quintals/acre (75% higher than non PINS), mung 2.7 quintals/acre(18% lower than non PINS), udid 2.2 quintals/acre (19% lower than non PINS), turmeric 39 quintals/acre (133% higher than non PINS), vegetables 50.4 quintals/acre(308% higher than non PINS), wheat 9.2 quintals/acre (33% higher than non PINS), gram 4.9 quintals/acre (132% higher than non PINS), jowar 5.8 quintals/acre (55% higher than non PINS) and sugarcane 55 metric tons/acre (6% higher than non PINS) and grapes 8.7 metric tons/acre (45% higher than non PINS). This suggests that production of most of the crops under the PINS adopter was higher than the non PINS farmers.

The production pattern of various crops of the sample household under pvtPINS is shown in Table 5.28. The production of various crops under the pvt PINS was as soybean 7.8 quintals/acre (55% higher than non PINS), maize 13.7 quintals/acre (4% higher than non PINS), wheat 9.8 quintals/acre (42% lower than non PINS), gram 3 quintals/acre (50% higher than non PINS), sugarcane 54 metric tons/acre (6% higher than non PINS) and pomegranate 76.5 quintals/acre (150% higher than non PINS). It is seen that majority of crops production was higher for the PINS adopter than the PINS non-adopters. Overall the findings suggest that for most of the crops the

production was reported higher under the PINS farm than for the non PINS farm, this indicates that the PINS improves productivity of most of the crops.

Table 5.26: Production pattern of the sample households – Govt PINS

Sr. No.	Season/ crop	Beneficiary Farmers (Quintal/acre)	Non-beneficiary Farmers (Quintal/acre)	% change in BF over NBF (Quintal/acre)
	Kharif			
1	Soya	4.02	3.1	29.8
2	Soya (Intercrop Tur)	5.9	3.0	98.8
3	Tur	4.1	--	--
4	Tur(Intercrop soya)	2.9	1.5	93.3
5	Tur (Intercrop Cotton)	2.03	2.0	1.6
6	Udid	0.0	2.3	--
7	Cotton	8.9	6.3	40.4
8	Cotton(Intercrop Tur)	3.3	2.0	62.6
9	Vegetables	220.0	0.0	--
	Summer			
11	Ground Nut	4.05	0	--

Source: Field survey

Table 5.27: Production pattern of the sample households – coop PINS

Sr. No.	Season/ crop	Beneficiary Farmers (Quintal/acre)	Non-beneficiary Farmers (Quintal/acre)	% change in BF over NBF (Quintal/acre)
	Kharif			
1	Rice	--	9.8	--
2	Soya	4.8	2.87	65.6
3	Soybean (Intercrop Tur)	6.5	2.04	217.1
4	Tur (Intercrop Soybean)	2.7	1.27	108.3
5	Cotton	5.7	--	--
6	Groundnut	9.8	5.6	74.5
7	Mung	2.7	3.3	-18.2
8	Udid	2.2	2.7	-19.0
9	Turmeric	38.9	16.7	133.1
10	Corn	21.3	--	--
11	Vegetables	260.0	123.0	111.4
	Rabi			
12	Wheat	9.2	6.9	32.9
13	Gram	4.9	2.1	132.1
14	Jowar	5.8	3.8	54.5
15	Onion	--	77.0	--
	Summer			
16	Gr. Nut	4.6	--	--
17	Onion (Seed)	2.8	--	--
	Perennial			
18	Sugarcane	543.8	512.34	6.1
19	Grape	87.2	60	45.4
20	Banana	300.0	0	

Source: Field survey

Table 5.28 Production pattern of the sample households - pvt PINS

Sr. No.	Season/ crop	Beneficiary Farmers (Quintal/acre)	Non-beneficiary Farmers (Quintal/acre)	% change in BF over NBF (Quintal/acre)
	Kharif			
1	Soybean	7.75	5	55.0
2	Cotton	7.1	--	--
3	Maize	13.7	13.1	4.2
4	Vegetables	230.0	--	--
A	Rabi			
5	Wheat	9.8	16.7	-41.3
6	Jowar	6.0	--	--
7	Gram	3.0	2.0	50.0
8	Onion	141.7	--	--
B	Perennial			
9	Sugarcane	542.6	513	5.8
10	Grape	95.1	--	--
11	Pomegranate	76.5	30.62	150.0
12	Banana	60.0	--	--
13	Other horticulture	49.8	--	--

Source: Field survey

The impact of MIS on the production is shown in Table 5.29. Table compares the production of various crops under flood, drip and sprinkler irrigation. For soybean crop the yield was 25% higher under sprinkler irrigation than flood method, while it was same under the flood and drip. While for soybean as intercrop the yield was 77% higher under sprinkler and 74% higher under drip than flood. For tur as intercrop yield was 57% higher under sprinkler and 77% higher under drip than flood. For cotton crop around 66% higher yield under sprinkler and drip than flood. For groundnut yield was 120% higher under drip than flood. For mung yield was 40% lower under drip than flood. For udid yield was 18% lower under sprinkler than flood. For wheat around 4-8% lower yield under drip and sprinkler than flood was reported. For jowar crop 16% higher yield under sprinkler than flood was reported. For gram around 35% higher yield under sprinkler and 28% lower under drip than flood was reported. For onion 22% higher yield under sprinkler than flood was reported. For sugarcane the yield was 6% higher under drip than flood method.

The findings shows that the MIS increased yield for soybean, tur, cotton, groundnut, jowar, onion and sugarcane crops, while yield was decreased for udid, mung and wheat under MIS. In general the findings indicate that for majority of crops the yield under MIS was higher than the

flood method, while there was not much difference between sprinkler and drip methods.

Table 5.29: Production Impacts of PINS with MIS

Sr. No.	Major Crops	Season	Sprinkler (with PINS) (Quintal/ acre)	Drip (with PINS) (Quintal/ acre)	Canal/Flood irrigation (both PINS & Non-PINS) (Quintal/acre)	% change in yield under sprinkler over flood	% change in yield under drip over flood
1	Soybean	Kharif	5.17	4.12	4.11	25.72	0.21
2	Soybean (intercrop Tur)	Kharif	5.56	5.47	3.14	76.96	73.88
3	Tur (intercrop Soybean)	Kharif	2.40	2.72	1.53	57.20	77.57
4	Cotton	Kharif	9.07	8.87	5.35	69.62	65.85
5	Groundnut	Kharif	--	10.29	4.68	--	119.82
6	Mung	Kharif	--	9.44	15.87	--	-40.48
7	Udid	Kharif	2.00	--	2.43	-17.70	--
8	Wheat	Rabi	9.15	8.62	9.37	-2.39	-8.06
9	Jowar	Rabi	6.00	0.00	5.17	16.06	--
10	Gram	Rabi	5.14	2.75	3.82	34.62	-27.98
11	Summer Onion	summer	3.09	--	2.53	21.99	--
12	Sugarcane (metric tons/acre)	Perennial		53.94	51.44		4.87

Source: Field survey

5.4.5 Impact on Water saving

World over, it is proved that MIS are basically water saving systems. Besides saving, it distributes water evenly over the command area with minimal losses. It has also ability to adjust the water application rate as per the water requirement of the crop. We observe that though the farmers in India are aware of these, in no. of cases, availability of exact and dependable data on water application vis-à-vis saving etc.(from farmers); becomes difficult to obtain. We feel that though the farmers are aware that the water quantum will depend on the season, stage of the growth of plant/tree as well as crop/fruit, they don't have clear idea about the reduction of water quantum to be made applicable. One possible reason for this, is that there is no harm takes place to the crops even some more water is applied under MIS. So if there is no problem in water availability, there may be a tendency of farmers not to shut off the systems immediately after the required watering is done. We are sure that over the period the farmers will become cautious of this aspect and then reliable data would be available. As discussed earlier, the sample farmers reported that the extent of water

saving due to adoption of PINS and participation in WUA was 32.8 per cent in case of cooperative PINS and 36.7 per cent in Govt. PINS.

5.4.6 Other Economic, Social and Environmental Benefits of PINS and MIS

Apart from saving water there are other benefits of the PINS, these are presented in Table 5.30. Maximum benefits were reported under the coop PINS MIS farmers. More than 50% of the farmers under the govt PINS reported the four main benefits of the PINS with MIS: cultivated land saved due to less need to construct field channels, less maintenance cost compared to conventional flow irrigation, frequency of maintenance is less compared to conventional flow irrigation and less water logging or water salinity. More than 50% of the pvt PINS with MIS farmers reported that reduction in fertilizer use, reduction in weeding cost reduction in labour use were the three main benfits of MIS. The findings suggests that apart from water saving the major benefits of PINS with MIS were, saving of land by avoiding field channels, reduction in frequency and maintenance cost of irrigation system, weeding cost, water logging and labor cost.

Table 5.30: Other Economic, Social and Environmental Benefits of PINS with MIS

(% farmers agreed)

Sr. No.	Particulars	Govt PINS	Coop PINS	Pvt PINS
1	Cultivated land saved due to less need to construct field channels	51.3	73.5	30.4
2	Less maintenance cost compared to conventional flow irrigation	64.1	72.9	37.5
3	Frequency of maintenance is less compared to conventional flow irrigation	56.4	62.6	44.6
4	Reduction in over-extraction of ground water	43.6	53.5	46.4
5	Saving of energy consumption due to sharing through common pump set/PINS	48.7	70.3	25.0
6	Reduction in pressure on pump set/tube well due to less extraction	41.0	54.8	16.1
7	Less water logging or water salinity	66.7	58.1	42.9
8	Less pest attack/Reduced use of pesticides	33.3	50.3	42.9
9	Reduction in fertilizer use	35.9	53.5	71.4
10	Reduction in weeding cost	23.1	58.1	69.6
11	Reduction in labour use	30.8	57.4	76.8
12	Effective allocation of water among farmers	23.1	65.8	26.8
13	Reduction in migration of family members due to more availability in water	10.3	40.0	3.6
14	Increase in social cohesion among the water users/villagers in managing the water	48.7	56.1	17.9

Source: Field survey

Apart from water saving the major benefits of PINS with MIS were, saving of land by avoiding field channels, reduction in frequency and maintenance cost of irrigation system, weeding cost, water logging and labor cost. There is a lack of awareness about ISO standards, training and testing facility for PINS and MIS. Therefore, there is a scope for providing these facilities for farmers at the block level. The main problems faced by the farmers were planning and installation of PINS with MIS, delay in receiving subsidy for MIS, power to run PINS and MIS, quality of components and damage of MIS in field from rodents.

5.5 Adoption, Performance and Management of PINS by WUAs:

Around 15 PINS+MIS are getting developed in Maharashtra are in co-operative sector in southern Maharashtra. These appear to be managed well under the guidance of local sugar-cooperatives. The development or conversion of these lifts schemes into PINS+MISs will be trend setting development, which will have positive effect on other schemes. Along with the regular major and medium irrigation projects, the GoM also has taken up 20 lift irrigation projects, which have very large command areas. These are planned with flow/gravity canal system. There is a large scope to have MIS for distribution system of these projects.

5.5.1 Details of Associated PINS Projects in Maharashtra

The PINS+MIS covered under the survey are mostly lift scheme on rivers or storages created by tapping the water within the banks of the rivers. The details about the water sources and command area are given in Table 5.31. Average life span for PINS is reported as 24 years, which appears for the pumps and rising/pumping mains. As can be seen from the table, the lift schemes are located on the rivers/storages in the rivers.

Soils of 2/3rd schemes are moderately fertile, around 20% with very fertile and balance are less fertile, getting water logged. Crop pattern has perennials (S'cane and horticultural crops like grapes, or pomegranates) and seasonal crops for rotation cover soybean, tur, and cotton in Kharif, while wheat, gram and Jowar taken in rabi season.

Table 5.31: Details of Associated PINS Projects in Maharashtra

Sr. No	Particulars	Type of PINS- Coop PINS
1	Average Life Span of the PINS (Years)	24
2	Feeder irrigation source (% distribution):	
A	Canal	
b	Tube well	
c	Tank	
d	River	100
e	Any other	
3	Type of the irrigation project (% distribution):	
a	Major	0
b	Medium and minor	100
4	Total Area covered under the PINS Project WUA (acre/WUA)	434.3
5	Total number of beneficiaries /WUA	185.6
6	Nature of the land in the command area of PINS Project (% distribution):	
a	Very fertile	18.2
b	Moderately fertile	63.6
c	Less fertile due to salinity	9.1
d	Less fertile due to water logging	0.0
e	Less fertile since exposed to erosion/or for any other reason	9.1
7	Type of cultivation practice:	
a	Plots periodically left fallow	27.3
b	Zero or minimum tillage practiced on it	
c	Crop rotation practiced on it	72.7
d	Crops grown during Kharif (2015):	
	Kharif crop-1	Soybean
	Kharif crop-2	Tur
	Kharif crop-3	Cotton
e	Crops grown during Rabi (2015-16)	
	Rabi crop-1	Wheat
	Rabi crop-2	Gram
	Rabi crop-3	Jowar
f	Crops grown during Perennial (2015-16)	
	Perennial Crop-1	Sugarcane
	Perennial Crop-2	Grape
	Perennial Crop-3	Pomegranate

Source: Field survey

5.5.2 Annual Operation & Maintenance (O&M) Cost

The costs details for all 10 coop WUAs are given in Table 5.32 based on the total ICA of 4343 ac, the cost per ac works out to Rs. 2,499/-, which appears quite reasonable. It is felt that the provisions for other items need to be considered as expenditure, such as sinking funds etc.

Table 5.32: Annual Operation and Maintenance Cost on coop PINS

Sr. No	Particular's	All 10 WUA Total Area: 4,343 ac		Per WUA (Average area per WUA is 434.3 acre)		Per Acre	
1	Heads of expenses	Expenses (Rs.)	As a %age	Expenses (Rs.)	As a %age	Expenses (Rs.)	As a %age
2	Electricity Charges	75,85,000	70	7,58,500	70	1,746	70
3	Repairing/Maintenance of tube well /canal PINS	14,40,000	13	1,44,000	13	332	13
4	Other Expenses	18,27,500	17	1,82,750	17	421	17
5	Total annual Operation and Maintenance Cost on PINS (Rs):	1,08,52,500	100	10,85,250	100	2,499	100
6	Frequency of maintenance works undertaken (Number/Year):	48 in 10 Pins. i.e. 4.8/PINS					

Source: Field survey

5.5.3 Functioning and Activities of WUA

Major issues related to WUAs were covered under the survey, and findings are presented in Tables 5.33 and 5.34. The PINS+MISs surveyed are original lift schemes have been getting converted to MIS, as they face problem of water logging, labour cost etc. They were functioning well and have long standing and experience. So overall they are functioning well, managed well etc. So, overall responses to various questions on the issues related to the WUAs are positive. In fact we feel that these schemes will set an example for future conversions likely to take place.

The average members of the WUAs are around 160, and overall satisfaction of facilitator's role is "good", this appears oblivious in case of WUAs running satisfactorily for long time. There is no any PIN-MIS scheme with tube well in Maharashtra. Table 5.34 gives details about function of WUAs. They are supposed to meet once in a month, which 11.4 times, it indicates that they meet fairly well. We observe that 36.4% response to the requirement of assistance to WUA. Our past experience also indicate, a necessity of some organisation for solving the problems of WUAs, trainings, refreshers training, and recognition at Govt. level for good WUAs.

Table5.33: Some aspects of functioning of PINS WUA

(Responses by WUA office bearers)

Sr. No.	Particulars	Coop PINS
1	(a) No.ofGeneral Bodymeetings conducted during 2015-16 (No/WUA)	11.36
2	(b) No. of decisions taken in the meetings during 2015-16 (No/WUA)	21.91
3	(c) No. of decisions implemented during 2015-16(No/WUA)	20.36
4	Is there any influence of political parties in selection of office bearers of WUA (% agreed)	18.18
5	If yes, whether influential persons in WUA take all major decisions regarding activities of WUA? (% agreed)	50
6	Was there any rehabilitation problems generated by Installation of PINS Project (% agreed)	27.27
7	If yes, whodidtherehabilitation orconstruction? (% agreed) :	
8	Contractor	33.3
9	WUA	66.7
10	(c) Does WUA need any assistance for its Management? (% agreed)	36.36
	If Yes, from whom:	
a	Government	
b	NGO	50
c	CBOs	
d	Others	
16	Does the WUA get any annual matching grant from Government for operation and maintenance of PINS project? If Yes,	No
17	Mention the amount (Rs/WUA) :	0

Source: Field survey

Table 5.34: Major activities of PINS WUA

(% farmers agreed)

Sr. No	Major activities	Coop PINS
1	Operation & Maintenance of PINS Project	90.91
2	Deciding the timing of water release	81.82
3	Judicious water distribution	81.82
4	Collection of water rates	90.91
5	Collection of per capita operation and maintenance cost	72.73
6	Dispute settlements	81.82
7	Seed or Fertiliser distribution	0
8	Produce collection	0
9	Money lending to members	0
10	Any other	0

Source: Field survey

5.5.4 Water Resource Management by WUA/TUA

In general, all water resource management is taken care of by the WUA. Though there is some flexibility adopted in payment of the water charges by farmers to WUA, majority of them pay the charges regularly (Table 5.35).

Table 5.35: Water Resource Management by WUA/TUA

(% WUA office bearer agreed)

Sr. No.	Particulars	Cooperative PINS
1	Is the Irrigation Management Transferred to WUA?	100
2	Who does the water distribution?	
A	WUA	100
B	Individual farmers	
3	Is the water rates and the operation and maintenance cost of PINS project arebeing collectedb yWUA?	100
4	Whether the operation and maintenance cost of PINS project and water rates are paid by its member regularly?	100
5	If Yes, periodicity of its collection the operation and maintenance cost of PINS project:	
A	Annually	72.7
B	half-yearly	0
C	Quarterly	0
D	After Harvesting Crop (Season wise)	27.3

Source: Field survey

5.5.5 Benefits Provided by WUA to its Members

The benefits of WUAs are mainly related to water as can be seen from Table 5.36. Proper distribution and related benefits have highest responses. The 81.8 per cent of WUAs have experienced better financial situation due to PINS.

Table 5.36: Benefits accrued by the members of WUA

(% WUA office bearer agreed)

Sr. No.	Benefits accrued	Coop PINS
1	Water arrives in time	100
2	Timely information on release of water from canal	100
3	More information on how to use water judiciously	100
4	proper distribution of water among farmers	100
5	Less conflicts around water or less water theft	90.9
6	More information on crops and technologies	91
7	Improved maintenance of the system	100
8	Environmental problems such as water logging and salinity resolved compared to pre-WUA period	45.5
9	Quality of groundwater improved due to less extraction compared to pre-WUA period	9.1
10	Enhanced financial situation	81.8
11	Any other	

Source: Field survey

5.5.6 The major constraints faced by PINS-WUAs

Water availability and fund constraints are the two major issues reported by PINS-WUAs (Table 5.37). Significant changes/improvements have been experienced after formation of WUAs or after introduction of MIS. Majority of WUAs opined that there is inadequate support from Government for their activities.

Table 5.37: Major problems faced by the WUA

(% WUA office bearer agreed)

Sr. No.	Constraints	Coop-PINS
1	Fund constraints	63.64
2	Water availability	45.45
3	Maintenance and repair of PINS	18.18
4	Support from Govt.	72.73
5	Poor participation of WUA members	9.09
6	Non-participation of farmers in the command area	9.09
7	Unsolved conflicts	9.09
8	Political interference	18.18
9	Any other(please mention)	0

Source: Field survey

Chapter VI

Performance of PINS Programme in Telangana

6.1. Introduction

Telangana was formed as 29th state of India with Hyderabad as its capital in 201in 2014. The state is situated on the Deccan Plateau in the Central stretch of eastern sea board of the Indian Peninsula. It covers 114,800 square Kilometres (44,300 sq. miles). The region is drained by two major rivers, with about 79 percent of the Godavari river catchment area, and 69 percent of the Krishna river catchment area, but most of the land is arid due to higher elevation of most of the state compared to rivers. Telangana is also drained by several minor rivers the Bhima, the Manjira and the Musi. The state is surrounded by Maharashtra on north and north-west: Karnataka on the West: Chattishgarh on the north-east and Odisha lies on its west.

Rice is the major food crop of the state. Other important crops are tobacco, mango, cotton and sugarcane. The major kharif coarse cereals maize, jowar, bajra, ragi are produced in the state. Out of the total geographical area 40.5 percent is under net area sown, 23.9 percent is under forests, 10.5 percent is under current fallow lands, 7.7 percent is under non-agricultural uses and 5.4 percent is under barren and uncultivable land. Net cropped area is 46.54 lakh hectares. Agriculture production depends upon the distribution of rainfall. The influence of south-west monsoon is predominant.

6.2 Irrigation Development and Management in Telangana:

There are two major rivers Godavari and Krishna flow through the state. But still the agriculture sector of Telangana depends primarily on rainfall. Though there are other sources of irrigation, well irrigation is the main source in Telangana. The net irrigated area in Telangana increased from 16.82 lakh hectares in 2000-2001 to 20.04 lakh hectares in 2010-2011. The extent of irrigation i.e., percentage share of area under irrigation in total net sown area in the state stood at 44.61 percent in 2010-11 and

had increased from percent in 2000-2001. Adilabad, Rangareddy, Mahaboobnagar and Medak districts are low irrigation intensity districts. Moreover the triennium 2010-13 before bifurcation, the net area irrigated was 20.35 lakh hectares and increased to 21.01 lakh hectares in the triennium 2013-16 ie., the increase is about 3.26 percent. Similarly the increase in gross irrigated area from 2010-13 to 2013-16 is reported as 5.19 percent. The increase in intensity of irrigation between the two triennia is 1.86 percent. The details of net and gross irrigated areas in Telangana state are presented in Table 6.1.

Table 6.1 Intensity of Irrigation

Sr. No.	Period	Net Irrigated Area (ha)	Gross Irrigated Area (ha)	Intensity of Irrigatiojn %
1	2010-13	2035053	2806648	137.92
2	2013-16	21-1545	2952315	140.48

Source: Statistical Abstract of Telengana

6.2.1 Growth of Irrigation in Telengana

The log linear growth rates $Y = ae^{bt} + u^t$for net and gross area irrigated are estimated to identify the states of irrigation in Telangana state. In this connection time series data from 1991-1992 to 2014-15 for net and gross area irrigated are taken for the analysis. To observe the variation the total period is divided into two sub-periods viz., 1991-92 to 2002-03 and 2003-04 to 2014-15. The details of growth rates are presented in Table 2.2. The growth of net area irrigated is statistically found to be significant in the second sub-period and the total period. This inferences that there is no significant growth in the first sub-period i.e., the initial years of post-reform period. Similar result is also found in case of gross irrigated area. The intensity of irrigation is not found to be statistically significant in any sub period and the total period. This inference that due to inadequate water supply from different sources of irrigation, the land cannot be substantially irrigated in the second season of the crop.The details of Log-Liner Growth rates of Irrigation in Telangana state are presented in Table 6.2.

Table 6.2 Log-Liner Growth rates of Irrigation in Telangana

Sr. No.		1991-92 to 2002-03	2003-04 to 2014-15	1991-92 to 2014-15
1	Net Area Irrigated	0.013	0.038*	0.019*
		(1.386)	(3.301)	(4.992)
2	Gross Area Irrigated	0.016	0.040*	0.024*
		(1.470)	(3.523)	(5.990)
3	Intensity of Irrigation	0.003	0.002	0.005
		(1.416)	(0.201)	(1.703)

Source: Statistical Abstract of combined Andhra Pradesh
Notes: () figures in 't' values; * 1% level of significance

The details of area and farmers covered urban different sources of irrigation in Telangana for two different Census periods i.e., 2005-06 and 2010-11 are presented in the following Tables 6.3.

Table 6.3 Growth in Area and Farmers Covered Under Different Sources of Irrigation in Telangana

Census period	Total		Canals		Tanks		Wells		Tube wells		Other sources		Total exclusive No. holdings receiving irrigation	Area (Ha)
	No. of farmers	Area (Ha)	No. of farmers	Area (Ha)	No. of farmers	Area (Ha)	No. of farmers	Area (Ha)	No. of farmers	Area (Ha)	No. of farmers	Area (Ha)		
2005-06	4827747	6299501	345589	297630	694774	240045	448256	512025	596012	749431	81828	71298	1927339 (39.92)	1870425 (29.69)
2010-11	5553982	6196825	584964	439161	338911	216465	774270	697721	844966	740919	58637	59569	2467988 (44.44)	2153836 (34.76)

Source: Agricultural Census

As per two census periods 2005-06 and 2010-11, the total number of holdings increased from 48.28 lakhs to 55.54 lakhs in 2010-11, which shows an increase of 15.04 percent. Out of the total number of holding in 2005-06 only 39.92 percent of holdings received irrigation from all sources while in 2010-11, out of 55.54 lakhs of holdings only 44.44 percent of holdings received irrigation from all sources. Similarly out of 62.99 lakh hectares in 2005-06 only 29.69 percent of area was irrigated and in 2010-11, of the total 61.97 lakh hectares, 34.76 percent of the area was irrigated. This inferences that there is an increase in irrigated area from 2005-06 to 2010-11 by 15.15 percent from all sources of irrigation.

6.2.2 Growth in sprinkler and drip in Telangana:

Out of the total number of 29753 farmers, 58.43 percent of farmers have used drip and 41.57 percent have used sprinkler irrigation system in 2014-15. In 2015-16, out of a total of 39,545 farmers 77.43 percent have utilized drip irrigation and 22.57 percent have utilized sprinkler irrigation system (Table 6.4). It is observed that the number of farmers used drip have increased in 2015-16 by 76.13 percent while the number of farmers used sprinkler system have decreased by -27.84 percent in 2015-16. The reason for the decrease is the problems of maintenance of sprinkler irrigation system.

Table 6.4 Increase in area and farmers under Sprinkler and Drip Irrigation

Name	Drip		Sprinkler		Total	
	No.	Area(Ha)	No.	Area(Ha)	No.	Area(Ha)
2014-15	17385	17190.39	12368	12084.18	29753	29274.57
2015-16	30620	31191.41	8925	8665.72	39545	39857.13

Source: Telangana State Micro Irrigation Project, Hyderabad

The details of District-wise distribution of sprinkler and drip systems are presented for the old 9 districts of Telangana for the year 2014-15 and 2015-16 in Table 6.5. Observing the district-wise use of sprinkler and drip irrigation systems in 2014-15 and 2015-16, both the number of farmers and area under these two systems of irrigation showed a significance difference from 2014-15 to 2015-16. On the whole in Telangana state the number of farmers under drip irrigation has increased from 17385 in 2014-15 to 30620 in 2015-16 i.e., an increase by 76.13 per cent, while the number of farmers under sprinkler system has decreased by -27.84 per cent between the two periods. Moreover the area under drip irrigation is increased 81.45 per cent in 2015-16 while the area under sprinkler irrigation has decreased by 28.29 per cent. Across the districts, the area under drip irrigation has increased in all districts from 2014-15 to 2015-16. On the other hand, the area under sprinkler irrigation system has substantially decreased from 2014-15 to 2015-16 in all districts except in Mahboobnagar and Nizamabad district.

Table 6.5 District-wise distribution of Sprinkler and drip in Telangana

District Name	Drip				Sprinkler			
	2014-15		2015-16		2014-15		2015-16	
	No.	Area(Ha)	No.	Area(Ha)	No.	Area(Ha)	No.	Area(Ha)
Adilabad	930	858.97	2062	2048.98	2068	1977.61	1403	1326.85
Karimnagar	1646	1529.42	2494	2350.28	1986	1961.16	548	537.1
Khammam	671	896.49	1200	1632.29	200	193.7	68	55.23
Mahabubnagar	2605	2926.54	7285	7041.82	1640	1615.1	2914	2874.78
Medak	3763	3612.54	5463	5828.94	4018	3966.7	1769	1743.34
Nalgonda	2211	2229.22	2840	3194.29	809	783.11	582	556.13
Nizamabad	1657	1648.95	2788	2943.26	417	417	601	597.64
Ranga Reddy	1988	1757.27	2588	2492.78	341	319.59	296	290.15
Warangal	1914	1730.99	3900	3658.77	889	850.21	744	684.5
Grand Total	17385	17190.39	30620	31191.41	12368	12084.18	8925	8665.72

Source: Telangana State Micro Irrigation Project, Hyderabad

6.2.3 Progress in Participatory Irrigation Management in Telangana:

The main objectives of Participatory Irrigation Management (PIM) include participation of stake holders in operation, maintenance of irrigation systems, agriculture productivity enhancement and water management. After the reorganization of the state of Andhra Pradesh the new state of Telangana was formed on 2nd June, 2014 with 10 districts.

Telangana region had less experience in canal irrigation. However, many surface irrigation projects are close to the completion state, some of which have been on-going over the last 20-30 years. The carrying capacity of the distribution system had been declining overtime owing to the lack of maintenance and repairs. Under these circumstances, funds through WUAs (Water Users Associations). DCs (Distributary Committees) became handy to carryout works of their choice. This had boosted the local farmers' confidence in WUAs.

The number of WUAs, distributary Committees and Project Committees in major, medium and minor irrigation systems to which elections are to be conducted now in Telangana state is presented in Table 6.6 below.

Table 6.6: Number of Farmer Organizations in Different Irrigation Systems in Telangana

S.No.	Farmers Organization	Major	Medium	Minor	Total
1	WUA's	744	173	3876	4793
2	DC's	97	--	--	97
3	PC's	8	26	--	34

The last elections to WUAs were conducted in united state of Andhra Pradesh in 2008; subsequent elections to be conducted in the year January, 2010, January 2012 and January 2014 were not conducted due to several reasons. Now the entire body of WUAs became vacant by January, 2014. In view of expiry of term of all TC Territorial Constituency) members in January, 2014, elections are to be conducted to the total number of territorial constituency members. There are 4793 WUAs in the state.

It is observed that the number of farmers used drip has increased in 2015-16 by 76.13 per cent while the number of farmers used sprinkler system has decreased by 27.84 per cent in 2015-16. The reason for the decrease in the number of sprinkler systems is the problems in maintenance of the sprinkler system. Moreover, the area under drip irrigation system has increased by 81.45 per cent while the area under sprinkler system has decreased by -28.29 per cent from 2014-15 to 2015-16. Across the districts, the area under drip irrigation has increased in all the districts from 2014-15 to 2015-16. On the other hand the area under sprinkler irrigation system has substantially decreased from 2014-15 to 2015-16 in all districts a except in Mahaboobnagar and Nizamabad districts.

Capacity Building of Farmer's Organization:

The state government has initiated an exhaustive capacity building programme for the office bearers of the farmer's organizations. These organizations have a training centre of their own at each circle level. These representatives are being taken to exposure visits to other states as well as for better appreciation of the management and operation of the irrigation system.

The state government has provided adequate financial support to these organizations for efficient management of the system. The financial

support is provided as tax re-ploughs and also the deferred maintenance works. The water users associations are permitted to take up works up to Rs. 5 lakhs by themselves while the works above the this limit are tendered. The works out of tax re-plough are also administratively sanctioned by the water users associations only.

Entire Water Tax Collection is being ploughed back to the Farmer's Organizations (WUA/DC/PC) for taking up operation and maintenance in the area of operation as stated in Table 6.7.

Table 6.7: Allocation of Funds for WUAs

	Allocation						
	WUAs		D.Cs		P.Cs		Gram
	Works	Admn.	Works	Admn.	Works	Admn.	Panchayat
Major	50%	10%	15%	5%	14%	1%	5%
Medium	50%	10%	-	-	30%	5%	5%
Minor	80%	10%	-	-	-	-	10%

Source: Government of Telangana, Office of the Commissioner, CAD, Irrigation & CAD Department

6.3 Overview of PINS Programmes in Telangana:

Since there are no government PINS projects with MIS available in the state, alternatively the projects with MIS scheme are installed connected to the irrigation source of tube-wells/bore-wells in the state. This MIS scheme was installed and implemented by twelve private agencies in the state. From 2014 onwards, the MIP scheme (NMMI) was subsumed into National Mission for Sustainable Agriculture (NMSA) as one of the component as On-Farm Water Management (OFWM) and the modal department is agriculture department (HOD). The physical and financial achievements under micro-irrigation project in Telangana are as follows in Table 6.8.

Table 6.8 Physical and financial achievements under MIP in Telangana

Year	Physical in Ha			Financial
	Drip	Sprinkler	Total	(Rs. In lakhs)
2003-06	32331	34314	66646	8330.00
2006-07	30461	9700	40161	9276.00
2007-08	42185	12600	54785	13748.00
2008-09	39516	15650	55166	13808.00
2009-10	47316	18750	66066	30369.00
2010-11	41259	17650	58909	24386.00
2011-12	35719	115416	51135	34231.00
2012-13	47385	8	47393	40652.00
2013-14	39501	0	39501	32672.00
2014-15	36742	16993	53736	35008.90
2015-16	31191	8666	39857	32231.69
Total	423608	573355	573355	274712.60

Source: Telangana State Micro Irrigation Project, Hyderabad

Out of 17.12 lakh hectares of net irrigated area irrigated with ground water, only 5.73 lakh hectares are covered under micro-irrigation, leaving a balance potential of 11.39 lakh hectares for micro-irrigation (Table 6.9). In all the districts the MIP projects through MIS scheme connecting to tube-well irrigation are implemented. About 5,50,212 numbers of micro-irrigation systems were installed with a coverage of area of 5,50,212 hectares the total number of beneficiaries being 2,96,436.

Table 6.9: District wise number of PINS covered area in Telangana

Sl. No.	District	Net Irrigated area with bore-wells (in lakh ha)	MIP covered area (in lakh ha)	MIP to be covered (in lakh ha)
1	Mahboobnagar	2.18	1.34	0.84
2	Ranga Reddy	0.70	0.41	0.29
3	Medak	1.64	0.85	0.79
4	Nizamabad	1.76	0.40	1.36
5	Adilabad	0.68	0.42	0.26
6	Karimnagar	4.69	0.46	4.23
7	Warangal	2.60	0.56	2.08
8	Khammam	0.92	0.37	0.55
9	Nalgonda	1.95	0.96	0.99
	Total	17.12	5.73	11.39

Source: Telangana State Micro Irrigation Project, Hyderabad

The drip system of MIS is provided for cotton crop with a total initial fixed cost of Rs. 1,06,120 of which 10.612 is given subsidy for BCs small/marginal farmers and for others the subsidy is given to a maximum of Rs. 21,224. Moreover, the sprinkler irrigation system of MIS is provided for groundnut crop with a total fixed cost of Rs. 17,880 of which Rs. 4,470 is given as subsidy for SC/ST, BCs small/marginal and for others. MI project in Telangana is mainly based on well and tube-well irrigated areas. The mechanism of supply/purchase of MIS equipments/material installations on fields are all through the empanelled MI companies. The area under fertigation is approximately 10 per cent of the sanctioned area in the state. A total of 2,96,434 farmers are benefitted through MIP covering an area of 5,50,212 hectares in the state. The percentage of saving of water varied from 49 per cent in case of tomato to 54 per cent in case of Vegetables and sugarcane. On the other hand, the percentage of energy saved from a low of 49 per cent in case of tomato to 54 per cent in case of Vegetables and sugarcane.

6.3.1 Coverage of PINS (MIS) in the districts of Telangana:

There are two types of MIS systems viz.,drip and sprinkler. In all districts the MIP projects through MISscheme connected to tube-wells are implemented upto 2015-16. The district-wise distributions of MIS through feeder irrigation source are presented in following Table 6.10.

Table 6.10 Feeder Irrigation source-wise distribution of PINs in the state

District	Irrigation basin/ project	No. of MIS Installed					Total number of beneficiaries					Area covered (Ha)				
		Canal	Tube wells	Tanks	River	Any Other	Canal	Tube wells	Tanks	River	Any Other	Canal	Tube wells	Tanks	River	Any Other
Adilabad	Tube well / bore well		128476					69517					128476			
Karimnagar	Tube well / bore well		40238					21803					40238			
Khammam	Tube well / bore well		79897					44934					79897			
Mahabubnagar	Tube well / bore well		38050					26869					38050			
Medak	Tube well / bore well		39783					21217					39783			
Nalgonda	Tube well / bore well		43436					31052					43436			
Nizamabad	Tube well / bore well		50195					34930					50195			
Rangareddy	Tube well / bore well		36463					13350					36463			
Warangal	Tube well / bore well		93672					32762					93672			
State Total	Tube well / bore well		550212					296434					550212			

Source: Telangana State Micro Irrigation Project, Hyderabad

From the above Table, it can be seen that upto 2015-16, 5, 50,212 numbers of micro-irrigation systems were installed with a coverage of area of 5, 50,212. Moreover the total number of beneficiaries is 2, 96,436.

6.3.2 Cost pattern on PINS:

The Telangana state micro-irrigation project prescribed the initial capital cost requirement/provision on PINS-MIS in the state. The drip system of MIS is provided for different crops with a total initial fixed cost of Rs. 1, 06,120 of which Rs. 10,612 is given as subsidy for BCs small and marginal farmers and for others the subsidy is given to a maximum of Rs. 21,224. Each drip system is targeted to irrigate an area of one hectare. On the other hand the sprinkler irrigation system of MIS is provided for different crops with a total fixed cost of Rs. 17,800 of which Rs. 4,470 is given as subsidy for SC/ST, BC small/marginal farmers and for others. Each system of sprinkler is targeting to irrigate an area of one hectare. All the details can be observed from following Table 6.11.

Table 6.11 Initial Capital Cost Provisions on PINS - MIS in the State

Type of MIS	Total Initial fixed Cost (Rs.)		Total area irrigated (bigha/local unit)
	Actual	**Less subsidy**	
Drip	106120	SC,ST - NIL BC, SF/MF - 10612 Others - 21224	1 ha
Sprinkler	17880	SC,ST, BC,SF/MF & Others - 4470	1 ha

Source: Telangana State Micro Irrigation Project, Hyderabad

6.3.3 Installation of PINS-MIS in the state:

Telangana state micro-irrigation project has not at all coined PINS in the action plan since inception, but a very few of MI installations are done by taking the irrigation from canals and tanks. MI project in Telangana is mainly based on the well and tube-well irrigated areas. The mechanism of supply/purchase of MIS equipments/material installation on fields are all through the empanelled MI companies of MIP) is giving the awareness on fertigation and chemigation through the drip system due to non-availability of water soluble fertilisers. Very few farmers doing fertigation through drip system. The area under fertigation is approximately 10 per cent of the

sanctioned area in the state. All the details can be viewed from following Table 6.12.

Table 6.12 Average Cost of PINS Equipments and Installations in the State

PINS – MIS Equipments	Equipment Cost (Rs)	Installations Cost (Rs)	Periodicity of servicing provided (Number per Year)
Drip Equipments			
Control Head	6985.34	483.00	"5 years free of cost and 5 years at the cost of farmers"
Main / Sub Main pipes	8341.90		
Laterals	89166.06		
Emitters			
Total Drip System	104493.30		
Sprinkler Equipments			
Control Head	-	-	"5 years free of cost and 5 years at the cost of farmers"
Main / Sub Main pipes	13425		
Laterals	4455		
Emitters			
Total Sprinkler System	17880		

Source: Telangana State Micro Irrigation Project, Hyderabad

6.3.4 District-wise coverage of PINS-MIP:

The details of district-wise number of farmers and area covered upto 2015-16 under MIP are presented in the following Table 6.13. A total of 2, 96,434 farmers are benefitted through MIP covering an area of 5,50,212 hectares in the state. The number of farmers varied from 13,350 in Khammam district to 69,517 in Mahaboobnagar district. Similarly the area covered from a low of 36,463 hectares in Khammam to 1,28,476 hectares in Mahaboobnagar district.

Table 6.13 Average Cost of PINS Equipments and Installations in the State

Districts	No.of farmers	Area covered (Ha)
Mahboobnagar	69517	128476
Ranga Reddy	21803	40238
Medak	44934	79897
Nizamabad	26869	38050
Adilabad	21217	39783
Karimnagar	31052	43436
Waranga	34930	50195
Khammam	13350	36463
Nalgonda	32762	93672
Total	296434	550212

Source: Telangana State Micro Irrigation Project, Hyderabad

6.3.5 Crop-wise water and energy saved (per hectare) with drip irrigation:

The details of crop-wise water and energy saved per hectare with drip irrigation are presented in Table 6.14. The percentage of saving of water varied from 49 per cent in case of tomato to 54 per cent in case of Vegetables and sugarcane. On the other hand the percentage of energy saved from a low of 49 per cent in case of tomato to 54 per cent in case of Vegetables and sugarcane. Moreover the percentage increase in yield ranged between 15 to 30 per cent in case of pomegranate to 35 to 40 per cent in case of papaya and mango.

Table 6.14 Crop-wise water and energy saved per hectare with drip irrigation in the State

Crop	Water saved in (mm) per ha per season				Energy Saved (kwh) per ha				Yield Increased (%)
	flood irrigation	Drip irrigation	Net saving	% of saving	flood irrigation	Drip irrigation	Net saving	% of saving	
Sweet orange	1136	530	606	53	1307	610	697	53	25-60
Sugarcane	1634	748	886	54	1881	861	1020	54	20-40
Pomegranate	1363	663	700	51	1569	763	806	51	15-30
Vegetables	891	408	483	54	1026	470	557	54	20-40
Papaya	2196	1060	1136	52	2528	1220	1307	52	35-45
Mango	1114	520	594	53	1283	599	684	53	35-45
Tomato	994	504	490	49	1145	580	564	49	20-40
Chilli	994	480	514	52	1145	553	592	52	20-40
Banana	2196	1087	1109	51	3033	1501	1532	51	32-50

Source: Telangana State Micro Irrigation Project, Hyderabad

6.4. Adoption, Performance and Management of PINS (MIS) by Farmers:

6.4.1 Details of Adoption of PINS-MIS

The number of beneficiary and non-beneficiary sample households selected under the study in Telengana was 200 and100, respectively. On an average, the average number of years of farming experience was reported to be around 24 years. The average per household net operated area is reported to be 2.26 hectares of which 2.24 hectares is reported as owned land and 0.02 hectares is leased-in land. Between beneficiary and non-beneficiary farmers, beneficiary farmers have enjoyed more irrigational

fertilities than non-beneficiary farmers. The per household area under drip system is reported to be 1.12 hectares.

The higher percentage of area under irrigation is reported to be under tube-wells for both beneficiary and non-beneficiary farmers. The percentage of irrigated area for beneficiary farmers ranged from 0.35 per cent under tanks to 63.84 per cent under tube-well. On the other hand the percentage of irrigated area for non-beneficiaries ranged from 0.95 per cent under tanks to 62.98 per cent under tube-wells.

On an average the area under PINS (MIS) is reported to be 1.11 hectares (Table 6.15). All the 200 sample farmers are provided drip system and the sprinkler system is provided only for five farmers. On the whole, the per household amount spent on MIS is reported to be Rs. 8,443. The per household spent on MIS varied from Rs. 6,660 in case of marginal farmers to Rs. 10,000 in case of large farmers.

Table 6.15 Average areas under PINS Project by farmer category

(Area in ha per hh)

Farmer category	Area under PINS (MIS)
Marginal (upto 2.50 ac)	0.88
Small (2.51 to 5.0 ac)	1.14
Medium (5.01 to 10.0)	1.13
Large (>10.0)	1.39
Total	1.11

Source: Field Survey

Two types of MIS viz., drip and sprinkler systems are adopted as micro-irrigation systems under PINS programmes. All the 200 sample farmers are provided drip system and sprinkler system is provided only for five farmers. The per household total cost of the drip system is reported to be Rs. 1 lakh with a subsidy of 90 percent, while the per household total cost of sprinkler system is reported as Rs. 17,880 with a subsidy of 25 percent. The subsidy for both of the micro-irrigation systems is given by TSMIP (Telangana State Micro Irrigation Project) under the subsidy programme of PMKSY. The details can be viewed from the Table 6.16.

Table 6.16 Adoptions of Micro Irrigation Systems (MIS) under PINS Programs

Type of MIS used	No. of farmers used	%.of farmers used	Average area under MIS (ha/hh)	Total cost of the system (Rs/hh)	Amount paid the farmers (Rs/hh)	Subsidy (%)	Whogivesthesubsidy*	Name of the subsidy programme
Drip system	200	100	1.11	100000	10000	90	TSMIP	PMKSY
Sprinkler	5	2.5	0.04	17880	4470	25	TSMIP	PMKSY

Source: Field Survey

There are three main reasons behind the adoption of PINS (MIS) programme. They are:

1. To get assured amount of water for irrigation.
2. To get better and stable crop yield and farm income and
3. To save more water and to cover more area under irrigation. All the sample beneficiary farmers are benefitted by participating in Tube-well User Association (TUA). Out of 200 sample beneficiary farmers, forty number of farmers are participatory in four TUA of which one TUA is not functioning properly.

All the total sample beneficiary farmers reported that the representatives of authorised dealers of manufacturing have installed MIS on their fields. All the sample beneficiary farmers invariably reported that water quality testing has been carried out prior to installation of MIS to their fields. Across the crops the per hectare cost of cultivation varied from a low of Rs. 3,768 in case of redgram to a maximum of Rs. 1,82,974 in case of ginger. On an average, the per hectare cost of cultivation in rabi season reported from a low of Rs. 19,466 in case of bengalgram to a high of Rs. 63,265 in case of vegetables. Moreover, the average per hectare cost of cultivation of perennial crops reported to be a high of Rs. 22,10,210 in case of sweet orange, while a low of Rs. 1,17,686 in case of papaya.

6.4.2 Benefits accrued by participating in TUA

Out of the total sample of beneficiary farmers 90 percent of the farmers reported to be benefitted by 56 percent of increase in area under irrigation. About 95 percent of farmers reported that their agricultural

income has increased by 45 percent prior to participating in TUA. Moreover 94 percent of farmers reported that they have derived about 40 percent of increased water saving due to judicious use of water. Nearly 60 percent of farmers reported that they are benefitted by 48 percent of increase of electricity saving by participating in TUA. All the details can be observed from the Table 6.17.

Table 6.17 Benefits accrued by participating in TUA

Benefits accrued	% farmers benefited	Extent of benefit (% increase)
Area under irrigation has increased	90.00	56.00
Agricultural income has increased	95.00	45.00
Water saving due to judicious use of water	94.00	40.00
Electricity saving	60.00	48.00

Source: Field Survey

6.4.3 Impact of PINS with MIS on Cropping Pattern and Production:

Comparing beneficiary with non-beneficiary farmers, the percentage change in area due to PINS programme is reported to decline by 9.68 per cent for kharif crops and an increase by 351.71 per cent for rabi crops (Table 6.18). Between beneficiary and non-beneficiary farmers, the beneficiary farmers could achieve more production of respective crops in respective seasons than the non-beneficiaries. Moreover the percentage of change in beneficiaries over non-beneficiaries in achieving production ranged from 30 per cent in case of paddy to 100 per cent in case of Redgram.

The details of per hectare production of various crops grown by the beneficiary and non-beneficiary farmers are presented in Table 6.19. Observing between beneficiary and non-beneficiary farmers, the beneficiary farmers could achieve more production of respective crops and respective seasons than non-beneficiaries. Glancing over beneficiary and non-beneficiaries, the percentage change varied from 21.90 per cent in case of paddy to 100 per cent in case of redgram during kharif season. On the other hand, the percentage of change in beneficiaries over non-beneficiaries in achieving production ranged from 30 per cent in case of paddy to 100 per cent in case of redgram. The percentage change in beneficiaries over non-beneficiaries in case of sweet orange crop grown as perennial crop is reported to be 200 per cent.

All the crops under drip irrigation have achieved more per hectare production than the yield achieved under the other sources of irrigation other than drip (Table 6.20).

Table 6.18 Impact of MIS on Cropping Pattern of the Sample Households

(Area in ha, % of GCA)

Sl. No.	Season/ crop	Beneficiary Farmers		Non-beneficiary Farmers		Overall		% change in BF over NBF
		Area (ha)	% of total	Area in ha	% of total	Area in ha	% of total	
A	Kharif crops							
	Paddy	0.285	8.87	0.15	6.14	0.240	8.12	90.54
	Jowar	0.028	0.88	0.03	1.08	0.028	0.94	7.69
	Maize	0.144	4.47	0.00	0.00	0.096	3.24	N.A
	Red gram	0.055	1.70	0.04	1.66	0.050	1.69	35.00
	Cotton	0.922	28.67	1.55	63.56	1.131	38.25	-40.50
	Turmeric	0.326	10.13	0.25	10.38	0.301	10.20	28.80
	Soya	0.056	1.73	0.13	5.48	0.082	2.76	-58.33
	Ginger	0.051	1.57	0.00	0.00	0.034	1.14	N.A
	Chilli	0.049	1.51	0.03	1.33	0.043	1.46	50.00
	Vegetables	0.059	1.83	0.0	0.00	0.039	1.32	N.A
	Total Kharif Crops	1.973	61.36	2.18	89.63	2.043	69.12	-9.68
B	Rabi crops:							
	Paddy	0.227	7.05	0.08	3.40	0.179	6.05	173.17
	Maize	0.141	4.37	0.02	1.00	0.102	3.45	479.17
	Jowar	0.051	1.57	0.00	0.00	0.034	1.14	N.A
	Bengal Gram	0.093	2.90	0.00	0.00	0.062	2.10	N.A
	Green Gram	0.099	3.08	0.02	0.66	0.071	2.42	512.50
	Red Gram	0.115	3.59	0.04	1.66	0.090	3.06	185.00
	Ground nut	0.190	5.92	0.04	1.66	0.140	4.75	370.00
	Total Vegetable	0.053	1.64	0.01	0.33	0.038	1.28	550.00
	Total Rabi Crops	0.968	30.12	0.21	8.72	0.716	24.23	355.71
C	Perennial crops :							
	Sweet orange	0.079	2.45	0.04	1.65	0.066	2.24	95.00
	Papaya	0.051	1.57	0.00	0.00	0.034	1.14	N.A
	Pomegranate	0.019	0.60	0.00	0.00	0.013	0.43	N.A
	Total Perennial crops	0.274	8.52	0.00	0.00	0.183	6.18	N.A
D	Gross cropped area :	3.215	100.00	2.437	100.00	2.956	100.00	31.92

Source: Field Survey data.

Table 6.19 Production Pattern of the Sample Households

(Quintal/ha)

S.No	Season/crop	Beneficiary Farmers	Non-Beneficiary Farmers	% of change in BF over NBF
A	Kharif crops:			
	Paddy	32	26.25	21.90
	Jowar	6	4	50.00
	Maize	30	0	0.00
	Red gram	8	4	100.00
	Cotton	12	7	71.43
	Turmeric	32	25	28.00
	Soya	7	4.5	55.56
	Ginger	20	0	0.00
	Chilli	40	28	42.86
	Vegetables	250	160	56.25
B	Rabi crops:			
	Paddy	39	30	30.00
	Maize	40	21	90.48
	Green Gram	5	3	66.67
	Red Gram	8	4	100.00
	Ground nut	12	8	50.00
	Total Vegetable	280	200	40.00
C	Perennial crops:			
	Sweet orange	75	25	200.00
	Papaya	75	0	0.00
	Pomegranate	25	0	0.00

Source: Field Survey data.

Table 6.20 Production Impacts of PINS with MIS

(Quintal/ha)

Major Crops	Drip (with PINS)	Canal/Flood/other irrigation (both PINS & Non-PINS)	%change in yield under drip over flood
Paddy	-	30	0.00
Maize	40	30	33.33
Red gram	12	5	140.00
Cotton	15	8	87.50
Turmeric	38	8	375.00
Soya	8	5	60.00
Chilli	50	30	66.67
Vegetables	300	220	36.36
Green Gram	5	3	66.67
Ground nut	15	8	87.50
Sweet orange (tonnes/ha)	35	10	250.00

Source: Field Survey data.

All the beneficiary farmers expressed that they are benefitted through installation of MIS:

1. By getting adequate water to their fields.
2. Reduction in over extraction of ground water
3. Saved energy consumption

4. Less water logging and
5. Less maintenance costs etc.

6.4.4 Determinants of Adoption of PINS

The probit model analysis explains that among the explanatory variables the marginal effect of operated area is positively associated with increase in agricultural yield, income, water and energy saving but negatively associated with fertilizer and pesticide use (Tables 6.21 to 6.23). The positive association implies that due to the marginal effect of operated area, the yield, income, water and energies are saved to a significant level. On the other hand, the negative association inferences that the fertilizers and pesticides are being used more than the required doses. Hence the model finally explains that the positive change in required amount of water will be resulted in an increase in agricultural yield, income and energy saving to a significant level.

Table 6.21 Factors influencing Adoption of PINS (Probit Model)

(Dependent variable: Increasing Agricultural Yield and Income, Yes=1, No=0)

Predictor Variables	Coefficient	Marginal effects	Std Error	Z value	Pr (>|z|)
Intercept	0.9189502	-	0.8078736	1.14	0.255
Age of the head of the household	0.0044454	0.0012018	0.0046255	0.26	0.795
Years of schooling	-0.0505926**	-0.0136776	0.0066036	-2.06	0.040
Agricultural experience of the household	-0.0199715	-0.0053993	0.0040699	-1.32	0.188
Amount of loan taken	0.00000071	0.00000019	0.00000025	0.74	0.460
Membership other than TUA	0.1081479	0.0292376	0.0562825	0.52	0.604
Operational area	0.1479781***	0.0400056	0.0208842	1.91	0.056
Area under MIS	-0.8992583**	-0.243113	0.0977887	-2.44	0.015
Sufficient of water	1.124813*	0.391829	0.129021	3.31	0.001
No interruption of power supply	0.0247131	0.0066789	0.059886	0.11	0.911
Pseudo R^2	0.1260	No. of observations =200			
LR Chi-square	26.24	Degree of freedom= 9			

Notes: Significance codes: *(1 percent), **(5 percent) and ***(10 percent)

Source: Computed (using STATA) from field data

Table 6.22 Factors influencing Adoption of PINS (Probit model)

(Dependent variable: Water saving, Yes=1, No=0)

Predictor Variables	Coefficient	Marginal effects	Std Error	Z value	Pr (>|z|)
Intercept	-0.1769451	-	0.8427434	-0.21	0.834
Age of the head of the household	-0.0014628	-0.0003467	0.0044765	-0.08	0.938
Years of schooling	-0.0354373	-0.0084003	0.0062874	-1.34	0.181
Agricultural experience of the household	-0.022687	-0.0053779	0.0039828	-1.33	0.182
Amount of loan taken	0.0000015	0.00000036	0.00000029	1.23	0.220
Membership other than TUA	0.0947472	0.0224596	0.0551865	0.41	0.684
Operational area	0.1522424***	0.0360887	0.0194528	1.87	0.062
Area under MIS	-0.1292414	-0.0306363	0.088684	-0.35	0.730
Sufficient of water	1.038382*	0.3353435	0.1373898	2.90	0.004
No interruption of power supply	1.217606*	0.2839204	0.055203	4.57	0.000
Pseudo R^2	0.2587	No. of observations =200			
LR Chi-square	54.51	Degree of freedom= 9			

Notes: Significance codes: *(1 percent), **(5 percent) and ***(10 percent)

Source: Computed (using STATA) from field data

The estimated results with energy saving as the dependant variable indicate that only two explanatory variables are found to be significant at 1 and 5 per cent probability levels respectively. The marginal effects of these two variables are found to be positively associated with energy saving (Table 6.23).

Majority of the beneficiaries expressed the problem of power supply to MIS and a few farmers reported the problem of operation and maintenance. Minimum percentage of farmers reported the problem of scheduling of micro-irrigation.

Majority of the farmers suggested that the MIS subsidy is to be extended from 1 hectare to 3 hectares and reduction in input price also. Almost all farmers suggested intermittent power supply.

Table 6.23 Factors influencing Adoption of PINS (Probit model)

(Dependent variable: Energy saving, Yes=1, No=0)

Predictor Variables	Coefficient	Marginal effects	Std Error	Z value	Pr (>|z|)
Intercept	0.0890256	-	0.8165671	0.11	0.913
Age of the head of the household	0.020666	0.0052689	0.0041021	1.27	0.202
Years of schooling	0.0007714	0. 0001967	0.0059207	0.03	0.974
Agricultural experience of the household	-0.0090451	-0.0023061	0.0036247	-0.63	0.527
Amount of loan taken	- 0.0000000437	-0.000000011	0.00000022	-0.05	0.960
Membership other than TUA	-0.2026996	-0.0516789	0.0548757	-0.94	0.346
Operational area	0.4129459*	0.1052819	0.0298656	2.92	0.003
Area under MIS	-0.38722	-0.098723	0.0875414	-1.10	0.273
Sufficient of water	-0.2975995	-0.0673451	0.0814356	-0.73	0.468
No interruption of power supply	0.4673384**	0.1182558	0.0565936	2.09	0.036
Pseudo R^2	0.1211	No. of observations =200			
LR Chi-square	25.82	Degree of freedom= 9			

Notes: Significance codes*(1 percent), **(5 percent) and ***(10 percent)

Source: Computed (using STATA) from field data

6.5 Adoption, Performance and Management of PINS (MIS) By Tube-well Users Associations (TUAs):

The average life span of PINS in Telengana is about 17-18 years. Out of total 50 members covered under four tube-well user Associations, only 40 beneficiaries, 10 each from each association are taken as sample for the analysis. About 65 percent of the tube-well users reported that their land in command area of the PINS project is moderately fertile, while 35 percent of the users reported to have less fertile land. All the sample farmers reported to have practiced crop rotation in their land. The crops grown during kharif (2015) are paddy, maize and turmeric while paddy, pulses and groundnut are grown during rabi season. All the above details can be viewed from the following Table 6.24.

Table 6.24 Details of Associated PINS Project

Particulars		Tubewell PINS
Average Life Span of the PINS (Years)		17-18
Feeder irrigation source (% distribution):		
	Tube well	100
	Any other	-
Type of the irrigation project (% distribution):		
	Major	-
	Medium	-
	Minor	100
Total Area covered under the PINS Project TUA (acre)		137
Total number of beneficiaries of the Project/TUA		40
Nature of the land in the command area of PINS Project (% distribution):		
	Very fertile	
	Moderately fertile	65
	Less fertile due to salinity	35
	Less fertile due to water logging	
Less fertile since exposed to erosion/or for any other reason		
Crops grown duringKharif(2015):		
	Kharif crop1	Paddy
	Kharif crop2	Maize
	Kharif crop3	Turmeric
Crops grown during Rabi (2015-16)		
	Rabi crop1	Paddy
	Rabi crop2	Pulses

Source: Field Survey

Out of the total cost of Rs. 5,50,000 of the PINS system per TUAs, 44.45 per cent was invested on pumpsets and power units, while 54.55 per cent of the amount expended towards system layouts. Moreover the per TUA installation cost is reported to be Rs. 60,000 of which 83.33 per cent is expended towards installation of pumpsets and power units, while 16.67 per cent is towards system layouts.

On an average, the total annual operation and maintenance cost of PINS per TUA accounts for Rs. 16,000 of which 87.50 per cent towards repairing and maintenance of tube-wells and 12.50 per cent towards electrical charges. Generally the maintenance works will be undertaken once in a year. The details can be seen from the following Table 6.25.

While enquiring the members of TUAs about their satisfaction towards the facilitator (NGO), 55 per cent have reported that they have good satisfaction about the facilitator, 30 per cent of the members reported

average satisfaction and 20 per cent of the members reported poor satisfaction.

Table 6.25 Annual Operation and Maintenance Cost on Tubewell PINS

Heads of expenses	Expenses (Rs)
Electricity Charges	2000
Repairing/Maintenance of tube well/canal PINS	14000
Other Expenses	-
Total annual Operation and Maintenance Cost on PINS (Rs):	16000
Frequency of maintenance works undertaken (Number/Year):	1

Source: Field Survey

Six decisions were taken in twelve general body meetings conducted during 2015-16 of which five decisions were implemented. All the water users expressed the need of assistance from NGO.

All the water users under TUAs, expressed their preferences in the following way. The first preference was given to the decision of timely water release, while the second preference was judicious water distribution, operation and maintenance of PINS project was given third preference and collection of per capita operation and maintenance cost as fourth preference. Ultimately the final preference was towards collection of water rates. The details can be observed from the following Table 6.26.

Table 6.26 Major Activities of PINS TUA

(Ranks)

Major activities	Tubewell PINS
Operation & Maintenance of PINS Project	3
Deciding the timing of water release	1
Judicious water distribution	2
Collection of water rates	5
Collection of per capita operation and maintenance cost	4
Dispute settlements	6

Source: Field Survey

The inflow of income is due to collection of annual maintenance fees, while the outflow of income is through expenditure on electricity bill and repairing expenses. During 2015-16, total amount collected from WUA members was Rs 36000 whereas Rs 26500 was spent on maintenance activities.

About 58 per cent of the office bearers reported good relationship with irrigation department, while 42 per cent of the bearers reported average relationship. Moreover, 45 per cent of the office bearers reported good relationship with department of agriculture, while 40 per cent of the office bearers reported average relationship.

Water Resource Management by TUA:

The office bearers of TUAs expressed that about 66.67 percent of management is transferred to TUAs and remaining 33.33 percent of management is under the control of individual farmers. All 66.67 percent of office bearers reported that the water rates and operation and maintenance cost of PINS project are being collected by TUA and all the TUA members are paying operation and maintenance cost of PINS project and water rates regularly. The operation and maintenance cost of PINS project are being collected monthly. On the whole, it can be inferred that those members that are involved in TUAs are very regular in maintaining or paying water rates regularly. All the above details are furnished in the Table 6.27.

Table 6.27 Water Resource Management by TUA
(% TUA office bearer agreed)

Particulars	Tube well PINS
Is the Irrigation Management Transferred to TUA?	66.67
Who does the water distribution? :	
TUA	66.67
Individual farmers	33.33
Is the water rates and the operation and maintenance cost of PINS project arebeing collected by TUA?	66.67
Whether the operation and maintenance cost of PINS project and water rates are paid by its member regularly?	66.67
If Yes, periodicity of its collection the operation and maintenance cost of PINS project:	
Annually	-
half-yearly	-
Quarterly	-
monthly (As and when required)	66.67

Source: Field Survey

Out of four TUAs, one TUA consisting of 10 members is not functioning properly. As a result, the PINS Project was not implemented

properly. This TUA may be referred to that which was under the management of individual farmers.

Due to formation into TUAs the farmers could receive three benefits viz., (i) timely release of water to their fields and judicious use of water, (ii) improved maintenance of the system and (iii) more information on crops and technologies and thereby improved quality of ground water due to less extraction compared to pre-TUA periods.

About 66.67 per cent of TUA members reported to have received sufficient water throughout the year. Nearly 33.33 per cent of water users reported that the PINS system is not functioning properly and also due to improper management of PINS system, they received inadequate water to their farm plots. Non-payment of water rates and maintenance charges by the members is also another reason for getting inadequate supply of water to their fields.

Among the problems faced by the TUAs, 32 per cent of the problems arose out of the fund constraints. Nearly 40 per cent of the problems are due to water availability. About 18 per cent of the problems are due to maintenance and repair of PINS and only 10 per cent of the problems arose due to poor participation of TUAs' members.

Nearly 70 per cent of the users reported that there is less water logging problem prior to formation into TUA. Almost all water users agreed that there was no salinity in water, dug well pollution, ground water pollution and crop yields. 50 per cent of the users reported that there were no labour problems and no problems in crop yields.

All the water users reported that there are no constraints of water logging, salinity, inter and intra village conflicts and crop yields after formation into TUAs. All the water users of TUAs received better results after formation into TUAs than pre-TUA period.

Chapter – VII

Summary and Conclusions

7.1. Backdrop

Water is universally accepted as a symbol of life as it is the most crucial for maintaining an environment and ecosystem conducive to sustaining all forms of life. The demands for drinking, domestic activities, livestock, agriculture, industries, power generation and other uses are all increasing to meet the requirements of increasing population and also to cater for the enhanced per capita requirement due to rise in living standard. Water scarcity for agriculture has been growing year after year due to various reasons, for which the government has been very keen to increase the water use efficiency with its new slogan 'more crops per drop'. Thus, the government has envisaged to promote MIS and increase the area under these water saving technologies. The Pressurised Irrigation Network System (PINS) is one such new innovative concept that acts as interface between water source and MIS in farm plots and increases the area under irrigation through adoption of MIS. It comprises of pipe network with controls, pumping installations, power supply, filtration, intake well/diggy. It is a common and shared infrastructure (by group of farmers) facilitating individual beneficiary install and operate MIS.

The present study intended to assess the effectiveness of institutional arrangements for management of PINS projects and the bottlenecks for their smooth functioning in India. Since Gujarat, Rajasthan, Maharashtra and Telengena are the leading states of the India promoting the PINS and MIS, the present study has undertaken in these four states. The WUAs in the study areas of the selected states were interviewed to capture the dynamics of community based irrigation management. Under different command areas, the study analysed system performance of PINS Project with MIS such as drip and sprinklers in terms of their functioning, costs and benefits, adoptability.

In this chapter, the major findings from the selected four states have been summarised and state specific policy implications have been highlighted.

7.2 Data and Method

The major objectives of the study were:

i) To undertake a broad situation analysis of various PINS programs implemented in select states of India;
ii) To assess the extent of adoption and performance of PINS in different scenarios in the country;
iii) To analyse the institutional arrangements for management, operation and maintenance of PINS in the country;
iv) To identify the major constraints in adoption, management, operation and maintenance of PINS in the country;
v) To recommend suitable policy measures to enhance the effectiveness and techno-economic performance of PINS in the country.

The study covers four major states (Rajasthan, Gujarat, Maharashtra and Telengana) of the country promoting PINS with MIS in their states. The data were collected from sample households and PINS-WUAs as per the distribution stated in Table 7.1.

Table 7.1: PINS Sample Size Distribution in Selected States

States	No. of Beneficiary Households	No. of Non-Beneficiary Households	No. of PINS-WUAs
Gujarat	200	100	27
Rajasthan	200	100	26
Maharashtra	250	105	75
Telengana	200	100	32
Grand Total	850	405	160

In Gujarat and Telengana, all the selected PINS were tube well PINS where as in Rajasthan, all the selected PINS were canal PINS. In Maharashtra, three types of PINS were selected: government PINS (100% government funded), cooperatives PINS (partially funded by government and managed by

group of farmers) and private PINS (owned and managed by individual farmers). In both Maharashtra, both ground water and surface water was used as irrigation sources.

Four kinds of survey schedules were administered on the major stakeholders such as (i) Implementing Agencies/ Promoting Companies, (ii) PINS Water User Association (WUAs), (iii) Beneficiary Households and (iv) Non-Beneficiary Households. In addition to survey method, the Focused Group Discussion and Key Informant Interviews were conducted to capture institutional dynamics in operation and maintenance in various command areas of the country. PINS operators, WUA management committee members and farmers were interviewed for understanding the effectiveness of institutional arrangements for operation and management of irrigation systems and distribution of irrigation water and the difficulties they face.

Simple statistical tools, case studies and probit models were used for data analysis and interpretation of results.

7.3 Summary of Findings

7.3.1 Overview of PINS Programme in India

The land area under irrigation in India has expanded from 22.6 million hectares in 1950 to about 91.53 million hectares in 2011-12, with 52 per cent area being irrigated by surface irrigation through canal network. Unfortunately, the overall efficiency of canal irrigation system is very low which leads to poor utilization of irrigation potential, created at huge cost. On the other hand, the demand for increasing irrigation coverage has been growing. For enhancing the irrigation efficiency, the MIS is being promoted through many programmes. The concept of Pressurized Irrigation Network System (PINS) is one such programme which was developed at Design Office of Sardar Sarovar Narmada Nigam Limited (SSNNL) as a necessity step to introduce MIS in the command area of Sardar Sarovar Narmada Project (SSP). Later on, the concept was used in various other states. Since it is a new concept got popularised in last ten years, the literature and statistics on the same is mostly unavailable. Therefore, only aforesaid four front runner states were included in the study for the detailed study.

Gujarat: Government of Gujarat has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The pilot project on Pressurized Irrigation Network System (PINS) is one such effort started in 2007-08 in the command area of SSP. Accordingly, about 25 pilot projects were initiated in the state covering 1029 farmers with 1491.6 ha of CCA and estimated budget of Rs 1306.3 lakh. The average spending incurred per PINS was Rs 35.4 lakhs against the estimated Rs 52.3 lakhs. The estimated per hectare expenditure on PINS at Chak level was Rs 20340. Because of PINS, the per hectare water savings was estimated to be to the tune of Rs 15000 for *Bhal* and *Bara* areas (mainly saline areas) and Rs 19560 for other zones, respectively. The project work was carried out by Jain Irrigation Ltd (56%), Parikhit Industries (32.0%), EPC Industries (8.0%) etc.

Though the Government of Gujarat followed a proactive approach to increase the adoption of PINS by the water users, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to various reasons. The farmers did not want to change the cropping pattern which was highly water intensive. They did not want to spend anything on installation of MIS since canal water was available to them plentily almost free of cost. There are no much strict rules and regulations enforced to check the illegal use of canal water and water theft.

Looking at the unsatisfactory experience of Canal PINS in the state, an attempt was made by the Irrigation Department in devising a suitable solution to address various issues. The main features included promotion of Under Ground Pipe Line System (UGPL) Network for micro canals such as Minors, which has been discussed in next section. The combination of UGPLs and PINS replacing Minors, Sub-Minors and field channels (FCs) has also been put in some places in the state.

However, the tube well PINS have been operating in the state since a long ego as a viable method of irrigation in the state. The Government of Gujarat introduced the policy of pressurized irrigation system in the command area of public tube wells under Gujarat Water Resources Development Corporation (GWRDC). As per the Government norms, Micro Irrigation System (MIS) provided in the command area of 309 tube wells

covering 1452 Ha in five districts of the state i.e. Banaskantha, Mehsana, Patan, Gandhinagar and Sabarkantha. The State Government had decided in March 2013 to provide MIS in Government tube wells at 100% Government cost in total nine districts. Accordingly the State Government provided MIS system in 162 tube wells in 2013-14 covering 1531 Ha and 1037 farmers. The MIS works covering 2984 ha of 3780 farmers were in progress in 208 tube wells which was likely to be completed in 2014-15. Till January 2016, a total of 674 tube wells have been covered by GWRDC out of which 54.0 per cent was through government subsidy and remaining 44 per cent were given partial assistance.

Rajasthan: The Government of Rajasthan has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The Pressurised Irrigation Network System (PINS) Programme in Rajasthan is mainly concentrated in two major irrigation projects, i.e., Indira Gandhi Neher Project in Bikaner district and Narmada Irrigation Project in Jalore and Barmer districts. Thus, the main feeder source for PINS programme was canal. No other kinds of PINS such as tube well PINS or private PINS were not available in the selected areas of Rajasthan.

Under IGNP, the PINS project was started on pilot basis in Bikaner district from 2012-13 and initially only 33000 hectare area was covered. Recently, the Centre has approved around Rs 1,659 crore for PINS projects in the state (TOI, 2016). With these new irrigation projects, around 347.66 lakh hectares of area can be irrigated with sprinkler system in Bikaner, Churu, Hanumangarh, etc. Under these projects under Indira Gandhi Nahar Project (stage-II), sprinkler irrigation systems are proposed for optimum utilisation of available water. Total culturable command area (CCA) of these projects is 3, 47,566 hectares, out of which sprinkler irrigation system has already been established in 27,449 hectares under the pilot project.

The PINS projects under IGNP are being operated in bigger area around 200 to 600 ha in one diggy, whereas the size of PINS project in Narmada Project at Jalore and Barmer are of smaller size of with 90 to 100 hectares. Under Narmada canal, about 2, 35000 hectares area has been irrigated in

Sanchore and Chittalwana (Jalore), Gudha malani and Dhorimanna (Barmer) districts. All areas of Jalore and Barmer districts have been benefitted through Narmda Canall where all irrigated areas are with PINS only. There is no flood irrigation allowed in the region which is main reason for successful working of PINS project in these regions. Another reason for success of PINS project in Sanchore area is that the groundwater level is very high and groundwater is salty. Thus, the farmers failed through tubewell irrigation in their field. As the only option, the farmers adopted canal PINS and succeeded in making agricultural prosperity.

Maharashtra: In Maharashtra state the types of PINS projects are of three types - government PINS (100% government funded), cooperatives PINS (partially funded by government and managed by group of farmers) and private PINS (owned by individual farmers). There are government PINS (govt PINS) and cooperative PINS (coop PINS) in Buldhana, Kolhapur, Sangli and Yavtmal districts, while private PINS (pvt PINS) are spread across many districts, with high penetration in districts like Nashik and Ahmednagar. In the state, the sources of water for PINS are river, tube well, dug well, and storages by weirs, dams etc.

There are large no. of lift irrigation schemes in co-operative sector, in southern part of western Maharashtra (1,01,205 ha) in Krishna basin (i.e. on Krishna river and its tributaries). These lifts can be considered as PINS with flood irrigation. However, over the years, the lands under them are becoming saline/water logged. For this reason, as well to save labour, fertilizers and water, initiatives have been taken through some schemes for converting the flow distribution systems into MIS. We obtained a list of 15 such schemes (from the micro irrigation manufacturing companies), and included some of them in our survey.

There are other 11 irrigation projects, under which flow/canal irrigation systems are not economical, as these projects have command mainly located in hilly region. The total area under these 11 projects is 54,100 ha. With the area under lifts on Krishna etc., the total ICA works out to (54,100+ 101,205=) 1, 55,305 ha. We feel that, if the financial assistance

is made available to these lifts, they would get converted from PINS+Flow into PINS+MIS rapidly, as the trend is already set by 15 schemes converted.

Besides, regular flow/canal irrigation projects, GoM has also taken up around 20 Lift Irrigation projects for 5.89 lakh ha, these are at various stages of development/completion. The CCA of individual projects ranges from 1,873 ha for AndhaliLift (Dist:Satara) to 2.240 lakhs ha for Krishna-Koyna Lift (Southern Western Maharashtra). Though the distribution of water is under gravity/flow under regular irrigation projects; in some projects, the lift irrigation is also adopted for water distribution, e.g. on two irrigation projects (i.e. along with the water distribution by gravity flow), they are [i]Dahini lift scheme on Bembala Project in Yavatmal District - 6,968 ha, [ii]Tajnapur Lift under Nathsagar(Godavari) Project in Aurangabad District: 6,960 ha, Dahini Lift is functioning partially.

Only two companies have responded to provide this information, they are (i) Jain Irrigation Systems Ltd, Jalgaon and (ii) Netafim Irrigation India Pvt. Ltd, Pune. About 12 co-operative PINS-MIS (drip based) are located in southern western Maharashtra, and while a sprinkler based unit is located in Vidarbha, have been implemented by these two agencies. One more drip based unit is partially completed in Govt sector and it is also located in Vidarbha.

Telengana: It is newly constituted state where there are no government PINS projects with MIS available in the state, alternatively the projects with MIS scheme are installed connected to the irrigation source of tube-wells/bore-wells in the state. From 2014 onwards, the Micro Irrigation Project (MIP) scheme was subsumed into National Mission for Sustainable Agriculture (NMSA) as one of the component as On-Farm Water Management (OFWM). Out of 17.12 lakh hectares of net irrigated area irrigated with ground water, only 5.73 lakh hectares are covered under micro-irrigation, leaving a balance potential of 11.39 lakh hectares for micro-irrigation under PINS. In all the districts the MIP projects through MIS scheme connecting to tube-well irrigation are implemented. About 5,50,212 numbers of micro-irrigation systems were installed with a coverage of area of 5,50,212 hectares the total number of beneficiaries being 2,96,436.

The drip system of MIS is provided for cotton crop with a total initial fixed cost of Rs. 1, 06,120 of which Rs 10, 612 is given as subsidy for BCs small/marginal farmers and for others the subsidy is given to a maximum of Rs. 21,224. Moreover, the sprinkler irrigation system of MIS is provided for groundnut crop with a total fixed cost of Rs. 17,880 of which Rs. 4,470 is given as subsidy for SC/ST, BCs small/marginal and for others. MI project in Telangana is mainly based on well and tube-well irrigated areas.

7.3.2 Performance of PINS Programmes in Gujarat:

The tubewell PINS was popular in several districts in Gujarat whereas the canal PINS was not well adopted by the farmers. The majority of farmers (68.7%) had less than 1 ha area under tubewell PINS. About 95.3 per cent of sample beneficiary farmers adopted drip whereas the 10 per cent of them adopted sprinkler in the state. The total cost of drip and sprinkler systems was Rs42950 and Rs30133 per household (hh) in the study areas. The major motivating factors for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation (79.3%), better and stable crop yield and farm income (78.0%), saving more water and to cover more area under irrigation (67.3%), facilitating judicious or efficient distribution of water among the water users (54.7%) and avoiding unnecessary conflicts with other farmers (28.7%).

The water saving due to judicious use of water (94.0%), increase in agricultural income (86.7%), getting water in right time (88.0%), proper distribution of water among farmers (62.7%), getting more information on how to use water judiciously (56.7%), electricity saving (54.0%) and improved maintenance of the system (26.7%) were the major benefits accrued by the beneficiary water users/farmers.

The proportion of area under more remunerative Rabi crops was also found to be higher (28.7% of GCA) in case of beneficiary farmers as compared to non-beneficiary farmers. It was observed that, except few crops like groundnut, mung and cumin, beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers. The percentage change in yield under drip over flood and change in yield under sprinkler over flood has been spectacular with respect to some crops like castor

(117.6% and 102.1%, respectively) and cotton (83.1%). Among Rabi crops, major benefits were observed in the case of wheat (by 83.3% and 108.4%, respectively), fennel (55.1%), rapeseed-mustard (59.9%), and tobacco (by 84.6%).

Some of the factors those helped in generating some benefits were better water management by WUA members (58.0%), better education and awareness of the farmer (43.3%), more area under PINS-MIS (34.0%) and more area during Rabi (37.3%) were the major ones. The results of Probit model indicated that, more area under PINS-MIS, uninterrupted power regular supply, more depth of tubewell, sufficiency of water in PINS and group membership helped in realising the benefits like increase in yield and income, water saving and energy saving by the beneficiary farmers.

Among the major activities undertaken by different types of PINS TUAs, operation and maintenance of PINS project, deciding the timing of water release, judicious water distribution, collection of water rates, collection of per capita operation and maintenance cost were the major activities of Govt. TUAs.

The main source of income for these TUAs were annual maintenance fees collected whereas the major heads of expenditures were the expenditure on electricity bill, repairing expenses, salary expenses. Besides, in case of PINS, the charges to Irrigation Department and some miscellaneous expenses were incurred by the WUA/TUAs.

The major benefits provided by the WUAs to its members were arrival of water in time, proper distribution of water among farmers, more information on how to use water judiciously, saving of water, electricity and labour cost, improved maintenance of the system and less conflicts around water.

WUAs/TUAs also faced some constraints in management of their associations. Among these constraints, the funds constraints, unavailability of required quantity of water, unavailability of proper maintenance and repairing services and electricity problems are the major ones.

7.3.3 Performance of PINS Programme in Rajasthan:

Since the sprinkler system is very useful on sandy topography in Rajasthan, the same has been very popular in the state. The average area covered by the farmers under sprinkler and drip was 3.63 ha and 0.02 ha per households having access to those systems. The total cost of sprinkler and drip systems was Rs 265000 and Rs 60820 per household in the study areas. It was found the average subsidy amount received by the farmers was only 15 per cent on sprinkler and 70 per cent on drip. Jain Irrigation was the main agency in Rajasthan who had supplied MIS to the farmers under various subsidy norms.

The major motivating factor for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation. Other factors like better and stable crop yield and farm income, saving more water and to cover more area under irrigation, facilitating judicious or efficient distribution of water among the water users and avoiding unnecessary conflicts with other farmers were considered as important factor (though not most important factors) by the farmers.

Impacts of Adoption of PINS-MIS on Water Saving, Irrigated Area and Crop Yield and Farmers' Income

Among different benefits accrued by the beneficiary farmers by participating in WUA, the increase in area under irrigation (100%), increase in agricultural income (99.0%), water saving due to judicious use of water (97.5%), getting water in right time (88.0%), timely information on release of water from canal (82.5%), proper distribution of water among farmers (68.0%), getting more information on how to use water judiciously (56.7%) and electricity saving due to use of shared pump sets attached with PINS (58.0%) were the major ones. The extent of water saving, electricity saving, increase in irrigated area and increase in farmers income due to adoption of PINS-MIS was 39.2 per cent, 39.4 per cent, 58.5 per cent and 44.7 per cent, respectively.

About 55.5 per cent farmers complained about not getting sufficient water throughout the year. Inadequate water availability in canal due to less rainfall and land located in tail region were found to be some of the major

reasons for inadequate water availability. Among water users, about 72.5 per cent were used to pay the operation and maintenance cost of PINS project and water rates regularly, out of which the majority (43.5%) pay these fees annually to the office bearers of WUA.

As far as area and yield impacts are concerned, it was found that the average yields as well as area under majority of crops are higher in case of beneficiary compared to non-beneficiary households. Overall, 12.3 per cent more area was cultivated by the beneficiary households. Among Rabi crops, the beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers in case of crops like gram, isabgul and cumin. Among summer crops, the beneficiary farmers got better crop yields as compared to non-beneficiary farmers in case of crops like bajra and fodder crops.

The major problems faced by the farmers were insufficient electricity for operation of PINS (60%), inadequate water availability (37.5%), difficulty in getting subsidy for MIS system (26%) and the problems related to operation and maintenance of the PINS-MIS system. The farmers suggested that the subsidy may be provided to set up solar unit with PINS so that water can be provided to farmers when electricity is not available for irrigation. Farmers also emphasized that they should be given more subsidy on MIS, especially sprinkler systems since they purchase pipe and nozzle from local market with fairly high price.

As regards performance of WUAs is concerned, all the PINS systems were constructed on minor or sub-minor of Indira Gandhi Canal in Bikaner or Narmada Canal project in Jalore and Barmer. The average area covered under each PINS WUA was 246.8 ha per PINS and the average number of beneficiaries covered was 84. The size of PINS was much larger in Bikaner, followed by Barmer and Jalore. The entire cost on PINS equipments and installations was borne by the state Govt. The beneficiary farmers only had to pay the operation and maintenance cost.

The major component of operation and maintenance cost on PINS was electricity charges and repairing/maintenance of canal PINS, accounting for about 46.24 per cent and 35.8 per cent of total operation and maintenance cost, respectively. The number of members of WUA was 84, out of which 39 members (46%) did not join the WUA. Those who did not join the WUA

expressed various reasons for not joining the WUA. About 28.2 per cent of them expressed that they are not able to put pipelines due to not getting loan, since they don't have land. About 33.3 per cent of them expressed that they stay in other chaks and they don't want to cultivate their land due to long distance (average 70-75 km).

Among the major activities of WUA, operation & maintenance of PINS Project, deciding the timing of water release, judicious water distribution, collection of water rates, collection of per capita operation, maintenance cost and dispute settlements were the major activities of WUAs. The main sources of income for these WUAs were annual maintenance fees and annual electricity fees collected whereas the major heads of expenditures were the expenditure on electricity bill, repairing expenses, salary expenses.

The major benefits provided by the WUAs to its members were arrival of water in time, proper distribution of water among farmers, more information on how to use water judiciously, saving of water, electricity and labour cost, improved maintenance of the system and less conflicts around water. The crop yield has improved significantly during post-WUA situation with about 81 per cent WUAs reporting higher yield compared with pre-WUA situation. The average irrigated area has increased from 36.9 ha per WUA during pre-WUA situation to 228.2 ha during post-WUA situation, by more than 06 times, while the returns from agricultural production has increased by more 04 times during post WUA situation compared with pre-WUA situation.

As far as the sufficiency of irrigation water is concerned, only 23 per cent of WUAs agreed that they are getting sufficient water throughout the year after formation of WUA. Normally they get the canal water for about 5 months during Rabi while, during Kharif, they depend on rainfall. Some of them could be able to provide life saving irrigation during Kharif as well.

7.3.4 Performance of PINS Programmes in Maharashtra:

The source of irrigation for all govt PINS was tanks/storages, for coop PINS sources were river and storages/tanks and for pvt PINS the sources were well and river in Maharashtra. Since, the govt PINS projects were around 100% funded by the government, there was no cost for the farmers.

Regarding the coop PINS farmers, average expenditure was Rs. 47,200 on PINS project, and there was no considerable variation on the expenditure on PINS across the landholding class of farmers. About the pvt PINS farmer, the expenditure on PINS project was Rs. 87,325 and there was not much variation across the farmers' landholding class. These findings suggest that being a part of cooperative system could save PINS project cost by around 50%.

The reasons to adopt PINS were to get assured water, better yield and increase in area under irrigation. The pvt PINS adopter farmers were interested in personal benefits in comparison with the govt and coop PINS adopter. The main benefits of coop and govt PINS were an increase in area under irrigation by around 60%, farm income and water saving by more than 35%, and 35% saving in electricity.

The majority (80-96%) of the members of the coop PINS WUA were aware about the functioning, while the awareness among the govt PINS was comparatively not good. The entire coop PINS WUA members paid O&M cost regularly.

Most important reasons for inadequate supply of water were the inadequate water availability in the water source for PINS and poor rainfall, moreover, for govt PINS inefficient functioning of the PINS system was also an additional reason.

The total cost of the drip under govt PINS was around 20,000 Rs, which was very low, the reason was that in this case the manufacturers of the drip system provided the system at very low rates i.e. 20,000 Rs/acre(because of huge subsidy). Under the coop PINS the average cost of the drip irrigation system was around 50,000 Rs/acre and for sprinkler it was 8863 Rs/acre. The average cost of drip irrigation system under pvt PINS was 48,306 Rs/acre. For drip irrigation system farmers under coop PINS received 19% subsidy, while under pvt PINS received 25% subsidy. For sprinkler the subsidy received was 54% of the total cost of the system.

The findings suggest that PINS helps to increases the area under cultivation during the summer season or under the perennial crops. It is also reported that the most preferred method of irrigation under PINS was drip irrigation over sprinkler and flood. For most of the crops the production was

reported higher under the PINS farm than for the non PINS farm, this indicates that the PINS improves the productivity of most of the crops. The MIS increased yield for soybean, tur, cotton, groundnut, jowar, onion and sugarcane crops, while yield was decreased for udid, mung and wheat under MIS. For majority of crops the yield under MIS was higher than the flood method, while there was not much difference between sprinkler and drip methods. Regarding the water saving under MIS, in principal there is water saving under MIS than flood.

Apart from water saving the major benefits of PINS with MIS were, saving of land by avoiding field channels, reduction in frequency and maintenance cost of irrigation system, weeding cost, water logging and labor cost.

There is a lack of awareness about ISO standards, training and testing facility for PINS and MIS. Therefore, there is a scope for providing these facilities for farmers at the block level. The main problems faced by the farmers were planning and installation of PINS with MIS, delay in receiving subsidy for MIS, power to run PINS and MIS, quality of components and damage of MIS in field from rodents.

As regards the performance of PINS-WUAs is concerned, these PINS+MIS are mostly lift scheme on rivers or storages created by tapping the water within the banks of the rivers. Average life span for PINS is reported as 24 years, which appears for the pumps and rising/pumping mains. The income per acre works out Rs. 6,550/- and expenses are Rs. 6,490/-. Thus, the WUAs meet all their expenses, but not keeping any amount aside for sinking funds, etc. There are no cases of defaulters in water charges payments. WUAs look forward to get some financial assistance from Govt. particularly, as they normally don't get any assistance for conversion.

There are around 100 farmers located within the command of these schemes but have their other arrangements, so they did not joined the society. In other words, they would have become member of the WUA, in absence of other arrangements.

The benefits of good lift co-operatives are numerous. WUA bearers give highest marks to (i) water on time & proper water distribution within member farmers and over the time span, (ii)timely communication with the

farmers, (iii)enhanced financial condition/position of WUA. Farmers have reported only 3 months during which the less water is available. But we feel that such condition will occur in draught conditions. If federation is formed for all WUAs, it can look into such problems, and pursue the matters with Govt.

7.3.5 Performance of PINS Programmes in Telengana:

On an average the area under PINS -MIS was 1.11 hectares per hh. All the 200 sample farmers were having drip system and only for five farmers had sprinkler system. On the whole, amount spent on MIS was Rs. 8,443 per hh.

There are three main reasons behind the adoption of PINS (MIS) programme. They are: (i) to get assured amount of water for irrigation; (ii) to get better and stable crop yield and farm income and (iii) to save more water and to cover more area under irrigation. On an average, 40 farmers participated in a TUA. The percentage change in production realised by the beneficiaries over non-beneficiaries ranged from 30 per cent in case of paddy to 100 per cent in case of Redgram. All the crops under drip irrigation have achieved more per hectare production than the yield achieved under the other sources of irrigation.

The output from probit model reveals that among the explanatory variables the marginal effect of operated area is positively associated with increase in agricultural yield, income, water and energy saving but negatively associated with fertilizer and pesticide use. The positive association implies that due to the marginal effect of operated area, the yield, income, water and energies are saved to a significant level. On the other hand, the negative association signifies that the fertilizers and pesticides are being used more than the required doses.

Majority of the beneficiaries expressed the problem of power supply to MIS and a few farmers reported the problem of operation and maintenance. Majority of the farmers suggested that the MIS subsidy should be extended from 1 hectare limit to 3 hectares limit and reduction in input price also. Almost all farmers suggested the need of regular power supply.

The average life span of PINS was about 7-8 years. On an average, the total annual operation and maintenance cost of PINS per TUA accounts for Rs. 8,000 of which 87.50 per cent towards repairing and maintenance of tube-wells and 12.50 per cent towards electrical charges. The inflow of income is due to collection of annual maintenance fees, while the outflow of income is through expenditure on electricity bill and repairing expenses.

Due to formation of TUAs the farmers could realise three major benefits viz., (i) timely release of water to their fields and Judicious use of water, (ii) improved maintenance of the system and (iii) more information on crops and technologies and thereby improved quality of ground water due to less extraction compared to pre-TUA periods.

About 66.67 per cent of TUA members reported to have received sufficient water throughout the year. Nearly 33.33 per cent of water users reported that the PINS system is not functioning properly and also due to improper management of PINS system, they received inadequate water to their farm plots.

7.4 Policy Implications of the Study

The major policy implications emerged from four state specific studies on working of PINS have been presented separately as fallows.

7.4.1 Policy Implications: Gujarat

The water resources for irrigating more area have been a challenge for the country. It is desirable to utilize the available water resources more judiciously, so that the 'more crops per drop' slogan of the Govt can be realized and farmers income can be doubled within the stipulated time period. Thus, PINS infrastructure with MIS is inevitable for the farmers since it saves the water and the collected water can be used for further increase in area under irrigation. The present study has examined some aspects of working of PINS at different levels. During the survey, the sample farmers have also given some useful feedbacks which have been discussed earlier. Besides, some additional suggestions on different types of PINS those are drawn from the study are presented below.

Suggestions on Canal PINS

- Though the State Government has followed an innovative approach by developing and implementing the concept of PINS, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to some specific reasons. The farmers did not want to change the cropping pattern which was highly water intensive. Thus, it is necessary to discourage more water consuming cropping pattern, by encouraging suitable cropping pattern through some incentive structure.

- It was found that the farmers did not want to spend any amount on MIS since canal water was available to them almost free of cost. Thus, it is suggested to revise the water rates which are very less and strict rules and regulations should be enforced to check the illegal use of canal water and water theft.

- Farmers having land at favourable locations (canal vicinity) do not find it to be a lucrative proposition. One of the major factors that contributed to less adoption of canal PINS in the state was that, PINS Projects were located very close to minors or sub minors, from where farmers are able to get water in alternative ways. Thus, it is suggested to re-lunch this canal PINS programme with required amendments by locating these projects at far off places where farmers are struggling to get irrigation water. Though it involves little more investments in term of infrastructure expenditure, the adaptation and long-term sustainability would be surely achieved just like the success of PINS projects in Sanchore region in Rajasthan.

- The areas where PINS+MIS is techno-economically not feasible, normal/conventional flow irrigation as per present SSNNL policy may be allowed to continue.

- Majority of sample farmers were marginal with small land holdings who faced difficulties in getting bank loans due to incomplete land documents and other outstanding debts. The measures may be taken to provide affordable credit facilities to small and marginal farmers.

Suggestions on Tube well PINS:

- The study finds that maintenance and electricity cost for beneficiaries of tube well PINS is a major part of their expenses which is reasonably high, thus the subsidy may be given on electricity provided to farm plots.

- Drip system is damaged at some cases due to animal attack (pig, rat, squirrel, rabbit, blue bulls) and sometimes due to poor awareness of agricultural workers. Thus better quality systems should be provided. The fencing subsidy may be provided to encourage fencing by farmers.

- Services provided by some companies were unsatisfactory; frequency of their visits was insufficient. Thus there is a need to take measures to regulate the agencies supplying MIS to the farmers and adhering to standard norms on maintaining quality and providing proper and regular services for the repairing of the PINS-MIS within reasonable time limits. There is also a need to have more testing facilities for quality checking of equipments.

- Farmers are unaware, uneducated about use of PINS and MIS. So the required extension advisory services should be provided to the farmers, especially on maintenance and applicability of PINS-MIS for different crops. The training and awareness programmes should be regularly conducted to impart training to farmers on need, importance and use of MIS with PINS and also to promote fertigation and chemigation.

Suggestions on UGPL with PINS:

- Since underground pipeline system (UGPL) pipeline infrastructure is used as PINS as well as for conventional irrigation, the new scheme has been well adopted by some farmers in Gujarat. However, there are some issues in implementation of UGPL in Sub-Minors. Farmers were not willing to pay 10 per cent, their contribution, which was later on reduced to 2.5 per cent. Farmers are continuously growing some crops and hence not willing to allow laying of UGPL. There is a need of strict adherence of Government guidelines so as to complete the implementation work in a time bound manner. Provisions should be made to pay required compensation for crop loss for laying of UGPL.

- Due to poor maintenance of field channels, the nearby lands are affected by water logging. Thus, it is suggested to arrange regular repairing and maintenance of minors and field channels, which are used by UGPL.

- Due to poor management culture in WUAs, the maintenance and distribution of water was badly affected in some cases. In so many cases, WUAs were not formed that affected to regulate the proper supply of water among water users. Thus, there is need to strengthen existing WUAs and to form WUAs in a time bound manner, where they are not available.

- The combination of UGPLs and PINS replacing Minors, Sub-Minors and FCs need to be systematically promoted to help saving land as well as water. The UGPL system with PINS should gradually focus on more adoption of MIS with appropriate financial incentives for effective management of irrigation water while taking care of farmers' preferences for different cropping pattern. The services of NGOs and model WUAs may be taken as motivators for more adoption of water saving technologies under UGPL with PINS.

7.4.2 Policy Implications: Rajasthan

The ever-increasing difference between water availability and consumption is causing severe shortage of water in many fields. This is a growing concern all over the world but India is most vulnerable because of the growing demand and in-disciplined lifestyle. The water resources for irrigating more area have been a challenge for the country. It is desirable to utilize the available water resources more judiciously, so that the 'more crops per drop' slogan of the Govt can be realized and farmers' income can be doubled within the stipulated time period. Thus, PINS infrastructure with MIS is inevitable for the farmers since it saves the water and the collected water can be utilised for further increase in irrigation and farmers' income.

The study finds that PINS with MIS has been highly successful in Narmada Project in Sanchore and Indira Gandhi Nahar Project (IGNP) in Bikaner district. The impact of these PINS projects on water saving, irrigated area expansion, crop yield and farmers' income has been praiseworthy. On the same time, it is necessary to strengthen these projects further by considering the inputs provided by the different stakeholders so as to enhance the irrigation benefits. Some of the observations were made during the study which are summarised below.

- The average size of WUA in Rajasthan is usually high, sometimes covered about 900 ha under one PINS project with more than 200 beneficiary farmers. Very large size of WUA becomes very difficult to manage. Among these large number of water users, the equitable distribution of water also becomes very difficult. As a result, the tail end beneficiaries turned out to be non-beneficiaries in real sense, since they don't get irrigation water. Thus, it is suggested to install more number of PINS and reduce the number of farmers per PINS-WUA, which would help in proper distribution of water among the farmers irrespective of location of plots in the command area of PINS.

- It was recommended to provide 15 sprinkler points to each outlet provided at farmer's field. However, due to larger size of PINS command area and large number of beneficiaries, the number of outlets has not

been provided in proportion to size of plots. A large size of plot with less number of outlets fails to discharge required amount of water to the crops in the entire plot. Moreover, sometimes, more number of sprinkler points were found in a smaller plot, while less number of sprinkler points in large plot size affected the irrigation provision. Thus, it is suggested to provide more outlet points in larger size plots, so that required number of sprinklers can be used.

- Moreover, same time is allotted to all plots irrespective of their location. However, due to lower pressure at tail end region, the tail end farmers did not get enough water compared to head region farmers.

- Due to scarcity of irrigation water, some of the non-beneficiary farmers depend only on rain water. Thus they demand to expand the coverage of PINS to their area. Thus, it is necessary to expand PINS coverage so as to ensure proper water distribution among the farmers.

- In some cases, due to close vicinity to canal, some farmers didn't install MIS in their farm plot, and they used to irrigate by flood method. Thus, the measures need to be taken to check water theft. More stringent policy should be implemented to check the same.

- In case of IGNP, it was observed that, on side of canal, PINS systems have been promoted, while on the other side, farmers are irrigating using flow method. It is necessary to discourage the flow irrigation and encourage the MIS with suitable incentives, so that more water scarce areas can be irrigated in Rajasthan.

- In some cases, the condition of minor canal was not in proper state. It is suggested to cement/renovate the minors/sub-minors regularly for supplying water to PINS in better way which would expand their irrigation efficiency.

- It was observed that some promoting companies supplying the irrigation infrastructures and servicing are not functioning genuinely. As

a result, the farmers are facing repeated troubles. Due to low quality of materials, frequent repair happens to be inevitable. On the other hand, much more time is being consumed for repairing and high charge is being imposed since the technician covers a long distance to reach the farmer's village.

- There is urgent need to provide more number of servicing centres, at least one at taluka level. On the other hand, local people should be trained to cater the need of the farmers.

- Some instances were found, where there were a large number of incomplete diggies (mainly in Gudha malani, Barmer district) since the promoting agency left the scene in between without completing the work. Thus, it is suggested to examine the performance of these promoting companies and treat them with appropriate incentives/ disincentives.

- The farmers have expressed concern over less subsidy on sprinkler as it is evident that only about 15 per cent subsidy has been realised by the farmers. It is suggested to relook at the subsidy policy of the government on MIS, particularly on sprinklers.

- As suggested by some promoting companies, submersible pump sets should be promoted, which can reduce the requirement of separate pump house, reduce the maintenance requirement and are convenient to use.

- PINS programme in the command area of IGNP was started on pilot basis in Bikaner district since 2012-13. This project area was not covered fully in many areas due to some reasons, may be, the financial constraints. As a result, some diggies could not be made functional properly. Moreover, IGNP system is operating since last 20 years and farmers were habituated and benefited through flood irrigation till then. With the changed situation, farmers were worried about the technical

problems related to PINS. Thus it is necessary to provide training and counselling to the needy farmers.

- During first two years of installation of PINS and formation WUA, the WUA members and implementing agency/promoting companies work together. During this period, all maintenance cost are borne by the implementing agency/promoting companies. There is provision to provide proper training to WUAs to manage the PINS system. However, the quality of such training programme needs improvement. The promoting companies that work closely with the PINS system and the water users should be allowed to take part in training provided to the farmers.

- The cost of electricity has been a major share of total cost of crop cultivation. Farmers often requested to provide more subsidy on electricity or to provide solar pump sets to lift the water. At some places, electricity infrastructures have been damaged since a long time, for which more than 500 hectares of land failed to be irrigated. In spite of repeated requests of the farmers, the electricity facilities could not be restored. Thus, it is suggested to take up the farmers' concern in a time bound manner. On the other hand, fully automated solar systems need to be promoted in order to meet the farmers need. At some places, the outlets were kept open, when not in use. This resulted in choking of outlet pipes during regular storms/ sand dunes in the state. Thus, it is suggested to provide outlet covers to keep it closed while not in use.

7.4.3 Policy Implications: Maharashtra

- It is realised that, if the financial assistance is made available to the lifts Schemes, they would get converted from PINS+Flow into PINS+MIS rapidly, as the trend is already set by 15 schemes in the state.
- The distribution systems of lift projects will also be converted into PINS+MIS, though not envisaged at the conceptual stages. There is an advantage for lifts, that on the way from pumps to the delivery point,

there can be sufficient head available to use MIS by directly hooking up to the rising/pumping main.

- There is a large scope for PINS+MINS for (i)Co-operative lifts, (ii)lifts on Other Govt Projects with lift as distribution System, (iii)Govt. Lift irrigation projects themselves, (iv)individual lifts including lifts on Minor Irrigation Schemes, and in the long run of pipe distribution systems in place of flow irrigations.

- The costs of the drip systems were higher under coop and pvt PINS than the govt norms. Therefore it is suggested that the cost norms for drip irrigation system may be revised so that the farmers can afford the drip irrigation system.

- Extension activities for increasing the awareness about efficient use of water under the MIS, water requirement of the crops as per the crops critical growth stages and season wise are recommended.

- There is a lack of awareness about ISO standards, training and testing facility for PINS and MIS. Therefore, there is a scope for providing these facilities for farmers at the block level.

- We observe that some sort of refreshers training etc. need to be arranged at different levels for WUA office-bearers, member farmers etc. Such training should beon co-operative, new technologies in irrigation andagriculture-cultivation, processing, post harvesting issues. There is also a need of a body such as federation, which can put forth the issues faced by these WUAs.
- We feel that for Maharashtra, being a leading state in MIS, comprehensive testing facilities for MIS components need to be developed in the state Agricultural Universities.

7.4.4 Policy Implications: Telengana

- Though the PINS-MIS scheme is being implemented by private agencies, the subsidy is being provided by Telangana State Micro-Irrigation Project. Due to delay in release of funds from Central Government the release of subsidy to farmers is accordingly delayed. As a result the farmer could not receive the benefit in time and could not proceed further. Thus, it is requested to release the funds by Central Government in time.

- In recent years, the tanks in Telangana are being renovated through the programme of Mission Kakatiya. This renovation should be extended to all other tanks which in turn will be useful to irrigate more land in various parts of Telangana. Thus, the PINS-MIS programme be initiated through tank irrigation also.

- The amount of subsidy for all inputs and also to the machinery should be enhanced as the input prices has increase many fold.

- Awareness generation programme on PINS-MIS should be carried out more frequently with larger scale and such programmes being carried out by NGOs should be encouraged through incentives. More training programmes should be conducted and more frequently such training programmes (i.e., once in a month in every mandal head-quarters) should be carried out.

- Training programmes to farmers to create awareness about fertigation and chemigation must be conducted.

- The implementing agencies and department officials (TS-MIP) should ensure thorough checking of MIS systems before installations and should provide timey services for any maintenance related problems.

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