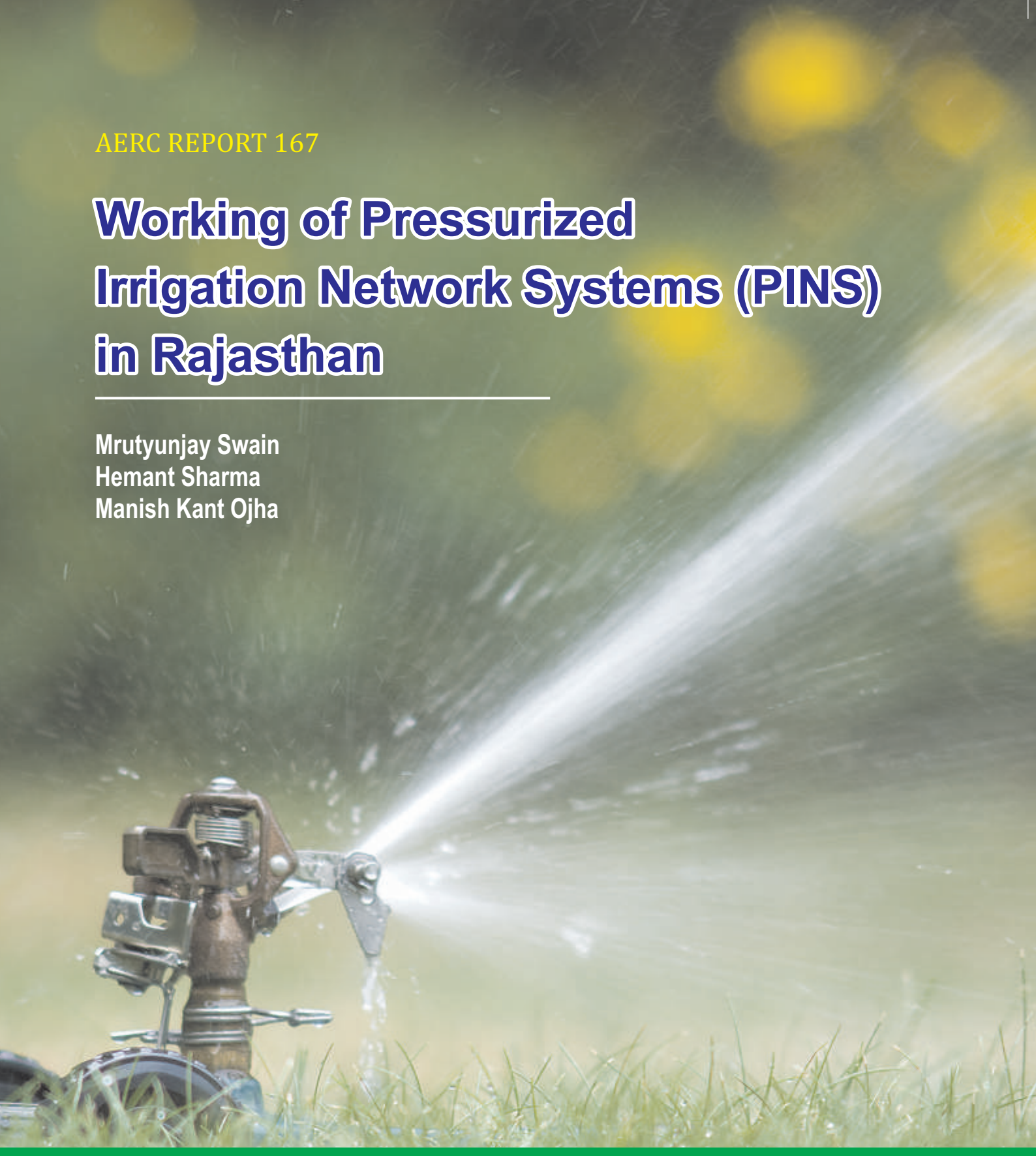
AERC REPORT 167

Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan

Mrutyunjay Swain
Hemant Sharma
Manish Kant Ojha



Agro-Economic Research Centre
For the States of Gujarat and Rajasthan
(Ministry of Agriculture & Farmers Welfare, Govt. of India)
Sardar Patel University
Vallabh Vidyanagar, Dist. Anand, Gujarat

March 2017

AERC REPORT 167

Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan

Mrutyunjay Swain
Hemant Sharma
Manish Kant Ojha

Report submitted to:

Directorate of Economics & Statistics
Department of Agriculture, Cooperation & Farmers Welfare
Ministry of Agriculture & Farmers Welfare,
Government of India, New Delhi

Agro-Economic Research Centre
For the states of Gujarat and Rajasthan
(Ministry of Agriculture and Farmers Welfare, Govt. of India)
Sardar Patel University,
Vallabh Vidyanagar, Dist. Anand, Gujarat

March 2017

AERC Report No. 167

Prepared by

Dr. Mrutyunjay Swain, *Sr. Research Officer/Assistant Professor (SS)*
Dr. Hemant Sharma, *Research Officer/Assistant Professor*
Mr. Manish Kant Ojha, Research Associate

Research Team

Shri Manish Makwana, Research Associate
Shri Sagar Sharma, Research Assistant
Sri Hitesh Rohit, Research Assistant
Sri Paresh Rohit, Research Assistant
Mr. Faruk G. Vohara, Computer
Mr. Jaswant N Singh, Computer

Printing and Circulation In-charge:

Shri Deep K. Patel

Published by

The Director
Agro-Economic Research Centre
For the states of Gujarat and Rajasthan
(Ministry of Agriculture and Farmers Welfare, Govt. of India)
H.M. Patel Institute of Rural Development, Opp. Nandalaya Temple,
Post Box No. 24, Sardar Patel University,
Vallabh Vidyanagar 388120, Dist. Anand, Gujarat.

Ph. No. +91-2692-230106, 230799
Mobile- 09822437451; 7383554616
Fax- +91-2692-233106
Email: director.aerc@gmail.com; directoraercgujarat@gmail.com

Draft Submitted in February 2017
Final Daft Submitted in March 2017

Citation: Swain, M., H. Sharma and M.K. Ojha (2017), "Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan" AERC Report No. 167, Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanagar, Anand, Gujarat.

Foreword

Rajasthan is the largest State of the country. 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 two third part of the State is a part of the great Thar desert which is bigger than most of the states (except MP, UP, AP and Maharashtra). This further aggravates the water crisis. About 61 percent of the area in the State lies in arid and semi-arid agro climatic tract. The soil in this area has poor fertility, low water holding capacity and high infiltration rate. The State has cultivated area of almost 20 million hectares but due to limited water availability and low rainfall, only about 20 per cent of the total cultivated area is irrigated.

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 Pressurized Irrigation Network Systems (PINS) with MIS have the potential to achieve this objective. Owing to growing importance of PINS-MIS for enhancing the water use efficiency in the State, the Ministry of Agriculture and Farmers Welfare, Govt. of India had assigned us to undertake a study on '*Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan*' with an objective to assess the extent of adoption and performance of PINS and to analyse the institutional arrangements for management, operation and maintenance of PINS in the state as well as to identify the major constraints in adoption, management, operation and maintenance of PINS in the state. This study is a part of all-India coordinated study covering four major states such as Gujarat, Rajasthan, Maharashtra and Telengana. Our Centre has coordinated this all India study.

The study is based on both primary and secondary level data. The study results show that PINS programme in the State is mainly functional in canal command areas of the selected districts (Bikaner, Jalore and Badmer) and they are functioning very well. Existing stringent water governance

policies have been enforced to regulate water supply to the farmers. There is no flood irrigation allowed in the PINS command area which is main reason for successful working of PINS project in these regions. On the basis of the findings, relevant policy suggestions have been made.

I am thankful to authors and their research team for putting in a lot of efforts to complete this excellent piece of work. I also thank the Ministry of Agriculture and Farmers Welfare, Government of India for the unstinted cooperation and support. I hope this report will be useful for those who are interested in water resources management in Rajasthan.

Agro-Economic Research Centre
For the states of Gujarat and Rajasthan
(Ministry of Agriculture and Farmers Welfare, Govt. of India)
Sardar Patel University, Vallabh Vidyanagar 388120,
Dist. Anand, Gujarat, India

(Dr. S.S. Kalamkar)
Director

Acknowledgements

The study on *"**Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan**"* has been carried out at the Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanagar, as suggested and sponsored by the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India.

We have benefited immensely from various scholars and officials from different government departments while carrying out this study. At the outset, we would like to thank **Dr. Shirish Kulkarni**, Vice Chancellor of our University and Chairman, AERC Governing Body as well as **Dr. Mahesh Pathak**, Honorary Advisor of our Centre for their constant encouragement and support for undertaking such research activity at the Centre.

We are grateful to **Dr. Tushaar Shah**, International Water Management Institute (IWMI), Colombo-Anand Office, for his advice and guidance during the study. We thank **Mr. Rajiv Chaudhury**, Former Chief Engineer, Narmada Canal Project and **Mr. Amarjeet Maherda**, Chief Engineer, Indira Gandhi Nahar Project (IGNP) and **Mr. Dinesh Solanki**, Executive Engineer, IGNP for their unstinted support during the study. We also thank Mr. **Avinash P. Ganapatye,** Former Executive Engineer, SSNNL for providing technical guidance on canal PINS. We would like to record our sincere thanks to all other officials of Government of Rajasthan for their invaluable help.

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.

We thank all the workshop participants for giving their suggestions on draft proposal of the study. We also thank the constructive comments/suggestion given by the Dr. Sangeeta Shroff, Professor and

Officer In-charge, Gokhale Institute of Politics and Economics (Deemed University), Pune, Maharashtra on the draft report.

We have also received support and encouragements from our colleagues in the Centre while carrying out the study. We would specifically thank all my colleagues at our Centre for their inputs and assistance in publication of the report.

Thank to Shri Deep Patel for designing the cover page of report and making necessary arrangements for printing the report.

Agro-Economic Research Centre
For the states of Gujarat and Rajasthan
(Ministry of Agriculture and Farmers Welfare, Govt. of India)
Sardar Patel University,
Vallabh Vidyanagar 388120, Anand, Gujarat.

Mrutyunjay Swain
Team Leader

Contents

List of Tables

List of Figures

List of Annexure

List of Abbreviations

ACZ	Agro-Climatic Zones
Av.	Average
BCM	Billion Cubic Meter
CCA	Culturable Command Area
CN	Command Network
CAGR	Compound Annual Growth Rate
CU	Coefficient of Uniformity
Cum	Cubic meters
EU	Emission Uniformity
FMI	Flood Method Of Irrigation
GCA	Gross Cropped Area
GIA	Gross Irrigated Area
GOG	Government Of Gujarat
GOI	Government Of India
GGWA	Gujarat Ground Water Authority
ha	Hectare
HDPE	High Density Polythelene
HHs	Households
HP	Hours Power
IGNP	Indira Gandhi Nahar Project
kg	Kilograms
MAF	Million Acre Feet
MDIS	Micro Drip irrigation System
mha	Million Hectares
MIS	Micro Irrigation System
MOM	Management Operation and Maintenance
mt	Metric Tonnes
NWDA	National Water Development Agency
NWDT	Narmada Water Dispute Tribunal
NIA	Net Irrigated Area
O&M	Operation And Maintenance
OBCs	Other Backward Classes
NSA	Net Sown Area
PINS	Pressurized Irrigation Network Systems
PIM	Participatory Irrigation Management
PVC	Polyvinyl Chloride
R&D	Research And Development
SSNNL	Sardar Sarovar Narmada Nigam Limited
SSNP	Sardar Sarovar Narmada Project
Sq. Km.	Square Kilometre
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 very keen to increase the water use efficiency with its new slogan 'more crop per drop'. Thus, the Government has envisaged promoting MIS and increasing the area under these water saving technologies. The Pressurised Irrigation Network System (PINS) is one such 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. It is a common and shared infrastructure (by group of farmers) facilitating individual beneficiary for installing and operating MIS.

Objectives of the Study

a) To undertake a broad situation analysis of various PINS programs implemented in select districts of Rajasthan;

b) To assess the extent of adoption and performance of PINS in different scenarios (Public vs private, surface irrigation vs ground water irrigation, PINS with MIS vs PINS with flood irrigation etc) in the state

c) To analyse the institutional arrangements for management, operation and maintenance of PINS in the state

d) To identify the major constraints in adoption, management, operation and maintenance of PINS in the state

e) To recommend suitable policy measures to enhance the effectiveness and techno-economic performance of PINS in the state.

6.1 Summary of Findings

For Rajasthan state, the data was collected from three selected districts, viz., Bikaner, Jalore and Barmer. Since there were no other kinds of PINS available, only available PINS were selected from surface irrigation command areas (mainly canal). The beneficiary households (households having access to irrigation water in Government PINS Command area) were selected. About 200 beneficiary and 100 non-beneficiary households were covered for the detailed study.

- **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 available in the selected areas of Rajasthan. Under Narmada canal, about 2, 35,000 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 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.

- 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 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 average spending on an individual PINS project with the capacity to irrigate about 100 hectares including the charges of electricity connections is estimated to be about 37.0 lakhs in Rajasthan. 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 adoption of PINS with sprinkler irrigation system in place of conventional irrigation method in Narmada command area in Rajasthan has resulted in widespread benefits. The CCA has increased from 1.35 lakh hectares to 2.46 lakh hectares, an increase by 78 per cent. The number of villages benefitted for irrigation has increased from 89 to 233. The value of food production has been estimated to increase by 2.8 times from Rs 534 crore under flood irrigation to Rs 1480 crore under sprinkler.

- **Adoption, Performance and Management of PINS by Farmers:** Promoting MIS was the main purpose of installing PINS in the selected water scarce districts of the Rajasthan state. 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 major motivating factors for the beneficiary farmers for adoption of PINS-MIS were was 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.

- 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 yield 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 had enjoyed 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 sprinkler.

- Among various other benefits, reduction in fertiliser use (84.7%), reduction in weeding cost (52.0%), saving of land due to PINS (64.0%), 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%) were the major socio-economic and environmental benefits accrued by the farmers due to adoption of PINS-MIS.

- 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.

- 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%).

- **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. The size of PINS was much larger in Bikaner, followed by Barmer and Jalore.

- The total expenditure on 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. 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.

- 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. 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.

- 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.

- 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.

Policy Implications

- 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 irrigation.

- 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 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, thus 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 large 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 limited budget. As a result, some diggies were not made functional properly. Moreover, IGNP system is operating since last 20 years and farmers were habituated and benefited through flood irrigation since then. With the changed situation, farmers were worried about the PINS system related technical problems. 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 subsidise 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.

Chapter I

Introduction

1.1 Background

India is an agrarian economy where land and water are two key natural resources on which farmers depend for their livelihoods. Farmers' development depends on 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 (Hussain and Hanjra 2004). 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. Water is one of the most critical inputs for agriculture. Water affects the performance of the crops not only directly but also indirectly by influencing the availability of other nutrients, the timing of cultural operations, etc. The availability of adequate water for irrigation is a key factor in achieving higher productivity (Levidow et al., 2014). However, 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 in farming encompasses a group of interrelated activities occurring in an economic, cultural and social context and hence farming activities are influenced by values and social norms as well as by economic, financial and technical imperatives. 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 (Feather and Amacher, 1994). 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.

The availability of water is highly uneven in space and time in India. Precipitation is confined to only about three or four months in the year and varies from 10 cm in the western parts of Rajasthan to over 1000 cm at Cherapunji in Meghalaya. Due to large variation in the precipitation, floods and droughts are common phenomena in our Country.

Owing to presence of large tracts of arid and semi-arid lands, where the surface and sub-surface water resources are highly limited, coupled with the spurt in industrial and domestic consumption of water due to a high rate of population growth, the competition for this limited commodity is increasing day-by-day in the country. Further, the over-exploitation is depleting the existing water resources at critical rates even in areas hitherto known for their having irrigation water in aplenty, resulting in irrigation water becoming both scarce and expensive. Thus, to feed the ever growing population, the agricultural production needs to be boosted by following better soil-water management techniques that could provide the arid and semi-arid lands better access to irrigation water without actually increasing the stress on available water resources.

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.

In India, most of the irrigation networks are unlined and huge amount of the irrigation water is lost in main canal, distributary, minors and field channels. Navalawala (1991) found that about 71per 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 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 to manage water consumption 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. MIS 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 (PINS)

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.

Figure 1.1. Concept of PINS- Network Bridge between Canal and MIS in the Field

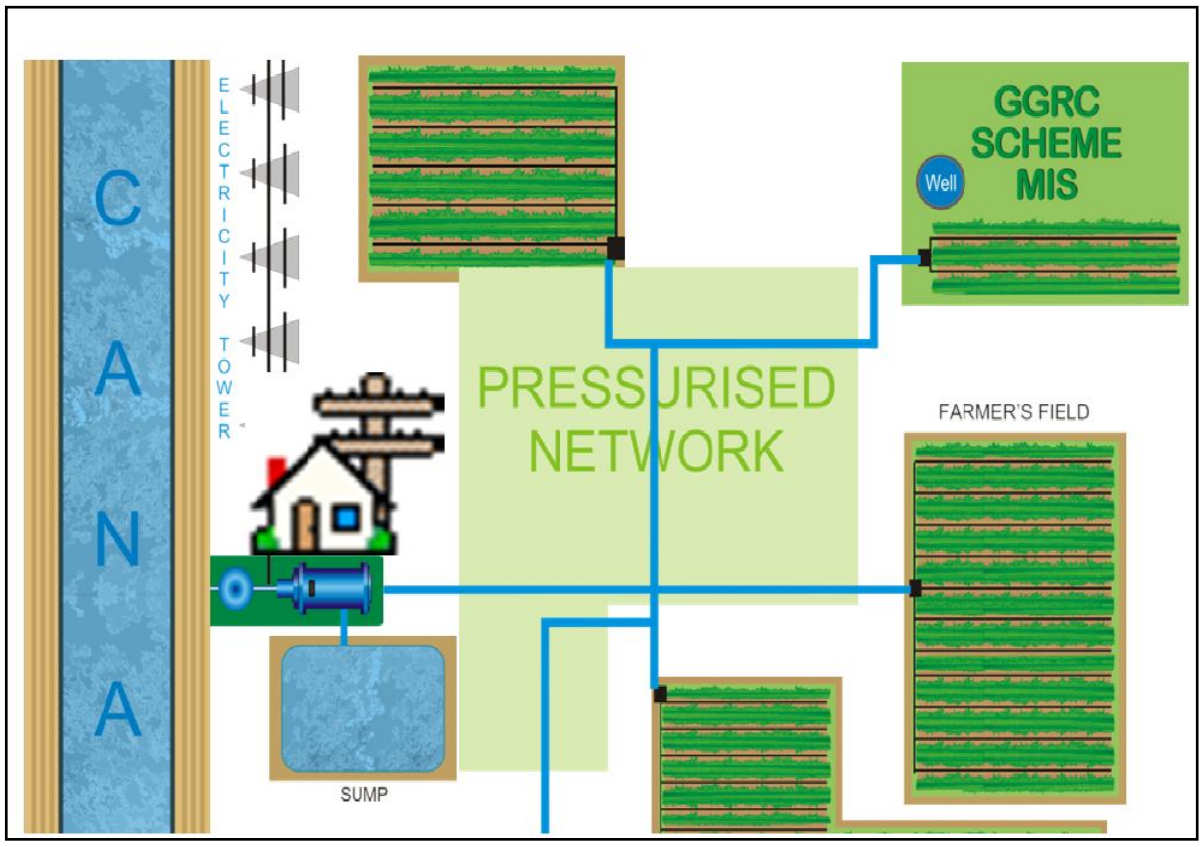


Figure 1.2. Components of PINS

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.

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 (5to 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

Sr. No.	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	Labor/unskilled	Skilled manpower
21	Energy requirement	No	Yes

Source: Ganpatye (2011)

1.3 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. 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 required in PINS, the present study will evaluate 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 needed to survey WUAs in PINS command area, beneficiary farmers in the command area using MIS in their lands and non-beneficiary farmers around the PINS command area. It intended 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 tubewells 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.

1.4 Review of Literature

India is an agrarian 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. Water is one of the most critical inputs for agriculture. The availability of adequate water for irrigation is a key factor in achieving higher productivity. However, 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 in farming encompasses a group of interrelated activities occurring in an economic, cultural and social context and hence farming activities are influenced by values and social norms as well as by economic, financial and technical imperatives. 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 (Narayanamoorthy, 2005). 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.

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. 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 (Viswanathan and Bahinipati, 2015). 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 per annum, 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 January 2006 to increase the area under improved methods of irrigation for better water use efficiency to provide stimulus to 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 Sivanappan (1994).

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. (2009) 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, the study suggests various technical and policy interventions for increasing the adoption of these two water saving technologies.

It is worth-mentioning that promoting MIS 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 micro irrigation technologies and increasing area under irrigation with the saved water is the main objective of promoting PINS. 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 coordinated study, to which the present study is a part, attempts to examine various aspects of PINS performance in major states of the country.

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 districts of Rajasthan;

b) To assess the extent of adoption and performance of PINS in the state

c) To analyse the institutional arrangements for management, operation and maintenance of PINS in the state

d) To identify the major constraints in adoption, management, operation and maintenance of PINS in the state

e) To recommend suitable policy measures to enhance the effectiveness and techno-economic performance of PINS in the state.

1.6 Coverage, Data and Methodology

The study was a part of coordinated project covering four states (Gujarat, Rajasthan, Maharashtra and Telengana). The study on working and performance of PINS was undertaken by Agro-Economic Research Centre, Vallabh Vidyanagar.

For Rajasthan state, the data was collected from three selected districts, viz., Bikaner, Jalore and Badmer. Though there was requirement to select the PINS from both surface irrigation command and groundwater irrigation command areas, only canal PINS were available in Rajasthan. The beneficiary households (households having access to irrigation water in Government PINS Command area) were selected as stated in Table 1.3. To facilitate comparison, non-beneficiary households in adjacent areas of Govt. PINS 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.

As per the stated distribution, 200 beneficiary and 100 non-beneficiary households were covered in the state (Table 1.3). The distribution of PINS Projects covered from which the desired numbers of sample farmers were also presented in the same table. In total 26 PINS projects were covered under the study in Rajasthan.

Table 1.3: PINS Sample Size Distribution for Rajasthan

(Beneficiary, Non-beneficiary Farmers and WUAs)

Districts	Canal-PINS with MIS			Total No. of 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

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 bad performing PINS, so as to differentiate the different kinds of management culture practiced in different PINS-WUAs.

The pre-decided PINS sample size distribution was slightly modified as per local condition and availability. The major type of MIS was sprinkler in the state. No other kind of MIS found popular in the state.

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 Interview 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 descriptive statistics were used for data analysis and interpretation of results. The performance of PINS-MIS were evaluated with respect to water saving, irrigation productivity, costs and benefits of the systems.

1.7 Limitations of the study

The study is basically about assessing the performance of PINS in Rajasthan 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. 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 ego, 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 six 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 2nd chapter discusses about irrigation development and management in Rajasthan with some illustrations and discussions district wise and source wise. 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 3rd chapter provides the overview of PINS programmes in Rajasthan with a discussion on coverage of PINS, cost pattern on PINS, prospects and constraints in promotion of PINS in the state.

The 4th chapter assesses the adoption, performance and management of PINS by farmers. The chapter starts with a brief discussion about socio-economic profile of water users, their land holdings, asset holding and sources of credit etc. the reasons behind adoption of PINS, benefits accrued by participating in WUA, farmers' awareness and perceptions about functioning of WUA, details of adoption of PINS and MIS, factors influencing the adoption of PINS and MIS, planning and installation of PINS and MIS, operation and maintenance costs incurred by farmers on PINS and MIS, impact of PINS and MIS on cropping pattern and production, impact of PINS and MIS on irrigated crop area, details of water used and impact on water saving, other economic, social and environmental benefits of PINS and MIS, factors responsible for benefits accrued from PINS and

MIS, training, education and awareness about PINS and MIS, farmers feedback to improve working and performance of PINS, constraints in operation and maintenance of PINS at household level and some suggestions provided by the sample farmers.

The 5th chapter discusses the adoption, performance and management of PINS by WUAs. The details of associated PINS Project, capital cost on PINS equipments and installations, annual operation and maintenance cost on PINS, details of PINS-Water Users Association (WUA), functioning and activities of WUA, details of income and expenditure of WUA, relationship of WUA with related Organisations, water resource management by WUA, benefits provided by WUA to its members, constraints in operation and maintenance of PINS at WUA level have been discussed in this chapter.

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

Chapter II

Irrigation Development and Management in Rajasthan

2.1 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.

2.2 Rainfall Pattern and Drought in Rajasthan

The rainfall is erratic and there is large variation in the rainfall pattern in the State. It may be seen from the Table 2.1 that the average rainfall has varied a lot that has increased from 450.5 mm in 1660-61 to 786 mm in 2013-14. The average rainfall has again fallen to 665.7 next year, i.e., 2014-15. The average annual rainfall ranges from 100 mm in Jaisalmer to 800 mm in Jhalawar. For the 22 eastern districts, the average rainfall is 688 mm whereas for the remaining western districts, the rainfall is only 318 mm.

Table 2.1: Rainfall Pattern in Rajasthan

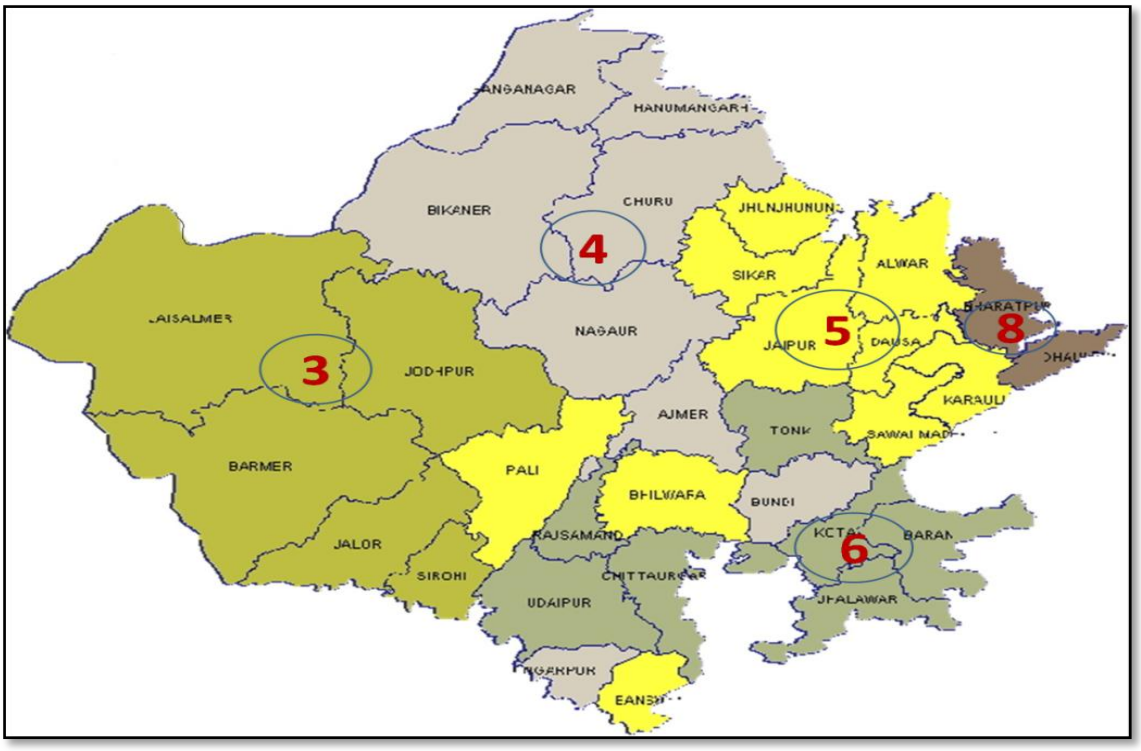
Period	Normal Rainfall (in mm)	Actual Average Rainfall(mm)	%Variation Over Normal
1960-61	575.1	450.5	-21.7
1970-71	575.1	622.7	8.28
1980-81	575.1	427.3	-25.7
1990-91	575.1	727.3	26.46
2011-12	463.3	753.1	62.6
2012-13	463.3	635.0	37.1
2013-14	463.3	786.0	69.7
2014-15	463.3	665.7	43.7

Source: Rajasthan Agricultural Statistics at a Glance, various issues, Commissionerate of Agriculture, Government of Rajasthan, Jaipur

Due to low level of average rainfall and highly erratic pattern of rainfall, the State has witnessed frequent drought and famine conditions in the past fifty years. There have been 48 drought years of varied intensity in the period 1901-2002, which means that the chance of occurrence of a meteorological drought in the state is 47 per cent (Rathore, 2004). A detailed analysis has revealed that in only 9 out of these years none of the districts in the state were affected by droughts. The picture is even worse at the village level. The number of severe and very severe drought years is larger in the western and southern districts of Rajasthan even though the southern region receives high average rainfall. Ray and Shewale et al (2001) on the basis of analysis of a 124 year time-period (1875- 1998) found that the probability of occurrence of droughts was maximum in West Rajasthan. The probability of moderate drought in Rajasthan was found to vary between 17- 24%, and between 2-14% in case of severe drought. During the year 2002 when about 29% of the total area of the country was affected by drought, the seasonal rainfall departure (%) for west Rajasthan and east Rajasthan were -71 and -60 respectively.

As stated in Figure 2.1, the recurrence period (year) of drought was once in 3 years for the districts like Barmer, Jaisalmer, Jalore, Jodhpur and Sirohi. The recurrence period of once in 4 years was seen in the districts Ajmer, Bikaner, Bundi, Dungarpur, Sriganganagar, Nagaur, Hanumangarh and Churu. For districts Alwar, Banswara, Bhilwara, Jaipur Jhunjhunu, Pali, Sawai Madhopur, Sikar, Dausa and Karauli, the frequency of droughts was once in 5 years and for Chittorgarh, Jhalawar, Kota, Udaipur, Tonk, Rajsamand and Baran, the frequency was once every 6 years. The least drought occurring frequency of once in every 8 years was seen for the Bharatpur and Dholpur districts.

Fig. 2.1: Drought Frequency for Different Districts in Rajasthan



Source: Disaster Management & Relief Department, Government of Rajasthan

2.3 Water Resources Availability and Requirement in Rajasthan

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 area West of Aravali, mainly forms part of the “Great Thar Desert" with average rainfall of 318.7 mm. The state has only 1.16 percent of the country’s total surface water resources or 21.71 billion cubic meters (BCM). On the basis of a more realistic indication of available surface water at 50 percent dependability, the state has 16.05 BCM of economically usable surface water (Table 2.2). The state has created capacity to harness and store 11.29 BCM, or around 70 percent of available water. Irrigation potential of 3.4 million hectares has been created, against a potential of 5.1 million hectares. Rajasthan has 1.72 percent of the country’s groundwater, translating to around 11.36 BCM. Dependent on inflows into the rivers, 17.88 BCM is allocated through inter-state agreements, although not dependable due to political compulsions of the upper riparian states. On paper, water use can be expanded by a further 30 percent. However, given the capital-intensive nature of construction projects and budget caps that prevent the irrigation department

from sanctioning new projects, the more realistic assessment of additional availability is economically usable water of around 21 percent.

Table 2.2: Water Resource Availability in Rajasthan

(in BCM)

Category	Availability in BCM(as percentage of economically usable water) (1)	Usage in BCM (as percentage of economically usable water) (2)	Percentage Used (2/1)
Internal surface water	21.71	-	-
(a) Economically usable	16.05 (35.6)	11.29 (31.6)	70
(b) Economically non-usable	5.66	-	-
Groundwater	11.36 (25.2)	11.77 (39.3)	104
Inter-state/external water	17.88 (39.2)	12.66 (35.4)	71
Total state water resources	50.96	-	70
Total economically usable state water resources	45.09 (100)	35.72 (100)	79

Note: (1) The figures in parentheses are the percentage of total water usage as percentage of total economically usable state water resources.

Source: Planning Department, Govt. of Rajasthan, Jaipur (2015)

Surface water resources are scarce and confined to the south and southeast of the state. The central and western parts of the state are devoid of any drainage and have very limited surface water, which too is not replenished due to low and erratic rainfall. High temperatures and low humidity in these parts further add to rainwater loss due to evapotranspiration. The River Chambal, and according to some sources River Mahi, are considered the perennial rivers of the state; although actual availability of water is questionable. These rivers receive almost all their flow during the short monsoon months. The surface water available in all basins is 25,931 million cubic meters (MCM) as shown in Table 2.3. According to the planning department of this only 62 percent or 16,054 MCM is considered economically usable at 50 percent dependability.

Table 2.3: Economically Usable Water by River Basin in Rajasthan

(in MCM)

Basin wise Availability of Surface Water (MCM)			
Basin	Mean Availability (in MCM)	Economically Usable Water (at 50 % dependability)	Percentage of Usable Water
Shekhawati	221	105	47
Ruparail	210	180	85
Banganga	569	449	79
Gambhir	805	353	44
Parwati	226	138	61
Sabi	268	168	63
Banas	4,837	4,039	84
Chambal	11,541	5,203	45
Mahi	3,755	3,149	84
Sabarmati	960	800	83
Luni	1,224	452	37
West Banas	551	406	74
Sukli	190	112	59
Other Nala	91	32	35
Outside Basin	483	468	97
Total	25,931	16,054	62

Note: Water available for use (excluding non-potable portion) when 50 % of available resource is being used
Source: Water Resources Planning Department, Government of Rajasthan, Jaipur

There exists a huge deficit between the available water and demand. Demand of water for irrigation is high and irrigation presently uses 83 per cent of total water resources of the state. With an increase in population along with water demand for non-agriculture purposes, the share of water for agriculture is set to reduce to 70 per cent by 2050 (ID&R, 2005). Correspondingly non-agricultural water demand which was 4.2 BCM in 2005 is expected to reach 5.1 BCM in 2015 and 8.07 BCM in 2045 (Table 2.4). This means the state will slip from scarcity to an absolute scarcity zone.

Table 2.4 Water Demand and Supply Gap in Rajasthan

(In billion cubic meters)

Purpose/Year	2005			2015			2045		
	Surface	Ground	Total	Surface	Ground	Total	Surface	Ground	Total
Demand									
Domestic	0.5	2.1	2.6	1.0	2.2	3.2	2.5	2.2	4.7
Livestock	0.1	0.8	0.9	0.3	0.8	1.1	0.5	0.8	1.3
Irrigation	20.0	15.9	35.9	26.0	14.0	40.0	36.0	13.1	49.1
Others	0.3	0.4	0.7	0.4	0.4	0.8	1.0	1.0	2.0
Total	20.9	19.2	40.1	27.7	17.4	45.1	40.0	17.1	57.1
Availability									
Intrastate	5.8	7.5		8.0	7.5		16.9	7.5	
Inter-State	12.2			13.0			15.0		
Sub Total			25.5			28.5			39.4
Recycled									
Domestic	0.8			1.1			1.1		
Irrigation		6.0			6.5			7.2	
Sub Total			6.8			7.6			8.3
Total	18.8	13.6	32.4	22.1	14.0	36.1	33.0	14.7	47.7
Shortage			7.7			9.0			9.4

Source: Hooda, 2013

Table 2.5 presents the component-wise uses of water resources in Rajasthan. It may be seen that, 83 present water use in irrigation purpose in 2008 whereas its decline 70 present in 2050 due to population increase. Drinking water use demand increase from 11 to 19 present in 2050. The demand supply gap will increase from 9 BCM in 2008 to 9.4 BCM in 2050. The average per capita water availability was declined up to 450 m3 in 2050 which was very low according to world standards of around 500 m3 required for per person.

Table 2.5 Component-wise Water Use in Rajasthan

(In percentage)

Water use in Rajasthan	2008	2050
Agriculture	83	70
Drinking water use	11	19
Industry and Other uses	6	11
Demand Supply Gap in Current	9 BCM	> 9.4 BCM
The Average Per Capita Water Availability in 2050	-	450 Cubic meter

Source: Hooda, 2013

2.4 Growth in Irrigation Provisions in Rajasthan

At present, less than one fourth of the State's area is under irrigation. At the time of independence there was 1 major project, 43 medium and 2272 minor projects and the irrigation potential was only 4 lakh ha. Hence after independence the state irrigation department was formed in 1949 with the objective of increasing the production of the food and fodder and to establish a suitable irrigation system to control the losses due to drought and flood. With this objective many projects were taken up by the Irrigation Department to increase the irrigation potential. At present the numbers of irrigation projects are 4786 and the irrigation potential in the state has reached to the amount of 2.812 Mha.

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 2.6 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: 2.6 Sources by Net Irrigated area in Rajasthan (1985-86 to 2013-14
('000 hectare)

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

Five year average growth rates of net irrigated area were worked out and are presented in Table 2.7. Growth rates were positive in 1986-90, 1991-95, 2001-05 and 2011-14 period. Growth rates were negative in all sources except tube well during the period of 2006-2010, which implies that except tubewell, the irrigation from all other sources have declined during this period. However, during the recent period of 2011 to 2014, the irrigation from all sources has increased with overall rate of annual growth of 4.78 per cent.

Table: 2.7 Growth of source wise net irrigated area in Rajasthan (1985-86 to 2013-14)

Year	Canals	Tanks	Tube-Wells	Wells	Other Sources	Total
1986-90	1.44	4.89	18.86	2.10	24.61	3.35
1991-95	0.70	6.44	12.70	6.02	12.99	5.07
1996-2K	1.73	-22.58	6.75	0.73	-0.64	1.25
2001-05	0.48	10.25	12.40	0.18	13.39	3.33
2006-10	-4.25	-36.34	8.43	-8.80	-4.51	-1.84
2011-14	4.36	9.02	6.76	1.14	27.14	4.78

Source: Department of Water Resources, Government of Rajasthan, Jaipur

2.5 Progress in Participatory Irrigation Management in Rajasthan

The Irrigation Enquiry Committee, 1938 also known as Visvesvaraya Committee, recommended entrusting irrigation to a village or group of villages if the farmers were willing to cooperate in irrigation management. The Command Area Development Programme started in 1974 envisaged the participation of farmer organisations from the start. The Sixth Plan emphasized the need for participation of farmers in the scientific management of water resources. The Seventh Plan reiterated the need for participation at farmers in the management of irrigation. The National Water Policy, 1987 also stressed the involvement of farmers in various aspects of water management particularly in water distribution and collection of water rates. The Committee on Pricing of Irrigation Water (1992) also recommended farmers participation in the management of irrigation systems. It is estimated that in 1995 only 804,000 hectares were being managed by Water User Associations (WUAs).

The National Water Policy (2002) has stressed on participatory approach in water resources management in the state. It has been recognized that participation of beneficiaries in water resource management will help considerably in proper upkeep of irrigation system and optimal utilization of irrigation water. The participation of farmers in the management of irrigation

would promote responsibility for operation and maintenance and collection of water charges from the areas under the jurisdiction of Water Users' Association (WUAs). A one-time functional grant is provided to the registered WUAs under the programme. Minimum contribution of 10 per cent for beneficiaries has been made mandatory in the cost of construction of field channels, full package OFD works, reclamation of water logged areas and one time functional grant to WUAs.

The equitable and optimal use of water from canal irrigation has been a matter of continuing concern. The traditional approach of pursuing these objectives through the field-level functionaries of irrigation department had its limitations. The participation of actual beneficiaries through PIM and the maintenance of village-level distribution channels through WUAs have been found useful. There is broad consensus that this has been a step in the right direction. This needs to be pursued more vigorously with genuine empowerment of WUAs. The objective should be to cover the entire command of all major and medium projects with WUAs by the end of the Eleventh Plan. The experience across States has been uneven. It is reported that 55501 water users associations (WUAs) have been formed and their state-wise distribution is indicated in Table 2.8.

Table 2.8 State-wise number of WUAs formed and irrigated area covered upto 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	1	(0.0)	1	(0.0)
11	Karnataka	2279	(4.1)	1052.41	(10.3)
12	Kerala	3930	(7.1)	148.48	(1.5)

Table 2.8 Contd...

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	Orissa	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

2.6 Challenges for Irrigation Water Management in Rajasthan

The importance of water in the State was recognised even during the pre independence period and the old tradition of water conservation and harvesting is reflected in numerous old structures like Tankas, Khadins, Johads, Bawaries etc. Irrigation facilities were limited at the time of independence, and there were 1 major, 43 medium and 2272 minor projects in the State with irrigation potential of only 4 lakh ha. At present 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 irrigation provisions, 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. But in spite of this it has not been possible to keep pace with population growth, increasing requirements, and technological changes. Some of the main challenges being faced by the water sector, as listed below, clearly indicate that a lot more is to be done for integrated water resources development and management.

- Inadequate availability of water for meeting demands of all sectors and uneven temporal and spatial distribution of water
- Harnessing of remaining 40 per cent of internal surface water resources

- Inadequate maintenance resulting in deteriorated condition and low efficiencies of existing water supply projects
- Financial constraints for implementing new projects and for adequate maintenance of existing facilities
- Inefficient management and reluctance to adopt modern water saving technologies, like pressure irrigation/volumetric measurement/leak detection and control, by developers and users both
- Ensuring effective groundwater control and management and also conjunctive use of surface and groundwater
- Environmental sustainability and mitigating environmental degradation in terms of water logging and salinity and deteriorating quality of water due to pollution and over exploitation of groundwater
- Resettlement and rehabilitation problem of displaced population due to implementation of water resources projects
- Financially non sustainable water rates
- Recurring droughts and effective drought management
- Inadequate institutional infrastructure and human resource development for adopting new technologies and innovative approach
- Inculcating participatory approach in development and management of water resources
- Inter-sectoral coordination

For optimum utilization of available water, water storage structures like construction of farm ponds, water storage tanks, construction of doggies and pipeline are being promoted under various schemes : (a) diggy-cum-sprinkler are very beneficial in canal commands areas, where canal closure and breakage and under supply of water is a common phenomenon, (b) water storage tanks become vital in well and tube well irrigated area where water is drawn from 300-600 feet depth and electricity is in short supply or available during nights, in such cases water storage tanks acts as reservoir for storage of water from wells/tubes wells which ensures as-and-when-irrigation in required quantities, (c) rain water harvesting structures particularly the farm ponds are useful in runoff water collection during rainy season which is used for life saving irrigation during Kharif when there is long dry spell or normal irrigation in Rabi season.

2.7 Policies and Programmes for Irrigation Development in Rajasthan

At the time of independence the existence of water resources sector infrastructure was negligible and there were very few major or large size water resources development projects. Therefore, the main thrust of the policy makers in the post independence era was towards construction of new projects and facilities. The water rates were highly subsidised during that period as increasing agricultural production for self reliance was the main target. But in quest for creating more and more facilities of large size, the consolidation of created facilities by proper maintenance and management and through smaller water harvesting structures got neglected. Further, the Water Resources Development Departments' main job centered around construction of new projects. The increased food production as a result of green revolution in seventies probably made the planners complacent and the allocation to irrigation sector gradually reduced to such an extent that on one side the project completion periods started increasing, resulting in high cost and time over runs and on the other side the maintenance of existing facilities started getting deferred due to non availability of funds. In eighties the gap between the potential created and utilised, widened. The deteriorated condition of facilities created got noticed and drew attention of planners. The thrust area of planning changed and shifted to modernisation and rehabilitation of project. But this shift also neglected the basic concept of management and involvement of users and the activities more or less revolved around construction activities renovation and lining of distribution systems.

The environmental and financial sustainability of the water resources was not given its due importance. Thus, it is evident that the review and evaluation of results were not given priority and the reaction time was too long for refinement and modification of the policy. In 1987 the National Water Policy addressing most of the problems of water sector was declared but again its percolation to the States took long time delaying its implementation. The problems being faced by the water sector in the country as a whole and the State of Rajasthan in particular clearly indicate that a radical change in policy and implementation methodology was required. The State of Rajasthan adopted the National Water Policy in December, 1989 and soon after the process of Study for preparation of State Water Policy and Plan was started and was commissioned in the year 1994.

Major Thrust Areas of State Water Policy

The Government of Rajasthan has recently adopted the State Water Policy, keeping in view the provisions contained in the National Water Policy and the specific conditions and problems of the State. The policy addresses all the issues for maximum development and optimum utilisation of scarce water resources in the State. The problems being faced by the State and the future scenario with a long term emphasizes the need of time-bound action plan for successful implementation of the State Water Policy and the Plan. The plan is based on some assumptions/projections regarding the development of water resources and the utilisation efficiencies. An analysis of these clearly shows that a lot has to be achieved in the next 45 years e.g. the surface water utilisation has to be increased by 60 per cent from present utilisation of about 10 BCM, distribution system efficiency has to be increased to 74per cent from present estimated efficiency of 54per cent, average on-farm irrigation efficiency has to be significantly increased to about 70per cent from present estimated efficiency of below 27 per cent. If we fail to implement the plan in terms of water resources development and management, the non-agricultural water demands, which are related to population and to some extent industrial growth, expected to more than double in the next 45 years, will have to be first fulfilled which will reduce the irrigation water availability and the irrigation in projected area will not be achieved and may significantly reduce. If a hypothetical assumption of present state of development and management to continue is made than in the year 2045 the present irrigated area will further reduce by 28 per cent where as the population would increase by 88 per cent. It also highlights the needs of sustainability of water resources, especially the water quality, to meet the future drinking water and irrigation requirements.

Chapter III

Overview of PINS Programmes in Rajasthan

3.1 Introduction

Rajasthan is the driest and most water- scarce state of the country. The demand for water however has been continuously rising due to high population growth, need for expansion of irrigation for agriculture and rural livelihoods, urbanization and industrialization, posing great challenges in management of fresh water resources, its accessibility and use. The State's water sector is faced with serious problems of poorly maintained water infrastructure, below average water use efficiencies, falling water tables, inadequate drinking water and poor sanitation, and degradation of surface and groundwater quality among others. Recognizing the challenges ahead, the State Government has in recent years taken several initiatives, including formulation of a State Water Policy and participatory and integrated approaches to water management. It has established a separate department, namely Surface Water Resources Planning Department (SWRPD) to coordinate and monitor water related activities of all water using-departments of the state and other stakeholders. An action plan for the implementation of State Water Policy also exists but not much headway has been made in its implementation.

The state of Rajasthan has 10 per cent of India's land, 5 per cent of its population and only 1 per cent of its water resources—a disadvantage by a factor of ten for supply of irrigation water vs agriculture area. Acute water shortage, erratic rainfall and recurring droughts in every district have exacerbated the situation. Over 60 per cent of the population depends for livelihood on agriculture or horticulture, often marred by low productivity due to unreliable, inadequate or non availability of irrigation. About 70 per cent irrigation is done through wells or tube-wells energised mainly by grid-power or diesel generators. Approximately, 60,000 farmers are waiting for grid-based electricity connections for irrigation. Extension of electric-grid is not feasible in far-flung areas; almost 70 per cent area in the State is classified as desert.

Moreover, ground water has deteriorated rapidly in the last two decades. Out of 249 blocks, nearly 200 are in the highly critical zone. Almost 90 per cent of groundwater withdrawal in the State is utilised through flood or furrow-irrigation methods with mere 35 to 45 per cent water-use-efficiency. Rajasthan is blessed with one of the best solar insolation on earth (6-7 kWh/m2/day) combined with maximum sunny days in a year, about 325, which makes it one of the most attractive destinations for harnessing solar energy for various purposes, especially irrigation. Subsidies available under various programmes were clubbed and the State committed to grant the total subsidy upto 86 per cent of the capital cost. The solar water pump scheme was scaled up from a mere target of 50 in 2010-11 to 500 (900 per cent increase) in 2011-12; to 2,200 (over 340 per cent increase) for 2012-13; and, to 10,000 (354 per cent increase) for 2013-14.

Potential of different MIS such as drip and sprinkler was assessed using the state-wise secondary data (Raman 2010). For assessing the potential of MI in different states the variables considered were: state-wise and source-wise irrigated area, cropped area and crop-wise suitability for different MI systems. While making the assessment, the irrigated area under paddy and crop area under canal irrigation were not considered. 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.1 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% (Table 3.1). 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.

Table 3.1: Potential and Actual Area under MI in Different States

(Area in '000 ha)

State	Drip			Sprinkler			Total		
	P	A	%	P	A	%	P	A	%
Andhra Pradesh	730	363.07	49.74	387	200.95	51.93	1,117	564.02	50.49
Bihar	142	0.16	0.11	1,708	0.21	0.01	1,850	0.37	0.02
Chhattisgarh	22	3.65	16.58	189	59.27	31.36	211	62.92	29.82
Goa	10	0.76	7.62	1	0.33	33.2	11	1.09	9.95
Gujarat	1,599	169.69	10.61	1,679	136.28	8.12	3,278	305.97	9.33
Haryana	398	7.14	1.79	1992	518.37	26.02	2,390	525.5	21.99
Himachal Pradesh	14	0.12	0.83	101	0.58	0.58	115	0.7	0.61
Jharkhand	43	0.13	0.31	114	0.37	0.32	157	0.5	0.32
Karnataka	745	177.33	23.8	697	228.62	32.8	1,442	405.95	28.15
Kerala	179	14.12	7.89	35	2.52	7.19	214	16.64	7.77
Madhya Pradesh	1,376	20.43	1.48	5,015	117.69	2.35	6,391	138.12	2.16
Maharashtra	1,116	482.34	43.22	1,598	214.67	13.43	2,714	697.02	25.68
Nagaland	11	0	0	42	3.96	9.43	53	3.96	7.48
Orissa	157	3.63	2.31	62	23.47	37.85	219	27.1	12.37
Punjab	559	11.73	2.1	2,819	10.51	0.37	3,378	22.24	0.66
Rajasthan	727	17	2.34	4,931	706.81	14.33	5,658	723.82	12.79
Tamil Nadu	544	131.34	24.14	158	27.19	17.21	702	158.52	22.58
Uttar Pradesh	2,207	10.68	0.48	8,582	10.59	0.12	10,789	21.26	0.2
West Bengal	952	0.15	0.02	280	150.03	53.58	1,232	150.18	12.19
Others	128	15	11.72	188	30	15.96	316	45	14.24
Total	11,659	1,428.46	12.25	30,578	2442.41	7.99	42,237	3,870.86	9.16

P=Potential; A= Actual area.

Source: Raman (2010) and Indiastat 2010.

The area covered under Micro Irrigation in the Rajasthan compared to other states in the country is given in the Table 3.2. 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).

Table3.2: Share of Rajasthan in area covered under Micro Irrigation Systems

(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

3.2 Progress in PINS and Micro Irrigation in the State

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 (IGNP) 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 Rajasthan.

3.2.1 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 tubewells irrigation in their field. As the only option, the farmers adopted canal PINS and succeeded in making agricultural prosperity.

3.2.2 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 3.3.

Table 3.3: State wise Utilizable flow of Narmada Water

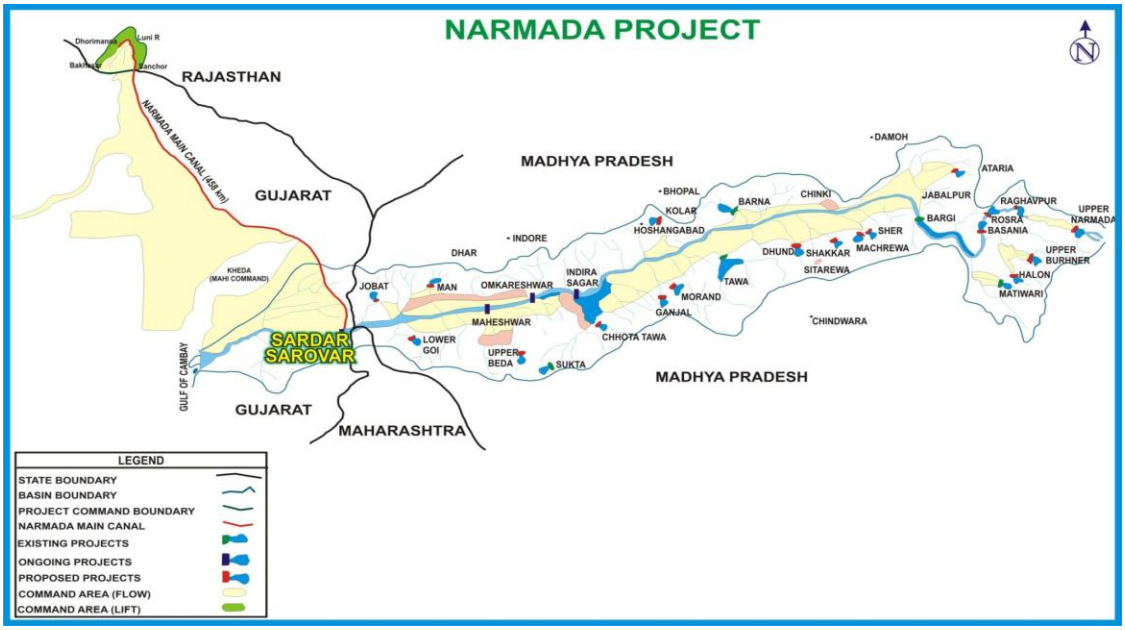
(Million Acre Feet per year)

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 3.1). 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 3.1. Map of 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 3.4).

Table 3.4 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

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.

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 3.5). 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.

Table 3.5 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

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.

3. 3 Cost Structure on PINS

The estimated cost on PINS project in Rajasthan is stated in Table 3.6. 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 3.6: 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

Figure 3.2 Diggi for storage of water in Rajasthan

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 jumped to 28080 ha and 129522 ha in 2011-12 (Table 3.7). No wonder Rajasthan has the highest area (15.14 lakh hectare) irrigated by sprinklers (discussed earlier, see Table 3.2).

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. Micro irrigation is also essential if Rajasthan wants to continue to reap benefits of the Indira Gandhi canal that gets its supply from Punjab. The inflow has been reducing over the years and the Indira Gandhi Nahar Pariyojna (IGNP), the authority which manages the canal network, undertook a pilot project on sprinkler irrigation in 2012-13.

Table 3.7: 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

3.5 Performance of PINS in Narmada Canal Command in Rajasthan

In Rajasthan, generally traditional flood irrigation methods (basin, border and furrow) are used to irrigate crops, wherein the entire soil surface is almost flooded without considering the actual consumptive requirements of the crops. These practices have created the problems of water logging and salinity and reduction in the overall irrigation efficiency hardly up to 30 percent. Therefore the state is in dire need to adopt modern efficient irrigation methods like sprinkler and drip. Sprinkler irrigation method offers several advantages over surface irrigation methods, including higher water use efficiency, better fertilizer application and high yield (Camp et.al., 2001). However, high wind velocity and use of saline water may restrict its application in arid regions. Drip irrigation

method is not affected by high wind velocity as it applies water directly to the root zone of plants (Sharma, 2001).

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.

As discussed earlier, sprinkler is the major type of MIS adopted under PINS programme in the state. The sprinkler irrigation have major advantages as compared to other methods include: higher crop yields, saving in water, increased fertilizer use efficiency, reduced energy consumption, tolerance to windy atmospheric conditions, reduced labor cost, improved diseased and pest control, feasible for undulating sloppy lands, suitability on problem soils and improved tolerance to salinity (Michael, 2008).

As stated in Table 3.8, 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

Table 3.8: 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

Continued.....

S.N	Component	Pressure Irrigation	Gravity Irrigation	Net Increase/Decrease (+/- arks)
(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

3.6 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.

Existing Crops

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.

Adoption of New Crops

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 3.8 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.

Table 3.8 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		
	Irrigated Area	Unirrigated 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
Total 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
Niser-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 vegetables	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

3.7 Constraints in Promotion of PINS

There are a number of constraints in making the PINS sustainable in the long run in the state. Some of these are:

System deficiency: There are many problems like deterioration of control and measuring structures, leakages and seepage at various places, erosion of banks and beds, siltation and weed infestation. These are serious problems, hindering farmers to take over the system management on technical and financial considerations.

Uncertainty of water availability: The uncertainty of water availability due to poor rainfall or other related causes is another important aspect that makes farmers understandably reluctant to take on the responsibility for managing the system. The deliveries of water need to be made reliable, flexible, practical and responsive to need. The engineers on their part may not be confident about ensuring supply of the requisite quantity of water to the WUAs, as would be obligatory in terms of the MOU signed between Irrigation Agency and WUA.

Further, the farmers who have their holdings at the head of the canal tend to appropriate more water than required, whereas the farmers at the tail end often fail to get their apportioned share of water. Head-enders, therefore, have vested interest in continuing the existing arrangements. The tail-enders may not be keen to form WUAs as water supply in such areas remains inadequate and erratic and they remain apprehensive that the situation will not be materially altered if an association is formed. These differences in perceptions and conflicts of interests inhibit them coming together.

Fear of financial viability: Maintenance and operation of the system demands huge finances. Farmers have got the apprehension that in absence of surety of finance, it would be difficult for them to fulfill the requirement of funds for operation and maintenance. They feel that when government is not able to handle the system with huge money available with them, how farmers would be able to do justice?

Lack of technical knowledge: Apart from the financial uncertainty, lack of technical input is one of the inhibiting factors to take over the system.

Lack of leadership: On account of limited exposure of the farmers to the rest of the world and PIM in particular, potent leadership is lacking, rather on account of limiting knowledge. At times so called local leaders give the negative or unclear version before other farmers which further create misunderstanding among the farmers bringing them sometimes into a fix.

Lack of publicity and training: Seeing is believing; and knowledge brings confidence in people. This aspect is lacking and there is a constraint to adoption of PIM.

Demographic diversity: Due to variation in economic, ethnic, education levels etc. diversity of farmers, PIM is taking much time to make an impact on irrigation water management. To handle this aspect deep study, analysis and solution need be found out.

WUAs v/s Panchayats: In many of the areas, where WUAs have been formed, there is a clash of interest among Panchayats and WUAs on who is to own and manage the system.

These issues need to be handled carefully at different levels so as to facilitate smooth functioning of PINS which has huge potential to influence the water saving, crop production and productivity.

Chapter IV

Adoption, Performance and Management of PINS by Farmers

4.1 Introduction

As discussed in earlier Chapter, the progress in various PINS programmes and adoption of certain types of PINS depend on various factors such as suitability to farmers' preference on cropping pattern and methods of irrigation, nature of existing access to available water resources and existing policy regimes etc. This chapter particularly examines the perceptions and experiences of the farmers/ water users in terms of the adoption, benefits and costs of accessing irrigation water from available PINS systems. Thus, the adoption, performance and management of the PINS structures by the farmers are the core issues which have been discussed in this chapter.

4.2 Socio-Economic Profile of Water Users

The socio-economic characteristics of sample households are presented in Table 4.1. It can be seen from the table that the average age of respondent of selected beneficiary and non-beneficiary farmers was around 47 years. The length of education was 4.4 years and 5.4 years for beneficiary and non- beneficiary farmers, respectively. The beneficiary farmers depicted better results with respect to average number of people engaged in agriculture and participation in village level organizations. About 13 per cent of the sample households belonged to general caste, while the majority of about 78 per cent were from other backward classes (OBCs) and remaining are the SC/ST households in both the groups. Thus, the beneficiary and non-beneficiary farmers had similar socio-economic status in the study area, except few contrasting characteristics.

Table 4.1 Socio-economic Characteristics of Sample Households

Particulars	Beneficiary Farmers	Non-Beneficiary Farmers	Overall
Number of sample farmer households	200	100	300
Average age of respondent (years)	47.1	46.8	47.0
Average years of respondent education	4.4	5.4	4.7
Agriculture as main occupation (% of respondents)	100.0	100.0	100.0
Gender (% of respondents):	100.0	100.0	100.0
Male	99.0	100.0	99.3
Female	1.0	0.0	0.7
Average family size (No.)	7.7	7.5	7.6
Average number of people engaged in agriculture	3.3	3.1	3.2
Average years of experience in farming	23.1	24.7	23.6
% of farmers being a member of any association	22.0	6.0	16.7
Caste (% of households):	100.0	100.0	100.0
SC	6.0	13.0	8.3
ST	1.5	0.0	1.0
OBC	80.0	73.0	77.7
General	12.5	14.0	13.0

Source: Field survey data.

4.3 Land Holdings, Asset Holding and Sources of Credit

The details of land holding pattern of the sample households have been presented in Table 4.2. The average size of owned land and cultivated area was 6.15 ha and 5.36 ha per household (hh), respectively. Out of net operated area of 5.55 ha per hh, about 3.69 ha of land (66.5%) was under irrigation. It is interesting to note that the non-beneficiary farmers had more gross cropped area compared to beneficiary farmers by 0.63 ha more per hh. The gross cropped area for beneficiary farmers and non- beneficiary farmers was 5.57 ha and 6.2 ha respectively. However, the cropping intensity of beneficiary farmers was higher than the non-beneficiary farmers. The cropping intensity for

beneficiary farmers and non-beneficiary farmers was estimated to be 107.8 per cent and 98.1 per cent respectively. The land leased-in tendency was found more in case of beneficiary group farmers than non-beneficiary farmers.

Table 4.2 Operational Landholding of the Sample Households

Particulars	Beneficiary Farmers	Non Beneficiary Farmers	Overall
Total Operational Holding	5.96	6.93	6.28
Owned land	5.78	6.89	6.15
Area under cultivation	4.98	6.12	5.36
Leased-in	0.25	0.21	0.23
Leased-out	0.07	0.00	0.05
Net operated area (NOA)	5.16	6.33	5.55
Net irrigated area	4.01	3.06	3.69
Net unirrigated area	1.15	3.27	1.86
Fallow Land	0.80	0.60	0.73
Gross cropped area (GCA)	5.57	6.20	5.78
Cropping intensity (%)	107.9	98.1	104.2

Source: Field survey data

The details on distribution of farm assets by beneficiary and non-beneficiary farmers are presented in Table 4.3. It can be seen from the table that the beneficiary farmers were more mechanized as compared to non-beneficiary farmers, almost in all respect. It can be seen that the number of tractor, harrow, cultivator, electric motors, diesel engines and MIS systems were found more for beneficiary farmers to their counterpart. The beneficiary farmers were found to be more progressive and enterprising, thus level of adoption of farm implements is better in case of beneficiary farmers.

Table 4.3 Distribution of Farm Assets

(Number/household; Area in Ha.)

Particulars	Beneficiary Farmers	Non-beneficiary Farmers
Tractor, Trailer/trolley	0.41	0.26
Harrow and cultivator	0.36	0.21
Electric motor	0.13	0.06
Diesel engine	0.49	0.44
Drip system (No/hh)	0.01	0.00
Drip system (Area/hh)	0.02	0.00
Sprinkler system (No/hh)	8.46	6.69
Sprinkler system (Area/hh)	3.63	1.75
Any other (camel cart, tractor trolley, rotavator for BF and camel cart and tube well for NB)	0.06	0.10

Source: Field survey

It may be noted from Table 4.4 that, the major sources of institutional credit was commercial banks followed by cooperative banks, for both beneficiary and non-beneficiary farmers. It was observed that only 32 percent of sample households could get access to institutional sources of credit. Among those who had taken the loans, the per hh amount of loans taken was Rs 1.84 lakh and 1.64 The main purpose of taking loans from banks was seasonal crop cultivation.

Table 4.4 Agricultural Credit Outstanding by the Sample Households

Sources	Beneficiary Farmers			Non-beneficiary Farmers		
	Amount of loan taken (Rs/HH)	Rate of interest (%)	Amount of loan outstanding (Rs/HH)	Amount of loan taken (Rs/HH)	Rate of interest (%)	Amount of loan outstanding (Rs/HH)
Commercial banks	191447	4	26579	167440	5	42800
Co-operative Credit Societies	168125	5	66042	65100	5	8500
Other banks	-	-	-	-	-	-
Government programmes	235000	4	0	400000	7	0
Informal sources (Money lenders, Traders/Commission agents etc)	-	-	-	40000	12	40000
Total	184063	4	40547	164906	5	37344

Source: Field survey

Among the sources of irrigation, bore wells and tube wells, followed by canal and dug wells were the major sources of irrigation for the sample households (Table 4.5). For both groups of farmers, canal was found to be the major sources contributing about 91.2 per cent of total irrigated area. The tube wells contributed to only 6.2 per cent of total irrigated area. Thus, surface water was the main source of irrigation for the selected sample households. The tank, river/pond and other water sources accounts meager share in irrigating crops of sample farmers. It may be noted that all beneficiary households had irrigation facility whereas only 74 per cent of non-beneficiary household had access to irrigation facility.

Table 4.5 Sources of Irrigation

(% of farmers, % of net irrigated area)

Particulars	Beneficiary Area	Beneficiary Farmers	Non-beneficiary Area	Non-beneficiary Farmers	Overall Area	Overall farmers
Canal	93.69	100	85.72	74	91.15	91.33
Open/ dug well	0.46	1	6.40	4	2.35	2.00
Tube-well	5.41	6.5	7.88	6	6.20	6.33
Tank	0.44	0.5	0	0	0.30	0.33
Others	-	-	-	-	-	-
Total	100	100	100	100	100	100

Source: Field survey data.

4.4 Average Area under PINS Project

It may be seen from Table 4.6 that the farmers were evenly distributed over different size class with respect to average area covered by them under PINS. About 24.5 per cent farmers had the PINS area of 2 to 4 ha. 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 (Table 4.7). 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 4.8). 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 4.6 Distribution of Beneficiary Farmers According to Area under PINS

Area under PINS (Area in ha.)	No. of farmers	% farmers
Up to 1 .0	32	16.0
1-2	54	27.0
2-4	49	24.5
4-6	27	13.5
> 6	38	19.0
Total	200	100.0

Source: Field survey data

Table 4.7 Average Area under PINS Project by Farmer Category

(Area in Ha)

Farmer category	Area under PINS
Marginal (Up to 1 .0 ha)	0.71
Small (1-2)	1.50
Semi-medium (2-4)	2.79
Medium (4-6)	4.59
Large (> 6 ha)	8.76
All farmers	3.49

Source: Field survey data.

Table 4.8 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

4.5 Details of Adoption of PINS and 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 4.9 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.

4.9 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

4.6 Factors Influencing the Adoption of PINS and MIS

As depicted from Table 4.10, 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 4.10 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

4.7 Benefits Accrued from Adoption of PINS-MIS

Different benefits accrued by the beneficiary farmers by participating in WUA are presented in Table 4.11. 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 (Table4.12). More than six months a year, farmers did not get any canal water for irrigation.

Table 4.11 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

Table 4.12 Location of plot in the command area of the PINS project and sufficiency of irrigation water

Particulars	% farmers agreed
Location of plot under PINS:	
Head region	34.00
Middle region	27.00
Tail region	39.00
Do you get sufficient water throughout the year	55.50
% farmers not getting sufficient water throughout the year	44.50
Number of months not with sufficient water	6.58
% of farmers experienced conflicts in water distribution	20.00

Source: Field survey

Farmers were also asked about the reasons for inadequate supply of water to the farm plot (Table 4.13). It was found that inadequate water availability in canal, water theft by other farmers, less rainfall and land located in tail region were some of the major reasons for inadequate water availability. The inadequate supply of water often led to conflicts among the water users (Table 4.14).

Though there were no serious conflicts among the farmers, few conflicts due to misunderstanding among the water users were revealed during the field survey.

Table 4.13 Reasons for inadequate supply of water to the farm plot

(% farmers agreed)

Reasons	Most Important	Important	Least Important	Total
Water availability is inadequate in canal/tube well	74.16	16.85	8.99	100.00
Water theft by others	64.04	21.35	14.61	100.00
Land is located in tail region	55.06	26.97	17.98	100.00
Poor rainfall	64.04	15.73	20.22	100.00
PINS system is not functioning properly.	48.31	39.33	12.36	100.00
MIS fitted on my land is not functioning properly.	44.94	41.57	13.48	100.00
Non-payment of water rate and maintenance charges by the member	13.48	28.09	58.43	100.00
Wastage of water due to mismanagement of water distribution by WUA members	7.87	30.34	61.80	100.00
Partiality in water distribution by WUA members	7.87	30.34	61.80	100.00
Unresolved conflicts among WUA members	3.37	23.60	73.03	100.00
Any other (please mention)	-	-	-	-

Source: Field survey

4.14 Major causes of conflicts among water users/WUA members

Causes of conflicts in water distribution	% farmers agreed
Water availability is inadequate	92.50
Mismanagement / Partiality in water distribution by WUA members	17.50
Unresolved conflicts among WUA members	20.00
Different political affiliation of WUA office bearers and WUA members	2.50
Any other (Electricity Issue)	2.50
Any other (Water Theft Issue)	25.00

Source: Field survey

4.8 Farmers' Awareness and Perceptions About Functioning of WUA

As far as the farmers' awareness and perceptions about functioning of WUA are concerned, it was found that about 92.0 per cent of WUA members were aware about the rules and regulations of WUA (Table 4.15). There were no much political interferences in functioning of WUA in the study areas. About 72.5 per cent water users 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.

Table 4.15 Farmers' Awareness and Perceptions about Functioning of WUA

Particulars	% farmers with positive response
Do you know rules and regulations of WUA?	92.00
Do you know who are the office bearers of WUA?	14.00
Do you see any influence of political parties in selection of office bearers of WUA?	4.50
If yes, whether influential persons in WUA take all major decisions regarding activities of WUA?	2.50
Do you pay operation and maintenance cost of PINS project and water rates regularly?	72.50
If Yes, It is paid:	
Annually	43.50
half-yearly	6.50
Quarterly	9.50
monthly (As and when required)	7.00
As and when required	6.00

Source: Field survey

4.9 Planning and Installation of PINS and MIS

The details of planning and installations of PINS-MIS are presented in Table 4.16. It may be seen that, the major portion of task of planning and installations has been fulfilled by the representatives of authorized dealers or manufacturers such as Jain Irrigation and others (48.0%). However, the major channel for supply/purchase of MIS equipments/material was through the local markets (90.0%). The fertigation and chemigation practices were followed by very less number of farmers with the average area of 0.01 ha per hh. The proportion of micro irrigated area supplied with insecticides/ herbicides was also very less

(3.5%). The water quality testing has been carried out prior to installation of MIS in case of only 0.05 per cent of farmers.

Table 4.16 Planning and Installation of MIS

Particulars	% farmers agreed
(a) Agencies installed MIS on farmer's field:	
Representatives of authorized dealers of manufacturers (Jain/Netafin)	48.00
Government Agency (Extension Agency/ Irrigation Advisory Services/University)	6.00
Private consultants	19.50
Farmers themselves	26.50
Any other (please specify)	0.00
(b) Channel for supply/purchase of MIS equipments/material:	
Through dealers (distributors appointed by manufacturers)	4.50
Through Govt. Agency	5.50
Through local market	90.00
(c) Fertigation and chemigation practices followed:	
Average area under fertigation (Ha/hh)	0.01
Proportion of micro irrigated area supplied with insecticides/ herbicides (%)	3.5
(d) Used saline water in MIS	-
% of micro irrigated area affected by saline area	0.0
(e) Water quality testing has been carried out prior to installation of MIS (%)	0.05

Source: Field survey

4.10. Operation and Maintenance Costs incurred by farmers on PINS and MIS

The annual operation and maintenance costs incurred by farmers on PINS and MIS for major crops for Kharif season and Rabi season have been stated in Tables 4.17 to 4.20. It may be noted that the major heads of expenditure in both the seasons were the land preparatory work, harvesting cost, fertiliser/FYM and seed

cost. 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 during Kharif and from 2.6 per cent 11.1 per cent of total cost of cultivation of major crops.

Table 4.17 Annual operating cost of cultivation (A2+FL) with PINS-MIS (Kharif season) in Rs/Ha

(Rs/Ha.)

Operating cost	Bajra	Castor seed	Guar	Groundnut	Moong	Moth
Land preparatory work	3523	5139	2885	4058	2917	2889
Seed and seed sowing	1578	2746	1503	7937	3472	2667
Fertilisers/ FYM	1314	3381	1773	3855	694	3222
Pesticides	295	1476	727	3114	972	667
Labour cost on fertiliser/pesticide application	938	861	723	1643	2222	2000
Weeding and interculture	845	1808	1194	1824	0	222
Irrigation cost	542	1812	676	2149	0	222
Harvesting cost	2932	3950	2411	4078	3264	1689
Others	850	2086	108	1177	0	0
Total cost	12818	23257	12000	29836	13542	13578

Source: Field survey

Table 4.18 Annual operating cost of cultivation (A2+FL) with PINS-MIS (Kharif season) in Percent of total cost

(% of total cost)

Operating cost	Bajra	Castor seed	Guar	Groundnut	Moong	Moth
Land preparatory work	27.5	22.1	24.0	13.6	21.5	21.3
Seed and seed sowing	12.3	11.8	12.5	26.6	25.6	19.6
Fertilisers/ FYM	10.3	14.5	14.8	12.9	5.1	23.7
Pesticides	2.3	6.3	6.1	10.4	7.2	4.9
Labour cost on fertiliser/pesticide application	7.3	3.7	6.0	5.5	16.4	14.7
Weeding and interculture	6.6	7.8	9.9	6.1	0.0	1.6
Irrigation cost	4.2	7.8	5.6	7.2	0.0	1.6
Harvesting cost	22.9	17.0	20.1	13.7	24.1	12.4
Others	6.6	9.0	0.9	3.9	0.0	0.0
Total cost	100.0	100.0	100.0	100.0	100.0	100.0

Source: Field survey

Table 4.19 Annual operating cost of cultivation (A2+FL) with PINS-MIS (Rabi season) in Rs/Ha

(Rs/Ha)

Operating cost	Wheat	Gram	Rapeseed and mustard	Cumin	Isabgol	Ajwain	Methi	Potato	Onion
Land preparatory work	5236	3540	3666	4349	3810	1786	5283	6658	6250
Seed and seed sowing	4181	2891	1703	3640	3415	804	2968	19837	6250
Fertilisers/ FYM	3622	1852	1650	2847	2732	3571	3050	10598	3125
Pesticides	1452	2173	550	1519	1323	1786	2133	3261	0
Labour cost on fertiliser/pesticide application	1630	1690	1072	1682	1610	1071	1767	1630	6250
Weeding and interculture	1665	1166	684	1030	1003	1071	583	6793	0
Irrigation cost	2003	1502	2253	2003	1752	1502	2003	1502	2003
Harvesting cost	4776	6836	2647	4139	5111	3036	3583	6793	6250
Others	492	43	5984	2073	324	0	2000	0	0
Total cost	25056	21693	20210	23282	21081	14627	23371	57073	30128

Source: Field survey

Table 4.20 Annual operating cost of cultivation (A2+FL) with PINS-MIS (Rabi season) in Percent to total

(% of total cost)

Operating cost	Wheat	Gram	Rapeseed and mustard	Cumin	Isabgol	Ajwain	Methi	Potato	Onion
Land preparatory work	20.9	16.3	18.1	18.7	18.1	12.2	22.6	11.7	20.7
Seed and seed sowing	16.7	13.3	8.4	15.6	16.2	5.5	12.7	34.8	20.7
Fertilisers/ FYM	14.5	8.5	8.2	12.2	13.0	24.4	13.1	18.6	10.4
Pesticides	5.8	10.0	2.7	6.5	6.3	12.2	9.1	5.7	0.0
Labour cost on fertiliser/pesticide application	6.5	7.8	5.3	7.2	7.6	7.3	7.6	2.9	20.7
Weeding and Interculture	6.6	5.4	3.4	4.4	4.8	7.3	2.5	11.9	0.0
Irrigation cost	8.0	6.9	11.1	8.6	8.3	10.3	8.6	2.6	6.6
Harvesting cost	19.1	31.5	13.1	17.8	24.2	20.8	15.3	11.9	20.7
Others	2.0	0.2	29.6	8.9	1.5	0.0	8.6	0.0	0.0
Total cost	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Field survey

4.11 Impact of PINS and MIS on Cropping Pattern and Production

The area effects and production effects of PINS and MIS has been presented in Table 4.21 and Table 4.22. However, there is clear cut pattern is observed among the beneficiary and non-beneficiary farmers with respect to different crops in the study areas. The average area under majority of crops is higher in case of beneficiary compared to non-beneficiary households. Overall, 12.3 per cent more area was cultivated by the beneficiary households. The area effect was higher in Rabi season where there was 91.9 per cent higher area cultivated by the beneficiary farmers due to their access to irrigation facilities from PINS-MIS(Table 4.21). Moreover, the proportion of area under more remunerative Rabi crops was also found to be higher (45.6% of GCA) in case of beneficiary farmers as compared to non-beneficiary farmers (26.7%). However, the proportion of area under Kharif was more among non-beneficiary farmers over beneficiary farmers by 19.6 per cent, basically due to their more dependence on rainfall.

Among the Kharif crops grown by sample farmers, bajra, guar, kharif oilseeds such as castor and groundnut were the major crops. Among the Rabi crops, wheat, gram and rapeseed-mustard were the major crops. Total summer crops contributed only about 1.4 per cent and 0.9 per cent of GCA of the sample beneficiary and non-beneficiary farmers, respectively.

The impacts of PINS in terms of variations in crop productivity of various crops between beneficiary and non-beneficiary farmers have been presented in Table 4.22. It may be observed that, among Kharif crops, the beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers in case of crops like bajra, guar and groundnut. 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 had enjoyed 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 sprinkler.

Table 4.21 Impact on Cropping Pattern of the Sample Households

(Area in Ha., % of GCA in bracket)

Sl. No.	Season/ crop	Beneficiary Farmers (BF)		Non-beneficiary Farmers(NBF)		% Change in BF over NBF
		Area (Ha.)	% of total	Area (Ha.)	% of total	
A	Kharif crops					
1	Bajra	1.16	(20.9)	1.48	(29.7)	-21.09
2	Jowar	0.00	(0.1)	0.00	(0.0)	-
3	Other Cereals	0.00	(0.0)	0.00	(0.0)	-
4	Total cereals	1.17	(21.0)	1.48	(29.7)	-20.76
5	Total Kharif Pulses	0.13	(2.3)	0.14	(2.9)	-8.97
6	Groundnut	0.12	(2.1)	0.05	(0.9)	158.90
7	Sesamum	0.00	(0.1)	0.02	(0.4)	-76.00
8	Castor	0.32	(5.8)	0.12	(2.4)	170.25
9	Total Kharif oilseeds	0.45	(8.0)	0.19	(3.7)	140.97
10	Kharif Fodder	0.00	(0.0)	0.00	(0.0)	-
11	Kharif Guar	1.20	(21.6)	1.79	(36.0)	-32.81
12	Total Kharif Crops	2.95	(53.0)	3.59	(72.4)	-17.85
B	Rabi crops:					
13	Wheat	0.50	(9.1)	0.20	(4.0)	151.56
14	Maize	0.00	(0.0)	0.00	(0.0)	-
15	Jowar	0.00	(0.0)	0.00	(0.0)	-
16	Total Rabi Cereals	0.50	(9.1)	0.20	(4.0)	151.56
17	Gram	0.92	(16.4)	0.32	(6.4)	189.28
18	Total Rabi Pulses	0.92	(16.4)	0.32	(6.4)	189.28
19	Rapeseed and Mustard	0.23	(4.1)	0.01	(0.2)	1869.18
20	Cumin	0.62	(11.1)	0.57	(11.5)	9.08
21	Other spices	0.07	(1.3)	0.02	(0.4)	224.45
22	Total Spices	0.69	(12.4)	0.59	(11.9)	17.02
23	Onion	0.00	(0.0)	0.00	(0.0)	-
24	Total Vegetable	0.01	(0.2)	0.00	(0.0)	-
25	Total fruits	0.02	(0.3)	0.01	(0.2)	121.35
26	Isabgol	0.18	(3.1)	0.20	(4.0)	-11.22
27	Total Rabi Crops	2.54	(45.6)	1.32	(26.7)	91.93
C	Summer crops					
28	Bajra	0.08	(1.4)	0.05	(0.9)	71.88
29	Total Summer Cereals	0.08	(1.4)	0.05	(0.9)	71.88
30	Summer Fodder crops	0.00	(0.0)	0.00	(0.0)	-37.50
31	Total Summer Crops	0.08	(1.4)	0.05	(0.9)	70.38
32	Gross cropped area	5.57	(100.0)	4.96	(100.0)	12.26

Source: Field Survey data.

Table 4.22 Impacts on Crop Yields

(Qtl/ha)

Sl. No	Season/ crop	Beneficiary Farmers(BF)		Non-beneficiary Farmers(NBF)		% Change in BF over NBF	
		Irrigated	Unirrigated	Irrigated	Unirrigated	Irrigated	Unirrigated
A	Kharif crops						
1	Bajra	9.3	5.8	4.7	4.6	98.85	26.58
2	Jowar	-	6.3	-	-	-	-
3	Groundnut	15.6	10.8	13.0	10.8	20.16	0.10
4	Sesamum	2.3	5.6	-	0.0	-	-
5	Castor	21.0	19.2	23.3	28.6	-9.79	-33.02
6	Kharif Guar	4.8	4.0	4.5	1.6	5.19	142.07
B	Rabi crops						
7	Wheat	16.2	-	20.7	-	-21.76	-
8	Gram	7.7	-	7.0	2.0	9.33	-
9	Rapeseed and Mustard	9.0	-	-	0.0	-	-
10	Cumin	4.9	-	4.6	3.3	5.79	-
11	Isabgol	7.2	-	4.5	5.1	57.90	-
C	Summer crops						
12	Bajra	16.29	-	7.15	-	127.71	-
13	Summer Fodder	625.0	-	250.00	-	150.00	-

Source: Field Survey data

4.12 Irrigated Crop Area under PINS and MIS

The irrigated cropped area under PINS with MIS among sample farmers in Rajasthan is presented in Table 4.23. It is worth mentioning that the area under PINS –MIS is mainly covered with sprinkler systems in Rajasthan because of the sandy topography. The coverage under drip is very limited while the area covered under flood has been nil, the practice which is praiseworthy since the use of only MIS under PINS is rarely observed which is practiced in Rajasthan. This enhances

the water use efficiency and increases the area under irrigation with help of saved water.

Table 4.23. Distribution of area under irrigation by type

(Ha/hh, % of total crop area)

Sl. No	Season/ crop	Area under drip	Area under sprinkler	Area under flood	Total Irrigated area
A	Kharif crops				
1	Bajra		0.055		0.055
2	Total cereals		0.055		0.055
3	Total Kharif Pulses		0.005		0.005
4	Groundnut		0.022		0.022
5	Sesamum		0.002		0.002
6	Castor		0.203		0.203
7	Total Kharif oilseeds		0.227		0.227
8	Kharif Fodder		0.001		0.001
9	Kharif Guar		0.174		0.174
10	Total Kharif Crops		0.461		0.461
B	Rabi crops:				
11	Wheat		0.505		0.505
12	Total Rabi Cereals		0.505		0.505
13	Gram		0.915		0.915
14	Total Rabi Pulses		0.915		0.915
15	Rapeseed and Mustard		0.227		0.227
16	Cumin		0.621		0.621
17	Other spices		0.071		0.071
18	Total Spices		0.691		0.691
19	Onion	0.001	0.000		0.001
20	Tomato	0.001	0.000		0.001
21	Potato	0.000	0.009		0.009
22	Pomegranate	0.008	0.000		0.008
23	Mango	0.006	0.000		0.006
24	Papaya	0.003	0.000		0.003
25	Fruits	0.017	0.000		0.017
26	Isabgul	0.000	0.175		0.175
27	Total Rabi Crops	0.019	2.522	0	2.541
C	Summer crops				
28	Bajra		0.079		0.079
29	Other summer crop		0.001		0.001
30	Total Summer crops	0	0.080		0.080
31	Gross cropped area	0.019	3.063	0	3.082

Source: Field Survey data.

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

The other economic, social and environmental benefits of PINS and MIS have been briefly presented in Table 4.24. Among various benefits, 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%) were the major socio-economic and environmental benefits accrued by the farmers due to adoption of PINS-MIS.

Table 4.24. Other Economic, Social and Environmental Benefits of PINS with MIS

Particulars	No. of farmers agreed	% farmers agreed
Cultivated land saved due to less need to construct field channels	128	64.0
Frequency of maintenance is less compared to conventional flow irrigation	88	44.0
Reduction in fertilizer use	65	32.5
Reduction in weeding cost	104	52.0
Reduction in labour use	114	57.0
Effective allocation of water among farmers	70	35.0
Reduction in migration of family members due to more availability of water	122	61.0
Reduction in over-extraction of ground water	66	33.0
Saving of energy consumption due to sharing through common pump set/PINS	78	39.0
Reduction in pressure on pump set/canal due to less extraction	35	17.5
Less water logging	66	33.0
Less pest attack/reduced use of pesticides	27	13.5
Increase in social cohesion among the water users/villagers in managing the water	55	27.5

Source: Field survey

4.14 Factors Responsible for Benefits Accrued from PINS and MIS

Some of the factors those helped in generating some benefits as discussed in preceding section were more area under PINS-MIS (79.5%), more area during Rabi (79.5%), better water management by WUA members (70.5%), better education and awareness of the farmer (55.5%) were the major ones (Table 4.25).

Table 4.25. Determinants of the Benefits accrued by participating in WUA

Benefits accrued	No. of farmers	% farmers benefited
Better education and awareness of the farmer	111	55.50
More area under PINS-MIS	159	79.50
More area during Rabi	169	84.50
More area during summer	19	9.50
More depth of tube well	7	3.50
More Horsepower of pump	25	12.50
No interruption in regular supply of power/electricity	40	20.00
Better water management by WUA members	141	70.50
Any other (in-time water arrival and lower labour cost)	4	2.00

Source: Field Survey

4.15 Training, Education and Awareness about PINS-MIS

Training, education and awareness among the farmers about the operation, maintenance and benefits of PINS-MIS are very essential for better adoption of these water saving technologies. The level of awareness was examined by asking some useful questions as stated in Table 4.26. It may be seen that about 49.5 per cent of them knew about the ISO Standards of various irrigation equipments. However, only 21 per cent farmers agreed that there was facility for training farmers in adoption, operation and maintenance of MIS in their locality. Also only 14 per cent expressed that there was some testing facility for evaluating performance of micro irrigation system components (e.g. Emitters, filters, laterals etc.) in their locality.

Table 4.26. Training, Education and Awareness about PINS-MIS

Particulars	No. of farmers agreed	% Of farmers agreed
A. Do you know which ISO Standards pertaining to irrigation equipments (Yes-1, No-2)	99	49.5
If yes, Do you know which ISO Standards pertaining to irrigation equipments (ISO -1/TC23-2/SC18-3)	98	49
B. Do you know where there is any testing facility for evaluating performance of micro irrigation system components (e.g. Emitters, filters, laterals etc.) in your locality? (Yes-1, No-2)	28	14
D. Do you know where there is facility for training farmers in adoption, operation & maintenance of MIS in your locality? (Yes-1, No-2)	42	21
E.1. Average distance of the training centre from your village.(in Km.)	30	-
F.1.How many days are required for its repair:	3	-

Source: Field survey

4.16 Farmers Feedback to Improve Working and Performance of PINS

The major feedback provided by the farmers on the problems faced and lessons learnt after the adoption of PINS-MIS is presented in Table 4.34 and Table 4.35. 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 (Table 4.27). The irrigation water is supplied to the farmers' field among the members of WUA in a rotation basis within allotted time slot. For any reason, if the electricity is not available in a particular slot, the concerned farmer fails to get the irrigation water, or gets minimum amount of water depending on existing level of cooperation among the farmers. Thus the majority of farmers demand solar system to get rid of this energy crisis. Also the popularity of solar pumps among the farmers is gradually increasing in the state.

Table 4.27. Farmer's feedback on the problems faced and lessons learnt in adoption of PINS-MIS

(% farmers agreed)

Particulars	Problems faced (No. of farmers	Problems faced (in %)	lessons learnt, if any
Planning and installation	26	13.0	1. Diggi covering less farmers. 2. Chak area should be lesser per WUA/PINS. 3. Outlet was not suitably placed. 4. Proper valve system required.
Availability of suitable pump sets and system components	13	6.5	
Getting subsidy for the system	52	26.0	1. Getting subsidy before system installation. 2. Subsidy was not received because contractor purchased system.
Quality of various components	16	8.0	1. Filter system required.
Testing of equipments	12	6.0	1. No testing centre so testing centre required.
Water availability and quality	75	37.5	
Energy supply to PINS-MIS	120	60.0	1. Solar system required for irregular power supply during irrigation.
Operation and maintenance	46	23.0	1. Need company service centre in village. 2. Repairing cost was high because service centres were located far from villages so company charged more service charges. 3. Local person should be trained for providing quick services at village level.
Scheduling of micro-irrigation	12	6.0	
Fertigation and Chemigation	5	2.5	
After sale services by manufacturers	10	5.0	
Damage from rodents (squirrels, rats etc) and insects etc.	39	19.5	1. Blue Bull and Rodent problems.
Extension advisory services for farmers, especially for PINS-MIS	7	3.5	
Training of farmers	35	17.5	1. Training centre required in near village.

Source: Field survey

Table 4.28. Farmer's suggestions to improve working and performance of PINS-MIS

Sl. No.	Suggestions	No. of beneficiary farmers	% beneficiary farmers agreed
1	Expenses on electricity are very high. Thus it is requested to provide subsidy on electricity	68	34
2	Subsidy may be provided to set up solar unit with PINS and water provided to farmers when electricity was not available for supplying days during irrigation.	103	51.5
3	Farmer purchase pipe and nozzle from local market. some financial help is requested	41	20.5
4	Measures need to be taken to check water theft. More stringent policy should be implemented to check water theft.	14	7
5	Water availability to the tail enders is insufficient. Thus better water management is required	40	20
6	More number of diggis need to be constructed and number of farmers per diggy should be reduced	24	12
7	Road infrastructure need to be developed for better communications	22	11
8	Farmers need training centre for use of Sprinkler system and management of PINS System for economically viable crop cultivation practices under PINS.	20	10
9	PINS components like control button, valves, pipes, pump sets etc need repairing facility in nearby village through government.	25	12.5
10	Certified seed, pesticides, etc are distributed through WUA and farmers association.	6	3
11	Political influences should be reduced.	1	0.5
12	Farmer wanted to get water all seasons	14	7
13	Need to focus on regular cleaning and maintenance of canal system.	18	9
14	If needed then redesign of PINS and degree for some area with specific agro climatic and geographical locations.	11	5.5
15	WUA not working properly	6	3
16	Crop is damaged because of animal attack (pig, rat, squirrel, rabbit and blue bulls) thus fencing subsidy should be provided increasing income of farmers.	2	1
17	Using appropriate motor pumps in PINS for better implementation.	7	3.5

Source: Field survey

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. Thus, more subsidy or financial incentives are requested. Among other major suggestions provided by the beneficiary farmers, the need 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, were noteworthy.

Some of the major concerns and suggestions expressed by the non-beneficiary farmers have been stated in Table 4.29. Some of their agricultural areas are located very far from command area. 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%). Due to scarcity of irrigation water, some of the non-beneficiary farmers 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 MIS in their farm, 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 same (23%). In some cases, the condition of minor canal is not in proper condition. It is suggested to cement the canal system for supplying water through PINS in better way to provide more irrigation (29%).

Table 4.29. Non –beneficiary farmer's suggestions to improve working and performance of PINS –MIS

Sl. No.	Suggestions	% Non beneficiary farmers
5	Water availability to the tail enders is insufficient. Thus better water management is required	51
6	More number of PINS and diggis need to be constructed and number of farmers per diggy should be reduced	46
1	Incomplete PINS project work need to be completed within stipulated time.	32
2	Need to cement the canal system for supplying water through PINS in better way to provide more irrigation.	29
4	Measures need to be taken to check water theft. More stringent policy should be implemented to check water theft.	23
7	Road infrastructure need to be developed for better communications	18
9	Certified seed, pesticides, etc are distributed through WUA and farmers association.	11
11	Crop is damaged because of animal attack (pig, rat, squirrel, rabbit and blue bulls) thus fencing subsidy should be provided increasing income of farmers.	15
12	Using more efficient pumpsets in PINS for better implementation.	11

Source: Field survey

Chapter V

Adoption, Performance and Management of PINS by WUAs

5.1 Introduction

The Pressurised Irrigation Network System (PINS) is essentially meant to be handled by the farmer community since it is a common and shared infrastructure that facilitates individual beneficiary for installing and operating MIS. Given the high capital investment required in PINS, the sustainability of PINS largely depends on the nature of community management, viable functioning of the water users associations (WUA). The effective institutional arrangement is necessary for orderly Management, Operation and Maintenance (MOM) of water releases and distribution. The present chapter has attempted to assess how the WUAs in PINS command area have been successful in managing the issues of the beneficiary farmers in the command area using MIS in their lands. It has assessed the effectiveness of institutional arrangements/WUAs for management of PINS projects and the bottlenecks for their smooth functioning.

5.2 Details of Associated PINS Project

The present study has covered various types of arrangements where WUAs are functioning as stated in Table 5.1. The feeding source for all PINS was canal. 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. The size of PINS was much larger in Bikaner, followed by Barmer and Jalore. The major crops grown during Kharif were bajra,

guar, castor and moth and during Rabi the major crops were wheat, cumin, rapeseed-mustard and isabgul.

Table 5.1. Details of Associated PINS Project

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
Tubewell	–	–	–	–
Tank	–	–	–	–
River	–	–	–	–
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
Type of cultivation practice:				
Plots periodically left fallow	0.0	35.3	25.0	26.9
Zero or minimum tillage practiced on it	100.0	52.9	75.0	65.4
Crop rotation practiced on it	0.0	11.8	0.0	7.7
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

5.3 Capital Cost on PINS Equipments and Installations

The details of capital expenses on Canal PINS at a WUA level considering average area of 100 hectares to be covered under single PINS has been shown in Table 5.2. The total expenditure on 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.

Table 5.2: Details of Capital Expenses on Individual PINS

(Analysis of rates for CCA of 100 ha; Rs. Rupees in lakh)

Sr. No.	Nature of work	Cost	% Share
(A)	Civil work		
	Cost of Diggie	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.	13.538	36.59
	Cost of 100 Ha.	31.498	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	36.998	100.00

Source: Department of Water Resources, Govt. of Rajasthan

5.4 Annual Operation and Maintenance Cost on PINS

The annual operation and maintenance cost on PINS is presented in Table 5.3. It may be seen that 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. 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. The frequency of payment made for the maintenance works undertaken by the WUA is normally found to be 3.6.

Table 5.3. 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 etc.)	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

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 5.4). Some other reasons were Crop failure due to natural calamities and inability of selling crop output in time at right price.

Table 5.4 Reasons for non-payment of operation and maintenance costs of PINS

Reasons	Most Important	Important	Least Important	Total
Did not get enough water	78.18	20.00	1.82	100.00
PINS Project implementation was defective and did not work	63.64	29.09	7.27	100.00
Not satisfied with maintenance of the system	56.36	32.73	10.91	100.00
Crop failure due to natural calamities	38.18	23.64	38.18	100.00
Crop failure due to pest attack	16.36	9.09	74.55	100.00
Crop output was not sold in time	23.64	30.91	45.45	100.00
Good price of crop output was not realized	10.91	43.64	45.45	100.00
Heavy household consumption	1.82	30.91	67.27	100.00
Any other (please mention)	-	-	-	-

Source: Field survey

5.5 Details of Formation and Management of PINS-Water Users Association (WUA)

The Irrigation Department mainly acted as facilitator/catalyst for formation of all WUAs in the command areas (Table 5.5). 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 have less or no land or they are facing the problem of '*Jamabandi*'. 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). It is worth-mentioning that about 13 non-members in every WUA are availing facilities of the PINS system mainly due to mutual understanding among the members of WUA.

Table 5.5. Details of PINS-Water Users Association (WUA) (N=26)

Particulars	WUA agreed (%)
(a) Who acted as facilitator/catalyst for formation of WUA/TUA	
Government Department Official	100.0
NGO	0.0
Community Organiser	0.0
Any Other	0.0
(b)Satisfaction over the facilitator:	
Good	65.4
Average	15.4
Poor	19.2
(c) Number of members of WUA (No/WUA)	84
(d) Number of farmers having land in the PINS Command area but did not become the member of WUA (No/WUA):	39
(e)Reasons of their not joining the WUA (%):	
Not able to put pipelines due to not getting loan, since they don't have land	28.2
They stay in other chaks they don't want to cultivate their land due to long distance (Av. 70-75 km)	33.3
Canal goes through their land & land size is low, Jamabandi not given.	20.5
Don't want to pay anything for PINS Project	-
PINS Project implementation was defective	-
Getting water from other sources	-
Not satisfied with office bearers of WUA/TUA	-
Belongs to opposite political parties	-
Don't want to carry out any agricultural operations on plot	-
Don't see agriculture remunerative	-
Any other (Insufficient water in diggi etc.)	17.9
(f) Number of non-members of WUA/TUA who avails the facilities of PINS Project	13

Source: Field survey

5.6 Functioning and Activities of WUA

As far as the functioning and activities of WUA/TUA is concerned, the no. of general body meetings conducted during 2015-16 was 03 each WUA (Table 5.6). The number of decisions taken in the meetings during the year was about two in these associations. It may be noted that 96 per cent of the WUAs wanted to get assistance from Government for operation and maintenance of PINS project.

Table 5.6. Some aspects of functioning of PINS WUA/TUA

Particulars	Responses by WUA office bearers
(a) No. of General Body meetings conducted during 2015-16 (No/WUA)	2.96
(b) No. of decisions taken in the meetings during 2015-16	1.54
(c) No. of decisions implemented during 2015-16	1.79
Is there any influence of political parties in selection of office bearers of WUA (% agreed)	15.38
If yes, whether influential persons in WUA take all major decisions regarding activities of WUA? (% agreed)	0.00
Was there any rehabilitation problems generated by Installation of PINS Project (% agreed)	0.00
If yes, who did the rehabilitation or construction?	-
Contractor	-
WU A	
(c) Does WUA need any assistance for its Management? (% agreed)	96.15
If Yes, from whom:	
Government	100
NGO	0
CBOs	0
Others	0
Does the WUA get any annual matching grant from Government for operation and maintenance of PINS project?	Nil
If Yes,	-
mention the amount (Rs/WUA :	-

Source: Field survey

Some of the specific activities undertaken by different types of PINS WUA/TUAs are presented in Tables 5.7. 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, maintenance cost and dispute settlements were the major activities of WUAs.

Table 5.7. 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

5.7 Details of Income and Expenditure of WUA

The details of income and expenditure of WUA is presented in Table 5.8. 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. Besides, in case of PINS, the charges to Irrigation Department and some miscellaneous expenses were incurred by the WUA.

There were some members of WUA who could not pay their due in time. The office bearers of these WUAs were asked about the causes of such kind of behaviour of some members of their WUA. 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 and (iii) crop failure due to pest attack and other reasons, (iv) poor financial position (Table 5.9).

Table 5.8: Details of income and expenditure of WUA

(Amount in rupees)

Particulars	Income /Expenses	Percent to total
Inflow to the account (Income)		
Water rate collection	1807.7	1.5
Annual maintenance fees collected	44420.0	35.8
Annual electricity/diesel fees collected	57221.2	46.2
Earnings from business activities of the WUA, if any (e.g., sale of fertilizers)	0.0	0.0
Interest income	0.0	0.0
Loans from banks or individuals	0.0	0.0
Any other	20499.3	16.5
Total Income	123948.2	100.0
Outflow from the account (Expenses)		
Charges to Irrigation Department	1807.7	1.5
Expenditure on electricity bill	57221.2	46.2
Repairing expenses	44420.0	35.8
Salary expenses	13500.0	10.9
Travel and Conveyance expenditure	3900.0	3.1
Audit expenses	0.0	0.0
Loan repayment/interests paid	0.0	0.0
Office rent	1100.0	0.9
Miscellaneous expenses		0.0
Any other	1999.3	1.6
Total Expenditure	123948.2	100.0

Source: Field survey

Table 5.9 Reasons for non-payment of operation and maintenance costs of PINS

Reasons	% WUA office bearer agreed
Did not get enough water	78.18
PINS Project implementation was defective and did not work/ incomplete PINS work	63.64
Not satisfied with maintenance of the system	56.36
Crop failure due to natural calamities	38.18
Crop failure due to pest attack	16.36
Crop output was not sold in time	23.64
Good price of crop output was not realized	10.91
Poor financial position	34.62
Heavy household consumption	1.82

Source: Field survey

5.8 Relationship of WUA with related Organisations

It was observed that the office bearers of the WUA have maintained good relationship with various associated departments and organisations as stated in Table 5.10. About 69.2 per cent of WUA office bearers agreed that they maintain a good relationship with Public Works Department and Irrigation Department, while about 61.5 per cent of them expressed to have good relation with Agriculture Department.

Table 5.10: Relationship with the Government Departments and Other Organizations.

(% WUA office bearer agreed)

Particulars	Good	Average	Poor
Public Works Department (PWD)	69.23	15.38	15.38
Irrigation Department	69.23	15.38	15.38
Department of Agriculture	61.54	7.69	30.77

Source: Field survey

5.9 Benefits provided by WUA to its members

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 (Table 5.11). About 88 percent sample farmers expressed that they got irrigation water in time, whereas about 80 per cent of farmers revealed that it helped them in proper distribution of water among farmers.

Table 5.11 Benefits accrued by the members of WUA

(% WUA office bearer agreed)

Benefits accrued	Most Important	Important	Least Important
Water arrives in time	84.62	3.85	0.00
Timely information on release of water from canal	0.00	0.00	0.00
More information on how to use water judiciously	34.62	26.92	11.54
Proper distribution of water among farmers	42.31	38.46	0.00
Less conflicts around water or less water theft	11.54	26.92	26.92
More information on crops and technologies	19.23	15.38	15.38
Improved maintenance of the system	26.92	19.23	7.69
Environmental problems such as water logging and salinity resolved compared to pre-WUA period	15.38	11.54	7.69
Quality of groundwater improved due to less extraction compared to pre-WUA period	11.54	7.69	11.54
Enhanced financial situation	3.85	15.38	11.54
Any other (More area coverage)	3.85	0.00	0.00

Source: Field survey

5.10 Water Resource Management by WUA

Some questions were asked to the water users regarding various aspects of water resource management by WUA (Table 5.12). In case of 73.1 per cent of WUAs, the irrigation management was transferred to WUA. In remaining cases, the PINS system was jointly managed by the farmers and the Irrigation Department. In 84.6 per cent cases, WUAs were performed the duty of proper water distribution among the farmers in the command area. About 69.2 per cent WUAs also collected the water rates and the operation and maintenance cost of PINS projects. In remaining cases

of about 30 per cent WUAs, Irrigation Department and village leaders managed the distribution of water distribution. The periodicity of the collection the operation and maintenance cost of PINS project was carried out annually in case of 46.2 per cent WUAs. For other 46.2 per cent WUAs, the the collection the operation and maintenance cost of PINS project was carried out as when required, mainly on monthly basis.

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 (Table 5.13). 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.

Table 5.12 Water Resource Management by WUA

Particulars	% WUA office bearer agreed
Is the Irrigation Management Transferred to WUA?	73.08
Who does the water distribution? :	
WUA	84.62
Individual farmers	3.85
No Specific	11.54
Is the water rates and the operation and maintenance cost of PINS project are being collected by WUA?	100.00
Whether the operation and maintenance cost of PINS project and water rates are paid by its member regularly?	69.23
If Yes, periodicity of its collection the operation and maintenance cost of PINS project (%):	
Annually	46.15
half-yearly	3.85
Quarterly	3.85
Monthly (As and when required)	46.15

Source: Field survey

Those who did not get sufficient water mentioned that technical fault in PINS systems is resulting in supplying less water to their fields which are placed in the tail ends of the ayacut area of PINS. Few of them mentioned that poor rainfall caused less water availability for irrigation which caused less supply to their fields

(Table 5.14). Less availability of canal water due to poor rainfall that acts as the feeder source for PINS reduced the water supply to farmers' field. Some farmers expressed that existing minor conflicts among the water users related to water distribution have resulted in water shortage to their fields. Water availability is inadequate and mismanagement /partiality in water distribution by WUA members were the major causes of conflicts among the water users in the study region (Table 5.15).

Table 5.13 Sufficiency of Irrigation Water for the WUA Members

Particulars	Responses
Do WUA members get sufficient water throughout the year (% WUA members agreed)	23.07
If No, Average no. of months of insufficient water	5.05

Source: Field survey

Table 5.14 Reasons for Inadequate Supply of Water to the Farm Plot (N=26)

(% WUA office bearer agreed)

Reasons	Most Important	Important	Least Important
Water availability is inadequate in canal	53.85	0.00	0.00
PINS system is not functioning properly.	11.54	19.23	0.00
PINS system was not managed properly.	15.38	11.54	7.69
Non-payment of water rate and maintenance charges by the member	0.00	15.38	0.00
Unresolved conflicts among WUA members	3.85	7.69	7.69
Poor rainfall	19.23	7.69	0.00
Any other (1. System was not working, 2. maintenance & cleaning of canal, 3. Electricity problem)	23.08	0.00	0.00

Source: Field survey

Table 5.15 Causes of Conflicts Among Water Users (N=26)

(% WUA office bearer agreed)

Reasons	Most Important	Important	Least Important	No. of Agreed Respondent
Water availability is inadequate	42.31	0.00	0.00	11
Mismanagement / Partiality in water distribution by WUA members	19.23	11.54	0.00	8
Unresolved conflicts among WUA members	7.69	7.69	0.00	4
Different political affiliation of WUA office bearers and WUA member	0.00	3.85	3.85	2
Any other (Water theft)	19.23	0.00	0.00	5

Source: Field survey

5.11 Constraints in Operation and Maintenance of PINS at WUA level

WUAs also faced some constraints in management of their associations some of which is already discussed in earlier sections. Some more constraints have been stated in Table 5.16. It may be seen that among these constraints, 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 trend analysis of the problems faced by the WUAs under different set up has been presented in Tables 5.17. It may be seen 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. It may be noted that, 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.

Table 5.16 Major Problems Faced by the WUA

(% WUA office bearer agreed)

Constraints	Most Important	Important	Least Important
Fund constraints	84.62	15.38	0.00
Water availability	46.15	23.08	3.85
Maintenance and repair of PINS	57.69	42.31	0.00
Support from Govt.	42.31	34.62	23.08
Poor participation of WUA members	34.62	19.23	15.38
Political interference	7.69	7.69	15.38
Any other (1. system was not completed, 2. Electricity problem, 3. Unavailability of service centre)	23.08	3.85	0.00

Source: Field survey

Table 5.17 Trends in Impacts and Constraints Faced by the WUA

(% WUA office bearer agreed)

Constraints	More	Less	No
Before WUA formation			
Water logging	34.62	23.08	42.31
Tank /dug well pollution	23.08	3.85	73.08
Labour problems	19.23	30.77	50.00
Inter and Intra village conflicts	19.23	7.69	73.08
Crop yields	7.69	38.46	53.85
Average Irrigated area (Ha)	36.92		
Value of Agricultural production(Rs/Ha)	11666		
After WUA formation			
Water logging	23.08	42.31	34.62
Tank /dug well pollution	0.00	26.92	73.08
Labour problems	53.85	38.46	7.69
Inter and Intra village conflicts	7.69	46.15	46.15
Crop yields	80.77	15.38	3.85
Average Irrigated area (Ha)	228.16		
Value of Agricultural production (Rs/Ha)	49067		

Source: Field survey

Chapter VI

Summary and Conclusions

6.1 Introduction

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 facilitating 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. It is a common and shared infrastructure (by group of farmers) facilitating individual beneficiary for installing and operating MIS.

The present study intended to assess the effectiveness of institutional arrangements for management of PINS projects and the bottlenecks for their smooth functioning. Accordingly, the WUAs were in the study area 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 sprinklers and drip in terms of their functioning, costs and benefits, adoptability for different soils and field crops.

Thus the major objectives of the study are:

a) To undertake a broad situation analysis of various PINS programs implemented in select districts of Rajasthan;

b) To assess the extent of adoption and performance of PINS in the state

c) To analyse the institutional arrangements for management, operation and maintenance of PINS in the state

d) To identify the major constraints in adoption, management, operation and maintenance of PINS in the state

e) To recommend suitable policy measures to enhance the effectiveness and techno-economic performance of PINS in the state.

The study was a part of coordinated project covering four states (Gujarat, Rajasthan, Maharashtra and Telengana). The study on working and performance of PINS was coordinated by our Centre, i.e., Agro-Economic Research Centre, Vallabh Vidyanagar.

For Rajasthan state, the data was collected from three selected districts, viz., Bikaner, Jalore and Barmer. The farmers were selected from available canal PINS since no other kinds of PINS were available. The beneficiary households (households having access to irrigation water in canal PINS command area) were selected. About 200 beneficiary and 100 non-beneficiary households were interviewed for the detailed study.

6.2 Summary of Findings

6.2.1 Irrigation Development and Management in Rajasthan

Rajasthan is the largest state of India with high population growth and has agrarian economy with greater drought vulnerability. The state occupies 10 percent of the total geographical area of the country, but the vast geographical area commands only 1 percent of the total water resources in the country. 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 and aberrant. Thus the crops are grown in the state under high risk.

The per capita annual water availability in the State is about 780 cubic meters (Cum) on the basis of projected population July, 2009 against minimum

requirement of 1000 cum. It is estimated that the availability would fall below 450 cum by 2045. Rajasthan is a deficit state with respect to groundwater as well as available irrigation water. It contains about 11 percent of total land resource of the country but the availability of the total water resource of the country is hardly 1 percent. Maximum utilization/ exploitation of these water resources have resulted in the irrigation of 32 percent of the area in the state.

At the time of independence there was only 1 major project, 43 medium and 2272 minor projects and the irrigation potential was only 4 lakh ha. 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.

At present, less than one fourth of the State's area is under irrigation. 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.

Policies and Programmes on Irrigation Development in Rajasthan

At the time of independence the existence of water resources sector infrastructure was negligible and there were very few major or large size water resources development projects. Therefore, the main thrust of the policy makers in the post independence era was towards construction of new projects and facilities. The water rates were highly subsidised during that period as increasing agricultural production for self reliance was the main target. In eighties the gap between the potential created and utilised, widened. The deteriorated condition of facilities created got noticed and drew attention of planners. The thrust area of planning changed and shifted to modernisation and rehabilitation of project.

In 1987 the National Water Policy addressing most of the problems of water sector was declared but again its percolation to the States took long time delaying its implementation. The problems being faced by the water sector in the country as a whole and the State of Rajasthan in particular clearly indicate that a radical change in policy and implementation methodology was required. The State of Rajasthan adopted the National Water Policy in December, 1989 and soon after the process of Study for preparation of State Water Policy and Plan was started and was commissioned in the year 1994.

The State Water Policy, keeping in view the provisions contained in the National Water Policy and the specific conditions and problems of the State, addresses all the issues for maximum development and optimum utilisation of scarce water resources in the State. There is a need of time-bound action plan for successful implementation of the State Water Policy and the Plan. It also highlights the needs of sustainability of water resources, especially the water quality, to meet the future drinking water and irrigation requirements.

Progress in Participatory Irrigation Management

The Irrigation Enquiry Committee, 1938 also known as Visvesvaraya Committee, recommended entrusting irrigation to a village or group of villages if the farmers were willing to cooperate in irrigation management. The National Water Policy, 1987 also stressed the involvement of farmers in various aspects of water management particularly in water distribution and collection of water rates. The Committee on Pricing of Irrigation Water (1992) also recommended farmers participation in the management of irrigation systems. It is estimated that about 8,04,000 hectares were being managed by 55501 Water User Associations (WUAs) in India in 2011, out of which Rajasthan had only about 0.9 per cent share.

6.2.2 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.

Under Narmada canal, about 2, 35,000 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 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.

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 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.

Sprinkler is the major type of MIS operational in the state. 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 jumped to 28,080 ha and 1, 29,522 ha in 2011-12. No wonder Rajasthan has the highest area (15.14 lakh hectare) irrigated by sprinklers in the country.

The average spending on an individual PINS project with the capacity to irrigate about 100 hectares including the charges of electricity connections is estimated to be about 37.0 lakhs in Rajasthan. 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.

It is worth mentioning that 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.

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. The CCA has increased from 1.35 lakh hectares to 2.46 lakh hectares, an increase by 78 per cent. The number of villages benefitted for irrigation has increased from 89 to 233. The value of food production has been estimated to increase by 2.8 times from Rs 534 crore under flood irrigation to Rs 1480 crore under sprinkler.

6.2.3 Adoption, Performance and Management of PINS by Farmers

Promoting MIS was the main purpose of installing PINS in the selected water scarce districts of the Rajasthan state. 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.

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. The inadequate supply of water often led to conflicts among the water users (Table 4.15). Though there were no

serious conflicts among the farmers, few conflicts due to misunderstanding among the water users were revealed during the field survey.

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 planning and installations of MIS on the farmers field is concerned, the major portion of task of planning and installations has been fulfilled by the representatives of authorized dealers or manufacturers such as Jain Irrigation and others (48.0%). However, the fertigation and chemigation practices were followed by very less number of farmers with the average area of 0.01 ha per hh.

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%).

6.2.4 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. The size of PINS was much larger in Bikaner, followed by Barmer and Jalore.

The total expenditure on 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. 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.

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. 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.

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.

6.3 Policy Implications

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.

References

Amarasinghe, U. A., Shah, T., Turral, H. and Anand, B.K. (2007), India's water future to 2025-2050: Business as usual scenario and deviations. Research Report 123, IWMI. 52pp.

Anonymous (2006), Water A shared responsibility, United Nations World Water Development Report, 2006

Anonymous (2011), Central Water Commission, Annual Report 2010-11.

Camp, C.R., E. J. Sadler, W. J. Busscher, R. E. Sojlka and D. L. Karrlin (2001), Experiencing with sprinkler irrigation for agronomic crops in the southeastern USA.

Devasirvatham V. (2009), A Review of Subsurface Drip Irrigation in Vegetable Production. CRC for Irrigation Futures Irrigation Matters. Series No. 03/09.

Dhawan B. D. and Datta H S. (1992), Impact of irrigation on multiple cropping. Economic and Political Weekly. 28:15-18.

Dhawan, B. D. (1988), Irrigation in India's Agricultural Development: Productivity, Stability, Equity. New Delhi: Sage Publications, Second Edition, New Delhi: Commonwealth Publishers.

Dhawan, B. D. (2002), Technological Change in Indian Irrigated Agriculture: A Study of Water Saving Methods. New Delhi: Commonwealth Publishers.

FAO (2000), Technical Handbook on Pressurized Irrigation Techniques, Food and Agriculture Organization of the United Nations, Rome.

Feather, Peter M. and Gregory S. Amacher (1994) Role of information in the adoption of best management practices for water quality improvement. Agricultural Economics,11(2-3):159-170

Ganpatye, A.V. (2011), 'Concept and Design of PINS', Seminar on Pressurised Irrigation Network System, SSNNL, Gandhinagar, March 07, 2011

Gittinger J, Price. (1984), Economic Analysis of Agricultural Projects, Second Edition, The Johns Hopkins University Press, London.

Hegde, N. G. (2012). Water Scarcity and Security in India. In 99th Indian Science Congress, KIIT University, Bhubaneswar, pp. 3-7.

Hooda, Sweta Mirdha (2013), Rajasthan Water Assessment:Potential for Private Sector Interventions, International Finance Corporation, New Delhi

Hussain, Intizar and Munir A. Hanjra (2004) Irrigation and Poverty Alleviation: Review of the Empirical Evidencey, Irrigation and Drainage 53: 1-15.

ID&R (Investigation, Design & Research, 2005. Report of the Expert Committee on Integrated Development of Water Resources. Department of Water Resources, Government of Rajasthan, http://www.water.rajasthan.gov.in/content/water/en/waterresourcesdepartment/rulespoliciesandacts/vision2045.html, Accessed on 12th March 2017.

INCID (1994), Drip Irrigation in India, Indian National Committee on Irrigation and Drainage, New Delhi

Ishfaq, M. (2002), "Water New Technology", Global Water Institute, Lahore, Pakistan

Jiterwal R. C. (2008), Impact of drip irrigation technology among farmers in Jaipur region of Rajasthan. Ph.D. thesis submitted to Rajasthan Agricultural University, Bikaner. Campus: Jobner.

Kulkarni S. A. (2005), Looking Beyond Eight Sprinklers. Paper presented at the National Conference on Micro-Irrigation, G. B. Pant University of Agriculture and Technology, Patnagar, India.

Kundu D. K., Neue H. U and Singh R. (1998), "Comparative Effects of Flooding Sprinkler Irrigation on Growth and Mineral Composition of Rice in an Alfisol" proceedings of the National Seminar on Micro- Irrigation Research in India: Status and Perspective for the 21st Century, Bhubaneswar.

Levidow, Les, Daniele Zaccaria, Rodrigo Maia, Eduardo Vivas, Mladen Todorovic, Alessandra Scardigno (2014) Improving water-efficient irrigation: Prospects and difficulties of innovative practices, Agricultural Water Management, Volume 146, pp.84-94.

Machibya, Magayane, Makarius Mdemu and Bruce Lankford (2004), Irrigation Efficiency and Productivity Manual, RIPARWIN Project, Department for International Development (DFID), UK.

Michael, A. (2008) "Irrigation Theory and Practice", Second edition (revised and enlarged) Vikas Publishing House PVT. Ltd, Delhi, India.

Mukherji, A. and Kishore, A. (2003), Tubewell transfer in Gujarat: A study of the GWRDC approach. Research Report 69. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Narayanamoorthy, A. (1997), "Economic Viability of Drip Irrigation: An Empirical Analysis from Maharashtra", Indian Journal of Agricultural Economics, Vol.52, No.4, October-December, pp.728-739.

Narayanamoorthy, A. (2005), "Economics of Drip Irrigation in Sugarcane Cultivation: Case Study of a Farmer from Tamil Nadu", Indian Journal of Agricultural Economics, Vol. 60, No. 2, April-June, pp. 235-248.

Narayanamoorthy, A. (2008), 'Drip Irrigation in India', Water Policy 6, 117-130.

Narayanamoorthy A. (2010), Potential for Drip and Sprinkler Irrigation in India. Research report submitted to Gokhale Institute of Politics and Economics (Deemed University), Pune.

Narayanamoorthy A. (2015) "Drip and Sprinkler Irrigation India: Benefits, Potential and Future Directions". Alagappa University, Karaikudi, Tamil Nadu, India pp.253-266, http://www.iwmi.cgiar.org/Publications/Other/PDF/Paper%2015% 20of% 20NRLP%20series%201.pdf, Accessed on 15th October 2015.

Navalwala, B.N. (1991), Waterlogging and its Related Issues in India, Journal of Irrigation and Power, 55-64.

Postal S, Polak P, Gonzales F and Keller J. (2001), Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and Poverty", Water International. 26(1).

Prasad, R. K. (1993), Conjunctive Use of Surface Water and Ground Water, in Proceedings, National Workshop on Action for Optimum utilization of water resources, September 16-17, Water and Power Consultancy Services (India) Ltd., New Delhi, pp:33-49.

Ramah, K. (2008), Study on drip fertigation in maize based cropping system. PhD Thesis, Tamil Nadu Agricultural University, Coimbatore.

Raman, S (2010): "State-wise Micro-Irrigation Potential in India-An Assessment", unpublished paper, Natural Resources Management Institute, Mumbai.

Rathore M S (2004), State level analysis of drought policies and impacts in Rajasthan, India. Working paper 93, Drought series paper no. 6, International WaterManagement Institute

RPCB (Rajasthan Pollution Control Board), (2010), Climate Change Impacts, Mitigation and Adaptation Science for Generating Policy Options in Rajasthan, Government of Rajasthan

Rosegrant W Mark (1997), Water Resources in the Twenty-First Century: Challenges and Implications for Action, Food and Agriculture, and the Environment Discussion Paper 20, International Food Policy Research Institute, Washington D.C., U.S.A.

Sahu R. K. and Rao V. N. (2005), Development and evaluating of Micro Drip Irrigation System in farmer's field. Drainage and Irrigation Water Management. Pp:118-135.

Sanmuganathan, K., and Bolton, P. (1988), Water Management in Third World Irrigation Schemes-Lessons from the Field. ODI Bull. No. 11, Hydraulics Research, Wallingford, U.K.

Sekar, I. (2008), Conjunctive Water Productivity and Water Transaction in Tank Irrigation Rice Cropping System, Division of Agricultural Economics, IARI, New Delhi.

Sen Somnath (2012), Impact Assessment of Micro Irrigation Scheme in Madhya Pradesh. Project Report Department of Horticulture, Govt. of M.P.

Sinha Ray, K. C. & SheWale, M. P. (2001). Probability of occurrence of drought in various sub divisions of India. Mausam, 52, 541-546.

Shah, T. (1993), Groundwater Markets and Irrigation Development: Political Economy and Practical Policy, Oxford University Press, New Delhi.

Shah, T., Ballabh, V., Dobrial, K., Talati, J. (1994) "Turnover of State Tubewells to Farmers Cooperatives, Assessment of Gujarat's Experience, India." Paper presented at the International Conference on Irrigation Management Transfer, Wuhan, China, 20-24 September.

Shah T, Alam M, Kumar D, Nagar RKN and Singh M. (2000), Pedaling out of Poverty: Social Impact of a Manual Irrigation Technology in South Asia. IWMI Research No. 45. International Water Management Institute: Colombo, Sri Lanka.

Shah, Tushaar, Ashok Gulati, Hemant P., Ganga Shreedhar and R.C. Jain (2009), "Secret of Gujarat's Agrarian Miracle after 2000", Economic and Political Weekly, Vol. XLIV, No. 52, December 26, pp. 45-55.

Sharma, B. R. (2001), Availability, status and development and opportunities for augmentation of groundwater resources in India, Proceeding ICAR-IWMI Policy Dialogue on Ground Water Management, November 6-7, 2001 at CSSRI, Karnal, pp. 1-18.

Sharma, B. R., Amarasinghe, U., and Cai, X. L. (2009), Assessing and improving water productivity in conservation agriculture systems in the Indus-Gangetic Basin. In 4th World Congress on Conservation Agriculture-Innovations for Improving efficiency, Equity and Environment, New Delhi, India, pp. 4-7.

Siag Mukesh, Chawla,J. K., Vashist Ajay and Bhushan Indu (2009), Efficient use of canal water through drip irrigation in cotton (Gossypium hirutum). Indian Journal of Agricultural Sciences, 79(10):794-797.

Singh H. P. and Pachauri C. P. (2005), Role of Krishi Vigyan Kendra for adoption of drip irrigation technology at Ratlam district of Madhya Pradesh. Indian Research Journal of Extension Education, 5:138-139.

Sivanappan, R.K. (1994), "Prospects of Micro Irrigation in India", Irrigation and Drainage System, Vol.8, No. 1 pp. 49-58.

Srivastava, R. C., Mohanty, S., Singandhuppe, R. B., Mohanty, R. K., Behera, M. S., Ray, L. I., and Sahoo, D. (2010), Feasibility evaluation of pressurized irrigation in canal commands. Water Resources Management, 24(12), 3017-3032.

Times of India (TOI) (2016), Lift Canal Projects Get a Lifeline in Parched Raj, April 16.

Vaidyanathan A, Krishnakumar A, Rajagopal A and Varatharajan D. (1994), Impact of Irrigation on Productivity of Land. Journal of Indian School of Political Economy, 6(4), pp-601-645.

Vaidyanathan, A. (1998), Water Resource Management: Institutions and Irrigation Development in India. New Delhi, India: Oxford University Press.

Viswanathan, P K and Chandrsekhar Bahinipati (2015) Exploring the Socio-Economic Impacts of Micro-Irrigation System (MIS): A case study of Public Tube wells in Gujarat, Western India (2015), South Asia Water Studies (SAWAS) Journal, Volume 1, Issue 1, pp. 1 - 25.

WMO (World Meteorological Organization) (2005), Groundwater: the invisible resource (http://www.wmo.ch/web.en/wdwfea.html).

Annexure 1: Agro-Climatic Zone in Rajasthan

Zone	Area	Total Area (million ha)	District Covered	Average Rainfall (mm)	Temp OC		Major Crops		Soils
					Max.	Min.	Kharif	Rabi	
IA	Arid western plain	4.74	Barmer & part of Jodhpur	200-370	40	8	Pearlmillet Mothbean Sesame	Wheat, Mustard, Cumin	Desert soils and sand dunes aeolian soil, coarse sand in texture some places calcareous
IB	Irrigated north western plain	2.1	Sriganganagar, Hanumangarh	100-350	42	4.7	Cotton, Clusterbean	Wheat, Mustard, Gram	Alluvial deposites calcareous, high soluble salts & exchangeable sodium
IC	Hyper arid partial irrigated zone	7.7	Bikaner, Jaisalmer, Churu	100-350	48	3	Pearlmillet Mothbean Clusterbean	Wheat, Mustard, Gram	Desert soils and sand dunes aeolian soil, loamycoarse in texture & calcareous
IIA	Internal drainage dry zone	3.69	Nagaur, Sikar, Jhunjhunu, Part of Churu	300-500	39.7	5.3	Pearlmillet Clusterbean Pulses	Mustard, Gram	Sandy loam, sallow depth red soils in depressions
IIB	Transitional plain of Luni basin	3	Jalore, Pali, Part of Sirohi, Jodhpur	300-500	38	4.9	Pearlmillet Clusterbean sesame	Wheat, Mustard	Red desert soils in Jodhopur, Jalore & Pali sierzems in Pali & Sirohi
IIIA	Semi arid eastern plains	2.96	Jaipur, Ajmer, Dausa, Tonk	500-700	40.6	8.3	Pearlmillet Clusterbean	Wheat, Mustard,	Sierozens, eastern part alluvial,

							Sorghum	Gram	west north west lithosols, foot hills, brown soils
IIIB	Flood prone eastern plain	2.77	Alwar, Dholpur, Bharatpur, Karoli, S.Madhopur	500-700	40	8.2	Pearlmillet Clusterbean Groundnut	Wheat, Barley, Mustard, Gram	Alluvial prone to water logging, nature of recently alluvial calcareous has been observed
IVA	Sub-humid southern plains	3.36	Bhilwara, Sirohi, Udaipur, Chittorgarh	500-900	38.6	8.1	Maize, Pulses, Sorghum	Wheat, Gram	Soil are lithosolsat foot hills & alluvials in plains
IVB	Humid sothern plains	1.72	Dungarpur, Udaipur, Banswara, Chittorgarh	500-1100	39	7.2	Maize, Paddy Sorghum Blackgram	Wheat, Gram	Predominantly reddish medium texture, well drained calcareous, shallow on hills, deep soils in valleys
V	Humid south eastern plain	2.7	Kota, Jhalawar, Bundi, Baran	650-1000	42.6	10.6	Sorghum Soyabean	Wheat, Mustard	Black of alluvial origin, clay loam, groundwater salinity

Source : www.krishi.rajasthan.gov.in

Appendix I:

Reviewer Comments on the Draft Report

"Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan"

1.	Title of report	**"Working of Pressurized Irrigation Network Systems (PINS) in Rajasthan"**
2.	Date of receipt of the Draft report	March 24, 2017
3.	Date of dispatch of the comments	March 30th, 2017
4.	Comments on the Objectives of the study	Objectives of the study have been satisfied.
5.	Comments on the methodology	Proper sampling and methodology have been used.
6.	Comments on analysis, organization, presentation etc.	Detailed analysis has been undertaken. However, in Table 4.22 (p70) it is observed that for several crops such as rabi cereals, other spices, the yield is higher for Non-Beneficiaries. Therefore some more explanation may be given as to why PINS (BF) could not achieve the same.
7.	References:	Major references covered
8.	General remarks:	The study is a detailed analysis on working of PINS in Rajasthan. Minor editing may be done. For eg. May be chak and not chalk area (p 75).

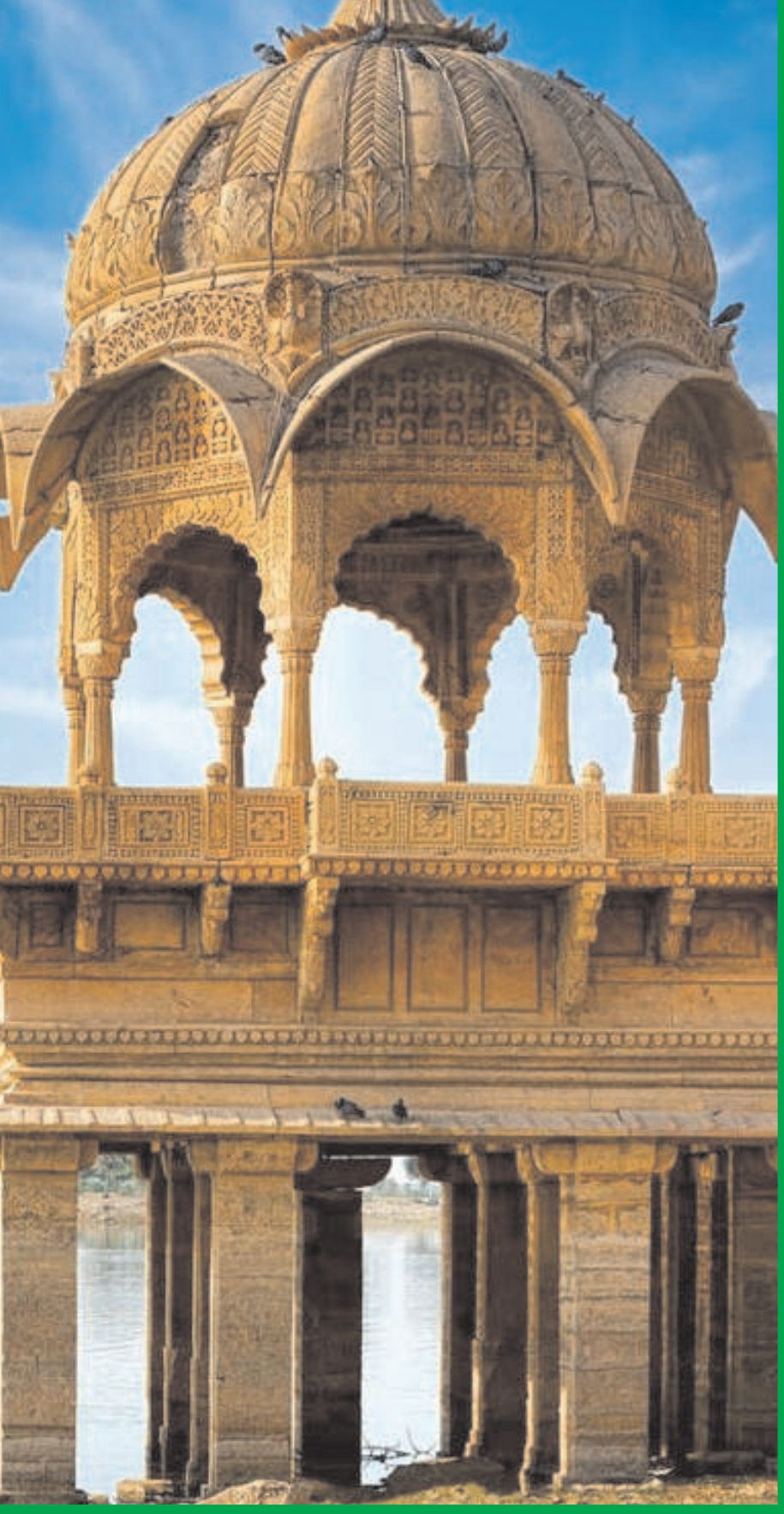
9. Overall view on acceptability of report: The report is acceptable and with minor corrections as suggested, if necessary, it may be treated as final.

*****

Appendix II:

Action Taken on Comments

All comments have been considered carefully and necessary changes/additions/modifications have been made at appropriate places in the report.



Agro-Economic Research Centre

For the States of Gujarat and Rajasthan

(Ministry of Agriculture & Farmers Welfare, Govt. of India)

H.M. Patel Institute of Rural Development

Opp. Nanadalaya Temple, Post Box No. 24

Sardar Patel University

Vallabh Vidyanagar 388120, Dist. Anand, Gujarat

Ph. No. +91-2692-230106, 230799; Fax- +91-2692-233106

Email: director.aerc@gmail.com; directoraercgujarat@gmail.com

Websites: www.aercspu.ac.in; www.spuvvn.edu

Lajja :- (02692) 233864