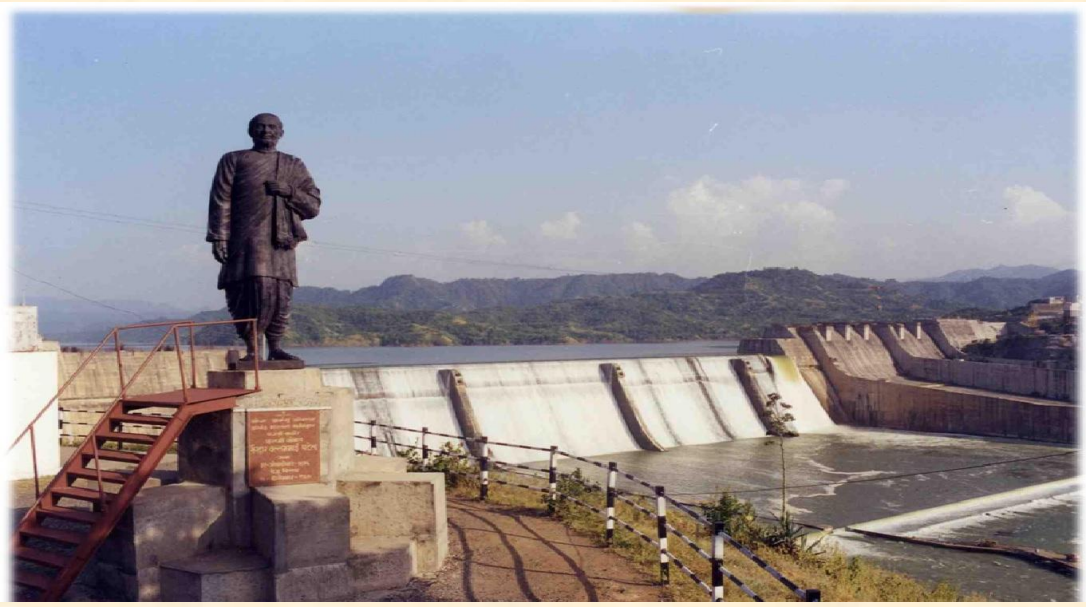
AERC REPORT 166

Working of Pressurized Irrigation Network Systems (PINS) in Gujarat

Mrutyunjay Swain
S. S. Kalamkar
Kalpana Kapadia

March 2017



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

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Report submitted to the

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

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March 2017

AERC Report No. 166

Prepared by

Dr. Mrutyunjay Swain, *Sr. Research Officer/Assistant Professor (SS)*
Dr. S.S. Kalamkar, *Director and Professor*
Ms. Kalpana Kapadia, Research Associate

Research Team

Shri T. B. Parihar, Research Associate
Shri N. G. Chauhan, Research Fellow
Ms. Rinku Rathod, Research Fellow
Ms. Jigisha Devani, Research Assistant
Ms. Priyanka Patel, Research Assistant
Mr. Jaswant N Sigh, Computer

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 Report submitted- March 2017

Citation: Swain, M; S.S. Kalamkar and Kalpana Kapadia (2017), "Working of Pressurized Irrigation Network Systems (PINS) in Gujarat" AERC Report No. 166, Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanagar, Anand, Gujarat.

Foreword

Gujarat is endowed with diverse agro-climatic resources. The water resources of the state are enriched with many rivers some of which are perennial while many are seasonal. The perennial large rivers like Narmada, Tapi, Mahi and small ones like Daman Ganga etc., are flowing in the South and middle Gujarat. On the other hand in North Gujarat, the rivers are not only very few but also seasonal in flow. Sabarmati, Banas, Rupen and Saraswati are the important ones. The total surface water potential of the state is 38.5 thousands MCM of which 32.3 thousands MCM is contributed by South and Central part of Gujarat. The contribution from North Gujarat is only of the order of 2 thousand MCM. As against this, the ground water potential is only 16 thousands MCM. The water requirement from agriculture which was 93 during 2000, will be going down steadily and it will contribute to 80 per cent of the total water requirement by 2025. This reduction is mainly due to the more percentage demand by other sectors and not due to reduction in the quantity of water required in this sector. In fact by 2025 the state needs 16 thousand MCM more of water for agriculture.

The erratic and insufficient rainfall, depleting ground water resources especially in North Gujarat and Kutch, water logging and secondary salinization development in South and middle Gujarat coupled with poor irrigation efficiency envisages the need of a better water use efficient method of irrigation in the state. Pressurised Irrigation Network Systems (PINS) along with Micro Irrigation (MI) is one of the answers to mitigate the above said problems. With this background, the Ministry of Agriculture and Farmers Welfare, Govt. of India had entrusted us a study on '*Working of Pressurized Irrigation Network Systems (PINS) in Gujarat*' 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 undertaken by our Centre covering four major states such as Gujarat, Rajasthan, Maharashtra and Telengana.

The study is based on both primary and secondary level data. The study results show that PINS programme was initially lunched in canal command of Narmada Canal in the State and then adopted in tubewell command areas in some districts. Though the canal PINS in the state have not performed well due to various reasons, the tubewell PINS are found to benefit the farmers in many ways. However, canal PINS can be more useful if they can be placed at far off places from canal and more stringent water governance rules are need to be enforced to check the illegal water theft by some farmers. On the basis of the findings, relevant policy suggestions have been made.

I am thankful to authors and the 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 policies and governance issues related to irrigation water management in the State.

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 Gujarat**"* 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 **Mr. S. S. Rathore**, Chairman and Managing Director, SSNNL, Government of Gujarat, Gandhinagar; **Dr. M. B. Joshi, GM (Technical and Coordination)** SSNNL, Government of Gujarat, Gandhinagar and Mr. P.K. Dave, GM (PIM), SSNNL, Government of Gujarat, Gandhinagar for providing the necessary data and support in data collection. We also thank Mr. **A.V. Ganapatye,** Former Executive Engineer, SSNNL for providing technical guidance on canal PINS in Gujarat. We would like to record our sincere thanks to all other officials of GoG as well as Gujarat Water Resources Development Corporations (GWRDC) 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.

Lastly but not least, we thank the all other AERC staff for their direct and indirect support.

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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

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List of Abbreviations

ACZ	Agro-Climatic Zones
ASMO	Area Sown More Than Once
AIMO	Area Irrigated More Than Once
Av.	Average
BCM	Billion Cubic Meter
Bgl	Below Ground Level
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
GGRC	Gujarat Green Revolution Company
GWRDC	Gujarat Water Resources Development Corporation
ha	Hectare
HHs	Households
HP	Hours Power
kg	Kilograms
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
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
SSY	Sujalam Suphalam Yojana
Sq. Km.	Square Kilometre
TUA	Tubewell Users Association
TRA	Total Reporting Area
UGPL	Underground Pipeline System
VSA	Village Service Area
WUA	Water User Associations

Executive Summary

Background

Water scarcity for agriculture has been growing year after year due to various reasons, for which the Government has 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 new concept which was initiated in the state of Gujarat during the period of developing the command area of Sardar Sarovar Narmada Project. 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. 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 Gujarat;

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.

Summary of Findings

- For the study, the data was collected from three selected districts, viz., Mehesana, Patan and Gandhinagar. PINS were selected from both surface irrigation command areas (mainly canal) and groundwater irrigation command areas (mainly tube well). The beneficiary households (households having access to irrigation water in Government PINS Command area) were selected. A total of 200 beneficiary and 100 non-beneficiary households were covered for the detailed study.

- **Overview of PINS Programme in Gujarat:** Gujarat State has been one of the front runners among states in India in promoting PINS. In fact, the concept of Pressurized Irrigation Network System (PINS) was developed at Design Office

of Sardar Sarovar Narmada Nigam Limited (SSNNL) with the necessity of introduction of MIS in the command area of SSP. The Government of Gujarat has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. With the pilot project on Pressurized Irrigation Network System (PINS), about 25 pilot projects were initiated in the state covering 1029 farmers with 1491.6 ha of CCA and estimated budget of Rs 1306.3 lakh.

- It is worth mentioning that both water savings and energy savings are estimated to be higher in case of tube well PINS with drip compared to tubewell with flood irrigation or surface with flood irrigation. Water savings by use of MIS with PINS is realised to the tune of 50 to 75%, whereas the energy savings by the same is realised to the tune of 25 to 76 per cent.

- **Bottlenecks in Adoptability and Promotion of Canal PINS:** Though the Government of Gujarat followed a proactive approach to increase the adoption of PINS by the water users, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to various reasons. The farmers did not want to change the cropping pattern which was highly water intensive. They did not want to spend anything on MIS since canal water was available to them almost free of cost. There were no much strict rules and regulations enforced to check the illegal use of canal water/water theft. Unavailability of necessary power network, insufficient power availability in agri-mains and higher costs estimates provided by the MIS suppliers were some of the reasons.

- **Under Ground Pipe Line (UGPL) System in Gujarat:** Looking at the unsatisfactory experience of Canal PINS in the state, an attempt was made by the Irrigation Department in devising a suitable solution to address various issues. The combination of UGPLs and PINS replacing Minors, Sub-Minors and FCs has also been put in some places in the state. So far, the UGPL work has been completed in 2.58 lakh ha of 5441 Chaks in 61 talukas of the state. Additionally, the UGPL work is in progress in about 3.06 lakh ha covering a total length of pipelines of 88.84 lakh metres in 7164 Chaks which is a record in the history of Irrigation Infrastructure Development in India.

- The major benefits of UGPL system are the land saving and water saving (up to 10-20 %), less implementation period, feasibility even in flood zone / undulating area, avoidance of land fragmentation, integrating field channels with the sub-minors and less O & M expenditure. Moreover, there are some issues in implementation of UGPL in sub-minors. Farmers were not willing to pay 10%, their contribution, which was later on reduced to 2.5%.

- **Progress and Expenditure Pattern on Tube well PINS:** Among three types of water sources, tube well is the major source of water for successful PINS operation in the Gujarat state. The Government of Gujarat introduced the policy of pressurized irrigation system in the command area of public tube wells under Gujarat Water Resources Development Corporation (GWRDC). As per the Government norms, Micro Irrigation System (MIS) provided in the command area of 309 tube wells covering 1452 ha in five districts of the state i.e. Banaskantha, Mehsana, Patan, Gandhinagar and Sabarkantha. The State Government has decided in March 2013 to provide MIS in Government tube wells at 100% Government cost in total nine districts.

- Under each Tubewell PINS, on an average, 09 farmers were covered beneficiaries were covered under each Tube well Water Users Association (TUA) with average area of 11 ha per TUA. The Tubewell PINS have been well adopted in Gujarat and has a wide coverage. As revealed from focussed group discussion with the farmers, the higher maintenance cost and energy cost has discouraged the farmers in increasing its further adoption.

- **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 Gujarat state. About 95.3 per cent of sample beneficiary farmers adopted drip whereas the 10 per cent of them adopted sprinkler in the state. Since the sprinkler system is less water saving MIS compared to drip system, the same has not been very popular in the state.

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

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

- The proportion of area under more remunerative Rabi crops was also found to be higher (53.7% of GCA) in case of beneficiary farmers as compared to non-beneficiary farmers. It was observed that, except few crops like rapeseed-mustard and fennel, beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers. The percentage change in yield under drip over flood and change in yield under sprinkler over flood has been spectacular with respect to some crops like castor (117.6% and 102.1%, respectively) and cotton (83.1%). Among Rabi crops, major benefits were observed in the case of wheat (by 83.3% and 108.4%, respectively), fennel (55.1%), rapeseed-mustard (59.9%), and tobacco (by 84.6%).

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

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

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

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

- **Adoption, Performance and Management of PINS by WUAs:** Among three types of WUAs, the average life span UGPL system is highest of about 50 years followed by Pvt tube well (TW) PINS of 20 years and Govt TW PINS of about 19 years. Though there was 25 canal PINS implemented in Gujarat state, none of them were found functional. The average area covered under each PINS WUA was 19.2 ha per Pvt TW PINS, 22.2 ha under Govt. TW PINS and 34.6 ha per UGPL.

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

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

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

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

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

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 present study has examined some aspects of working of PINS at different levels. During the survey, the sample farmers have also given some useful feedbacks which have been discussed earlier. Besides, some additional suggestions those came out of the study are discussed below.

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

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

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

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

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

Chapter I

Introduction

1.1 Background:

Water, being a necessity for crop production, is one of the most important natural resources for sustaining human life on earth. However, owing to the 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 & 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 using pressurized irrigation system for improving water use efficiency.

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. Navalwala (1991) found that about 71% of the irrigation water is lost in the whole process of its conveyance from head works and application in the field. The breakup of the losses is as main and branch canal (15%), distributaries (7%), water courses (22%) and field losses of 27 per cent. The situation is particularly

bad in minor irrigation systems of plateau areas of eastern India, where the overall irrigation efficiency varies between 20 per cent and 35 per cent. These systems are located in coarse soil area and have rolling topography. Due to this, the conveyance losses are high and the system suffers from inadequate supply and poor water availability especially during lean season. Therefore the need of the hour is to increase irrigation efficiency of existing projects and use saved water for irrigating new areas or reducing the gap between potential and actual irrigated areas. Shifting to pressurized irrigation can be an option for increasing this irrigation coverage and efficiency.

Much of the water scarcity in India is due to spatial variation in demand and supply of water and inefficient use of water. Irrigation is the largest water consuming sector, accounting for more than 80 per cent of the total withdrawals. Yet, irrigation so far has covered only about 40 per cent of the gross cropped area, even though India has the largest irrigated area in the world. Given the increasing scarcity and also non-agricultural water demand, demand management is receiving special attention. In India, although a number of demand management strategies in the irrigation sector have been introduced with a view to increasing the water use efficiency (Vaidyanathan 1998; Dhawan 2002), the net impact of these strategies in increasing the water use efficiency so far has not been very impressive. One of the demand management strategies introduced relatively recently to manage water consumption in Indian agriculture is micro-irrigation systems (MIS). Unlike flood method of irrigation (FMI), micro-irrigation supplies water at the required interval and in desired quantity at the location where water is demanded using a pipe network, emitters and nozzles. Therefore, MI in principle results in low conveyance and distribution losses and leads to higher water use efficiency.

1.2. Importance and Concept of Pressurized Irrigation Network Systems (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

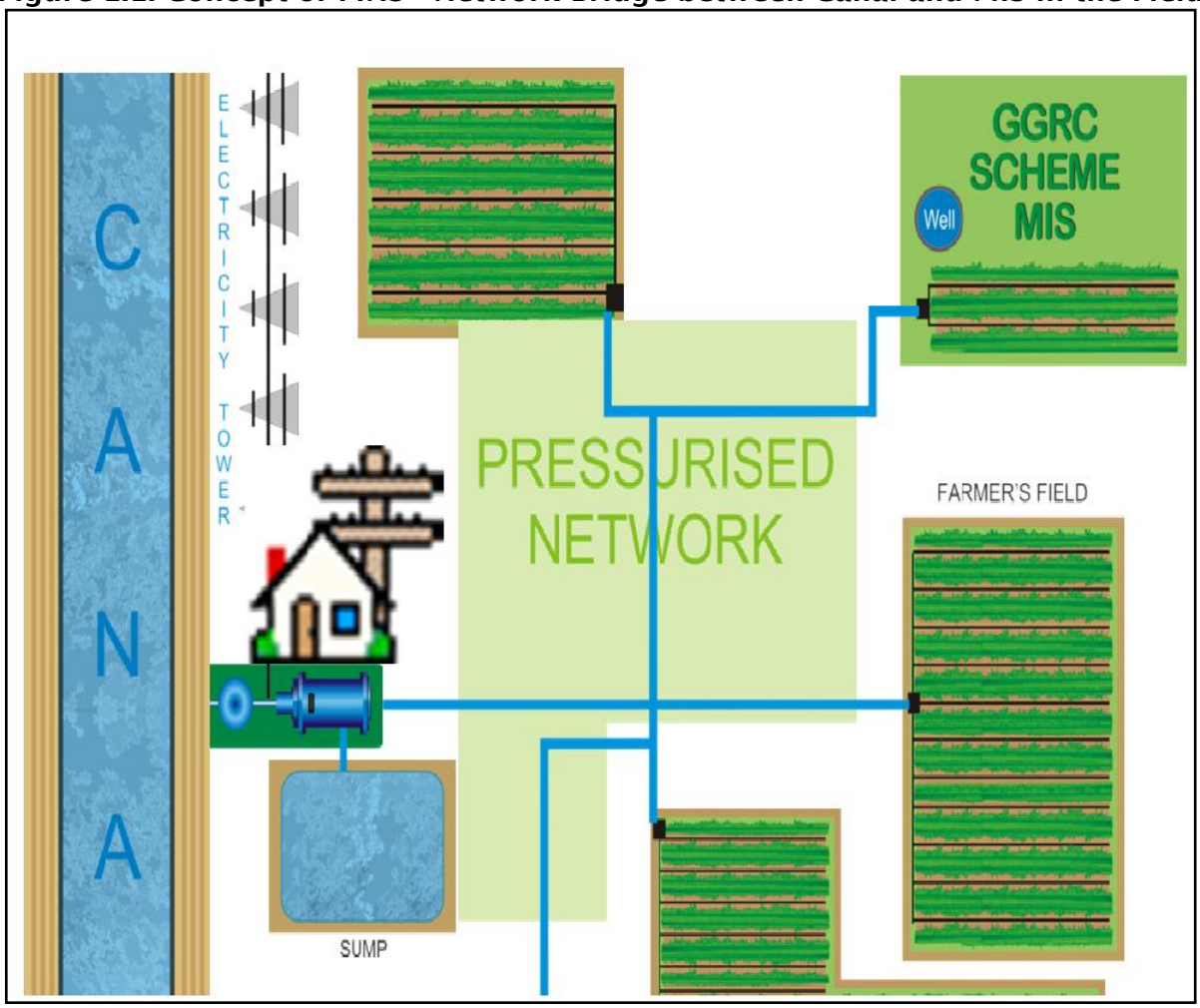


Figure 1.2. Components of PINS in Gujarat

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 (5 to 8 Ha)	Low	About 50 connections

Source: Ganpatye (2011)

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

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

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

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

1.4 Review of Literature

India is an agriculture economy where land and water are two key natural resources upon which farmers depend for their livelihoods and development. Farmers' development depends upon interactions of these and other resources, institutions, actions and policies and their ultimate outcomes. It would be naive to perceive that all rural poverty problems could be solved through improving the poor's access to water alone through development of irrigated area in rainfed conditions. However, though water is only a single element in the poverty equation, it plays a disproportionately powerful role through its wider impacts on such factors as food and other essential agricultural production. 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. 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. Investment in micro irrigation also appears to be economically viable, even without availing State subsidy. Despite this, the total potential of micro irrigation in India is estimated at around 69 Mha. However, currently the coverage of micro irrigation is only 7.7 Mha (2015). With the current target of achieving 0.5 mn hectare/ annum coverage, it would take a very long time to realise the potential estimates of micro irrigation in India.

Micro irrigation has seen a steady growth over the years. Since 2005, area covered under micro irrigation systems has grown at a CAGR of 9.6 percent. Geographically, states with the largest area under micro-irrigation include: Rajasthan (1.68 mh), Maharashtra (1.27 mh), Andhra Pradesh (1.16 mh), Karnataka (0.85 mh), Gujarat (0.83 mh) and Haryana (0.57 mh). Majority of the area covered under micro irrigation systems comes under sprinkler irrigation with 56.4 percent, while 43.6 percent comes under drip irrigation. Area under drip irrigation has shown stronger growth in recent years, growing at a CAGR of 9.85 percent in the 2012-2015 periods while sprinkler irrigation has grown at a pace of 6.60 percent in the same time period. Overall, the area under micro-irrigation has grown at a CAGR of 7.97 percent in this time frame. A centrally sponsored scheme on Micro irrigation was launched in Jan 2006 to increase the area under improved methods of irrigation for better water use efficiency to provide stimulus agricultural growth. The term micro irrigation describes a family of irrigation systems that deliver water through small devices on the soil surface very near the plant or below the soil surface directly into the plant root zone. Micro-irrigation technologies commonly use of water in scarce areas, constitute

one such intervention with the ability to use water more efficiently in irrigated agriculture. These technologies can improve productivity; raise incomes through crop yields and outputs; and enhance food security of households. India has the largest irrigated area in the World, the coverage of irrigation is only about 40 percent of the gross cropped area. One of the main reasons for the low coverage of irrigation is the predominant use of flood (conventional) method of irrigation, where water use efficiency is very low due to various reasons. Available estimates indicate that water use efficiency under flood method of irrigation is only about 35 to 40 percent because of huge conveyance and distribution losses Rosegrant (1997).

Dhawan and Datta (1992) reported that irrigation enables the poor and smallholders to achieve higher yields. The productivity of crops grown under irrigated conditions is often substantially higher than that of the same crops under unirrigated/rainfed conditions. Higher productivity helps to increase returns to farmers' endowments of land and labor 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.

Vaidyanathan et al (1994) reported that studies carried out across different countries including India have confirmed that irrigation plays a paramount role in increasing the use of yield increasing inputs and enhancing cropping intensity as well as productivity of crops.

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.

Kundu et al (1998) reported that India has enormous potential for both Drip Irrigation Management (DIM) and for Sprinkler Irrigation Management (SIM).

Study indicated that DIM is considered to be highly suitable for wide spaced and high value commercial crops, it is also being used for cultivating oilseeds, pulses, cotton and even for wheat crop. Closely grown crops such as millets, pulses, wheat, sugarcane, groundnut, cotton, vegetables, fruits, flowers, spices and condiments have been found to be suitable to cultivate under sprinkler irrigation. Importantly, an experimental study suggests that sprinkler irrigation can also be used successfully even for cultivating paddy crop.

Shah et al (2000) reported that the distribution of irrigation benefits tends to be more or less equal in every size of land holding. Study showed that micro-irrigation technologies such as sprinkler, drip irrigation and trickle irrigation, self-target the poor, and empower them by enabling them to raise their incomes permanently. With modest investments of as little as 15-25 per cent per household, landless households can produce fruits and vegetables for family consumption or sale.

Postal (2001) 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 percent for different crops.

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 ha-1 . 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 B:C 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 MDIS can easily be recovered.

Kulkarni (2005) reported that though both drip and sprinkler irrigation method of irrigation are treated as micro irrigation, there are distinct characteristics differences between the two in terms of flow rate, pressure requirement, wetted area and mobility. While drip method supplies water directly to the root zone of the crop through a network of pipes with the help of emitters, sprinkler irrigation method sprinkles water similar to rainfall into the air through nozzles which subsequently break into small water drops and fall on the field surface. Unlike flood irrigation method, drip irrigation method supplies water directly to the root zone of the crop, instead of land, and therefore, the water losses occurring through evaporation and distribution are completely absent.

Singh and Pachauri (2005) concluded that adoption of drip irrigation is the best suited in the water scarcity area and where labour is expensive and the crop value is high. Agriculture growth and development become sustainable only if a judicious use of limited water and soil resources is made with the help of modern science and technology in M.P.

Jiterwal (2008) reported that drip irrigation system is one of the important device in the area where scarcity of water for irrigation. Study also 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) reported that drip irrigation is not widely used for vegetable production, although it has the potential to improve irrigation performance. From this review, it can be concluded that sub-surface drip irrigation (SDI) might improve water use efficiency, and reduce environmental impact more than surface drip. There would be large benefit for vegetable producers in the Sydney region. It may also overcome two important objections to drip irrigation, the high ongoing cost and the disruption to normal cultural practices.

Siag et al (2009) a study was conducted during 2003-06 to optimally utilize the drip irrigation system already available with the orchardists of southwest Punjab where in, adaptive research trails at farmers' fields using drip irrigation of cotton (Gossypium hirstum L.) with paired row planting were laid in Abohar (Ferozepur district) to seethe performance of crop and compare with the farmer's practice of applying irrigation through flooding. 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) with water savings of 30%, besides early maturity, labor savings and risk coverage under risk coverage under heavy downpour than the flooding method. The economic analysis showed that the method of using drip irrigation in cotton was technically feasible and economically viable in canal command area with a benefit cost ratio of (2.03:1) as compared to flooding (1.88:1).

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. He also found the benefit-cost ratio of the system was 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.

Sen (2012) reported that 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. A centrally sponsored scheme on Micro irrigation was launched in Jan 2006 to increase the area under improved methods of irrigation for better water use efficiency to provide stimulus to agricultural growth. As per the requirement of irrigation water and suitability of stored water quality for the crop in the area, micro-irrigation system is required.

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 that under 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 present study attempts to examine various aspects of PINS performance in Gujarat.

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 Gujarat;

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.

1.6 Coverage, Data and Methodology

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

For Gujarat state, the data were collected from three selected districts, viz., Mehesana, Patan and Gandhinagar. PINS were selected from both surface irrigation command areas (mainly canal) and groundwater irrigation command areas (mainly tube well). 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 Projects and households having installed PINS with some private contribution (Pvt 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.

The study was intended to focus mainly on performance of canal PINS in the state. Since all the canal PINS were found dysfunctional, the focus of the study shifted to Tube well PINS, Pvt PINS and other alternative programmes such as Underground Pipeline (UGPL) Programme, which the Government of Gujarat has initiated due to failure of canal PINS. As per the stated distribution, 200 beneficiary and 100 non-beneficiary households were covered in the state (Table 1.3). Out of 200 beneficiary households (hhs), 150 households were having access to Government PINS with MIS. Remaining 50 were drawn from Private PINS with MIS and Underground Pipeline (UGPL) Programme. Out of 100 non-beneficiary hhs, about 10 samples were drawn from peripheral regions of defunct Govt-PINS failing to provide any irrigation facility.

The distribution of PINS Projects covered from which the desired number of sample farmers were drawn is stated in Table 1.4. In total, 27 PINS projects were covered under the study in Gujarat. Out of 27 selected PINS projects, 25 PINS

projects were having associated water user associations (WUA), while other two were defunct PINS project with providing any irrigation water and without having any WUA. There were also three private PINS projects covered under the survey. The Private PINS was defined as the PINS established with some private investment. For example, if WUA contributed some part of PINS expenditure, it was covered under private PINS. Where the private PINS installed with cent per cent private investment, they were given priority under this category.

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

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

Notes: BH: Beneficiary households, NBH: Non-beneficiary households.
Source: Field survey

Table 1.4: Distribution of Sample PINS Projects across study districts

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

Source: Field survey

The care was taken to select PINS Projects from various types of command areas such as Canal, Tube Wells and Tanks, so as to assess the institutional

dynamics in operation and maintenance of the irrigation systems. Non-beneficiary households were selected from the irrigation command area around the PINS project. The care was also taken to include both good performing PINS and unsatisfactory performing PINS, so as to differentiate the different kinds of management culture practiced in different PINS-WUAs.

The pre-decided PINS sample size distribution was slightly modified as per local condition and availability. The major type of MIS was drip 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. Additionally, the survey schedule meant for beneficiary households was administered for private PINS and the survey schedule meant for non-beneficiary households were administered for defunct Govt PINS not able to provide irrigation water to intended beneficiaries.

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 statistical tools were used for data analysis and interpretation of results. The performance of PINS-MIS would be 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 Gujarat 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. Since these structures on canal command have not been adopted by the intended farmers, the study on main issues around Canal PINS could not be done properly, though the same has been done nicely for tubewell PINS in the state.

Some aspects of the study such as costs and benefits of PINS before and after installation of PINS were based on the recall method. Where the installations were carried out a long 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 Gujarat 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 Gujarat with a discussion on district wise and irrigation source-wise 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)/Tubewell Users Association (TUA), functioning and activities of WUA or TUA, details of income and expenditure of WUA, relationship of WUA with related Organisations, water resource management by WUA/TUA, 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 Gujarat

2.1. Introduction:

The state of Gujarat is situated on the western side of India covering an area of 196,024 sq. km. It accounts for about six percent of the total geographical area of India and five percent of the population and accounts for about 2.6 per cent of the total fresh water resources in the country. Almost one third of the coastline of the Indian sub-continent belongs to Gujarat. Gujarat has a pride place in the Indian economy. It is one of those states of India where economy has always performed better than the national average. The economic performance of the state may be considered as even more remarkable in view of the fact that the state has limited natural resources. It has limited mineral base and its water resources are scarce with most of the rivers flowing through the state having reasonable water during rainy season only. The state can be broadly divided into South, North, Saurashtra and Kachchh regions. Vast areas of the state, mainly in the central and northern Gujarat, are plain lowlands. The salient features of these regions in terms of hydrology, groundwater occurrence, agricultural practices and socio-economy are presented in Table 2.1. Water resources in Gujarat are concentrated primarily in the southern and central part of the mainland. Saurashtra and Kutch region in the northern mainland with exceptionally high irrigation needs, have limited surface and groundwater resources. A significant percentage of the water in the state (both surface and groundwater) is consumed by the agricultural sector for irrigation purposes.

The major rivers flowing in Gujarat are Narmada, Sabarmati, Tapi, Purna, Damanganga, Rukmavati etc. The Government of Gujarat has been giving due attention to accelerate the pace of water resources development in the state so as to increase the net water availability by creating additional storage, completion of ongoing projects, improvement in water use efficiency, bridging

the gap between the potential created and its utilization, restoration and modernization of old irrigation system, conjunctive use of ground and surface water, promoting participatory irrigation management, large scale people's participation in water conservation programmes and inter-basin transfer of water (GoG, 2013).

Table2. 1: Salient Features of the Four Regions of Gujarat

Regions	Districts	Features
North Gujarat	Ahmedabad, Gandhinagar, Patan, Mehsana, Dahod, Banaskantha, Panchmahals and Sabarkantha.	Arid to semi-arid climate; groundwater is the main source of irrigation; deep, alluvial aquifer system that is over-exploited; enterprising farmers; highly developed dairying and dairy co-operatives.
South Gujarat	Anand, Kheda, Vadodara, Bharuch, Surat, Narmada, Navsari, Valsad and Dangs.	Humid and water-abundant part of Gujarat; large areas under canal irrigation systems such as Mahi, Ukai-Kakarapar, Karjan, Damanganga and Sardar Sarovar; conjunctive use of groundwater and canal surface water though farmer initiative; enterprising farmers; strong Dairy cooperatives.
Saurashtra	Amreli, Bhavnagar, Junagadh, Jamnagar, Porbandar, Rajkot and Surendranagar.	Arid to semi-arid climate; groundwater the main source of irrigation; hard rock aquifers have poor storativity; open dug wells are the main source of irrigation; Agriculture dependent mostly on monsoon; early withdrawal of monsoon is a curse for kharif crop.
Kachchh	Kachchh	Arid to semi-arid climate; groundwater the main source of irrigation; limited area with tube wells in productive aquifers having poor strorativity with open dug wells are the main source of irrigation; agriculture dependent mostly on monsoon; early withdrawal of monsoon the curse of kharif crop.

Source: Jain (2012).

The main source of water for Gujarat is surface water. The State has 185 river basins and the available quota of water in the State is 55608 million cubic meters, out of which, 38100 million cubic meters is surface water, which is only 2 per cent of the entire quota of surface water of the country (Table 2.2). Average per capita water availability of about 980 m^3 per year puts the state in the 'water scarce' category. Intra-state variation in per capita water availability (1570 m3 in south and central Gujarat to 414 m3 in north Gujarat) is also eye-catching (GOG, 2011). Moreover, the available quota of surface water is also not distributed properly. Gujarat, Saurashtra and Kutch have water resources of 80 per cent, 17 per cent and 3 per cent respectively. Against this, the total geographical area of these regions is 45 per cent, 33 per cent and 22 per cent respectively. The underground water resources of State are 17508 million cubic meters. The quota of available surface and underground water is used for drinking purpose,

industries, agriculture and hydral power, fisheries etc. Out of which, nearly 80 per cent quota is used for agricultural production, in which irrigation also plays an important role. The state has very limited ground water resources for irrigation purposes. Open wells and tube wells forming the main sources of irrigation in the state serve primarily as sources of protective irrigation. As per latest available information, storage capacity of the State is of about 18.359 BCM, which accounts for the share of 7.25 percent in all India storage capacity (www.pib.nic.in).

Table2. 2: Details of Water Resources of Gujarat

Region	Total Water Quota (MCM)	Surface Water (MCM)	Ground Water (MCM)	Storage capacity of existing reservoirs (Except Sardar Sarovar) (MCM)	per cent of Water Resources	per cent of area
Central & South Gujarat	38105	31750	6355	10400	69	25
North Gujarat	6342	2100	4242	2100	11	20
Saurashtra	9723	3600	6123	2250	17	33
Kutch	1438	650	788	250	3	22
Total	55608	38100	17508	15000	100	100

Source: http://guj-nwrws.gujarat.gov.in (Accessed on January 24, 2014).

Climate and Rainfall Pattern:

Gujarat is known to be drought prone state with 70 percent of its geographical area classified as semi-arid and arid land types. Gujarat has varying topographic features though a major part of the state was dominated by parched and dry region. Out of 8 agro-climatic zones[1], five are arid to semi-arid in nature, while remaining three are dry sub-humid in nature. Broadly, Gujarat has a tropical climate viz., sub-humid, arid and semi-arid, are spread over different regions of the state. Out of total area of the state, 58.6 per cent fall under arid and semi-arid climatic zone. The arid zone contributes 24.94 per cent, while the semi-arid zone forms 33.66 per cent of the total area of the state. Gujarat has a tropical monsoon climate that ranges from sub humid to semiarid as the annual rainfall decreases northwards and westwards. Daily minimum and maximum temperatures range from 13° C to 27 ° C in January and 27 ° C to 41 ° C in May. Extreme minimum is about 5 ° C and maximum is 46 ° C. The relative humidity is very high during the wet season (June-October) and low in the hot season

[1] The distinctive features of agro-climatic zones of Gujarat state are briefly presented in *Annexure I.*

(March-May). Winds are generally light to moderate with some increase in force during the monsoon (GOG, 2011).

Precipitation, the primary source for Gujarat's water supply varies widely from year to year and area to area. Sometimes floods and water shortage occur in the same year. While the wettest areas are in the South, most of Gujarat's people and farmlands are in the drier Northern and Western parts of the State. The rainfall depends on the local winds which change their directions accordingly to the seasons. The average rainfall for the state during 1982-2011 was 798 mm compared to the all-India average of 1100 mm. About 95 per cent of the total annual rainfall is received during three months (July, August and September). Rainfall in the large parts of Gujarat is not only inadequate but also varies widely from year to year (Fig. 2.1). The average of deviation of annual rainfall from long-term normal is (-) 15.43 per cent during a period of 1969-70 to 2010-11. Every year the amount of rainfall is different in different areas of Gujarat. The analysis on rainfall pattern in Gujarat reveals that the average annual rainfall over different parts of the state varies widely from 300 mm in the Western half of Kutch to 2100 mm in the Southern part of Valsad district and the Dangs. Besides, the number of rainy days in a season varies from one part of the state to another. The range is from minimum of 16 days in Kutch to maximum of 48 days in Surat and the Dangs (GoG, 2012a). Generally, the number increase as one moves towards the eastern and the southern parts of the State (Table 2.3). Rainfall is the most significant source of ground water recharge and hence changes in the rainfall pattern leaves distinct imprint on the ground water regime of an area.

Table 2.3: Pattern of rainfall in Gujarat

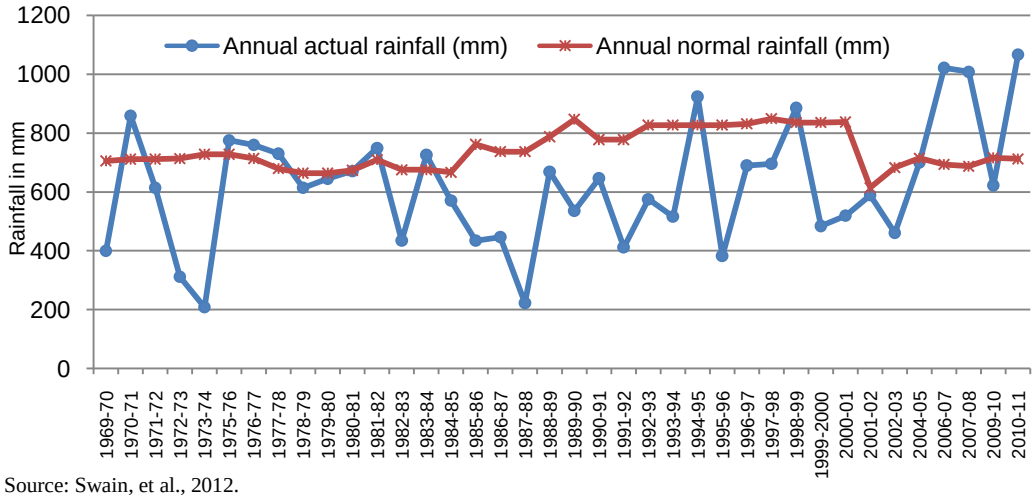
Sr. No.	Region	Average Annual rainfall	Rainy days
1	South Gujarat	> 1100 mm	120
2	Central Gujarat	800 – 1000 mm	30 – 70
3	Saurashtra	400 – 800 mm	20 – 30
4	Kutchh	< 400 mm	10 – 20

Source: http://guj-nwrws.gujarat.gov.in/downloads/water_related_issues.pdf

About two-third of the area of the state is under arid and semi-arid tropics, where the risk and instability in agricultural production and productivity usually remain quite high. As such majority of the area of the State is rain-fed and there is acute shortage of irrigation water in this area. There are very few

perennial rivers in the State (out of a total of 185 rivers) and limited facility of surface irrigation. Perennial rivers are located in 20 per cent area of the State, which accounts for 80 per cent of surface water of the State. This leads to drought every third year. The drought is such a menace that not only it eats away billions of rupees but along with it, because of lack of surface and ground water resources, millions of cattle and shepherds have to migrate from Saurashtra, Kachchh and North Gujarat to the area of South Gujarat in search of water, food and fodder. Further, in order to mitigate scarcity, the State Government has to undertake scarcity relief works at a huge cost (GOG, 2011).

Figure 2.1: Rainfall Pattern in Gujarat (1969-70 to 2010-11)



Source: Swain, et al., 2012.

2.2 Irrigation Development in Gujarat

Gujarat government has played an important role in developing physical infrastructure for agriculture, namely irrigation, power and roads (Gulati et al., 2009). The state has about 104 lakh ha under cultivation of which about 65 lakh ha is estimated to have irrigation potential through surface and groundwater sources (Parthasarthy, 2010). This indicates that through proper water resource development planning about 63 percent of the net cultivated area could be brought under irrigation. The ultimate irrigation potential through the surface water is assessed at 39.40 lakh hectares which includes 17.92 lakh hectares through Sardar Sarovar Project (Table 2.4). Similarly in respect of ground water resources, it is estimated that about 25.48 lakh hectares (about 25 per cent of

net cultivated area) can be irrigated. Thus, total ultimate irrigation potential through surface and ground water is estimated to be 64.88 lakh hectares. Up to June 2012, the state has created about 33.33 lakh ha of irrigation potential while about 74.98 per cent of total irrigation potential created has been utilized (GOG, 2013). It was observed that the irrigation potential created and utilization through surface water in the state has increased significantly during the recent past. The irrigation potential created has increased from 21.91 lakh hectares in 2007-08 to 32.46 lakh hectares in 2011-12. Similarly, the utilization of irrigation potential created has increased from 16.99 lakh hectares in 2007-08 to 23.79 lakh hectares in 2011-12 (up to June 2012). On the other hand, the irrigation potential created through ground water has declined sharply from 20.35 lakh hectares in 2007-08 to 0.87 lakh hectares in 2011-12 resulting in overutilization by 137.9 per cent (Swain, et al., 2012).

Table 2.4: Irrigation Potential and its Utilization in Gujarat (2012-13)

(In Lakh ha)

Sr. No.	Particulars	Ultimate Irrigation Potential (lakh ha)	Irrigation Potential created up to June 2012 (cum)	Maximum Utilization up to June 2012 (cum)
1	Surface Water	39.40	32.46	23.79
	1.1 Major and Medium Irrigation Schemes including indirect benefits of Sujalam Suphalam Spreading Canal, bandharas of Kutch. Big check dam of Surendranagar district.	18.00	16.48	12.96
	1.2. Sardar Sarovar Project	17.92	5.59	1.93
	1.3 Minor Irrigation Scheme		2.79	1.63
	1.4 Indirect Benefits through Minor irrigation works such as percolation tanks, safe stage, etc.	3.48	1.57	1.24
	1.5 Indirect Benefits through check dams			
2	Groundwater (Govt. and Private)	25.48	0.87	1.20
	2.1 Groundwater Tube Wells		0.87	1.20
3	Grand Total (1+2)	64.88	33.33	24.99

Source: GOG (2013), p.13.

The major, medium and minor irrigation schemes are implemented in the State. Before independence, irrigation was possible through only two large-scale irrigation projects viz. Hathmati Project and Kharicut Project. After independence, construction was undertaken for irrigation projects such as Shetrunji, Dantiwada, Kakrapar Weir, Ukai, Kadana, Dharoi, Vanakbori Weir etc. and at the end of 2012-13, 19 major and 70 medium irrigation projects have been completed.

Moreover, more than 1000 minor irrigation projects have also been completed. The changes in irrigation potential and utilisation in Gujarat state through major, medium and minor irrigation project during the period from 1992-93 to 2011-12 is presented in Table 2.5.

Table 2.5: Growth in Irrigation Potential and Utilisation in Gujarat State: 1992-93 to 2011-12

Sr No	Year	Total of Major and Medium Irrigation		Total of Minor Irrigation including private wells		Total of Major, Medium & Minor Irrigation		per cent Indicate Increase / Decrease (-) over Previous Year Irrigation				Overall	
						Medium, & Minor Irrigation		Major & Medium Irri		Minor Irrigation			
		P	U	P	U	P	U	P	U	P	U	P	U
1	1992-93	12.69	10.48	21.98	18.05	34.67	28.53						
2	1993-94	12.90	11.14	22.02	18.07	34.92	29.21	1.65	6.3	0.18	0.11	0.72	2.38
3	1994-95	13.17	11.49	22.1	18.14	35.27	29.63	2.09	3.14	0.36	0.39	1.00	1.44
4	1995-96	13.32	11.70	22.21	18.29	35.53	29.99	1.14	1.83	0.5	0.83	0.74	1.21
5	1996-97	13.47	11.90	22.35	18.43	35.82	30.33	1.13	1.71	0.63	0.77	0.82	1.13
6	1997-98	13.65	12.11	22.47	18.53	36.12	30.64	1.34	1.76	0.54	0.54	0.84	1.02
7	1998-99	13.76	12.35	22.61	18.65	36.37	31.00	0.81	1.98	0.62	0.65	0.69	1.17
8	1999-00	13.90	12.46	22.73	18.75	36.63	31.21	1.02	0.89	0.53	0.54	0.71	0.68
9	2000-01	13.98	12.75	23.98	20.97	37.96	33.72	0.58	2.33	5.5	11.84	3.63	8.04
10	2001-02	14.04	12.87	24.94	23.92	38.98	36.79	0.43	0.94	4	14.07	2.69	9.1
11	2002-03	14.52	13.18	25.51	24.46	40.03	37.64	3.42	2.41	2.29	2.26	2.69	2.31
12	2003-04	15.97	13.86	26.55	24.99	42.52	38.85	9.99	5.16	4.08	2.17	6.22	3.21
13	2004-05	16.86	14.32	27.06	25.5	43.92	39.82	5.57	3.32	1.92	2.04	3.29	2.5
14	2005-06	17.82	14.85	27.8	26.35	45.63	41.2	5.69	3.7	2.77	3.33	3.87	3.47
15	2006-07	18.54	15.06	26.95	26.56	45.49	41.62	4.04	1.41	-3.06	0.81	-0.28	1.02
16	2007-08	19.58	15.09	27.38	27	46.96	42.09	5.61	0.2	1.6	1.66	3.23	1.13
17	2008-09	20.47	15.12	27.83	27.04	48.3	42.16	4.55	0.2	1.64	0.15	2.85	0.17
18	2009-10	20.92	15.38	29.24	27.81	50.16	43.19	2.2	1.72	5.07	2.85	3.85	2.44
19	2010-11	21.37	15.49	29.34	27.87	50.71	43.36	2.15	0.72	0.34	0.22	1.1	0.39
20	2011-12	22.07	14.9	29.37	27.87	51.44	42.77	3.28	-3.81	0.1	0	1.44	-1.36

Notes: P- Potential and U- Utilisation
Source: GOG (2013a).

2.4 Source wise Irrigation in the State

Out of total reporting area of 18.8 million hectares, about 53 percent area was net sown during 2007-08. Very surprisingly, the share of net sown area in

total reporting area has increased during last two decades. Out of about 9.97 mha of net sown area, about 4.23 mha area was net irrigated (Table 2.6). Thus, about 42.5 per cent of net cropped area in the state was under irrigation. It can be also observed from the table that percentage of ASMO to NSA has increased by 10.3 percent points during 1980-81 and 2007-08, whereas percentage of AIMO to NIA has increased by 16 percent points during the corresponding period. This indicates that more land was put under irrigation during recent past, may be due to availability of irrigation. Therefore irrigation intensity in the state was higher than cropping intensity.

Table 2.6: Details on Cropped and Irrigated Area in Gujarat

		Cropped and Irrigated Area in Gujarat (00 ha)					
Sr. No.	Item	1981-81	1990-91	2000-01	2005-06	2006-07	2007-08
1	Total Reporting Area (TRA)	188220	188219	18118	188118	188102	188102
2	Net Sown Area (NSA)	95765	92962	94333	97222	98009	99658
3	% NSA to TRA	50.9	49.4	50.1	51.7	52.1	53.0
4	Area Sown more than Once (ASMO)	11694	13386	10637	17725	20065	22456
5	% ASMO to NSA	12.2	14.4	11.3	18.2	20.5	22.5
6	Gross Cropped Area (GCA)	107459	106348	104970	114947	118074	122114
7	Net Irrigated Area (NIA)	20026	24376	28060	39074	42376	42333
8	%NIA to NSA	20.91	26.22	29.75	40.19	43.24	42.48
9	Area Irrigated more than once (AIMO)	3318	4729	5361	8568	10411	13808
10	%AIMO to NIA	16.57	19.40	19.11	21.93	24.57	32.62
11	Gross Irrigated Area (GIA)	23344	29105	33421	47642	52787	56141
12	% GIA to GCA	21.72	27.37	31.84	41.45	44.71	45.97
13	Cropping Intensity (%)	112.21	114.40	111.28	118.23	120.47	122.53
14	Irrigation Intensity (%)	116.57	119.40	119.11	121.93	124.57	132.62

Source: GoG (2013), p. 36 and 38.

Gujarat farmers rely on different sources of irrigation that include canals, tube wells, open wells and tanks. It can be seen from the Table 2.7 that though there was significant increase in area irrigated by canal and tube wells in the state (each increased by 2.1 times between 1980-81 to 2007-08) in absolute term, the share of area irrigated by canal in net irrigated area has remained unchanged at the level at about 19 per cent during the period 1980-81 and 2007-08 whereas irrigated area through tube wells and open wells has slightly declined from 79.32 per cent in 1980-81 to 78.02 per cent in 2007-08. Thus, still the tube wells and open wells have been the major sources of irrigation in the state. District-wise data also shows that wells and tube wells are by far the dominant source of irrigation everywhere in Gujarat (Shah, et al., 2009). Surat is only district where the gross area irrigated by canals (about 67 percent) exceeds

the area irrigated by wells and tube wells. Thus, the pressure on groundwater exploitation has considerably increased in Gujarat. In fact, ground water has been over utilized in the state. Also the high cost associated with groundwater irrigation is affecting profitability of agriculture (Mehta, 2012). The success of agriculture in Gujarat in recent years has been founded on groundwater irrigation, therefore, if Gujarat fails to manage its groundwater, its agrarian gains will evaporate (Shah, et al., 2009).

Table 2.7: Area Irrigated by Sources in Gujarat State

		Sources of Irrigation (NIA) Area in 00 ha					
Sr. No.	Sources	1980-81	1990-91	2000-01	2005-06	2006-07	2007-08
1	Govt. Canals	3668	4731	3476	7782	7892	7710
		(18.3)	(19.4)	(12.4)	(19.9)	(18.6)	(18.2)
2	Wells-Tubewells	15884	19301	24347	30242	33070	33027
		(79.3)	(79.2)	(86.8)	(77.4)	(78.0)	(78.0)
3	Tanks	409	314	153	422	398	454
		(2.0)	(1.3)	(0.5)	(1.1)	(0.9)	(1.1)
4	Other Sources	65	30	84	628	1016	1142
		(0.3)	(0.1)	(0.3)	(1.6)	(2.4)	(2.7)
5	All Sources	20026	24376	28060	39074	42376	42333
		(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Note: Figures in parenthesis are percentage to total net irrigated area.

Source: GoG (2013), p. 38

2.5. Ground Water Resource Availability in Gujarat

As mentioned earlier, groundwater (wells and tube wells) is the dominant source of irrigation everywhere in Gujarat. Ground water has emerged as an important source to meet the water requirements of various sectors including the major consumers of water like irrigation, domestic and industries. The annual replenishable ground water resource of the state has been estimated as 18.43 bcm and net annual ground water availability is 17.35 bcm (Table 2.8). The annual ground water draft is 12.99 bcm and the stage of ground water development is 75 per cent (Table 2.9). For the control and regulation of ground water resources, the state government has constituted the Gujarat Ground Water Authority (GGWA) in 2001. Also, the Gujarat State Water Policy was issued by the state government on June 29, 2004. The distric-twise groundwater resources availability, utilization and stage of development are presented in Tables 2.8 and 2.9.

Table 2.8: Ground Water Resources Availability, Utilization and Stage of Development in Gujarat

(Hectare meter)

Sl. No.	District	Annual replenishable Ground water Resource				Total	Natural Discharge During Non Monsoon Period
		Monsoon Season		Non-Monsoon Season			
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources		
1	2	3	4	5	6	7	8
1	Ahmedabad	42855	9201	0	6344	58400	3183
2	Amreli	53311	11937	0	10395	75643	4390
3	Anand	36140	20410	0	22777	79327	5034
4	Banaskantha	75245	10429	0	14779	100452	7702
5	Bharuch	27267	2442	0	5872	35582	1779
6	Bhavnagar	59601	18823	0	11176	89601	4480
7	Dang	7279	769	0	148	8197	410
8	Dohad	23648	4940	0	4832	33419	1671
9	Gandhinagar	36170	4142	0	2761	43073	2154
10	Jamnagar	69388	13718	0	15797	98903	4945
11	Junagarh	108495	15514	0	16805	140814	8367
12	Kachchh	57305	14760	0	10957	83023	4426
13	Kheda	45152	18769	0	19792	83713	4532
14	Mahesana	67996	7963	0	10537	86496	5537
15	Narmada	15434	1707	0	4733	21874	1324
16	Navsari	19699	9360	0	17835	46893	2345
17	Panchamahal	38192	10648	0	16317	65157	3258
18	Patan	17698	2678	0	4051	24428	1882
19	Porbandar	13670	2137	0	1633	17440	1189
20	Rajkot	95766	24925	0	21920	142611	7415
21	Sabarkantha	79300	11717	0	23175	114192	5710
22	Surat	34638	30486	0	46970	112094	8653
23	Surendranagar	50109	4347	0	5720	60175	3296
24	Tapi	27153	6269	0	18074	51496	4636
25	Vadodara	91518	12340	0	22598	126456	6323
26	Valsad	27697	5611	0	9771	43080	2969
	State Total (ham)	1E+06	276042	0	345769	1842539	107610
	State Total (bcm)	12.21	2.76	0	3.46	18.43	1.08

Source: CGWB (2011), Ground Water Year Book 2010-11 (http://cgwb.gov.in/documents/Ground per cent20Water per cent20Year per cent20Book-2010-11.pdf).

Table 2.9: Ground Water Resources Availability, Utilization and Stage of Development Gujarat

(Hectare meter)

Sl. No.	District	Net Ground Water Availability	Annual Ground Water Draft			Projected demand for Domestic and Industrial uses upto 2025	Net Ground Water Availability for Future Irrigation Use	Stage of ground Water Development (per cent)
			Irrigation	Domestic & Industrial Water Supply	Total			
1	2	9	10	11	12	13	14	15
1	Ahmedabad	55216	49236	6851	56087	9597	6527	102
2	Amreli	71253	46242	2523	48765	3532	21479	68
3	Anand	74293	36300	4904	41204	6875	31118	55
4	Banaskantha	92749	121408	5451	126859	7638	4068	137
5	Bharuch	33803	17056	1947	19003	2729	14017	56
6	Bhavnagar	85121	49885	5394	55279	7561	27675	65
7	Dang	7787	742	541	1283	758	6287	16
8	Dohad	31748	12517	4205	16722	5547	13685	53
9	Gandhinagar	40920	64534	3038	67572	4257	0	165
10	Jamnagar	93958	57402	4305	61707	6033	30523	66
11	Junagarh	132447	85963	6573	92536	9203	37281	70
12	Kachchh	78597	67518	4058	71576	5694	9788	91
13	Kheda	79181	44546	5610	50156	7862	26773	63
14	Mahesana	80959	114465	5321	119786	7455	78	148
15	Narmada	20549	6465	1488	7953	2085	12000	39
16	Navsari	44549	23496	2224	25720	3117	17936	58
17	Panchamahal	61899	25735	5355	31090	7007	29157	50
18	Patan	22545	32396	1779	34175	2495	0	152
19	Porbandar	16251	13096	1099	14195	1618	2611	87
20	Rajkot	135196	86797	7448	94245	10344	38056	70
21	Sabarkantha	108482	80484	5385	85869	7738	20261	79
22	Surat	103441	35801	5977	41778	8369	59271	40
23	Surendranagar	56879	34027	2574	36601	3605	19247	64
24	Tapi	46861	9412	1337	10749	1824	35625	23
25	Vadodara	120133	64200	7541	71741	10566	45367	60
26	Valsad	40111	13664	2552	16216	3578	22869	40
	State Total (ham)	1734928	1193387	105480	1298867	147087	531699	75
	State Total (bcm)	17.35	11.93	1.05	12.99	1.47	5.32	75

Source: CGWB (2011), Ground Water Year Book 2010-11 (http://cgwb.gov.in/documents/Ground per cent20Water per cent20Year per cent20Book-2010-11.pdf).

2.5.1 Hydrogeology

The diverse terrain conditions have given rise to different ground water situations in the State. Major part of the state is underlain by hard rock consisting of gneisses, schist, phyllites, sandstones and basalts. Remaining area in the north and central Gujarat is occupied by the soft rocks including coastal alluvium. The development of ground water from phreatic zone is mainly through dug wellsand shallow tube wells. The yield from dug wells varies from 1 to 5 lps (CGWB, 2011). The high relief areas in the eastern and north-eastern parts of the state occupied by the Deccan Traps and the Achaeans respectively have steep

topographic gradients resulting in high run-off, and therefore, provide little scope for groundwater recharge. The groundwater potential in this terrain is limited. The large alluvial tract extending from Banaskantha district in the north to Surat and Valsad districts in the south constitutes the largest most potential groundwater reservoir in the state. The aquifers are extensive, thick, hydraulically connected and are moderate to high yielding. Almost the entire Saurashtra and Kutch regions are occupied by a variety of hard and fissured formations including basalt and consolidated sedimentary formations with semi consolidated sediments along the low-lying coastal areas. The compact and fissured nature of rocks gives rise to discontinuous aquifers with moderate yield potential. The friable semi-consolidated sandstone forms an aquifer with moderate yield potential. The coastal and deltaic areas in the state form a narrow linear strip and are underlain by Tertiary sediments and Alluvium. Though highly potential aquifers occur in these areas, salinity is a constraint for groundwater development. Groundwater withdrawal requires to be strictly regulated so that it does not exceed the annual recharge and also that it does not disturb the hydro-chemical balance leading to seawater ingress. The quality of groundwater in both hard rock and alluvial terrain is, by and large, suitable except in the coastal areas, estuarine tract and the Rann where the degree of mineralisation in groundwater is rather high and salinity is common. Salinity in groundwater is also noticed in the arid and semi-arid tract (Jain, 2012).

2.5.2 Categorisation of Areas:

The estimation of ground water resources has been carried out considering talukas as assessment units. Based on the level of groundwater development, the assessment units have been categorised[2] as safe, semi-critical, critical and over exploited. There are five major aquifers in alluvial sediments out of which the top one has dried up due to over exploitation. As per latest data available, as on March 2009, out of 223 assessment units in Gujarat, 27 have been categorized as Over-exploited, 6 as Critical, 20 as Semi- critical, 156 as Safe and 14 as Saline (CGWB, 2013). Over exploited talukas are mostly located in North Gujarat alluvial plain area (Table 2.10).

[2] The stage of development was computed as gross ground water draft for all uses*100/ annual net ground water available Categorization: Over Exploited - level of GW development > 100 per cent; Critical - level of GW development between 90 and 100 per cent; Semi Critical-level of GW development between 75 and 90 per cent.

Table 2.10: Categorization of Talukas in Gujarat

Sl. No.	District	Categarisation of Talukas in Gujarat		
		Semi-Critical	Critical	Over- Exploited
1	Ahmedabad	Detroj Rampura, Mandal, Sanand, Viramgam		City- Dascroi, Dholka
2	Banaskantha	Danta	Palanpur	Deodar, Deesa, Dhanera, Tharad, Vadgam, Kankrej
3	Gandhinagar			Dehgam, Gandhinagar, Kalol, Mansa
4	Mahesana		Vadnagar	Bechraji, Kadi, Kheralu, Mahesana, Satlasna, Unjha, Vijapur, Visnagar
5	Sabarkantha	Prantij	Vadali	
6	Bharuch	Amod		
7	Kheda	Kapadvanj, Kathlal, Kheda, Mahemdabad		
8	Vadodara	Karjan, Sinor, Vadodara		
9	Jamnagar	Okhamandal		
10	Junagarh	Keshod, Sutrapada		
11	Porbandar			Porbandar
12	Surendranagar	Muli	Idar	
13	Kutch	Abdasa, Rapar	Bhuj, Nakhatrana	Anjar, Bhachau, Mandavi
14	Patan			Chanasma, Patan, Sidhpur
Talukas Assessed	**223**	**20**	**6**	**27**

Source: CGWB (2011a), p. 120.

The ground water development is quite high in the Central Gujarat in parts of Banaskantha, Patan, Mehsana, Gandhinagar, Ahmedabad, in the Western part of State in Katchh district and also in certain coastal pockets of Porbander district. As per CGWB (2011a), there has been about 17 percent increase in the assessment of annual replenishable ground water resources of 2009 as compared to 2004. This may be attributed to significant increase in recharge structures such as check dams, percolation tanks and other structures in various parts of the state. There has been about 13 per cent increase in the ground water draft estimates in 2009. While the number of taluks having totally saline water remained the same, the total number of over-exploited and critical blocks has decreased (CGWB, 2011a). As per the groundwater resource estimation completed recently for the Gujarat state for the year 2009 a noteworthy shift is seen in a large number of assessment units (Taluka) from the critical to semi-critical/safe category in the semi-arid Saurashtra region, when compared with 2002 (Table 2. 11).

Table 2.11: Status of Groundwater Development in Gujarat State: 2002 and 2007

Region	No. of Blocks/talukas: Year-2002						No. of Blocks/talukas: Year 2007					
	Total Talukas	Over Exploited	Critical	Semi-Critical	Safe	Saline	Total Talukas	Over Exploited	Critical	Semi-Critical	Safe	Saline
North Gujarat	91	**24**	8	23	29	7	90	**23**	3	6	51	7
Kachchh	10	**3**	1	4	1	1	10	**3**	2	2	2	1
Saurashtra	71	**2**	3	32	32	2	72	**1**	1	4	64	2
South Gujarat	51	**1**	0	4	42	4	51	**0**	0	8	39	4
TOTAL	223	**30**	12	63	104	14	223	**27**	6	20	156	14

Sourcde: CGWB (2011a) and http://guj-nwrws.gujarat.gov.in/downloads/water_related_issues.pdf

However, at the same time, there is significant increase in the use of electric/submersible pump sets (mostly used for groundwater) as compared to diesel pump sets (mostly used for surface water) in the state indicates heavy withdrawal of groundwater (Table 2.12).

Table 2.12: Growth in Water Extraction Devices for Irrigation 1977- 2003.

Year	Diesel Pump Sets (00)	Electric pumpsets/Submersible pump sets (00)
1977	4221	794
1982	3920	1722
1988	4714	2908
1992	4191	3356
1997	3672	4072
2003	4367	4683
2007	NA	NA

Source: GOG (2013), p- S43.

2.5.3 Ground Water Quality Problems

Problem of salinity ingress is being faced by Gujarat along Saurashtra and Kachchh coast for coastline of approximately 1125 kms. The problem is severe along Una-Madhavpur stretch of Saurashtra and Maliya-Lakhpat stretch of Kachchh Region. In these stretches in select tracts intensive agricultural development and exploitation of ground water and poor recharge from upland areas has resulted into sea water ingress even up to 5 to 6 km inland causing salinity (Box 2.1). The factors responsible are, i) irregular and very low precipitation; ii) highly porous geological formations; iii) low natural charge; iv) poor land management; v) excessive withdrawal of water for irrigation; vi) the phenomenon of salinity ingress has adversely affected the lives of people, both on agricultural front and drinking water front (http://guj-nwrws.gujarat.gov.in). It is estimated that approximately 10.80 lakh of people of 534 villages are badly

affected by salinity. About 7 lakh ha of cultivable land has become useless and about 32750 numbers of wells have gone dry.

Box 2.1: Ground Water Quality Problems in Gujarat	
Contaminants	Districts affected (in part)
Salinity (EC > 3000 µS/cm at 25 ° C)	Ahmdabad, Amreli, Anand, Bharuch, Bhavnagar, Banaskantha, Dohad, Porbandar, Jamnagar, Junagadh, Kachchh, Mehsana, Navsari, Patan, Panchmahals, Rajkot, Sabarkantha, Surendranagar, Surat, Vadodara
Fluoride (>1.5 mg/l)	Ahemdabad, Amreli, Anand, Banaskantha, Bharuch, Bhavnagar, Dohad, Junagadh, Kachchh, Mehsana, Narmada, Panchmahals, Patan, Rajkot, Sabarkantha, Surat, Surendranagar,Vadodara
Chloride (> 1000 mg/l)	Ahmedabad, Amreli, Bharuch, Bhavnagar, Banaskantha, Porbandar, Jamnagar, Junagadh, Kachchh, Dohad, Patan, Panchmahals, Sabarkantha, Surendranagar, Surat, Vadodara, Rajkot
Iron (>1.0 mg/l)	Ahemdabad, Banaskantha, Bhavnagar, Kachchh, Mehsana Narmada
Nitrate (>45 mg/l)	Ahemdabad, Amreli, Anand, Banaskantha, Bharuch, Bhavnagar, Dohad, Jamnagar, Junagadh, Kachchh, Kheda, Mehsana, Narmada, Navsari, Panchmahals, Patan, Porbandar, Rajkot, Sabarkantha, Surat, Surendranagar,Vadodara,

Source: http://cgwb.gov.in/gw_profiles/st_Gujarat.htm

2.5.4 Ground Water Crisis:

The North Gujarat, Saurashtra and Kachchh regions are mostly ground water scarcity areas of the state. In north Gujarat the ground water scarcity areas cover parts of Panchmahals, Banaskantha, Mehsana, Gandhinagar and Ahmedabad districts of Gujarat. The scarcity in these areas is faced on account of erratic and scanty rainfall, high level of irrigation development and partly due to inherently saline formations. Major part of Saurashtra covering parts of Surendranagar, Jamnagar, Junagadh, Bhavnagar, Amreli and Bhavnagar district experience acute scarcity of water resources on account of fissured hydrogeological formation which have limited storage and low transmission capacity, scanty and erratic rainfall and partly due to inherent saline nature of formations and salinity ingress the along the coastal aquifers. The Kachchh district also faces acute shortage of water frequent failure of monsoon creating drought like situation, limited aerial extent of productive aquifers, high level of ground water development and also partly due to inherently salinity in the coastal aquifers.

Columbia Water Center in its on the study of the severe groundwater crisis in the Mehsana region of Northern Gujarat and concludes that the current pattern

of groundwater exploitation is both costly for the state and unsustainable for farmers, and could lead to the complete failure of agriculture in the area within a few years if left unchecked. North Gujarat is naturally endowed with one of the richest alluvial aquifers of India but its uncontrolled exploitation for irrigation has resulted in many undesirable consequences. Over-exploitation of groundwater had caused drying up of open wells and dug-cum-bored wells in alluvial parts of north Gujarat. Falling groundwater table had not only resulted in an increase in the capital cost of tube well construction but also added to variable costs of energy used for lifting water and well maintenance (Ranade and Kumar, 2004).

2. 6 Progress in Water Conservation and Micro Irrigation

After having harnessed all possible sources, the state government launched massive drive for water conservation. The State adopted an integrated approach for efficient and sustainable water resources development and management, which is inclusive in scope (http://guj-nwrws.gujarat.gov.in). This includes:

- Water Conservation
- Micro irrigation management
- Participatory Irrigation Management
- Interlinking of rivers and inter-basin transfer of water
- Strengthening of existing canal system
- Salinity ingress prevention

2.6.1 Water Conservation

Generally, rainfall occurs for three to four monsoon months in a year. Irrigation tanks, ponds and other micro water-sheds, known as 'small water bodies' store the run-off water and provide assured water supply throughout the year. Even from the earliest times people realised the importance of minor irrigation sources. The level of prosperity of a village directly depends upon the availability of water in minor irrigation sources. Further, 'small water bodies' contribute to ecological balance and provide water supply for rural and urban population (Sivasubramaniyan, 1994). The state government is taking up maximum work to deepening of tanks, construction of Khet talavadi, check dam,

bori bundh etc. for underground water recharge. There is a good response from the farmers to types of work. Taking such type of works there is considerable increase in agriculture produces resulting in increase of revenue income and standard of living of village people is lifting up day by day.

After the famine years of 1986-87 to 1989 and irregular and scarce rainfall in the next few years, limited system of recharge of underground water, reduction of the surface water etc., more and more underground water was required and as a result, the underground water level declined at rapid rate every year in the State. Moreover, due to failure of monsoon in 1999-2000, most of the reservoirs and dams of Kutch, North Gujarat and Saurashtra remained empty, which resulted in acute shortage of drinking water in the State. This resulted in a grave problem of supplying drinking water in the urban and rural areas of the State. The State Government, after careful consideration, undertook a massive exercise of preventing the excess rainfall water being drained in the ocean by preserving this precious water in possible areas by recharging the underground water, through construction of check dams and deepening existing tanks. By launching massive drive for water conservation and ground water recharge, the State Government has already put up nearly 6 lakh water harvesting structures depending upon soil, topography and availability of water. These include about 1.59 lakh check dams and bandharas, 2.49 lakh farm ponds (Khet talavdis), 1.25 lakh boribundhs, numerous terrace talavdis, van talavdis, sim Talavdis etc. As a result of this, the declining trend of ground water level has been arrested and improvement is visible. Water Resource Department has constructed 88312 check dams out of above. About 24,497 ponds have been deepened and thus their storage capacity has been enhanced. Further, in order to assess the quantum and extent of the ground water, about 1,200 observation points have been established (http://guj-nwrws.gujarat.gov.in).

Under the "Sardar Patel Participator Water Conservation Project" nearly 76477 check dams have been constructed up to March 2013. The said check-dams have been constructed with public private participation. It is observed that after construction of check dams, in five districts of Saurashtra, the underground water level has come up to the extent of 0.65 mtrs to 13.30 mtrs. Earlier, peoples' groups, voluntary institutions and donors used to bear 40 percent of the expenditure and Government's share was 60 per cent. This ratio has now

been changed to 80:20 (Government: Beneficiaries). The check dams are constructed by the group or institute decided. In North Gujarat and other area of the State, where suitable sites are not available for the construction of check dams, deepening of existing ponds / tanks have been promoted on a large scale to store and conserve water and ground water recharging during monsoon with financial contribution ratio of 90:10 (Government: Beneficiaries). The objective behind this is to prepare and construct a check dam with less expenditure. As people themselves construct the check-dam, they take enough care in construction of the check dam and prevent involvement of vested interests and misappropriation of money. This scheme has also been largely welcomed by the people of the State.

2.6.2 Storages of Water

Considering the extreme situation the State is facing, attention was focused on creation of storages of water throughout the State. Storage reservoirs are vital to the exploitation of water resources for sustained development of the State. Several large projects like Ukai, Kadana, Dharoi, Bhadar, Shetrunji, Sardar Sarovar (SSP) were taken up in the Five-Year Plans along with several other major, medium projects. As per Socio-Economic Review 2012-13, out of total 202 dams with total storage capacity of 15921.04 million cubic metres, 47 dams (having storage capacity of 13089.05 million cubic metres) are in Gujarat region, 20 dams (having storage capacity of 330.55 million cubic metres) are in Kachchh region and 135 dams (having storage capacity of 2501.44 million cubic metres) are in Saurashtra region. At the end of December 2012, the gross storage in the reservoirs was 9515.56 million cubic metres, which was 59.77 percent against the total storage capacity. The reservoir gross storage by region at the end of June, September and December-2012 is shown in the Table 2.13.

Table 2.13: Reservoir Storage by Region

Region	No. of Dams	Storage Capacity (in Million cubic metres)	Gross Water Storage		
			June 2012 (in Million cubic metres)	September- 2012 (in Million cubic metres)	December 2012 (in Million cubic metres)
Gujarat	47	13089.05	4043.6	11793.84	9313.24
Kachchh	20	330.55	65.89	119.19	85.4
Saurashtra	135	2501.44	225.68	451.36	216.92
Gujarat State	202	15921.04	4335.17	12364.39	9515.56

Source: Flood Control Cell, Gujarat Water Data Centre, Sector-8, Gandhinagar as quoted in GOG (2013, Socio-Economic Review 2012-13).

2.6.3 Micro-Irrigation

Micro irrigation, comprising drip and sprinkler, has emerged as a tool for effective management of resources which save water, fertilizer as well as electricity and distribute water evenly unlike other irrigation systems. Water use efficiency under both systems is very high as it saves substantial amount of water losses. Studies have claimed water saving of 40 – 80 percent and productivity gains up to 100 percent (Sivanappan 1994; Palanisami et al. 2011). The Government has taken up initiative for regulating water use for agriculture by spreading micro irrigation technology. Gujarat has created Gujarat Green Revolution Company (GGRC) in 2005, a special purpose vehicle to expedite the promotion of drip irrigation among farmers. GGRCL offers attractive subsidy loan to adopters, but more importantly has fast tracked and simplified the administrative procedures for accessing these. As a result, the spread of micro-irrigation technologies is more rapid in Gujarat than other states during recent years (Gulati et al, 2009; Shah et al., 2009). Any farmer can get subsidy of Rs. 60,000/- per hectare or 50 per cent of the MIS cost (derived based on crop spacing) whichever is less for any area and any crop. Tribal Farmer of tribal area can get additional 25 per cent subsidy from Tribal Department of GOG. The GGRC was instrumental in spreading micro irrigation over 70,000 hectares of land during the year 2009-10 (GOG, 2011). State Government has decided to bring all State run tube-wells in Northern Gujarat under micro irrigation so as to save ground water. As a result of this, about 245 tube-wells are connected to micro irrigation system; work is in progress on another 600 tube-wells (http://guj-nwrws.gujarat.gov.in). Many villages in Gujarat have adopted 100 per cent drip and sprinkler irrigation systems to water crops. In June 2009, more

than 93 thousand farmers in Gujarat have adopted drip irrigation for their total 1.51 lakh hectare land (GOG, 2012).

2.6.4 Rainwater Harvesting

Rapid expansion of groundwater use in the last three decades has resulted in a steep decline in the groundwater table and led to drying up of a huge number of wells, low well productivity, rapid rise in well and pumping depths, deteriorating groundwater quality, and also salinity ingress in many areas. In response to this situation, rainwater harvesting offers a critical and promising solution to replenish and recharge the groundwater (in areas where geologic conditions are conducive). Rain is the most important source of all water and in an endless cycle, rain rejuvenates all fresh water resources. Rainwater recharges the surface sources and slowly seeps into the ground to reach and replenish the underground aquifers. In a typical setting, much of the rainwater is lost to surface flows. Rainwater harvesting for agriculture generally involves the creation of structures such as check dams, ponds, and percolation tanks to slow the flow of water, and to collect and hold limited quantities at a planned set of places along the flow path. The primary objective is to increase the percolation of the rainwater into the ground to recharge the groundwater table. This leads to a rise in the water table levels, increased supply of water in wells, and a longer period of availability of water (Gandhi and Bhoomoriya, 2011). As mentioned earlier, by launching massive drive for water conservation and ground water recharge, the State Government has already put up nearly 6 lakh water harvesting structures depending upon soil, topography and availability of water.

Rainwater harvesting is simply catching rain where it falls and using it to storage and recharging the aquifers. With rapid urbanization, lakes, ponds and green areas that contribute to recharge have reduced drastically. Catchment areas have been paved and reclaimed for construction. Thus, rainwater is unable to seep into the ground, because the land is sealed for miles with concrete buildings and a network of roads. As a result even when the rains come, no recharge can take place. Instead, this precious rainwater rushes out through drains, nallas and flows out into rivers and to the sea. Looking to the above critical position of ground water, scarcity of water, and water requirements in future, the state government has decided a policy for rain water harvesting

system to all present government buildings. Metropolitan Areas have notified rules under which no new building plan is approved without corresponding rainwater harvesting structure. The D/o Roads & Buildings have been directed to ensure that all major Govt. constructions including educational institutions had adequate rainwater harvesting facilities. The Urban Development and Urban Housing Department has issued necessary orders Gujarat Town Planning Act, 1976 to incorporate the rules for RWH. The work of rain water harvesting system is completed in 24103 SM up to the year 2012-13.This has resulted in recharging the ground water in the same area.

2.7 Progress in Participatory Irrigation Management

Increasing conflicts among users and the unsustainable use of water in many areas result from limited coordination among various water resource (surface and groundwater) development initiatives, and the absence of policies defining water entitlements, pricing, and inter-sectoral allocation rules; and if these policies exist, the inconsistencies among some of them. Over the past few years several high-level commissions have been appointed to deal with water management issues and also new national/state policies have been promulgated.[3] However, not much of it has been implemented effectively. This divide between the problem and practice has led to extensive loss of credibility of the state apparatus for water development and management. Problem is balancing between service providers and users of all kind. Participatory Irrigation Management (PIM) is emerging as an important tool for ensuring better equity in distribution of water, which in turn also results in better operation and maintenance (O&M), better on farm management, and increased productivity. In April 1987, the Ministry of Water Resources, Governemnt of India, issued guidelines for farmers' participation in water management. In 1995, the Gujarat Government approved policy resolution for implementing PIM in the state and subsequently approved model bye-laws for irrigation cooperative societies and a

[3] At the national level, a number of national commissions have been constituted by the central government to review specific water policy issues as well as plan for a long-term development of the water sector. Among them, the notable ones are the Committee on Pricing Irrigation Water 1992 (for rationalization of water rates, volumetric water allocation, and system modification), Committee on Private Sector Participation in Major and Medium Irrigation Projects 1995 (documenting the rationale, feasibility, and actual state level initiatives for involving the private corporate sector, especially in the construction and modernization of irrigation schemes) and the National Commission of Integrated water Resources Development Plan 1997 (developing a national master plan for the water sector by synthesizing and updating similar plans prepared earlier by the CWC as well as investigating the economic, technical, and institutional issues in the water sector from a national perspective (ADB, 2009).

model memorandum of understanding between government administration and water user association. An action plan was finalised for implementing government policy resolution on PIM. A year later, i.e. 1996, a state level working group for participatory management was formed and entrusted the responsibility for 13 pilot projects through Chief Engineer, PIM. Since then a large number of WUA have been formed and are working in various parts of the state (Gandhi and Namboodiri, 2011).

For promoting PIM in the state, the Government has decided to cover maximum possible command area under PIM. The Government has also passed "Gujarat Cooperatives and Water Users Participatory Irrigation Management Act-2007". The Government has taken up initiative to involve beneficiaries and stakeholders in irrigation management by enacting PIM Act in 2007. Under the provisions of this Act, Water Users' Association (WUA) is formed from amongst the beneficiary farmers in command area of an irrigation project. About 90 per cent of cost for community mobilization is borne by the Government. Rehabilitation of canals is completed by the Government before handing over to WUAs. The WUA contributes 10 per cent of the rehabilitation cost. Preference is given to WUA to carry out rehabilitation by them. A canal can be handed over to WUA even prior to rehabilitation, if the WUA so demands. Advance payment of the order of 1one third of the estimated cost is given to WUA for starting the work (http://guj-nwrws.gujarat.gov.in). Under this scheme 21215 ha has been covered during the year 2011-12 (GOG, 2013). As of today 1834 WUAs have been established in the command area of various irrigation projects and about 4.29 lakh hectare area has been served by these WUAs under PIM. The state accounts for about 12.9 percent share in total WUAs formed at the national level which covered about 3.33 percent national handed over area. The proposed PIM objectives of the Government in Narmada command Areas is presented in Table 2.14.

Table 2.14: Proposed PIM Programme in Gujarat

Year	Area Proposed to be handed over (000 ha) by		Total Area Proposed to be handed over (000 ha)
	Water Resources department	Narmada Department	
2010-11	110	0	110

2011-12	115	0	115
2012-13	115	200	315
2013-14	115	250	365
2014-15	120	220	340
2015-16	120	350	470
2016-17	120	300	420
2017-18	120	245	365
2018-19	120	228	348
2019-20	120	0	120
Total	1175	1793	2968

Source: Narmada & Water Supply Department, 2010, as quoted in Parthasarathy, (2010).

In order to improve the capabilities of the farmers in irrigation management, the irrigation department has stressed the incorporation of exposure visits for the WUA Presidents to irrigation projects with well performing WUAs within the state. The learning from the exposure visits and clarifications are put on record to be used at a later stage. These visits have improved the understanding of the WUAs on efficient water management practices; made them aware that WUA decides the area to be irrigated, prepare irrigation schedule etc.; that regular meetings and records maintenance. As quoted by Parthasarathy (2010), the experiences so far indicates that PIM programme has resulted in changes in water allocation, distribution and management in almost all areas served by the WUAs.

2.8 Other Initiatives for Irrigation Development and Management

2.8.1 Salinity Ingress prevention programme

The State has the longest sea coast line of 1600 km, which is about one third of total coast line of India. Owing to rapid depletion in ground water, ingress of salinity ingress in coastal area has been a major threat rendering the land infertile (GOG, 2011). Recommendations were made by a High Level Committee for the constructions of tidal regulators and weirs near the ocean bank, recharge tanks, recharge reservoirs, recharge wells, check-dams and spreading channel etc. near the sea cost to prevent salinity ingress in the underground water. Realizing the danger lying ahead, the State government has taken up measures to arrest further advancement of salinity by taking up series of steps. The measures taken to prevent salinity ingress are as: 10 tidal regulators; 23 bandharas; 12 recharge reservoirs, 645 check-dams, 17 recharge tanks, 397 recharge wells, 4487 nala plugging, 100 kilometer long spreading channel and

afforestation over 5867 hectares completed. Also the protection works against sea erosion in South Gujarat completed in 26 kilometer length benefitting 92,300 people residing in 4577 houses. Allocation of Rs. 200 crore has been made for salinity ingress prevention schemes of Gujarat under the States Special Needs under the 12th financial Commission. Similarly, allocation of Rs. 150 crore has been made by GOI for salinity ingress prevention scheme under 13th finance commission. During the year 2009-10, the Department constructed 4 bandharas, 905 check dams, 2 recharge reservoirs, 54 recharge tanks, 19 kilometer long spreading channels in Saurashtra and Kachchh to arrest further advance of salinity.

2.8.2 River Linking Projects

After having exhausted all resources, inter basin transfer of water is the only option left. National Water Policy (2002) emphasis that water should be made available to water deficit area by transfer from other areas having surplus water. Interlinking of rivers is a leading step to divert surplus water from surplus to deficit basins. The State has already taken very important and leading steps for interlinking of rivers. Some of the interlinking projects taken up are i) Harnav – Guhai Link ; ii) Sabarmati – Saraswati Link; iii) Mukteshwar –Harnav Link; iv)17 en route rivers on alignment of Narmada Main Canal and v) 21 en route rivers on alignment of Sujalam Sufalam Spreading canal. The proposed link canals are Damanganga – Sabarmati - Chorwad Link; Ukai – Gordha Link Canal and Dev – Sukhi Link Canal. Besides, the link canals related to Gujarat State have been proposed by National Water Development Agency (NWDA) working under the Ministry of Water Resources, Government of India.

2.8.3 Sujalam Suphalam Yojana:

To bring permanent solution of the issues of water and flood in Gujarat, an ambitious project has been undertaken by the State Government. This project, called Sujalam Sufalam, is expected to bring solution of age old problems of famine in 10 districts which do not have irrigation facilities. The state government has identified water scarce district of North Gujarat, Central Gujarat, Saurashtra and Kachchh, which are being covered under the Sujalam Suphalam Yojana (SSY). Under this scheme, water is being made available through Sardar

Sarovar dam and other reservoirs, and on other, efforts are made to collect, store and recharge every drop of water to take the maximum benefits (Parathasarthy, 2010). The irrigation department data envisages that with the implementation of the project, about 4.65 lakh ha of land will benefit (Table 2.15). Sujalam Sufalam Spreading canal is an unlined canal of 337 km length traversing through seven districts. The canal is having a capacity of carrying 2000 cubic feet per second (cusecs) of water. The canal all along its course has major structures for crossing 21 Rivers, 2 National Highways, 27 State Highways, 07 Railway lines. Besides, there are 600 other structures.

Table 2.15: Area to be benefited by Sujalam Suphalam Yojana

Sr No	Name of Component	Area (in 000 ha) (Approx)
1	Sujalam Suphalam Spreading Canal and four pipelines from Narmda Main Canal to Sujalam Suphalam Spreading Canal and Big Check Dems of rivers	120
2	Lift Irrigation Schemes (Pipelines from Narmada Main Canal to Reservoirs of North Gujarat) (Assured water for existing command area of reservoirs of North Gujarat)	14
3	Big check dams of Surendranagar District (107+28)	19
4	44 Bandharas of Kachchh District	29
5	Check Dams in Kachchh	2
6	Extension of existing command in North Gujarat	54
7	Panam High Level Canal	18
8	Kadana Left Bank High Level Canal	5
9	Check Dams of Panchmahals & Dahod District	80
10	Creation of additional storage (minor irrigation schemes of North Gujarat, Deepening of Ponds etc.	3
11	Total	466

Source: Narmada and Water Resources Department Government of Gujarat 2010 as quoted in Parathasarthy, 2010.

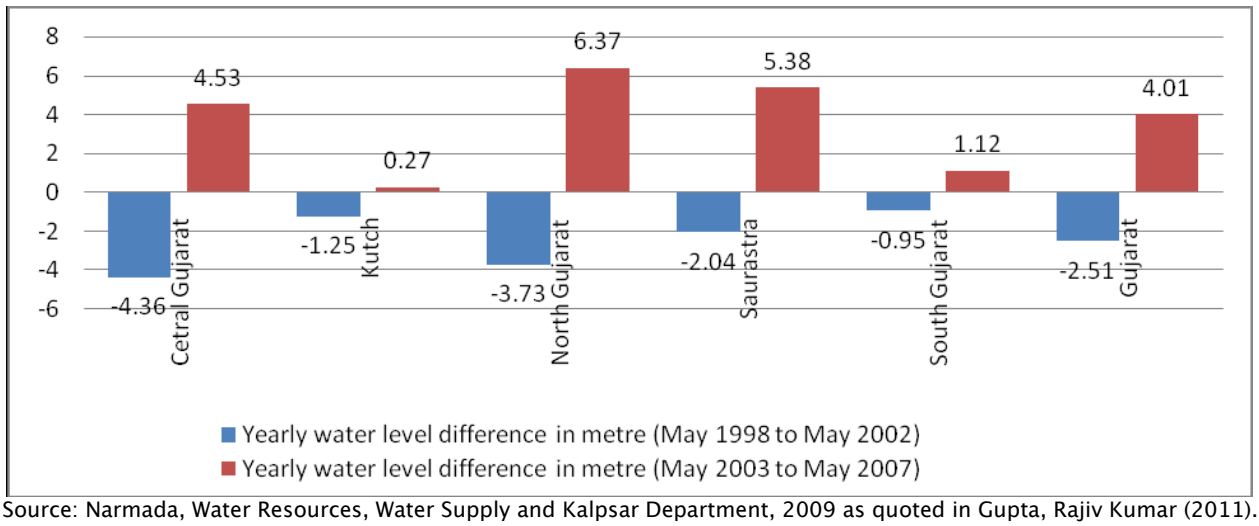
2.8.4 Extension, Renovation and Modernization:

Extension, Renovation and Modernization of canal system of existing major and medium Irrigation Schemes are under progress on a large scale to bridge the gap between irrigation potential created and its utilization. During the year 2012-13 (upto June, 2012), the total 7.58 lakh ha area had been planned to be covered under this scheme, out of which the works in about 2.65 lakh ha area has been completed (GOG, 2013).

2.8.5 Groundwater Recharge in Gujarat:

The state government has undertaken some unconventional initiatives in managing the groundwater economy, which is mainstay of its irrigated agriculture. For one, the government has enthusiastically made common cause with farming communities in undertaking decentralized rainwater harvesting and groundwater recharge work. By adopting an aggressive recharge strategy that has contributed significantly to stabilizing the ground water levels and even reversing the trend of groundwater depletion, the Saurashtra region of Gujarat has become a role model for other states to follow (Jain, 2012). As discussed earlier, ground water level in the state varies considerably depending on aquifer geology, geomorphology and rainfall. South-West monsoon is the main source of ground water recharge. The shallowest level is observed in the month of August, while the deepest is observed in the month of May. As mentioned earlier, there is noteworthy change in groundwater level due to various schemes implemented by the state government. The analysis reveals that during pre-monsoon (May) water level ranges in general from 2 to 20 m bgl, while during post-monsoon (November) it varies in general from less than 1 to 10 m below ground level(bgl) (http://cgwb.gov.in). It has been noted by Gupta et al, (2011) that the average depletion of water levels in north Gujarat before the launch of this massive programme was around 3m per year, which by now would have cumulatively declined almost 20-26m, leading to a sharp rise in electric consumption for withdrawal of ground water (Fig. 2.2). But there has been a reported average water level rise of about 4m during recent years. The comparison of depth to water level of Post Monsoon 2008 with decadal mean Post Monsoon (1998-2007) also indicated that there was rise in water level of more than 2 m is prominent in Gujarat.

Figure 2.2: Ground water level fall/rise (in metres)- 2002 and 2007



Source: Narmada, Water Resources, Water Supply and Kalpsar Department, 2009 as quoted in Gupta, Rajiv Kumar (2011).

As discussed earlier, the assessment of groundwater resources of Gujarat for the year 2009 reveals a noteworthy shift in a large number of assessment units from critical to semi-critical/safe category in the semi-arid Saurashtra region, when compared with 2002. This is significant against the backdrop of decline of groundwater levels and groundwater depletion in large parts of the arid and semi-arid regions of the country (Jain, 2012). The Saurashtra region was facing problems of declining groundwater levels and ground water depletion prior to 2002 but in the post 2002 scenario, there has been an overall steady rise and stabilization in post monsoon ground water levels. Although, Saurashtra experienced above average rainfall during the period, the limited period available for infiltration of rainfall during the monsoon does not allow significantly enhanced recharge due to the limited storage of the underlying aquifers. The analysis of the drivers indicate that the intervention of decentralized rain water harvesting and artificial recharge to ground water taken up on a mass scale in the Saurashtra and Kachchh regions have prolonged the period of recharge to the aquifers during post monsoon season resulting into this miracle of stabilizing the ground water levels and even reversing the trend of ground water depletion

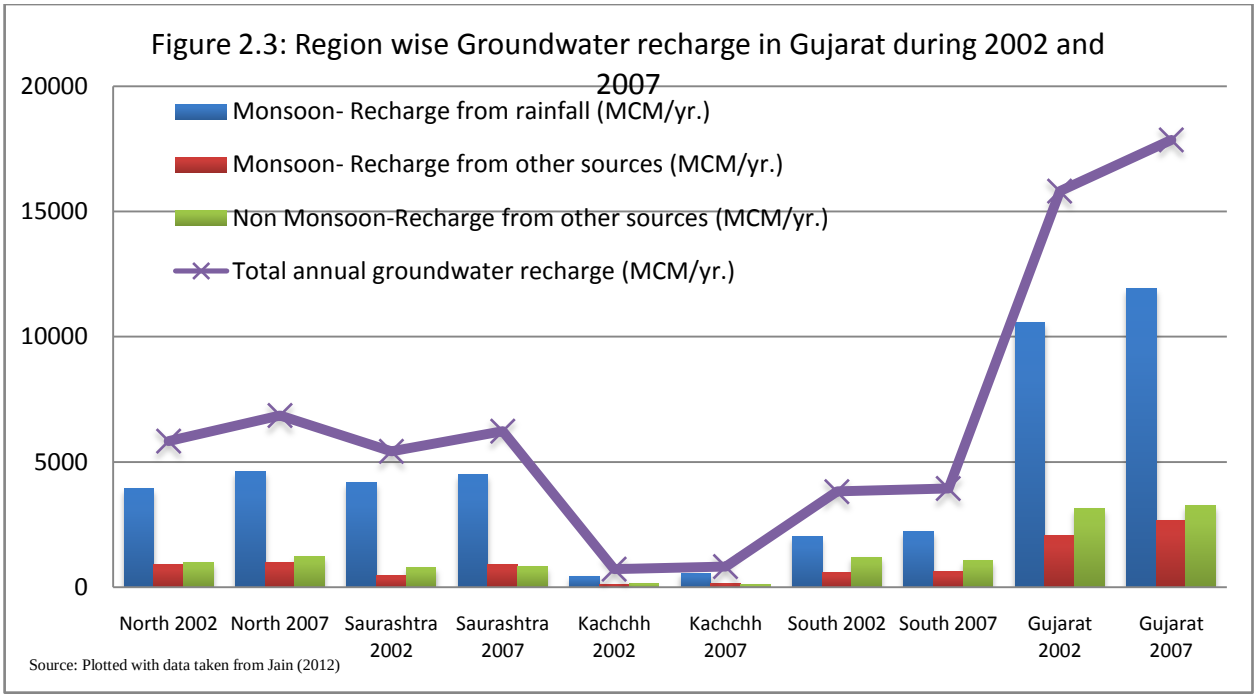


Fig. 2.3 presents a region wise disaggregation of the estimated contribution of rainfall and other sources to the ground water recharge for 2002 and 2007 scenario (for details please see Jain, 2012). Rainfall is the most important contributor to groundwater recharge throughout the state during the monsoon season. As a result, the impacts could be felt everywhere. Besides, in the South Gujarat region having large number of reservoirs and a large network of irrigation canals, the seepage from reservoirs and return flows from surface irrigation are major contributors to groundwater recharge. The contribution from seepage from reservoirs and flow irrigation to recharge is comparatively less important in other regions of the state. Whereas in Saurashtra, North Gujarat and Kachchh regions in the state which have relatively large areas under groundwater irrigation the seepage from groundwater irrigation forms the second most important driver to groundwater recharge. However some other interventions are by their nature confined to one or more of the four regions. For example, if canal irrigation underwent major changes, its impact will be strongly felt in southern Gujarat where much of canal irrigation is located. Contrary to this, if the increased availability of water through canal irrigation system has been a major driver for building up of groundwater resources in Gujarat, one should not expect to see large impacts in North Gujarat, Saurashtra and Kachchh which have only a small share in canal irrigated area in the state. The decentralized

groundwater recharge activities are concentrated in Saurashtra and Kachchh; hence its impact is more likely to be visible in these regions. This implies that groundwater recharge activities which are concentrated mostly in Saurashtra, North Gujarat and Kachchh regions would reflect region specific impact on groundwater recharge if they form a dominant driver for recharge. Jain (2012) highlighted the expected influence of various drivers on groundwater recharge in different regions of Gujarat which is presented in Table 2.16.

Table 2.16: Expected influence of different drivers on recharge to groundwater in Gujarat.

	Drivers responsible for ground water recharge	Regions likely to be affected			
		South Gujarat	Kachchh District	North Gujarat	Saurashtra
1.	Rainfall	↑↑↑↑	↑↑↑↑	↑↑↑↑	↑↑↑↑
2.	Canals	↑↑↑↑	↑	↑↑	↑↑
3.	Storage tanks and Ponds	↑↑↑↑	↑↑	↑↑↑	↑↑↑
4.	Irrigation return flows	↑↑↑↑	↑	↑↑	↑↑↑
5.	Check dams and percolation tanks	↑	↑	↑↑	↑↑↑↑

Source: Jain (2012).

2.9 Strategic Options

Tenth Plan was declared as a Water Plan for focused attention on the integrated development of water resources in the country (Planning Commission, GOI, 2007). The strategic options suggested by the many researchers are as follows:

- Water is a finite resource and it has to be shared between the various sectors and sub-sectors optimally. There is a need to increase investments in conservation of water, improved techniques to ensure its timely supply, and improve its efficient use.
- Need to shift our focus from 'water resources development' to 'water resources management' by restructuring and strengthening existing institutions for better service delivery and resource sustainability. Planning for big water resources projects should be interdisciplinary with all environmental, ecological and human concerns internalized and thereby assessing the impacts by a concrete statute.
- State government need to be persuaded to enact /implement the suggested legislation for ground water regulation, dam safety and flood plain zoning. The central government should also take the initiative for

drawing up guidelines and initiating policy changes for private sector participation in the irrigation sector.

- 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.
- The pricing structure for water needs a serious review to reflect the scarcity value of water. Water charges must ensure that the revenues earned by state governments cover the operation and maintenance (O&M) costs of irrigation and water supply systems.
- Stress has to undoubtedly continue on developing water resources but more emphasis now has to be laid on sustainable management of water resources for optimal production along with the completion of on-going projects and their development. Efforts need to be concentrated on the quick completion of ongoing projects, especially the old ones, and proper maintenance of the created infrastructure. The assistance programmes of the central government need to be restructured to encourage this.
- Over exploitation of ground water is leading to falling water levels in many areas especially, the hard rock areas. The systematic approach to the management of ground water requires a sustainable legal framework.
- For optimal utilisation of the water resources and to ensure sustainable development, the highest standards of scientific activity have to be taken up in the sector. With this objective, research and development (R&D) efforts have to be speeded up through sponsored research as well as through invited research proposals.
- Reuse and recycling of wastewater management for irrigation without a detrimental effect on crops and the soil is another aspect that needs to be tackled in a systematic manner, in addition to the management of poor quality of groundwater, which is fairly widespread in the country.
- The allocation of water to agriculture is facing a losing battle with the industrial, domestic, power and other sectors. At the same time, there is the compulsion of enhancing agricultural production in an eco-friendly sustainable manner with limited land and water resources. There is, therefore, an urgent need of the speedy transfer of resource-efficient

technology to increase the productivity of water at field and the regional level.

- The success of agriculture in Gujarat in recent years has been founded on groundwater irrigation and therefore if Gujarat fails to manage its groundwater, its agrarian gains will evaporate. Therefore, Gujarat must do a major rethink on its water resources strategy. Rational planning and utilisation of water storage is critical to sustaining the tempo of agricultural growth Gujarat has generated.
- The groundwater-irrigated agriculture in North Gujarat, Saurashtra and Kachchh is steadily building up an accumulated groundwater deficit that imposes high energy costs on the state and is also rushing towards unsustainability.
- Gujarat must consider spreading its large reservoir storage on a much larger area as a strategy of securing its agricultural future. One way of doing this is to use a portion of the surface storage for "groundwater banking", an idea which is well-tested in Australia and the US but whose time has come in Gujarat as well (Shah, et al., 2009).

Chapter III

Overview of PINS Programme in Gujarat

3.1 Introduction

Globally, fresh water at a tune of 3,240 M km3 is being utilized. Of this, 69 per cent is being used in agriculture sector, 8 per cent in domestic, 23 per cent in industrial and other sector. In India, around 88 per cent water is being used in agriculture sector, covering around 91.53 mha area under irrigation. Due to liberalization of industrial policies and other developmental activities, the demand for water in industrial and domestic sectors is increasing day by day, which forces to reduce the percentage area under irrigation. The growing demand from the population calls for more efforts to enhance agricultural production. 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 91.53 million hectares in 2011-12, with 52 per cent area being irrigated by surface irrigation through canal network. Unfortunately, the overall efficiency of canal irrigation system worldwide is very low which leads to poor utilization of irrigation potential, created at huge cost. In India, most of the canal irrigation networks are unlined and huge amount of the irrigation water is lost in main canal, distributory, minors and field channels. The breakup of the losses (of about 70%) is as follows: 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. Thus 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 with MIS can be an option for increasing this irrigation efficiency.

3.2. Overview of PINS Programmes in Gujarat

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

Figure 3. 2. Coverage of Sardar Sarovar Narmada Project (SSNP)

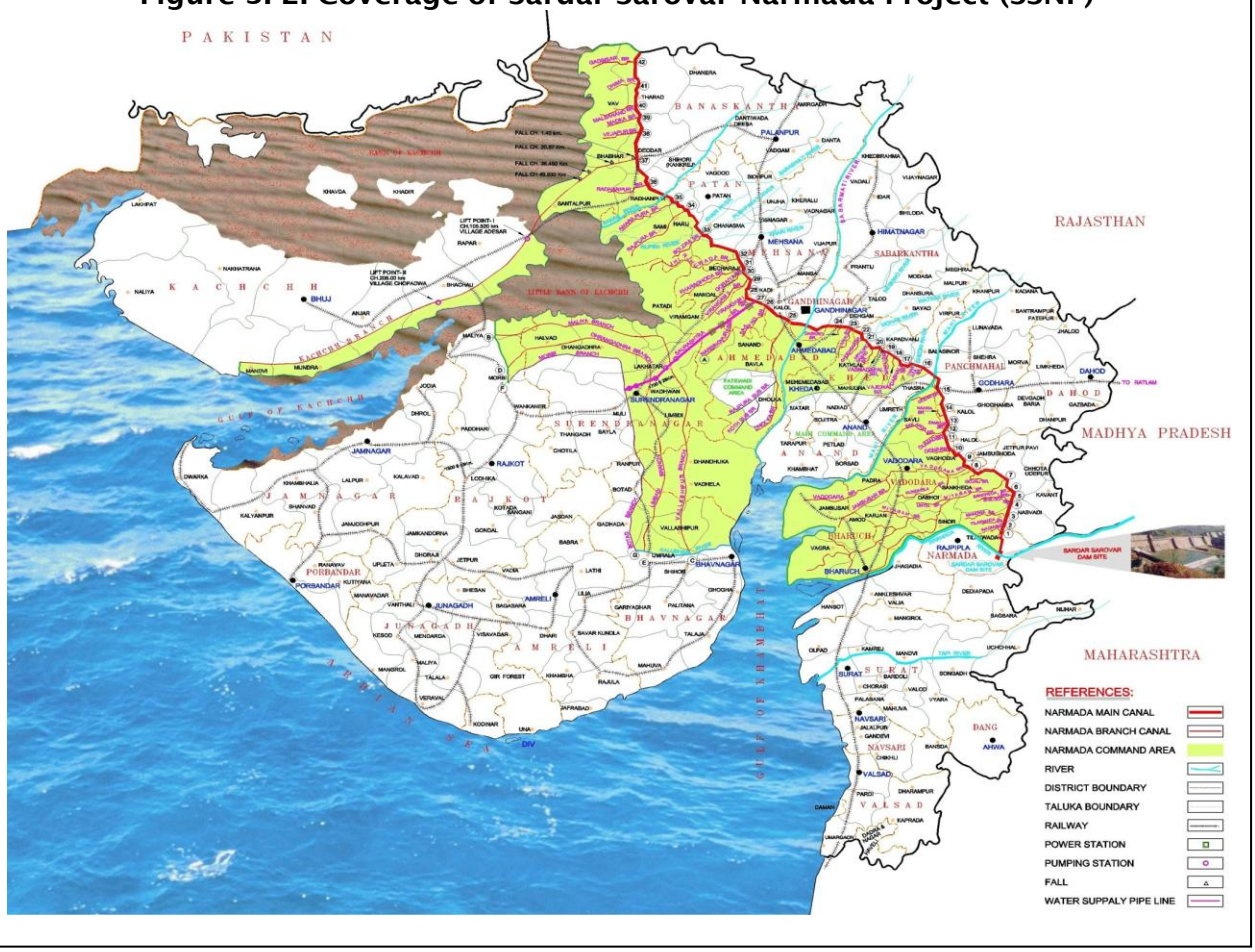
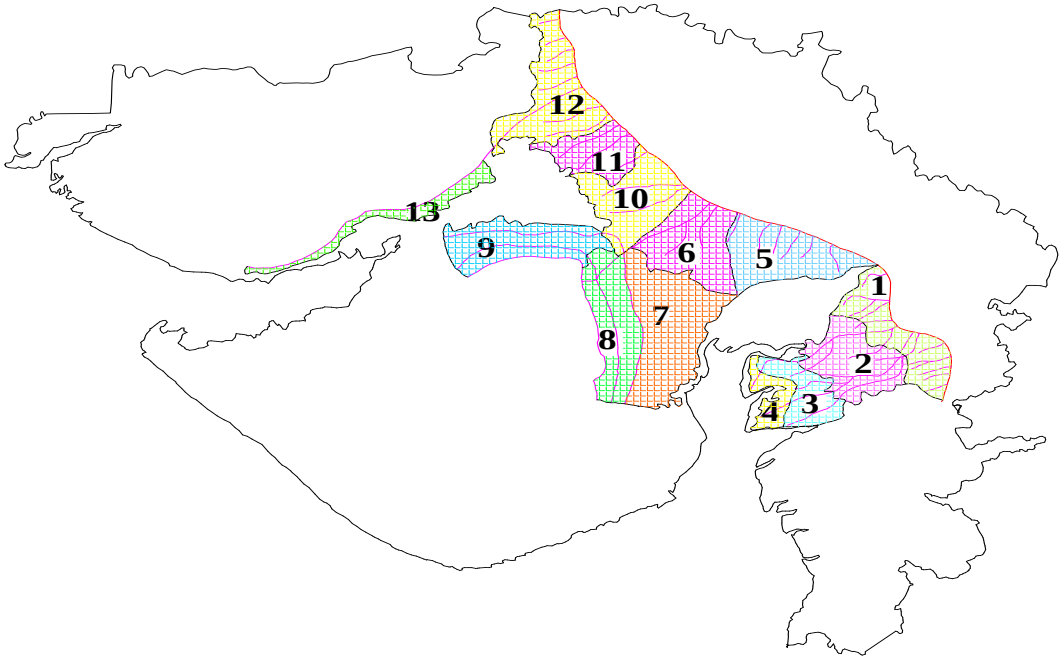


Figure 3.3. Agro-Climatic Zones in SSP Canal Network



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

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

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

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

Government of Gujarat has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. The pilot project on Pressurized

Irrigation Network System (PINS) is one such effort started in 2007-08. The details of coverage of this programme are presented in Table 3.2. About 25 pilot projects were initiated in the state covering 1029 farmers with 1491.6 ha of CCA and estimated budget of Rs 1306.3 lakh. The project work was carried out by Jain Irrigation Ltd (56%), Parikhit Industries (32.0%), EPC Industries (8.0%) etc (Figure 3.4).

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

Figure 3.4. Distribution of Agencies Carried Out the Canal PINS in Gujarat

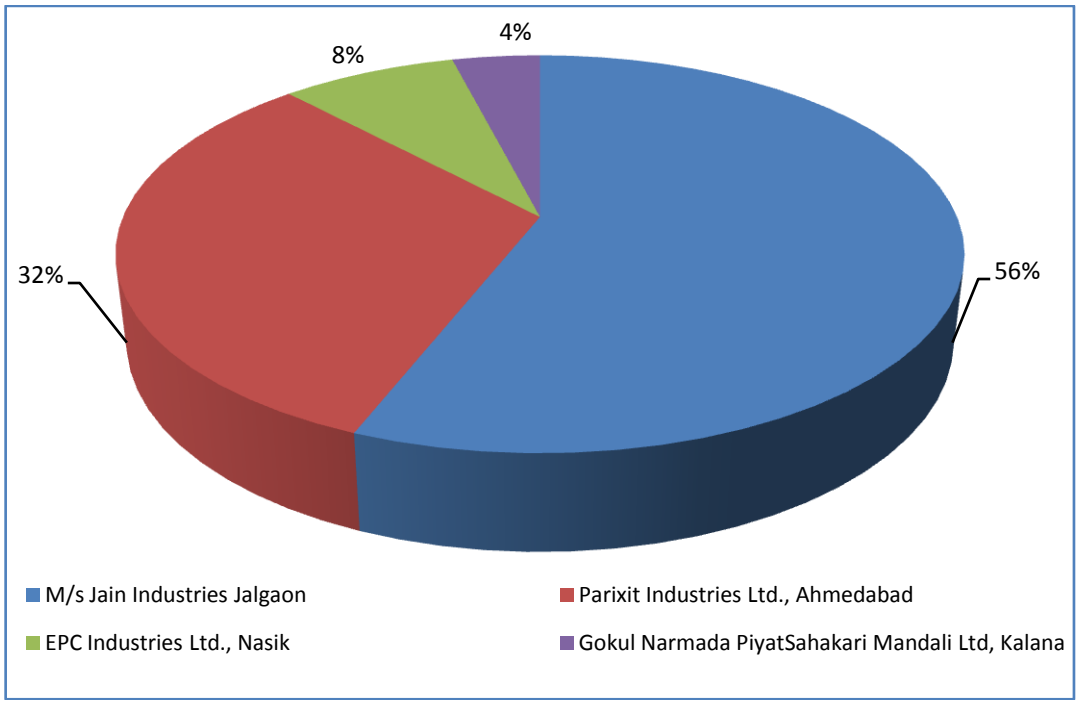


Table 3.2. Status of Implementation of PINS Pilot projects in Gujarat
(As on January 2014)

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

Source: SSNNL, Gandhinagar

3.3 Estimated Expenditure and Pay Back period on PINS

It may be noted from Table 3.2 that the average spending on an individual PINS varied from Rs 10.0 lakhs to 63.0 lakhs depending on the size of PINS and the pumpset installed and length of pipelines used for PINS project. The average spending incurred per PINS was Rs 35.4 lakhs against the estimated Rs52.3 lakhs. The estimated per hectare expenditure on PINS at Chak level was Rs 20340 (Table 3.3). It may be noted that the case of 24 hrs electric, HVDS/ express feeder is very cost effective and attractive option. However, 24 hours electricity is to be made available at Chak level i.e. 6 connections per VSA. This can be made possible through HVDS and express feeders. However, the option 2 with power availability of 8 hrs through agri feeder is highly desirable and cost effective alternative as it is in tune with GOG's policy of power distribution for agriculture in the state and the estimated per hectare expenditure on PINS as per the option2 was Rs 28740.

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

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

(Rs/ha)

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

Source: Ganapatye(2011)

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

(Rs/Ha)

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

Source: Ganapatye(2011)

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

(Case of Wheat with Sprinkler)

(Rs/Ha)

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

Source: Ganapatye(2011)

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

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

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

3.4 Bottlenecks in Adoptability of Canal PINS

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

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

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

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

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

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

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

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

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

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

Some snapshots on Canal PINS structures on Narmada Canal command area may be seen from Figures 3.5 to 3.9.

Figure 3.5. Intake Well Cum Pump House at Badarpur Minor, Laxmipura

Figure 3.6. Deusana PINS Pilot Project

Figure 3.7. Inlet Arrangement for Canal PINS

Figure 3.8. Intake Arrangement through Tank

Figure3.8. Inside Arrangements and Filtration units for PINS

Figure3.9. Inspection of PINS by the officials

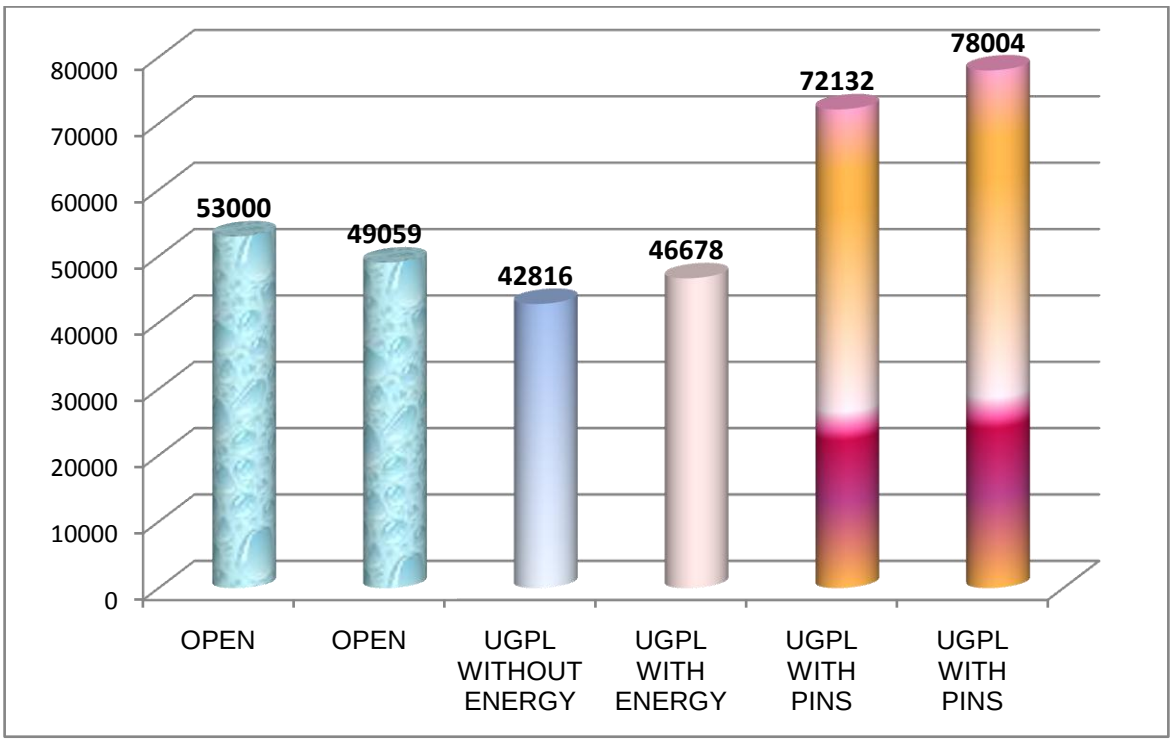
3.5 Under Ground Pipe Line (UGPL) System in Gujarat

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

Figure 3.10. Layout of UGPL in Gujarat

Thus, the UGPL system can be combined with PINS for effective management of irrigation water while taking care of farmers' preferences for different cropping pattern. As per a case study conducted by SSNNL, Government of Gujarat, the estimated per hectare cost for different combinations of UGPL and PINS is presented in Figure 3.11. It may be observed that the per hectare cost for of UGPL and PINS is maximum of Rs 78004 compared to all other combinations. However, it has potential to generate better results too.

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



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

Table 3.7 : Progress in UGPL in Gujarat

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

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

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

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

According to UGPL Policy 2014 of Government of Gujarat, No restriction of technical options selected for the scheme. The group of farmers have to decide the alignment of sub minor which is underground and therefore there is no question of land acquisition. However, if open channel is selected by farmers, farmers will be expected to contribute their land. The SSNNL will pay 97.5% of the total cost. The group of farmers is expected to pay 2.5% of the cost as a labour component to the cost of scheme. The purpose is to inculcate a sense of ownership in farmers. O&M of sub minor will be responsibility of beneficiary farmers of chak. Alignment of UGPL and locations of Turn-outs is to be decided in consultation with Farmers. Tri-partite Agreement (Beneficiary Farmers, Implementing Agency & SSNNL) has to be signed for each Chak.

3.6. Progress and Expenditure Pattern on Tube well PINS

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

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

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

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

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

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

Sr. No.	District	Taluka	No. of working open wells	No of open wells with PDC	Total No. of Open wells
1	Ahmedabad	Dashkoie	53	51	104
		Dhodaka	18	24	42
		Bavada	8	30	38
		Sanand	21	59	80
		Viramgam	14	27	41
		Detroaj	23	34	57
		Mandal	9	13	22
		Total	146	238	384
2	Surendranagra	Chotila	2	13	15
		Patadidasada	10	17	27
		Muli	0	23	23
		Vadhvan	0	4	4
		Limbadi	0	1	1
		Sayala	0	10	10
		Dhangdhara	2	22	24
		Total	14	90	104
3	Bhavnagar	Tadaja	0	1	1
		Gariyadhar	0	1	1
		Total	0	2	2
4	Botad	Botad	0	2	2
		Total	0	2	2
5	Rajkot	Rajkot	0	1	1
		Total	0	1	1
6	Morabi	Vankaner	0	1	1
		Morabi	0	3	3
		Halvad	3	18	21
		Total	3	22	25
7	Junagadh	Vanthali	0	1	1
		Visavadar	0	1	1
		Total	0	2	2
8	Amreli	Amreli	0	1	1
		Dhari	0	2	2
		Babra	0	1	1
		Lathi	0	1	1
		Kunkavav	0	1	1
		Liliya	0	1	1
		Total	0	7	7
9	Gandhinagar	Gandhinagar	41	42	83
		Kalol	19	19	38
		Mansha	20	13	33
		Dehagam	21	95	116
		Total	101	169	270
10	Sabarkantha	Talod	4	16	20
		Prantij	13	30	43
		Himmatnagar	5	24	29
		Idar	4	3	7
		Vijaynagar	1	2	3
		Khedbrahma	0	1	1
		Total	27	76	103
11	Aravalli	Bhiloda	1	1	2
		Megharaj	0	2	2
		Modasa	0	1	1
		Bayad	0	2	2
		Total	1	6	7
	Total Openwell of GWRDC		292	615	907

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

Among different agencies associated with supplying MIS and components of PINS, Jain Irrigation was the major one. It covered about 197 tube wells covering 1388 beneficiaries with 1904 ha of land (Table 3.11). On an average, 09 farmers were covered beneficiaries were covered under each Tube well Water Users Association (TUA) with average area of 11 ha per TUA. The expenditure on Tube well PINS has been presented in Table 3.12. The total expenditure on Tubewell PINS was Rs 2.64 lakhs whereas the expenditure on MIS component was Rs9.87 for all beneficiaries under a single TUA. The per beneficiary expenses on MIS in a TUA was Rs 1.3 lakh on an average, which includes all components of MIS such as drip, sprinkler and all necessary accessories and pipes.

Table 3.11 : Tube well PINS covered by Jain Irrigation in Gujarat

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

Source: Jain Irrigation, Vadodara

Table 3.12: Details of Expenses on Tube well PINS in Gujarat

(Rs in Lakh)

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

Source: Jain Irrigation, Vadodara

The revised unit cost for drip irrigation system with and without inclusion of water sump sizes in Gujarat, as decided by Gujarat Green Revolution Company Ltd (GGRC), has been presented in Table 3.13. Two standard lateral size have been considered with various sump sizes and spacing. The cost of drip system varies from Rs30, 024 to Rs 1,28, 154 depending on the crop spacing and sump sizes with lateral size of 12. In the same case, the drip cost without any sump attached with it varies from Rs18949 to Rs1, 06,053 for different crop spacing. Similarly, the cost of drip system varies from Rs30, 099 to Rs 1, 49, 169 depending on the crop spacing and sump sizes with lateral size of 16. In the same case, the drip cost without any sump attached with it varies from Rs21024 to Rs 1, 27,066 for different crop spacing.

The unit cost for sprinkler irrigation system in Gujarat, as decided by GGRC, has been presented in Table 3.14. The unit cost for sprinkler irrigation system varies from Rs 11996 to Rs 50721 for various plot sizes and HDPE coupler sizes. Per The higher HDPE coupler size of 75 mm can only be fitted in the land having area more than 1 ha, while the HDPE coupler size 90 mm can only be fitted in the land having area more than 3 ha.

The unit cost for mini sprinkler system for various water sump sizes in Gujarat, as decided by GGRC, has been presented in Table 3.15. Two standard lateral sizes (25 mm and 33 mm) have been considered with various sump sizes and crop spacing. The cost of sprinkler system varies from Rs 54150 to Rs 102223 depending on the crop spacing and sump sizes with lateral size of 25. Similarly, the cost of sprinkler system varies from Rs 63475 to Rs 115878 depending on the crop spacing and sump sizes with lateral size of 32.

Table 3.13: Revised Unit Cost for Drip Irrigation System with & without inclusion of water sump cost in Gujarat (w.e.f. 01.03.2016)

(Figures in Rs./ha)

Lateral Size	Particular		Crop Spacing / Lateral Spacing (Mtr.)											
			12 x 12	10 x 10	9 X 9	8 X 8	6 X 6	5 X 5	4 X 4	3 X 3	2.5 x 0.6	2 X 0.6	1.5 X 0.6	1 X 0.6
12 mm	Sump size-40m3	Total MIS Cost	40949	42373	43285	48534	52699	55099	55554	62285	74727	82798	96386	128154
	Sump size-25m3	Total MIS Cost	35424	36848	37760	43009	47162	49552	50004	56735	69176	77248	90836	122603
	Sump size-20m3	Total MIS Cost	33299	34723	35635	40884	45037	47427	47879	54600	67042	75113	88701	120469
	Sump size-13m3	Total MIS Cost	30024	31448	32360	37609	41762	44152	44604	51310	63752	71823	85411	117179
	Total MIS Cost Excluding Sump Cost		18949	20373	21285	26534	30687	33077	33529	40230	52626	60698	74285	106053
16 mm	Sump size-40m3	Total MIS Cost	43024	44863	46059	51653	56868	60115	61807	70624	83121	93291	110412	149167
	Sump size-25m3	Total MIS Cost	37499	39338	40534	46121	51318	54565	56257	65074	77571	87741	104862	143616
	Sump size-20m3	Total MIS Cost	35374	37213	38409	43996	49188	52430	54122	62939	75436	85606	102727	141482
	Sump size-13m3	Total MIS Cost	32099	33938	35134	40721	45913	49145	50832	59649	72146	82316	99437	138192
	Total MIS Cost Excluding Sump Cost		21024	22863	24059	29646	34838	38070	39754	48531	61020	71191	88311	127066

Source: GGRC, Vadodara

Table 3.14: Unit cost for Sprinkler Irrigation System in Gujarat (w.e.f. 01.03.2016)

(Figures in Rs.)

	HDPE Pipe Coupler size		
Area	63mm	75MM	90MM
0.4 hac.	11996	NA	NA
1 hac.	19464	20781	NA
2 hac.	27886	29666	NA
3 hac.	NA	NA	35887
4 hac.	NA	NA	45201
5 hac.	NA	NA	50721

Source: GGRC, Vadodara

Table 3.15: Unit cost for Mini Sprinkler Irrigation System in Gujarat (w.e.f. 01.03.2016)

(Figures in Rs.)

Lateral Size	Particular		Crop Spacing / Lateral Spacing (Mtr.)				
			11 x 11	10 x 10	9 X 9	8 X 8	7.5 X 7.5
25 mm	Sump size-40m3	Total MIS Cost	76251	81148	88961	93904	102223
	Sump size-25m3	Total MIS Cost	70701	75598	83411	88354	96672
	Sump size-20m3	Total MIS Cost	68566	73463	81276	86219	94537
	Sump size-13m3	Total MIS Cost	65276	70173	77986	82929	91247
	Total MIS Cost Excluding Sump Cost		54150	59047	66861	71803	80122
32 mm	Sump size-40m3	Total MIS Cost	85575	91396	100345	106707	115878
	Sump size-25m3	Total MIS Cost	80025	85845	94795	101157	110328
	Sump size-20m3	Total MIS Cost	77890	83711	92660	99022	108193
	Sump size-13m3	Total MIS Cost	74600	80421	89370	95732	104903
	Total MIS Cost Excluding Sump Cost		63475	69295	78245	84606	93778

Source: GGRC, Vadodara

3.7 Prospects and Constraints in Promotion of PINS in the State

As revealed from the analysis of various kinds of PINS in Gujarat state reveals that, the main canal PINS has not been successfully adopted by the farmers in the state, though the concept can be significantly useful for better economical use of

the irrigation water. It has the potential to enhance the irrigation coverage substantially with increase in farm yields. However, farmers did not want to change the cropping pattern which was highly water intensive. They did not want to spend anything on MIS since canal water was available to them plentily almost free of cost. There were no much strict rules and regulations enforced to check the illegal use of canal water and water theft. Thus the location factor played a key role in less adoptability of Canal PINS. The PINS structures have been erected mostly close to minor or sub-minor, from where farmers are able to get free access with some illegal methods. Had it been placed at far off places where tail end farmers are struggling to get the water, the adoptability would have been much better, though the expenditure on each of the Canal PINS would have been little more.

Looking at substitutes of Canal PINS, the state Government started the UGPL scheme on big way, which was adopted by the farmers in much better way since it did not affected much to their overall water consumption. Though the system has the potential to increase the water use efficiency at later stage, there are some issues in implementation of UGPL in Sub-Minors. Farmers were not willing to pay 10%, their contribution and are not willing to allow laying of UGPL. Pipe suppliers are unable / not willing to supply in sufficient quantity at reasonable rates. It is becoming difficult to persuade them to maintain regular supply. Moreover, the water saving is much less with UGPL compared to MIS. Thus the Government need to adopt some stringent rules on flood method of irrigation, discouraging more water consuming crops and promoting MIS with some incentive structures.

The Tubewell PINS have been adopted in a much better and sustainable manner in Gujarat and has a wide coverage. As revealed from focussed group discussion with the farmers, the higher maintenance cost and energy cost has discouraged the farmers in increasing its further adoption.

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 selected beneficiary and non-beneficiary farmers was around 57 and 54 years respectively. The length of education was about 9.1 years for beneficiary and non- beneficiary farmers. The beneficiary farmers also depicted better results with respect to average number of people engaged in agriculture, average years of experience in farming and participation in village level organizations. About 87 to 90 per cent of the sample households belonged to general caste, while about 9 to 12 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.

Table 4.1: Socio-economic Characteristics of Sample Households

Particulars	Beneficiary Farmers	Non-Beneficiary Farmers
Number of sample farmer households	150.00	85.00
Average age of respondent (years)	56.87	54.01
Average years of respondent education	9.05	9.13
Agriculture as main occupation (% of respondents)	96.00	97.65
Gender (% of respondents):		
Male	99.0	100.0
Female	1.0	0.0
Average family size (No.)	5.97	5.26
Average number of people engaged in agriculture	2.13	2.25
Average years of experience in farming	30.97	27.60
% of farmers being a member of any association	34.67	25.88
Caste (% of households):		
SC	2.00	0.00
ST	0.00	0.00
OBC	8.67	12.94
General	89.33	87.06

Source: Field Survey

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 land holding was 2.16 ha per household, out of which 2.05 ha of land was under irrigation. It is interesting to note that the non-beneficiary farmers enjoyed better irrigation facility compared to beneficiary farmers by 0.23 ha more per hh. On the other hand, the gross cropped area for non- beneficiary farmers and beneficiary farmers was 2.82 ha and 3.35 ha respectively. The cropping intensity for beneficiary farmers and non-beneficiary farmers was estimated to be 167.3 per cent and 115.6 per cent respectively. Thus, cropping intensity for beneficiary group was higher than non-beneficiary farmers. The land leased-in tendency was found more in case of non-beneficiary group farmers than beneficiary farmers. Since the canal water was available almost free of cost to the non-beneficiary farmers, most of them were

close to minor and sub-minor canals, they used their personal pump sets to draw water from the canal networks, thus had more area under irrigation.

Table 4.2: Operational Landholding of the Sample Households

(Ha/household)

Particulars	Beneficiary Farmers	Non-Beneficiary Farmers	Overall
Owned land	1.84	1.67	1.78
Leased-in	0.17	0.79	0.40
Leased-out	0.01	0.01	0.01
Net operated area (NOA)/ Own area cultivated	2.00	2.44	2.16
Net irrigated area	1.97	2.20	2.05
Net un-irrigated area	0.03	0.10	0.06
Gross cropped area (GCA)	3.35	2.82	3.16
Cropping intensity (%)	167.29	115.62	146.20

Source: Field Survey

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. It can be seen that the number of tractor, harrow, cultivator, electric motors and MIS systems were found more for beneficiary farmers to their counterpart. In case of non-beneficiary farmers, except number of diesel engine, no other assets were found in more numbers compared to beneficiary farmers. 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	21	18
Harrow and cultivator	19	7
Electric motor	11	10
Diesel engine	6	7
Drip system (% of hh)	94.7	3.5
Drip system (Area/hh)	0.73	0.02
Sprinkler system ((% of hh)	10.7	0
Sprinkler system (Area/hh)	0.46	0
Any other	0	0

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. The main purpose of taking loans from banks was seasonal crop cultivation (Table 4.5). About 74 per cent of beneficiary and 98.7 pe cent of non- beneficiary farmers had taken loans for agricultural purposes.

Table 4.4: Agricultural Credit Outstanding by the Sample Households

(Rs/hh)

Sources	Beneficiary Farmers			Non-beneficiary Farmers		
	Amount of loan taken (Rs)	Rate of interest (%)	Amount of loan outstanding (Rs)	Amount of loan taken (Rs)	Rate of interest (%)	Amount of loan outstanding (Rs)
Commercial banks	235115.5	6.9	166880.0	164333.3	4.9	161666.7
Co-operative Credit Societies	143100.1	4.0	132884.1	104210.5	4.3	30912.1
Other banks	0.0	0.0	0.0	62500.0	2.3	37625.0
Government programmes	0.0	0.0	0.0	0.0	0.0	0.0
Informal sources (Money lenders, Traders/Commission agents etc)	0.0	0.0	0.0	0.0	0.0	0.0
Total	109200.0	5.4	91831.1	41305.4	3.8	39547.1

Source: Field Survey

Table 4.5: Purpose of Agricultural Loan Availed

(% to total farmers)

Purpose	No. of Beneficiary farmers	Non-Beneficiary Farmers
Seasonal crop cultivation	74	98.7
Purchase of tractor and other implements, livestock	1	1.3
Consumption expenditure, Marriage and social ceremonies etc.	0	0.0
Total Farmers	75	100.0

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 4.6). For both groups of farmers, tube wells were found to be the major sources contributing about 94.9 per cent of total irrigated area. Thus, groundwater 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.

Table 4.6: Sources of Irrigation

(% of net irrigated area)

Particulars	Beneficiary Area	Beneficiary Farmers	Non-beneficiary Area	Non-beneficiary Farmers	Overall Area	Overall Farmers
Canal	9.92	4.43	9.65	8.33	9.82	5.84
Open/ dug well	0.25	0.63	2.79	5.21	1.17	2.29
Tube- well	89.83	94.94	74.32	77.08	84.22	88.48
Tank	0.00	0.00	0.26	1.04	0.09	0.38
Others	0.00	0.00	12.99	8.33	4.70	3.01
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Field Survey

4.4 Average Area under PINS Project

It may be seen from Table 4.7 that the majority of farmers (68.7%) had area under PINS less than 1 ha. About 23.3% farmers had the PINS area of 1 to 2 ha/ Only 1.3 per cent farmers had PINS area more than 4 ha. On the other hand, the marginal farmers had 0.49 ha area under PINS, on an average (Table 4.8). The small, medium and large farmers had 1.44 ha, 2.63 ha and 6.0 ha area under PINS.

Table 4.7 Distribution of farmers according to area under PINS

(Area in Ha.)

Area under PINS	No. of farmers	% farmers
Up to 1 .0 ha.	103	68.7
1.01-2.0 ha.	35	23.3
2.01 to 4.00 ha.	10	6.7
4.01 to more	2	1.3
Total	150	100.0

Source: Field Survey

Table 4.8. Average area under PINS Project by farmer category

(Area in Ha.)

Farmer category	Area under PINS
Marginal (up to 1.0 ha.)	0.491
Small (1.01 to 2.0 ha.)	1.441
Medium (2.01 to 4.0 ha.)	2.626
Large (4.0 to more)	5.995
Total	0.928

Source: Field Survey

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 Gujarat state. It may be noted from the Table 4.9, about 95.3 per cent of sample beneficiary farmers adopted drip whereas the 10 per cent of them adopted sprinkler in the state. Since the sprinkler system is not very water saving MIS compared to drip system, the same has not been very popular in the state. The average area covered by the farmers under drip and sprinkler was 0.73 ha and 0.46 has per households having access to those systems. The total cost of drip and sprinkler systems was Rs42950 and Rs30133 per household (hh) in the study areas. It was found the average subsidy amount was near about 93 per cent on MIS received by the farmers under tube wells PINS. Some of the farmers had received cent per cent subsidy whereas some other had availed 75 per cent subsidy on MIS. Gujarat Green Revolution Company (GGRC) was the main agency in Gujarat who supplied MIS to the farmers under various subsidy norms.

It is worth-mentioning that about 68.7 per cent of beneficiary farmers receiving subsidy with an average amount of Rs 1842 per hh were from marginal farmer category (Table 4.10). On the other hand, only 1.3 per cent of large farmers received the subsidy with an average of Rs 21230 per hh.

4.9. Adoption of Micro Irrigation Systems (MIS) under PINS Programmes

Type of MIS used	No. of farmers used	%.of farmers used	Average area under MIS (Ha./hh)	Total cost of the system (Rs/hh)	Amount paid the farmers (Rs/hh)	Subsidy (%)	Received subsidy from State Government (%)	Agency for the subsidy programme
Drip system	143	95.33	0.73	42950	3153.2	92.77	95.3	GGRC
Sprinkler	15	10.00	0.46	30133	2233.3	91.33	10	GGRC
Others	0	0.00	0.00	0	0.00	0.00	0	NA

Source: Field Survey

Table 4.10 Distribution of farmers according to subsidy received on MIS

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

Source: Field Survey

4.6 Factors influencing the Adoption of PINS and MIS

As depicted from Table 4.11, the major motivating factors for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation (79.3%), better and stable crop yield and farm income (78.0%), saving more water and to cover more area under irrigation (67.3%), facilitating judicious or efficient distribution of water among the water users (54.7%) and avoiding unnecessary conflicts with other farmers (28.7%).

Table 4.11: Factors influencing the adoption of PINS-MIS

(% of total farmers)

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

Source: Field Survey

4.7 Benefits Accrued by Participating in Water Users Association (WUA)

The water users under tube well command are generally termed as tube well users association (TUA). Different benefits accrued by the beneficiary farmers by participating in TUA are presented in Table 4.12. The water saving due to judicious use of water (94.0%), increase in agricultural income (86.7%), getting water in right time (88.0%), proper distribution of water among farmers (62.7%), getting more information on how to use water judiciously (56.7%), electricity saving (54.0%) and improved maintenance of the system (26.7%) were the major benefits accrued by the beneficiary water users/farmers.

Table 4.12. Benefits accrued by participating in TUA

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

Source: Field Survey

4.8 Farmers' Awareness and perceptions about functioning of WUA/TUA

As far as the farmers' awareness and perceptions about functioning of WUA/TUA are concerned, it was found that about 99.3 per cent of TUA members were aware about the rules and regulations of WUA/TUA (Table 4.13). There were no much political interferences in functioning of WUA/TUA in the study areas. About 98.7 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 (70.7%) pay these fees annually to the office bearers of TUA.

Table 4.13. Farmers' Awareness and perceptions about functioning of WUA/TUA

Particulars	% farmers with positive response
Do you know rules and regulations of WUA?	99.33
Do you know who the office bearers of WUA are?	90.67
Do you see any influence of political parties in selection of office bearers of WUA?	2.00
If yes, whether influential persons in WUA take all major decisions regarding activities of WUA?	2.00
Do you pay operation and maintenance cost of PINS project and water rates regularly?	98.67
If Yes, It is paid:	
Annually	70.67
half-yearly	3.33
Quarterly	10.00
monthly	13.33
As and when required	1.33

Source: Field Survey

4.9 Planning and Installation of PINS and MIS

The details of planning and installations of PINS are presented in Table 4.9. It may be seen that, the entire task of planning and installations has been fulfilled by the representatives of authorized dealers or manufacturers (jain/netafin). The major channel for supply/purchase of MIS equipments/material has been through the dealers (distributors appointed by manufacturers). The fertigation and chemigation practices were followed by about 46.7 per cent of farmers with the average area of 0.79 ha. The proportion of micro irrigated area supplied with insecticides/ herbicides was about 74.7 percent. The water quality testing has been carried out prior to installation of MIS in case of about 25.3 per cent of farmers.

Table 4.14. Planning and Installation of MIS

Particulars	No. of farmers agreed	% farmers agreed
(a) Agencies installed MIS on farmer's field:		
Representatives of authorized dealers or manufacturers (jain/netafin)	150	100
Government Agency (/Extension Agency/ Irrigation Advisory Services/University)	0	0
Private consultants	0	0
Farmers themselves	0	0
Any other (please specify)	0	0
(b) Channel for supply/purchase of MIS equipments/material:		
Through dealers (distributors appointed by manufacturers)	150	100
Through Govt. Agency	0	0
Through local market	0	0
(c) Fertigation and chemigation practices followed:	70	46.67
If yes, Average area under fertigation (Ha.)	0.79	-
Proportion of micro irrigated area supplied with insecticides/ herbicides (percentage)	-	74.69
(d) Used saline water in MIS		
If yes,	7	4.67
% of micro irrigated area affected by saline area	3.79	3.79
(e) water quality testing has been carried out prior to installation of MIS (if Yes)	38	25.33

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 has been stated in Table 4.15 and Table 4. 16. It may be noted that the major heads of expenditure in both the seasons were the land preparatory work and fertiliser/FYM followed by the harvesting cost.

Table 4.15. Annual operating cost of cultivation (A2+FL) with PINS-MIS (Kharif season)

(Rupees per Ha.)

Operating cost	Cotton		Castor		Jowar		Urad	
Land preparatory work	17575.9	(16.0)	14379.8	(20.5)	10286.0	(30.1)	3231.8	(19.8)
Seed and seed sowing	9728.5	(8.8)	7442.9	(10.6)	5641.1	(16.5)	2174.4	(13.3)
Fertilisers/ FYM	26860.3	(24.4)	16521.0	(23.5)	4540.7	(13.3)	3324.1	(20.3)
Pesticides	15684.7	(14.3)	6061.8	(8.6)	1581.1	(4.6)	2353.1	(14.4)
Labour cost on fertiliser/pesticide application	3685.2	(3.3)	2314.5	(3.3)	857.2	(2.5)	157.9	(1.0)
Weeding and interculture	6258.2	(5.7)	5336.8	(7.6)	567.6	(1.7)	1042.5	(6.4)
Labour charges for irrigation	2300.4	(2.1)	3001.3	(4.3)	0.0	(0.0)	0.0	(0.0)
Harvesting cost	27226.4	(24.7)	14378.1	(20.5)	10332.3	(30.3)	3767.9	(23.0)
Others	728.6	(0.7)	799.6	(1.1)	347.5	(1.0)	297.9	(1.8)
Total cost	110048.1	(100.0)	70235.8	(100.0)	34153.5	(100.0)	16349.4	(100.0)

Source: Field Survey

Table 4.16. Annual operating cost of cultivation (A2+FL) with PINS-MIS (Rabi season)

(Rupees per Ha.)

Operating cost	Wheat		R&M		Fennel		Jowar	
Land preparatory work	9256.6	(18.2)	8896.0	(23.9)	16454.1	(21.0)	4726.0	(31.1)
Seed and seed sowing	6192.7	(12.2)	2142.9	(5.8)	6889.2	(8.8)	1598.5	(10.5)
Fertilisers/ FYM	9736.4	(19.2)	7655.4	(20.6)	11060.9	(14.1)	3127.5	(20.5)
Pesticides	3412.3	(6.7)	2136.0	(5.7)	11458.8	(14.7)	0.0	(0.0)
Labour cost on fertiliser/pesticide application	1167.9	(2.3)	825.3	(2.2)	3587.9	(4.6)	0.0	(0.0)
Weeding and interculture	3877.6	(7.6)	1714.3	(4.6)	6854.4	(8.8)	0.0	(0.0)
Labour charges for irrigation	2924.1	(5.8)	2339.8	(6.3)	5212.5	(6.7)	0.0	(0.0)
Harvesting cost	13583.0	(26.7)	10992.6	(29.5)	16627.9	(21.3)	5560.0	(36.5)
Others	638.2	(1.3)	521.3	(1.4)	69.5	(0.1)	208.5	(1.4)
Total cost	50788.8	(100.0)	37223.6	(100.0)	78215.3	(100.0)	15220.5	(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 4.17 and Table 4.18. However, there is no clear cut pattern is observed

among the beneficiary and non-beneficiary farmers with respect to different crops in the study areas. The proportion of area under more remunerative Rabi crops was also found to be higher (53.7% of GCA) in case of beneficiary farmers as compared to non-beneficiary farmers (Table 4.17). However, the proportion of area under Kharif was marginally more (by 3.8 %) among non-beneficiary farmers over beneficiary farmers since the non-beneficiary farmers were more dependent on rainfall. Among the Kharif crops grown by sample farmers, cotton, kharif oilseeds such as castor and paddy were the major crops. Among the Rabi crops, wheat and maize were the major crops. Total summer crops contributed about 1.2 per cent and 0.7 per cent of GCA of the sample beneficiary and non-beneficiary farmers, respectively.

The variations in crop productivity of various crops between beneficiary and non-beneficiary farmers have been presented in Table 4.18. It may be observed that, except few crops like rapeseed-mustard and fennel, beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers.

Table 4.17: Impacts on Cropping Pattern

(Area in Ha per HH)

Sl. No.	Season/ crop	Beneficiary Farmers (BF)		Non- Beneficiary Farmers (NBF)		% Change in BF over NBF
A	Kharif crops					
1	Bajra	0.045	(1.3)	0.040	(1.4)	11.5
2	Jowar	0.057	(1.7)	0.030	(1.0)	90.5
3	Other Cereals (paddy)	0.026	(0.8)	0.040	(1.4)	-34.1
4	Total cereals	0.128	(3.8)	0.110	(3.8)	16.5
5	Tur	0.008	(0.2)	0.000	(0.0)	100.0
6	Urad	0.050	(1.5)	0.040	(1.4)	24.9
7	Moong	0.014	(0.4)	0.020	(0.7)	-32.1
8	Moth	0.008	(0.2)	0.010	(0.3)	-20.1
9	Total Kharif Pulses	0.079	(2.4)	0.070	(2.4)	13.1
10	Groundnut	0.006	(0.2)	0.110	(3.8)	-94.2
11	Sesamum	0.012	(0.4)	0.010	(0.3)	19.9
12	Castor	0.541	(16.1)	0.440	(15.3)	23.0
13	Total Kharif oilseeds	0.559	(16.7)	0.560	(19.5)	-0.1
14	Cotton	0.453	(13.5)	0.470	(16.4)	-3.7
15	Brinjal	0.016	(0.5)	0.000	(0.0)	NA
16	Bottle Gourd	0.016	(0.5)	0.000	(0.0)	NA
17	Lady Finger	0.026	(0.8)	0.000	(0.0)	NA
18	Falsha/Cherries	0.012	(0.4)	0.000	(0.0)	NA
19	Choli	0.002	(0.1)	0.000	(0.0)	NA
20	Bitter Gourd	0.004	(0.1)	0.000	(0.0)	NA

21	Tomato	0.013	(0.4)	0.000	(0.0)	NA
22	Papadi	0.007	(0.2)	0.000	(0.0)	NA
23	Kharif Vegetables	0.096	(2.9)	0.000	(0.0)	NA
24	Lucrean	0.020	(0.6)	0.000	(0.0)	NA
25	Jowar	0.121	(3.6)	0.000	(0.0)	NA
26	Kharif Fodder	0.141	(4.2)	0.150	(5.2)	-5.9
27	Kharif Guar	0.054	(1.6)	0.040	(1.4)	34.9
28	Total Kharif Crops	1.510	(45.1)	1.400	(48.8)	7.9
B	Rabi crops:					
29	Wheat	0.330	(9.8)	0.220	(7.7)	50.0
30	Maize	0.000	(0.0)	0.000	(0.0)	NA
31	Jowar	0.014	(0.4)	0.000	(0.0)	NA
32	Total Rabi Cereals	0.344	(10.3)	0.220	(7.7)	56.5
33	Gram	0.000	(0.0)	0.010	(0.0)	-100.0
34	Moong	0.000	(0.0)	0.010	(0.0)	-100.0
35	Total Rabi Pulses	0.000	(0.0)	0.020	(0.7)	-100.0
36	Total Rabi Oilseeds	0.149	(4.5)	0.320	(11.2)	-53.3
37	Cumin	0.008	(0.2)	0.010	(0.3)	-20.1
38	Fennel	1.190	(35.5)	0.047	(1.6)	2432.4
39	Fenugreek	0.003	(0.1)	0.010	(0.3)	-68.0
40	Dill seeds (Suva)	0.005	(0.2)	0.010	(0.3)	-48.0
41	Coriander	0.002	(0.1)	0.000	(0.0)	NA
42	Others	0.000	(0.0)	0.050	(1.7)	-100.0
43	Total Spices	1.209	(36.1)	0.127	(4.4)	851.7
44	Onion	0.002	(0.0)	0.000	(0.0)	NA
45	Potato	0.000	(0.0)	0.090	(0.0)	-100.0
46	Lady Finger	0.000	(0.0)	0.020	(0.0)	-100.0
47	Other Vegetable	0.006	(0.2)	0.000	(0.0)	NA
48	Total Vegetables	0.008	(0.2)	0.110	(3.8)	-93.1
49	Isabgul	0.000	(0.0)	0.010	(0.0)	-100.0
50	Tobacco	0.037	(1.1)	0.290	(10.1)	-87.2
51	Fodder	0.054	(1.6)	0.040	(1.4)	34.9
52	Other Rabi Crops	0.000	(0.0)	0.310	(0.0)	-100.0
53	Total Rabi Crops	1.801	(53.7)	1.447	(50.5)	24.5
C	Summer/Perennial crops					
54	Jowar	0.000	(0.0)	0.010	(0.3)	-100.0
55	Total Summer Cereals	0.000	(0.0)	0.010	(0.3)	-100.0
56	Sesamum	0.000	(0.0)	0.000	(0.0)	NA
57	Total Oilseeds	0.000	(0.0)	0.000	(0.0)	NA
58	Summer Moong	0.000	(0.0)	0.01	(0.3)	-100.0
59	Pomegranate	0.012	(0.4)	0.000	(0.0)	NA
60	Aonla	0.016	(0.5)	0.000	(0.0)	NA
61	Lemon	0.013	(0.4)	0.000	(0.0)	NA
62	Total Summer Crops	0.041	(1.2)	0.020	(0.7)	103.8
D	Gross cropped area	3.352	(100.0)	2.867	(100.0)	16.9

Note: Figures in parentheses are the percentages of GCA.

Source: Field Survey

Table 4.18. Production Pattern of the Sample Households

(Quintal/Ha.)

Sl. No.	Crops	Beneficiary Farmers(BF)		Non-beneficiary Farmers (NBF)		% change in BF over NBF	
		Irrigated	unirrigated	Irrigated	unirrigated	Irrigated	Unirrigated
A	Kharif crops						
1	Bajra	18.1	–	18.1	–	–	–
2	Jowar	14.6	–	13.4	–	8.0	–
3	Paddy	27.6	–	25.3	–	8.3	–
4	Tur	22.8	–	–	–	–	–
5	Urad	3.7	–	3.1	3.8	17.1	–
6	Moong	2.8	–	–	0.1	–	–
7	Moth	6.0	–	2.3	2.9	22.2	–
8	Groundnut	25.0	–	21.4	–	14.7	–
9	Sesamum	6.7	–	2.2	–	67.5	–
10	Castor	28.6	–	21.1	–	26.4	–
11	Cotton	25.1	–	19.9	–	21.0	–
12	Brinjal	343.6	–	–	–	–	–
13	Bottle Gourd	155.8	–	–	–	–	–
14	Lady Finger	127.3	–	–	–	–	–
15	Falsha/Cherries	34.6	–	–	–	–	–
16	Choli	139.0	–	–	–	–	–
17	Bitter Gourd	100.1	–	–	–	–	–
18	Tomato	573.4	–	–	–	–	–
19	Papadi	129.7	–	–	–	–	–
20	Lucrean	306.9	–	–	60.0	–	–
21	Jowar	288.7	–	170.2	28.8	41.0	–
22	Kharif Fodder	291.3	–	170.2	34.2	41.6	–
23	Kharif Guar	9.9	–	7.8	3.8	21.8	–
B	Rabi crops:						
24	Wheat	31.1	–	27.9	–	10.0	–
25	Maize	–	–	–	–	–	–
26	Jowar	12.5	–	–	–	–	–
27	Rabi Moong	–	–	2.0	–	–	–
28	R&M	14.6	–	14.9	–	-1.6	–
29	Cumin	8.2	–	3.0	–	63.3	–
30	Fennel	11.2	–	31.7	–	-183.0	–
31	Fenugreek	5.4	–	1.8	–	67.3	–
32	Dill seeds (Suva)	10.3	–	11.1	–	-8.3	–
33	Coriander	10.0	–	–	–	–	–
34	Onion	125.1	–	–	–	–	–
35	Potato	–	–	199.1	–	–	–
36	Lady Finger	–	–	41.7	–	–	–
37	Isabgul	–	–	6.3	–	–	–
38	Tobacco	25.3	–	16.9	–	33.1	–
39	Fodder	87.7	–	41.4	–	52.8	–
C	Summer/Perennial crops						
40	Jowar	–	–	16.7	–	–	–
41	Summer Moong	–	–	12.5	–	–	–
42	Pomegranate	89.0	–	–	–	–	–

Source: Field Survey

The production impact of adoption of PINS with various types of MIS over flood method of irrigation is presented in Table 4.19. It may be noted that, among kharif crops, the percentage change in yield under drip over flood and change in yield under sprinkler over flood has been spectacular with respect to castor (117.6% and 102.1%, respectively) and cotton (83.1%). Among Rabi crops, major benefits were observed in the case of wheat (by 83.3% and 108.4%, respectively), fennel (55.1%), rapeseed-mustard (59.9%), and tobacco (by 84.6%).

Table 4.19. Production Impacts of PINS with MIS

(Quintal/Ha.)

Sl No.	Crops	Drip (with PINS)	Sprinkler (with PINS)	Canal/Flood irrigation (both PINS & Non-PINS)	%change in yield under drip over flood	%change in yield under sprinkler over flood
A	Kharif crops					
1	Bajra	-	-	18.08	-	-
2	Jowar	-	-	14.58	-	-
3	Paddy	-	-	27.60	-	-
4	Tur	-	-	22.83	-	-
5	Urad	-	-	3.74	-	-
6	Moong	-	-	2.75	-	-
7	Moth	-	-	6.00	-	-
8	Groundnut	-	-	25.02	-	-
9	Sesamum	-	-	6.67	-	-
10	Castor	30.49	26.48	25.94	117.57	102.11
11	Cotton	24.27	-	29.19	83.14	-
12	Brinjal	455.49	-	135.82	335.36	-
13	Bottle Gourd	262.71	-	43.19	608.23	-
14	Lady Finger	153.46	-	85.40	179.69	-
15	Falsha/Cherries	32.80	-	41.70	78.67	-
16	Choli	-	-	139.00	-	-
17	Bitter Gourd	100.08	-	-	-	-
18	Tomato	573.38	-	-	-	-
19	Papadi	129.73	-	-	-	-
20	Lucrean	-	-	306.91	-	-
21	Jowar	250.20	-	284.92	87.81	-
22	Kharif Fodder	250.20	-	293.04	85.38	-
23	Kharif Guar	6.95	-	10.22	67.97	-
B	Rabi crops					
24	Wheat	26.12	33.99	31.35	83.32	108.42
25	Jowar	-	-	12.51	-	-
26	R&M	10.78	-	18.00	59.87	-
27	Cumin	-	-	8.17	-	-
28	Fennel	7.93	-	14.38	55.12	-
29	Fenugreek	-	-	5.42	-	-

30	Dill seeds (Suva)	–	–	10.26	–	–
31	Coriander	–	–	10.01	–	–
32	Onion	–	–	125.10	–	–
33	Tobacco	22.24	–	26.30	84.56	–
34	Fodder	–	106.57	74.02	–	143.98
C	Summer/Perennial crops					
35	Pomegranate		88.96	–	–	– –

Source: Field Survey

4.12 Impact of PINS and MIS on Irrigated Crop Area

The impact of PINS with MIS on irrigated cropped area is presented in Table 4.20. It may be noticed that the area under drip and sprinkler has been much lower compared to that under flood, the practice which needs to be reversed so as to enhance the water use efficiency and to increase the area under irrigation with help of saved water. Among sample households, the average area under flood was 1.30 ha whereas the area under drip was 0.95 ha. However, in case of some major crops like castor, cotton, kharif vegetables, summer/perennial crops, the area under drip was higher compared to area under flood irrigation.

Table 4.20. Distribution of area under irrigation by type

(Ha/HH)

Sl. No.	Crops	Area under drip	Area under sprinkler	Area under flood	Total Irrigated area
A	Kharif crops				
1	Bajra	0.000	0.000	0.045	0.045
2	Jowar	0.000	0.000	0.057	0.057
3	Other Cereals (paddy)	0.000	0.000	0.026	0.026
4	Total cereals	0.000	0.000	0.128	0.128
5	Tur	0.000	0.000	0.008	0.008
6	Urad	0.000	0.000	0.050	0.050
7	Moong	0.000	0.000	0.014	0.014
8	Moth	0.000	0.000	0.004	0.004
9	Total Kharif Pulses	0.000	0.000	0.075	0.075
10	Groundnut	0.000	0.000	0.006	0.006
11	Sesamum	0.000	0.000	0.012	0.012
12	Castor	0.348	0.020	0.222	0.541
13	Total Kharif oilseeds	0.348	0.020	0.240	0.559
14	Cotton	0.381	0.000	0.070	0.451
15	Brinjal	0.010	0.000	0.006	0.016
16	Bottle Gourd	0.008	0.000	0.008	0.016
17	Lady Finger	0.016	0.000	0.010	0.026
18	Falsha/Cherries	0.010	0.000	0.002	0.012

Table 4.20 Continued...

19	Choli	0.000	0.000	0.002	0.002
20	Bitter Gourd	0.004	0.000	0.000	0.004
21	Tomato	0.013	0.000	0.000	0.013
22	Papadi	0.007	0.000	0.000	0.007
23	Kharif Vegetables	0.068	0.000	0.028	0.096
24	Lucrean	0.000	0.000	0.020	0.020
25	Jowar	0.002	0.000	0.120	0.121
26	Kharif Fodder	0.002	0.000	0.139	0.141
27	Kharif Guar	0.005	0.000	0.049	0.054
28	Total Kharif Crops	0.803	0.020	0.730	1.505
B	Rabi crops:				
29	Wheat	0.030	0.023	0.276	0.330
30	Jowar	0.000	0.000	0.014	0.014
31	Total Rabi Cereals	0.030	0.023	0.291	0.344
32	Total Rabi Oilseeds (R&M)	0.005	0.000	0.112	0.118
33	Cumin	0.000	0.000	0.008	0.008
34	Fennel	0.057	0.000	0.065	0.124
35	Fenugreek	0.000	0.000	0.003	0.003
36	Dill seeds (Suva)	0.000	0.000	0.005	0.005
37	Coriander	0.000	0.000	0.002	0.002
38	Total Spices	0.057	0.000	0.083	0.142
39	Onion	0.000	0.000	0.002	0.002
40	Other Vegetable	0.006	0.000	0.000	0.006
41	Total Vegetables	0.006	0.000	0.002	0.008
42	Tobacco	0.010	0.000	0.028	0.037
43	Fodder	0.000	0.002	0.052	0.054
44	Total Rabi Crops	0.108	0.025	0.568	0.703
C	Summer/Perennial crops				
45	Pomegranate	0.012	0.000	0.000	0.012
46	Aonla	0.016	0.000	0.000	0.016
47	Lemon	0.013	0.000	0.000	0.013
D	All Crops	0.951	0.045	1.298	2.248

Source: Field Survey

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

Table 4.21. Other Economic, Social and Environmental Benefits of PINS with MIS

Sr. No.	Particulars	No. of farmers	% farmers agreed
1	Cultivated land saved due to less need to construct field channels	64	42.7
2	Less maintenance cost compared to conventional flow irrigation	81	54.0
3	Frequency of maintenance is less compared to conventional flow irrigation	41	27.3
4	Reduction in over-extraction of ground water	37	24.7
5	Saving of energy consumption due to sharing through common pump set/PINS	51	34.0
6	Reduction in pressure on pump set/tube well due to less extraction	41	27.3
7	Less water logging or water salinity	89	59.3
8	Less pest attack/Reduced use of pesticides	79	52.7
9	Reduction in fertilizer use	127	84.7
10	Reduction in weeding cost	132	88.0
11	Reduction in labour use	134	89.3
12	Effective allocation of water among farmers	57	38.0
13	Reduction in migration of family members due to more availability in water	20	13.3
14	Increase in social cohesion among the water users/villagers in managing the water	17	11.3

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 Better water management by WUA members (58.0%), better education and awareness of the farmer (43.3%), more area under PINS-MIS (34.0%) and more area during Rabi (37.3%) were the major ones (Table 4.22).

Table 4.22. Determinants of the Benefits accrued by participating in WUA

Benefits accrued	No. of farmers	% farmers benefited
Better education and awareness of the farmer	65	43.33
More area under PINS-MIS	51	34.00
More area during Rabi	56	37.33
More area during summer	32	21.33
More depth of tube well	36	24.00
More Horsepower of pump	35	23.33
No interruption in regular supply of power/electricity	28	18.67
Better water management by WUA members	87	58.00
Any other (in-time water arrival and lower labour cost)	2	1.33

Source: Field Survey

4.15 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 4.23 and Table 4.24. The major suggestions were to impart training to farmers on need, importance and use of MIS with PINS, provide better quality components of MIS so as to reduce the damages caused by rodents (squirrels, rats etc) and insects etc., need to promote fertigation and chemigation, need to take measures to regulate agencies supplying MIS to the farmers and adhering to standard norms on maintaining quality and providing proper and regular services for the repairing of the MIS subsystem within reasonable time limits, need to have more testing facilities for quality checking of equipments, need to provide the required extension advisory services to the farmers, especially on maintenance and applicability of PINS-MIS for different crops.

Table 4.23. Farmer's feedback on the problems faced and lessons learnt in adoption of PINS-MIS

(% farmers agreed)

Particulars	No. of farmers	Problems faced	Lessons learnt, if any
Planning and installation	4	2.67	
Availability of suitable pump sets and system components	1	0.67	Small size pipe
Getting subsidy for the system	1	0.67	Proper work
Quality of various components	5	3.33	
Testing of equipments	9	6.00	To need testing centre nearby village
Water availability and quality	18	12.00	Salty water, high water rate, and they did not get enough water
Energy supply to PINS-MIS	3	2.00	Need to reduce electricity bill and maintenance cost,
Operation and maintenance	16	10.67	Service from agency is very satisfactory
Scheduling of micro-irrigation	1	0.67	
Fertigation and Chemigation	15	10.00	
After sale services by manufacturers	4	2.67	Need to learn repairing work
Damage from rodents (squirrels, rats etc) and insects etc.	31	20.67	Blue bulls

Extension advisory services for farmers, especially for PINS-MIS	4	2.67	
Training of farmers	48	32.00	Farmers need to attain training programme for awareness on the water use

Source: Field Survey

Table 4.24. Farmer's suggestions to improve working and performance of PINS -MIS

Sl. No.	Suggestions	No. of beneficiary farmers	% beneficiary farmers agreed
1	Maintenance and electricity cost is high, thus more subsidy should be given on electricity	6	4.00
2	Drip system is damaged because of animal attack (pig, rat, squirrel, rabit, blue bulls) thus fencing subsidy should be provided.	29	19.33
3	PINs MIS components such as valve, pipes, pump sets, nosals etc. need repairing.	8	5.33
4	farmers are unaware, uneducated about pins benefit so training facility and awareness programme should be provided by the Government.	15	10.00
5	Farmer getting less canal water in summer, thus more canal water supply during summer.	2	1.33
6	Supply of power is not sufficient as per required, thus power supply should be provide for longer duration.	3	2.00
7	Fertigation could not be properly done due to some problems.	6	4.00
8	Farmer demand more canal water since tube well water is becoming very scarce.	13	8.67
9	Service provide by companies (natafim, parixit, jain) unsatisfactory, frequency of their visits is insufficient.	25	16.67
10	Some farmers demand more tubewell to increase irrigation coverage.	18	12.00
11	More farmer or more area should be covered under PINs MIS in the state.	24	16.00
12	water testing facility should be available because water is very saline	15	10.00
13	More soil testing facilities and soil health card should be provided	5	3.33
14	Tillage problems are there due to presence drip, so farmers leave some land as fallow. Better technology required for flexible or easy placement of the drip	6	4.00

Source: Field Survey

Some of the major concerns and suggestions expressed by the non-beneficiary farmers have been stated in Table 4.25. Some of their agricultural areas are located very far from command area. Due to scarcity of irrigation water, they depend only on rain water. Thus they demand to increase coverage of PINS to their area. In some cases, due to less land and monetary problems, they didn't want to install drip in their farm, and they used to irrigate by flood method. Some of the farmers, though having the drip system could not use the same due to defunct tube wells. Some incentives should be given for immediate tubewell repairing.

Table 4.25. Non-beneficiary Farmer's suggestions to improve working and performance of PINS -MIS

Sl. No.	Suggestions	No. of Non-beneficiary farmers	% Non-beneficiary farmers agreed
1	Due to Money problem they could not adopt the system, They demand subsidy to adopt MIS	20	23.53
2	Their Land is very far from command area, Scarcity of water is a big problem they depend only on Rain water, Thus they demand to increase coverage of PINS to their area.	37	43.53
3	Less land so they don't want to install drip in their farm, and they are irrigating by flood method. Strong measures should be taken to discourage flood irrigation.	6	7.06
4	Incentives should be given to change cropping pattern suitable for MIS adoption	8	9.41
5	Drip is successful only in limited crops. Thus farmer demand more UGPL kind of irrigation facilities.	4	4.71
6	Farmer did not get good price of their production. They demand better marketing facility	6	7.06
7	They have drip system but tube well is broken thus could not use drip. Some government incentives should be given for tube well repairing.	8	9.41

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 three types of arrangements where water WUAs are functioning as stated in Table 5.1. Among three types of WUAs, the average life span UGPL system is highest of about 50 years followed by Pvt tube well (TW) PINS of 20 years and Govt TW PINS of about 19 years. Though there was 25 canal PINS implemented in Gujarat state, none of them were found functional. The feeder irrigation source is mainly tube well for all TW PINS and canal for UGPL. All the irrigation projects covered were mainly medium and minor irrigation projects. The average area covered under each PINS WUA was 19.2 ha per Pvt TW PINS, 22.2 ha under Govt. TW PINS and 34.6 ha per UGPL. The major crops grown

during Kharif were cotton, castor and bajra and during Rabi the major crops were wheat, rapeseed-mustard and tobacco.

Table 5.1. Details of Associated PINS Project

Particulars	Govt TW PINS	UGPL	Pvt TW PINS
Average Life Span of the PINS (years)	19.18	50.00	20.00
Feeder irrigation source (% distribution):			
Canal	0.00	100.	0.00
Tube well	100.00	0.00	100.00
Tank	0.00	0.00	0.00
River	0.00	0.00	0.00
Any other	0.00	0.00	0.00
Type of the irrigation project (% distribution):			
Major	0.00	0.00	0.00
Medium	0.00	0.00	0.00
Minor	0.00	100.0	0.00
Total Area covered under the PINS Project WUA (Ha./WUA)	22.23	34.6	19.18
Total number of beneficiaries of the Project/WUA (Average)	25.86	47.00	50.00
Nature of the land in the command area of PINS Project(% distribution):			
Very fertile	86.36	50.00	0.00
Moderately fertile	13.64	50.00	100.00
Less fertile due to salinity	0.00	0.00	0.00
Less fertile due to water logging	0.00	0.00	0.00
Less fertile since exposed to erosion/or for any other reason	0.00	0.00	0.00
Type of cultivation practice (%):			
Plots periodically left fallow	0.00	0.00	0.00
Zero or minimum tillage practiced on it	88.00	8.00	4.00
Crop rotation practiced on it	0.00	0.00	0.00
Crops grown during Kharif (2015)(% of WUAs):			
Cotton	91.67	4.17	4.17
Castor	90.48	4.76	4.76
Bajra	83.33	16.67	0.00
Crops grown during Rabi (2015-16) (% of WUAs):			
Wheat	85.71	9.52	4.76
Rapeseed & Mustard	88.24	5.88	5.88
Tobacco	75.00	12.50	12.50

Source: Field survey

5.3 Capital Cost on PINS Equipments and Installations

The details of capital expenses on tube well PINS by TUA has been shown in Table 5.2. The total expenditure on Tubewell PINS was Rs 2.64 lakhs whereas the expenditure on MIS component was Rs9.87 for all beneficiaries under a single TUA. The per beneficiary expenses on MIS in a TUA was Rs 1.3 lakh on an average, which includes all components of MIS such as drip, sprinkler and all necessary accessories and pipes. It may be seen that the total expenditure on Tubewell PINS was highest in Mehsana (Rs 3.84 lakh) and was lowest in Kutch district (Rs1.51 lakh).

Table 5.2: Details of Capital Expenses on Tube well PINS by TUA

(Rs in Lakh per TUA)

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

Source: GGRC, Vadodara

In case of some WUAs, the farmers had to make one time payment at the time of initiation of PINS WUA, which has been stated in Table 5.3. This amount varied from Rs 13000 to Rs 50 000 depending on area covered per farmer. On an average, it was Rs 29714 per households covered under PINS WUA.

Table 5.3: Capital Cost on PINS per Farmer

Farmer category	Amount spent in Rupees per hh
Marginal (upto 1.0 ha.)	13000
Small (1.01 to 2.0 ha.)	33000
Medium (2.01 to 4.0 ha.)	50000
Large (4.0 to more)	0
Total	29714

Note: only 7 farmers paid by the amount for the PINS and 143 farmers did not pay any amount for the same.

Source: Field Survey

5.4 Annual Operation and Maintenance Cost on PINS

The annual operation and maintenance cost on PINS is presented in Table 5.4. It may be seen that the major component of operation and maintenance cost on PINS was electricity charges and repairing/maintenance of tube well/canal pins, accounting for about 54 per cent and 45 per cent of total operation and maintenance cost, respectively. Among other expenses, the travel expenses of office bearers and office stationeries etc accounting for about 1 to 1.5 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 twice.

Table 5.4. Annual Operation and Maintenance Cost on PINS

(Expenses in Rs)

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

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

Source: Field survey

5.5 Details of PINS-Water Users Association (WUA)/Tube well Users Association (TUA)

The Irrigation Department or Other related Government departments like Gujarat Water Resources Development Corporation (GWRDC) or Sardar Sarovar Narmada Nigam Ltd (SSNNL) mainly acted as facilitator/catalyst for formation of WUA/TUA in the command areas. It may be noticed that about 95.0 per cent of WUA/TUAs were formed directly by the Government department while remaining 5.0 per cent of WUA/TUAs were formed by the community organisers (Table 5.5). The majority of the water users were satisfied over the facilitators in forming WUA/TUA in case of Govt.TW PINS and Pvt. PINS. However, the majority were not

satisfied with the formation of WUA under UGPL since the project is in initial stage and process of formation is also in initial stage. The number of members of WUA/TUA varied between 12 and 28 depending on the type of WUA/TUA. Some members those did not join the WUA/TUA expressed that, they are able to get the water from other sources, for which they did not feel any need to be a member of such association. It is worth-mentioning that about 14 non-members in TUA and 20 members in UGPL are availing facilities of the PINS system mainly due to mutual understanding among these members.

Table 5.5. Details of PINS-Water Users Association (WUA)/Tube-well Users Association (TUA) (Govt. PINS=22, Pvt. PINS=3, UGPL=2)

(% TUA agreed)

Particulars	Govt TW PINS	Pvt TW PINS	UGPL
(a) Who acted as facilitator/catalyst for formation of WUA/TUA:			
Government Department Official	95.5	0.0	100.0
NGO	0.0	0.0	0.0
Community Organizer	4.5	100.0	0.0
Any Other	0.0	0.0	0.0
(b)Satisfaction over the facilitator:			
Good	77.3	66.7	0.0
Average	13.6	33.3	0.0
Poor	9.1	0.0	100.0
(c) Number of members of WUA/TUA (No/WUA)	11.8	16.7	27.5
(d) Number of farmers having land in the PINS Command area but did not become the member of WUA (No/WUA):	3.7	0.0	5.0
(e)Reasons of their not joining the WUA/TUA:			
Don't want to pay anything for PINS Project	0.0	0.0	0.0
PINS Project implementation was defective	0.0	0.0	0.0
Getting water from other sources	95.5	0.0	100.0
Not satisfied with office bearers of WUA/TUA	0.0	0.0	0.0
Belongs to opposite political parties	0.0	0.0	0.0
Don't want to carry out any agricultural operations on their plots	0.0	0.0	0.0
Don't see agriculture remunerative	0.0	0.0	0.0
Any other	4.5	0.0	0.0
(f) Number of non-members of WUA/TUA who avails the facilities of PINS Project	13.5	0.0	19.5

Source: Field survey

5.6 Functioning and Activities of WUA or TUA

As far as the functioning and activities of WUA/TUA is concerned, the no. of general body meetings conducted during 2015-16 was 2 each for TUA and UGPL and once for Pvt. TUA (Table 5.6). The number of decisions taken in the meetings during the year was about three in these associations. It may be noted that none of the WUAs get any annual matching grant from Government for operation and maintenance of PINS project.

Table 5.6. Some aspects of functioning of PINS WUA/TUA
(Responses by WUA office bearers)

Particulars	Govt TW PINS	Pvt TW PINS	UGPL
(a) No. of General Body meetings conducted during 2015-16 (No/WUA)	1.6	1.0	2.0
(b) No. of decisions taken in the meetings during 2015-16	3.2	3.0	2.0
(c) No. of decisions implemented during 2015-16	3.2	3.0	2.0
Is there any influence of political parties in selection of office bearers of WUA (% agreed)	0.0	0.0	0.0
If yes, whether influential persons in WUA take all major decisions regarding activities of WUA? (% agreed)			
Was there any rehabilitation problems generated by Installation of PINS Project (% agreed)	0.0	0.0	0.0
If yes, who did the rehabilitation or construction? :			
Contractor			
WUA			
(c) Does WUA need any assistance for its Management? (% agreed)	6.0	1.0	0.0
If Yes, from whom:			
Government	6.0	1.0	0.0
NGO	0.0	0.0	0.0
CBOs	0.0	0.0	0.0
Others	0.0	0.0	0.0
Does the WUA get any annual matching grant from Government for operation and maintenance of PINS project?	0.0	0.0	0.0
If Yes,	0.0	0.0	0.0
mention the amount (Rs/WUA :	0.0	0.0	0.0

Source: Field survey

Some of the specific activities undertaken by different types of PINS WUA/TUAs are presented in Tables 5.7 to 5.9. Among the major activities, Operation & Maintenance of PINS Project, Deciding the timing of water release, judicious water distribution, Collection of water rates, Collection of per capita operation and maintenance cost were the major activities of Govt. TUAs. However, in case of pvt. TUAs, the operation & maintenance of PINS project and dispute settlements were found to be the major activities. In the case of UGPL, operation & maintenance of PINS project and collection of water rates were found to be the major activities.

Table 5.7. Major activities of Govt. Tube well PINS

(% farmers agreed)

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

Source: Field survey

Table 5.8. Major activities of Private Tube well PINS

(% farmers agreed)

Major activities	Most Important	Important	Least Important
Operation & Maintenance of PINS Project	100.0	0.0	0.0
Deciding the timing of water release	0.0	0.0	0.0
Judicious water distribution	100.0	0.0	0.0
Collection of water rates	0.0	0.0	0.0
Collection of per capita operation and maintenance cost	0.0	100.0	0.0
Dispute settlements	0.0	100.0	0.0
Seed or Fertiliser distribution	0.0	0.0	0.0
Produce collection	0.0	0.0	0.0
Money lending to members	0.0	0.0	0.0
Any other	0.0	0.0	0.0

Source: Field survey

Table 5.9. Major activities under UGPL Programme

(% farmers agreed) (No-2)

Major activities	Most Important	Important	Least Important
Operation & Maintenance of PINS Project	50.0	0.0	50.0
Deciding the timing of water release	0.0	50.0	0.0
Judicious water distribution	50.0	0.0	0.0
Collection of water rates	100.0	0.0	0.0
Collection of per capita operation and maintenance cost	0.0	50.0	0.0
Dispute settlements	0.0	0.0	0.0
Seed or Fertiliser distribution	0.0	0.0	0.0
Produce collection	0.0	0.0	0.0
Money lending to members	0.0	0.0	0.0
Any other	0.0	0.0	0.0

Source: Field survey

5.7 Details of Income and Expenditure of WUA

The details of income and expenditure of different types of WUA/TUA is presented in Table 5.10. The main source of income for these TUAs were annual maintenance fees collected whereas the major heads of expenditures were the Expenditure on electricity bill, repairing expenses, salary expenses. Besides, in case of PINS, the charges to Irrigation Department and some miscellaneous expenses were incurred by the WUA/TUAs.

There were some members of TUA/WUA who could not pay their due in time. The office bearers of these TUA/WUAs were asked about the causes of such kind of behaviour of some members of their TUA/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 (iii) crop failure due to various reasons (Table 5.11).

Table 5.10: Details of income and expenditure of WUA

(Amount in rupees per WUA in 2015-16)

Particulars	Govt TW PINS	Pvt TW PINS	UGPL
Inflow to the account (Income):			
Water rate collection	0	0	0
Annual maintenance fees collected	186411	205900	10000
Annual electricity/diesel fees collected	0	0	0
Earnings from business activities of the WUA, if any (e.g., sale of fertilizers)	0	0	0
Interest income	0	0	0
Loans from banks or individuals	0	0	0
Any other	0	0	0
Total Income	186411	205900	10000
Outflow from the account (expenses):			
Charges to Irrigation Department	4888	0	0
Expenditure on electricity bill	82364	90900	0
Repairing expenses	58355	75000	0
Salary expenses	34727	40000	0
Travel and Conveyance expenditure	0	0	0
Audit expenses	0	0	0
Loan repayment/interests paid	0	0	0
Office rent	0	0	0
Miscellaneous expenses	6523	0	10000
Any other	0	0	0
Total Expenditure	186411	205900	10000

Source: Field survey

Table 5.11 Reasons for non-payment of operation and maintenance costs of PINS

(% WUA office bearer agreed)

Reasons	Govt TW PINS
Did not get enough water	100.0
MIS system did not work	0.0
PINS Project implementation was defective and did not work	0.0
Not satisfied with maintenance of the system	100.0
Crop failure due to natural calamities	50.0
Crop failure due to pest attack	50.0
Crop output was not sold in time	0.0
Good price of crop output was not realized	0.0
Heavy household consumption	0.0
Any other (please mention)	0.0

Source: Field survey

5.8 Relationship of WUA with related Organisations

It was observed that office bearers of the WUA have maintained good relationship with various associated departments and organisations as stated in Table 5.12.

Table 5.12: Relationship with the Government Departments and Other Organizations

(% WUA office bearer agreed)

Particulars	Good	Average	Poor
(A) Govt TW PINS			
Public Works Department	100.00	0.00	0.00
Irrigation Department	100.00	0.00	0.00
Department of Agriculture	100.00	0.00	0.00
(B) Pvt TW PINS			
Public Works Department	0.00	0.00	0.00
Irrigation Department	0.00	0.00	0.00
Department of Agriculture	0.00	0.00	0.00
(C)UGPL			
Public Works Department	100.00	0.00	0.00
Irrigation Department	100.00	0.00	0.00
Department of Agriculture	100.00	0.00	0.00

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 5.13). However, in case of Pvt. TUA, arrival of water in time, proper distribution of water among farmers and water saving were the prominent ones. Since the PINS system was shared among the participating members, the electricity and labour costs were also shared among them which were highly beneficial to them.

Table 5.13. Benefits accrued by the members of WUA

(% of WUA/TUA office bearers agreed)

Benefits accrued	Govt TW PINS	Pvt TW PINS	UGPL PINS
(a) Water arrives in time	95.5	100.0	100.0
(b) More information on when water arrives	36.4	0.0	0.0
(c) More information on how to use water judiciously	50.0	33.3	50.0
(d) proper distribution of water among farmers	59.1	100.0	100.0
(e) Less conflicts around water	31.8	0.0	0.0
(f) Nil or Less water theft	22.7	0.0	50.0
(g) More information on crops and technologies	0.0	0.0	0.0
(h) Improved maintenance of the system	13.6	33.3	50.0
(i) environmental problems such as water logging and salinity resolved compared to pre-WUA period	0.0	0.0	0.0
(j) Quality of groundwater improved due to less extraction compared to pre-WUA period	4.5	0.0	0.0
(k) Enhanced financial situation	4.5	33.3	0.0
(R) Any Other	0.0	0.0	0.0
(i) Water Save	63.6	100.0	50.0
(ii) Electricity save	36.4	0.0	0.0
(iii) Labour cost reduce	31.8	0.0	0.0
(iv) Increased irrigated area	18.2	0.0	0.0
(v) Fertiliser Cost reduce	9.1	0.0	0.0
(vi) Time saving	9.1	0.0	0.0

Source: Field survey

5.10 Water Resource Management by WUA/TUA

Some questions were asked to the water users regarding various aspects of water resource management by WUA/TUA (Table 5.14). In case of all Govt WUAs/TUAs, the irrigation management was transferred to WUA/TUAs. In all cases, WUAs were performed the duty of proper water distribution of water among the farmers in the command area. All the WUAs also collected the water rates and the operation and maintenance cost of PINS projects. However, in some UGPL WUAs, farmers directly paid the water rates to the Irrigation Department. The periodicity of the collection the operation and maintenance cost of PINS project was normally carried out annually.

As far as the sufficiency of irrigation water is concerned, about 82 per cent of Tubewell WUAs, all the Private WUAs and 50 per cent UGPL WUAs agreed that they are getting sufficient water after formation of WUA (Table 5.15).

Table 5.14: Water Resource Management by WUA/TUA

(% WUA office bearer agreed)

Particulars	Govt TW PINS	Pvt TW PINS	UGPL PINS
Is the Irrigation Management Transferred to WUA/TUA?	100.0	-	100.0
Who does the water distribution?			
TUA/WUA	100.0	100.0	100.0
Individual farmers	0.0	0.0	0.0
Is the water rates and the operation and maintenance cost of PINS project are being collected by WUA/TUA?	100.0	100.0	50.0
Whether the operation and maintenance cost of PINS project and water rates are paid by its member regularly?	95.5	100.0	100.0
If Yes, periodicity of its collection the operation and maintenance cost of PINS project:			
Annually	95.5	0.0	100.0
half-yearly	0.0	0.0	0.0
Quarterly	0.0	0.0	0.0
monthly (As and when required)	0.0	100.0	0.0

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 5.16). Some farmers expressed that existing minor conflicts among the water users related to water distribution have resulted in water shortage to their fields (Table 5.17).

Table 5.15. Sufficiency of irrigation water for the TUA/WUA members

Particulars	Govt TW PINS	Pvt TW PINS	UGPL PINS
Do WUA members get sufficient water throughout the year (% WUA members agreed)	81.82	100.00	50.00
If No, Average no. of months of insufficient water	4	0	6

Source: Field survey

Table 5.16 Reasons for inadequate supply of water to the farm plot

(N = Govt. PINS 4 and UGPL 1)
(% WUA office bearer agreed)

Reasons	Govt TW PINS	UGPL
Water availability is inadequate in canal/tube well	0.0	100.0
PINS system is not functioning properly	100.0	0.0
PINS system was not managed properly	0.0	0.0
Non-payment of water rate and maintenance charges by the member	0.0	0.0
Unresolved conflicts among WUA members	0.0	0.0
Poor rainfall	25.0	100.0
Any other	0.0	0.0

Source: Field survey

Table 5.17. Causes of conflicts among water users

(% WUA office bearer agreed)

Reasons	Govt TW PINS	Pvt TW PINS	UGPL
Water availability is inadequate	9.09	100.00	0.00
Mismanagement / Partiality in water distribution by WUA members	0.00	0.00	0.00
Unresolved conflicts among WUA members	0.00	0.00	0.00
Different political affiliation of WUA office bearers and WUA member	0.00	0.00	0.00
Any other (please elaborate)	0.00	0.00	0.00

Source: Field survey

5.11 Constraints in Operation and Maintenance (O&M) of PINS at WUA level

WUAs/TUAs 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 5.18. It may be seen that among these constraints, the funds constraints, unavailability of required quantity of water, unavailability of proper maintenance and repairing services and electricity problems are the major ones.

Table 5.18. Major problems faced in O&M by the WUA

(% WUA office bearer agreed)

Constraints	Govt TW PINS	Pvt TW PINS	UGPL
Fund constraints	27.27	0.00	50.00
Water availability	13.64	100.00	0.00
Maintenance and repair of PINS	77.27	100.00	50.00
Support from Govt.	4.55	0.00	0.00
Poor participation of WUA members	4.55	0.00	0.00
Non-participation of farmers in the command area	4.55	0.00	0.00
Unsolved conflicts	0.00	0.00	0.00
Political interference	0.00	0.00	0.00
Any other(please mention)			
(i) Electricity problem	13.64	100.00	0.00
(ii) Animal problem	27.27	0.00	0.00
(iii) Theft problem	9.09	0.00	0.00
(iv) Promoting company problem	13.64	0.00	0.00

Source: Field survey

The analysis of the problems faced by the WUAs under different set up has been presented in Tables 5.19 to 5.21. It may be noticed from the Table 5.19 that the situation has improved a lot in case of Govt- Tube wells PINS such as inter and intra village conflicts, labour shortage issues and salinity problem. In case of Pvt- Tube well PINS, the crop yield has improved a lot. In case of UGPL, crop yield has improved but water logging problems have also increased. It may be noticed that, in all three cases, the value of agricultural production has increased significantly, while the area effect has been significant in case of Govt. Tube wells and Pvt Tube wells, not in the case of UGPL.

Table 5.19. Constraints faced by the WUA (Govt- Tube wells PINS)

(% WUA office bearer agreed)

Constraints	More	Less	No
Before WUA formation:			
Water logging	0.00	0.00	100.00
Salinity	90.91	4.55	4.55
Tank /dug well pollution	0.00	0.00	100.00
Groundwater pollution	0.00	4.55	95.45
Labour problems	81.82	13.64	4.55
Inter and Intra village conflicts	31.82	45.45	22.73
Crop yields	0.00	100.00	0.00
Irrigated area (Ha)	18.12	0.00	0.00
Value of Agricultural production (Rs/Ha)	109178.2	0.00	100.00
After WUA formation:			
Water logging	0.00	0.00	100.00
Salinity	9.09	45.45	45.45
Tank /dug well pollution	0.00	0.00	100.00
Groundwater pollution	0.00	4.55	95.45
Labour problems	18.18	68.18	13.64
Inter and Intra village conflicts	0.00	45.45	54.55
Crop yields	95.45	4.55	0.00
Irrigated area (Ha)	21.75		
Value of Agricultural production (Rs/Ha)	213017.5	0.00	0.00

Source: Field survey

Table 5.20. Constraints faced by the WUA (Pvt- Tube well PINS)

	(% WUA office bearer agreed)		
Constraints	More	Less	No
Before WUA formation:			
Water logging	0.00	0.00	100.00
Salinity	0.00	0.00	100.00
Tank /dug well pollution	0.00	0.00	100.00
Groundwater pollution	0.00	0.00	100.00
Labour problems	0.00	100.00	0.00
Inter and Intra village conflicts	0.00	100.00	0.00
Crop yields	0.00	100.00	0.00
Irrigated area (Ha)	15.5	0.00	0.00
Value of Agricultural production (Rs/Ha)	111756	0.00	0.00
After WUA formation:			
Water logging	0.00	0.00	100.00
Salinity	0.00	0.00	100.00
Tank /dug well pollution	0.00	0.00	100.00
Groundwater pollution	0.00	0.00	100.00
Labour problems	0.00	0.00	100.00
Inter and Intra village conflicts	0.00	100.00	0.00
Crop yields	100.00	0.00	0.00
Irrigated area (Ha)	22.18	0.00	0.00
Value of Agricultural production (Rs/Ha)	187333	0.00	0.00

Source: Field survey

Table 5.21. Constraints faced by the WUA (UGPL PINS)

	(% WUA office bearer agreed)		
Constraints	More	Less	No
Before WUA formation:			
Water logging	0.0	50.0	50.0
Salinity	100.0	0.0	0.0
Tank /dug well pollution	0.0	0.0	100.0
Groundwater pollution	0.0	0.0	100.0
Labour problems	100.0	0.0	0.0
Inter and Intra village conflicts	100.0	0.0	0.0
Crop yields	0.0	0.0	100.0
Irrigated area (Ha)	23.98	0.0	0.0
Value of Agricultural production (Rs/Ha)	133440	0.0	0.0
After WUA formation:			
Water logging	50.0	0.0	50.0
Salinity	100.0	0.0	0.0
Tank /dug well pollution	0.0	0.0	100.0
Groundwater pollution	0.0	0.0	100.0
Labour problems	0.0	0.0	100.0
Inter and Intra village conflicts	0.0	100.0	0.0
Crop yields	100.0	0.0	0.0
Irrigated area (Ha)	23.98	0.0	0.0
Value of Agricultural production (Rs/Ha)	172638	0.0	0.0

Source: Field survey

Chapter VI

Summary and Conclusions

6.1 Introduction

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 new concept which was initiated in the state of Gujarat during the period of developing the command area of Sardar Sarovar Narmada Project. 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. 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, 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.

Thus the major objectives of the study are:

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

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.

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

For Gujarat state, the data was collected from three selected districts, viz., Mehesana, Patan and Gandhinagar. PINS were selected from both surface irrigation command areas (mainly canal) and groundwater irrigation command areas (mainly tube well). 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.

6.2 Summary of Findings

6.2.1 Irrigation Development and Management in Gujarat

The state of Gujarat is situated on the western side of India covering an area of 196,024 sq. Km. Almost one third of the coastline of the Indian sub-continent belongs to Gujarat. The major rivers flowing in Gujarat are Narmada, Sabarmati, Tapi, Purna, Damanganga, Rukmavati etc. The Government of Gujarat has been giving due attention to accelerate the pace of water resources development in the state so as to increase the net water availability by creating additional storage, completion of ongoing projects, improvement in water use efficiency, bridging

the gap between the potential created and its utilization, restoration and modernization of old irrigation system, conjunctive use of ground and surface water, promoting participatory irrigation management, large scale people's participation in water conservation programmes and inter-basin transfer of water.

Gujarat government has played an important role in developing physical infrastructure for agriculture, namely irrigation, power and roads. The state has about 104 lakh ha under cultivation of which about 65 lakh ha is estimated to have irrigation potential through surface and groundwater sources. This indicates that through proper water resource development planning about 63 percent of the net cultivated area could be brought under irrigation. The ultimate irrigation potential through the surface water is assessed at 39.40 lakh hectares which includes 17.92 lakh hectares through Sardar Sarovar Project. Similarly in respect of ground water resources, it is estimated that about 25.48 lakh hectares (about 25 per cent of net cultivated area) can be irrigated. Thus, total ultimate irrigation potential through surface and ground water is estimated to be 64.88 lakh hectares. Up to June 2012, the state has created about 33.33 lakh ha of irrigation potential while about 74.98 per cent of total irrigation potential created has been utilized.

Gujarat farmers rely on different sources of irrigation that include canals, tube wells, open wells and tanks. Though there was significant increase in area irrigated by canal and tube wells in the state (each increased by 2.1 times between 1980-81 to 2007-08) in absolute term, the share of area irrigated by canal in net irrigated area has remained unchanged at the level at about 19 per cent during the period 1980-81 and 2007-08 whereas irrigated area through tube wells and open wells has slightly declined from 79.32 per cent in 1980-81 to 78.02 per cent in 2007-08. Thus, still the tube wells and open wells have been the major sources of irrigation in the state.

Progress in Participatory Irrigation Management

For promoting PIM in the state, the Government has decided to cover maximum possible command area under PIM. The Government has also passed "Gujarat Cooperatives and Water Users Participatory Irrigation Management Act-2007".

The Government has taken up initiative to involve beneficiaries and stakeholders in irrigation management by enacting PIM Act in 2007. Under the provisions of this Act, Water Users' Association (WUA) is formed from amongst the beneficiary farmers in command area of an irrigation project. About 90 per cent of cost for community mobilization is borne by the Government. Rehabilitation of canals is completed by the Government before handing over to WUAs. The WUA contributes 10 per cent of the rehabilitation cost. Under this scheme 21215 ha has been covered during the year 2011-12. As of today 1834 WUAs have been established in the command area of various irrigation projects and about 4.29 lakh hectare area has been served by these WUAs under PIM. The state accounts for about 12.9 percent share in total WUAs formed at the national level which covered about 3.33 percent national handed over area.

6.2.2. Overview of PINS Programme in Gujarat

Gujarat State has been one of the front runners among states in India in promoting PINS. In fact, the concept of Pressurized Irrigation Network System (PINS) was developed at Design Office of Sardar Sarovar Narmada Nigam Limited (SSNNL) with the necessity of introduction of MIS in the command area of SSP. The Government of Gujarat has put in lots of efforts to replace conventional irrigation by micro irrigation so as to improve water use efficiency and to increase area under irrigation in the state. With the pilot project on Pressurized Irrigation Network System (PINS), about 25 pilot projects were initiated in the state covering 1029 farmers with 1491.6 ha of CCA and estimated budget of Rs 1306.3 lakh. The project work was carried out by Jain Irrigation Ltd (56%), Parikhit Industries (32.0%), EPC Industries (8.0%) etc. For encouraging the adoption of MIS, 50 to 75 per cent subsidy was provided to the farmers and necessary credit facilities were also provided to the farmers for purchasing the MIS.

The average spending on an individual PINS varied from Rs 10.0 lakhs to 63.0 lakhs depending on the size of PINS and the pumpset installed and length of pipelines used for PINS project. The average spending incurred per PINS was Rs 35.4 lakhs against the estimated Rs52.3 lakhs. The estimated per hectare expenditure on PINS at Chak level was Rs 20340. Taking the Rs 20340, being the

lower, as the average capital cost per hectare on PINS, the payback period on investments made by the farmers on cotton cultivation with adoption of PINS and drip systems varies from 1.7 years to 2.8 years depending on location specific factors in the state.

It is worth mentioning that both water savings and energy savings are estimated to be higher in case of tube well PINS with drip compared to tubewell with flood irrigation or surface with flood irrigation. Water savings by use of MIS with PINS is realised to the tune of 50 to 75%, whereas the energy savings by the same is realised to the tune of 25 to 76 per cent.

Bottlenecks in Adoptability and Promotion of Canal PINS

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

Under Ground Pipe Line (UGPL) System in Gujarat

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

The underground pipeline system (UGPL) facilitates the supply of water through underground pipelines from the minor or sub-minors upto the centre of Chak or sub-Chak from where water distributed to farmers field who can use

flood method of irrigation or micro irrigation. Thus, the UGPL system can be combined with PINS for effective management of irrigation water while taking care of farmers' preferences for different cropping pattern. The per hectare cost for of UGPL and PINS is maximum of Rs 78004 compared to all other combinations. However, it has potential to generate better results too.

So far, the UGPL work has been completed in 2.58 lakh ha of 5441 Chaks in 61 talukas of the state. Additionally, the UGPL work is in progress in about 3.06 lakh ha covering a total length of pipelines of 88.84 lakh metres in 7164 Chaks which is a record in the history of Irrigation Infrastructure Development in India.

The major benefits of UGPL system are the land saving and water saving (up to 10-20 %), less implementation period, feasibility even in flood zone / undulating area, avoidance of land fragmentation, integrating field channels with the sub-minors and less O & M expenditure. Moreover, there are some issues in implementation of UGPL in sub-minors. Farmers were not willing to pay 10%, their contribution, which was later on reduced to 2.5%. Farmers are continuously growing some crops and hence not willing to allow laying of UGPL. The farmers are demanding for some provision of crop compensation in that case. Pipe suppliers are unable / not willing to supply in sufficient quantity at reasonable rates. It is becoming difficult to persuade them to maintain regular supply.

Progress and Expenditure Pattern on Tube well PINS

Among three types of water sources, tube well is the major source of water for successful PINS operation in the Gujarat state. The Government of Gujarat introduced the policy of pressurized irrigation system in the command area of public tube wells under Gujarat Water Resources Development Corporation (GWRDC). As per the Government norms, Micro Irrigation System (MIS) provided in the command area of 309 tube wells covering 1452 ha in five districts of the state i.e. Banaskantha, Mehsana, Patan, Gandhinagar and Sabarkantha. The State Government has decided in March 2013 to provide MIS in Government tube wells at 100% Government cost in total nine districts including above five of North Gujarat and Ahmedabad, Surendranagar, Rajkot and Kutch. Accordingly the State

Government provided MIS system in 162 tube wells in 2013-14 covering 1531 Ha and 1037 farmers. The MIS works covering 2984 Ha. of 3780 farmers were in progress in 208 tube wells which was likely to be completed in 2014-15. It was planned to take up and complete MIS in 542 tube wells in 2015- 16. Thus, overall 1221 tube wells of nine districts were planned to be provided MIS covering 13982 ha.

Among different agencies associated with supplying MIS and components of PINS, Jain Irrigation was the major one. It covered about 197 tube wells covering 1388 beneficiaries with 1904 ha of land. On an average, 09 farmers were covered beneficiaries were covered under each Tube well Water Users Association (TUA) with average area of 11 ha per TUA.

The Tubewell PINS have been adopted in a much better and sustainable manner in Gujarat and has a wide coverage. As revealed from focussed group discussion with the farmers, the higher maintenance cost and energy cost has discouraged the farmers in increasing its further adoption.

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

The major motivating factors for the beneficiary farmers for adoption of PINS-MIS were to get assured amount of water for irrigation (79.3%), better and stable crop yield and farm income (78.0%), saving more water and to cover more

area under irrigation (67.3%), facilitating judicious or efficient distribution of water among the water users (54.7%) and avoiding unnecessary conflicts with other farmers (28.7%).

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

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

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

Some of the factors those helped in generating some benefits as discussed in preceding section were better water management by WUA members (58.0%), better education and awareness of the farmer (43.3%), more area under PINS-MIS (34.0%) and more area during Rabi (37.3%) were the major ones.

The major suggestions provided by the farmers were to impart training to farmers on need, importance and use of MIS with PINS, provide better quality components of MIS so as to reduce the damages caused by rodents (squirrels, rats etc) and insects etc., need to promote fertigation and chemigation, need to take measures to regulate agencies supplying MIS to the farmers and adhering to

standard norms on maintaining quality and providing proper and regular services for the repairing of the MIS subsystem within reasonable time limits, need to have more testing facilities for quality checking of equipments, need to provide the required extension advisory services to the farmers, especially on maintenance and applicability of PINS-MIS for different crops.

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

6.2.5 Adoption, Performance and Management of PINS by WUAs

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

The total expenditure on Tubewell PINS was Rs 2.64 lakhs whereas the expenditure on MIS component was Rs9.87 for all beneficiaries under a single TUA. The per beneficiary expenses on MIS in a TUA was Rs 1.3 lakh on an average, which includes all components of MIS such as drip, sprinkler and all necessary accessories and pipes. As far as annual operation and maintenance cost is concerned, the major component of operation and maintenance cost on PINS was electricity charges and repairing/maintenance of tube well/canal pins, accounting for about 54 per cent and 45 per cent of total operation and maintenance cost, respectively.

Some of the specific activities undertaken by different types of PINS WUA/TUAs have been discussed. Among the major activities, Operation & Maintenance of PINS Project, Deciding the timing of water release, judicious

water distribution, Collection of water rates, Collection of per capita operation and maintenance cost were the major activities of Govt. TUAs. However, in case of pvt. TUAs, the operation & maintenance of PINS project and dispute settlements were found to be the major activities. In the case of UGPL, operation & maintenance of PINS project and collection of water rates were found to be the major activities.

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

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

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

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

6.3 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 present study has examined some aspects of working of PINS at different levels. During the survey, the sample farmers have also given some useful feedbacks which have been discussed earlier. Besides, some additional suggestions those came out of the study are discussed below.

- Though the State Government has followed an innovative approach by developing and implementing the concept of PINS, the existing practices of farmers such as relying more on conventional flow method for irrigation did not change much due to some specific reasons. The farmers did not want to change the cropping pattern which was highly water intensive. Thus, it is necessary to discourage more water consuming cropping pattern, by encouraging suitable cropping pattern through some incentive structure.
- It was found that the farmers did not want to spend anything on MIS since canal water was available to them almost free of cost. Thus, it is suggested to revise the water rate which is very less and strict rules and regulations should be enforced to check the illegal use of canal water and water theft.
- Farmers having land at favourable locations (canal vicinity) do not find it to be a lucrative proposition. One of the major factors that contributed to less adoption of canal PINS in the state was that, PINS Projects were located very close to minors or sub minors, from where farmers are able to get water in alternative ways. Thus, it is suggested to re-lunch this canal PINS programme by locating these projects at far off places where farmers are struggling to get irrigation water. Though it involves little more investments in term of infrastructure expenditure, the adaptation and long-term sustainability would be surely achieved just like the success of PINS projects in Sanchore region in Rajasthan.

- The areas where PINS+MIS is techno-economically not feasible, normal/conventional flow irrigation as per present SSNNL policy may be allowed to continue.
- Majority of sample farmers were are marginal with small land holdings who faced difficulties in getting bank loans due to incomplete land documents and other outstanding debts. The measures may be taken to provide affordable credit facilities to small and marginal farmers.

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Annexure I: Salient Features of Agro Climatic Zones in Gujarat State

Zone	Climate	Districts Covered	Rainfall (mm)	Major Crops	Soil
South Gujarat (Heavy Rain Area.)	Semi-arid to dry sub-humid	Navsari, Dang, Valsad and Valod, Vyara, songadh and Mahuva taluks of Surat.	1500 and more	Rice, Sorghum, Ragi, Kodra, Seasamum, Pigeonpea, Groundnut,Cotton, Sugarcane, Chillies, Wheat, Gram	Deep black with few patches of coastal alluvial, laterite and medium black
South Gujarat	Semi-arid to dry sub-humid	Surat and Amod, Ankleshwar, Broach, Dekdopada, Honsot, Jhagadia, Nanded, Sagbara and Valia talukas of Bharuch.	1000-1500	Rice, Wheat, Gram, Perlmillets,Sorghum, Maize, Kodra, Ragi, Pigeonpea, groundnut, Sesamum, Castor, Cotton, Sugarcane, Chillies,	Deep black clayey
Middle Gujarat	Semi-arid	Panchmahals, Baroda and Anand, Balasinor, Borsad, Kapadvanj, Kheda, Matar, Ahmedabad, Nadiad, Petlad and Thasara and taluks of Kheda.	800-1000	Rice, Wheat, Gram, Perlmillets,Sorghum, Maize, Kodra, Ragi, Pigeonpea, groundnut, Sesamum, Castor, Cotton, Sugarcane, Potato, Rapeseed & Mustard.	Deep black, medium black to loamy sand
North Gujarat	Arid to semi-arid	Sabarkantha, Gandhinagar, Dehgam, Daskroi, Sanand talukas of Ahmedabad, Deesa, Dhenera, Palanpur, Dandta, Wadgam taluks of Banaskantha and Chanasma, Kadi, Kalol, Kheralu, Mehsana, Patan, Sidhpur, Visnagar, Vijapur taluks and Mehsana.	625-875	Rice, Wheat, Gram, Perlmillets,Sorghum, Maize, groundnut, Sesamum, Castor, Cotton, Sugarcane, Cumin, Rapeseed & Mustard.	Sandy loam to sandy
Bhal & Coastal Area	Dry sub-humid	Bhavnagar (Vallabhipur, Bhavnagar talukas), Ahmedabad (Dholka, Dhanduka talukas), and Vagra, Jambusa talukas of Bharuch.	625-1000	Rice, Pearl millets.	Medium black, poorly drained and saline
South Saurashtra	Dry sub-humid	Junagadh, Ghodha, Talaja, Mahava taloukas of Bhavnagar Kodinar, Rajula and Jafrabad talukas of Amerli and Dhoraji, Jetpur, Upleta talukas of Rajkot.	625-750	Rice, Maize, Sugarcane Wheat, Gram Pearl millets ,Sorghum, Groundnut, Seasamum,Cotton, Pulses, rapeseed & mustard	Shallow medium black calcareous
North Saurashtra	Dry sub-humid	Jamnagar, Rajkot, Chotila, Limdi, Lakhtar, Muli, Sayla, Wadhwan talukas of Surendranagar and Gadheda, Umrala, Botad, Kundla, Dihor, Garidhar, Palitana talukas of Bhavnagar and Amreli, Babra, Lathi, Lalia, Kunkavav, Khamba, Dhari taluks of Amreli.	400-700	Pearlmillets, Sorghum, Groundnut, Seasamum, Castor, Cotton, Pulses.	Shallow medium black
North West Zone	Arid to semi-arid	Kutch, Rajkot, Malia Halvad, Dhrangdhra, Dasada taluks of Surendranagar, Sami and Harij taluks of Mahsana, Santhalpur, Radhanpur, Kankrej, Deodar, Vav, Tharad taluks of Banaskantha and Viramgam taluka of Ahmedabad.	250	Rice, Wheat, Gram, Perlmillets,Sorghum, Maize, Pigeon pea, groundnut, Sesamum, Castor, Cotton, Rapeseed & Mustard , barley.	Sandy and saline

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Govt. of Gujarat, Gandhinagar

Appendix I:

Reviewer Comments on the Draft Report

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

1.	Title of report	**"Working of Pressurized Irrigation Network Systems (PINS) in Gujarat "**
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	The authors have satisfied the objectives of the study
5.	Comments on the methodology	The sampling and methodology used is accepted.
6.	Comments on analysis, organization, presentation etc.	The report reveals that detailed field work has been undertaken. However, Table 4.18 and pages 89, 91 and 92 need to be checked. In page 89 it is mentioned that "it may be observed that except few crops like groundnut, mung, cumin, beneficiary farmers had enjoyed better crop yields as compared to non-beneficiary farmers". However, from Table 4.18, it can be observed that for moong the production is 2.7 quintals for beneficiaries and 0 for non-beneficiaries Again in case of groundnuts, the yield for beneficiaries is 25 quintals per hectare but for non-beneficiaries the yield is 2.3 quintals per hectare. So beneficiaries have much higher yield. In case of cumin also the yield for beneficiaries is 8.2 quintals per hectare and 0.0 for non-beneficiaries though area is 0.01 hectare.Therefore the statement on p 89 as mentioned above may be checked. From Table 4.18, p 91, it is observed that for beneficiaries for total kharif the yield is 61.1 quintals per hectare while for non-beneficiaries it is 104.1 quintals per hectare. Similar case with rabi and summer crops. Further how is production

in quintals per hectare calculated for total kharif, total rabi, total summer and all crops is not known. In case of all crops yield is 50.7 quintals per hectare for beneficiaries and 154.30 quintals per hectare for non-beneficiaries. Was not able to comprehend what unirrigated stands for in Table 4.18. If non-beneficiary sample is indicating higher yields than beneficiary sample, then what are implications for policy and PINS.

Even Table 4.17 may be checked. For example (p 90) while area under fennel for non beneficiary farmers shows 0.00, the yield is shown as 1.5 quintals per hectare in Table 4.18 (p 91).

In Table 4.19, the production per quintal/hectare is 24.64 for cotton with drip-PINS and much higher for canals/flood at 74.41.Production per hectare is also higher for canal/flood for wheat, total vegetables. So when the government is trying to propagate drip irrigation what does this imply for policy.

In Table 4.20 the unit for area is missing. In Table 4.17 it appears that gross cropped area is 3.352 hectares for beneficiary farmers and 2.82 hectares for non-beneficiary farmers. In Table 4.20 it indicates that total irrigated area is 27.07 (unit?). The same may be clarified.

7. References: All important references have been used in the study.

8. General remarks: The report is acceptable after taking into consideration the comments.

9. Overall view on acceptability of report. The report is acceptable after more detailed analysis of table 4.17, 4.18 and Table 4.19 and clarification of Table 4.20.

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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. Some typographical errors in Tables 4.17 to 4.20 have been corrected and necessary changes have been incorporated in the text.

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. 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