KEY ISSUES FOR SUCCESSFUL IMPLEMENTATION OF CANAL BASED MICRO IRRIGATION : EXPERIENCES OF GUJARAT, INDIA

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Abstract

India has been a water stressed country in general. Because the largest consumer of water is agriculture sector, water saving efforts need to focus on water sector as a strategic move. Pressurized Irrigation Network Systems (PINS) augmented with Micro Irrigation Systems [MIS] is viewed as a promising water saving technology. In spite of persistent efforts for implementation of the said technology, India has not attained a significant headway. A noteworthy observation is that MIS is successful in case of Ground Water but the other way round in the case of Surface Water. Success stories like Narmada Command of Rajasthan are only a few and the area covered in total is also very small. In order to provide actual experiences of design and implementation of PINS and MIS, a discussion has been made in this paper on some pilot projects envisaged and tried to be implemented in the command area of the Sardar Sarovar Project within the Gujarat State as it is the only large project in India which has been designed with protective irrigation philosophy, i.e. minimum water required to protect the crop is supplied which inevitably requires water saving technologies. Some examples of some other projects have also been cited. Findings at a glance include evaporation and seepage losses nullifying the primary objective of water savings, difficulties in synchronization of canal operation schedules with the requirements of the MIS, unfavourable ratio of investment versus farm holding size, issues of electricity availability, etc. Finally, the implementation of MIS ends up with transferring the stress from water to electricity is the conclusion arrived at.

CONSTRAINTS OF WATER AVAILABILITY AND WATER QUALITY IN GUJARAT

Gujarat is divided in to four regions - South Gujarat which also includes Central Gujarat, North Gujarat, Saurashtra and Kachchh as shown in Figure-1. South Gujarat is water rich and is also having clayey soil, North Gujarat is water stressed and having alluvial soil, Saurashtra is facing shortage of water and is having a mix of black cotton soil with gravels whereas Kachchh is having sandy soil and a large area of desert. Coastal length of Gujarat is the highest in India which is 1664 kilometers.

Except South and Central Gujarat there has been scanty water in the entire state. If compared the per capita water availability, it is much less than India’s average and from 2001 onwards there is a significant reduction therein which has caused concern. This is because of population growth, development of industries and climate change. Overall scenario of Gujarat i.e. surface water and groundwater is shown in Table-1.

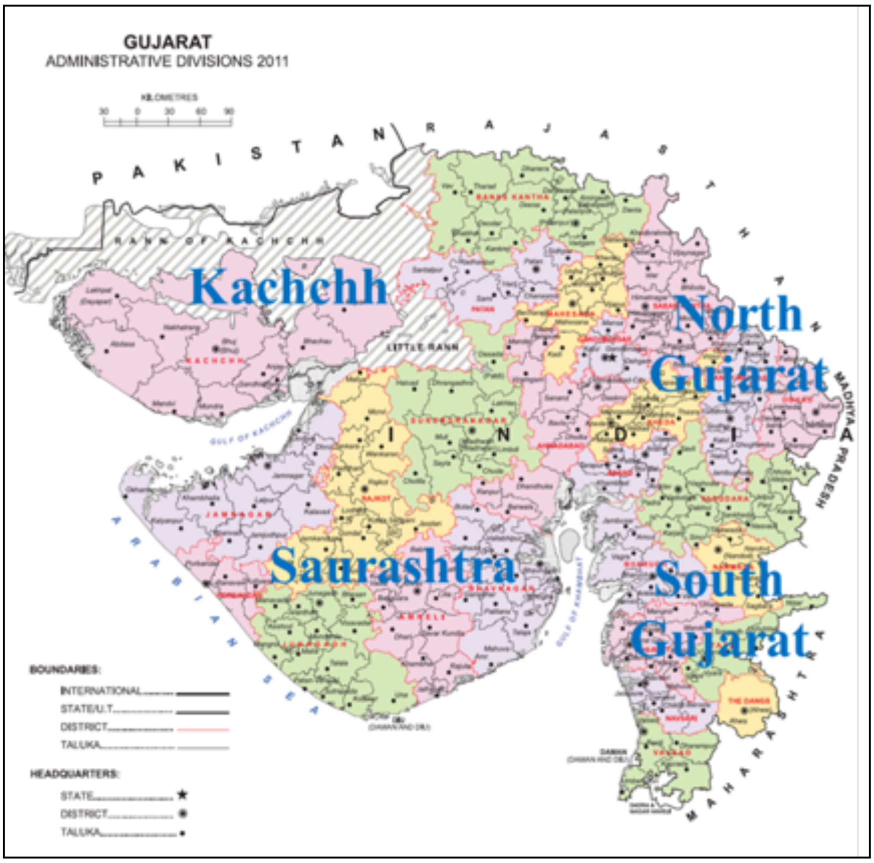

Figure-1 Regions of Gujarat

Table-1 Surface water scenario of Gujarat

Region	**Area in % of Geographical Area of Gujarat State**	**Surface Water in Mm^3**	**Ground Water in Mm^3**	**Total Water in Mm^3**	**Per Capita Per Annum Availability in m^3 in 2011 and (2001)**
South and Central Gujarat	25	31750	3950	35700 (71 %)	1695 (1880)
Saurashtra	33	3600	4300	7900 (16 %)	487 (540)
North Gujarat	20	2100	3300	5400 (11 %)	309 (343)
Kachchh	22	650	450	1100 (2 %)	658 (730)
Total	**100**	**38100**	**12000**	**50100 (100 %)**	**893 (990)**

Figure-2 shows that in Saurashtra and Kachchh there are many small river basins coupled with low yields due to scanty rainfall. In South and Central Gujarat, a few but big river basins are there. Table-2 shows that rainfall and number of river basins are inversely proportionate and therefore in Saurashtra and Kachchh, rivers are many but small and non-perennial. Medium and major dams are feasible on a few rivers because of such a discrepant situation. In total 85 major and medium dams have been constructed as per availability of sites and no more sites are technically feasible for such dams.

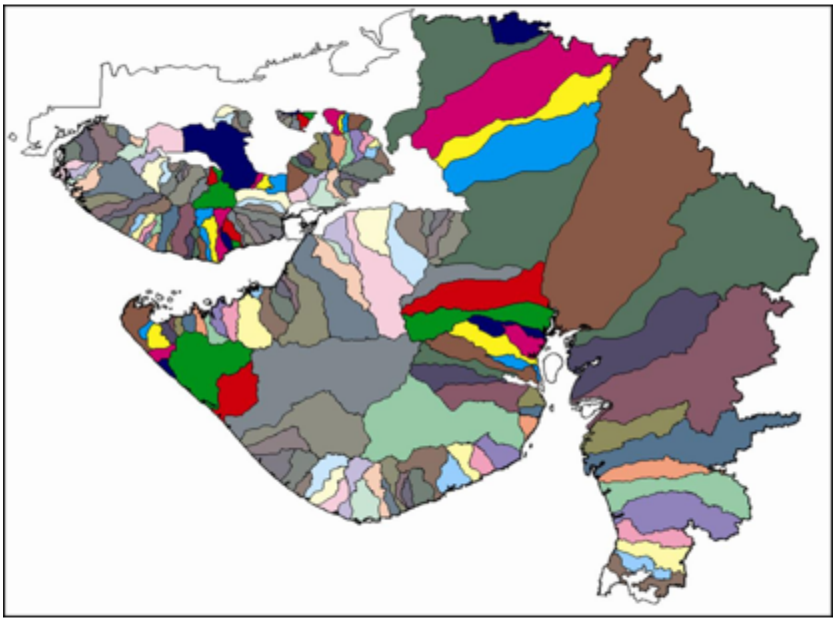

Figure-2 River Basins of Gujarat

Table-2 Rainfall Distribution of Gujarat

Name of Region	Annual Rainfall in mm	No. of River Basins
North, Central and South Gujarat	800 to 2000	17
Saurashtra	400 to 800	71
Kachchh	Less than 400	97

Technical feasibility became a major challenge for the construction of major and medium dams in Gujarat. Obviously, because of scanty surface water, ground water exploitation became a serious in last a few years. Quantity and quality of water always become a contemporary issue in most of the cases.

WAY-OUTS TRIED BY GUJARAT

In the context of issues related to quantity and quality of water, Government of Gujarat had to use the available water resources to the maximum possible extent by planning the water resource projects for extensive irrigation rather than intensive irrigation, constructing many small dams wherever feasible, implementing schemes for inter-basin transfer of water, increasing efficiency of the distribution systems, increasing on farm efficiency, recycling of water, etc.

Sardar Sarovar Project became a classical example of extensive irrigation in India. It is one of the largest projects of the world with 1.8 million hectare of command area and 75,000 km long canal network, having a large encompassment of 9600 villages and 135 towns to be supplied domestic water, has been designed with protective irrigation approach of planning and design. When the rainfall is delayed or insufficient during monsoon, limited water is supplied to the farmers so that their kharif crop is protected is the basic idea. Average delta designed in the command area is 45 cm. Extensive irrigation has been planned in order to implement the protective irrigation approach. Large command area of Sardar Sarovar Project has been classified in to 13 regions based on parameters like annual rainfall, land irrigability class including drainage characteristics, groundwater quality and quantity, cropping pattern, alignment and the command of major branches, etc. Soils in Gujarat are grouped in to six broad types i.e. (i) deep black (ii) medium black, (iii) coastal alluvia, (iv) alluvial loam, (v) alluvial sand and (vi) desert sand; for the purpose of planning command areas of irrigation projects. The Soil Survey Manual (IARI 1970) recognizes six irrigability classes of soils as listed in Table-3.

Table-3 Irrigability Classes

Class 1	Lands that have few limitations for sustained use under irrigation
Class 2	Lands that have moderate limitations for sustained use under irrigation
Class 3	Lands that have severe limitations for sustained use under irrigation
Class 4	Lands that are marginal for sustained use under irrigation because of very severe limitations
Class 5	Lands that are temporarily classified as not suitable for sustained use under irrigation
Class 6	Lands not suitable for sustained use under irrigation

Open channel gravity flow has been adopted to serve almost the entire command area except some special areas wherein special irrigation strategies have been designed to address specific requirements. As per the land irrigability classification, the designed delta varies between 38 cm to 45 cm.

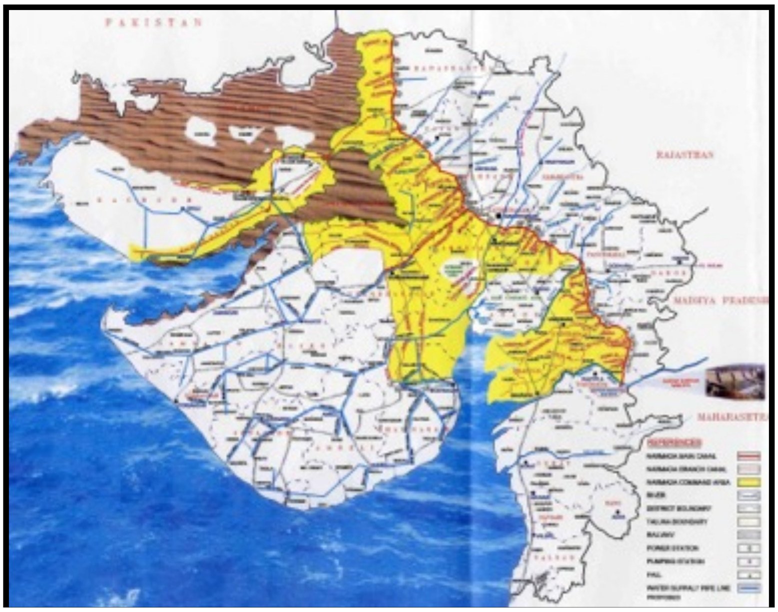

Figure-4 Command Area of Sardar Sarovar Project in Gujarat State, India

In order to tap the maximum surface water, mor than 40,000 small dams or checkdams were constructed between 2000 and 2006. For inter-basin transfer of water, large schemes like Sujalam Sufalam and Sau Ni Yojana were also implemented. To increase the efficiency of distribution systems, lsot of the canal network in the state was lined. In order to promote the on farm efficiency, subsidized pressurized irrigation systems were offered.

EXPERIENCES OF MICRO IRRIGATION IN SARDAR SAROVAR PROJCT

Command area of Sardar Sarovar Project is 1.8 million ha with average delta of only 42 cm. It is not possible to irrigate for the farmers to fulfill the irrigation requirement of Kharif and Rabi seasons with traditional methods. As village level efficiency and farm level efficiency are the key to success of the extensive irrigation approach, alternatives must be tried out.

It was thought that Micro Irrigation System (MIS) could become a good solution in this case. As the Canal flow has been gravity up to minor level which means water is available up to up each Village Service Area (VSA) which is approximately 300 ha, it was found that there was a need to drawing water from the canal, storing in a natural depression or a sump and further taking the water to the farm level in order to ensure continuous flow available at the farm level. In order to meet with the requirement of the gradient, Pressurized Irrigation Network System (PINS) from minor canal to the farm was envisaged which was connected with MIS within the farm.

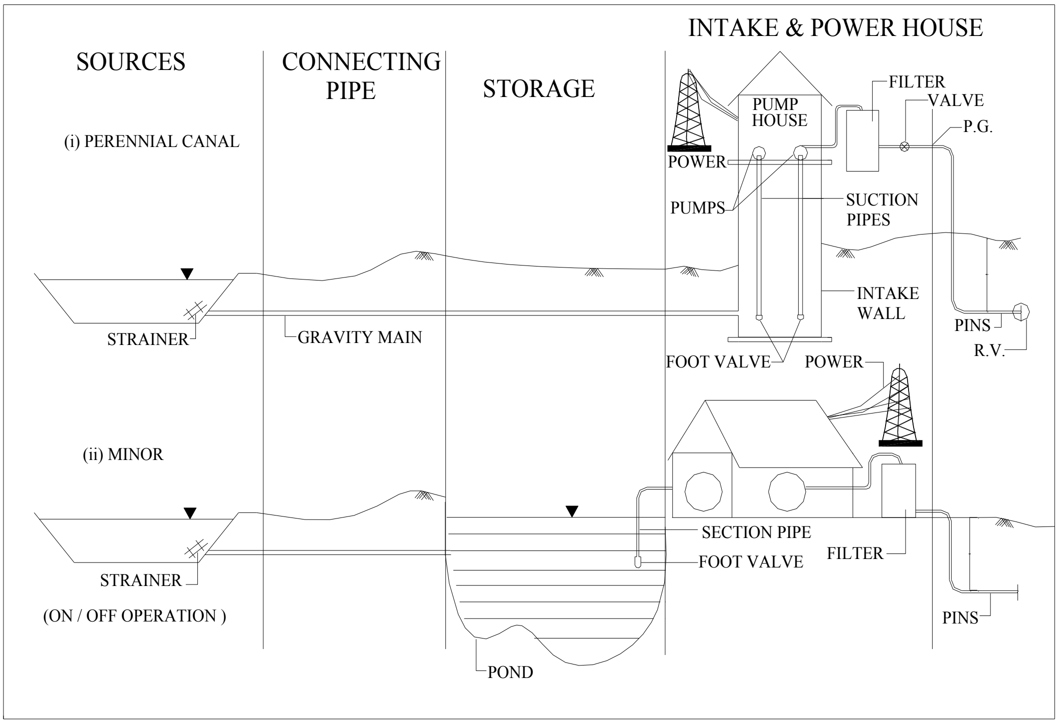

Figure-5 Schematic Layout of PINS

The extent of PINS was the most crucial part of the design as singular control for the entire VSA means a large pumping station to pressurize a long pipeline network and segregating the same would require more number of pumping stations and smaller but many pipeline networks to be pressurized. Three different levels for Pressurization of village level pipeline networks were studied - VSA level, Chak (a part of VSA with approximately 50 ha bound by local topographical ridges and used as a distribution unit) level and Sub-chak (part of chak with approximately 8 ha used as a distribution unit) level. For economizing the system, water is taken from the water source up to the center of the chak by gravity flow through plastic or PVC pipes. A Chak is then re-oriented radially into sub-chaks and pressurized flow is actually resorted to only at the head of sub-chaks. Above strategy was further analyzed for power supply options – (24 hours and 8 hours). In case of 24 hour power availability, no storage was required as continuous water supply was available. However, for 8 hour power availability, a storage arrangement for 16 hours was required to be created in the vicinity of point of pressurization. Existing village pond, natural depressions, new artificial storage, etc. were the options for the same which required approximately 1200 m^2 land for 1 day storage. Moreover, in the latter option, i.e. 8 hour power availability, three times the capacity of pumping as compared to the former option with 24 hour power availability was required. Electricity was considered as the source of power considering limitations of the diesel pumps like maintenance, pollution, etc.

One more factor was required to be considered while designing the PINS and MIS based distribution system – the canal network was designed as rotational supply i.e. on-off operation of the minors. The on-off cycle was designed to be on 7 day period which means the minors would be supplied water for 7 days and would be inoperative for the subsequent 7 days. This was considering the fact that supplying water to the entire command area at a time would require greater discharge in the entire canal system right from the main canal to the minor canals which would be economically unviable. Considering all the said factors, following options from canal operation point of view were studied in detail in the year 2006 and the final cost thereof is summarized in Table-4.

Option 1: Direct lifting form Perennial Canal (branch canal or distributary) at the VSA Level

Option 2: Pond with 9 day storage with minor as a source (7 day On-Off basis)

Option 3: Minors operated at half design discharge for all days with 24 hours electricity supply at chak level

Option 4: Pond of one day storage and minors operated at half designed discharge with electricity availability for 8 hours at chak level

Option 5A: Direct lifting from Perennial Canal all along both the Banks with 8 hours of electricity supply

Option 5B: Direct lifting from Perennial Canal all along both the Banks with 24 hours of power supply

Electricity supply options i.e. 8 hours and 24 hours have been considered as PINS would be incomplete without appropriate power supply. Therefore, various workable options related to the electricity sector were explored. Materials of the pipe were taken as PVC and HDPE to compare different alternatives. Ponds were considered lined and unlined to compare the relationship between the cost and the efficiency. As the design of the MIS was within the farms, they were independent of the design of the PINS.

Table-4 Summary Results of Techno-Economic Study

Option	Storage		Pipes		Pump House and Pond	Electrical Pumps	Total Capital Cost (Rs./ ha)			
							PVC		HDPE	
	With Lining	Without Lining	PVC	HDPE			With Lining	Without Lining	With Lining	Without Lining
1	--	---	47791	69713	900	3600	---	52291	---	74213
2	53000	37000	34354	49695	3240	4800	95394	79394	110735	94735
3	---	---	10275	14700	3240	2400	---	15915	---	20340
4	6000	4080	10275	14700	3240	4800	24315	22395	28740	26820
5A	---	---	10275	14700	2000	4800	---	17075	---	21500
5B	---	---	10275	14700	2000	2400	---	14675	---	19100

Out of above options, Option 3 was found to be the most economical but difficult to operate. Options No. 4, 5A and 5B were more realistic and practicable. The State Government decided to take up about 25 PINS pilot projects in the SSP command to explore its wide scale applicability.

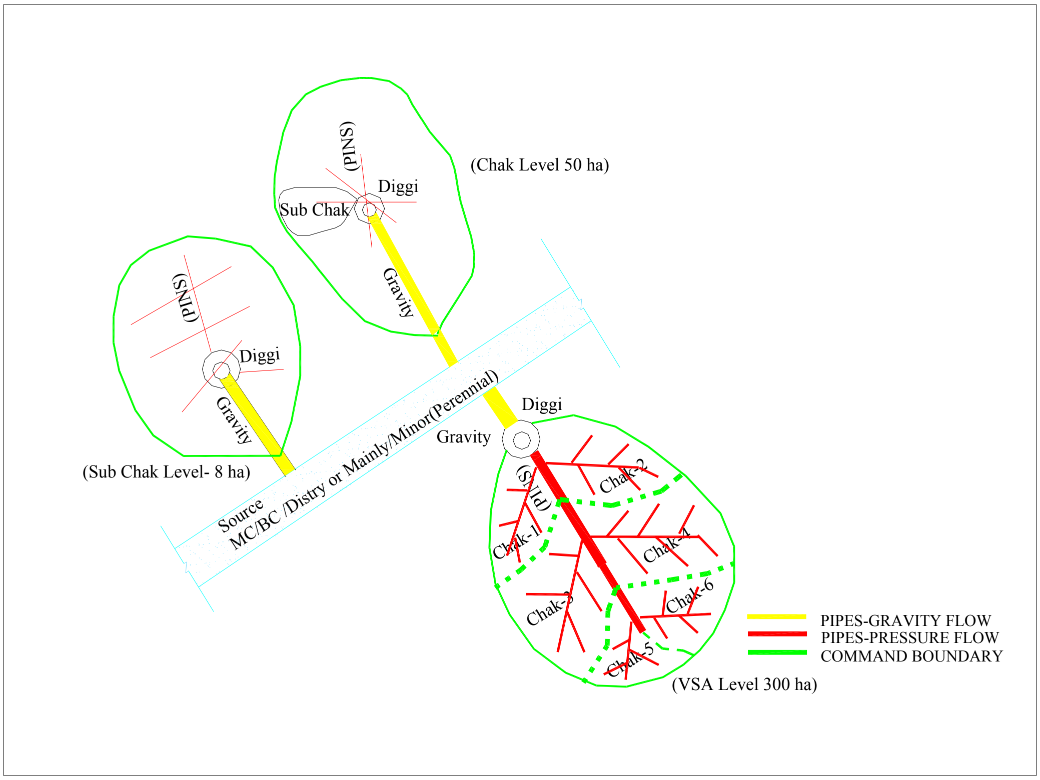

Figure-6 Different levels of pressurization (VSA, Chak and Sub-chak levels)

Integration of canal irrigation with MIS through PINS had many tangible and intangible benefits like water savings, increase in yield, saving in fertilizer, energy savings, etc. were estimated to be around Rs. 20680/- per hectare in some areas with low irrigability and Rs.34080 per hectare in other areas on the price level of 2006. Thus, payback period was short. Optimization of use of available delta, addition in irrigated area due to optimization of use of available delta, possibilities of bringing problematic soil under irrigation in command, improvement and sustaining of soil health, reduction in soil and ground water pollution, possibility of use of poor quality of water available through conjunctive use, improvement in quality of crop, effective conjunctive use of ground water, diversification of cropping pattern, generation of employment and development of industries, etc. were very important advantages of the PINS.

In total 24 pilot projects in the various agroclimatic zones were taken up with Options 4, 5A and 5B as per the local site situations. During and after implementation, acceptance among the beneficiaries was found low and overall success was also very low irrespective of the area or the option of distribution method i.e. option 4, 5A or 5B. Some reasons learnt for the same were following.

- PINS being an innovative concept, farmers waited for success at other places.
- Initial investment was high which became a discouraging factor.
- Total cost of common infrastructure and recurring expenditure were to be shared by the beneficiary farmers and preparing a large number of farmers at a time within the distribution unit became very difficult. Lack of coherence was the problem.
- Command area of the Project was not fully developed and therefore in the head reaches, beneficiaries got adequate (more than what they were eligible for) water even without application of any unconventional method which discouraged them to appreciate the need of more efficient methods. Imposition of legal and administrative control on higher-than-eligible drawl from the canal was not tried by the government.
- Low land holding was the cause of lack of investing capacity. Majority of the beneficiaries were marginal farmers.
- Irrigation charges versus electricity charges was so lopsided a proposition that water saving was no more an attraction to the farmers. This factor got more propelled because of non-imposition of limiting the water drawl in the head reaches of the canals.
- Synchronized operation of canals with the PINS was really an issue for the engineers of the Sardar Sarovar Project. 24 hour power supply could really sort out this issue but everywhere it was not available. Wherever 8 hour power supply was provided by the Government, it was not continuous and for fixed timing. The power supply on intermittent basis with no fixed schedule made it difficult to operate the rotation of water supply. This technical challenge made all the efforts useless. Demand based rotation of water supply remained a far dream, even supply based rotation of water became a nightmare.
- Bank Loans was difficult for many due to various reasons like incomplete land records, land mortgage and other outstanding debts.

EXPERIENCES OF MICRO IRRIGATION IN DHAROI PROJECT

Mehsana district of Gujarat had a severe issue of exploitation of ground water which went down up to depth of more than 100 m. Surface water remained the only source of irrigation after year 2000. Some progressive farmers in village Varvada of Taluka – Unjha, District – Mehsana formed a Water Users Association and applied for subsidized electricity as they had to lift water from the canal which was in cutting. The Energy Department did not provide them the subsidy and therefore they found an alternative through solar based lifting of water and applying the same through MIS in to the farms of the village. In total they were 40 farmers with 34 hectare land in total which means their farm holding was very small. They constructed a sump of 500 m^3 and provided 2 pumps of 5 H.P. each. A large sump freed them from the constraint of canal operation. They got developed a mobile phone application for operation of the MIS with advanced payment system. This experiment was made in 2014 and was very much advanced from technology point of view. Their dependence on solar made them independent of the vagrant power supply of the Government which added the element of reliability of rotational operation and that, too, demand based which perhaps became the biggest boon for the entire Water Users Association. All the constraints that were there in the command area of the Sardar Sarovar Project were there for the said Water Users Association but they had formed a coherent group, they were small in number and were determined to overcome the challenges and they addressed each of the challenges wisely. However, the biggest factor that brought such overwhelming success was non-availability of water by any other option which compelled them to adopt such an innovation. But at the same time, determination, coherence and wisdom of the farmers of Varvada could not be under-estimated considering the fact that this small and well set example could not be replicated elsewhere in Gujarat in spite of similar situation at many locations. It is from this experiment learnt that in order to implement successful engineering projects, social engineering is a prerequisite.

CONCLUSION

Unlike ground water based pressurized irrigation system (which is run on the same pump or motor which lifts the water without any additional electricity), surface water based pressurized systems require electricity power for distribution of water which is perceived as additionality by the farmers because they are not habituated to use power for distribution of surface water. This is felt as a burden to them. Forming of association and sharing of common system requires a special type of mindset. Assured power supply for specific duration and schedule is inevitable for successful implementation of rotations of water supply through PINS. Capacity building of small land holding farmers and addressing their local issues and conditioning them to form a coherent group as a part of social engineering may help a lot in large scale implementation of PINS. The limitation of electricity production is also required to be considered while going for large scale implementation of projects of PINS as after all the pressure on water might be transferred to electricity by such efforts. A special study is required to be carried out as to how to scale up the implementation of projects of PINS within the said limitation. Absence of complexities in ground water based pressurized irrigation systems have made them very successful and their small scale has given them an added advantage.

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