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Irrigation management along with micro irrigation system (MIS) community tube wells in Gujarat

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■ **ABSTRACT :** Participatory irrigation management (PIM) with micro irrigation improving water and fertilizer use efficiency through appropriate technological and policy interventions with an objective to relieve pressure on fragile groundwater appears to be the prime challenge in the Gujarat state. Ground water is the key factor defining agricultural land use in Gujarat state. Government of Gujarat has aggressively promoted micro irrigation technologies in Gujarat by providing 100 per cent subsidy through Gujarat Water Resource Development Corporation Ltd. operated tube wells by implementation of PINS (Pressurized Irrigation Network System) along with MIS. These tube wells had been in operation by farmer co-operative societies in Gujarat by participatory irrigation management since long and used to deliver the water with flow irrigation. Now introduction of micro irrigation aims to provide timely and adequate supply of water to crops for improving the agricultural production. Each tube well envisages covering a demarcated area and growing specified crops which requires specific water requirement in specific time period of growth. Earlier without micro irrigation implementation in many tube wells water levels used to go down and due to this, actual coverage under irrigation was much below the targeted coverage. Tail end reaches of command of the tube well used to suffer from inadequate and unreliable supplies. Most of the area was deprived of irrigation facilities. This gap is now filled up by implementing pressurized irrigation networking along with micro irrigation systems. It is found that there is a substantial improvement the operation, maintenance and management of the system by involving both the water users groups (farmers) and Gujarat Water Resource Development Corporation Ltd. (GWRDC) (the owner of the Tube wells). The life of tube well has increased and electricity consumption as well as maintenance is reduced to a great extent. These are the results of participatory irrigation management. Obviously farmers in a command area of community tube well will be in a large number, with different concepts, priorities, requirements etc. To bring these varied interests together and enable them to be effective partners in management of irrigation system is both challenging and time consuming. It is necessary that the behaviour and attitude of the Government officers need to be changed and make conducive to work with farmers and users in order to develop a collective and self-regulative work culture. This should ultimately result in to improvement of "On- farm water use efficiency" and the affordability for the farmers to adopt the systems and doing irrigation through micro irrigation only. The multifold advantages of drip and sprinkler irrigation systems over conventional flow irrigation would bring large sale adoption of these technologies.

■ **KEY WORDS :** Participatory irrigation management, Water use efficiency, Micro irrigation, Tube well

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Participatory irrigation management has assumed grate importance in India in the last few decades due to the growing difficulties faced in water resource management. It comes to realize that end user–farmer involvement and participatory management leads to substantial improvements.

There is continuous increasing crisis in water resource management in India and this is becoming increasingly serious as development accelerates. Scarcity of water becoming common and frequent and the quality of water is suffering as well. The management of water distribution across the vast areas of the country and almost millions of users, in a sustainable manner is becoming a major challenge. There is crisis in the management of available water sources and also difficult to generate new sources – surface water as well as ground water because of huge investment requirements, project implementation delays, problems of maintenance, institutional difficulties and environmental concerns.

The inadequate crisis in the management of ground water because of excessive exploitation against insufficient recharge resulting in receding water tables in many areas.

Promoting PIM through water users associations is very complex since it has to cross through various political, economic and administrative barriers. The process of implementation has to overcome each of these hurdles. Political will has been one of the important requirements for bringing about a paradigm shift in irrigation management.

The crucial role of irrigation in food production as well as livelihoods needs no emphasis. The technical and economical solutions to these problems are typically known and often simple, but their institutional management in a participative political economy framework is becoming very difficult and posing a serious challenges.

Requirement of participatory irrigation management (PIM) :

Initial efforts :

The role of governments in the construction and management of irrigation systems has existed for a long time. In Gujarat state, G.W.R.D.C. Ltd running tube wells which is operated by farmer co-operative societies under public management for irrigation to make available ground water for the farmers as decades ago tube well construction was very costly and not viable to individual small and marginal farmers. Electricity connecting was difficult in those days and even today also. However, government controlled irrigation systems frequently show low water use efficiency, poor maintenance, weak financial sustainability and excessive dependence on subsidies.

The experience shows that if farmers actively participate in irrigation management there is marked improvement in water utilization efficiency. With participation, there is increase in the area under irrigation and also in the number of farmers who gain access to irrigation.

In GWRDC Kutch dist. Bhuj Ta. T/w Vavdi , the irrigated area increased by 3 times (6.64 ha to 20.82 ha) and number of beneficiary farmer increased by 3 times (2 farmers to 7 farmers) after Warabandi and implementing PINS along with MIS in the command area of Vavdi T/w *Design Data Sheet approved by Gujarat Green Revolution Company Ltd (GGRC) vide GWRDC TS163 Dt.31-3-14 co-operation between farmers was found to increase and due to this, many water related disputes get sorted out. The ground water has been utilized with great control and economy with PIM.

A change/transfer in irrigation management whereby farmer co-operative societies take over the management of operation and maintenance while Govt. (GWRDC) mainly focus on implementing PINS along with MIS in tube well command area by approved agencies of GGRC with 100 per cent subsidy. Such ideas have led to the promotion of participatory irrigation management (PIM).

The PIM broadly refers to the formation of groups of water users/ farmers in a formal body for the purpose of managing parts or whole of an irrigation system. The bodies are often called water users' associations (WUA) but also go by other names such as irrigation co-operatives or PPP model (Public Private Partnership Module). PIM implies the involvement of water users in different aspects and levels the management of the water including planning, design, construction, maintenance and distribution. The primary objective of PIM is typically to achieve better availability and utilization of the water through participatory process that gives farmers a significant role in the management decisions of water in their tube wells.

This system of farmer management is preferred

since it is felt that the farmer have a stronger incentive to manage water more productively and can respond more quickly to management problems in the system, particularly at farm level. Moreover, transferring responsibilities has also come to be seen as a way to reduce pressures on complicated govt. procedure of financial and technical sanction's of budget and manpower and tender and other procedure for maintenance and little transparent and obligatory works. While at the same time improving irrigated agricultural production and ensuring long term sustainability of irrigation systems.

The initiation is also to encourage efforts by individuals to take responsibility for management of the resource (Tube Well) , in the belief that individuals have great stake and better information for making efficient resource allocations.

Fig. 1 : Community filtration unit on GWRDC tube well

Objectives of PIM :

End user (Farmer) participation in the management of irrigation systems typically seeks following objectives:

- Improve efficiency of irrigation systems.
- Ensure sustainability of irrigation systems.
- Improve performance of irrigated agriculture
- Reduce pressures on Government departments
- Permit farmers to play a greater role, which is a major shift away from conventional government policy.
- To create sense of ownership of water resource and irrigation system among the users so as to promote economy in water use and preservation of the system.
- To improve service delivery through better operation and maintenance.
- To achieve optimum utilization of available resources through better/sophisticated methods, accurately as per crop needs.
- To achieve equity in water distribution.
- To increase production per unit of water, where water is scarce and to increase production per unit of land where water is adequate.
- To make best use of natural precipitation and ground water in conjunction with canal irrigation for increasing irrigation and cropping intensity.
- To encourage better use of water through better choice of crops, cropping sequence, timing of water supply, period of supply and frequency of supply, depending on soils, climate and other infrastructure facilities available in the commands such as roads, markets, cold storages etc. to maximize the income and returns.
- To encourage collective and community responsibility of the farmers for collecting water charges and making payment to Govt. department.
- To create a healthy atmosphere between the Govt. department and farmers.

Govt. of Gujarat policy for PIM :

In 1995 the Government of Gujarat approved policy resolutions for implementing PIM in the state and subsequently approved model bye-laws for irrigation co-operative societies and a model memorandum of understanding between Government Administration and Water Users Association. An action plan was finalized for implementing Government policy resolution on PIM. A year later, in 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 Water User's Associations have been formed and are working in various parts of the state. Finalize by enactment of PIM Act in 2007. Declared WALMI (Water and Land Management Institute) as the nodal agency for promoting, capacity building and monitoring PIM.

Main features of PIM act 2007 :

- Act seeks scale up PIM by giving statutory support to the combined efforts of water resource Department (WRD), Farmers and Non-Government

Organizations (NGOs).

- Declaration of minor irrigation scheme service area by notification in the official gazette.
- Formation of WUA of each minor irrigation scheme service area if the association represents 51 per cent of the holders of land and aggregate area of land held by such holders is not less than 51 per cent of service area.
- Agreement to turnover irrigation management by the Govt. to WUAs.
- After the agreement, joint inspection of water source /irrigation scheme shall be carried out.
- Repairs as per joint inspection shall be carried out by the WUA with 10 per cent cash contribution by farmers.
- Supply of water from minor irrigation scheme on volumetric basis.
- Association is authorized to collect water charges over and above rates fixed by Govt. as many be necessary.
- WUA retains 50 per cent rebate on water charge collection. The rebate amount and additional water charge/fee is retained by the WUA which is used towards cost of operation and maintenance (O and M).

PIM by adopting micro irrigation :

Earlier in all tube wells irrigation has done by flood irrigation (traditional irrigation) methods. Tube wells runs on 3 phase electric supply and availability of electricity for agriculture is 8 hrs interrupted in Gujarat state. Hence, all the members of WUA divide the timing according to their land requirement and water requirement.

$$Q\,(Ips) = \frac{HP * 75 * \text{motor efficiency} *}{Head}$$

*Motor efficiency generally taken as 68 per cent

Water requirement for flood for one irrigation	: 50 mm[1]
Irrigation interval for flood	: 4 days[2]
Water Requirement for MIS	: 4 mm[1]
Irrigation interval for MIS	: Daily[2]

- Water requirement for any crop comes in mm/ day,1mm means 1 lit per 1 m^2.
- Irrigation interval 8 hr/day.

Area which can be covered under flood irrigation with available water (ha).

$$= \frac{\text{Discharge (Q) x 2.88 x irrigation interval (4 day)}}{\text{Water requirement for flood for one irrigation (50 mm)}}$$

Area which can be covered under micro irrigation with available water (ha).

$$= \frac{\text{Discharge (Q) x 2.88 x irrigation interval (1day)}}{\text{Water requirement for micro irrigation for one irrigation (4 mm)}}$$

The water use efficiency under conventional flood method of irrigation, which is predominantly practiced is very low due to substantial conveyance and distribution losses. Recognizing the fast decline of irrigation water potential and increasing demand for water micro irrigation is the only solution which includes both drip and sprinkler method of irrigation.

Micro irrigation is provide to be an efficient method in saving water and increase water use efficiency as compared to conventional surface method (flood irrigation), where water use efficiency is only about 35-40 per cent. Micro-irrigation is also found to be reducing energy (electricity)requirement, weed problems, soil erosion and cost of cultivation. Under micro irrigation, unlike flood method of irrigation, water is supplied at a required interval and quantity using pipe network, emitters and nozzles. Therefore, the conveyance and distribution losses are reduced completely which result in higher water use efficiency under MI.

Participatory irrigation management in GWRD Ltd run tube wells and operated by farmer juth/co-operative societies runs at its successful level by considering the water availability for future use and increasing demand from farmers. Warabandhi/Scheduling have been introduce to increase water use efficiency. In flow irrigation it is needed 50mm water requirement per day (50 lit/m^2) and water need to be given at 4 days interval while in micro irrigation, when water is directly applied to root zone of the crop its need to satisfy only moisture requirement and it will be 4 mm per day (4 lit/m^2) and it will be given at every day or alternate day. While reducing water consumption, it also reduce substantial amount of electricity required for irrigation purpose, by reducing working hours of irrigation tube well. Apart from reducing water consumption, drip method of irrigation also helps reducing cost of cultivation and improving productivity of crops as compared to the same crops cultivated under flood method of irrigation. More area to be covered with same HP motor and same water depth, just by adopting

micro irrigation. In spite of having different head units (Filter Units) by way of PIM it is required only one head unit as it reduces cost per ha considerably. Maintenance cost of tube well also get distributed among WUA. Conveyance losses becomes very less by using PVC pipes rather than earlier RCC pipes and open water channels. Micro irrigation can also be adopted in all kind of lands, which is not generally possible through flood irrigation method. By way of micro irrigation in PIM it 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. Given the population growth and increasing requirement of agricultural commodities, there is need to increase area under cultivation. PIM with micro irrigation is viable option for expanding area under cultivation.

Though both drip and sprinkler irrigation of irrigation are treated as micro irrigation, there are distinct characteristics difference between the two in terms of flow rate, pressure requirement, wetted area and mobility.

Fig. 2 : On filed installation of drip irrigation system

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 root zone of the crop, instead of land, and, therefore, the water losses occurring through evaporation and distribution completely absent. The on farm irrigation efficiency of properly designed and managed drip irrigation system is estimated to be about 90 per cent while the same is only about 35 to 40 per cent for flood irrigation (Fig. 2).

Fig. 3 : On field installation of sprinkler irrigation system

In sprinkler irrigation method, water saving is relatively low upto 70 per cent as compared to drip irrigation since sprinkler irrigation method supplies water over the entire field of the crop (Fig. 3).

Rotational water supply in micro irrigation :

The biggest challenge in participatory irrigation management is warabandhi or broadly speaking scheduling the water supply from the source.

In micro irrigation it is need to accurately determining how much and when to water required. The amount of water needed by any crop is influenced by soil type, exposure and the plants 'thirstiness'. Soils vary greatly in their rate of percolation – sand very fast, loamy medium and clay very slow. The effect is that the denser the soil the more the water spreads laterally as it's percolating. Therefore, the soil, further apart, the more clay. Watering frequency is also influenced by soil type. Plant water needs have been both empirically and scientifically determined. Plants are well defined in groups; no supplemental water, drought tolerant, low water, moderate water and regular water. Those needs have further been scientifically quantified by the plant's evapotranspiration-abbreviated ET. This is the combined water lost from both transpiration from plant leaves and evaporation from soil and wet leaves. It is also know as crop or plant water use. Water needs are further influenced by location, exposure, wind and weather.

Steps to determining watering schedule in drip irrigation system :

– Finding crop water requirement per day
– How many emitters (Drippers) to use and how much emitter lines

– Determining the watering days and times (Electricity availability).

Warabandi (Mehra *et al.*, 2012) system of water distribution is followed for surface irrigation system specially in canal irrigation system to try to resolve the issue that tail end fields receive less amount of water compared to field situated at or near the head of water courses. This is because of seepage losses in unlined water course. The same issue happens in tube well irrigation system by flood irrigation method. For improving the water supply for the tail end fields considering seepage losses, for modification in roster of conventional Warabandhi system for achieving equitable water distribution under existing land holding in command area of tube well micro irrigation is the ultimate solution.

Important aspect of irrigation management requires efficient and fair distribution of water. Water distribution method affect the performance of irrigation system and ultimately affect the water use efficiency of the project. Main aim of irrigation system operation is to supply the water as and when it is required. The art and the science of the distribution of water over the time and space are termed as irrigation scheduling. For deciding the amount of irrigation and its scheduling, it is necessary to calculate crop water requirement. Table 1 considering climatic and soil water relationship. This requires calculation of consumptive use of water by crop over the growth period.

The term Warabandi is originated from two vernacular words "Wara" and "Bandi" . The meaning of wara is turn and bandi means fixation. Taken together, the term Warabandhi means rotation of water supply according to a fixed schedule. Warabandi is a system of equitable water distribution by turns according to a predetermined schedule specificying the day, time and duration of supply to each irrigation in proportion to holding in the outlet water source.

For implementation of Warabandi the following requirements are fulfilled :

– To provide irrigation networking (preferably pipelines) to ensure water to every holding within command area.
– To ensure design discharge at every outlet.
– Farmer's participation.

In flood irrigation system for tube well irrigation source, when tube well is running for 8 hrs when 3 phase power available, a watercourse receives an authorized share of water at a constant rate for 8 hours continuously and water distribution proceeds from head to tail. Thus, each farmer is entitled to receive the entire water in a water course only on a specific week day and at a specific time including. night time as per availability of power. A schedule of water supply indicating the time of starting and closing to a particular land holding is know as roster of turns. There is no provision in the system of flood irrigation to compensate any individual farmer who may fail to receive his turn or share of water for any reason, because there is no un allotted time.

In micro irrigation system, water requirement is much lesser than flood system. Entire network is pressurized pipe networking. No issue of non-getting water to tail plots of command area. Entire command area is sectioned in equal parts as entire field is supplied water through pressurized irrigation networking and at every outlet flow will get at particular pressure as per design and entire system is valve operated.

As per design criteria total working hours per day depends upon :

– Distance between crop rows (Lateral spacing)
– Distance between plants (Dripper spacing)
– Dripper discharge (lit. per hr)
– Crop water requirement
– Pump suction head
– Pump HP
– Discharge at pump outlet
– Calculate separate flow of valve than number of shifts (No. of shifts define as how many valve operate at one time, it is ultimately depends upon final discharge given by pump/motor)
– If we know, how many required number of shifts in entire design area and which time taking for one shift. Then easily calculate total working hours per day.
– Generally 8 hrs electricity available on the field. If total working hour more than 8 hours then alternate irrigation interval provided. If total working hours per day are higher than farmers number and area, the solution is to utilize diesel engine for active MIS system.

General formula for valve sectioning (Scheduling) for mirco irrigation :

Irrigation rate (Unit mm / hour).

= (Dripper discharge, lph)/ (Crop to crop spacing, m)/ (Row to row spacing, m)

Operating hours per shift (hour).

= (Irrigation rate, mm/hr)/(Crop water requirement, mm/hr)

Total working hours per day.

= (Operating hours per Shift) / (Number of Shifts per day)

Table 1 : Sample design data for tube well

System details	
Irrigation system	MIS
Area (ha)	6.64
Crop	Cotton
Crop spacing	1.37 * 0.6
Emitter spacing	Inline
Emitter discharge	4
Emitter per plant	One
Irrigation rate (Mm/hr)	4.87
Lateral spacing (M)	1.37
Water requirement (Mm/day)	5
Operating hours per shift (Hr)	1.03
No. of shift per day	12
Total working hours per day	12.36
Available flow at the outlet of the water source (Lps)	11.53
Maximum flow per shift (M^3/hr)	9.11
Maximum head required (M)	177
Irrigation interval	Alternate
Water source	Bore well
Water source depth (M)	152
Delivery size (Inch)	4
Pump (hp)	40
Pump flow (M^3/hr)	41.49

Design criteria for open field channel :

- The total area considered for planning is divided into chaks and sub chaks.
- After finalizing chaks and sub chaks, the alignment of the water course and field channel network has been determined.
- The water course and field channel has been designed with capacity of 0.61 lit/sec/ha.
- The bed width is kept 0.3 m depth of water is taken as 0.2 , side slope is kept 1.5 : 1 and wetted perimeter as 1.021 m. There is no provision of lining of water courses well as field channel.
- The value of rugosity constant is adopted as 0.018
- The field drain and collecting drains have been aligned according to topography of land.

Table 2 : Valve sectioning for tube well design

Shift flow (lps)	Valve no.	Area (ha)	Flow of submain (lps)
4.3	1	3184	4.3
8.54	2	3184	4.3
	3	3135	4.24
8.17	4	3035	4.1
	5	3013	4.07
4.55	6	3369	4.55
8.91	7	3311	4.48
	8	3280	4.43
8.77	9	3260	4.41
	10	3229	4.36
3.97	11	2937	3.97
8.28	12	3064	4.14
	13	3061	4.14
8.32	14	3070	4.15
	15	3082	4.17
8.41	16	3048	4.12
	17	3177	4.29
9.11	18	3307	4.47
	19	3436	4.64
8.41	20	3232	4.37
	21	2986	4.04

Table 3 : 100 per cent subsidy in micro irrigation project pH-1details

Districts	Tubewell	No. of beneficiary
Gandhinagar	30	348
Sabarkantha	16	168
Surendranagar	22	161
Mehsana	30	645
Patan	30	513
Banaskantha	50	333
Kutch	71	239
Total	249	2407

Brief description of GWRDC project :

Scope of work :

Working procedure for GWRDC project 100 per cent drip execution work :

- Identifying the beneficiary farmers of particular tube well (Standard policy adopted from dept. to consider

beneficiary farmer who is taking water from the said tube well from last 3 years) and collected his documents like revenue record , ID proof and tube well electricity bill for HP confirmation.

- Locate the beneficiary farmers field in tube well command area map.
- Making survey of the fields of beneficiary farmers and identifying their cropping pattern and field requirements.
- Calculating the water flow from delivery pipe diameter, depth of water and pump HP and make it cross checking with physical flow coming in delivery Kundi /bypass Kundi.
- Designing irrigation networking as per tube well discharge from tube well delivery point to farmer's field.
- Designing micro irrigation system (a) drip (b) sprinkler- rain port as per cropping pattern of farmer and farmer's field requirement and future prospective of cultivation.
- Preparing cost – estimation of PINS + MIS system for entire tube well .
- Technically checking the design by Govt. Department and providing technical sanction to execute the work.
- Preparing the trenches as per design.
- Laying of PVC pipelines in trenches and making installation activities by fixing of valves and other accessories as per design requirement including Gromaate –Take off installation work.
- Installation of filter station at tube well delivery point.
- Commissioning and trial run of the entire system.
- Check and rectify the leakages if any.
- Check the uniform design discharge at every delivery point and emitter discharge.
- Handing over the system to farmers.
- Giving information regarding agronomy and Other general operation and maintenance services to farmers.

Participatory irrigation management in GWRDC Ltd project of 100 per cent drip to tube wells phase-1 :

Govt. of Gujarat has giving this 100 per cent subsidy to tube wells running by farmer juth /co-operative societies. During flood irrigation method these beneficiary farmers need to run tube well for full time to reach water requirement and it also creates in between crises among farmers related to water distribution. As the ground water level goes down and down it has chance to failure of tube wells. By adopting micro irrigation the entire area of beneficiary farmers is to be irrigated in less period of time. Also farmers can irrigate more area which they have left during earlier flood irrigation period. By adopting valve sectioning it is much easier to make irrigation and giving water to crop need based and actual required. The second benefit is fertilizer consumption comes one third as farmers can directly inject fertilizer through drip pipelines, which saves quantity as well as give much efficient result. More number of area can irrigate at a time with micro irrigation and it will come to actual participatory irrigation management by efficient use of water. The cost benefit ratio also increases at farmers level as their cultivation cost is reduced by reducing fertilizer cost as well as electricity charges. Labour cost for deweedings is also reduced considerably. More area under irrigation comes to more production and ultimate benefit to farmers. Initial high one time investment cost for micro irrigation is barred by government. It also much helpful to farmers and give much appreciation to participatory irrigation management. The win situation is at both side from Government as well as faremrs. Government get benefit that the water source (tube well) life increases and ground water depletion reduces. Land fertility increases by micro irrigation and concept of participatory irrigation really worth.

Summary and conclusion :

Gujarat is state of water scarcity. Despite of the existing situations few efforts are being laid to overcome challenges of water degradation in the state. Farmers at large are using flood irrigation leading to over irrigation; Ground water is the major factor limiting productivity in the state and is declining rapidly. Water efficient technologies are thus, seriously required in the state for the sustainable use of water resources as well for sustaining agriculture in the state, thus, micro irrigation system holds many promises to address the challenges of the state. Keeping the specific nature, spread, crops, and technical needs regarding to sprinkler and drip in the state different approaches required to be taken up like GWRDC Ltd run tube wells, for successfully implementing these technologies at a large scale. All public water resources used in irrigation need to be made compulsorily under micro irrigation.

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