A TURNING POINT? WATER SAVING TECHNOLOGIES IN NORTH GUJARAT'S GROUNDWATER SOCIO-ECOLOGY

Rajnarayan Indu[1] , Ajinkya Borkar[2] and Alpa Dave[2]

Abstract

Micro-irrigation systems help saves water, energy, labour, pesticides and fertilizer and there is less scope for waste. If chosen properly and used correctly, this technology increases crop production. The North Gujarat Initiative project of the International Water Management Institute initiated interventions using Water Saving Technologies (WST) in Banaskantha district five years ago. The project also introduced vermi-culture and horticulture along with WST. This three-way intervention has brought about a 'synergic' effect in the farm economy of Banaskantha district. Bith the farm economy and non-farm economy has changed significantly in the region. A large increase in the farm income has brought about a new dimension in the life-style of the farmers who adopted this technology. The introduction of micro irrigation has turned into a movement and is perhaps playing a significant role in pushing agriculture to a significantly higher level of resource-productivity.

1. INTRODUCTION

Technology enhances the socio-economic development in a society. This is a worldwide phenomenon. Rosenberg (1982) in his book 'Inside the Black Box' writes that "technical progress is inseparable from the history of civilisation itself, dealing as it does with human efforts to raise productivity under an extremely diverse range of environmental conditions". Technical progress, the diffusion of new technology and finally the 'spin-off" in a typical technology has an impact upon productivity and growth. From telephone to television, automobile to mobile phone, information technology, and hybrid seed to dry land farming and flood irrigation to micro irrigation – all have brought development and changes in the socio-economic conditions in a country. However, the degrees of change depends upon the internalization of technologies and their intensive and extensive uses in the society. For example, extensive and intensive use of technologies in medicine, communications and computers are changing the world scenario in a different dimension. The term 'technology' has been described or defined in many different ways and in many related things[3] .

The process of development of a particular technology gives rise to parallel development in some other technologies in order to provide alternative, competitive and appropriate solutions for different economic, geographical and social environment needs. Technological development also becomes necessary to mitigate the adverse effects of a particular technology, for example, the changes in plastic technology to mitigating the harmful effects of its pollutants. It is seen that technological development encompasses and influences a very large segment of the society and the 'spin-offs' of technological development, in general, are beneficial to the society at large. Overall, technological development is a continuous, inevitable process. It benefits society largely, provided appropriate checks and balances are applied to ensure that the adverse effects are avoided to the extent possible. It is also to be insured that technology is reaching to the last person of society so that society gets its benefit, whether it is mobile phone or micro-irrigation.

---

[1] Centre for Action, Research and Education in Water, A Division of INREM Foundation, Anand, Gujarat

[2] North Gujarat Initiative, IWMI-Tata Water Policy Programme, Palanpur, Gujarat

[3] In the Longman – Dictionary of Contemporary English, "Technology" defined as – (1) knowledge about scientific or industrial methods or the use of these methods; (2) machinery and equipment used or developed as a result of this knowledge (p. 1481; 3rd edition, 1995).

Where water is available in plenty, people go for conventional flood and furrow method of irrigation. In this method, plant gets water more than it needs. There is loss of water due to evaporation, transportation (conveyence loss) and there is water-logging between the rows and between the plants.

In water stressed areas, people traditionally applied water using earthen pots with tiny holes at the root zone of the plant. The same principle has been developed into a durable, portable, and affordable technology, during the last five decades. The entire amalgamation of such technologies are today together known as water saving technology (WST). Especially after the second world war, with the creation of inexpensive, weather-resistant plastic (Postel et al., 2001), development of drip or sprinkler irrigation system became easy although commercial perfection and large scale use took place in Isreal before 40 years. This irrigation system, also known as micro-irrigation, is practised where availability of irrigation water is scarce.

Compared to the conventional flood and furrow irrigation, the micro-irrigation system saves water, by reducing the loss of water due to transportation (conveyence loss) and evaporation between the plants. Since most types of weeds grow very less or not at all, weeding operation is almost nil, thus saving labour. Fertilizers and pesticides are used through pipes mixed with water flow therefore no extra labour is required for its application. Using this technology, the yield of crops incresed by about 100% to 200% from the same unit of area (Sivanappan, 1994 and GGRC, 2008). The two major environmental problems associated with flood irrigation - soil salinity and water logging - are also completely absent under Drip Method of Irrigation (Narayanamoorthy, 2004).

About eight different micro-irrigation systems are in practice now namely, (1) Micro Tube Drip, (2) Mini Sprinkler, (3) Micro Sprinkler, (4) Easy Drip/ KB Drip, (5) Inline Drip, (6) IDE Local Sprinkler, (7) Overhead Sprinkler and (8) Naan Sprinkler. Individually all these apparatus have their specific use, which depends on the soil condition, crop to be grown and water quality. There are many manufactureres in India and world wide. However, in India certain parts of the sprinklers and drips are imported. World's first commercial production started by Netafim; and in India, during 1989, Jain Irrigation started pioneering effective water-management through Drip Irrigation. Before Jain Irrigation, Netafim used to import and assemble the complete system.

Micro-irrigation technologies (drip and sprinkler-based systems), first perfected in Israel during the 1960s, have spread to many other parts of the world, especially the US (Shah and Keller, 2002). During 1970s this technology was introduced in India mostly in the water stressed areas of Maharastra and southern India. Micro-irrigation is especially well adapted for undulating terrain, shallow soils, porous soils, and water scarce areas. Saline/brackish water can also be used since water is applied daily, which keeps the moisture and salt stress stays at a minimum (Sivanappan, 1994).

Narayanamoorthy cited from ICID (International Commission on Irrigation and Drainage) survey that area under micro-irrigation has increased from just 40 ha in 1960 to about 54,600 ha in 1975 and further to about 1.78 mha in 1991 [INCID, 1994]. According to recent estimates, the global area under micro-irrrigation has roughly expanded by 75% since 1991, which could be approximately 2.8 mha (Narayanamoorthy, 2004). However, ICID database shows that India's total irrigated area is 57.19 mha of which the area under sprinkler is 658,500 ha and area under micro-irrigation is 260,000 ha and total total area under sprinkler and micro-irrigation is 918,500 ha, that is, only 1.6% of the total irrigated area (ICID, 2008). As seen from the available data, in India the area under micro-irrigation is a very small proportion of the total irrigated area. There are 35 countries in the world using drip irrigation systems including the US. US alone accounts for over 35% of the world total drip irrigated area (Narayanamoorthy, 2004). People are now beginning to realise that drip irrigation gives 2 times more yield, save water, labour, energy [if metered], increases income if there is good market price, and its many other positive outcomes. However, this technology has not been internalized within the farmers' society despite its scope. While discussing the adoption of drip irrigation technology in north Gujarat in his book, Dinesh Kumar inferred that it is not only that awareness was low among farmers regarding WST, but the necessary economic incentives did not exist (Kumar, 2007). While cost of cultivation had increased due to the increased cost of abstraction of groundwater, people were not attempting to adopt WST or shifting to low water-consuming crops that could help them maintain the net income from every unit of water and land used (Kumar, 2007, 237).

Literatures in the past has attempted to find the benefit-cost ratio of using drip irrigation as compared with conventional flood irrigation. Sivanappan found the incremental benefit – drip cost ratio for various crops ranges from 1.35 to 13.35 excluding water saving and 2.78 to 32.32 including water saving. Drip irrigation is technically feasible and socially acceptable for large, small and marginal farms provided they get tailored or custom-built systems at affordable price. The system is also suitable for hilly and undulated tracts, coastal and sand terrains; and for water scarce areas of South and western India (Sivanappan, 1994). Alfalfa accounts for 13% of the total water for irrigation in Gujarat according to some estimates. An experiment was conducted in North Gujarat and it is found that drip irrigation of alfalfa vs. floor irrigation is economically viable and its B/C ratio is 1.28 to 2.78 when economic value of water is included (Kumar, 2007). This also reduced water application from about 7% to 43% and yield increased from 7.9% to 10.8% (Kumar 2007). Using drip or sprinkler gives higher yield, increases water productivity and help raise farmer's crop income.

North Gujarat has been experiencing a ground water crisis for the last three decades or more. The farmers of North Gujarat largely depend on groundwater for irrigation. Because of overexploitation, the crisis has deepened further. However, the region has responded with great resilience to perpetual water scarcity and variation in hydrology (deep alluvial, shallow alluvial and some hard rock zones) (Indu, 1999). Despite various types of irrigation management structures from individual ownership to group co-operatives, the farmers have found various solutions to the water crises. There was no application of water saving technologies in North Gujarat. However, in the last few decades, introduction of MI systems such as drips and sprinklers have improved crop output for those who have adopted the technology. The North Gujarat Initiative [NGI] was started (in 2002) as an action research project to identify ways to establish local management regimes for addressing north Gujarat's groundwater depletion problems in 30 villages" (Kumar, 2007). They had introduced '(1) high-valued and water-efficient orchard crops replacing conventional crops like wheat, bajra; (2) water-saving micro-irrigation technologies for alfalfa, row crops such as cotton and castor, and orchard crops; and (3) vermi-composting and use of organic manure for all crops, replacing chemical fertilizers to ensure enhanced biomass utilisation efficiencies and improved primary productivity and water-retention of degraded soils' (Kumar, 2007). Many farmers changed their cropping pattern from usual traditional crops such as bajra, wheat and alfalfa to high-return crops like pomegranate, grapes, gooseberry and other fruits. Some of them even cultivated flowers. Farmers producing potato, cotton and groundnut are getting 2-3 times more produce after adopting drip or sprinkler technology.

During nineties, this technology was in a stage of infancy with problems of affordability and acceptability and low rate of adoption and acceptance. There were lots of 'ifs and buts', doubts and prejudices for adoption in the initial stage in 2002. Eventually when farmers saw the results of WST in demonstration plots, they gradually came forward and started adopting the technology. Medium and large farmers were the ones to adopt WST in the beginning. In 2005, government of Gujarat introduced subsidies for micro-irrigation equipments with a new set up of GGRC (Gujarat Green Revolutionary Company) and came up with an easy scheme for disbursing subsidy for the MI. The subsidy of 50% plus 40% loan from bank and 10% down payment by the farmers with a more or less straight forward and transparent procedure (for details please see GGRC website, 2008), encouraged all categories of farmers, small and big, to adopt WSTs. It was initiated in 2002 by NGI and later other NGOs partnered with them to further strengthen the programme. The adoption rate increased to a very soon after the subsidy was introduced. The area has seen so much adoption of the technology that it feels like a movement. However, there are very farmers who have adopted and continuously using the technology for more than 5 years. Therefore it is too early to see and appreciate its full benefits and constraints. It may take some more years to assess the socio-economic impact.

There is literature available on the impact of MI technology on water productivity (Kumar 2007), benefit-cost ratio, increase in farm income (Sivanappan, 1994; Narayanamoorthy, 2004) technical efficiency, developing affordable designs for small plots of smaller farmers, potential market, and its use for poverty alleviation, (Postel; Polak; Gonzales and Keller, 2001). However, very little literature is available on changes in the socio-economic status of farmers using MI technology. There are studies on direct and indirect effects of large irrigation systems in the society (Bhattarai et al., 2007) but no specific studies on MI technology. There is a good discussion on adoption and impacts of MI technology in Maharastra by Namara, Regassa E., et al., 2005. They talk about advantages and disadvantages of technologies, as well as the factors influencing the adoption. They also talked about impact MI technology on women. There is a discussion on poverty and women with respect to MI technology. Introduction of a technology in society brings about changes – direct and indirect – which have many dimensions, namely, social, economical, psychological and cultural. It was found that level of awareness among farmers was low, drip system was least known, sprinklers were popular and perceptions of benefits and disadvantages was not very clear, however, the point of 'water-saving' by using MI system was almost agreed universally (Kumar, 2007). But by the end of 2007, farmers' concept regarding MI systems and WST changed. This study examines: [1] the takers of MI technologies; [2] whether adoption of MI systems improves farmers' socio-economic conditions including income from crop production; and [3] the influence of intervention among adopters and non-adopters by the way of accepting modern agricultural technologies and agronomic practices.

2. OBJECTIVES OF THE STUDY

The objectives of the paper are to: 1] determine the socio-economic profile of adopter farmers; 2] analyze the changes in farming systems of the adopters associated with introduction of MI system; 3] assess the depth or intensiveness of MI system use among the adopter-farmers; and, 4] analyze the socio-economic impact of MI system adoption, comprising assessment of household dynamic and socio-economic status (crop productivity, economics, net income from farming, food security, asset building) of adopters, and village-level dynamic--cropping systems, employment generation, exposure to new farming technology.

3. METHODOLOGY

We started with the following broad research questions: 1. Who are the adopters of MI technology and what are their social and economic backgrounds? 2. Whether adopters accepted or used other allied water saving practices, which extended or deepened the use of the WST or only used drip or sprinkler irrigation? 3. Whether the adopters brought more land under this technology or expanded the area under irrigation after adoption? 4. Do the adopters really achieve higher output and income due to MI adoption? 5. Do the farmers change their cropping pattern towards high-valued crops along with MI adoption? 6. What are the changes in the socio-economic status of the farmers after adoption? 7. Does there impacts of MI introduction extend beyond the adopter families?

The study villages were selected on the basis of the depth and extent of adoption of MI systems in the villages. Quantitative information was collected through a structured questionnaire, answered by selected farmers. In order to realize the specific objectives, the following methodology was employed:

1. Analysis of changes in farming system and socio-economic impacts at the household level through "before-and-after" (longitudinal) comparison of adopters and "with-or-without" (cross sectional) comparison between adopters and non-adopters.
2. Focus group discussion – among adopters and non-adopters separately in intervened and selected villages were selected from the diocese of NGI and other agencies, to gather socio-economic information – cropping system, cropping pattern, agricultural labour scenario etc.

3.1 Sample Design and Sample Size

Two types of villages were selected for the study. First: the villages with extensive adoption of MI systems where almost all the WSTs and water-saving practices are found, with the largest number of adopters. Second: the villages where least number of WSTs and practices and very few adopters. Also, non-adopters from the first category (that with high rate of WST adoption) were also selected to understand their reasons for non-adoption. We collected secondary information regarding adoption from NGI as they made the first intervention for MI system in north Gujarat. We have tried to select sample from the oldest adopters (before 2002). Socio-economic changes cannot be seen with 2 years of income, as the income and consumption gap would be narrow. However, we selected a sample of recent adopters from districts of Patan and Mehsana (which have low adoption rates) also since the surge of adoption was very high from 2005 onwards.

We selected 63 adopters randomly from 5 talukas of Banaskantha district as it is the first district of intervention. The talukas are Amirgadh, Dantiwada, Deesa, Palanpur and Vadgam. 32 non-adopters were randomly selected from the same talukas of Banaskantha district, but a few have been selected from the newly intervened talukas like Siddhpur of Patan district and Unjha of Mehsana district. The 63 adopters and 32 non-adopter farmers are from 35 different villages from three districts.

3.2 Weakness of the Data

First of all, recall data are generally weak. Secondly, we did not find farmers who had been adopters of MI technology for long period of time. About 26% of the households (16 households) were recent adopters--during 2006 and 2007. The recent adopters could not realize the full benefits of the technology due to lack of experience.

3.3 About the Study Area

The total geographical area of Banaskantha is 10400.10 km^2. The total population of the district is 2504244, of which rural population is 2228743, and urban population is 275501. The total number of farmers is 482803 and the total cultivable area is 8.19 lac ha.

4. RESULTS AND DISCUSSION

4.1 Profile of the farmers

The selected adopters are largely (56%) large farmers owning more than 4 ha of land. The total number of family members among the selected adopter households is 496 (51% male). The total number of family members in the non-adopter families is 189 (53% male). Our sample has the largest number of households belonging to the Mali caste (29%), followed by Patels (24%) and Chaudhuries (24%). All these three castes have divergent socio-cultural background, which eventually influences their decision making in cultivation, and therefore in adopting a new technology. In Deesa taluka of Banskantha district, the member of Mali community played a strong role in the economic development. In our sample, Malis are from Deesa and Dantiwada taluka. The Patels and Chaudhuries are mainly from Palanpur and Vadgam talukas and a very few from Deesa. The verbal history says (as we have heard from very elderly persons) that Malis came from Marwar of Rajasthan, Haryana and western part of Uttar Pradesh after the Second World War. Being outsiders, there is possibility of this community being more progressive and enterprising in their farming practices. In contrast, the relatively more localized communities of Jats and Thakors have less orientation towards commercial farming. These reflect on our samples too; in the case of non-adopters 66% households are a mix of Chaudhury, Patels and Thakors. Only two of the non-adopter households belong to *Mali* community.

The total irrigated land of the sample households is 436.54 ha; more than 86% land is irrigated. This is because all sample farmers have own sources of irrigation in their owned land. There are 63 bore wells; among the sample householdsm, there are those having more than two bore wells. The capacity of pumpsets range from 7.5 - 115 HP; and the mean value of the pump capacity is 23 HP.

4.2 Adoption of WST

Micro-irrigation technology offers several products. They are being chosen according to the holding of land, need of the crop, affordability of the farmers, and availability in the market including its after-sales services. This means that the devices are space, price, service and need specific.There are eight types of systems (already discussed). Coupled with one of the eight systems of MI (mentioned earlier), vermiculture and change in cropping pattern towards horticulture, greatly enhance production and income of adopters. Vermiculture and horticulture are discussed in later sections.

Of the eight different MI systems available, five are mainly use by our sample farmers. They are: (1) Micro Tube Drip[4], (2) Mini Sprinkler, (3) Inline/On line Drip, (4) Overhead Sprinkler, and (5) Naan Sprinkler. We have put the year-wise adoption of different systems of MI technology among the adopters in Table 2 (Annexure) and charts. We have shown the adoption of vermiculture and horticulture also. While big farmers are adopting MI technology, marginal and small farmers unable to afford WST may go for vermiculture as they will have a ready market for vermi-compost. Horticulture gives the highest income after adopting WST. Farmers grow vegetables in between the rows of orchards so long as flowering does not take place in the orchard trees. Many a time the farmers could recover more than 50% of their initial investment in WST in the first year itself.

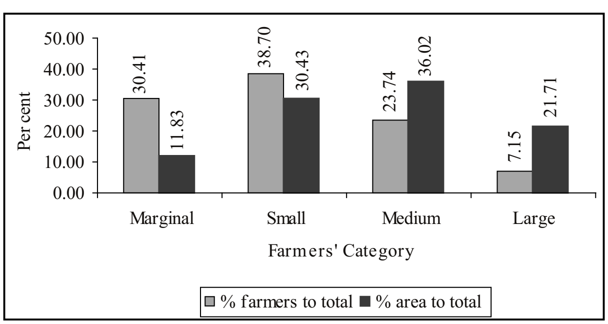
Many villagers do minor repair and maintenance of these systems, however we found that sprinklers are popular among Deesa farmers and drip systems are popular in Palanpur and Vadgam area. *Mali* farmers of Deesa area have very large holdings, they grow groundnut after potatoes and prefer sprinklers; whereas Palanpur and Vadgam area farmers grow cotton after potatoes and they prefer drip irrigation. Many farmers from Palanpur and Vadgam are shifting to sprinkler recently as they found that managing sprinklers is easier than managing drips. They feel that manoeuvring one place to other is easier for sprinkler than drips.

Amongst the adopters, 25% adopted MI only after 2005. Almost 50 - 80% of large farmers adopted MI technology – a higher number in comparison to marginal and small farmers. The number of small and marginal farmers adopting MI technology may grow now, with the introduction of subsidy. We found from that data that out of the total adopters in his list, 7.15% are large farmers, medium farmers (23.74%), marginal (30.41%), small (38.70%) and (Chart – 1), that is about 69% new adopters are from marginal and small farmers' group[5]. This shows the impact of subsidy. Vermiculture that was adopted by 70% of the marginal, small and medium farmers together.

GGRC data also says that after subsidy (2005) the adoption of micro-irrigation technology has risen substantially amongst marginal, small and medium size farmers. Chart 2 and 3 show the situation of Gujarat and in the districts Banaskantha, Mehsana, and Patan respectively for all kinds or micro-irrigation instruments adopted through GGRC. In our selected farmers, few of them adopters after 2005. Some farmers avoid subsidies because of the time and effort spent to obtain them. Others have increased their irrigation area after technology adoption since they could irrigate more area with the same amount of water. Many farmers adopted new equipments after the subsidy.

Our selected adopters have had MI technology for 3 to 5 years only; only a few of them have had it for 5-12 years. It is difficult to find the impact of adoption so early. However, we have observed the extent of adoption among users. Many of them changed from overhead sprinkler (1991, 1996) to inline drip system (2005) or to Naan sprinkler (2002) and brought larger area of land under MI technology systems. The older

Chart 1: Farmers and their area under sprinkler
(Data from a dealer of Deesa after subsidy)



[4] Despite increase in MI technology, there is a decline in adoption of Micro-tube drip and overhead sprinkler systems. The system was adopted in 1991 but lost is popularity after 1996, because farmers found it inconvenient because of clogging. There was some more adoption in 2000, but no adoption after 2005 among the sample farmers.

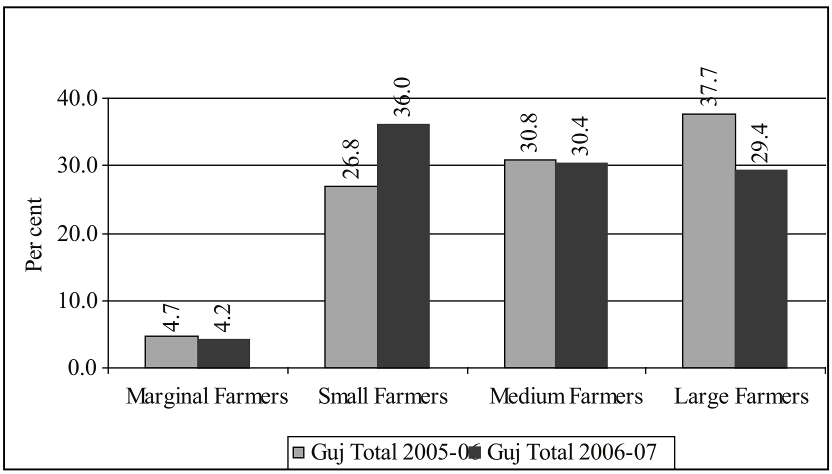
[5] Data obtained from one year of the sale of a MI System dealer in Deesa.

adopters do not like to give much importance to subsidy. This has been reflected in the ranking for 'reasons for adopting' given by the adopter farmers for adopting the technology, which we have discussed in later section. Subsidy has boosted the adoption but adoption it was initiated and accepted because of the benefits it gave.

4.3 Changes in Cropping Pattern

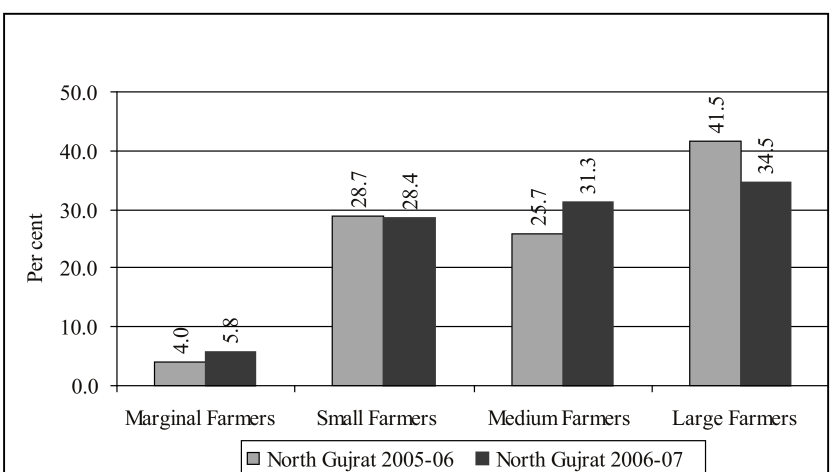
There is a shift in the cropping pattern among the selected adopter farmers shown in Chart 4. The adopter farmers opted for high return crops immediately after technology adoption. Although scarcity of water is a driver in adoption of WSTs, higher incomes is also a motivating factor. Bajra crop reduced by 79% over the surveyed areas and cotton, fennel, potato and groundnut increased by about 117%, 20%, 14% and 32% respectively. The reduction in the area of vegetable probably does not reflect in the chart. We have not captured the area in between the rows of orchards of different fruit crops; plenty of vegetables are grown in these rows during the gestation period of the first fruit harvest. Horticulturists sometimes recover half of their investments of the drip or sprinkler within one or two seasons of vegetables growing. The sum total of those areas is quite large, which may show much increase in vegetable adoption, particularly among orchard farmers.

Chart 2: Area under Micro-Irrigation in Gujarat 2005-06 and 2006-07



Source: GGRC

Chart 3: Area under Micro-Irrigation in north Gujarat 2005-06 and 2006-07



Source - GGRC

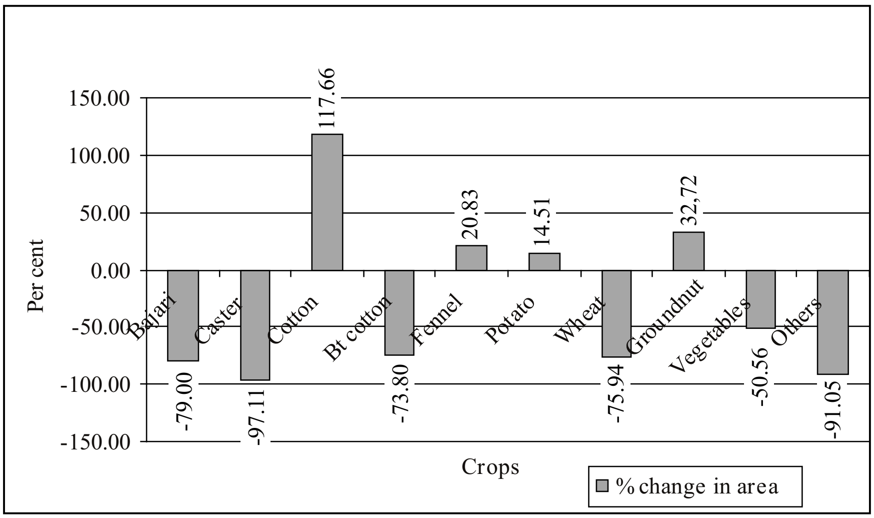
4.4 Changes in crop income and production after adoption

If the technology helps raising the farmers' income, then farmers would agree to adopt that technology. We have analysed the percentage increase in net income per hectare of irrigated crops after the adoption of WST.

The landholding category-wise analysis shows an increase in net income by more than 300% from unit hectare of the crop (Table 1). The marginal farmers received the same income increment as large farmers. The marginal farmers are usually more efficient in using their inputs and hence secure higher returns. Increases in income could be owing to different factors such as: 1) more intensive use of land; 2) increased crop yields; 3) higher market value of the produce; and, 4) shift towards higher yielding varieties.

Results of crop-wise analysis of the impact of the technology on yield and net income are presented in Table 2. It shows that the following: the yield of potato was only slightly higher for plots under WSTs in 2007.

Chart 4: Changes in Cropping Pattern before and after Adoption



Source: Field Data

However, the net return from the crop was higher for the plots irrigated by WST to an extent of 106%. This could perhaps be because the quality of the potato seeds used in the plots under WST was better. The potato produced in WST plots were of the same size, tasted better and looked glossy and hence fetched more price (Rs.5 against Rs. 4 for the crops irrigated under traditional method. Last year potato crop was attacked by a disease particularly in the adopters' plots. Since the technology was new to them, they were not able to use it

Table 1: Percentage increase in net income per ha after adoption of WST over the net income before adoption

Farmer Category	Before adoption		After adoption		% increase in income after adoption
	Area (ha)	Average net income Rs/ha	Area (ha)*	Average net income (Rs/ha)	
Marginal – 1	1.5	14487	1.5	58100	301.05
Small - 2	15.4	10761	10.3	40220	273.76
Medium – 3	79.3	12108	55.6	47340	290.98
Large – 4	492.5	13812	378.5	61947	348.50
	588.6	12792	446.0	51902	305.73

Source: Field Data; *Note: Some plots were not under WST properly and did not get the desired yield. Highest positve impact of WST on yield and net return was seen in the case of castor. In contrast to what was seen in the case of other crops, in the case of wheat, a reduction in yield was seen. Most of the farmers used WST for wheat on experimental basis. Hence, probably like in the case of potato, they could not use the technology properly.

Table 2: Percentage Change in Yield and Income Per Hectare after Adoption

Name of Crop	% change in yield after adoption	% change in net retun per ha after adoption
Fennel	2.04	89.67
Potato	5.78	105.82
vegetables	Not Applicable	124.02
Wheat	-0.46	41.90
Bajra (Kharif)	32.48	274.54
Bt cotton	48.36	56.00
Castor	172.39	394.39
Cotton	46.93	153.84
Fennel	100.00	501.72
Groundnut	37.23	97.34
Bajra (Summer)	-11.07	3.79

Source: Field data

4.5 Horticulture

Horticulture (chiku and berries), was practiced in very few places and did not fetch good returns before the WST intervention by NGI-IWMI in north Gujarat. Many expressed their ignorance and expressed happiness on seeing returns from orchards with WSTs. Now adopters are earning Rs. 1.51 lac from papaya, Rs. 1.96 lac from mango, and Rs. 2.30 lac from pomegranate from a hectare of land. The production of fruits takes more time than one season, depending on the fruit chosen, papaya takes 6 to 8 months, mango takes about 3 years and pomegranate about 18 months. During this gestation period farmers grow vegetables or any short-duration crop in between the plant rows. An orchard grower, thus, has two sources of income. The area under horticulture fruits, total net income and net income per hectare is is shown in Table 3.

4.6 Vermiculture

The vermiculture produces vermicompost. Using this as the manure results in the soil becoming more porous facilitating aeration. The moisture retention capacity of the soil also imporves. Selected farmers, particularly marginal and small farmers, seeing the great market, have adopted vermiculture to produce vermicompost as one of their enterprises. Eventually this has become a good source of income for them. Vermiculture has become an ancillary activity for WST users in this area. This requires little investment and gives very high return within a short period. In 2002, it was Rs. 500 kg, but after rapid adoption and replication of this activity across the region it has come down to Rs. 100 kg. It usually starts with 1 kg. worms and 20 kg Farm Yard Manure (FYM). The worms double and prepare approx 10 kg compost within 50-60 days. One kg worms can become 70 kg and produce 600 kg of compost in a year. (Source: NGI, Palanpur). In general the sale price ranges form Rs 1.80 to

Table 3: Area under Horticultural Crops and Income

Name of Crop	Area (ha)	Total Net Income (Rs)	Net Income (Rs/ha)
Chickoo	1.5	16100	11000
Grapes	1.4	171200	122000
Lemon	8.0	180000	23000
Mango	0.6	117500	196000
Papaya	0.1	15100	151000
Pomegranate	8.5	1954139	230000
Total Horticulture	20.1	2454039	122000

Source: Field Data

Rs. 2/- per kg. Among our selected households the earliest adopter was in the year 2002. In our sample, 12 farmers are practicing this venture; of these eight households (66%) are from smaller category of farmers. We found that return from a rupee of investment is Rs. 6, considering the total production of 5 years from 2002 to 2006. The average gross income per year per household is about Rs.8000 against the investment about Rs. 1300. Women generally look after vermiculture. *Ajba ben* saved Rs 72000 from her vermi-culture income and invested in overhead sprinklers and low cost drum kit for her small piece of land. One more example is *Heeraben*, for her it has become a livelihood.

4.7 Women's Outlook about Systems Micro Irrigation System in Agriculture

Adoption of WST has brought about an improvement in the quality of life of women by reducing their number of work hours[3]. According to one of the women farmers, before adoption of MI system, they were often not able to recover their cost of cultivation. About 77% women of the sample households felt that farm has become neat and tidy after the WST adoption. According to them, it increases production and saves water, power and labour. Now with electricity supply becoming timely, women can schedule their daily work conveniently.

Within a few years of WST adoption, women are now well experienced in running the system and can do minor maintenance like clogging of the system and fittings themselves. After installation of WST, their hard labor has reduced. Weeding work is now almost nil and applying fertilizer has become easy. The labour involved in sowing, and bundling and packing of dry straw has reduced. Plucking vegetables and fruits and making them ready for sale in the market are the additional responsibilities. Since many farmers changed their cropping pattern towards vegetables (chilly, brinjal) and orchards, the work pattern has changed (source: personal communication, Anuben) with disappearance of one type of wage labour and emergence of another. Women from landless households are deprived of wage labour in weeding operation. However, new farming operations such as vegetable picking, packing and marketing of the harvest are now generated, and can be taken up by landless women.

Some WST adopters have increased their livestock holding because of an increase in their incomes and availability of more spare time. Some others have chosen to reduce their livestock holding. One reason may be that the return on investment in livestock is lesser than that in land irrigated by WST. Another reason, which came out from group discussions, is that MI system has introduced precision farming, whereas managing livestock is still messy[6]. The farmers understand that by using WST system, they would get higher income.

4.8 Changes in Income among Adopters

There is reluctance amongst farmers to disclose their income from farming. We estimated the net farm income from cultivation data gathered during the survey. WST adopters have earned more than 108% from their farm during the year and 101% from all sources after adoption. Highest increase in farm income (more than 324%) was found among small farmers, as they also earned income from vericulture.

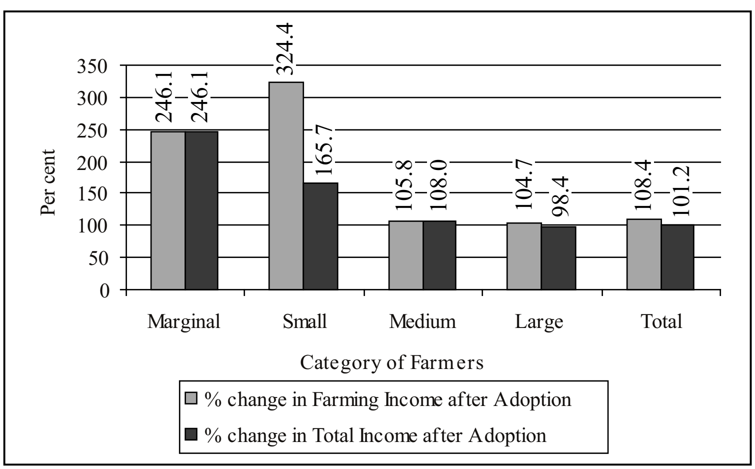
After adoption of WST, the total farm income of all adopters increased from Rs.1.17 crore to nearly Rs. 2.5 crore; and the total income including all both farming and non-farm activities increased from Rs. 1.25 crore to Rs. 2.6 crore. That means that the average household income of an adopter has gone up by Rs. 2 lac due to adoption. But, in the case of non-adopter, the average household income from all sources is only Rs. 54,766 and farm income is only Rs. 45,188.

4.9 Changes in Lifestyle of Adopters

There is a sharp change in the investments by farmers post WST adoption. The gross irrigated land has increased by more than 200%[7] (Chart 6). Farmers have taken land on lease and have irrigated them using micro-irrigation system, as they could irrigate more land by same available water and power supply. People who earlier took 2 crops can now grow 3 crops and also do inter cropping with horticulture. There is also an increase in purchase and use of agri-equipments. The increase is 22% for tractor, 27% for thresher 27.8%, 66.7% for planter, 128.6% for digger and 51% for others such as plough, harrow and cultivator. The sum total of asset of agri-equipments would be about Rs. 58.1 lac.

Holding of live stock has significantly reduced after adoption; bullocks by 37.6%, buffaloes by 7.5% and cows by 28.2%. Reduction in bullock is because of mechanisation of cultivation. The reduction in holding of buffaloes and cows is probably due to the differential income between crop cultivation and dairying. This has

Chart 6: Percentage Change in Farm and Total Income after Adoption



Source: Field Data

[6] One interesting question was asked, at this point of discussion to all the women mentioned above that if they were given 5 livestock or 5 bighas of land (without MI system) what they would like to keep? They agreed for livestock. But, when asked the next alternative that if the same size of land be given with MI system what they would prefer? They quickly agreed for land with WST.

[7] In flood irrigation 2 ha can be irrigated in 8 hr x 7 days i.e. 56 hrs in a week (not in horticulture). But, WST can irrigate 1 ha in 2-3 hours, so irrigated area increased among adopter farmers.

been more obvious when we discussed with the women members of the sample families. If farmers get more yield and income from the same area of land by using micro irrigation system, they refrain from holding more livestock, particularly when marginal income is less from livestock. About 32% people have taken new life insurance policies after having experienced significant increase in their farm income; the premium amount has increased by 61%. The total amount of premium went up to Rs. 17.5 lac from Rs. 11 lac after the adoption. This shows an increase in saving among WST adopters. The farmers do have other postal savings and investment in gold and silver, but we did not inquire about those details.

An interesting pattern is found in investment in consumer durables. There is reduction in investment on radio (-4.2%), but an increase in the investment in TVs both colour and black and white; 38 households have colour TVs. Before adoption only 17 households were using cycle, scooter, motorbike and cars and after adoption there are 52 households using any one of these vehicles. There is sharp rise of 206% investments in this. Many of them have more than two motorbikes and scooter in their homes. There is a negative investment of 42% in sewing machines since people can afford to go to a tailor.

The women members of WST adopter households expressed their interest in sending their children away from the village to get better and higher education since they are now able to afford higher tuition fee and expenses for boarding and lodging. Some families have sent their children for higher studies to Ahmedabad, Surat, Vallabh Vidyanagar and Anand. There is a sharp rise in incidence of private tuition also; with 77% of the sample families reportedly spending on private tuition. The expense towards this increased from Rs 7 lac to about Rs 23 lac, more than 3-fold increase. The number of households paying for private tuition increased from 11 to 47.

4.9.1 Other Positive Changes

Introducing the WST in this area has not only brought about significant changes in the lives of the farming community, but it also has impacted other sectors. A new business opportunity in the form of dealership of micro irrigation equipments is now created. In 2002, there was no dealer for micro-irrigation equipments in Palanpur town. The staff of NGI used to travel more than 150 km visiting Ahmedabad and Gandhinagar to purchase different components of MI systems such as lateral pipes, drippers and to manage assemblers. Within a year, in 2003, they could arrange three dealerships in Palanpur, two from IDE and one from Netafim, the largest manufacturer of drips and sprinklers internationally. Today, there are 91 dealers of MI equipments in North Gujarat, of which 72 are in Banaskantha, 11 in Mehsana and 8 in Patan.

Many potato farmers have now become cold storage owners, either individually or in groups. We met several potato growers who cherish the dream of opening a cold storage in Deesa taluka. The first cold storage of Banaskantha was established in 1985. In 2002, there were only 18 cold storages including two government managed ones. Now there are 62 cold storages functioning in Deesa and Palanpur talukas of Banaskatha. In Banaskantha there are 482803 cultivators and only about 4987 cultivators (1.03%) have adopted MI technology till January 2008; cultivable area of Banskantha is 819000 ha and only 9495 ha (1.16%) is under micro irrigation. What could be the impact when at least 25% of the cultivators and 25% of the cultivable land would have MI technology?

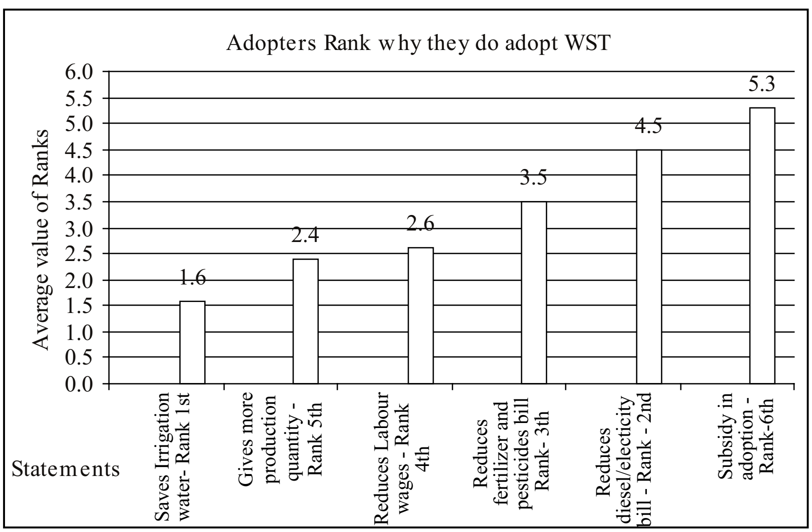
We found that among our sample adopters, farmers who have made good savings out of farming , particularly during the last few years, are interested in investing in non-farm sector. Owing to WST adoption, they have now got that extra time which they are using for obtaining good educating for their children. They also put their children in non-farm work such as vegetable selling, running whole-sale shops and provision store, running dealership of MI equipments (Netafim and Jain Irrigation). Some of them, who have greater savings, invest in cold storages. Large horticulturists (pomegranate) are considering setting up food processing units.

WST adoption also saves labour. There is a widespread misperception that WST will lead to unemployment. In reality, a new generation of high wage and high skill labour for farms with MI equipments, has emerged due to its intensive and extensive adoption for many crops. The labour rate for potato seed cutter is now Rs. 175 a day or even more, which was just Rs. 80 an year ago.

4.10 Reason for Adoption and Non-Adoption

As shown in chart 6, WST adopters reported "saving in irrigation water" most important, and "provision of subsidy" as the least important reason for technology adoption. The primary reason for not adopting WST was paucity of fund (Chart 7). The non-adopters are slowly beginning to realise the benefits of WST. However, there are several reasons for non adoption, other than finance. Use of MI equipments calls for meeting certain basic requirements such as: a) independent source of water in the farm; b) regular and timely supply of power unless the farmer uses drum kit which depends on gravitational flow[8]. If land is divided into many small parcels, it is difficult to derive sufficient incremental income benefit from WST adoption that offsets the additional costs associated with it. If many farmers share an irrigation well, equitable distribution of water becomes difficult, when MI equipment is used. Further, all the shareholders of the well may not be interested in the same technology. This was the case in Siddhpur area, where extension work has recently started[9]. Owing to three consecutive good monsoons, many farmers do not feel the pressure for using MI systems. The farmers also feel that getting loan from banks is quite challenging and time consuming. Some farmers had debts incurred during drought years, which were still not repaid, and hence could not take more risk for installing MI system. Priority to other social responsibilities is another hurdle in MI adoption. Above all, there is ignorance of the benefit of the MI systems and less severity of the crisis of irrigation water being felt by the farmers. In areas with sharp decline in groundwater table, government does not give permission for new electricity connections for bore wells. Many farmers rely on rain fed agriculture. Such constraints keep the farmers away from MI systems, even though many of them realize the benefit.

Chart 6: Reason for Adoption: Ranking



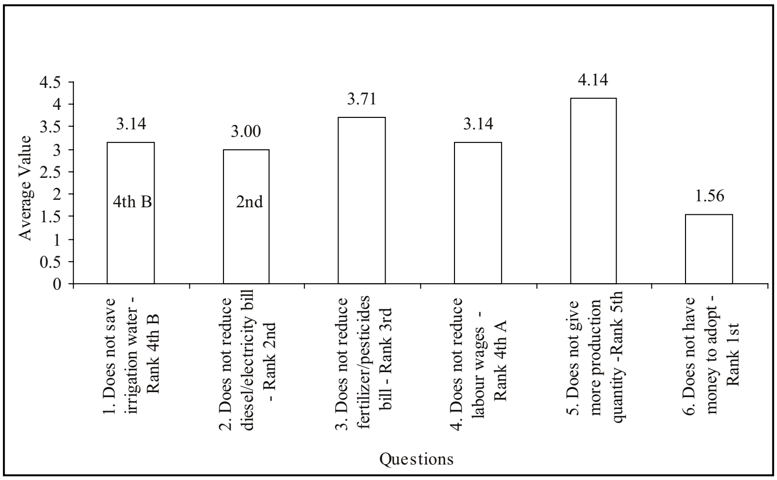
[8] The drum kit is useful for small land holdings.

[9] In Siddhpur area individually owned borewells are not many. In Jagnathpura village of Unjha taluka we talked to one farmer. He said that there were 35 bore wells in his village, of which only 4 bore wells are individually owned. Another 31 have 7 to 15 partners on each. Under such situation, it becomes difficult to convince all partners to adopt drip systems. In this area, poor quality groundwater is also a problem as it results in clogging for MI system. Recent availability of canal water in Samoda village and availability of water in plenty in Saraswati river also discourage the farmers from going for MI systems. The groundwater is available at a depth of 1000 to 1200 feet. Therefore the construction cost of well is also very high, about Rs 12 to 15 lac. In Kahoda village of Siddhpur taluka there are 75 to 80 bore wells, in which 4-5 bore wells are individually owned. Some bore wells have 70-75 partners. These farmers are small land holders (owing 4-5 vighas of land). So, they feel that WST is not economically viable for them.

5. FINDINGS AND CONCLUSIONS

The water saving technology for minor irrigation not only saves water, energy, and labour inputs but also increases farm income through higher production per unit of land. Though labour is saved for some agricultural operations which can create unemployment, a new generation of skilled labour has emerged - like potato seed-cutters who are earning Rs. 175 day, who were earning Rs. 70 day a few years ago. The technology was adopted because of shortage of perennial supply of labour, as the adoption does not require much labour for several agricultural operations. Introducing this technology opens up new opportunities in the form of large numbers of cold storage for potatoes and dealerships of MI equipments.

Chart 7: Reasons for Non-Adoption-Ranking



The study shown that Vermiculture can get very good results generating employment, increased incomes and improving soil productivity. This activity is often undertaken by women farmers, improving their economic conditions.

Micro Irrigation brought about a revolutionary increase in horticulture in north Gujarat. The unique three-way intervention made by NGI, i.e., growing vegetables between the rows of orchards during the gestation period of the fruit greatly increased cultivation and income. With two seasons of growing vegetables in the rows of orchards, farmers were able to recover 50% of their investment on MI.

WST has given a more than 100% increase in farm incomes. This gives a solid base to the farmers to go for non-farm investment, which can lead to greater economic development in the form of farm income for non-farm investment. A 'synergic' effect of spatial growth is already found in Deesa area. In this area there is growth of large number of cold storages, increasing number of WST dealerships, and newly trained workmanship for WST maintenances, buildings, markets and private businesses. Investing the extra income in education, particularly higher education will add a new dimension to the economic development of the region in the future.

Rinally, subsidy has made a boosted WST adoption. However, there are some complaints that the quality of the equipments is deteriorating because of low vigilance on quality control. This issue should be carefully handled to check and avoid the downfall in WST adoption.

WST adoption seems to be poor in dominantly canal-irrigated areas, areas with multiple ownership of wells and those where groundwater is highly saline.

Note: Kahoda village of Siddhpur taluka has 75-80 bore wells. Of these, 4-5 are of single owners. Some bore wells have 70-75 partners. Farmers are small land holders (average 4-5 vighas), so they feel WST is not economically viable for them.

Finally, it appears that there is huge potential for WST in the region. At present only 1% of the cultivable land is under micro irrigation. If such a small scale of adoption has brought about such significant positive changes, a higher scale of adoption can bring about dramatic changes in the region's agriculture and rural livelihoods.

5. ACKNOWLEDGEMENTS

The authors are thankful to the IWMI-TATA Water Policy Program for providing the financial support for undertaking this study.

REFERENCES

Bhattarai, M; Barker, R and Narayanamoorthy, A, (2007), Who Benefits from Irrigation Development in India? Implication of Irrigation Multipliers for Irrigation Financing, Irrigation and Drainage, 56, pp 207-225

GGRC, 2008, http:// http://ggrc.co.in/ Accessed February 27th

ICID, 2008, http://www.icid.org/, Accessed February 27th

Indu Rajnarayan and M. Singh (1999), Groundwater Socio-ecology in North Gujarat: Two Field-based Analyses, Working Paper Series no 9, The Policy School Project, Anand

Kumar, M. Dinesh, (2007), Groundwater Management in India: Physical, Institutional and Policy Alternatives, Sage Publications India Pvt. Ltd., New Delhi.

Longman Dictionary of Contemporary English; 1995; 3rd Edition, Longman Group Limited; p 1481

Namara, Regassa E., Upadhyay, Bhawana and Nagar, R K (2005), Adoption and Impacts of Micro-irrigation Technologies: Empirical Results from Selected Localities of Maharastra and Gujarat States of India; International Water Management Institute, Colombo; Research Repoert 93

Narayanamorthy, A (2004), Drip Irrigation in India: can it solve water scarcity?, Water Policy 6

Postal, Sandra, Polak, Paul, Gonzales, Fernado and Kellar Jack; 2001; Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and Poverty, International Water Resources Association, Water International, Vol. 26, No. 1, Pages, 3-13, March. [Also IDE publication Report 014, for private circulation]

Shah, Tushaar and Keller Jack; (2002), Micro-irrigation and the Poor: A Marketing Challenge in Smallholder Irrigation Development; In H. Sally and C. L. Abernathy (ed.), Private Irrigation in Sub-Saharan Africa: Regional Seminar on Private Sector Participation and Irrigation Expansion in Sub-Saharan Africa, Accra, Ghana, 22-26 Oct 2001; pp 165-183

Sivanappan, R. K (1994), Prospect of micro-irrigation in India, Irrigation and Drainage Systems 8: 49-58

Sivanappan, R. K (1994), Prospect of micro-irrigation in India, Irrigation and Drainage Systems 8: 49-58