IWMI-TATA
Water Policy Program

[This is a draft paper for discussion. Please do not quote.]

IWMI-Tata Water Policy Program

Annual Partners' Meet 2004

Promoting Micro-Irrigation in India*

Lessons from Maikaal

Shilp Verma
Stanzin Tsephal
Tony Jose

The research covered by this paper was carried out with generous support from the Swiss Agency for Development and Cooperation (SDC) under the IWMI-FiBL-bioRe collaborative research project titled "Growing Organic Cotton under Groundwater Stress". This is a pre-publication paper prepared for the IWMI-Tata Annual Partners' Meet, 2004.

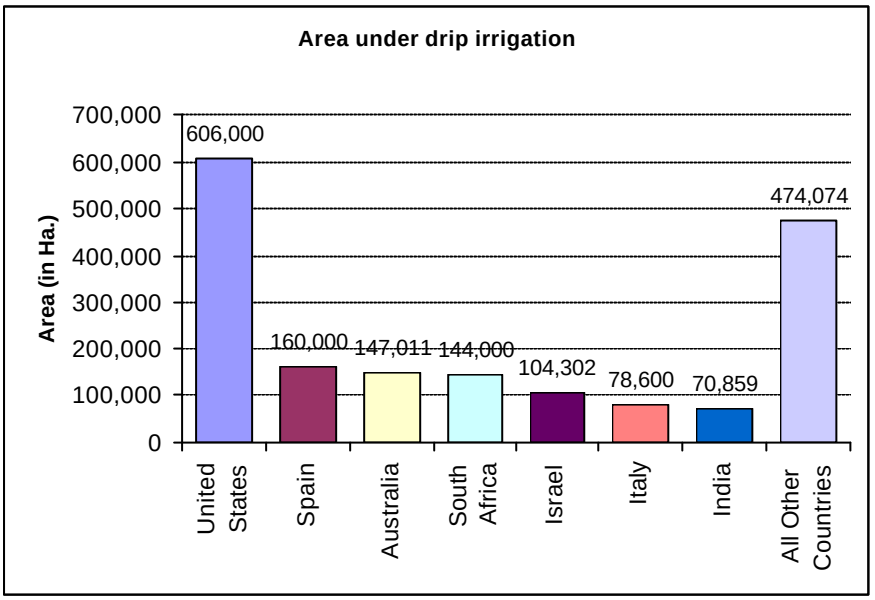
*** Based on Research by IWMI-Tata Core Team**

Visit: http://www.iwmi.org/iwmi-tata

1.0 INTRODUCTION

Drip irrigation, in its various forms, is the dominant mode of micro-irrigation in India. The benefits of these technologies in water scarce regions have been widely studied all over the world. A review of literature on drip-irrigation technologies strongly suggests significant financial, economic and social benefits of adoption of these technologies. However, the spread of drip irrigation in the Indian context has been far below potential and expectations.

Figure 1: Area under drip irrigation – Global Scenario (1991)



Data Source: INCID, 1994[3]

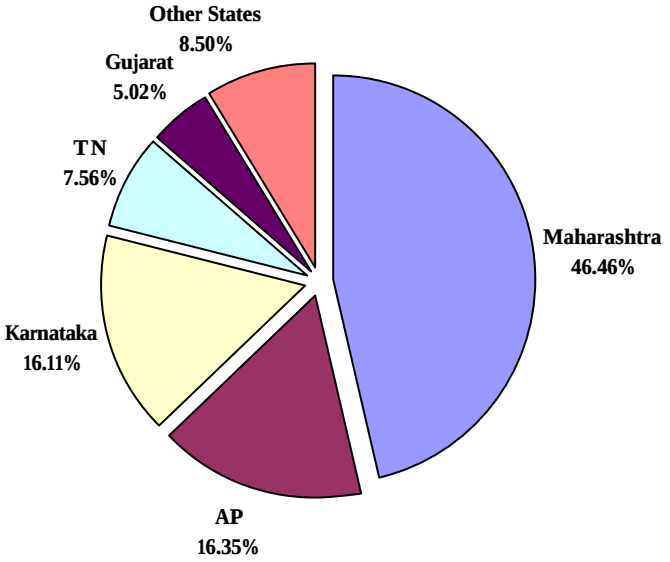
Ever since they were first introduced, the total area under drip irrigation has expanded rather sluggishly from 1500 ha in 1985 to a little over 70,000 ha in 1992 (Figure 1; INCID 1994[1]) and rapid growth has only been seen in recent years as the area spread to 225,000 ha in 1998 (Polak and Sivanappan 1998[2]). This, however, is still very low compared to an estimated potential of 10.50 million ha (Sivanappan, 1994[3]). Even with up to ninety percent government subsidies in some cases, the technology has failed to attract its target consumers in some of the most water-scarce regions of the country. It is still largely seen as the *Gentlemen* farmers' technology and is popular largely among large farmers in Maharashtra, and mostly for orchids and plantation crops (Figure 2; Figure 3; Kannan and Gurumurthy, 1999[4]; Shah and Keller, 2002[5]). Some of the prominent reasons for the sluggish growth are: [1] high initial capital investment; [2] lack of credit facilities; and [3] lack of information.

The farmers in the Maikaal region in Central India have shaken this belief and have forced the drip irrigation industry to wake up to their demand. What is most interesting is that while most government and non-government agencies have struggled to promote water saving technologies across the country, the people in this area have adopted and adapted these technologies on their own.

---

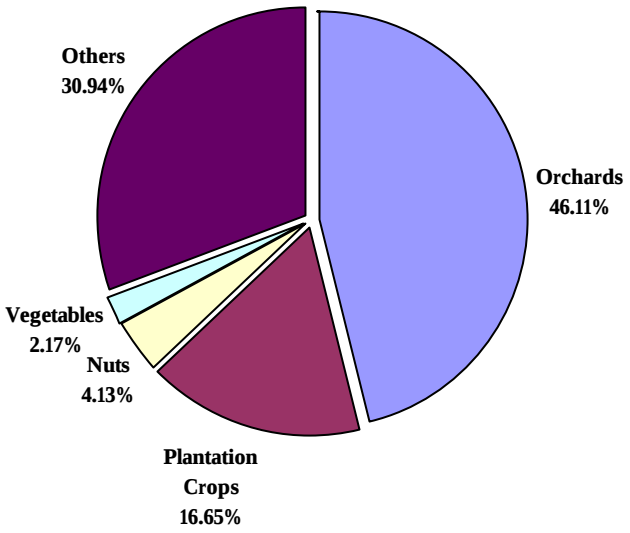
[1] INCID. (1994). *Drip irrigation in India*. Indian National Committee on Irrigation and Drainage, New Delhi.
[2] Polak, P. and Sivanappan, R. K. (1998). *The Potential Contribution of Low Cost Drip Irrigation to the Improvement of Irrigation Productivity in India.* India - Water Resources Management Sector Review, Report on the Irrigation Sector. The World Bank in cooperation with the Ministry of Water Resources, Government of India.
[3] Sivanappan, R. K. (1994). Prospects of micro-irrigation in India. *Irrigation and Drainage Systems*, No. 8: pp. 49-58.
[4] Kannan, S. and Gurumurthy, S. (1999). Drip irrigation and water management. *Yojana,* February. pp. 15-16.
[5] Shah, T. and Keller, J. (2002). *Micro-irrigation and the poor: A marketing challenge in smallholder irrigation development.* In Sally, H.; Abernethy, C. L. (Eds.), Private irrigation in Sub-Saharan Africa: Regional Seminar on Private Sector Participation and Irrigation Expansion in Sub-Saharan Africa.

Figure 2: State wise area under drip irrigation



Data Source: Kannan and Gurumurthy, 1999

Figure 3: Crop wise area under drip irrigation



Data Source: Kannan and Gurumurthy, 1999

This study was conducted to explore the various aspects of this grassroots innovation: its history and spread; its technical and financial viability vis-à-vis conventional drip/micro-tube systems; and the conditions and factors that lead to its successful large-scale adoption. The study was conducted in two districts: West Nimar (Madhya Pradesh) and Jalgaon (Maharashtra). The methodology included a survey of 180 farmers (including *Pepsee* adopters, Drip adopters and Non adopters) and semi-structured interviews with retailers and manufacturers of *Pepsee* systems.

2.0 GENESIS OF THE TECHNOLOGY

In the 1990's, precision irrigation technologies penetrated into West Nimar and its adjoining districts though the intervention of International Development Enterprises (IDE) and through the informal channel of progressive farmers. IDE began its work with Maikaal Cotton Spinning Mills, an Indo-Swiss Company and bioRe (a subsidiary of Maikaal Cotton, promoting organic cotton cultivation in the Maikaal region of Madhya Pradesh). Some progressive farmers had already begun trying out the drip irrigation technology in cotton cultivation. IDE encouraged bioRe's member farmers to experiment with their micro-tube technology for drip irrigation. For various reasons, IDE later moved out of the region; however, the seeds of water-saving it had sown there have blossomed and borne fruit (Shah and Keller, 2002). While bioRe continues to promote micro-tube kits, even they are too costly for many farmers who are unsure about the technology and are apprehensive and sometimes incapable of making the initial investments of Rs. 7,000-8,000 per acre.

The recurrence of drought like situation in the region for the last one decade has worsened the problem of rapidly depleting groundwater resources and low purchasing power of farmers, compelling many farmers to look for an alternate less expensive technology which would enable them to take summer crop and increase water and land productivity. A lot of innovations like using cycle tubes for drip irrigation etc. have been tried out by farmers in this region. But these

innovations were confined to a limited area and most of them failed to take-off in a big-way. Around 1998-99, a new innovation called *Pepsee* came up in this area and has since caught the imagination of small farmers in a big way.

Small candy manufacturers use light density plastics, disposable in nature, to fill ice candies which are sold as "*Pepsee*" in the local markets. The plastic candy is transparent and comes in a length of around 20 cm. This plastic roll is today being used in place of the drip tubes and is placed directly at the root zone of the plants. *Pepsee* systems (Figure 4) can therefore be described as low cost substitutes for drip irrigation systems made up of low density polythene ranging from 65-130 microns. The entire system is assembled locally and does not require huge skills to prepare. The cost of the plastic rolls comes to Rs. 50-60 per Kg. for the manufacturer and 65-80 per Kg. for the farmer. The farmers initially started using *Pepsee* systems for pre-monsoon sowing of the cotton crop. Two years ago, a recycled-plastic version of the *Pepsee*, popularly known as Black *Pepsee* came into the market. The Black *Pepsee* is cheaper and also removes the problem of algae attack which was a major trouble with the earlier product. Over the years, the use of *Pepsee* has spread to other crops like chilly, sugarcane and vegetables. In 2001, IDE-India has recognized the success of this grassroots innovation and has come up with its own version of the *Pepsee*, aptly named 'Easy Drip'.

Figure 4: The 'White' and 'Black' *Pepsee* in use

3.0 PERCEIVED ADVANTAGES AND DISADVANTAGES

Pepsee systems have many potential advantages when compared with flood irrigation systems. Most of these advantages are related to the low rates of water application. It can be argued that these benefits are not unique to *Pepsee* systems but are common to drip and micro-tube systems. However, these advantages combined with the very low capital investment requirement and the low levels of technical sophistication make *Pepsee* systems unique. The investment required for one acre of land under cotton (4x4 feet spacing) is as low as Rs. 4,000. This is only 59% of the investment required for a similar cotton plot with micro-tubes and 22% of that for conventional drip systems.

Moreover, one of the major problems with micro-tube kits and drip systems is that some of their components like micro tube and emitters are prone to damage by rats and rodents during storage and their replacement is expensive. In the case of *Pepsee*, this kind of risk doesn't exist because the system is mostly used for one season only.

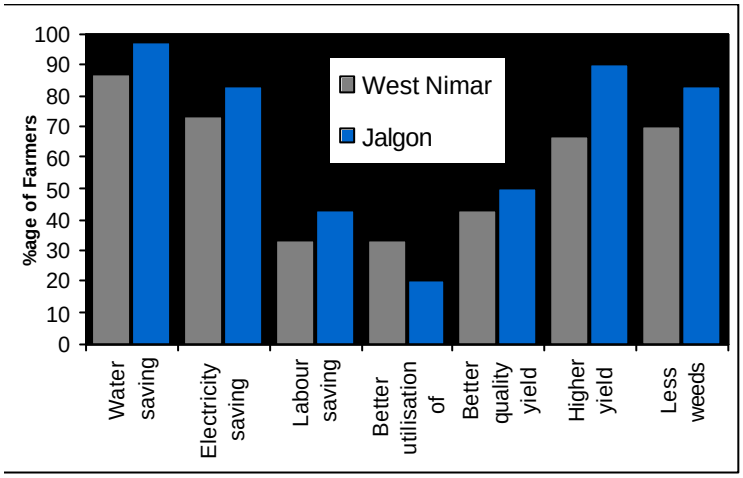


Figure 5: Perceived Advantages of *Pepsee* Systems in Jalgaon and West Nimar. (Source: Primary Survey, 2002)

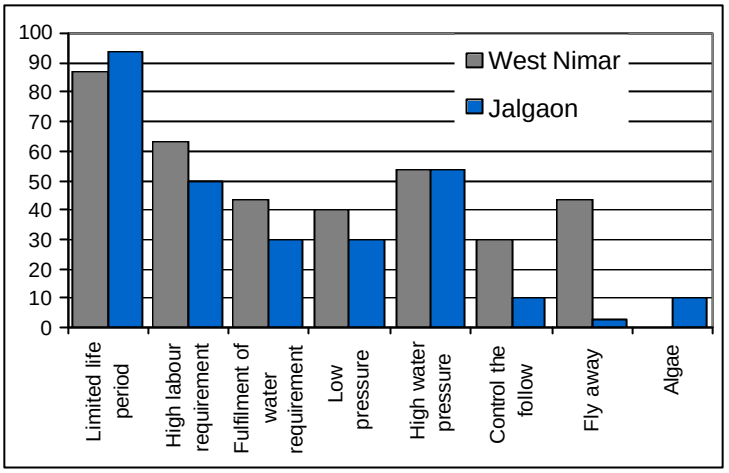


Figure 6: Perceived Disadvantages of *Pepsee* Systems in Jalgaon and West Nimar. (Source: Primary Survey, 2002)

Figure 5 and Figure 6 illustrate some of the advantages and disadvantages of *Pepsee* systems as perceived by cotton farmers in West Nimar and Jalgaon. Though the benefits and problems faced are largely the same, there are differences in relative importance which the farmers in West Nimar and Jalgaon attribute to them. This difference in perception across the two areas for same technology is primarily because of early penetration of matching technologies like micro-tubes and drips in Maharashtra (Jalgaon). In West Nimar, technologies like micro-tubes and drip systems are relatively new and the numbers of adopters is also less. Most farmers of West Nimar look at micro irrigation technologies only as a coping mechanism to groundwater stress. In Jalgaon, however, precision irrigation technologies have been popular for more than two decades and the farmers perceive other benefits such as higher yields, labour saving, etc as well.

4.0 Reasons for Adoption and Non-Adoption

The study also explored the factors influencing purchase decisions regarding *Pepsee* systems (Figure 7; Figure 8). The most widely perceived reason to adopt *Pepsee* was the fact that it leads to significant water saving at the farm level. The fact that *Pepsee* provides the benefits at less than half the price of micro-tubes and at one-fourth of the price of conventional drip systems gives *Pepsee* a niche in the market and was a significant factor in the farmers' decision making process.

Surprisingly, even at these low costs, majority of the non-adopters feel that the technology is too costly. A large number of non-adopters complained that they did not have enough water to irrigate their fields even with the reduced water requirements in *Pepsee.* On the other hand, nearly a fifth of non-adopters felt that they sufficient water and therefore did not feel the need for adoption. Some of the non-adopters found the technology too bothersome. This can be interpreted in two ways: either it is that they were not facing serious water scarcity, or they faced shortage of family labor. Only 10% of the non-adopters were totally unaware of the innovation or did not have sufficient information about it.

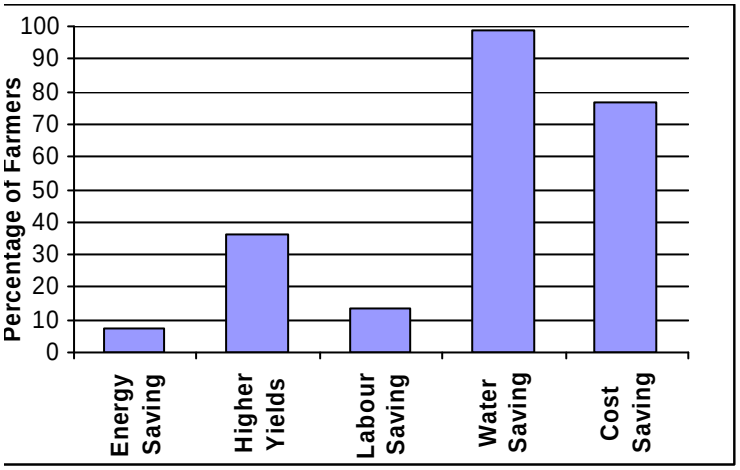


Figure 7: Reasons for Purchase of *Pepsee* Systems
(Source: Primary Survey, 2002)

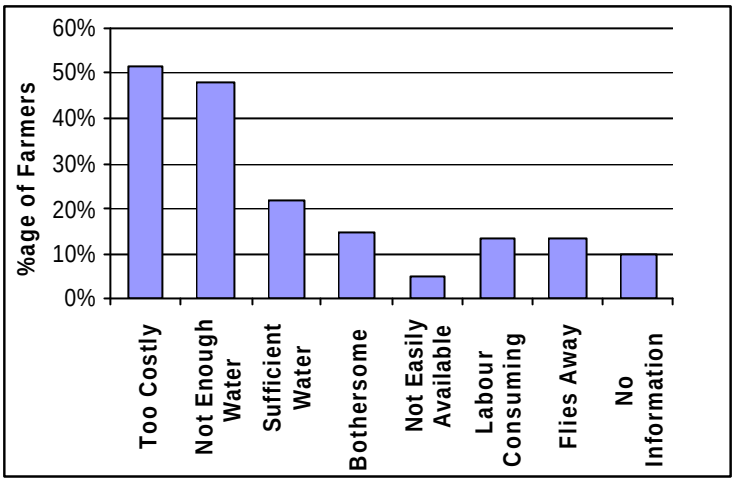


Figure 8: Reasons for not purchasing *Pepsee* Systems
(Source: Primary Survey, 2002)

5.0 FINANCIAL VIABILITY

Farmers' investment decisions depend primarily on subjective calculations of their incremental monetary costs and returns. Therefore, the incremental returns and costs as a result of installation of micro-tubes and *Pepsee* systems have been analyzed and compared. The benefits and costs that are non-financial in nature were excluded for the computation of financial viability indicators. Only labour cost was included as a number of farmers hired labour for installation of *Pepsee* for the first time.

Table 1: Cost Break-Up of *Pepsee* System of Irrigation

Item	Unit	Rate / Unit (Rs.)	Quantity Required	Value (Rs.)	Percentage of Total Cost
Lateral (*Pepsee* Straw,16 mm)	Kg.	65.00	12	780.00	17.52
Filter (Optional)	No.	1,200.00	1	1,200.00	26.96
Valve (2 inch)	No.	200.00	2	400.00	08.99
GTO	No.	1.50	100	150.00	03.37
Jointer	No.	0.75	15	11.25	00.25
PVC Pipe (2 inch Diameter)	No.	160.00	10	1,600.00	35.94
Accessories (includes elbow, thread, end cap etc)	-		-	150.00	03.37
Cost of Installation	Man Days	40.00	4	160.00	03.59
Total				**4,451.25**	

Source: Primary Survey, 2002

Investments Required[6]**:** For cultivation of cotton in one acre of land using *Pepsee* systems, the total initial investment was calculated as Rs. 4,451.25[7] (Table 1). This initial investment can be further reduced by 26% as the farmer can use the technology even without a filter in certain cases, depending upon the quality of water. The main difference between the costs break-up of

[6] The financial analysis has been done for cultivation of cotton (4x4 feet spacing) in one acre of land. Investments do not include the cost of digging well and installation of motor pumps as these costs are not specific to the adoption of these technologies and the farmer has to incur these costs even under flood irrigation.
[7] Initial investment in *Pepsee* includes the cost of filter INR 1,200 and is optional.

Pepsee systems and Micro-tubes is the cost of micro-tube and the 12 mm. lateral, which costs Rs. 3,800. This cost is replaced by the *Pepsee* straw, which costs only Rs. 780.

Table 2: Fixed and Variable Costs

Cost Head	*Pepsee* (Rs.)	Micro-tubes (Rs.)
Fixed Cost	3500.00	7425.00
Operations and Maintenance Cost*	791.25	58.75
Other Variable Costs	160.00	120.00
Total	**4,451.25**	**7,603.75**

Source: Primary Survey, 2002

*Amount may vary over years and across farmers

A look at the fixed and variable costs of *Pepsee* and micro-tubes (Table 2) indicates that variable cost is higher in case of *Pepsee.* A farmer needs to invest around Rs. 800 every year in the case of *Pepsee*; while in case of Micro-tubes, once the initial investment has been made the incremental investment in subsequent years is very low. *Pepsee* systems, therefore, spread the risk involved in investing in a new technology over a number of years and increase the motivation of farmers to experiment with water saving innovations.

Table 3: Financial Indicators of *Pepsee* and Micro-Tube Irrigation System#

Indicators	Cost Level	*Pepsee*	Micro-tubes
Internal Rate of Return (%)	**A**	45.00	40.00
	B	38.00	39.00
	C	18.00	28.00
Net Present Value (Rs.)	**A**	5,513.00	9,057.33
	B	4,390.75	8,791.06
	C	1,107.13	4,928.54
Benefit Cost Ratio	**A**	1.51	1.82
	B	1.41	1.80
	C	1.10	1.43
Payback Period		2.37	2.23

Source: Primary Survey, 2002

 # Assumption Notes:

- The life span of *Pepsee* and Micro-tubes' hardware (other than the *Pepsee* straw) is sometimes more than 10 years, but using conservative estimates for the purpose of financial calculations, we have taken seven years.
- In order to minimize uncertainty, while calculating financial indicators, an inflation rate of six percent and a discount rate of twelve percent have been assumed.

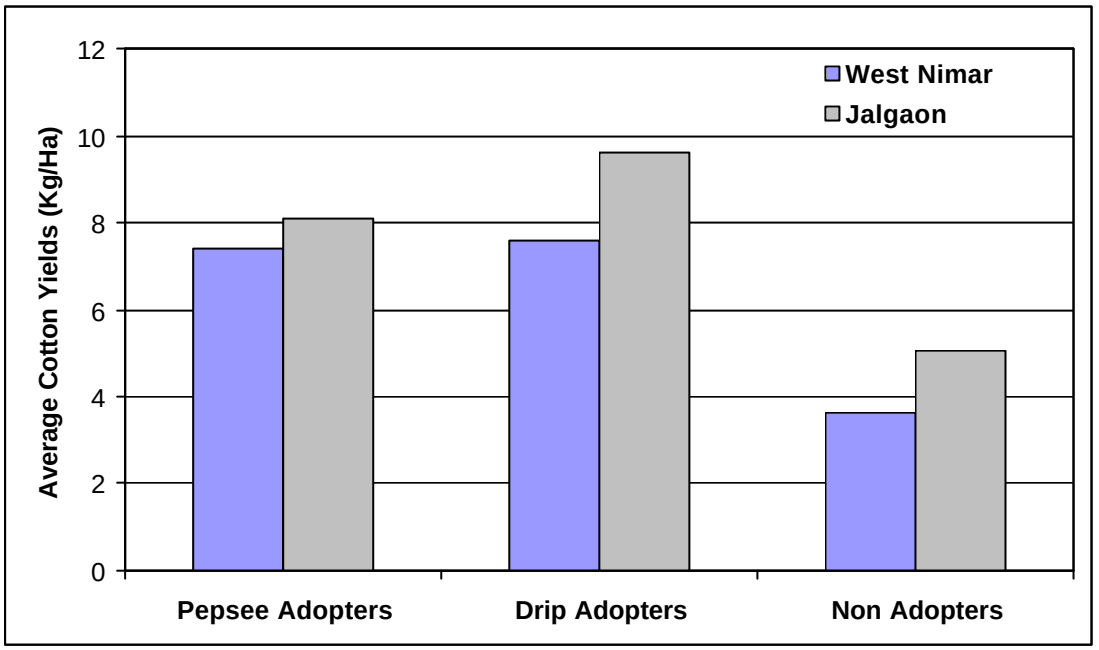
All four indicators (Table 3) reveal that investments in both micro-tubes and *Pepsee* systems are financially viable. The analysis also indicates that investment in micro-tubes is better than in *Pepsee*! Benefits in terms of yields and water saving are also marginally higher in the case of micro-tubes. Then, why do farmers take to *Pepsee* and have not adopted drips and micro-tubes?

The initial investment required for *Pepsee* systems is 41% less than the same for micro-tubes and 78% less than the same for conventional drip systems. Lack of information in terms of awareness and knowledge about application, utility, methods of operation and maintenance, also does not hinder its adoption. The farmers' risk gets spread across several years and in case they want to shift to micro-tubes or conventional drips in the future, they just need to make additional investments on laterals and micro-tube and no hardware of *Pepsee* will go waste. All these together explain the farmers' preference for *Pepsee.*

6.0 IMPACT OF ADOPTION

Pepsee systems make pre-monsoon sowing possible. The provision of irrigation, made possible through the use of *Pepsee*, leads to higher germination rate and lower incidence of pest attack. The impact of *Pepsee* on average cotton yields can be seen in Figure 9. Early sowing of cotton facilitated by *Pepsee* enables farmers to get the best prices in the market at the time of harvest. Farmers also believe that there is a significant improvement in the quality of the harvest through the use of *Pepsee* systems as each plant gets the right quantity of water at regular intervals unlike in flood irrigation where farmers tend to over-irrigate or under-irrigate depending on the availability of water and power and not based on crop water requirements.

Figure 9: Average Cotton Yields among Adopters and Non-Adopters



Source: Primary Survey, 2002

Does the adoption of *Pepsee* and other water saving technologies can help alleviate the problem of groundwater depletion? For answering this, we compared the pumping behavior of a *Pepsee* adopter and a flood irrigator. Table 4 shows the difference in pumping behavior between the two.

Table 4: Difference in pumping between *Pepsee* adopters and Flood Irrigators

Method of Irrigation	Number of Irrigations	Hours of Irrigation/Acre	Total Hours of Pumping
Pepsee	18	0.42 Hrs	7.50 Hrs
Flood	3	5.00 Hrs	15.00 Hrs

Source: Primary Survey, 2002

There is a (notional) saving of 50% in terms of water used. Therefore, adoption of *Pepsee* does lead to more efficient utilization of water. However, the question of the impact on the depleting groundwater table is a tricky one. Adoption of *Pepsee* has in fact led to greater pumping of water in some cases as it has helped farmers to undertake second crop of cotton which was not possible before this innovation. Also, on an average, there has been an increase of 2.2 acres in area under irrigation as a result of adoption of Pepsee. Farmers who could not irrigate at all

without this innovation (and were thus not pumping any groundwater) are now able to use the limited amounts available for irrigation. Moreover, the use of *Pepsee* is restricted largely to the pre-monsoon season. Post-monsoon, when there is sufficient water in the wells, farmers revert back to flood irrigation. Thus *Pepsee* adoption leads to more efficient utilization of water but not effective and sustainable management of groundwater resources at the basin level.

7.0 THE MARKET

Apart from the survey of farmers, discussions with a number of retailers and manufacturers were also held in both West Nimar and Jalgaon to understand the market dynamics and the supply chain of the innovation.

The market for *Pepsee* is totally demand driven and is growing fast as more and more retailers are getting into the business of selling *Pepsee* to cater to the increasing demand from the farmers. Till now, however, no manufacturer or seller is really pushing *Pepsee* as its share in their total business is only around one to three percent and the demand is seasonal in nature. Figure 10 identifies six different chains currently in operation in West Nimar and Jalgaon.

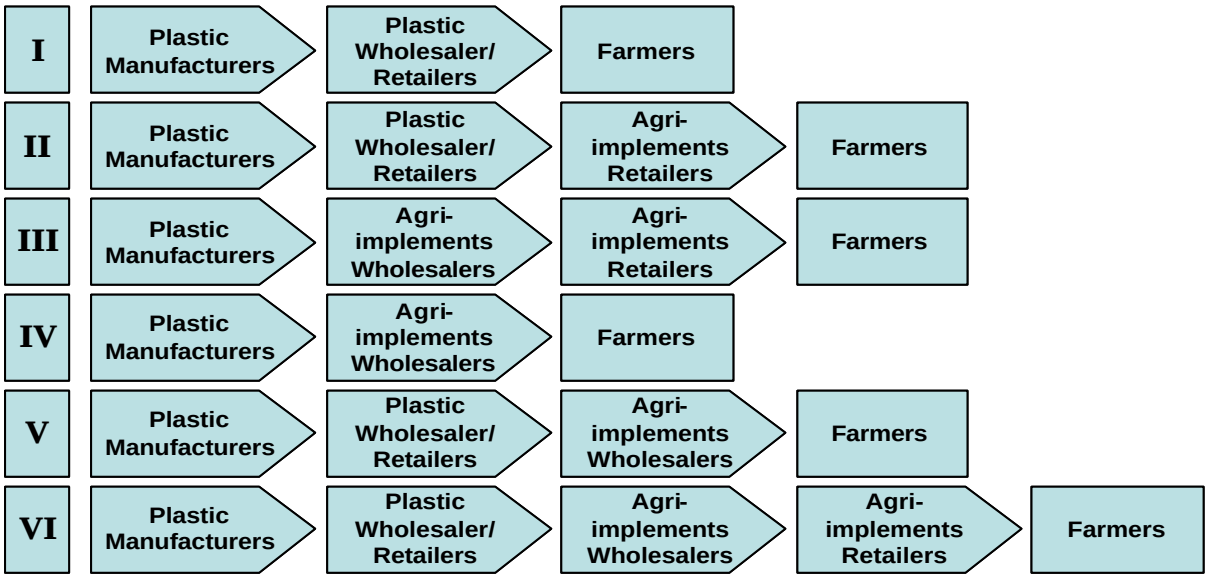


Figure 10: Different Supply Chains of *Pepsee* Systems

The supply chains in West Nimar and Jalgaon are different from each other. In West Nimar, the agriculture implements retailer has not assumed a significant role in the supply of *Pepsee* and hence the prominent models are I and II. The plastic wholesale market is situated in Indore, which is around 100 kilometres from Maikaal region. The retailers take order from farmers and deliver to farmers within two days. The transaction between retailers and plastic sellers in Indore is through telephone and the plastic seller delivers it at the shop. The transportation cost is approximately Rs. 8 per 30 Kg. box.

The small retailers in the villages get *Pepsee* directly from Indore and sell in the villages. They charge Rs. 75 per Kg. for the straw. The accessibility of farmers to the wholesale market is a problem in West Nimar and this has created problems for the farmers in terms of price discrimination and the variable quality of the product. Also, the range of products available to the users is limited. Models I and IV are more prominent in Jalgaon. There is a greater accessibility of farmers to the wholesale market and the farmers have greater choice in terms of

thickness and quality. There is no specific brand for *Pepsee* as such in West Nimar but in Jalgaon the market is more developed and there are a number of brands which are adaptations of *Pepsee.* Black *Pepsee,* which is the thicker version of *Pepsee* and is made of recycled plastic, is also available in Jalgaon.

8.0 PROMOTING MICRO-IRRIGATION IN INDIA

Micro irrigation technologies have been around in India for more than twenty-five years and several studies have highlighted the advantages of adopting these technologies. However, the technologies have failed to capture the kind of market share as would have been expected given the numerous advantages and significantly positive financial returns. Shah and Keller (2002) highlight two distinct aspects of low-cost micro-irrigation in India and Nepal: [1] Poverty focus, in terms of enhancing income and quality of output for poor farmers; and [2] Market development, in terms of ensuring the survival of distressed agrarian economies facing both water and energy crises. *Pepsee* systems have not only helped farmers in the Maikaal region in ensuring the sustainability of irrigated agriculture under worsening conditions of groundwater stress, but has also expanded the potential market of micro-irrigation technologies through significant cuts in the investments required for adoption.

The limited growth of micro-irrigation technologies in India so far can, to a large extent, be explained by the apparent gap between what has been marketed and where the demand lies. Over the years, government as well as non-government agencies have been promoting micro-irrigation as a 'New Concept in Agriculture' through a "Package Solution" with the following salient features: [1] Water Saving; [2] Good Pay Back Period and Internal Rate of Return; [3] Customized and Highly Sophisticated Technology; [4] Higher Yields and Better Quality of Output; and [5] Labour Saving. The farmers, on the other hand, have different priorities and concerns. They demand solutions and technologies that would provide them: [1] Assured Returns; [2] Lower Costs; [3] Simple Technology; [4] Generic Applicability; and [5] Higher and better Yields with fewer pumping hours. Clearly, there is an urgent need to bridge this demand-supply gap.

Table 5: Overview of *Pepsee* Systems

STRENGTHS	WEAKNESSES
1. Low cost 2. Low initial investment 3. Risk spread over number of years 4. Skill requirement is less 5. Shift to micro tube and drip feasible 6. Less transportation and storage problem	1. Limited life period & delicate 2. High labour requirement 3. High replacement cost of *Pepsee* 4. Cannot withstand high pressure of flow 5. Unequal distribution of water
OPPORTUNITIES	**THREATS**
1. Scope for improvement 2. Latent demand for water saving 3. Involvement of agencies for replication 4. Manufacturing process available everywhere 5. Shift from Flat to Metered electricity billing	1. Non standardization in product 2. Non performance of early adopters 3. Decreasing price of micro tube and drip 4. Environmental problems with polythene

The success of *Pepsee* systems marks the 'next' phase of growth in the micro-irrigation industry. The farmers in Maikaal have shown the way to bridging the apparent demand-supply gap. There are significant lessons for policy makers and promoters of water saving technologies from the Maikaal experience. These can broadly be listed as below:

1. **Inputs vs. Capital Investments:** There is a need to view water saving technologies as recurring input costs rather than capital investments that offer returns over the next eight-ten years. If the small farmers are to be targeted, policy makers must understand that they would be hesitant in making huge-capital investments in new technologies unless they are very sure of their results. Even when they are convinced about the returns, they might not be in a position to incur the huge capital costs due to poor access to good quality credit options.

2. **Demystification of Technology:** There is a need to transfer the technology into the hands of the users. Some of the most successful experiments are done not by scientists in the labs but by farmers in their backyards and fields. Unless the farmers will feel totally comfortable and competent in handling the technology intended for them, there is little chance that even sixty-seventy percent subsidies would bring the desirable results.

3. **Building in Modularity:** *Pepsee* systems are not complete substitutes for highly sophisticated drip technologies. Even our financial calculations and survey results indicate that the returns offered by micro-tubes and drip kits are higher that those offered by *Pepsee.* However, if *Pepsee* systems are viewed as a 'Stepping Stone' to adoption of higher-degree-of-sophistication-and-higher-cost technologies and if these technologies are designed in such a way that the transition is made simple and modular, the results can be very positive. 6 of the 8 farmers who discontinued the use of *Pepsee* after one-two years shifted to IDE's micro-tubes. Thus, there are indications that as the farmers get convinced about the results, become familiar with the technology; and possibly also improve their financial status in the process; they would shift to the more efficient technologies being marketed today.

4. **Operating Strategies:** In 2001, IDE started working on their own, improved version of *Pepsee,* aptly named 'Easy Drip'. This is a very encouraging sign as the presence of a professional agency would definitely help the innovation in spreading to new areas. Since the technology is in the nascent stage, there is a need to focus on three things: [1] Product Quality – both in terms of consistency and standardization as well in terms of longetivity of the product; [2] Ensuring easy availability through a reliable channel; and [3] Creating demonstrations of success in the target group.

5. **Where to Promote:** While promoting micro-irrigation, it is imperative that the nexus between energy and irrigation be kept in mind. Micro-irrigation technologies have tended to become popular where between water and energy, water is scarcer. In Maikaal also, people have responded positively to water saving technologies as they did not enough water to run their pumps for the available hours of electricity supply. If, on the other hand, power supply was the critical resource, people would prefer to run their pumps for every hour that electricity is supplied. Ignoring this critical nexus could lead to undesirable gaps in policy tools and results. A detailed discussion on the different aspects of this nexus is available in numerous studies done by the IWMI-Tata Water Policy

Program group (Shah, Scott, Kishore and Sharma, Forthcoming[8]; Kumar 2002[9]; Kishore and Verma 2002[10]; Kishore, Sharma and Scott 2002[11]) besides others.

6. **Water Saving?** Does micro-irrigation really save water? From what has been observed in Maikaal, adoption of these technologies does lead to improved water efficiency at the individual farm level. However, unless the technologies are adopted on a large scale, the impact would not be significant at the basin or sub-basin level. Can pre-monsoon adoption of *Pepsee* lead to basin-level water saving in the long run? Our contention is that as farmers begin to experience (and perceive) the entire range of benefits offered by micro-irrigation (higher yields, better quality of output etc), they would use these technologies throughout the cropping season and in the long run, *Pepsee* and other water saving systems would become a routine farming practice rather than a short-run water stress coping mechanism. It is only then that these technologies would lead to basin-level water saving. Now, it is for the policy makers to use this opportunity and promote this transition by providing an enabling policy environment.

[8] Shah, T., Scott, C., Kishore A. and Sharma A. (Forthcoming). *Energy-Irrigation Nexus in South Asia: Approaches to Agrarian Prosperity with Viable Power Industry*. Forthcoming IWMI Research Report 70.
[9] Kumar, Dinesh M. (2002). Micro Management of Groundwater in North Gujarat. *IWMI-Tata Water Policy Research Highlight, No. 5*. IWMI-Tata Water Policy Program, Anand.
[10] Kishore, A. and Verma S. (2002). What determines pumping behaviour of tube-well owners: Marginal cost or opportunity cost? *Water Policy Research Highlight, No. 6*. IWMI-Tata Water Policy Program, Anand.
[11] Kishore, A., Sharma, A. and Scott, C. (2002). Power supply to agriculture: Reassessing the options. *Water Policy Research Highlight, No. 7*. IWMI-Tata Water Policy Program, Anand.

IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

Through this program, IWMI collaborates with a range of partners across India to identify, analyse, and document relevant water-management approaches and current practices.

The policy program's website promotes the exchange of knowledge on water- resources management within the research community and between researchers and policy makers in India.

IWMI-TATA WATER POLICY PROGRAM
Elecon Complex, Anand-Sojitra Road
Vallabh Vidyanagar, 388120, Gujarat, India
Telephone: 91-2692-229311-12-13
Fax: 91-2692-229311
E-mail: iwmi-tata@cgiar.org
Website: http://www.iwmi.org/iwmi-tata

HEADQUARTERS
127, Sunil Mawatha, Pelawatte, Battaramulla, Sri Lanka
Mailing Address: P O Box 2075, Colombo, Sri Lanka
Telephone: + 94 – 11- 2787404, 2784080 Fax: +94 – 11- 2786854
E-Mail: iwmi@cgiar.org

REGIONAL OFFICE FOR ASIA
(Bangladesh, China, Nepal and Sri Lanka)
127 Sunil Mawatha, Pelawatte, Battaramulla, Sri Lanka
Mailing Address: P O Box 2075, Colombo, Sri Lanka
Telephone: +94 1 867404, 869080, 869081, 872178, 872181
Fax: +94 1 866854; E-Mail: iwmi@cgiar.org

CHINA
Centre for Chinese Agricultural Policy, Chinese Academy of Sciences,
Building 917, Datun Road, Anwai, Beijing 100 101, China
Telephone: +86 10 64889440, 64856535, 64856837
Fax: +86 10 648556533; E-Mail: j.wang@cgiar.org

NEPAL
GPO 8975 EPC 416, Kathmandu, Nepal
Telephone: +977 – 1 – 5542306, 5535382 (Ext 486)
Mobile Tel: 981022573; Fax: +977 – 1 -5536219
E-Mail: d.pant@cgiar.org

REGIONAL OFFICE FOR AFRICA
141, Cresswell Street, 0184 Silverton, Pretoria, South Africa
Mailing Address: Private Bag x813, Silverton 0127, South Africa
Telephone: +27 12 8424132, 4125, 4128, 4131, 4136-9
Fax: +27 12 8040753; E-Mail: d.merrey@cgiar.org

KENYA
c/o ICRAF, United Nations Avenue, PO Box 30677, Nairobi, Kenya
Telephone: +254 2524751, 524000; Fax: +254 2524001
E-Mail: c.mutero@cgiar.org

SENEGAL
c/o WARDA/ADRAO, BP 96 St. Louis, Senegal
Telephone: + 221 9626493, 9626441; Fax: +221 9626491
E-Mail: p.fraval@cgiar.org

GHANA
c/o KNUST, Kumasi, Ghana
Telephone/Fax: +233 51 60206
E-Mail: iwmi-ghana@cgiar.org

REGIONAL OFFICE FOR SOUTH ASIA
IWMI South Asia Regional Office, ICRISAT, Patancheru,
Andhra Pradesh 502 324, India
Telephone: +91- 40 - 23296161; Fax: +91- 40- 23241239
E-Mail: iwmi-southasia@cgiar.org

REGIONAL OFFICE FOR PAKISTAN, CENTRAL ASIA AND MIDDLE EAST
12KM, Multan Road, Chowk Thokar,
NiazBaig, Lahore 53700, Pakistan
Telephone: +92 42 5410050-53
Fax: +92 42 5410054; E-Mail: a.qureshi@cgiar.org

UZBEKISTAN
Apartment No. 103, Home No. 6, Murtazaeva Street,
Tashkent 700000, Uzbekistan
Telephone: +998 71 1370445; Fax: +998 71 1370317
E-Mail: v.hornikova@cgiar.org

REGIONAL OFFICE FOR SOUTH-EAST ASIA
(Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, Vietnam)
PO Box 1025, Kasetsart University, Jatujak,
Bangkok 10903, Thailand
Telephone: +66 2561 4433; Fax: +66 2561 1230
E-Mail: d.j.bandaragoda@cgiar.org