Contributing Paper

Developing Irrigation Options for Small Farmers

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DEVELOPING IRRIGATION OPTIONS FOR SMALL FARMERS: HARNESSING THE POTENTIAL OF THE POOR

By Keith Frausto

1. INTRODUCTION

The irrigated agriculture sector is facing increasing challenges in the face of rapid population growth, decreasing availability of land, and competition for scarce water resources. Due to decreasing investments and declining performance of many large-scale irrigation schemes, interest has been developing in recent years for seeking ways to improve the productivity and livelihoods of the world's small-scale farmers – farmers who typically cultivate less than five hectares of land. Comprising the majority of the farmers in developing countries, small-scale farmers should be perceived as key players in increasing global agricultural production and achieving food security.

In light of the enormous potential to successfully harness smallholder production, existing irrigation strategies need to be re-evaluated to include approaches that are effective in reaching smallholders as a potential market. When planning for irrigation expansion, small farmers need to be considered from the outset, rather than trying to figure out how to incorporate them when large systems begin to fail. One approach that should be considered is a *market-driven product development strategy* that has been successfully implemented in Asia since 1984. This strategy has resulted in over 1.3 million irrigation pumps purchased by farmers, with array of benefits and profits to smallholders, private sector entrepreneurs, and manufacturers. The process has also stimulated the identification of additional income-generating technologies and their demand among farmers. This paper will look at the evolution of the market-driven approach to reaching small farmers, the technologies that stimulated this approach, and the technologies that have recently been developed as part of the ongoing process.

The two technologies under discussion include:

The treadle pump – a low-cost foot operated irrigation pump used be farmers on shallow aquifers mostly in Asia. Over one million pumps have been purchased in Bangladesh alone, enabling farmers to irrigate up to ¾ of an acre of vegetables, cash crops and high value rice. Farmers recover the cost of the pump in one season, and earn a net income of at least $100 per year, with 20 percent of farmers earning $500-600 per year (Shah, 1999). The potential of this pump in Eastern India and Nepal alone is estimated as high as 10 million units, which would add 2.5 million hectares in irrigated acreage and US $1 billion a year in increased net income for small farmers. The treadle pump and other like it could offer a major contribution to increasing irrigation in Africa's vast dambos, vleis and other shallow aquifer areas.

Low-cost microirrigation technologies recently developed by IDE and other organizations offers another breakthrough technology approach to increasing smallholder irrigation potential. Over the last four years, the reduction of the cost of conventional irrigation by over 60 percent now enables smallholder the first opportunity to adopt this water-saving technology. Drip irrigation in particular offers poor farmers the chance to increase their water efficiency up to 50 percent at the same time improving yields by 30 percent or more.

2. THE CHALLENGE OF MEETING SMALLHOLDER POTENTIAL

For the most part bypassed by the green revolution and other successful innovations in agriculture production, smallholders live at or below the poverty level and are highly averse to risk; their very livelihoods are focussed on keeping the margin for error as small as possible. At the same time, smallholders are capable of managing irrigation systems efficiently provided they have access to affordable technologies that are easy to operate, maintain and repair. Small-scale systems and technologies are attractive since they put the operation, maintenance and management of systems directly in the hands of the individual farmers, thus eliminating any need for centralized control or management. Farmers are empowered since they are able to apply water when and where they need it. Capital costs are lower and local labor and skills are employed. In many cases, smallholders can be more productive with their yields and more efficient in water use than larger irrigation schemes (Ruotsi, 1999)

Unfortunately, most existing modern irrigation devices do not fit the plots of smallholders, and are far too expensive (in terms of capital or running costs) to be affordable. One key, then, to increasing the agricultural productivity of small farmers is access to affordable and efficient irrigation technologies.

As part of the development community's fascination with the field of appropriate technologies, a range of technologies, techniques and practices have been developed over the years on behalf of smallholders. However, many, if not most, technologies have been unsuccessful in their performance, application, dissemination or adoption. Development agencies have tried to encourage farmers to adopt bush pumps, rope-and-washer pumps, rower pumps, treadle pumps, pitcher pot systems, drag-hose sprinklers, hydraulic ram pumps, microirrigation systems, windmills, water harvesting techniques and a host of other technologies with mixed success. While it may be that some of the technologies simply did not perform to expectations, there is a natural tendency to over-emphasize the technology itself rather than pay attention to the process by which it is identified, modified, and disseminated. All too frequently the end customer -- the farmer – has been left out of the process altogether.

Frequently bypassed, too, is the role that marketing plays in the dissemination of new technology options. This is many times based on the lack of familiarity that governments and the development community have with marketing as an endeavor essential to the dissemination of concepts and products. Other times it is based on the assumption that technologies and other products and practices somehow sell themselves. As a result of uneven and haphazard approaches towards small farmers, the uptake of most appropriate irrigation technologies by small-scale farmers has been relatively poor.

International Development Enterprises, an NGO with headquarters in North America and Europe, has successfully developed and marketed two affordable technologies that improve the livelihoods of small-scale farmers in eight countries around the world. Based on experience gathered since 1984, IDE has been refining an approach to technology development, dissemination and marketing that has proven effective in achieving a high rate of sales and adoption among farmers. This approach has also succeeded in establishing the private enterprise networks in rural areas necessary for ensuring the availability of the technology to farmers at an affordable price, on a sustainable basis.

2.1 Experiences with the Treadle Pump in Asia

IDE began building its market-driven approach with the identification of the treadle pump -- a foot-operated, shallow lift suction pump capable of producing1 litre of water per second from depths up to 7 meters. The pump is made of mild sheet steel and can be produced locally by small-scale manufacturers. The pump enables marginal farmers to irrigate up to 1 acre of vegetables and other cash crops.

In Asia it has been estimated that farmers using the treadle pump typically earn a net profit of around US$ 100 per season by using the pump. Recent investigations (T. Shah et al 1999) indicate that this is a conservative estimate. Treadle Pumps in Asia are mostly installed on tubewells, but many variations are available that enable farmers to pump from surface water sources such as rivers, dams, ponds, open wells, etc. The cost of the treadle pump head in India and Bangladesh is US $ 9.00, with tubewell installation costing around $26 to the farmer for a total cost of $35 – less than one tenth of the cost of a diesel pump. The life-span of a treadle pump is around four to seven years, depending on many factors, including the salinity of the water, the quality of maintenance, type of aquifer etc. Yearly spare part replacements center around the inexpensive bucket valves.

The Treadle Pump was developed in Bangladesh during the mid ‘70s and early ‘80s by Gunnar Barnes and Nanendra Nath Deb under the Rangpur Dinajpur Rural Service (RDRS). Over this period of time, many generations of treadle pumps were methodically designed and tested in field conditions with farmers. By 1981, 2,000 treadle pumps had been sold in Bangladesh and by 1984 sales had reached 7,000 per year (Orr, Islam and Barnes, RDRS 1991). In 1984, International Development Enterprises began employing a marketing approach to the challenge of making the pump more widely available in Bangladesh through the private sector. IDE began concentrating on establishing a supply chain consisting of manufacturers, dealers, distributors, and technical installation/drilling teams called “mistries”. The bulk of IDE’s work focussed on creating demand through aggressive promotion and rural mass-marketing activities. By 1997, around 50,000 pumps were being sold per year in Bangladesh (with an additional 50,000 sold outside IDE’s marketing network), with a similar amount being reached per year in India by 1999.

IDE has since introduced the treadle pump to India, Nepal, Cambodia, Vietnam, Sri Lanka, Zambia and Haiti. Some limited work has also been initiated to bring the pump to the Philippines, Myanmar, Zimbabwe, and Malawi. By 1997, over 1.3 million treadle pumps hade been sold in Asia. With farmers earning on an average a net US$ 100 per year, this generates roughly US $130 million in income to farmers. Using a conservative multiplier effect of two to account for backward (supply chain) and forward (output market) marketing linkages, the gross annual income from the use of treadle pumps is estimated at US $260 million per year. Total costs for training, marketing and promoting by IDE for a 10 year period has been US$ 8 million with an investment by small farmers in purchasing the pumps for 10 years estimated at $46 million.

2.2 The Benefits of the Treadle Pump

The benefits of the treadle pump vary from country to country, but in general include:

- Enabling farmers to grow up to ¾ of an acre of vegetables, or cash crops
- Can increase dry season grain production (in Cambodia for example), and high yielding rice such as china boro in North Bengal and Bangladesh
- It increases land-use intensity
- Increases irrigated area
- Average crop yields are higher than those obtained by farmers using diesel pumps or other irrigation devices
- Allows farmers to extend their growing periods, making use of land previously left fallow during dry seasons
- Is a “gender friendly” technology in that it can provide increased economic opportunities for women (Carpene 1999 and Shah 1999).

While the treadle pump is often marketed as a “vegetable” pump, farmers in many locations quickly adopt its use to grain production. In Cambodia, farmers typically use the treadle pump in the preparation of nursery beds and the cultivation of rice on small plots during the dry season. A recent study in Cambodia that families using the treadle pump for rice production had an additional 342 kg of rice per year, enabling families food security for three months during the gap between harvests (Carpené 1999). In 1999, 21 percent of the farmers purchasing pumps during the last sales year in Cambodia were involved in rice production and out of these, over half had not been involved before.

A typical story comes from Cambodia:

Mr. T.T. is living in Svay Kun with his wife and four children, now ranging from 11 to 20 years of age. There was a time when even though the family owned 2.5 ha of land, their living conditions were very poor, as the land was not producing enough and the family had only one cow and had to look for outside help to till the land. Mr. T.T. often was worried, especially when thinking at the children who were growing. He was wondering how he could overcome the general feeling of helplessness and find a solution to prepare a better future for them.

Then, Mr. T.T. came in contact with IDE and the Rabbit treadle pump and it took very little for him to realize the possible development within his household if he could secure such a pump for the family. With his meager savings he was able to buy a treadle pump for 110,000 riels (US $30). The costs were kept to a minimum because he used branches of trees to fix the frame to support the pump head, and no apron was cast around the pump as it was installed in the middle of a rice field so that all the water could go directly to the land ot be irrigated.

Before getting the pump Mr. T.T. was growing only one crop of wet rice a year and 10 ar (.01 ha) of cash crops, mostly water melons. But once the pump was installed Mr. T.T. started growing rice also during the dry season and increased the size of the land for cash crop from 10 to 60 ar. Within the year he had a total income of 500,000 riels (US $142) from the selling of water melons and 1,100,000 riels (US $314) from the dry season rice. The family decided to use this extra income to build a proper house with a tiled roof, and a femail cow to increase the family stock. Mr. T.T. is still thinking about the future of his children but now does so with confidence. He is planning next year to buy a second pump to enlarge his agricultural production, and is also renting two more ha of land. The next task will be to dig a 10m x 10 m pond where he can start raising fish.

From Onesta Carpené, *Small Scale Irrigation in Cambodia*, final Evaluation presented to USAID Cambodia, July 1999

The benefits of increased cropping intensity and yields with the treadle pump may even overshadow its potential to bring more land under irrigation. Shah reports that yields per ha of treadle pump farmers often match (and sometimes surpass) diesel pump owner yields. This is evident in the Nepal Terai, Eastern Uttar Pradesh and North Bihar in India. Shah observes that increased cropping intensity, efficiency and higher incomes of treadle pump users changes the relationship between income and land holding size.

Treadle pumps are most useful in areas where economic conditions are generally poor. Inefficient water markets and low wages combine to make the treadle pump an attractive option for poor farmers. The treadle pump is an entry level technology for poor farmers who cannot afford to rent or purchase diesel pumps. However, in many cases, diesel pump owners are found to use treadle pumps to prime their engines, and to also irrigate small cash crop plots with family or hired labor. The sometimes complex relationship and comparisons between treadle pumps and diesel pumps can be highlighted by the following report from India:

"Bipinbhihari Meher, a farmer in Orrissa, India reports that "the possession of K. B. treadle pump has enabled us to counter the difficulties of irrigation through electric and diesel pump sets. We are no more dependent on others. In the last summer we would manage to harvest brinjal and tomato even though there was erratic electric supply and acute shortage of diesel in our area, and earned around 4,000 rupees. While admitting that the treadle pump cannot be helpful to take up large-scale farming, Bipinbihari complements its usefulness, saying "in the need hours we can substitute those fuel operated pumps by depending on it (the treadle pump).""

From A. Vimani, *Farmers Using Krishak Bandhu Pedal Pump in Orissa – A Profile Document*, IDE 1995

Farmers recognize the relative merits of both the treadle pump and diesel pump, and make decision on which to use based on landholdings, rental or purchase costs and running costs.

The Ganga-Brahmaputra-Meghana basin of eastern India, the Nepal Terai and Bangladesh contains some of the world's best groundwater resources, and it is here that programs focussed on marketing the treadle pump have enjoyed enormous success. IDE estimates $ 1 donor investment, matched by $ 3 farmer investment, has yielded $50 in increased farmer income. The return generated for the donor is 50:1 and better than 16:1 for the beneficiary (Shah 1999). In the following table IDE calculates donor investment against increase in income for some of IDE's programs in Asia:

Treadle Pump Program Investments and Returns

Program	**Pumps Sold**	**Donor investment**	**Farmer Investment**	**Estimated Cumulative increase in Income**
Bangladesh 13 yrs	1.2 million	$6.7 million	$33.4 million	$620 million
India 5 yrs	120,150	$4.27 million	$5.4 million	$32.4 million
Nepal 4 yrs	10,700	$792,000	$589,000	$2 million
Cambodia 4 yrs	9,715	$1.2 million	$369,170	$1.69 million
TOTAL	**1.34 million**	**$13 million**	**$39.8 million**	**$656 million**

Note: For this analysis a mean cost of $38 per installed pump has been used (the farmer investment). Return on investment has been calculated at $100 per year in increased income.

Applied in the Gangetic basin, the treadle pump allows for much lower investment costs compared with canal or mechanized irrigation. T. Shah (1999) compares capital investments of canal irrigation at US $4000 – 4500 per ha, deep tubewell irrigation at US $800-1,000 and the treadle pump at US $100-120 per hectare.

IDE projects that potential sales in Nepal may reach 20,000 per year with a 93,000 cumulative target. Projections in Cambodia may be upwards of 60,000 by 2008. These ultimate targets would help farmers realize an increased net income of US$ 33 million and US $21.8 million respectively.

2.3 The Treadle Pump in Africa

In Africa, the Treadle Pump was introduced in Senegal and Mali (between 1990 and 1995) with sales by 1996 reaching around 2,500 (E. Perry, 1997). During the technology transfer to Zimbabwe and other countries, the Bangladeshi treadle pump was redesigned to include a pressure delivery capacity, which resulted in a more expensive pump to farmers (around US $200). It may be that the higher cost of the pressure pump has had an unintended consequence on sales, especially in countries where marketing and promotion was not included as part of a dissemination strategy. In contrast, during a technology transfer to Zambia supported by the World Bank, IPTRID and FAO, the portable "river pump" version of the Bangladeshi treadle pump was introduced , and the current price for the treadle pump is around US $70. Over 1,500 pumps have been sold in Zambia between 1997 and 1999. In Kenya, Approtec has again redesigned the Treadle Pump so that it is lighter and more portable. It, too, costs around $70 and sales are reported to be gaining rapidly (Purcell, 1997).

At first glance, it may appear that conditions in Africa are much less favourable for a market-driven approach than in Asia. Manufacturing costs, the costs of raw materials and the cost of doing business are generally higher in Africa than in Asia. Population densities are lower, which provides a major challenge to any marketing effort. Information on agricultural market demands is lacking, resulting in market gluts when agricultural production is increased. Aquifers are deeper, drilling more difficult and physical conditions less homogeneous. The obstacles can appear to be enormous.

Despite these constraints, there are some major opportunities for the treadle pump and other shallow lift pumps in Africa. The first is the estimated 85,000 sq. km (Adam, 1997) of underutilized dambos, vleis, fadamas, bas fonds and other shallow water sources present in sub-Saharan Africa which could represent a vast, untapped opportunity for the dramatic expansion of smallholder controlled irrigation. In Zambia alone, there are an estimated 3.6 million hectares of dambos and other wetlands (Daka, 1998). In Zimbabwe and Malawi, there are 1.28 million and 259,000 hectares respectively (Adam, 1997). Recent studies indicate that dambos and other wetlands can be made agriculturally productive with little or no negative environmental impact.

Until there is more detail on the location, size and suitability of dambos in sub-Saharan Africe, only rough calculations can be made regarding the potential of the treadle pump. It is very likely that only a small percentage of the estimated 8.5 million hectares of dambos in Africa are suitable for agricultural use. The location, size, shape and quality of dambos varies too much to be able to draft a master plan for their development. However, even if only 10% of available dambos can be used for agricultural purposes, this represents 850,000 hectares – enough for roughly 2 million treadle pumps; more than have been sold in Asia since 1988. Tapping into this potential market requires a concerted, organized effort.

Another major opportunity is actually based on the lack of successful and affordable irrigation options for smallholders to date. By employing clear marketing strategies, the arrival of a new, successful technology is all the more exciting for farmers and can result in highly desirable word-of-mouth promotion. Level of interest also appears to be high among NGOs and other development agencies, thus allowing for some initial components of a supply and marketing chain. While less efficient than the private sector, NGOs can be instrumental in conducting initial promotional activities that will lead to demand creation.

Most surprisingly, the lack of technology options to date have allowed early adopters of the treadle pump to quickly capitalize on their newly found advantage in weak vegetable markets. In Zambia for example, farmers are experiencing much higher incomes than the US $100 estimated of Asian farmers, and net incomes of US $ 300 up to US $3,000 have been reported. Farmers are increasing the size of their gardens from .1 ha to .25 and .5 ha and incomes have increase by a range of six to tenfold (Daka, 1998). Information may be anecdotal and more rigorous data collection is needed, but the trends seem to indicate that the success of the early adopters themselves can help promote the technologies. What will be important to measure is the degree to which the successful agricultural entrepreneurs can sustain their incomes as more units are sold and more competition is created.

The current cost of the treadle pump in African countries represents a significant investment to small farmers, and it may be that current prices result in the technology to be marginally affordable, especially in light of a dearth of credit opportunities for African farmers. Reducing the cost of the treadle pump is obviously a major strategic objective in increasing the adoption of the technology. The major emphasis should be on increasing demand for the product, as a demonstrated increase in demand will encourage competition among manufacturers and allow for a lower per unit price. Manufacturer margins in Africa are very high, and the chances of lowering them cannot be expected unless there is a corresponding increase in sales. It should be remembered that the introduction of the treadle pump in Africa is still in relative infancy, and current funding levels and efforts are insufficient in comparison with the potential demand. If promotion of the treadle pump can be established on a coordinated, regional (as opposed to piecemeal) basis, the lowering of the cost of the pump and increasing its adoption can be met.

Many countries in Africa have already been evaluated as optimal for the treadle pump, inlcuding Malawi, Zambia, Zimbabwe, Tanzania, Kenya and Nigeria. At this point, further investigation, mapping and cataloguing of dambos is needed to better understand the potential application of this technology and to prepare specific plans for each country. Until a more rigorous approach is applied to exploring dambo potential, the potential for the treadle pump, rope pump and other technologies will be limited, and sporadic at best.

3. EMERGING DISSEMINATION PRINCIPALS

Success with the treadle pump over the years has enabled IDE to convert lessons learned into basic principals and guidelines essential to a market-driven approach:

- Farmers are approached and treated as potential customers rather than recipients of charity
- Products, technologies and services must be affordable to farmers and produce a net return of over 100 percent per year on the purchase price
- Each product is sold at a fair market price, including a reasonable profit for the local manufacturer, seller and installer
- Products must be able to be mass-marketed through the private sector, thus enabling a degree of sustainability over time
- Products must be able to be maintained and repaired locally without the use of expensive tools
- Products should be able to be manufactured locally, provided it costs less than importation.

3.1 Enabling Environment for Adoption of the Treadle Pump

Conditions in Asia that have made the treadle pump successful include:

- High population densities (allowing for cost-effective promotion and marketing)

- Low labor costs (resulting in less competition between labor-intensive vs. mechanised pumping technologies)
- Low manufacturing costs resulting from lower margins, higher competition and relatively good quality manufacturing capabilities
- The existence of rural dealers and distributors
- A widespread availability of shallow aquifers or other water sources
- A "fit" between farmers' plot sizes and the technology
- "Fit" between farmers' needs and their perceptions of the technology
- Ready vegetable and cash crop market outlets
- Donor commitment and funding available for rural mass-marketing, training of manufacturers and other private sector entitites

Treating farmers as customers represents a fundamental shift in attitude held by the development community in that it requires analyzing the rural poor's buying power, interests and needs. Viewing the poor as customers also gives us the opportunity to view them for their potential as a vast consumer market, and also as savvy investors who seek out attractive rates of return on their investments. This approach requires a stronger business orientation on part of planners, but the resulting opportunities can enable the development community to design irrigation strategies not only to reach unfullfilled agricultural market demand, but engage in *market creation* for related technology products, services and other inputs.

A second set of principals that merits some discussion is the aspect of involving the private sector. In this current age of dwindling development funds, it may suffice to point out that it is more cost effective to have the sales networks, after sales service, spare parts, installation services and such provided by the private sector. As long as there is a demand for the product along with reasonable profit margins, the private sector will remain involved in the dissemination of the technology. This continued involvement will ultimately ensure a higher potential of sustainability of the entire process.

3.2 A Successful Technology Dissemination Strategy

Regardless of location and technology, all products have to be *marketed* in order to reach customers. Perhaps the most overlooked and singularly most important aspect of the diffusion and subsequent adoption of technology is that of demand creation and promotion. Only a concentrated marketing strategy will create the demand among farmers that is so needed to establish the manufacture, sale, purchase and use of a technology on anything that remotely approaches a sustainable basis. This was apparent to investigators in Bangladesh who noted that: "An important aspect of the (treadle) pump's success has been the creation of a sales network of private dealers provided with technical support and marketing assistance by IDE, an NGO founded to assist the development of small business enterprises. Without this assistance, it is doubtful if such a network could have arisen." (Orr, Islam and Barnes, RDRS 1991).

A successful approach to technology dissemination and marketing needs to include the following set of activities, ranging from the initial identification of the technology to the establishment of a private sector network, and finally, the incorporation of specific activities that strive to ensure the sustainability of the network:

3.2.1. Technology Identification, Affordability and Farmer Feedback

- The importance of technology identification, selection and adaptation as a crucial preliminary first step cannot be underestimated; a technology that does not answer the needs of farmers will ultimately fail. The identification process needs to involve the farmer at every step of the way to ensure that the technologies are useful and respond to farmers needs, can be easily maintained, operated and repaired, and above all, are as affordable as possible. Designing for affordability itself requires a shift in mentality and thinking; all to often, engineers and development professionals pursue technological efficiency rather than affordability. Worse yet, many assume they know the needs of small farmers and don't bother consulting them. The pursuit for affordability needs to take into consideration the actual on-farm demands of the technology, and the trade-offs that farmers will be willing to make in order to be able to actually own a technology.

  Identifying truly affordable, income-generating irrigation technologies comprises a major step in identifying the size and location of the potential market demand among small farmers. Preliminary market research, product costing and rate of return projections will also help estimate the potential for the length and breadth of private sector involvement. There needs to be a significant potential market demand for a technology, product or service before it is worthwhile to engage the private sector as a vehicle for dissemination. Otherwise, cost per unit price will most likely stay high and sales low.

  In order to gain and maintain customer confidence and satisfaction, technologies should not be marketed until they are proven reliable. Variations of the technology can be introduced, but with the knowledge that multiple versions of the same technology can lead towards confusion in the marketplace among potential customers.

3.2.2. Establishing a Private Sector Supply Chain

- A private sector supply chain consisting of manufacturers, retailers and installation technicians needs to be established in order to make each technology accessible to farmers on a sustained basis. Sustainability is based on profitability for each component in the supply chain. Profitability is based on demand creation for the large market of small farmers. The objective is to create a demand for technologies so that private sector partners can receive through volume what they sacrifice in a lower per-unit price.

  - **Manufacturers:** While it is desirable to work with small-scale manufacturers, manufacturer selection should be based on their capacity to produce the highest quality technology at the lowest possible cost and not whether they are small, medium or large. Manufacturers need to be thoroughly trained and quality control (preferably done by an outside agency) ensured. Lower per-unit prices can be established and maintained, often by training more manufacturers and creating a climate of competition. On the other hand, many people mistakenly believe that demand for technologies can be created by training more manufacturers without investing in promotion and marketing. This scenario ultimately fails as production exceeds demand and manufacturers begin to lose interest.

- **Dealers, distributors, retailers**: involving rural traders is essential in order to make technologies available for purchase among farmers. Spare parts, replacement pumps and after-sales servicing must be available to small farmers locally.

  In many instances small-scale private sector dealers are themselves resource poor. Most rural traders will include the technologies only as one part of their overall product mix which could also include hardware items, fertilizers, pipes, paint etc. Private sector dealers and retailers are primarily interested in gaining profit from their endeavors. Training needs to be provided to private sector partners to ensure that they are capable of selling the product effectively, that they can provide the required after-sales servicing and that they are efficient and profitable as businesses. This is where enterprise development activities (and business development services) can overlap successfully with an marketing approach, resulting in increased incomes for both small businesses and farmers.

  Finally, private sector partners need to be supported with promotional materials and included in a coordinated, wide-ranging marketing effort. Most small rural traders cannot afford and nor invest in the level of promotional materials, and marketing efforts, except over time. This is where donor investment for subsidizing promotional efforts are crucial.

- **Installation technicians** are self-employed mechanics, rural masons, or rural drilling teams who have the primary responsibility of installing the technology and providing follow-up support to customers. In Asia, the cost of the treadle pump is kept considerably low by the widespread availability of drillers who can install tubewells efficiently and inexpensively. In some cases, drilling teams or mechanics are attached to rural dealers and distributors, creating an efficient link that can identify potential customers and provide them with installed technologies and technical support. In other times, these rural technicians operate independently, sometimes in both roles as technician and retailer.

3.3.3. Promotion and Demand Creation

After a technology has been successfully identified, the engine that drives the entire process of dissemination is the creation of a demand for the technology among farmers. The development of a demand and potential profits will enable a private sector network to develop around the manufacture and sale of the technology. The process needs to be carefully monitored; too much demand and not enough supply will frustrate potential farmer customers, just as too much supply and not enough demand will discourage the private sector, especially if too many “partners” (competition) have been recruited and trained to manufacture and market the technology. The relative health of the supply chain needs to be constantly monitored, and adjustments made relating to the location, timing and strength of the demand. The number of manufacturers, retailers and technicians can be increased, decreased or shifted over time in response to farmer demand.

Marketing and promotional efforts must be well-planned. A chaotic or random mixture of activities may result in confusion, frustrating or even annoying potential customers. A *marketing strategy* needs to be developed that is based on known conditions (a customer “profile” that reveals location, preferences, demographics etc., of potential customers), estimated demand (based on a measure of the applicability of the technology, the number of potential customers and the capacity of the private sector network “supply chain”), choice of media, communication channels, marketing channels and stage of development of the market. The marketing strategy should include clear targets and expectations so that performance over time can be measured. The *promotion mix* used to achieve sales needs to be carefully thought out and planned. IDE employs a wide range of promotional activities including feature-length popular movies, signboards, handbills, village drama, village market day events, calendars, brochures, videos and raffles. Again, the strategy needs to identify what technique is most effective under specific circumstances. Promotions can be static or dynamic, but hands-on contact between the farmer and the technology (through direct demonstrations) is one of the most effective techniques.

Volumes have been written on marketing in commercial and public sectors. Briefly, four “tools” should be considered when developing a marketing plan:

- Product: all aspects including the features, benefits, brand name, warranties etc
- Price: the costs that target adopters have to bear (including…discounts, allowances, payment period, credit terms …
- Place: the means by which the…product is delivered to the target adopters (including distribution outlets and channels for delivering services, …location, inventory and transport
- Promotion: “the means by which the…product is promoted to the target adopters including advertising, personal selling, sales promotions and public relations”. (Kotler and Roberto, 1989)

The duration of the coordinated marketing strategy should be based on the overall potential for the life of the technology. Experience has shown that sales increase dramatically, once market penetration has reached a critical mass. Fixing a hard and fast number or percentage for critical mass takes some trial and error, and needs to be monitored and analyzed carefully from the beginning.

In order to address the overall sustainability of the economic activity, activities that build on the capacity of the private sector need to be included early on. These include an emphasis on quality control, the provision of business development services, and increasing involvement with private partners to commit to and invest in market forecasting, supply chain management, and active promotion.

Governments and international development agencies either drastically underestimate the private sector's capabilities (sometimes never involving them) or overestimate their potential, by sometimes assuming that the private sector will somehow solve all problems. Both extremes can have negative consequences. The goal of private business is very much focussed on turning a profit, but it is in the interests of the small farmers that negotiations with the private sector should be as competitive and hard-nosed as possible.

Success with mass-marketing efforts such as those mentioned above continue in Asia and, to a limited extent, in Africa. With the reliability of the treadle pump well established, now is an excellent time to begin seeking out all areas in food deficit countries with this technology is applicable. In the meantime, with the success of treadle pump marketing approach increasing dramatically, IDE began in 1994 to test the validity of its principals and approach by investigating drip irrigation, another technology that holds great promise to small farmers.

4. DRIP IRRIGATION – CREATING A MARKET AMONG SMALL FARMERS

Drip irrigation is one of the most efficient forms of irrigation technology currently available. It is a technology by which water can be conserved and yields increased for farmers, especially those who are cultivating in semi-arid conditions of the world or in areas where competition over water resources is escalating. Drip irrigation offers many advantages over conventional flood irrigation including water savings, reducing labor required for irrigation, reducing soil erosion and increasing crop productivity. Despite these advantages, drip irrigation is being applied less than one percent of global irrigated acreage and adoption of the technology by smallholders in developing countries has been negligible. Reasons for the lack of uptake among small farmers include the fact that drip irrigation technologies are expensive (up to $3,000 per hectare), complicated to operate and maintain, and not configured to fit small plots.

Very simply, drip irrigation consists of running water through pipes supply small amounts of water continuously at the base of plants (surface drip) or directly to the roots (sub-surface type) through small holes called "emitters" that are attached to lateral lines. Technical advantages of drip irrigation compared to surface irrigation include:

- Improved application efficiency, leading to water savings and reduced potential for waterlogging
- Improved control over timing and depth of irrigation, leading to possible improvements in yield and quality of output
- Reduced demand for labour

- Effective irrigation of course or shallow soils and sloping lands
- Better use of small discharges
- Reduction in the land taken up by the distribution system
- Better use of poor quality water
- Reduced risk to health by elimination of standing water
- Unaffected by wind (compared with sprinkler)
- Permits accurate application of fertilizers
- Avoids leaf scorch and reduces the risk of foliar fungal disease
- Localised soil wetting reduces evaporative losses and weed growth between rows
- Operates at relatively low pressure thereby saving energy

(Cornish 1998)

Potential yield and water saving benefits of drip irrigation are highlighted in India:

Side by Side Trials: Comparison of Yields and Water Utilization: Conventional Surface Irrigation (flood/furrow) vs. Drip Irrigation

	Yield (MT/ha)			**Water Supplied (mm)**		
Crop	**Conventional Surface Irrigation**	**Drip Irrigation**	**Increase %**	**Conventional Surface Irrigation**	**Drip Irrigation**	**Water Savings %**
Banana	57.5	87.5	52%	1760	970	45%
Sugar Cane	128	170	33%	2150	940	56%
Tomato	32	48	50%	300	184	39%
Cotton	2.33	2.95	27%	89.53	42	53%
Cabbage	19.58	20	2%	66	26.67	60%
Watermelon	24	45	88%	330	210	36%
Chillies	4.23	6.09	44%	109.71	41.77	62%

Source: S.K. Suryawanshi, 1995, Success of Drip in India: An Example to the Third World, in, Microirrigation for a Changing World: Conserving Resources/Preserving the Environment. Proceedings of the Fifth International Microirrigation Conference, Orlando (USA) April, 1995.

Spurred by the potential of this technology, IDE began investigations in 1995 into reducing the cost of commercial drip irrigation and making it available to small farmers. IDE began R&D efforts in Nepal and quickly moved to initiate parallel activities in India in 1996 with funding from Canadian CIDA and Swiss Development Cooperation (SDC). The primary target customer profile for these activities included small and marginal vegetable farmers who are cultivating less than 5 acres of land in arid, semi-arid and mountain regions of India and Nepal where water scarcity is the most critical constraint to agricultural production. These farmers typically have no access to mechanized pumps or irrigation systems. A secondary target group included mulberry and cotton farmers in Andra Pradesh, Karnataka and Tamil Nadu in India who frequently have access to mechanical pumps. A third target group now under consideration are small farmers located at the tail-ends of canal command systems.

Drip irrigation is not a traditional irrigation technology. IDE began its investigations stimulated by the following problems associated with the current state of irrigation worldwide.

4.1 Problem Identification

- Opportunities for irrigation expansion are diminishing due to higher investment costs coupled with decreasing donor investments;
- Agriculture and irrigation in general need to achieve higher efficiencies in water usage, so that the maximum production can be achieved with less water
- Expansion of flood and furrow irrigation is itself problematic since negative effects include high costs and other negative impacts included waterlogging, erosion, salinization, etc.
- Technological irrigation options have, for the most part, bypassed small-farmers. Small-scale farmers represent the majority of farmers in the world, and represent an immense potential for increasing food security and productivity.
- Lack of divisibility of larger commercial systems render them inaccessible to small-farmers
- High capital costs of modern irrigation (including drip) is beyond the reach of most small-scale farmers
- Lack of marketing targeting small-scale farmers has left them with limited knowledge of the potentials of the technology and virtually no market outlets and technical assistance at their disposal.
- Lack of awareness of (or limited interest in) small scale farmers as a potentially large market for commercial drip companies

4.2 Design Criteria

- Low-cost: technologies must be considered affordable to small-scale farmers
- Divisibility: The systems needed to be configured to small, irregularly shaped or multiple plots of small farmers.
- Reliability: operation and maintenance needed to be low and manageable at the farm level, with little training required.
- Marketability: the greater the potential for "off-the-shelf" packages in kit form requiring little design and customization would increase sales volumes and ensure availability and affordability through decentralized marketing networks.
- Replicability: identifying low-cost components and materials available locally could stimulate decentralized production of the technology in-country and worldwide.

4.3 Process used:

- Needs assessment – feasibility study – to determine needs, conditions and farming practices of target customers.
- Identification of the key contributors to cost for standard drip systems which included emitters, filter systems, and drip lines.
- Identification of existing (but unapplied) low-cost technological options available within the commercial sector;
- Identification of existing plastics manufacturers

- Proof-of-concept prototype established
- 3-4 years of field trials in farmers' fields, with constant and rigorous feedback, leading to adaptation of the technology to local conditions, practices and affordability
- Side-by-side trials to measure performance against commercial drip systems to evaluate yield, water savings, uniformity etc.
- Identification of potential manufacturers, and marketing channels
- Test marketing with additional farmer feedback, focus groups, market surveys impact evaluations etc.

The above process is not entirely sequential since, for example, farmer feedback is still going on today to evaluate additional technical, training and agronomic inputs required by farmers to ensure the efficacy of the technology.

4.4 Nepal System:

IDE began developing a kit in Nepal that had the following features in response to the key costs associated with commercial drip systems:

- Expensive US $ .25 emitters were replaced with .70 mm holes heat punched or drilled in laterals and covered by a simple plastic sleeve or baffle. The sleeve itself is a 6 cm length of drip line cut horizontally and snapped over the hole. If clogging occurs, dripper holes can be quickly unplugged with a safety pin
- The filtration system consists of an off-the-shelf US$ 3.00 20 litre plastic tank placed at a height of 2 meters with a nylon cloth acting as a filter.
- Size of the system was scaled down to one-half an acre
- The system was designed to be shiftable, thus replacing capital inputs with labor, thereby enabling farmers to increase the amount of land being irrigated without increasing capital costs
- Components were all of HDPE plastic and manufactured locally
- Color coded pressure reducers, designed to be installed by the farmers in hilly areas to equalize pressure for lower terraces were developed.

4.5 Performance and impact:

The Bureau of Indian Standards has set a standard of no more than 5 percent variation for class A emmitters. The American Society of Agricultural Engineers (ASAE) specified standards as "excellent" for coefficient of variation for emitters of less than 5 percent, and "average" for variations from 11 to 15 percent. Uniformity of IDE drippers was found to be at 84 percent within terraces and 73 percent across all terraces varying in head from 2-4 meters.

During initial field trials all farmers at least doubled their irrigated area with the new systems, and some increased irrigated area by as much as four times. At the same time, they reported that the labor requirements for irrigation were cut in half. An investment of US$ 50 in the drip system increased annual income by US $50 - $170.

4.6 Subsequent Design Changes

To prevent the slipping of the baffles, IDE began to produce the baffles by injection moulding. To further reduce the cost of the Nepal system, IDE experimented with flexible PCV hose. The flexible hose system offered some distinct advantages over the HDPE system including lighter weight and higher flexibility to make it easier for farmers to shift their systems. Flexible PVC also allows for manufacture in countries where HDPE or LLDPE are not available.

4.7 India system:

When transferring the low-cost drip technology to India, it was discovered that HDPE extruded pipe was not as readily available as LLDPE pipe. Some difficulty was encountered with attempting to drill or heat punch drip holes on LLDPE and uniformity was not acceptable. Attention shifted to recommendations of former industry technicians, and IDE began exploring the potential of making use of "microtubes" consisting of flexible pipe with 1mm interior diameter. By inserting a microtube in a l2mm lateral, the end of the microtube effectively becomes the emitter. In field tests in Udaipur in Rajasthan, IDE investigated various emmitters (cut, straight, curly microtubes, Turbo keys etc.), pressure heads, lateral materials and lateral lengths to arrive at the optimal material, length and pressure head configuration.

Microtubes have two main advantages in that they are less expensive than commercial emittters and can be extended across rows, thereby reducing the number of laterals required. Another design advantage with microtubes is that they have a wider, straighter path than the internal zigzag path of commercial emitters. As a result, microtubes are less prone to clogging, the single greatest technical problem with drip irrigation. The lower potential for clogging also makes it possible to use more simple-low-cost filters and to lower the system pressure. Prevention against clogging is also accomplished by including small plastic or wooden pegs with all drip kits. These pegs are used to stake the end of the microtube so that they avoid direct contact with the soil. Microtubes were used early in the development of drip irrigation, but had been abandoned because, among other reasons, the monitoring of hundreds of microtubes on large-scale systems was determined to be too labor intensive a requirement for commercial farmers. However, microtubes now provide an excellent, low-cost technology solution for small-scale farmers.

In October, 1996, with support from the CIDA through its Small Project Environment Fund (SPEF) IDE initiated a research and development program to test the feasibility of the affordable microirrigation systems with various crops in the Udaipur district of Rajasthan. This programme led to the development of a range of systems in response to farmers' needs. With the microtube option, two basic kits were developed and field tested with farmers:

4.8 The Bucket Kit

The Bucket Kit is ideally suitable for kitchen gardens for women or landless farmers, and with urban gardens. It consists of a 20 litre bucket and one 10-meter long lateral fitted with 26 microtubes. It can irrigate 104 plants, (around 25 square meters) with four plants placed around each of the microtubes. The bucket is placed at a height of about .5 meters and is filled 3 to 4 times a day (depending on environmental conditions and plants grown). The kit costs around US$ 5.00 in India.

4.9 The Drum Kit

The Drum Kit is most useful for kitchen gardens and small commercial vegetable gardens. It can irrigate 100 square meters or 520 plants with one 200 litre drum of water, filled twice a day. The Drum Kit consists of 130, 1mm diameter microtubes, fitted to 5 rows of 12mm lateral pipes. These laterals are connected to a drum of water by a 16mm submain. A small, plastic tap is attached to the drum with an inexpensive in-line filter. Water flows from the drum to all microtubes, where water spreads out in a circular pattern of about .5 meters radius. Four plants are planted in each of the circles. The kit costs around $25 inclusive of the drum. The kit can be expanded in 125 square meter increments for US$ 14 for each unit.

4.10 Microsprinklers

The microsprinkler kit has 15 microsprinklers (each covering 4 meter diameter wetting pattern) and can irrigate 250 sq.m. It works at a pressure of 10-15 m by gravity or a single phase .5 hp pump. The kit costs US $20 and can irrigate closely spaced vegetables such as coriander, spinach, onion etc. For terraces with width more than 6m the Overhead Sprinkler kit is used. It has two impulse sprinklers which work at a pressure of 20 m by gravity or single phase .5 HP pump. The kit is useful in irrigating field crops such as wheat, green gram, soybean etc. A larger area is coverd by shifting the sprinkler in ½ acre plots (for US $35) or one acre plots (for US $58).

4.11 Affordable Microirrigation Technology (AMIT) Summary

Country	System	Coverage (sq. meters)	Current retail cost
India	Bucket / microtube	25 (kitchen garden, 100 plants)	US $5
India	Drum/Microtube	100 (small income and food garden)	$25
India	¼ Acre, microtube	1000 (small cash crop garden)	$57
India	Custom ½ acre shiftable system	2,000 (medium cash crop garden)	$100
Nepal	Shiftable PVC, baffle emitter	1200 sq.m	$50
Vietnam	Stationary, baffle emitter, PVC	100 (small garden)	$15-$19 (prototype)

4.12 Uniformity

Drip irrigation configuration normally has a large number of small outlets spread over the field. For a uniform growth of the crop in the field it is important to provide an equal quantity of water. But, as water passes under pressure from one end of a pipe to another, pressure losses along the line are created and hence, different outlets along the line gives different discharges. It is essential to design the systems so that discharge variation is limited. The theoretical limit of uniformity is 90 to 95%. With a small grant from SDC, IDE tested 600 of its drip systems in 21 watershed areas of Madhya Pradesh, Maharashtra, Himachal Pradesh, Gujarat and Andra Pradesh. The results of these tests are given in Annex II. Drip systems as seen below have been observed to have a uniformity that is consistently above 80%.

Test no.	1	2	3	4	5	6	7	8	9	10	Average
Drum kit	83.13	82.07	86.90	88.23	88.91	89.42	89.12	87.31	90.56	90.84	87.65
Bucket kit	89.93	89.23	92.29	92.83	90.17	90.34	90.87	92.64	92.41	92.22	91.29

These technologies can enable small farmers to:

- Feed their families and generate income to improve their general health and economic situations
- Can use this opportunity to expand their cultivated holding, a result of increased water availability and/or efficiency
- From increased income, they can also expand their cultivated area by adding more kits together
- Improve the local economies where they live by increasing the amount of food and other crops and generating needs for a service economy – either to support agriculture or for consumer goods than can now be purchased.
- Enable the expansion of activities for rural entrepreneurs to be engaged in the local assembling, training, installation and sale of kits.

Case Study:

Mary Kumar is a school teacher, and hence, not among the poorest farmers of india. She has installed a bucket kit in their garden of approximately 20 sq. m. As water is very scare in the village, they are buying water from a tanker and pay 125 rupees for 3,000 litres which they use in 10 days to cover all their different family uses. This means the water cost of the family is 12.5 Rs/day, which is almost what they spend for milk.

A pump in the village has dried out and since then, water has been very scarce: if they did not buy the water, they would have to walk for 15-30 minutes, which is not even so much, compared to many other villages.

Mary and her husband Hemant expect to grow tomotoes and eggplants on their small plot to save some 300 Rs per season (90 days), in vegetables which they can consume themselves. The initial investment of Rs. 200 for the bucket kit can be paid back. For their garden, they fill the bucket twice a day (40-50 litres) in winter and four times a day in summer, which means they spend 1-2 Rs per day on irrigation. Even at this extremely high cost for the water, it is economical to produce vegetables (90-180 Rs for the water compared to Rs 300 worth of vegetables).

From Urs Heirli, *Report on a Visit to Indore and Maikaal BioRe Ltd., (Bio-Cottong) for Micro-irrigation*, SDC 1998 (unpublished)

4.13 Current Sales of Microirrigation Technologies in India

In 1999 in India alone, a total of 3538 systems were sold through the private sector and local NGOs. This was accomplished during the current test marketing phase.

Type of Microirrigation Kit	Purchased by Men	Purchased by Women	Total
Bucket Kit (25 sq. m)	333	1112	1445
Drum Kits – all types (100 aw.m up to 1 acre for horticulture	711	56	767
Micro-sprinkler kits	728	32	760
Overhead Sprinkler kits	465	10	475
Customized systems	91	0	91
TOTAL	2328	1210	3538

Women have purchased 77 percent of the small bucket kits and 34 percent of the total systems. Sixty-five percent of the systems were acquired through local NGOs and 88 percent of the systems acquired by women were through local NGOs.

Sales patterns suggest that women are purchasing bucket kits primarily for food security – growing food for family consumption. Men seem to be purchasing the systems primarily to produce income for the family.

A study conducted in 1999 on behalf of Swiss Development Cooperation (SDC) revealed that the use of Low-cost drip irrigation produces the following:

- 55 percent savings on water over flood irrigation

For women this means less water carried from wells to their kitchen gardens. For those engaging in cash crop productions, this means less expense in pumping (manual or electric) and the threat of overexploiting their wells during the dry season.

- 58 percent savings on labor (both time and money)

For women, this means less time spent in weeding and carrying water. For cash crop farmers this means reduced inputs, yielding higher profits.

- 16 percent savings on fertilizer and pesticides

Besides the reduction in input costs, savings here mean that less residues are washing into the environment. For women this is also an important financial savings, since most of their expenditure does not have a direct financial return (since crops grown are eaten by the family). Lowered costs during the growing season means more cash available to purchase food during the growing period.

4.14 Diversification of Drum Kits based on Farmer Feedback

During 1999, the Drum kit has undergone further diversification based on market demand.

Name of kit	Examples of Primary Use	Coverage	Number of plants Irrigated
Vegetable Drum Kit	Vegetables such as tomato, peppers, okra	150 sq. m	500 plants
Horticulture Drum Kit	Papaya	350 Sq. m.	100 wide-spaced plants or close-spaced trees
Orchard kit	Mango	1 acre (4,000 sq. m)	40 wide-spaced trees
Cash crop Drum kit	Cotton	1000 sq. m.	1,400 plants

In addition, the Vegetable Drum Kit now comes in two configurations: one for flat land plots, the other specifically configured for mountain terraces.

4.15 1999 Innovations

In the past year feedback from farmers participating in 200 demonstrations led to the following changes in the systems:

- the inclusion of an in-line filter to minimize the clogging of microtubes
- LLDPE flexible sub-main. Traditionally, rigid PVC pipes are use the main and sub-main. These are not UV resistant and need to be buried under soil. Farmers desire was to be able to shift the entire configuration from one field to another. LLDPE pipes are UV protected (or resistant) and therefore have the advantage of being able to be left in the sunlight and also moved. LLDPE is flexible, allowing for it to be rolled up and packaged into small boxes and bags.
- Microtube peg: to overcome cloging of microtubes when they touch the wet soil. Another advantage of this peg is that it allows for the stable placement of the microtube so they are not disturbed by laborers or animals in the field.
- Installation manuals: Manuals printed in local languages and with self-explanatory sketches have been developed.
- In Nepal and Vietnam, the development of kit made out of flexible PVC materials will enable drip equipment to be manufactured in countries where HDPE or LLDPE materials are not available.
- In order to ensure that farmers are successful with the technology, IDE is evaluating the amount of agronomic training and support is required by farmers. IDE is also experimenting with “bundling” kits with other agricultural inputs such as seeds, fertilizers, pesticides etc. for a complete starter kit to the farmer.
- Through field trials, it is being discovered that landless farmers who only have a small strip of land around their houses can employ drip kits, sometimes to grow vine crops that cover the roofs of their houses. IDE is identifying high value produce (such as papaya) that can be grown under circumstances where land is at an absolute minimum.

Since initiating programs in Nepal and India, IDE has also brought the systems to Vietnam, Sri Lanka, China, Zimbabwe, Zambia, Haiti and Cambodia. It is clear that IDE is not the only organization involved in the effort of reducing the costs of drip irrigation. The bucket kit produced by Chapin Watermatics served as an inspiration of good packaging for IDE. In fact, IDE used imported Chapin tapes in its initial work in Sri Lanka, but discontinued its use after farmers found the drip tape fragile and prone to clogging. Also, the fact that the tape has to be imported from the U.S. eliminates the potential for local production. Still, it is reported that Chapin kits have had remarkable success in Kenya and other countries.

In Zimbabwe IDE, in partnership with ITC Rugby and ITDG Zimbabwe conducted in mid-1999 an initial review of drip irrigation activities currently taking place in that country. Commercial drip companies including Netafim and a company employing "T-Tape" have developed kits (that make use of imported tapes) ranging from 600 sq. meters up to a hectare. However, during the initial assessment of manufacturing capacity in Harare it was discovered that there were at least two companies that could produce mains, submains, laterals and microtubes at a cost similar to Asia. This it would appear that there is considerable room to a) produce kits locally at a price less than the current commercial companies b) provide competition to commercial companies, thereby potentially lowering the price to small farmers c) work in coordination with commercial companies whereby "generic" promotion of the drip irrigation concept to farmers could result in poorer farmers investing in the lower cost kits while wealthier farmers can make investments in the imported, more expensive kits.

In Sri Lanka, IDE has been working closely with GTZ to introduce the low-cost drip systems in the dry zones of the country. The technology, previously declared unnecessary by some experts, is being taken up rapidly by farmers. Until such time as local manufacturing can take be transfered, materials are imported from India. To date, over 1,700 drip kits have been purchased (either directly or on credit) by farmers in Sri Lanka.

In China, IDE began in March 1999 with a study to evaluate the feasibility of increasing the food production of small farmer by using low-cost drip systems in conjunction with rainfall storage cisters, known as dry wells. In May 1999 another visit was made and fifty kits were installed in Gansu and Shanxi Privinces. IDE installed the India microtube systems, the Nepal soft PVC systems and the locally made China Yanshan Institute coiled microtube systems. IDE also trained local water engineers and technicians and set up a process by which the technology could be monitored and farmer responses gathered.

The local Yanshan Institute drip systems appear to parallel the India microtube systems with the use of laterals fitted with microtubes. 95 percent uniformity is reported. Qui Wei Duo of the Yanshan Institute has also developed a shiftable system for wheat that is installed on several thousand acres. Price of the Chinese systems are about US $25 per acre.

Applicability of low-cost drip systems could be very high, since the Government of China is installing between 500,000 and one million rainfall storage systems known as "dry wells" per year in hill areas in Northwest China. There are already between 800,000 and 2 million dry wells installed in Gansu Province alone, with an additional 250,000 per year planned in that Province. There is also the potential of linking treadle pumps, dry wells and drip irrigation systems for a complete technology package for small farmers.

5. EXPANDING THE POTENTIAL

5.1 Treadle pump, rope pump and other similar technologies:

- In Asia, continued support and acceleration of the mass-marketing of the treadle pump in India, Nepal, Cambodia, Bangladesh.
- Identify and catalogue shallow aquifer potential in Philippines, Indonesia and other countries not yet exposed to the treadle pump
- Filter conditions in "non-treadle pump countries" through the "enabling environment" criteria to establish new target countries
- Coordinate with governments, donors and other institutions to reduce potential negative impact of subsidies and free distributions. Expand linkages with NGOs, governments and private sector (seed and fertilizer companies for example) and others to provide better agronomic support to farmers adopting the treadle pump.
- Identify and/or develop affordable low-horsepower (1 hp or less) diesel engines as the next potential breakthrough technology for treadle pump users.

- In Africa, accelerate mapping, cataloguing and assessing the potential for expanded use of dambos, vleis, fadamas, bas-fonds etc. and in doing so establish realistic target potential for their use on a country-by-country basis. This information is crucial in estimating market potential and related private sector involvement.
- Increase the awareness of recent research that highlights appropriate and environmentally sound exploitation of dambos and wetlands.
- Re-evaluate legislation restricting the usage of dambos and wetlands
- Establish strategies (and monitoring guidelines) for a common and coordinated approach to the utilization of dambos etc.
- Reduce restrictive taxes and import duties on raw materials for potential medium to small-scale manufacturers of the treadle pump
- Expand credit opportunities to small-scale farmers interested in purchasing the treadle pump
- Analyze agricultural market potential to be able to better target potential treadle pump customers and avoid seasonal gluts on vegetables and other crops

5.2 Microirrigation:

Conventional surface irrigation has reached 260 million hectares of farmland – 17 percent of the world's cropland (Crossen, 1992). Commercial drip irrigation reached somewhere between 2 million hectares, or 1 percent of irrigated cropland by the early 1990's. Eighty four percent of the 2 percent is concentrated in ten countries and is used primarily on large farms. High cost, lack of divisibility (commercial drip remains mostly customized to large plots) and certainly the lack of marketing targeting small farmers have kept the technology out of the hand of small farmers. With a reduction in the growth of irrigation, low-cost drip irrigation offers a major potential for:

- Providing a technology to small farmers working in small and marginal plots of land
- Providing a technology at a cost affordable to small, poor farmers
- Increasing production, yields, food security and income
- Expanding cultivated holdings, as a result of more water availability
- Reducing labor required for weeding and irrigating
- Expanding cultivated area enabling farmers to combine kits together as they increase profits
- Inproving local economies by increasing agricultural markets, service economies and the local private sector engaged in manufacture and assembly

Commercial drip companies in India target farms above one hectare by using a mostly customized, farm-by-farm approach. Small farmers are ignored, primarily because it is clearly easier to sell high-margin products to wealthy, larger farmers than try to hit volume sales with small farmers.

IDE believes there is a massive potential of increasing the adoption of drip irrigation among small farmers. The potential for expansion of drip irrigation in India alone, for example, could be as high as 10 million hectares (Sivanappan 1994), broken down as follows:

Horticultural crops - 5 million hectares (out of 8 million currently under irrigation)
Watershed initiatives – 2 million hectares
Water-short Canal command areas – 2 million hectares
Open wells - 1 million hectares

5.2 A Global Initiative to Expand the Adoption of Microirrigation

IDE envisions a global initiative to promote affordable microirrigation with medium-term goal (by 2015) to spread this technology to 20 developing countries and make affordable drip available to 21 million farmers, with an uptake of 60 percent (12.5 million systems used). This would put approximately 5 million hectares under drip irrigation, contributing to a total coverage in water-saving irrigation of 40 million hectares (commercial and affordable drip and sprinkler irrigation technologies).

Required for such an effort would include:

a. The formation of a *Global Initiative Task Force*: comprised of international and multilateral organizations, NGOs and the private sector. The task force will examine the potential of increasing the uptake of small-scale microirrigation technologies, water policy rammifications, and the potential of converting (or augmenting) to use of microirrigation technologies on canal command areas. Private sector companies would bring technical expertise and potentially benefit from the widespread demand created in such an effort.

One major responsibility of task force would be to analyze the shift in mentality that would probably be required for major institutions to look conversion of existing irrigation systems and the adoption of a small-scale approach. A major challenge too would be promoting the concept poor farmers as potential customers and investors in irrigation technologies.

b. Develop a Short-term (3 year) project that targets launching drip irrigation in 7 countries. This project would:

- Conduct feasibility studies, leading to field trials from which the technology can be adapted to local conditions, materials and farming practices (process outlined in Annex II)
- Identifying partners with which to work and build capacity to implement an accelerated and private-sector oriented dissemination project through training, technical assistance and collaboration
- Develop in-country capabilities in manufacturing, assembling, marketing and promotion of microirrigation products
- Evaluate the initial impact and efficacy of the project, publicize findings, lessons learned and plan expansion and wider-scale adoption.
- Establish marketing and promotion guidelines and strategies.

Goals and Objectives would include:

- The establishment of Affordable Microirrigation Technology Programs in 7 developing countries including India, china, Pakistan, and select countries in sub-Saharan Africa, the Aral Sea Basin, the Middle East and South and Central America.
- Develop the capacity to disseminate and put into use 5 million units benefiting 25 million rural men, women and children (from inception up to the year 2015).
- Five hundred field trials to be conducted and evaluated on farmers fields, leading to the adaptation of the technology, better understanding of impact on water savings, yields and water source issues
- Local products available for mass-marketing will be developed ranging from 25 square meters up to 1 hectare
- Participating organizations will be trained in how to demonstrate, install and maintain products. Further training will be conducted in marketing and promotional activities
- At least 20 manufacturers and 200 rural dealers in the seven countries will be in the position to launch production, distribution and mass-marketing and serve as the initial supply chain
- Marketing strategies will be in place in the seven countries, including market forecasting, product quality control systems and branding, appropriate marketing and promotional activities and at least 500 visible demonstrations to create market demand
- Local funding will be identified in at least 5 countries in order to support an accelerated mass-marketing effort.

c. Analyze lessons learned for "best practices" guidelines for further expansion and scaling-up. This would require evaluations, research projects (specifically geared towards measuring project and technology impact), conferences and public awareness campaigns to publicize the results of the project to bring small-farmer oriented microirrigation want water scarcity solutions to the forefront of the international arena.

6. CONCLUSIONS

Microirrigation technologies, treadle pumps, rope pumps and other technologies geared towards the needs of smallholders all have the potential of dramatically increasing food production. Small-scale irrigation options need to be taken into consideration as a priority whenever considering new irrigation initiatives. To take advantage of these technology options, a market-driven approach serves as an effective tool at engaging the private sector and establishing the large-scale dissemination of irrigation technology options on an economically sustainable basis.

Viewing the smallholder as a potential customer, instead of a passive recipient of charity or planning efforts, may require a major shift in the thinking of irrigation professionals. In practice, it unlocks a vast potential for identifying new technology options for small farmers, creating new markets, increasing the uptake of technologies, and accelerating the expansion of smallholder irrigation. The process is as important as the technologies themselves.

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Annex I

**Test Results of IDE-promoted affordable micro irrigation systems
1998**

<u>Discharge and uniformity</u>

For each of the systems the data has been collected from 10 different farmers' fields.
The main findings are presented in the tables below:

1. Discharge of drip systems (litres per hour)

Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Customised microtube system	2.52	2.38	2.57	2.51	2.74	2.78	2.39	2.48	2.48	2.42	2.53
Drum kit	1.94	1.89	1.62	1.52	1.16	1.15	1.03	0.91	0.62	0.62	1.24
Bucket kit	0.25	0.26	0.23	0.23	0.25	0.26	0.23	0.24	0.25	0.26	0.25

These discharge figures are perfectly as per expectation. The bucket kit uses drip tapes, hence the mean discharge is the lowest. Customised microtube system uses a pressure pump and hence its discharge is the highest. Individually the discharge of all the three systems is also satisfactory.

2. Discharge variation of the drip systems

Following is the variation of discharge from the mean discharge.

Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Customised microtube system	14.68	11.36	7.67	9.11	11.95	13.27	9.27	12.33	11.65	7.89	10.92
Drum kit	16.87	17.93	13.10	11.77	11.09	10.58	10.88	12.69	9.44	9.16	12.35
Bucket kit	10.07	10.77	7.71	7.17	9.83	9.66	9.13	7.36	7.59	7.78	8.71

In all the three cases the variation is within 15% and hence the system performance can be concluded as extremely satisfactory.

3. Discharge uniformity of the drip systems

Uniformity is reverse of variation and is popularly used as the key criteria of performance.

Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Customised microtube system	85.32	88.64	92.33	90.89	88.05	86.73	90.73	87.67	88.35	92.11	89.08
Drum kit	83.13	82.07	86.90	88.23	88.91	89.42	89.12	87.31	90.56	90.84	87.65
Bucket kit	89.93	89.23	92.29	92.83	90.17	90.34	90.87	92.64	92.41	92.22	91.29

In all the cases the uniformity is higher than 85%, which is considered as very good. Hence it could be concluded that all the systems are as par with the conventional drip systems in field conditions.

4. Discharge variation of the sprinkler systems

Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Over head sprinkler kit	16.05	18.80	17.25	18.65	12.89	12.89	13.67	16.20	10.15	19.39	15.59
Micro sprinkler kit	16.11	15.21	20.33	15.21	18.11	20.33	17.67	22.02	13.98	20.20	17.92

It is quite interesting to see that even the sprinklers are quite low on variation i.e. within 20%.

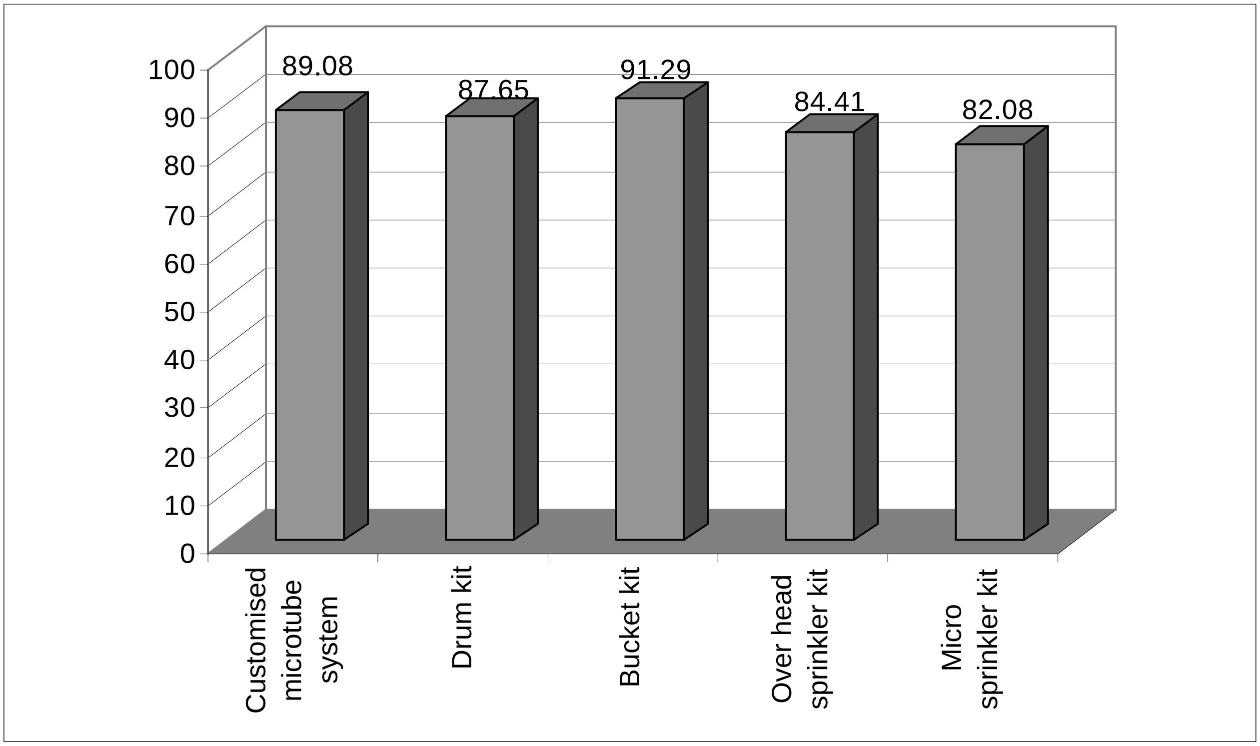
5. Uniformity of the sprinkler systems

Uniformity is reverse of variation and is popularly used as the key criteria of performance.

Test No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Over head sprinkler kit	83.95	81.20	82.75	81.35	87.11	87.11	86.33	83.80	89.85	80.61	84.41
Micro sprinkler kit	83.89	84.79	79.67	84.79	81.89	79.67	82.33	77.98	86.02	79.80	82.08

In both the sprinklers the uniformity is higher than 80%, which is considered as very good. Hence it could be concluded that the sprinkler heads used in the kits have been passed the selection.

The average uniformity of all the systems are presented graphically below



One can see that uniformity all the kits and systems are above 80%.

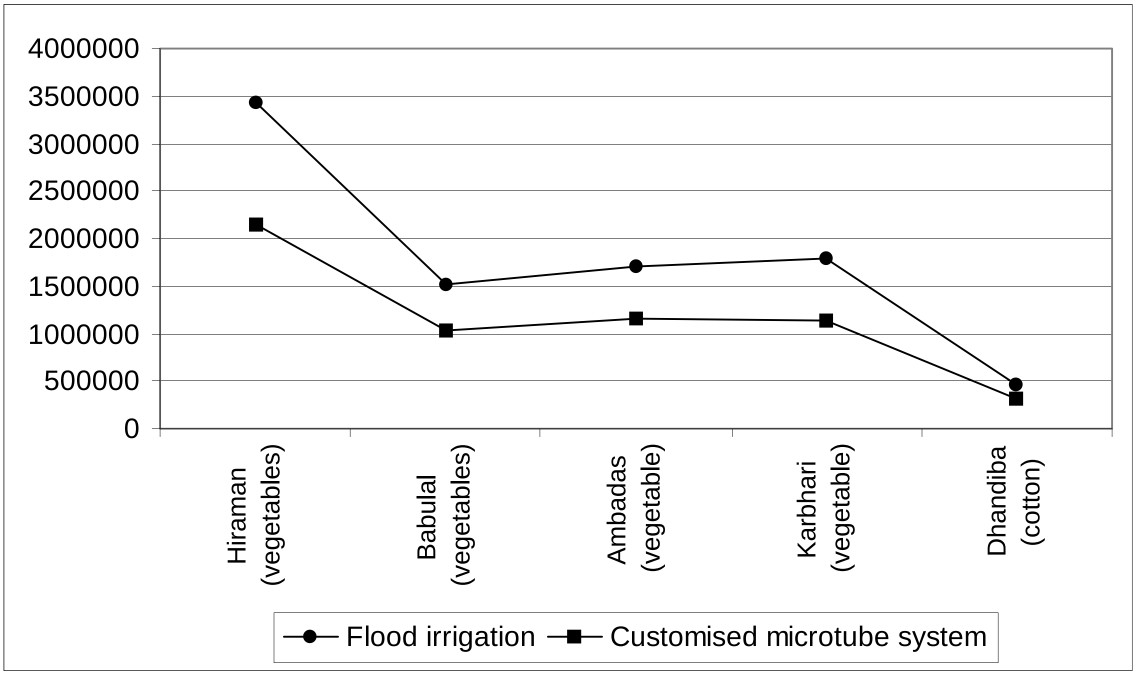
<u>Water use and water saving</u>

The comparative summary is given in the tables below.

1. Total volume of water applied by the farmers in one acre (litres)

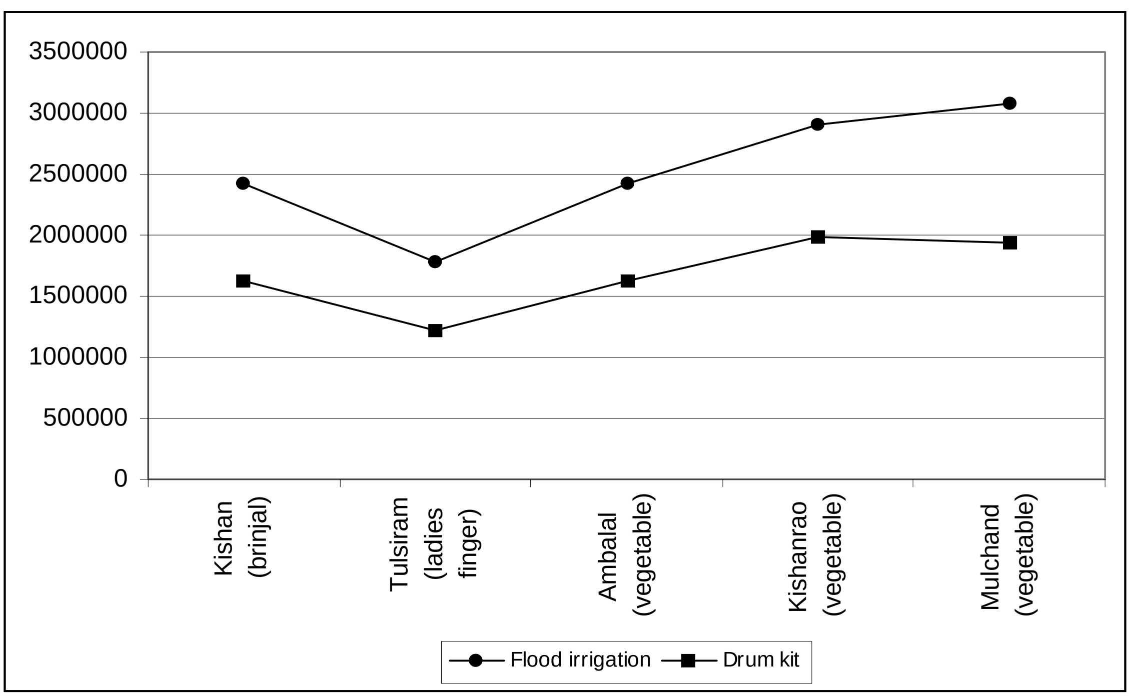
Comparative water used by the farmers using the customised microtube system and the conventional drip system is given in the following table and graph.

	Hiraman (vegetables)	**Babulal (vegetables)**	**Ambadas (vegetable)**	**Karbhari (vegetable)**	**Dhandiba (cotton)**
Flood irrigation	3428484	1516808	1712488	1785267	472865
Customised microtube system	2146934	1031851	1165743	1145301	308277



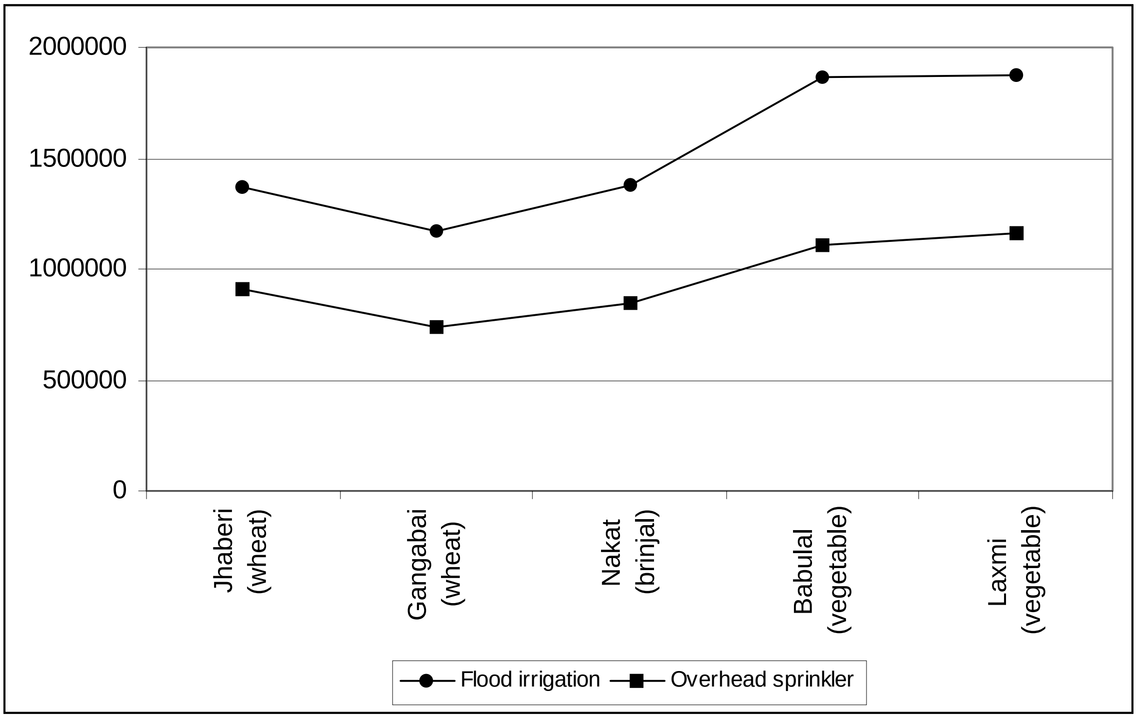
Comparative water used by the farmers using the drum kit and the conventional drip system is given in the following table and graph.

	Kishan (brinjal)	**Tulsiram (ladies finger)**	**Ambalal (vegetable)**	**Kishanrao (vegetable)**	**Mulchand (vegetable)**
Flood irrigation	2428200	1780680	2428200	2913840	3075720
Drum kit	1618800	1214100	1618800	1983030	1942560



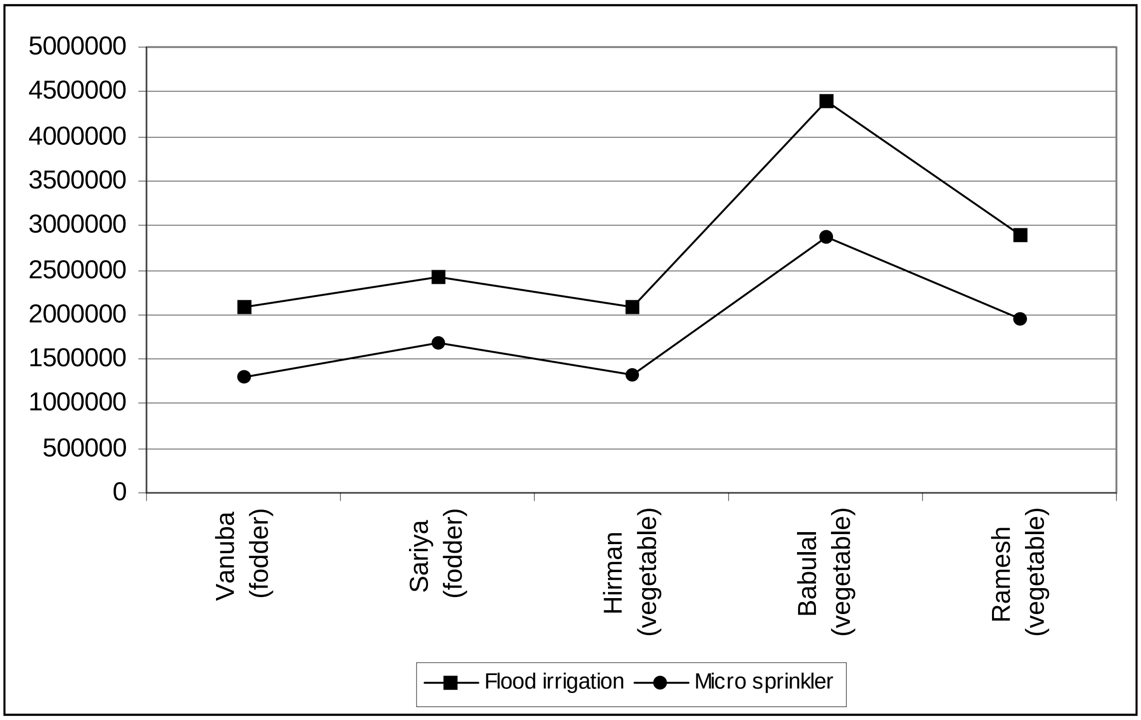
Comparative water used by the farmers using the overhead sprinkler kit and the conventional drip system is given in the following table and graph.

	Jhaberi (wheat)	**Gangabai (wheat)**	**Nakat (brinjal)**	**Babulal (vegetable)**	**Laxmi (vegetable)**
Flood irrigation	1368976	1167923	1379932	1865836	1872264
Overhead sprinkler	911386	738967	848092	1108204	1159402



Comparative water used by the farmers using the micro sprinkler kit and the conventional drip system is given in the following table and graph.

	Vanuba (fodder)	Sariya (fodder)	Hirman (vegetable)	Babulal (vegetable)	Ramesh (vegetable)
Flood irrigation	2092355	2419980	2087385	4400823	2891177
Micro sprinkler	1309373	1688832	1324669	2876839	1951362



Water saving (percentage)

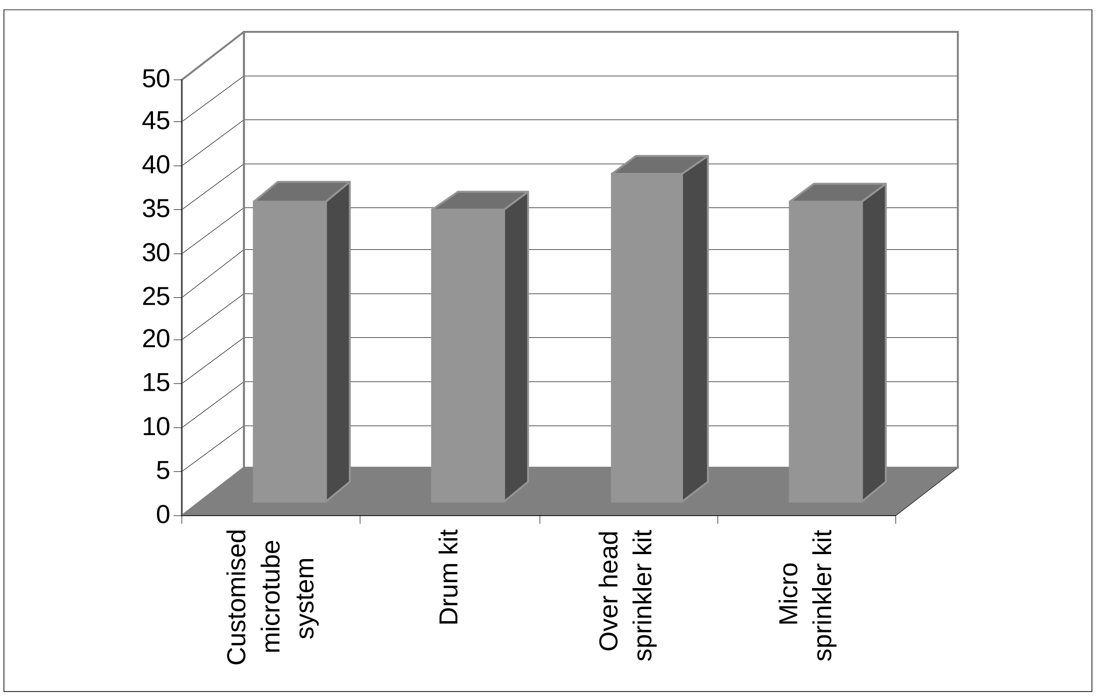
The percentage of water saved of the drip systems over the conventional flood irrigation system is given below:

	1	2	3	4	5	Average
Customised microtube system	37.38	31.97	31.93	35.85	34.81	34.39
Drum kit	33.33	31.82	33.33	31.94	36.84	33.45

The percentage of water saved of the sprinkler systems over the conventional flood irrigation system is given below:

	1	2	3	4	5	Average
Over head sprinkler kit	33.43	36.73	33.20	37.34	38.07	35.75
Micro sprinkler kit	37.42	30.21	36.54	34.63	32.51	34.26

Average water saving of all the systems is represented graphically below



Annex II

Recommended Process Methodology for Introducing Microirrigation into New Countries

When promoting a new technology, the manner in which it is introduced can be as much as a cause for success or failure as the technology itself. As a result of bringing the drip technology from country to country, IDE has developed a recommended process to follow when introducing the technology into new countries. This process attempts to ensure that farmer feedback, affordability and marketing are built into the effort from the very start.

Sequence of Activities

The first step in the process is an analysis of current attitudes, approaches and belief systems held by international and government agencies, and whether irrigation needs for small farmers are even considered. Currently, microirrigation, shallow lift irrigation pumps or other technological options are usually included apart from formal planning excercises focussed on larger scale canal command areas or dams. Therefore, a shift in attitude is required to look for small farm options first. While a range of technology options can be considered for introduction, emphasis should be on only those that have already a proven track record. Finally, there is always the possibility that the technology options do not truly answer farmers' needs, and there has to be flexibility built into the process that allows for shifting of strategy and a re-examination of options. This underscores the need to have strong feedback mechanisms built into the process with farmers.

With this in mind, the sequence of activities can be broken into 5 stages including:
- Pre-feasibility Desk Study
- Feasibility Study
- Field Trials
- Building a Rural Mass-marketing Program

1. Pre-feasibility Desk Study

Most feasibility studies will come directly from requests from NGO's, bilateral and multi-lateral agencies and scientific or research organizations. As mentioned, such requests already outline in general the situation and opportunities, as well as potential partners for collaboration.

The initial step is to do a "desk study" by review of recent literature, interviews with key players with experience in the country, and discussions with a wide range of organizations that can shed light on the potentials.

The desk study evaluates the following criteria:

- Agriculture and climate are conducive to improvements from micro-irrigation technologies, especially for poor farmers
- Water shortage appears to be a major constraint for poor farmers
- There is an operating environment conducive for technology introduction
- Economic policies favor private sector initiatives
- Potential partner organizations or collaborative projects with which to work
- Potential size of agricultural markets to justify intervention

The desktop study will rely heavily on literature research, interviews and networking with professionals and organizations working within and without the country.

2. Feasibility Study

The feasibility study (4-6 weeks) is a structured process that assesses both the potential for the technology to be adopted by farmers, but also the potential for the introduction, manufacture and marketing of the technology (the supply chain).

The Feasibility Study Process will focus on 9 Key Areas.

- <u>Operating Environment</u> (Are policies a help or a hindrance to introduction, manufacture, distribution and sale of the product or are there severe restrictions, or, intrusive subsidies?)
- <u>Geographic, Hydrologic and Climatic</u> (surface and sub-surface water, rainfall, erosion, watershed patterns, seasons)
- <u>Crops and Irrigation Practices</u> (major crops, irrigation practices, access, efficiencies and inadequacies) This information is essential for the reconfiguration of systems to respond to local needs.
- <u>Farmers, Their Problems, Their Practices</u> (subsistence and cash cropping, gender roles, plot sizes, availability of inputs and outlets for produce)
- <u>Materials and Manufacturing</u> (materials available locally for manufacture, identification of potential manufacturers and their capabilities)
- <u>Distribution and Dissemination</u> (dealers and networks, local NGOs or other groups that can be used for promotion and marketing)
- <u>Partners, Collaborators and Enablers</u> (identification of potential partner organization(s), potential funding, potential collaboration on existing projects)
- <u>Marketing and Targeting</u> (estimated size and location of customers, where first marketing can and should be done)
- <u>Field Trial Site Selection</u> (if all of the above are positive, where to launch stage 2)

Most important in the Feasibility Study is the identification of potential implementing organizations. It is fully realized that finding a partner first may self-select certain sites for study to the exclusion of others. However, this is a necessary restriction until the program is established and can expand to other areas of the country.

3. Evaluation of the Feasibility Study

Rating a feasibility study carries both quantitative and qualitative analysis. However, no two countries or set of conditions are alike. Our experience is that the following are some of the minimum conditions necessary for a positive feasibility analysis:

- Water is in short supply to a large number of farmers (farmers without irrigation are severely constrained and/or farmers using irrigation do not get enough water)
- Water carries a high value and there is incentive to save it and make agriculture more efficient
- There are at least 10,000-50,000 potential customers (farm families) that can use the kit or and adapted-customized technology package
- There is at least one potential manufacturer in the country, or the cost of importation will not render the technologies unaffordable
- There is a potential distribution chain that stretches down to village level
- Materials are available for manufacture and the fabrication price is such that farmers will get a 100% return in investment in the first year of use of the technology
- There are no unfair tax restrictions on manufacture or use of the technology
- There are no massive subsidies in place that distort the economics of farming such that drip irrigation would be at a restrictive disadvantage

The prospective implementing organization(s) will also be evaluated on the criteria of:

- They have an on-the-ground presence or network that can engage rural farmers
- They can incorporate the project into their programming
- They are committed to a private sector approach to dissemination (affordable technology sold rather than given as charity)
- They have or can secure staff that can carry out their activities
- Staff are available for training

4. Field Trials

25-75 field trial sites (depending on the size of the target area) will be identified and installed with drip or other microirrigation systems. The number will depend on the size of the country and the diversification of agriculture, the number of potential crops and the implementing capability of the partner organization(s).

These field trials will be done on small farmer fields. Imported "kits" and locally customized systems (for plots over 1/8th hectare) will be installed, farmers and participating organization personnel trained and a monitoring system will be put in place. Where possible, side-by-side plots without the trial systems will be identified for comparative purposes.

It will be important to do these field trials under the conditions that represent the potential market. It will require selection of farmers that are willing to participate, do self-monitoring, keep records (using either literate or pre-literate record keeping techniques) and participate in monitoring interviews.

Farmers will use the technology for two growing seasons (wet and dry) and will be monitored on at least a monthly basis. Monitoring indicators, that will combine quantitative and qualitative data, will include for each plot, season and crop:

- Amount of water used (compared to non-drip water requirements) – to determine water savings
- Uniformity of Flow (from microtubes or emitters) -- to ensure that all plants are receiving the same amount of water)
- Changes in Cultivation, Weeding or Fertilizer Application, especially crop spacing – to determine any minimal changes in farming practices are required or adaptation of technology
- Changes in Labor and Other Input Costs – to determine savings in production costs, leading to increased profit at sale
- Yields of Crops (compared to farmers' historical yields, control plots and known local yields) – to determine increases in production for family consumption and/or income generation from sale
- Increase in family food supply and/or cash generated from sale (as well as an assessment of local markets to absorb increased production)
- Innovations Made or needed by the Farmer – towards producing a locally acceptable product
- Feedback on Changes that should be made to the Technology – towards adaptation to maximize market demand
- Feedback on the "Value" of the Product – towards developing a marketing strategy and determining the price which the technology must be produced and sold

5. Evaluation of Field Trial Stage – Adaptation of the technology

At the end of this stage, there should be in a place a body of knowledge on how well affordable microirrigation works with small farmers. There will be an indication of acceptability, by interviewing both the farmers and their neighbors. Actual local success can be documented and used in marketing strategy formulation.

By working with manufacturers during this stage there should be several prototypes developed (that can replace the field trial imported units or be used in Stage 3 demonstrations – remembering that the adaptation process is a learning process and is on-going). A local design made from local materials will have been identified.

6. Further field trials with farmers

Farmers' reactions to the final prototype needs to be assessed through the use of focus group studies and other events.

7. Final Prototype and Manufacturer Gear-Up

From the field trials and on-going adaptation process a final set of products will emerge. These will be of the appropriate size, specifications and materials to meet local conditions. Working with several manufacturers (at least 2 in a country so as not to set up a monopoly), IDE will provide jigs and templates for production, as well as continuing to seek maximum affordable. At the same time quality control standards will be established. In cases where there is no capacity for local production, serious thought to initiating a technology transfer (for local extrusion or injection capabilities) should be strongly considered.

8. Distribution Network Development and Test Marketing

In the areas where mass-marketing will be launched, identification of market outlets must be done. Outlets may include private dealers (agricultural inputs, hardware, retail shops), agents (who will market the products in local bazaars or by visiting farmers), local NGOs (self-help groups, farmer clubs and associations, women's groups, etc), other operational NGOs, or international projects (irrigation or watershed projects).

Potential distributors will need to be recruited, oriented and trained on installation, operation and maintenance issues. This is an appropriate time for concentrating on Business Development Services and skills.

9. Marketing Strategy Development

This component includes:

<u>Market Forecasting</u> – matching needs, production capacity and dealer coverage in the short, medium and longer term, to determine annual and seasonal production and sales projections

<u>Logistics</u> – determining how products will move from manufacturer to dealer, and whether intermediate distributors (wholesalers or assemblers) are required to ensure smooth flow of the supply chain

<u>Commercialization and Branding</u> – to develop the optimum "packaging" for mass-marketing and determine whether "branding" would be advantageous, and what brand "presence" (name, logo and theme) would stimulate demand

<u>Promotional Activities</u> – the set of activities that will stimulate sales and demand, be it mass-media such as radio, video shows, brochures, posters, mass meetings, etc.

<u>Sustainability Strategizing</u> – these need to be built in from the beginning and include having estimates of overall market potential, ideas on the length of time required to achieve critical mass or market penetration. Thought has to be given to capacitizing the private sector to eventually take over responsbilities (and costs) of promotion, forecasting, supply chain management, brand management etc.

10. Demand Creation and Building a Rural Mass-Marketing Program

With an affordable product that has a demonstrated success, there is the possibility that the local private sector will take over the rural mass-marketing eventually. However, it is IDE's experience that the niche of the poor farmer is not a general target for the private sector, without some support. Early mass-marketing efforts will most likely have to be subsidized, and this is where donor funding can be crucial in the process of creating demand which can effectively be met by the private sector. Creating demand is a long-term process (say, ten years depending on demand potential) and a wide range of promotional materials and activities should be considered. It should be noted that supply chain management, quality control, customer feedback, training, and monitoring are also continuing activities that take place during this period.