Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and Poverty

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Abstract

Despite the impressive gains in global food production over the last half century, an estimated 790 million people remain hungry. Many of the chronically hungry are poor farm families, who have neither the means to produce the food they need nor sufficient income to purchase it. For them, access to irrigation water--or the means to use the water they have more productively-- is a key to increasing their crop production, their incomes, and their household food security. Ironically, a technology typically associated with wealthy farmers-- drip irrigation-- may hold the key to alleviating a significant share of rural hunger and poverty. A new spectrum of drip systems keyed to different income levels and farm sizes (beginning with a $5 bucket kit for home gardens) now exists and can form the backbone of a second green revolution--

this one aimed specifically at poor farmers in sub-Saharan Africa, Asia, and Latin America. We describe the experience with affordable drip irrigation to date--including its growing use in India and Nepal--as well as the wide range of geographic areas and conditions where these systems may be useful. We propose a major new international initiative to spread low-cost drip irrigation through private microenterprise, with the aim of reducing the hunger and increasing the incomes of 150 million of the world's poorest rural people over the next 15 years. Our estimates suggest that such an initiative could boost annual net income among the rural poor by some $3 billion per year and inject two or three times this amount into the poorest parts of the developing world's economies.

Keywords: irrigation, water scarcity, poverty, hunger, food production, drip irrigation, microenterprise.

Introduction

One of the clearest lessons of the last half century of agricultural development is that an adequate global supply of food is a necessary but not sufficient condition for eliminating hunger. World grain production has tripled since 1950, and now totals approximately 1.87 billion tonnes per year (Brown et al. 1999)—more than enough to provide an adequate diet for the world's 6 billion people. Yet the United Nations Food and Agriculture Organization (FAO 1999) reports that 790 million people—approximately one out of five in the developing world—are chronically hungry.

Like trickle-down economics, trickle-down food security does not work for the very poor. The impressive increases in national per capita grain production, stimulated by the green revolution, mask large pockets of severe hunger and poverty. The production and trade of more "surplus" food does not solve the problem of hunger because those most in need of the food are too poor to buy it, even at today's historically low prices. At the national level, for example, India is self-sufficient in grain; but more than half of India's children are underweight (Gardner and Halweil 2000).

The overwhelming majority of hungry people live in rural areas of South Asia and sub-Saharan Africa. They are among the 1.3 billion people who survive on less than $1 a day. They are typically landless laborers or cultivators of very small plots, from which they get neither sufficient crop production nor income to ensure household food security. In the so-called "poverty square" of South Asia, for example, more than half of the farmland consists of marginal and small farms less than 1 hectare in size. Moreover, because of rapid population growth, the average farm size in this region has decreased by half every 15 years since 1960 (Shah et al. 1999).

Small farmers could double the crop output and income generated by these small plots if they had access to a key ingredient of land productivity—water. In monsoon climates with a long dry season, as well as in semi-arid and arid regions, access to irrigation water is critical to boosting and stabilizing crop production. With a secure water supply, farmers can choose to invest in higher-yielding seeds, grow higher-value crops, and harvest an additional crop or two each year. Irrigated plots in developing countries commonly yield twice as much as rain-fed plots do (Postel 1999).

By raising small-farm productivity, access to irrigation water is also key to improving rural livelihoods and revitalizing rural economies. It creates jobs for people both with and without land, since more people are needed to harvest, process, and market the crops and to supply farm inputs. The additional farm income ripples through the local economy, generating employment and higher incomes for off-farm workers as well. Access to irrigation water broadens farmers' crop choices and enables them to grow higher-value vegetables and fruits for the marketplace. By creating more secure and stable rural communities, access to productivity-enhancing irrigation water can also help stem the tide of migration to already overcrowded cities and slums (van Hofwegen and Svendsen 2000).

Despite its remarkable gains, the modern irrigation age has failed to meet the widespread need for very inexpensive, divisible irrigation systems for poor farmers on small plots. The Green Revolution may have tripled the global harvest, but it completely bypassed the majority of the world's small farmers and their families. Ironically, an irrigation technology long viewed as appropriate only for wealthier farmers now appears to hold great promise for small, poor farmers—drip irrigation. New evidence from many parts of the world shows that, with affordable drip systems, small farmers can shift from subsistence production to higher-value production for the market, doubling their income and greatly enhancing household food security. The spread of affordable drip irrigation technologies can form the backbone of a second green revolution—this one aimed at sustainably lifting the production and incomes of poor farmers.

Irrigation's Missing Link

Global irrigated area has increased more than sixfold over the last century, from approximately 40 million hectares in 1900 to more than 260 million hectares. (Postel 1999, FAO). Today, 40% of the world's food comes from the 18% of cropland that is irrigated (Postel 1999, FAO). Extending irrigation to a portion of the 82% of cropland watered only by rainfall is essential to increasing global food production and, more directly, to reducing rural hunger and poverty.

Some 95% of the world's 1.1 billion farmers live in developing countries (van Hofwegen and Svendsen 2000). The vast majority of them cultivate plots less than 2 hectares (5 acres) in size. Although a small subset of these farmers may benefit from canal irrigation systems, most are in locations where subsidized surface schemes are too expensive or impractical to build. A portion of these small farmers are at the tail-ends of existing canal systems, but because irrigators in the head-reaches siphon off most of the water supply, they do not get sufficient water to markedly improve their productivity and incomes. Chambers (1988) has estimated, for example, that 25-40% of the area declared irrigated in India suffers from tail-end deprivation.

Groundwater is a potential source of irrigation water in many agricultural areas. However, even the least-expensive diesel pump-and-tubewell systems cost $350-500, way out of reach for farmers earning less than this amount in a year. Moreover, these systems are typically not economical on plots of less than 2 hectares, which makes them irrelevant to the majority of poor farmers (Polak et al. 1999a).

Raising the productivity of smallholders requires an entirely new approach to the design of irrigation systems. By and large, the irrigation sector has focused on (1) large-scale canal projects that deliver large quantities of water to farms, (2) large-scale groundwater projects, and (3) high-quality pressurized sprinkler and drip systems that greatly improve the efficiency of water application, but that are too expensive for smallholders. The big missing piece in global irrigation are systems designed for poor farmers on small plots who need access to irrigation water and/or a way to stretch a scarce supply of water. Such systems would meet the following criteria:

- <u>Affordability</u>. A spectrum of irrigation systems are needed that place affordability before top-quality, and that can be purchased by farmers earning no more than $200-300 per year.

- <u>Rapid payback</u>. Poor farmers are very risk-averse. They will typically be attracted only to innovations that increase returns two- to three-fold (Cornish 1997).

- Divisibility and Expandability. Systems must be adaptable to varying farm sizes, down to micro-plots of one-tenth of a hectare or less. Farmers must be able to purchase a system small enough to be affordable, and then to gradually expand the system as his/her income increases.

- Water-efficiency. A majority of the poorest farmers are in arid or semi-arid lands or tropical areas with a long dry season. For them, water for crop production is scarce. Systems that help them stretch their scarce supply of water enable them to expand their cultivated area, increase yields, diversify crop production, and generate more income.

Neither the private irrigation industry, the international development banks, the international agricultural research centers, nor government enterprises have made a concerted effort to fill this huge technological gap. Doing so clearly requires a new institutional approach and set of priorities. As Harvard economist Jeffrey Sachs (1999) has pointed out, "To the extent that the poor face distinctive challenges, science and technology must be directed purposefully towards them. In today's global set-up, that rarely happens. "

The Untapped Potential of Low-Cost Drip Irrigation

Drip irrigation is widely recognized as one of the most efficient methods of watering crops (Keller and Bliesner 1990). Since its commercial acceptance in the mid-1970s, the hardware used in drip irrigation systems has evolved to fit large fields and to minimize management and labor requirements. As a result, the standard hardware that is now available is expensive and rather sophisticated. What is not widely known, however, is that a spectrum of drip systems is now available that meet the above criteria for smallholders—affordability, rapid payback, divisibility, and water-efficiency. Generally viewed as a technology for large commercial farmers engaged in high-value agriculture, drip irrigation is now showing great promise for raising the land productivity, water efficiency, and incomes of poor smallholders. ~~Drip irrigation is widely recognized as the most efficient method of watering crops (source). What is not widely known, however, is that a spectrum of drip systems is now available that meet the above criteria for smallholders—affordability, rapid payback, divisibility, and water-efficiency. Long viewed as a technology for wealthy farmers engaged in high-value agriculture, drip irrigation is now showing great promise for raising the land productivity, water efficiency, and incomes of poor smallholders. It could well hold the key to a second green revolution—one aimed directly at those who missed out on the first one.~~

A Brief History of Drip Irrigation

The creation of inexpensive, weather-resistant plastic after World War II paved the way for drip irrigation. Through a network of perforated plastic tubing installed on or below the soil surface, drip systems deliver water under low pressure almost directly to the roots of plants through small holes or emitters. When well maintained and combined with soil-moisture monitoring or other ways of assessing crops' water requirements, drip irrigation can achieve application efficiencies as high as 95 percent (Vickers in press.) Losses to evaporation, deep percolation and surface runoff are negligible. Farmers can also apply fertilizer in measured quantities through drip systems, simultaneously reducing chemical use and the potential for land and water pollution.

Drip systems were developed for commercial applications by Israeli engineers. By the mid-1970s farmers in a half–dozen countries—Australia, Israel, Mexico, New Zealand, and South Africa—were using drip methods on a portion of their cropland (Postel 1992). Starting from a small base of approximately 56,000 hectares worldwide in the mid-1970s, drip and other microirrigation systems spread rapidly to 1.6 million hectares by 1991, the latest year for which a global survey has been completed (Bucks 1995). Bucks (1998) estimated that the global area under microirrigation has likely expanded by 75 percent since 1991, which would place the current total at approximately 2.8 million hectares.

This impressive growth is attributable to the higher crop yields and water use efficiencies obtained with drip irrigation and the wider dissemination of these field results. In countries as diverse as India, Israel, Jordan, Spain, and the United States, studies have consistently shown drip irrigation to reduce water use by 30-70% and to raise crop yields by 20-90% (Suryawanshi 1995, World Bank 1993). In India, research from a variety of institutions has consistently shown drip to cut water use by 30-60% and to raise yields by 5-50% compared with conventional surface irrigation methods (Indian National Committee 1994, Sivanappan 1994). (Table 1). As recently as 1985, India had only 1,000 hectares under drip irrigation (Indian National Committee 1994), but by 1998, the area under drip was estimated to have expanded to 225,000 hectares (Polak and Sivanappan 1998). Drip irrigation's combination of water savings and yield increases typically produces at least a doubling of water productivity—yield per unit water —and makes it a leading technology in the global challenge of boosting crop production in the face of serious water constraints (Postel 1999).

Conventional Drip Systems for Medium to Large Fields

Although the area under microirrigation has expanded 50-fold over the last two decades, it still represents only 1 percent of the world's total irrigated area. The principal barriers to its expansion have been high capital costs—typically ranging between $1,500 and $2,500 per hectare—and the lack of divisibility in commercially available systems. In India, for example, the typical small farmer cultivates five separate plots, each ranging in size from 0.1 - 0.2 hectares (Polak et al. 1997), but the largest manufacturer of drip systems in India does not sell a system appropriate for plots of less than 0.4 hectares (Polak 1997).

A principal reason for the high capital cost of most commercially available drip irrigation systems is that hardware components are optimized for fields of 4 hectares or larger and designed to minimize labor and management costs. Furthermore, the drip lines are relatively long (200– 400 meters) and the emitters (which do the dripping) are designed to be compact and to not interfere with mechanical cultivation of fields. In the case of row crops, the drip lines are often discarded after one growing season; with tree crops, they typically remain in place for several years. This requires: a) relatively large-diameter drip-line tubing ; b) sophisticated emitters that operate at relatively high pressures (one-atmosphere) while having flow paths that are large enough so they do not clog too readily, and (3) expensive filters to minimize clogging of the emitters. Drip systems on larger fields also require careful engineering and design to assure that the relative pressure differences among the emitters are small so that the application (drip-rate) throughout the field is uniform. (Keller and Bliesner 1990.)

By contrast, early drip systems were simple and used holes or micro-tubing instead of sophisticated emitters. These simple designs were abandoned because they did not fit the needs of modern medium- and large-scale farming in the developed countries. However, these early system designs are well-suited for drip-irrigating small plots: the drip lines can be relatively short and the elevation differences within the plot are typically minimal, so pressure losses are small. Moreover, there is usually sufficient labor to cultivate around the micro-tubing and to periodically inspect and clean the simple hole emitters or micro-tubes.

Some efforts have been made to promote drip irrigation for small plots, but until recently, no one imagined the full potential of a market-driven approach for extending affordable drip irrigation to serve poor farmers in developing countries.

Affordable Drip Systems for Small Farmers

Prospects for the expansion of drip irrigation have brightened markedly over the last several years with the development of a spectrum of drip systems keyed to different income levels and farm sizes. Results from field trials demonstrate that low cost drip systems easily pay for themselves in one growing season, and stimulate shifts to more intensive agricultural practices by small farmers. As discussed further below, the early stages of marketing low-cost drip systems in India and Nepal suggest enormous potential for sales growth, and, most importantly, for drip irrigation to markedly increase the incomes and food security of small farmers.

International Development Enterprises, a non-profit organization specializing in the creation and marketing of affordable small-scale irrigation, has developed four principal types of low-pressure gravity drip systems for small farmers (Polak and Sivannapan 1998, Polak et al. 1999, Polak 2000a):

- <u>Bucket Kits</u>. These entry-level systems consist of a simple 20-liter household bucket attached to a pole at about shoulder-height. The bucket is equipped with a 10-meter lateral line, from which 26 microtubes extend. (See Figure 1.) When placed mid-way between parallel crop rows, each microtube can irrigate 4 plants. The bucket needs to be filled with water 2-4 times per day. In this way, each bucket kit, which in India costs about $5 (including the bucket), irrigates 100 individual plants over a 25 m^2 area—enough to feed a six-person household. Since the labor burden (which often falls to women) of handwatering home gardens can discourage plots of this size, the bucket kit offers an initial step toward greater food security and cash income. Moreover, if the family can sell a portion of their crops, they can use the profit to expand their irrigation system.

- Drum Kits. One step up from the bucket kit, these systems consist of a 200-liter drum from which extend five lateral lines. Each lateral line is 10 meters long and fitted with 26 microtubes, allowing each drum kit to irrigate a 125 m^2 plot—an area five times larger than the bucket kit covers. Each drum kit costs $25, and can be expanded in 125 m^2 increments at a cost of $14 per increment. (See Figure 2.)

- Shiftable Drip Systems. These systems resemble more conventionl drip systems, but have much lower capital costs because they are designed to be shiftable instead of stationary. Whereas conventional systems require a plastic lateral line for each row of crops, these systems consist of shiftable lateral lines, each of which irrigates 10 rows. An off-the-shelf plastic tank placed 2-4 meters above the field (and equipped with a simple cloth filter) provides adequate pressure for the system. Water drips out of baffled holes in the lateral lines or out of microtubes extending from the laterals, rather than out of expensive emitters. The shiftable system, which was first developed in Nepal, works well for closely spaced, low-growing crops—including many vegetables—in areas with relatively low labor costs. These systems cost about \$50 for a 1,200 m^2 plot. (See Figure 3.)

- Stationary Microtube Systems. These systems consist of plastic lateral lines equipped with microtubes, and can be used on small or large plots. They cost approximately two-thirds less than conventional drip systems. The cost reduction results mainly from a system design that allows each lateral line—an expensive component—to irrigate four rows of crops instead of one or two. This is accomplished by extending microtubes from both sides of the lateral and positioning each one between two closely spaced parallel rows. The system is pressurized by a concrete tank placed about 4 meters above the field and equipped with a low-cost filter. The needed system pressure can also be derived by adapting an existing electric or diesel pump using a bypass valve. Stationary microtube systems cost approximately \$250 for 4,000 m^2 (1 acre), or \$625 per hectare—about a third as much as conventional drip systems.

Field tests suggest that the stationary microtube systems offer similar water-savings and yield benefits over traditional surface (flood/furrow) systems as the more expensive conventional drip systems offer. In field trials in Madhya Pradesh, India, with adjacent 2,000 m^2 plots of seed cotton, the field irrigated by a low-cost stationary drip system yielded 670 kg/ha compared with 500 kg/ha for the flood-irrigated field—a 34% yield gain. Water use was estimated to be 55% less with the low-cost drip system

(IDE 1998). Previous studies in Coimbatore in southern India comparing cotton irrigated by conventional drip versus flood systems showed water savings ranging from 43% to 79% and yield increases ranging from 25% to 40%. (Polak and Sivanappan 1998). Tests in Rajasthan, India, of the microtube system on sugar cane showed lower gains in yield (14%) than more expensive conventional drip systems (29%) when each was compared with flood irrigation methods (IDE 1998). In both the cotton and sugar cane trials, low-cost drip resulted in a substantial increase in water productivity—output per unit water—due to both the yield gains and water savings.

In early 1999, the Swiss aid agency, Swiss Development Cooperation, sponsored a study of low-cost drip systems used by a small sample of farmers in the Indian state of Maharashtra. The farms ranged in size from 100 m^2 up to 0.2 hectares and included a mix of drip system types. A variety of crops were irrigated on these plots, including beans, vegetables, papaya, and flowers. Compared with flood irrigation methods, the study found average water savings of 55%, labor savings of 58%, and reductions in expenditures on fertilizer and pesticides averaging 16%. With the drip systems, some farmers obtained cash profits for the first time, while others saw substantial increases—50% to more than 300% -- in their net profits. In addition, household consumption of fresh vegetables increased—from occasionally to almost daily—suggesting improved variety and nutrition in the diet. Finally, because drip-irrigated fields had fewer weeds, the work load on women and children was reduced (Bilgi 1999).

Low-cost drip systems have begun to spread rapidly where they have been introduced. So far, small farmers have purchased approximately 13,000 microirrigation systems, including about 8,000 in India, 2,300 in Nepal, and 1,700 in Sri Lanka. In addition, 60 systems are being field-tested in Vietnam and another 60 in Bangladesh. At the initiation of Fideicomiso de Riesgo Compartido, a technology transfer organisation (FIRCO) within the Ministry of Agriculture of the Government of Mexico, some 50 test plots have been established in four states in Mexico. In China, International Development Enterprises has established 160 demonstration plots in Gansu and Shanxi provinces. Preliminary results in virtually all cases look promising. For example, results with drum kits (costing $20-30 per 100 m^2) being tested in Vietnam show substantial yield increases, labor savings, and income gains (Van Quang 2000).

Moreover, a rapidly expanding array of low-cost drip systems is now available to small farmers in different parts of the world. The Israeli firm Netafim, the largest international drip irrigation company in the world, is now marketing a high-quality, 1000-m^2 system in China, India, and Africa. It is still too expensive, however, for very poor farmers. During the past 25 years, the Yanshan Institute in Beijing has installed thousands of hectares of low-cost microtube drip systems in China, although they are not yet available for small plots. And for the past several years, the New York-based non-profit Chapin Watermatics has distributed thousands of bucket kits for irrigating kitchen gardens to poor rural families in Africa and elsewhere.

The Worldwide Market for Affordable Drip Irrigation

During the last 30 years, drip irrigation has proven to be a high-quality method of irrigation for farmers in water-short areas, growing high-value crops, and able to invest $2000-2500 per hectare in new capital equipment. For the private drip irrigation industry, the principal markets have been in the Middle East (e.g., Israel and Jordan), southern and Mediterranean Europe (e.g., Greece and Spain), and in the United States (e.g. California). The total capitalized value of existing drip irrigation systems is on the order of $5-7 billion—an impressive figure, but a drop in the bucket compared with the estimated $1.9 trillion capitalized value of all existing irrigation assets worldwide (Postel 1999).

The emergence of affordable drip systems that are suitable for small plots has the potential to expand the area under drip irrigation many-fold. Although drip irrigation is not practical for closely spaced crops such as wheat, it can be used to irrigate most fruit and vegetable crops, as well as cotton and sugarcane—two thirsty and widely planted crops. It has the potential to greatly improve environmental conditions in the water-short, salt-laden Aral Sea basin, for example, where the majority of the nearly 8 million hectares of irrigated land is watered by highly inefficient furrow and flood methods (Postel 1999) Researchers estimate drip irrigation's potential in India to be on the order of 10 million hectares (Indian National Committee 1994), and the potential in China is likely equally large.

Perhaps more important than the size of the potential market, however, is the location of those markets and who they can benefit. Affordable drip systems are being installed in the hills of Nepal and northern India, where water from community tanks is scarce and cropland is terraced and prone to erosion. Drip systems have great potential as a feature of watershed projects in South Asia, sub-Saharan Africa, and elsewhere. In these areas, very labor-intensive efforts go into capturing and storing rainwater runoff—for example, by constructing check dams or tanks—but then that water is often applied very inefficiently to fields. Affordable drip systems could markedly raise the productivity of this harvested rainwater, thereby making watershed projects more economical. Low-cost drip systems also have the potential to raise the productivity and incomes of canal system "tailenders," whose supplies are often insufficient to irrigate their entire plot of land. For small farmers with human-powered pumps or who purchase groundwater through local water markets, affordable drip systems can reduce their water use and costs, or allow them to expand their crop production with the same quantity of water.

In short, the potential market for affordable drip irrigation is larger, more varied, and more geographically widespread than for conventional drip irrigation. The difference in these markets is akin to the difference between the supercomputers of the 1970s, which only a handful of universities could afford, and the desktop computers of the 1990s, which quickly spread to millions of households. Most importantly, making low-cost drip irrigation accessible to millions of smallholders would directly address the problems of poverty, hunger, and water scarcity that are entrenched and spreading in so much of the developing world.

Microenterprise and Rural Marketing

As any entrepreneur knows well, an idea or technology by itself will not change the world. To make a difference, it has to be sold. The existence of an innovative spectrum of afforable drip irrigation technologies in no way guarantees that these systems will come into widespread use. The potential customers are mostly very poor; many are illiterate. There are fewer mechanisms for targeted marketing—such as radio and television—to reach these customers. Rural infrastructure is often underdeveloped, making it harder to bring customers and markets together. In many ways, the cards are stacked against the dissemination of technologies for the rural poor.

Creating new markets that serve poor farmers is a critical but underattended component of the challenge of reducing rural poverty and hunger. The traditional approach to development taken by international aid agencies, regional banks, government agencies, and private non-governmental groups has too often treated poor farmers as recipients of charity rather than as paying customers. In order to achieve the productivity and economic gains that affordable drip irrigation offers, it is first essential to lay the groundwork for a sustainable system of local manufacturing, selling, and repairing of these technologies—in short, a sustainable network of microenterprise.

The Treadle Pump: A Model of Success

Fortunately, the creation of new markets for poor farmers is not wholly uncharted territory. Over the last 17 years, large areas of Bangladesh have been transformed by a human-powered water-lifting device called a treadle pump. The treadle pump is operated by a stair-step walking motion on two long bamboo poles or treadles, which in turn activates two steel cylinders. Groundwater is suctioned into the cylinders and dispelled into a field channel. Costing less than $35 (including installation of the tubewell), the treadle pump has enabled very poor farmers to have direct access to groundwater irrigation for the first time. Able to plant higher-yielding rice seeds as well as vegetable crops during the dry season, farmers investing in the treadle pump have experienced increases in net income averaging approximately $100 per year. Approximately 1.2 million treadle pumps have been sold in Bangladesh alone, leading one research team to call it "a run-away success." (Shah et al. 1999) With this simple technology, farmers are raising the productivity of more than a quarter million hectares of farmland and injecting an additional $350-650 million a year into the poorest parts of the Bangladeshi economy (Polak et al. 1999a, Postel 1999).

A key to understanding the treadle pump's remarkable success in Bangladesh has much to do with its marketing—an activity sometimes maligned and often ignored by development groups and international agencies. With a philosophy of treating poor people as customers, International Development Enterprises (IDE) worked to stimulate market demand through a creative information and marketing strategy, as well as to help spawn a self-sustaining network of local pump manufacturers, dealers, and installers. IDE made the technology known to farmers through billboards, calendars, and demonstrations at village and regional markets. A 90-minute movie featuring well-known Bangladeshi movie stars included the treadle pump in the plot, and was shown in open air settings to some one million people a year (Polak et al. 1999a).

Simultaneously, IDE worked directly with local manufacturers to diversify the production base, helped establish a network of dealers who would sell the pump at a reasonable profit, and trained a cadre of local technicians to install the pumps. This private sector network now consists of approximately 80 ~~70~~ manufacturers, 1100 ~~830~~ dealers, and more than 3000 ~~2,500~~ installers (IDE 2000). Since 1985, a total investment by donors of $12.6 million and by Bangladeshi farmers themselves of $39.8 million has yielded $650 million in increased income from crop production alone (Polak et al. 1999b).

IDE and its partners are now working to expand the market for treadle pumps in eastern India and Nepal, where the potential is estimated to number around 10 million pumps. If this market can be saturated, and annual income per pump of $100 materializes as in Bangladesh, then this simple technology would increase the annual income of South Asia's poorest households by $1 billion. According to Shah et al. (1999) who conducted an assessment of the social impact of the treadle pump in South Asia, such an accomplishment would be "one of the most powerful—and best targeted—poverty-alleviation interventions the world has ever seen."

Making it Happen: Expanding Low-Cost Drip Irrigation by One Million Hectares Per Year

Our research and field experience suggest that the potential crop production, food security, and income gains from affordable drip irrigation are much greater than that of the treadle pump. Building on the successful rural mass marketing of the treadle pump in Bangladesh, we are now initiating a new effort to further the use of affordable drip irrigation by smallholders in poor regions of the world. Our goal is an ambitious one—to expand the area under drip irrigation by 1 million hectares a year. We believe that such a bold initiative is required to confront the challenges of hunger, poverty, and water scarcity that remain entrenched and threaten to worsen in many parts of the developing world. Achieving this goal over the next 15 years could transform the farming intensity of approximately 30 million smallholder families, and increase the net incomes of 150 million of the world's poorest rural people by $3 billion per year.

The Places to Start

The largest concentrations of poor and hungry people are found in the rural areas of South Asia, northwestern China, and sub-Saharan Africa. The majority of poor farmers in these regions lack access to affordable irrigation, face production constraints resulting from seasonal or chronic water scarcity, and cultivate less than two hectares of land. As a result, these are logical places to launch a wider effort to spread affordable drip irrigation to small farmers.

As already noted, more than 13,000 small farmers have purchased and installed four different varieties of low-cost drip systems in India, Nepal, and Sri Lanka. They have demonstrated water savings of approximately 50%, crop yield increases of 30 to

70%, and shortened crop cycles. Some 4,000 of these systems have been installed by small hill farmers, which sets the stage for these areas to serve as training and demonstration centers for further dissemination in poor hill areas.

The greatest potential for expansion in South Asia is in India. The majority of that nation's estimated 10-million-hectare drip potential (Indian National Committee 1994) lies in the water-short states of Madhya Pradesh, Gujarat, Rajasthan, Maharashtra, Andhra Pradesh, and Tamil Nadu. A vibrant drip irrigation industry, which includes some 75 private companies, already exists in India. Unfortunately, the national government's policy of subsidizing drip systems of one hectare or larger ~~)~~ has steered the private sector toward larger systems, leaving the poorest and smallest farmers out of the market. However, a new sector of micro-enterprises has begun to produce drip packages for plots from 15 m^2 to 0.5 hectares, and there is hope that government subsidy policies will begin to support the adoption of small, low- cost systems.

In China, the poorest small farmers are disproportionately concentrated in the Yellow River basin in the north-central part of the country. Water scarcity is a worsening problem in the hilly Loess Plateau region, as well as in the north China plain, where water tables across a wide area are dropping a meter or more per year from the overpumping of groundwater. The Yellow River is virtually tapped out during the dry season, with no outflow to the sea for major portions of the year (Postel 2000).

In the upper portions of the watershed, the government has installed several hundred thousand rainwater storage systems (each with a capacity of 35 m^3) to enable one or two seasonal irrigations and thereby augment the yield of subsistence crops. Low-cost drip systems offer the potential to greatly increase the productivity of the scarce irrigation water from these rainwater cisterns. The results of feasibility studies carried out by IDE, and preliminary feedback from 160 poor farmers who have installed low-cost drip systems in Gansu and Shanxi provinces, indicate that the Yellow River basin is ripe for expanded use of small, affordable drip systems.

In sub-Saharan Africa, many of the constraints to expanding conventional irrigation will also constrain the spread of low-cost drip irrigation, including the lack of basic infrastructure, the absence of developed markets, and legal and cultural biases against women, who do 80% of the farm work in this region (Brown and Nooter 1991). However, preliminary information suggests a very large potential demand for the increased production of vegetables and other horticultural products using low-cost drip irrigation on small farms in peri-urban areas of South Africa. Because of its strong infrastructure and new water policy reforms focused on the poor, South Africa is a logical place to demonstrate the potential of low-cost drip irrigation in the region. If legal, cultural, and policy barriers can be overcome, affordable drip irrigation may have substantial potential in many other sub-Saharan African countries, where chronic water scarcity poses one of the most serious constraints to agriculture.

Other regions that seem ripe for the introduction of affordable drip irrigation include parts of the Middle East, North Africa, and the Aral Sea basin of Central Asia; however, preliminary feasibility studies have not yet been carried out in these regions. In Latin America, bucket kits for garden plots are currently being tested in Brazil, El

Salvador, Honduras, Nicaragua, and Yucatan in Mexico, with support from the Kellogg Foundation. Finally, because of their demonstrated ability to increase crop yields, low-cost drip systems may also offer benefits even in areas where water scarcity is not typically a constraint. For example, initial tests of low-cost drip systems in the Hue region of Vietnam indicate that farmers growing dry-season lettuce have doubled their income in comparison with hand- sprinkling (Polak 2000b).

Appropriate Water Conditions

Affordable drip systems can operate under a wide variety of water supply conditions. Simple bucket kits for home gardens, for instance, can be supplied by a community or family drinking–water well, and the bucket filled once or twice a day. With the bucket positioned at shoulder-height, sufficient pressure exists to operate the system.

With small farmers rapidly turning to groundwater as a supply source, and with water lifted from wells already under pressure, matching low-cost drip with groundwater irrigation makes sense in many areas. An array of affordable electric, diesel, and gasoline pumpsets are now in use by small farmers, for example, and drip systems could be connected to them for more efficient application of water to fields or to increase crop yields. For very low-income farmers, there is the intriguing possibility of combining low-cost drip with labor-intensive manual water-lifting technologies, such as the treadle pump. Farm families in Bangladesh, for example, who may be manually pumping groundwater for several hours a day during the dry season, might reduce their labor, increase their crop and water productivity, or both, by installing an affordable drip system.

In areas with no perennial water sources, water supplies often depend on labor-intensive water-harvesting techniques, such as the construction of check dams, percolation ponds, or tanks. All too often, these water supplies so painstakingly captured are then applied wastefully to fields through inefficient flood irrigation. The global low-cost drip initiative will work to establish partnerships with non-governmental organizations and community groups that are implementing watershed development projects to encourage the use of low-cost drip systems, where applicable, to improve water and labor productivity.

Opportunities to link affordable drip systems with canal irrigation projects also exist. As noted previously, in many canal systems, water is not distributed evenly, with much more going to the head-enders than to the tail-enders. The lost productivity, reduced income, and increased inequity caused by th tailender problem makes it one of the most serious unsolved problems in irrigation (Postel 1999). Where some means of short-term storage of canal-delivered water can be provided, tail-enders might shift to low-cost drip irrigation of higher-value crops in order to get more production, value, and income out of their limited water supply. Short-term storage would usually be needed because drip irrigation typically operates on a 1-3 day cycle, in contrast to the 14-day cycle of a typical canal system. Field trials are needed to test the feasibility of converting from surface methods to low-cost drip, including the testing of a variety of low-cost water storage options.

Steps in The Process

Spreading the use of low-cost drip irrigation to poor farmers through the private sector requires special attention to certain aspects of marketing and dissemination. The process begins with a multi-disciplinary feasibility study to determine if the conditions necessary for success—such as appropriate farm and plot sizes, farmer income, availability of irrigation water, and access to markets—exist in any given region of interest. If they do, the next step is to conduct field trials, obtain feedback from farmers, and then, based on this feedback, to modify the technology to better suit local conditions and farmer needs. These modified drip systems are then installed at several hundred demonstration sites, which are selected for their high visibility to potential small-farmer customers.

Ease of installation is an important key to the viability of large-scale dissemination of affordable drip systems. With conventional drip irrigation, a technician visits each farm, custom-designs a system for that farm, and then returns to install it—an intensity of skilled labor that adds substantially to the cost of conventional drip irrigation. For small systems applicable to plots of half a hectare or less, however, all the necessary components can be sold in unit packages, allowing the system to be expanded as needed to fit the plot size. With directions explained in an easy-to-understand picture booklet, the small farmer can install the system without a technician's help. Such off-the-shelf drip irrigation packages have been marketed in volume for home gardens in North America and Europe for years, and indications are that they work just as well for small farmers in Nepal and India.

For low-cost drip irrigation to spread widely and become a self-sustaining technology requires the creation of local private-sector supply chains. These might be initiated by existing drip irrigation companies, agricultural inputs companies, or new enterprises established to market packages of drip irrigation equipment along with seeds, soluble fertilizer, and biologial pest control materials. The plastic pipes, fittings, microtubes, filters, and gravity tanks that comprise a low-cost drip system are available off-the-shelf in most poor countries. IDE's experience in India and Nepal suggests that small plants to assemble and package the drip systems can be started for less than $1,000. These assembly plants then link with a network of village dealers and shops, supported by trained technicians, to form a private-sector supply chain for both the drip packages and spare parts.

The key to economic sustainability in the private sector is threshold sales volume—the point at which each manufacturer and dealer is selling enough products profitably to make a living. Effective marketing and promotion campaigns, which make small-farmer customers aware of low-cost drip, and motivate them to buy it, are critical to reaching supply-chain threshold sales volumes. However, since many small farmers in developing countries are illiterate and not reachable by mass media, it is essential to tailor all marketing and promotion strategies to local conditions. Based on previous experience, including the successful marketing of the treadle pump in Bangladesh, these might include wallboards, posters, and calendars; singers and dancers at village fairs and markets; as well as movies shown in rural settings. In our experience, an initial investment in marketing and promotion of up to $10 for each unit sold is needed to reach volume sales. This investment can be made by the private sector directly, through a government subsidy, or by foundations and other donors.

National, state, and local governments have important roles to play in creating policy climates and condtions that are conducive to the introduction and spread of low-cost drip irrigation. The Government of Mexico has been the first to assume a direct leadership role in the global initiative to spread drip irrigation. The government has supported laboratory testing of low-cost drip systems at the University of Mexico, and, as noted earlier, has supported field tests in several Mexican states. Because of the favorable results and positive farmer responses, field tests are now being expanded. This program in Mexico, along with those in India, Nepal, and China, will serve as demonstration and training sites for further dissemination of low-cost drip systems to other countries, fostering the establishment of a global network.

Other Critical Issues

For the low-cost drip irrigation initiative to succeed, a number of ancillary but critical issues will need to be resolved. One is access to markets. In countries such as China and India, with high population densities and reasonably good availability of transportation options, small farmers have access to markets to sell their vegetables, herbs, and other horticultural crops. This is not the case, however, in many parts of Africa, where populution densities are low, access to transport is poor, and local markets are easily saturated. In such areas, strategies will be needed to facilitate small-farmer access to regional and international markets.

Another critical issue is access to micro-credit. Many poor farmers will need credit in order to purchase a low-cost drip system, and in many areas, it is not available. Because the drip systems typically pay for themselves in one growing season, it would be possible to establish six-month payback terms, increasing the turnover rate of loans and the marketability of loan packages in the commercial market. Existing models for providing credit for items such as sewing machines through private-sector dealer networks are likely to be equally applicable to the provision of micro-credit for low-cost drip packages.

Conclusion

Combatting persistent rural hunger and poverty in a world of increasing water scarcity requires new approaches to agricultural and economic development. Millions of poor farm families lack access to irrigation water and/or to the technologies to use what limited water they have efficiently and productively. The spread of new low-cost drip irrigation systems, designed for a range of farm sizes and income levels, can open the door to irrigation's benefits for the millions of small farmers bypassed by the green revolution technologies. Drip irrigation's water-saving and yield-increasing potential raises the prospect of increasing the productivity and incomes of some of the poorest sectors of the rural population. Experience to date in India, Nepal, and China suggests substantial unmet demand for affordable drip irrigation.

We are launching a worldwide effort to spread low-cost drip irrigation in developing countries with the aim of reducing the hunger and increasing the incomes of 150 million of the world's poorest rural people over the next 15 years. Our estimates suggest that the widespread use of affordable drip irrigation has the potential to boost annual net income among the rural poor by some $3 billion per year and inject two or three times this amount into the poorest parts of the developing world's economies. This initiative is ambitious and will require effective partnerships among private-sector companies, nongovernmental organizations, agricultural research organizations, universities, government agencies, donors, and private foundations. We believe this initiative to be among the most constructive and promising responses to persistent poverty, hunger, and water scarcity that has been attempted to date.

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Table 1. Water Productivity Gains from Shifting to Drip from Conventional Surface Irrigation in India[1]

Crop	Change in Yield	Change in Water Use	Change in Water Productivity[2]
		(percent)	
Banana	+52	– 45	+173
Cabbage	+ 2	– 60	+150
Cotton	+27	– 53	+169
Cotton	+25	– 60	+255
Grapes	+23	– 48	+134
Potato	+46	~ 0	+ 46
Sugarcane	+ 6	– 60	+163
Sugarcane	+20	– 30	+ 70
Sugarcane	+29	– 47	+ 91
Sugarcane	+33	– 65	+205
Sweet potato	+39	– 60	+243
Tomato	+ 5	– 27	+ 49
Tomato	+50	– 39	+145

[1]Results from various Indian research institutes. [2]Measured as crop yield per unit of water supplied.

SOURCES: Postel 1999, based on data from Indian National Committee 1994, and Sivanappan 1994.

Figure 1. Schematic of a Bucket Kit System

Figure 2. Schematic of a Drum Kit, Microtube Version.

Figure 3. Schematic of A Drum Kit, Shiftable Hole and Baffle Version.

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