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Increasing the Productivity of the World's Micro-farmers

Paul Polak[1], Will Morgan [2], and Jeff Saussier[3]

Three quarters of the farmers in developing countries cultivate less than five acres. The productivity of these "micro-farmers" is the key to solving the growing problem of food security in the world. In light of this, it is remarkable that the development establishment has for so long ignored the critical needs of these "micro-farmers". The adoption of high yielding seeds and fertilizer combined with access to irrigation has tripled the global grain harvest in the past 30 years. But the harvest of micro-farmers has failed to keep up. The main constraint to tripling the harvest of small farmers, like their larger farmer neighbors, has been lack of access to affordable and divisible irrigation.

Western design processes have concentrated on optimizing efficiency rather than affordability. The result is that technology innovation stresses large scale (and expensive) rather than small-scale (and cheap).

Critical access to affordable "micro-irrigation" is beginning to be provided by the recent design of low cost "micro-plot" devices like treadle pumps, drip and sprinkler irrigation systems. Rural mass marketing of these devices through the private sector in rural areas (right down to village level) has made them available to the "micro-farmers" who have been by-passed. Rural mass marketing is the key to sustainability, in that this activates the private sector, creates demand and ensures continued supply of spare parts and replacements.

A Portrait of Micro-farmers in Developing Countries

A typical "micro-farmer's" holding may be divided into 4 or 5 "micro-plots", so tiny that modern western agricultural devices have no relevance. For example, 60% of farms in Bangladesh are less than 2 acres[1], and in Bihar (India) holdings are less than 2-1/2 acres)[2]. In Egypt 95% of holdings in 1984 were less than 5 acres[3]. while in China following the 1952 redistribution, 300 million landless peasants received 0.4 acres.[4]

[1] President, International Development Enterprises, 10403 W Colfax St, Lakewod, Colorado, USA 80215
[2] Program Officer, International Development Enterprises, Lakewood, Colorado, USA
[3] Monitoring and Evaluation Director International Development Enterprises, Lakewood, Colorado, USA

The typical small farm cash income of two or three hundred dollars a year or less makes the purchase of existing irrigation technology like five hundred dollar 5 horsepower diesel pumps totally out of the question. In Nepal, a 5-hp engine requires a command area of 5 acres. Commercial drip irrigation technology in India is not available for plots under 1 acre.

Micro-Farmers and Global Food Security

In 1994, 800 million people out of the global population of 5.5 billion went hungry[5]. Continued growth of the population will escalate the existing food security problems. Small farmers are disproportionately concentrated in food deficit rural areas where a single crop failure can turn these farmers into landless laborers or send them into urban ghettos.

By gaining access to irrigation, micro-farmers could double their harvest. The increased harvest would redress many food distribution imbalances. The increase in labor requirements for growing, harvesting and processing the crop would create jobs for rural landless laborers and increase the income available to buy food. The key to increasing the agricultural productivity of small farmers is opening their access to affordable and efficient agricultural technology, an unkept promise of the Green Revolution.

Bypassed by the Green Revolution

Global irrigated acreage has increased from 40 million hectares in 1900 to 255 million hectares to day[6]. Irrigated farmland now produces 40% of the world's food supply on 17% of its arable land. Between 1950 and 1990 world grain production tripled from 631 million tons to 1780 million tons, as a result of increased use of high yielding seeds, fertilizer and a rapid expansion in irrigation[7]. But rural poverty and hunger have not disappeared in spite of the optimistic early predictions of Green Revolution advocates. For example, 66% of the children under five in Bangladesh and 64% in India are underweight[8], in spite of the fact that both of these countries are net grain exporters. The increase in agricultural productivity stimulated by high-yield seeds and fertilizer has bypassed small farmers in developing countries[9]. While seeds and fertilizer are available in affordable units to micro-farmers, existing modern irrigation devices do not fit small plots, and are far too expensive to be affordable to the micro-farmer majority. Without irrigation micro-farmers can not reap the full benefits of the Green Revolution.

By-Passed By High Prices and Non-Divisibility

While some small farmers have access to canal irrigation, the average farm size served by large canal schemes is well over five acres. Private and public tubewells are increasingly popular, but the high cost and limited divisibility of mechanized pumps limit access by small farmers. The cheapest 5 hp diesel pump costs $500 (US) and can not pay for itself if used on less than five acres,

well above the means of farmers who earn $300 or so a year. Drip irrigation has not been adapted to fit the microplots of small farmers. No drip systems have been available in India, for example, for applications under one hectare

Affordability- The Sina Qua Non for Micro-Farmer Irrigation Devices

The whole direction of the irrigation design process optimizes efficiency instead of affordability. To fit the needs of small farmers, this western design paradigm needs to be reversed: technology design for small farmers must put first priority on affordability. Identifying the highest cost components of existing irrigation technologies and designing around them is the first step to reducing the cost for micro-farmers. This requires finding tradeoffs acceptable to micro-farmers as consumers.

Conventional irrigation devices need to be scaled-down to conform to the size and agricultural requirements of micro-plots and the cash constraints faced by micro-farmers. Ideal micro-irrigation technologies should be designed so they can be added to incrementally, like a LEGO set. In this way, a small farmer can make a tiny initial investment and use the income generated to expand the technology for the next season.

A Generation of New Affordable Micro-irrigation Devices

Three affordable micro-irrigation devices have been designed and mass marketed to micro-farmers in several countries by IDE, a Denver based non-profit development organization[10]. Our experience shows that the design and adaptation process requires 10% of time and effort. The other 90 % is spent on the mass dissemination strategy to put the technology in the hands of micro-farmers. This requires a long-range effort focussed on rural mass marketing, through the establishment of private sector networks, consisting of enterprises that manufacture, distribute, and install the technology. Rural mass marketing focuses on creating demand and ensuring availability at the village level.

A Farmer Based Technology Adaptation Process

The IDE method for technology adaptation (for affordability and divisibility) puts prototypes in the hands of small farmers, and the technology is then redesigned using farmers' feedback. The same adaptation process is followed when micro-irrigation devices that work in one country are transferred to a new country, or into different agro-climactic conditions. Detailed small farmer feedback is also used as a basis for the design of a rural mass marketing strategy.

IDE learned much of its methodology in the mass marketing of the foot operated treadle pump (see box).

Cutting the Cost of Drip Irrigation by Two Thirds

In semi-arid areas where water is precious, large farmers use drip irrigation to minimize evaporation losses by delivering water directly to the roots of plants. At a cost of a $1,000 an acre for crops like vegetables, conventional drip systems are not affordable for small farmers. A standard drip system uses a tank, a filter, and plastic drip lines to deliver water to each drip point in the field. Hundreds of emitters at each drip point control drip rate and prevent clogging. Plastic drip lines, filters and emitters are key contributors to cost.

To make drip irrigation affordable for micro-farmers, my colleagues and I, working with farmers in their fields, designed a variety of low cost drip systems that cut the cost of conventional systems by two thirds[11][12][13]. The cost of materials was reduced by making a lateral line movable so that it could be used on 4-10 rows of plants rather than one. The cost was further reduced by replacing emitters with microtubes or baffled holes, which are cheaper, plug less frequently, and are easier to unplug. They also make it possible to use simpler lower cost filters. Four low cost drip systems are now available.

1. **Bucket Kits** consist of a simple household bucket attached to a pole at shoulder height, which supplies a drip line with 26 microtubes, each of which waters four plants. A starter bucket kit costs $5 in India, including the bucket, and irrigates a 25 sq. meter kitchen garden to feed a family of 6, using 2-4 buckets of water a day. If the family sells some of the crop, they can use the profit to expand their system.

2. **The Drum Kit** uses a 200-liter drum instead of a bucket, and uses five lateral lines to irrigate a 125 square meter plot for a cost of $25. It can be expanded in 125 square meter increments at a cost of $14 for each expansion unit.

3. **Shiftable Drip Systems.** The shiftable drip system reduces capital cost by using increased labor. This is done by making lateral lines shiftable, so that each line is capable of irrigating ten rows of plants instead of one[14]. Water drips out of baffled holes or curled microtubes instead of more expensive emitters.

4. **Larger Low Cost Drip Systems** for 1000 to 10,000 square meters cost $625 a hectare for crops like cotton. One lateral line can irrigate four rows by using microtubes. This does not include the cost of a pressure pump.[15]

Side by side comparisons of low cost drip and surface irrigation with cotton, sugarcane, and mulberry in India found that low cost drip irrigation cut water use in half and increased crop yield by an average of 25%, paralleling earlier studies comparing conventional drip and flood irrigation in India[16]. Several thousand IDE

low cost drip systems have been purchased by micro-farmers in Nepal, India, Sri Lanka and Vietnam.

5. Low Cost Sprinkler Systems for Micro-farmers

Sprinkler irrigation, though not as efficient in water use as drip, is significantly more efficient than conventional flood irrigation and works well with non-rowed crops. But like commercial drip irrigation, conventional sprinkler systems are too expensive for micro-farmers and do not fit small plots. IDE has now made low cost sprinkler systems for micro-farmers in India and Nepal. This process has been much simpler than the process for designing low cost drip systems, because all the key components for low cost sprinkler systems are already available in the marketplace.

The first type of low cost sprinkler system consists of stationary micro-sprinklers, particularly useful for small plots of vegetables or other horticultural crops. The second system consists of a low cost overhead sprinkler attached to a flexible pipe and placed on a low cost tripod. By shifting this sprinkler six times, a small farmer can irrigate a half an acre of wheat at a total equipment cost of $26 (US), exclusive of the pressure source. This low-pressure system runs on 10-15 meters of head, which can be produced by gravity or a ½ hp electric pump.

Grass Roots Rural Mass Marketing

Even an affordable and divisible micro-irrigation technology is not going to solve the problem unless it is available to the majority of micro-farmers in rural areas. This requires promotion and a source for the technology, installation, service and spare parts.

The installation of 1.3 million Treadle Pumps in Bangladesh depended on a 10-year grass roots promotional campaign. Promotional campaigns based on the success of the Treadle Pump model are being introduced now to popularize low cost drip and sprinkler systems in India and Nepal.

A Sustainable Private Sector Supply Chain

To make each micro-irrigation technology accessible to small farmers on a sustained basis, the establishment of a private sector network of manufacturers, dealers, and technicians is critical[17]. Sustainability is based on profitability for each component of the supply chain. Profitability is based on demand creation for the large market of micro-farmers. Demand creation is achieved not only through targeted promotional activities, but by placing visible demonstrations in selected farmers' field (usually those noted for innovation).

IDE has found that at least four manufacturers are required to establish a competitive marketplace, and assurance of quality standards is a critical component for establishing long-term market demand for the product. In

Bangladesh, for example, the supply chain is made up of over 70 manufacturers, a thousand dealers and over 2500 installers that also provide maintenance and other support services.

Summary and Conclusions

Three quarters of the farmers in the world cultivate less than five acres. To the development establishment, these micro-farmers are truly a silent majority, yet they constitute a potent force in the world to directly address the growing problem of food insecurity. If the world's micro-farmers could triple their harvest in the same way that larger farmers have in the past 4 decades, the supply of food would increase in food deficient rural areas, and the resultant increase in jobs would directly address rural poverty.

The key constraint to increased micro-farmer productivity is the lack of access to affordable and efficient small-scale irrigation devices. This requires a design process that overturns western design values and focuses first and foremost on affordability and divisibility. To put this technology into the hands of millions of micro-farmers a long-term process of private sector-oriented rural mass marketing needs to be established. Treadle pumps, low cost drip systems, and low cost sprinkler systems provide three examples of how this can be accomplished.

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The Treadle Pump Story

Millions of farmers in Bangladesh grow only two crops a year on their small plots, in spite of the fact that a copious supply of regularly replenished groundwater is available 15 feet below the surface. To get at this water, Gunnar Barnes, a Norwegian development worker, designed a pump that a micro- farmer could buy by selling a sack of rice. A simple looking device, it is powered by walking on two bamboo treadles. This activates two steel cylinders that are made in a village workshop. The Treadle Pump costs a total of $35 installed on a tube well, less than one tenth of the cost of a diesel pump. By irrigating half an acre of dry season vegetables, a small farmer increases net income by a hundred dollars a year, diversifies crops, gains access to clean drinking water, and shortens their three month period of hunger.

IDE implemented a national rural mass marketing program for Treadle Pumps in Bangladesh, making the technology known through billboards, calendars, and demonstrations at village and regional markets. A 90 minute entertainment movie featuring top Bangladeshi movie stars embeds the treadle pump into the plot, and the movie shown in open air settings reaches an audience of a million people a year.

The ten-year experience of the Treadle Pump in Bangladesh shows that by implementing a national rural mass marketing program, 1.3 million Treadle Pumps have been installed through the local private sector. IDE has implemented similar projects in India, Nepal, Cambodia and Zambia, resulting in combined sales of 150,000 treadle pumps per year.

Each of these pumps provides an average increase in net cash income of $100 a year for small farmers, at an investment cost of $35. The 1.3 million treadle pumps therefore generate a net cash income of $130 million dollars per year for these small farmers Using a conservative 2.5 multiplier effect for the gross annual income of $260 million dollars per year, the effect on the local economy can be estimated at 650 million a year, including the impact on thousands of self-supporting enterprises that manufacture and distribute Treadle Pumps. Total costs for IDE's services over ten years was $8 million (US), and total investment by small farmers themselves over ten years was just under $46 million. The impact on the local economy over that same 10-year time span is estimated at over $6 billion.