OPENING SMALLHOLDER ACCESS TO LOW COST SMALL PLOT IRRIGATION

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THE SMALL FARMER AND WORLD HUNGER

The 75% of the farmers in developing countries who cultivate less than five acres and have been bypassed by the Green Revolution hold the key to world hunger. They and their families survive on two or three hundred dollars a year, and go hungry for part of the year. A single disastrous crop failure can turn them into landless laborers and send them into urban ghettos.

If the world's subsistence farmers could triple their harvest like their large farm neighbors, they would eliminate their own hunger and produce an income generating marketable surplus. The increased grain harvest in food deficient rural areas would redress the food distribution imbalance that contributes to rural hunger. The increase in labor requirements for growing, harvesting and processing the crop would create jobs, which would increase the income available to buy food and slow urban migration.

A PORTRAIT OF SMALLHOLDERS IN DEVELOPING COUNTRIES

In Bangladesh, 92% of the farms are less than 5 acres, and 60% are under 2 acres.[1] . In Bihar, India, 75.% of landholdings are less than two and a half acres)[2], and in Egypt, 95% of landholdings were less than five acres in 1984[3]. In China, when land redistribution took place in 1952, 300 million landless peasants each received an average of 0.4 acres of land.[4] Since each farm is usually divided into four or five separate plots, the small farmer global majority is farming on microplots so tiny that modern western agricultural devices have no relevance. To make things worse, 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.

THE IMPACT OF THE GREEN REVOLUTION ON SMALL FARMERS

A vigorous debate continues about the differing impact of Green Revolution seeds, fertilizer, and pesticides on large and small farmers. Critics assert that the Green Revolution makes rich farmers richer, and poor farmers poorer. Proponents point out that, since the biological technologies of the Green Revolution can be purchased in very small quantities, they are divisible, and equally available to small and large farmers. Both critics and proponents agree that increasing rural jobs and small farmer harvests would improve global food security. The heat of the debate about the equity of the Green Revolution obscures the most important issue. Key barriers currently block the access of small farmers to the tripled harvest available through the

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[1] Prosterman, L , Temple, M.N., and Hanstad, T.M. Agrarian Reform and Grassroots Development. Lynne Rienner Pbulishers, Boulder and London, 1990.

[2] Yougandhar, B N and Gopal Iyer, eds. Land Reforms in India- Bihar Constitutional Constraints. Vol.1, Sage Publications, New Delhi, 1993.

[3] Blaikie, MP, Cameron, J, and Seddon, JD. The Shruggle for Basic Needs in Nepal. Development Center of the Organization for Economic Co-operation and Development, Paris,1979, P230.

[4] Riad el-Chonemy, M. The Political Economy of Rural Poverty. The Case for Land Reform. Routledge, London and NY, 1990, p194.

Green Revolution. Most importantly, these barriers are totally reversible, beginning with the most important one: access to affordable irrigation water.

THE SMALL FARM IRRIGATION BARRIER

The most important barrier to the Green Revolution for small farmers is that they have limited or no access to affordable and efficient irrigation. Most of the increase in the global grain harvest in the past thirty years is the result of combining green revolution inputs with irrigation. But modern irrigation technology has been designed to fit the needs of the 25% minority of the world's farmers who cultivate more than five acres.

The average farm size served by large canal schemes is well over five acres. The last decade has witnessed phenomenal growth in the installation of public and private tubewells, but the cheapest diesel pumpset on a tubewell costs $500 (US) and does not pay for itself on small plots. For the majority of the world's farmers who cultivate less than five acres and earn under $300 a year, a purchase price of $500 is not affordable.

Huge untapped resources in surface and ground water could be made available to small farmers. But no water- lifting devices exist in the technology spectrum between counterbalanced buckets, which are too inefficient, and diesel pumps, which are too expensive.

India's experience illustrates this small plot irrigation deficit. It has become self-sufficient in grain production, but large poor and hungry populations remain. Rice is the most important subsistence crop, but yields remain under two tons per hectare, less than half of the yields in China and Japan. The fact that forty-five percent of India's rice crop is irrigated, compared with virtually all of China's and Japan's, accounts for most of this difference.

One sees vast brown plains in the winter dry season in Uttar Pradesh, where population density is high, plot sizes are small and water tables are less than 4 meters from the surface! Under similar conditions, larger farmers in India have profitably purchased and installed 13 million electric and diesel pumpsets. With appropriate irrigation equipment, India's small farmers could plant high yielding varieties of rice. They could eliminate the risk of crop losses from unseasonable droughts in the rainy season. They could mitigate the risk of destructive monsoon floods by planting irrigated modern varieties of rice in the dry season.

Breaking Irrigation Technology into Microplot Sized Pieces

Seeds can be divided into tiny packets that both fit the needs of tiny plots, are affordable to poor farmers. The same is true for the most part, for fertilizer. But it is decidedly not true for existing irrigation equipment. No existing drip irrigation system is available in India for plots under one acre. Yet inexpensive backyard drip kits are available in every hardware store in North America that can provide drip irrigation for a small kitchen garden. The smallest diesel pumpset in Nepal starts with a five acre command area.

Conventional irrigation devices need to be miniaturized to conform to the size and agricultural requirements of micro-plots. But because of the extreme limitations small farmers have in access to cash, ideal micro-irrigation technologies are 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 the investment generates to expand the technology for the next harvest.

A Farmer Based Technology Adaptation Process

Early prototypes in the design of affordable micro-irrigation technology are put in the hands of small farmers, and redesigned using their critical 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.

The development of a variety of affordable irrigation devices between buckets and diesel pumps, customized for plot sizes between 0.1 and 5 acres, would profoundly improve the productivity of small farms. Two recent innovations in affordable small scale irrigation technology demonstrate how the small farmer irrigation obstacle to an increased harvest can be removed.

The Treadle Pump Story

Millions of farmers in Bangladesh grow only two crops a year, 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 eight dollars, and a total of $35 installed on a tubewell, 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 the three month period of hunger.

Working at first in Bangladesh, IDE implemented a national rural mass marketing program for Treadle Pumps. Billboards, callenders, and demonstrations at village and regional markets made the technology known. A 90 minute entertainment movie featuring top Bangladeshi movie stars embeds the treadle pump story in a popular plot, and the movie is shown in open air settings to an audience of a million people a year.

To meet the demand generated by grass roots marketing strategies like the movie, IDE has facilitated the establishment of a local supply chain of 70 manufacturers and several thousand village dealers and technicians trained by IDE. Each of these micro-enterprises operates for a profit, and Treadle pumps are installed without subsidy. This rural mass marketing strategy then was applied, after adaptation, to initiate similar programs in India, Nepal, Cambodia, and Zambia. At present, approximately 150,000 Treadle Pumps are being installed each year in these countries.

One of the common objections raised by development policymakers to micr-irrigation technologies is that even if they improve the lives of poor farmers, their national impact is only a drop in the bucket because they are likely to be adopted by only a few people, and each pump only irrigates a small plot. The ten year experience of the Treadle Pump in Bangladesh sheds interesting light on this issue. By implementing a national rural mass marketing program, 1.3 million Treadle Pumps have been installed through the local private sector.

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. This amounts to an increase in net cash annual income of $135 million dollars a year for small farmers, and an increase in gross income of approximately $270 million a year. Using a 2.5 multiplier, the effect on the local and national economy can be estimated at $675 million a year. This does not include the economic impact of 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.

Low Cost Drip Irrigation for Smallholders

Six years ago, IDE set out to apply what it had learned from the Treadle Pump experience to other irrigation problems critical to the increased productivity of the world's micro-farmers. 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 and emitters are key contributors to cost.

To make drip irrigation affordable for small farmers, my colleagues and I designed a variety of low cost drip systems that cut the cost of conventional drip systems by two thirds[5] The investment in plastic pipes was reduced by making it possible for each plastic pipe (lateral) to serve 4-10 rows of plants instead of one. The cost was further reduced by replacing emitters with microtubes or baffled holes, which also are easier to unplug. This in turn made it possible to use simpler lower cost filters, and to lower system pressure. Four low cost drip systems are now available.

1. **Bucket Kits**
   This consists 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

   (INSERT FIGURE 1 HERE)

2. **The Drum Kit** uses a 200 liter drum instead of a bucket, and uses five lateral lines to irrigate a 125 sq meter plot for a cost of $26. It can be expanded to irrigate 250 sq meters for an additional $16.

(INSERT FIGURE 2 HERE)

3. **Shiftable Drip Systems.** The shiftable drip system substitutes low cost labor for capital by making lateral lines shiftable, so that each line is capable of irrigating ten rows of plants instead of one[6]. Water drips out of baffled holes or curled microtubes instead of more expensive emitters.

[5]Polak, Paul, Nanes, Bob, and Adhikari, Deepak. A Low Cost Drip System for Small Farmers in Developing Countries. Journal of the American Water Resources Association, Vol 33, #1, Feb/97.

[6] Polak, Paul, Nanes, Bob, and Adhikari, Deepak. A Low Cost Drip System for Small Farmers in Developing Countries. Journal of the American Water Resources Association, Vol 33, #1, Feb/97.

(INSERT FIGURE 3 HERE)

4. **Larger Low Cost Drip Systems** Larger systems from ¼ hectare to 4 hectares cost of $625 a hectare for crops like cotton, using microtubes to reduce the requirement for plastic delivery lines from one for every row to one for every four rows. This does not include the cost of a pressure pump.[7]

Side by side comparisons of low cost drip and furrow irrigation with cotton, sugarcane, and mulberry in India found that low cost drip irrigation cut water use in half and increased crop yield, paralleling numerous earlier studies comparing conventional drip and flood irrigation in India. Several thousand low cost drip systems have now been purchased by micro-farmers in Nepal and India, and their introduction has been initiated in Sri Lanka and Vietnam.

A GLOBAL INITIATIVE TO PUT ONE MILLION HECTARES A YEAR UNDER LOW COST DRIP IRRIGATION FOR SMALLHOLDERS

GRASS ROOTS RURAL MASS MARKETING

The design on new affordable micro-irrigation technology completes only the first ten percent of the process of stimulating increased micro-farm productivity through improved irrigation. The other 90 percent of the process is putting the technology into the hands of millions of small farmers. This requires a long term process of rural mass marketing, and the establishment of a sustainable private sector supply chain.

The installation of 1.3 million Treadle Pumps in Bangladesh depended on a 10 year grass roots promotional campaign. Open air village entertainments that popularized the technology were instituted for villages without electricity. An award winning ninety minute entertainment movie in the Bangladeshi tradition was produced by a popular local director using leading local actors and actresses. In the story line, a Treadle Pump provided the dowry that made the marriage possible. The movie was shown in open air settings using a generator powered projector and a large screen, and has been seen by a rural audience of a million people a year. Village dealers were organized to play a key role in publicizing each showing and used the interest stimulated by the film to generate sales. Three hundred demonstration sites were established by recruiting exemplary farmers growing high return cash crops irrigated by Treadle Pumps. Local dealers were encouraged to take advantage of farmer interest in demonstration plots to generate sales.

This type of grass roots marketing campaign is customized to fit each area where micro-irrigation technology is introduced. 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 sustainably accessible to small farmers, the establishment of a private sector network of manufacturers, deaters, and technicians is critical. A pump-priming investment in marketing can be an important motivator for manufacturers to make an investment in producing the technology. At least four manufacturers are required to establish a

[7] Progress Report on IDE Low Cost Drip Irrigation System. International Development Enterprises, Lakewood Colo., 1995.

competitive marketplace, and assurance of quality standards is a critical component for establishing long term market demand for the product.

A key to the recruitment of manufacturers, dealers, and technicians is the demonstration of sufficient volume demand for the product in the marketplace to ensure profitability. To increase market demand for Treadle pumps in Bangladesh, Bangladeshi project staff were recruited and trained to assist local dealers and well drillers to sell and install clusters of 20-30 pumps in key villages. This is the critical mass required for word of mouth to produce exponential sales. A variety of proactive strategies was used to recruit local and international development organizations to promote the technology and offer credit for its purchase to small farmers. A three day training course with a certificate increased the drilling and well completion skills of three thousand well drillers, and motivated them to promote the technology. A similar process was used for village based dealers. After product demand reaches a sufficient level, new manufacturers, dealers, and technicians enter the market on their own.

DESIGNING CHEAP

To gain access to the Green Revolution, the world's small farmers need a whole new generation of affordable, divisible mechanical devices like the Treadle Pump in the technology continuum between sickles and combines, bullocks and tractors, and headbaskets and trucks. International agricultural institutes in the current CGIAR network focus their efforts on biological technologies of seeds, fertilizer, and pesticides. It is remarkable that there is no existing agricultural research organization that provides a disciplined, marketplace oriented focus on the design and diffusion of affordable, divisible mechanical technology to open access to the Green Revolution for small farmers. A major new initiative is needed to address this deficit.

Affluent societies prefer breakthroughs that improve the efficiency of a technology to innovations that lower its price. Poor farmers in developing countries, on the other hand, admire efficient tools, but lack the money to buy them. They are extremely risk averse, and unlikely to buy any device that does not pay for itself in less than a year. They are long on labor, short on capital, and reluctant to invest more than fifty dollars in any tool. Small farmers and landless laborers make a fine art out of identifying acceptable compromises in quality and efficiency that contribute to lowering cost.

Designing affordable tools for small farms starts by identifying key contributors to the cost of existing technology, and finding lower cost alternatives. For example, the high cost of tubing in traditional drip systems was reduced by making drip lines portable. Reversing the historical design process may be a useful way to identify a more affordable earlier versions of tools that are better suited for small plots. For example, wheat harvesting progressed from the sickle to the scythe to the cradle. The cradle is a scythe that bunched the wheat and could harvest two acres a day. An updated version of the cradle is likely to be much more cost-effective for 1-2 acre plots of wheat than the modern combine.

Systematic field testing that incorporates small farmer feedback into design changes is critical in the development of a successful affordable product. The persistent and unyielding pursuit of affordability by identifying compromises in efficiency and quality acceptable to small farmers is a prerequisite for the design of affordable tools for small plots.

GRASS ROOTS DISSEMINATION

The institutions and strategies chosen for technology dissemination powerfully shape who gets the message, and who acts on it. The CGIAR network of Green Revolution agricultural research organizations have been extremely effective in communicating advances in biological technology to policy makers and decision makers in collaborating developing countries and the international donor community. But government institutions focus dissemination efforts on regions with superior soils and advanced infrastructure, which often leaves small farmers out. New grass roots dissemination strategies need to be implemented to steepen the slope of the diffusion curve for newly developed agricultural technology.

Recent advances in rural mass marketing provide effective strategies to reach small subsistence farmers. Grass roots marketing initiatives have successfully used village dramas, television soap operas, and private sector dealer networks to popularize devices ranging from oral rehydration salts to family planning devices. Existing rural private sector networks of producers, dealers and service providers have direct links with small farmers and provide a rich, relatively untapped resource for the mass dissemination of affordable biological and mechanical technologies.

For example, existing private sector networks of small manufacturers and village dealers and technicians were activated to market and install a million Treadle Pumps for small farmers in Bangladesh. An initial collaborative relationship was established with four small manufacturers to ensure that the quality of initially installed Treadle Pumps was sufficiently high to attract new buyers. A variety of techniques were used to interest 50 existing private sector manufacturers and several thousand village dealers and well drillers in the profit-making opportunities presented by the technology.

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Open air village dramas featuring the Treadle Pump were staged by a mobile theater group in villages without electricity. An award winning 90 minute movie with a traditional Bangladeshi plot was produced by a popular local director using leading local actors and actresses. In the story line, a Treadle Pump provided the dowry that made a marriage possible. The movie was shown in open-air settings using a generator powered projector and a large screen, and has been seen by a rural audience of a million people a year. Village dealers were organized to play a key role in publicizing each showing and used the interest stimulated by the film to generate sales.

Three hundred demonstration sites were established by recruiting exemplary farmers growing high return cash crops irrigated by Treadle Pumps. Local dealers were encouraged to take advantage of farmer interest in demonstration plots to generate sales. In response to growing marketplace demand, new manufacturers, dealers and well drillers became involved on their own initiative. After 10 years, annual sales of Treadle Pumps have risen to 170,000, and the number of

pumps installed to over a million. Similar grass roots marketing initiatives were successfully initiated in India, Cambodia, Nepal and Vietnam.

ELIMINATING THE SUBSIDY BARRIER

Once the design establishment produces farm machinery that is too expensive to be affordable for small farmers, governments in developing countries and development donors step in to address the affordability problem by providing subsidies. But most subsidies paradoxically inhibit the small farmer adoption of the technologies they are designed to promote.

When a subsidy is announced, small farmers delay their purchase until the subsidy becomes available. Producer inventories are flooded, and when and if subsidy funding becomes available, it reaches only a fraction of the demand which has been artificially inflated by the subsidy itself. Also, wealthier farmers are better able to pay bribes to gain access to subsidies than their small farm neighbors.

Shallow mechanized tubewells were subsidized in Bangladesh, for example, to make them available to poor farmers organized in co-operatives. Larger, wealthier farmers quickly took advantage of the subsidy by forming nominal co-operatives that installed subsidized wells. They then sold excess water at high prices to the small farmers for whom the subsidy was intended. Lowering the cost of technology to make it both affordable and profitable at a fair market price makes subsidies unnecessary.

A GLOBAL INITIATIVE FOR WATER SAVING IRRIGATION

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. My colleagues and I haveproposed a major new international initiative to spread low-cost drip irrigation through private microenterprise.[8] The goal of this global initiative is to put one million hectares a year under low cost drip irrigation for smallholders. Over the next fifteen years, this would put 30 million hectares of land cultivated by small farmers under low cost drip irrigation, 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.

[8] Postel, Sandra, Polak, Paul, Gonzalez, Fernando, and Keller, Jack. ---------- Water International, in process.