THE BIG POTENTIAL OF SMALL FARMS

BY PAUL POLAK

With the help of affordable irrigation and access to markets, farmers in the developing world can grow more food and climb out of poverty

Peter Mwete, an angular Zimbabwean man in his 20s, was weeding his tiny vegetable plot in the settlement of Marimari when I met him in 2002. The 100-square-meter plot—about the size of a typical suburban backyard—was enclosed by a two-meter-high fence of stout poles cut from the bush and wired together to keep wild and domestic animals out. Peter lived with his father and a 19-year-old brother; his mother had died from AIDS, and his brother was also dying. To feed his family and earn a living with fewer hands to do the work, Peter had installed a low-cost, gravity-fed drip-irrigation kit provided by International Development Enterprises (IDE), the organization I started in 1981.

Peter's plot consisted of eight raised beds neatly planted with rape leaves, cabbage and corn. In the middle of each bed, a movable drip line delivered water from a 40-liter plastic tank placed atop a wooden stand. Because the drip system brought water directly to the roots, it was far more efficient than watering the plants by bucket. As a result, the small plot produced enough corn and vegetables to meet most of the family's needs, and Peter expected to earn at least $90—a substantial income for a farmer in Zimbabwe—from selling the surplus. He told me that in the following year he planned to double the size of his plot and triple his income by replacing some of the leafy vegetables with more valuable crops, such as tomatoes and Irish potatoes. He also planned to raise his plot's productivity by fertilizing it. Because he could not afford chemical fertilizers, he intended to dunk a burlap bag filled with cow manure into a water drum and apply this "manure tea" to the roots of his vegetables through the drip system.

Over the past three decades, I have spoken with thousands of small farmers in the developing world, and their stories are strikingly similar to Peter's. They can increase their earnings by as much as $500 a year by intensively farming 1,000-square-meter (quarter-acre) plots of fruits and vegetables, but they need better cultivation methods, affordable irrigation and access to markets for their crops. Their struggle is part of a global challenge: by 2050 the world's farmers must feed nine billion people—three billion more than the current population—without much expansion in the amount of land and water devoted to agriculture. Water, in particular, has emerged as the key to boosting farm production and easing poverty, because nearly 1,000 liters of water are needed to grow one kilogram of grain. We must store more water for irrigation and manage the supply we have more effectively.

Until now, governments and develop-

CHEAP IRRIGATION is the key to alleviating rural poverty and hunger in the developing world. In India's Maharashtra state, farmers employ an inexpensive, gravity-fed drip-irrigation system to deliver water to their sunflowers and vegetables.

ment agencies have tried to tackle the problem through large-scale projects: gigantic dams, sprawling irrigation canals and vast new fields of high-yield crops introduced during the Green Revolution, the famous campaign to increase grain harvests in developing nations. Traditional irrigation, however, has degraded the soil in many areas, and the reservoirs behind dams can quickly fill up with silt, reducing their storage capacity and depriving downstream farmers of fertile sediments. Furthermore, although the Green Revolution has greatly expanded worldwide farm production since 1950, poverty stubbornly persists in Africa, Asia and Latin America. Continued improvements in the productivity of large farms may play the main role in boosting food supply, but local efforts to provide cheap, individual irrigation systems to small farms may offer a better way to lift people out of poverty.

The Amazing Treadle Pump

OF ALL HUMAN ACTIVITIES, agriculture leaves the biggest footprint on Earth. About 70 percent of the water diverted for human use now goes to farming; another 19 percent goes to industry, 9 percent to homes and the rest to evaporation from reservoirs. One of the accomplishments of the Green Revolution was to enlarge the world's irrigated land, which grew from 100 million hectares in 1950 to 276 million today. (A hectare is equal to 10,000 square meters, or about 2.5 acres.) The resulting jump in harvests lowered the price of food, which contributed to reducing poverty among subsistence farmers and city dwellers. This effect, however, was offset by population growth. Between 1990 and 2001 the number of people worldwide living in extreme poverty—surviving on $1 a day or less—declined from 1.22 billion to 1.09 billion, but the number earning less than $2 a day rose from 2.65 billion to 2.74 billion. The trend was most dire in sub-Saharan Africa, where the population in extreme poverty leaped from 227 million to 313 million.

The Green Revolution was designed to increase the overall food supply, not to raise the incomes of the rural poor, so it should be no surprise that it did not eradicate poverty or hunger. India, for example, has been self-sufficient in food for 15 years, and its granaries are full, but more than 200 million Indians—one fifth of the country's population—are malnourished because they cannot afford the food they need and because the country's safety nets are deficient. In 2000 189 nations committed to the Millennium Development Goals, which called for cutting world poverty in half by 2015. With business as usual, however, we have little hope of achieving most of the Millennium goals, no matter how much money rich countries contribute to poor ones.

American agricultural researcher Norman Borlaug—who received the Nobel Peace Prize in 1970 for his contributions to the Green Revolution—was recently asked what wealthy countries should do to reduce hunger in the world. He said that they should send food during emergencies but that the long-range solution is revolutionizing agricultural production, especially among subsistence farmers in developing countries. This plan would not only increase food supply but also create jobs and generate new income from selling excess grain.

The supply-driven strategies of the Green Revolution, however, may not help subsistence farmers, who must play to their strengths to compete in the global marketplace. The average size of a family farm is less than four acres in India, 1.8 acres in Bangladesh and about half an acre in China. Combines and other modern farming tools are too expensive to be used on such small areas. An Indian farmer selling surplus wheat grown on his one-acre plot could not possibly compete with the highly efficient and subsidized Canadian wheat farms that typically stretch over thousands of acres. Instead subsistence farmers should exploit the fact that their labor costs are the lowest in the world, giving them a comparative advantage in growing and selling high-value, intensely farmed crops.

I saw firsthand the need for a small-scale strategy in 1981 when I met Abdul Rahman, a farmer in the Noakhali district of Bangladesh. From his three quarter-acre plots of rain-fed

CROSSROADS FOR
AGRICULTURE AND WATER

THE PROBLEM:

- Although the Green Revolution significantly increased worldwide grain harvests, hunger and poverty stubbornly persist in Africa, Asia and Latin America. Farmers working small plots of marginal land cannot grow enough food to support their families.
- In sub-Saharan Africa alone, more than 300 million people survive on $1 a day or less. In India, more than 200 million people are malnourished.

THE PLAN:

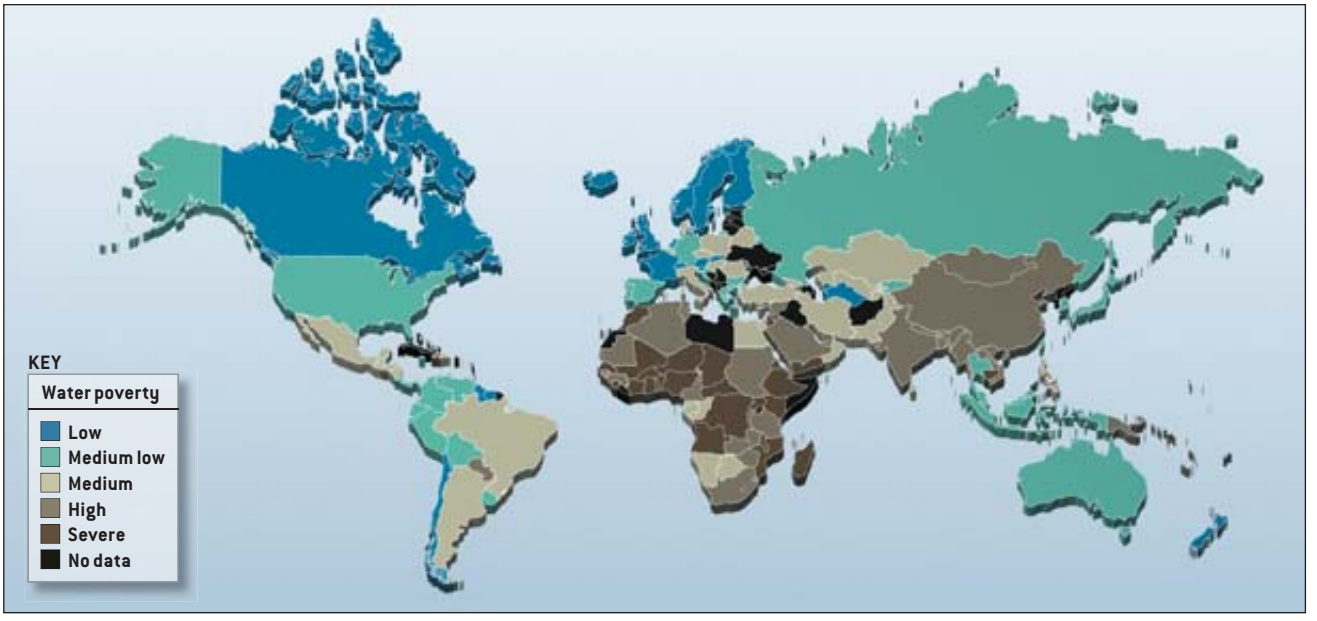
- Continued improvements in the productivity of large farms will expand the overall food supply, but efforts to reduce poverty should focus on increasing the incomes of small farmers.
- Individual irrigation systems employing inexpensive equipment, such as drip lines and storage tanks, can greatly enhance the yields of small plots. If farmers raise high-value crops such as tomatoes or chili peppers, they can boost their earnings by as much as $500 a year.

Growing marketable crops

PRECEDING PAGE: KENN BROWN (*photoillustration*) AND INTERNATIONAL DEVELOPMENT ENTERPRISES (*photograph*); THIS PAGE: IDE

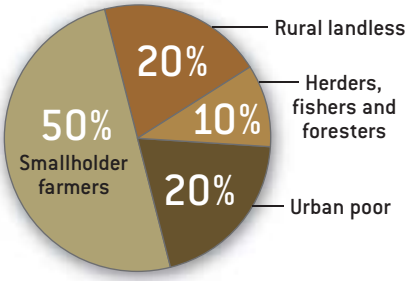
WATER AND POVERTY

Because water is so vital to agriculture, the lack of it has become one of the most important causes of poverty in the developing world. Researchers at the Center for Ecology and Hydrology in Wallingford, U.K., have developed an index that shows the effects of water scarcity by combining data on availability and access with information on water use and quality. Most of the countries with the greatest water poverty are in sub-Saharan Africa, but the problem is also dire in China, India and Bangladesh.



WATER SCARCITY takes its highest toll on small farmers, many of whom must eke out a living in semiarid areas far from wells or reservoirs. About half the world's hungry people are farmers who work small plots of land; another 20 percent are landless farm laborers who live in rural regions.

WHO ARE THE HUNGRY?




Farming a small plot

BRYAN CHRISTIE DESIGN; SOURCE: C. A. SULLIVAN AND J. R. MEIGH *Center for Ecology and Hydrology (map)*; JEN CHRISTIANSEN *(pie chart)*; IDE *(photograph)*

rice fields, Abdul could grow only 700 kilograms of rice each year—300 kilograms less than what he needed to feed his family. During the three months before the October rice harvest came in, Abdul and his wife had to watch silently while their three children survived on one meal a day or less. As I walked with him through the scattered fields he had inherited from his father, I asked what he needed to move out of poverty. "Control of water for my crops," he said, "at a price I can afford."

Soon I learned about a simple device that could help Abdul achieve his goal: the treadle pump. Developed in the late 1970s by Norwegian engineer Gunnar Barnes, the pump is operated by a person walking in place on a pair of treadles made of bamboo or another locally available material. The human-powered pump can irrigate half an acre of vegetables and costs only $25 (including the expense of drilling a tube well down to the groundwater). Abdul heard about the treadle pump from a cousin and was one of the first farmers in Bangladesh to buy one. He borrowed the $25 from an uncle and easily repaid the loan four months later. During the five-month dry season, when Bangladeshis typically farm very little, Abdul used the treadle pump to grow a quarter-acre of chili peppers, tomatoes, cabbage and eggplants. He also improved the yield of one of his rice plots by irrigating it. His family ate some of the vegetables and sold the rest at the village market, earning a net profit of $100. With his new income, Abdul was able to buy rice for his family to eat, keep his two sons in school until they were 16 and set aside a little money for his daughter's dowry. When I visited him again in 1984, he had doubled the size of his vegetable plot and replaced the thatched roof on his house with corrugated tin. His family was raising a calf and some chickens. He told me that the treadle pump was a gift from God.

Bangladesh is particularly well suited for the treadle pump

because a huge reservoir of groundwater lies just a few meters below the farmers' feet. In the early 1980s IDE initiated a campaign to market the pump, encouraging 75 small private-sector companies to manufacture the devices and several thousand village dealers and tube-well drillers to sell and install them. Over the next 12 years one and a half million farm families purchased treadle pumps, which increased the farmers' net income by a total of $150 million a year. The cost of IDE's market-creation activities was only $12 million, leveraged by the investment of $37.5 million from the farmers themselves. In contrast, the expense of building a conventional dam and canal system to irrigate an equivalent area of farmland would be in the range of $2,000 per acre, or $1.5 billion.

In terms of reducing poverty, the treadle pump has proved superior to more technologically advanced irrigation schemes. Starting in the 1970s, for example, the World Bank made low-interest loans enabling the government of Bangladesh to import diesel pumps for deep tube wells, a technology used in Nebraska to pull water out of the Ogallala aquifer. Each system cost $15,000 and could irrigate 40 acres. The government made them available to farmers for free. Another loan program allowed the government to import 10,000 diesel pumps for shallow wells, each of which cost $900 and irrigated 12 acres. Bank appraisers rated the program a success because it moved Bangladesh closer to rice self-sufficiency, but when the government subsidies ran out, farmers abandoned most of the deep wells because of their high operating costs. The shallow wells remained popular among larger, richer farmers, who became water lords and put many small farmers out of business.

SMALL-SCALE IRRIGATION

1,500,000
Bangladeshi farmers who have purchased treadle pumps

$49.5 million
Total investment in the pumps

$150 million
Total increase in the farmers' annual income

$1.5 billion
The cost of irrigating the same farmland with a conventional dam and canal system

The cost per irrigated acre was $375 for the deep diesel pumps, $133 for the shallow diesel pumps and only $66 for the treadle pumps—$50 of which came from the farmers. By focusing on creating a sustainable market, the treadle-pump project produced more income and left a gentler footprint on the environment. A similar approach is now needed to address the problem of naturally occurring arsenic in Bangladesh's groundwater, which is poisoning farmers. Because many Bangladeshis are willing and able to pay for a $7 household filter to rid their drinking water of arsenic, the obvious solution is to find private-sector distributors and subsidize purchases for those who cannot afford it. (IDE's organization in Bangladesh is currently promoting the filter.) As usual, though, the government and the donor community are calling for large-scale solutions such as centralized piped-water systems, which have not been effective in Bangladesh in the past.

Drop by Drop

OBTAINING WATER from wells or reservoirs is only half the challenge; farmers must also find better ways to deliver the water to their crops. Most irrigated farms in the developing world rely on inefficient surface-flooding methods that have remained unchanged for centuries. As a result, millions of acres of good cropland have been lost to waterlogging, salinization and excessive pumping from aquifers. The poorest farmers face an additional problem: many work on marginal land in semiarid areas. Some have limited access to surface water or wells, and others are totally dependent on rainfall. Drip irrigation, one of the most miserly ways of applying water to crops, would be a godsend for them, but most drip systems are too big, complicated and expensive to fit their needs.

In 1992 I visited a hill village in Nepal called Madan Pokhara where sprinkler systems supplied from small reservoirs irrigated the farms. I was disappointed to learn that the systems, each of which served three farmers, cost $1,000 apiece. I resolved to find a way to make it cheaper. I discovered that just about every other house in the village got its washing water from a small plastic pipe stuck in a stream above the house. Why not use the same cheap piping to bring water from streams to crops? We could replace the expensive reservoirs of the sprinkler system with used 55-gallon drums sunk in the stream. To replace the sprinklers, we could punch holes in the pipe with a hammer and nail and let water dribble out to the plants. I thought I was pretty smart until I ran this idea past Dan Spare, an irrigation engineer building a canal in Nepal's Kali Gandaki River basin. "You have just invented drip irrigation," he said. "The only problem is that the Israelis invented it 35 years ago."

I was convinced that drip irrigation could be tailored to the needs of subsistence farmers. In 2001, after seven years of development and field tests, IDE introduced an effective, low-cost drip system that resisted clogging and sold for one fifth the price of conventional equipment. Families could invest as little as $3 to buy a kit that irrigated a 40-square-meter kitchen garden, then reinvest some of the 300 percent annual return it generated to expand the system's coverage up to an acre or

TREADLE PUMPS have been adopted by many small farmers in Bangladesh and India because they cost only $25. A farm family using the pump to irrigate a half-acre plot can earn several times that amount in just the first season by selling the vegetables they grow. This Indian family is raising hot peppers. Treadle pumps are well suited for regions where the water table is relatively close to the surface.

more. In 2004 farmers in India purchased enough IDE equipment to irrigate 20,000 acres. Within 10 years I expect that low-cost drip systems will irrigate several million hectares in India alone, an amount larger than the total worldwide area under drip irrigation today.

Drip systems can also be used to irrigate crops with stored rainwater. Throughout history, farmers have devised ways to collect the copious water rushing off the fields during the monsoons that batter East Africa and South Asia every year. IDE is now developing a system that employs small settling ponds to remove silt from the rainwater, which is then diverted to an enclosed 10,000-liter storage tank. In the ensuing months, farmers use a hand pump to send water through the drip piping to their crops, which can be sold for high prices during the dry season. Because this system carries out the functions of a big dam for a small farm, we gave it the ironic name of NAWSA MAD, which is Aswan Dam spelled backward. (Aswan is perhaps the most controversial of the big dam systems in the developing world.) NAWSA MAD's storage tank, which will cost only $40, is undergoing final field tests in India and Africa.

THE AUTHOR

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POLAK is founder and president of International Development Enterprises (IDE), a nonprofit grassroots organization that has brought more than 12 million people living on small farms out of poverty since 1981. Earlier in his career, Polak was an entrepreneur and a practicing psychiatrist who received his M.D. from the University of Western Ontario in 1958; he developed a model of direct intervention for treating major mental illness, writing 80 scientific articles and book chapters on the topic. Polak recognized the links between mental illness and poverty, and his success as an entrepreneur enabled him to start IDE, which is based in Lakewood, Colo.

To Dam or Not to Dam?

PEOPLE USE ONLY about 10 percent of the freshwater that falls on our planet; the other 90 percent falls in underpopulated places such as the Amazon or comes all at once during rainy seasons and rushes past farmers' fields to the sea. The easiest way to produce more food for a growing population is to use the existing supply of irrigation water more productively, but that is not the only answer. Farmers currently use

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DRIP IRRIGATION brings water to vegetables grown in the hill villages of Nepal (*top*). International Development Enterprises was able to make the system affordable by using cheap plastic piping. The drip lines deliver water directly to the roots of the crops (*bottom*).

about 2,500 cubic kilometers of water every year, and the consensus is that even with improvements in productivity they will require about 20 percent more by 2025.

I have been a vocal critic of big dams that are built mindlessly, but I believe it would be a mistake to halt all dam construction. Careful planning is the key. The World Commission on Dams recently released a report that offered sensible procedures for mitigating the negative impacts of dams on the environment. The report also advocated examining alternatives to dams such as storing water underground, which eliminates evaporation losses and provides water closer to where it is needed.

In many places, groundwater tables are dropping two meters a year or more because of overpumping. Some aquifers can be replenished, though, by trapping monsoon rainwater and directing it underground. The state of Gujarat in India is a good example: it is hot and dry most of the year, and most of its rain falls during the monsoon season, when flooding is common. Starting in the 1980s, a Hindu religious movement called Swadhyaya Parivar led thousands of farmers in Gujarat to build waterways that direct monsoon runoff into large open wells. This collective action restored groundwater aquifers and significantly increased agricultural productivity. Development agencies should immediately conduct hundreds of Gujarat-type experiments and launch a major global initiative to scale up the most successful ones.

Another promising idea is to use drip and sprinkler systems in combination with the irrigation canals that lace croplands in India, China and other countries. Farmers on canals can get water only when their turn comes, and canal systems typically deliver water every two to three weeks, instead of the two- to four-day cycle that most high-value crops thrive on. Installing small storage tanks along the canals would enable farmers to irrigate their fields between the scheduled times of water delivery. Farmers in China are already successfully adopting this system, which they call "melons on a vine." In addition to increasing the amount of food grown and money earned for each liter of water, such efforts alleviate the damaging effects of waterlogging and salinization, both of which are made much worse by applying too much water at once.

New irrigation systems for farmers could also provide clean drinking water to many of the 1.1 billion people who lack access to it. Because more than 80 percent of these people live in poor rural areas rather than cities, building large, centralized, piped-water complexes to serve them all would be impractical and prohibitively expensive, costing hundreds of billions of dollars. But a system that combines irrigation with delivering drinking water can actually pay for itself. In 2004 IDE's organization in Nepal built small water-supply systems in eight hill villages. In addition to providing drinking water from clean springs for 10 to 15 families, each system delivered enough water to drip-irrigate several plots of off-season vegetables. We expect that the sales of these vegetables will pay for the water systems within one to two years and provide continuing income for the families after that.

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In much of Africa, rural villagers get water for both drinking and irrigation from nearby wells. Unlike the situation in Bangladesh, the water table is too deep to be accessed by treadle pumps. Hand pumps make it easier to get the water out of the ground, but most Africans cannot afford the $1,500 installation cost. (The hand pump that Peter Mwete used to obtain water for his plot in Marimari was donated to his village by a church group.) If the villagers form a water-users group, however, they can borrow the money for the hand pump. Assume that each of 30 families agrees to pay the group $7 a year for clean drinking water and that 15 of the families invest an additional $20 each to buy drip-irrigation systems. Each farming family earns an extra $100 a year from selling fruits and vegetables, out of which $30 is given to the water-users group. The group collects $210 a year from the water users and $450 a year from the farmers, which is enough to cover operating expenses and pay off the $1,500 loan in four years.

African governments and development agencies can encourage such arrangements by organizing the water-users groups, training the farmers and facilitating their access to markets. This strategy is much more effective than subsidizing the cost of installing the hand pumps, because the villagers are more likely to properly maintain the pumps if they own them. Of course, this approach may not work for every village; in some cases, for example, the wells may not produce enough water for both drinking and irrigation. But I believe that at least half the new rural drinking-water systems can be self-financing.

> It is absolutely essential that the rural poor invest their own time and money in the effort to move out of poverty.

The Price Tag

HOW MUCH WILL IT COST to feed three billion more people and cut poverty levels in half? All one can do is make an educated guess. On larger farms with good soils, where most of the gains in agricultural productivity have been made so far, I estimate that boosting harvests further will require a total investment of $20 billion over the next 10 years. It will take about $10 billion to support the continuing agricultural research at universities, national institutions and the centers in the Consultative Group on International Agricultural Research. Another $10 billion or more will be needed to double the productivity of existing irrigation systems and to build a small number of new large dams.

Reducing poverty, however, is more complicated than simply expanding the food supply, and estimates of the cost of achieving the Millennium Development Goals vary widely. Jeffrey D. Sachs of Columbia University and his committees of United Nations experts say wealthy countries must provide a total of more than $1.5 trillion of assistance funds to developing nations over the next 10 years, with the lion's share devoted to improving health, education, energy and road infrastructure [see "Can Extreme Poverty Be Eliminated?" by Jeffrey D. Sachs, on page 56]. My work with IDE, however, leads me to a different set of conclusions. First, although investments from the West are critical to prime the pump, it is absolutely essential that the rural poor invest their own time and money in the effort to move out of poverty. The crucial step is releasing the energy of Third World entrepreneurs. The good news is that one-acre farmers are already entrepreneurs and are surrounded by thousands of other businesspeople operating small stores and repair shops.

For each of the past several years, IDE's projects have increased the net annual income of more than 100,000 poor rural families by $500 at a cost of less than $200 per family. Assuming that pace can continue, reaching the Millennium Development Goals—which require bringing some 600 million people, or about 100 million families, out of poverty—would cost $20 billion. This investment would not cover all the infrastructure improvements that Sachs and others have advocated, but it would give rural families new income to educate their children and improve their farms, homes and health. What is more, I am confident that such a program would spur private agribusinesses to make a similar investment to build a market infrastructure for processing, grading, packaging and distributing the tomatoes, eggplants, chili peppers and other high-value produce grown by the newly empowered farmers.

If a small organization such as IDE, with an annual budget of $10 million and a staff of 600, can bring nearly one million people out of poverty every year, then surely the combined efforts of the wealthy nations can do much more. But development agencies must be willing to start at the bottom—at the level of the small farmer walking quietly on his treadle pump—and work their way up. SA

MORE TO EXPLORE

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More information about International Development Enterprises and its work can be found at **www.ide-international.org** and **www.iwmi.org/respages/PGW/treadle.htm**