# Poverty Reduction through Irrigation and Smallholder Markets (PRISM)

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## 1. Introduction

Today, more than 1.2 billion people live in "extreme consumption poverty"[1], which the international community defines as the equivalent of living on less than one dollar a day. Seventy-five percent of these people live in rural areas, have very small plots of land and depend on agriculture for their livelihood[2]. Solutions to rural poverty must focus on these rural poor farmers. These farmers must grow high-value crops on their small parcels of land, in order to materially enhance their wellbeing and incomes. But to do this, it usually requires irrigation.

Traditional surface irrigation practices have in the past been suitable for smallholders who are fortunate enough to have abundant low-cost supplies of water. However, the traditional practices smallholders use do not utilize water very efficiently in terms of crop yield per unit of the water applied. Furthermore, the income disparity between the millions of smallholders and the rest of society is widening while simultaneously there is growing competition for the world's finite freshwater resources. Therefore, since water is usually the most critical factor that directly affects the intrinsic production capacity of their land, it is critical that smallholders begin using more efficient water supply and irrigation technologies.

Unfortunately, the available configurations of the modern and efficient water supply strategies and irrigation technologies, which were typically designed for relatively well financed larger farms, are not well suited for the needs of smallholders. It does not work to simply downsize a sophisticated water management technology to fit a small plot. Polak, et al. (1997) recognized that it is not sufficient to merely scale-down "state of the art" irrigation technologies that are appropriate for larger commercial farms. Systems must be re-engineered to match smallholders' unique characteristics (e.g., small landholdings, low capital availability, low risk tolerance, and relatively low opportunity cost of family labor). Features that are important to smallholders include: 1) low investment cost; 2) suitable for various plot/field sizes at about the same cost per unit of area served; 3) rapid return on investment; 4) simple affordable maintenance; and 5) operating at very low pressure heads.

Thus, greater attention must be given to developing and disseminating appropriate water technologies that will enable smallholders to have access to and better control over water for crop production. Providing appropriate and efficient irrigation technologies requires the development of new low-cost products specifically designed for smallholders. Then manufacturing them as locally and inexpensively as possible and marketing them to the smallholders.

The following definition (which is from an engineering perspective) of a technology that would be appropriate for smallholders was presented by Amadei (2004): "An appropriate technology is usually characterized as small scale, energy efficient, environmentally sound, labor-intensive, and controlled by the local community. It must be simple enough to be maintained by the people who use it. In short, it must match the user and the need in complexity

[1] Rural Poverty Report 2001, International Fund for Agricultural Development, Oxford University Press Inc., New York, NY, 2001.
[2] Reaching the Rural Poor: A Strategy for Rural Development, World Bank 2001.

and scale and must be designed to foster self-reliance, cooperation, and responsibility."

The availability of affordable small-scale irrigation technologies (ASITs) unlocks the potential benefits of modern pressurized irrigation systems for literally millions of resource-poor farmers (even where water supplies were considered insufficient or too costly to acquire for traditional irrigation methods). With this belief, the International Development Enterprises (IDE), a non-profit organization, has taken up the challenge of developing and intensifying the use of ASITs in developing countries through a methodology it calls PRISM (Poverty Reduction through Irrigation and Smallholder Markets). PRISM envisions the smallholder as a micro-entrepreneur who transforms natural resources (land and water), human resources (labor and know-how), and purchased inputs, such as ASITs, into high value agricultural products that can be marketed at economically rewarding prices. IDE uses the PRISM methodology to assist in the creation of pro-poor rural market systems based on: a) exploring and identifying market opportunities, and b) good water control. Since water is an essential input in all agriculture production systems, ASITs play an important role in integrating smallholders into the market system and improving their livelihoods ( Heierli, 2000; Postel, et al. 2001).

PRISM was developed by the International Development Enterprises (IDE). IDE is a non-profit organization that employs market principles to strike at the roots of rural in the world's least developed countries. Since 1981, IDE has worked to reduce poverty in Asia and Africa by helping the rural poor increase their agricultural productivity and income. Using relatively few resources, IDE has helped empower some two million small-farm families to progress from subsistence agriculture to small-scale commercial farming and begin an upward spiral out of poverty.

IDE is working in Asia (India, Bangladesh, Cambodia, Nepal, China, Vietnam, Mynamar, Pakistan) and Africa (Zambia, Zimbabwe, Malawi, Niger). Currently, the Ethiopian Society for Appropriate Technology (ESAT) is collaborating with IDE to introduce the PRISM approach to Ethiopia.

## 2. Conceptual Foundations of PRISM

PRISM is founded on the following key concepts and principles:

- **Focus on the smallholder**. Effective solutions to poverty must deal with smallholders for the simple reason that they constitute the majority of the world's poor. We define smallholders as farmers cultivating between 20 square meters and two hectares of land. The term "smallholder" denotes a rural household operating in the context of at least under-developed market systems, with highly restricted access to land, water and capital.

- **Smallholders' comparative advantage in high value crops.** Smallholders have an important advantage over larger farmers in that their family labor can be applied to their small holdings with little or no cost o f supervision. The smallholder can capitalize on this characteristic to develop a comparative advantage on labor-intensive farming systems where the factors of production must be closely managed. Comparative advantage is most readily developed in the production of certain high value crops, such as fruits, vegetables, flowers, etc. With concentrated, labor-intensive production systems, it is possible for smallholders to achieve higher yields per unit area and better quality produce than farmers that cultivate larger areas with capital-intensive farming systems. Larger farms, on the other hand, are usually better suited to the production of staple crops, which require less intensive management and are more adaptable to mechanization than most high value crops.

  This comparative advantage of smallholders can be further enhanced through the provision of products and services that are suited to their unique characteristics and that will enhance their ability to grow and sell crops efficiently.

- **Designing solutions from a smallholder perspective.** Production technologies, both hardware and resource management practices, must be designed to suit the characteristics and resource availability of smallholders (Figure 1).

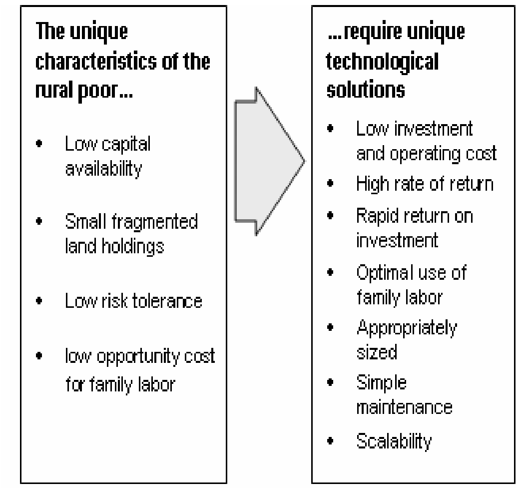


**Figure 1. Pro-Poor Technology Development**

- **The smallholder's place in the value chain.** Smallholders are micro-entrepreneurs and they are served by other micro and small enterprises' (MSEs) in input and output markets (see Figure 2). Smallholders' profitability depends on the degree to which they are integrated with these market systems, both as purchasers of agricultural inputs and producers of saleable crops.

- **Market demand is the driving force.** Demand for agricultural commodities provides the "pulling force" that drives the value chains in which smallholders participate.

- **Constraints to effective smallholder market participation.** Smallholders, and the MSEs that serve them, face a range of constraints at the farm level and in the input and output markets. The lack of water access and control is usually a key constraint. Other constraints may relate to technology, market information, access to credit, technical knowledge, and socially prescribed gender/socio-cultural roles.

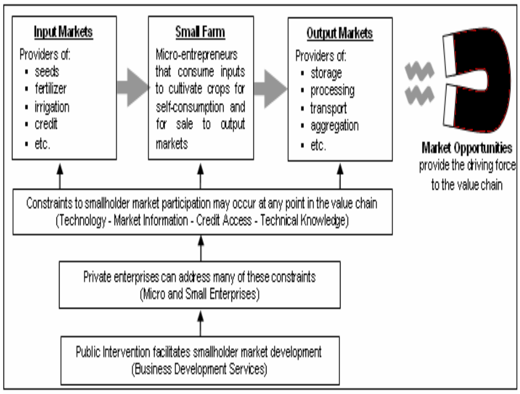


**Figure 2. Effective Interventions for Smallholder Market Development**

- **The role of public investment.** Public intervention in market facilitation is required to create market environments in which smallholders can participate effectively. Public intervention may take the form of Business Development Services (BDS) such as research and development, creating market linkages, awareness raising and demand creation, infrastructure development, and policy support.

## 3. The Three Pillars of PRISM

The PRISM approach is based on three pillars: water control, supply chains and market access

i) **Water control**: Water is often a key constraint to smallholder productivity. The livelihoods of the large majority of small-scale farm families are dependent on rainfed-agriculture. Their options to diversify into irrigated-agriculture are constrained by lack of appropriate and affordable water control technologies. In the PRISM approach, smallholder farmers are supported to get access to water lifting, water-storage and water-distribution technologies that are low-cost, simple and adaptable (these technologies will be discussed later in great detail).

ii) **Private supply chains for delivery of inputs and outputs:** Experience shows that smallholder farmers must have regular access to a series of inputs and services, such as seeds, fertilizers, agro-chemicals, low cost irrigation technologies, credit, transport, etc. These inputs and services are better delivered by the private sector. The private sector comprises exporters, importers, distributors, local manufacturers, whole sellers, retailers, installers and advisors. Usually, in remote areas with predominantly poor farmers, this private sector is missing or underdeveloped. This bottleneck can be overcome through supply chain development interventions.

iii) **Market access**: A primary cause of the persistent poverty faced by the rural poor is that they have limited interaction with markets. With less than one dollar per person per day, they cannot afford to purchase agricultural inputs or invest in production technologies, resulting in low land and labor productivity that does not raise much above subsistence levels. Consequently, they have little or no surplus production to sell to the market. The poor farmers' access to market is also constrained by many other factors, such as lack of market information on product demand and price, inadequate or no entrepreneurial skills, poor rood network and transport services. Often, small farmers get low price for their produce due to low product quality, their weak bargaining power and market glut at harvest time due to excess supply. PRISM views smallholders as entrepreneurs and enhances supports them to actively participate in markets by helping them produce marketable high value crops, access timely market and through market development interventions.

For the interest of this symposium, our presentation will concentrate on PRISM's pro-poor water control (micro-irrigation) technologies that have been developed and promoted by IDE in Asia and Africa (Zambia and Zimbabwe).

## 4. Micro-Irrigation Technologies

The water technologies that are described below include the following: treadle pumps and storage tanks to supply water for crop irrigation; and low-cost drip irrigation systems to apply water to high value crops. The development of these efficient and affordable water technologies provides smallholders with an essential tool for intensifying their farming practices. This allows them to grow high value crops and significantly boost their farming income.

### The Treadle Pump

The treadle pump is a true and mature appropriate water technology designed, manufactured and marketed with smallholders in mind. It is a simple low-cost manual (foot-operated) pump that can lift water from shallow groundwater sources or surface water bodies. The typical pump consists of two vertical cylinders fitted with pistons that are interconnected using a pulley (or lever) system so when using a stepping motion, as one treadle is pushed down the other treadle is moved up Basic treadle pumps can lift water from depths of up to seven meters with a flow rate ranging from about 30 to 80 liters per minute (lpm) depending on the rigor of the operator, water depth, and cylinder diameter. Pressure treadle pumps can no t only lift water, but also provide pressure heads of up to 20 m at the pump outlet.

Treadle pumps are beautifully suitable for agricultural use by smallholders because:

- They are inexpensive, for example, in Southeast Asia, the retail cost of a basic pump ranges from US $12 to $15 including the wood or bamboo treadles and support structure (see Figure 1). However, in Africa the typical cost ranges from $55 to $95 because pressure pumps are usually required and they generally have steel treadles and supports so they are compact and portable to facilitate moving to a secure location when not in use. The cost of a shallow borehole well (when necessary) varies according to local geological conditions, but typically ranges from $20 to $80 in alluvial soils.
- The design and construction of the pumps is simple, so local craftsmen can manufacture them using readily available tools and materials; and they can be maintained and repaired easily by the users. Parts requiring periodic replacement such as plastic piston seals, which are common to many popular hand pumps, are usually available in

local markets. The foot valve at the bottom of each cylinder is made from rubber that can be replaced using a discarded bicycle tire inner tube.

- Because they have two pistons, water is kept in motion during the up- and down-strokes resulting in a continuous flow and efficient use of manual energy.
- Leg muscles are used in a natural walking motion making it possible for an operator to pump for several hours per day delivering enough water to drip irrigate roughly 2,000 m² of vegetable cropped area.

Keller and Roberts (2003) presented the following brief history of treadle pumps:

“The treadle pump was developed in Bangladesh by an (NGO), Rangpur-Dinajpur Rural Services (RDRS), and popularized by another NGO, International Development Enterprises (IDE). Beginning in 1986, IDE-Bangladesh facilitated a market network of approximately 65 manufacturers, 700 dealers, and 5000 installers and stimulated demand for the pumps through mass media campaigns in rural areas (Hiereli 2000). To date, approximately 1.5 million treadle pumps have been distributed through market channels in Bangladesh and another half million have been distributed through similar programs in other Asian countries.”

Shah et al (2000) studied the socioeconomic impact of the treadle pump in eastern India, Nepal, and Bangladesh. The research indicated that treadle pumps enabled smallholders to intensively manage water and other inputs on “priority plots” within their land holdings, which significantly increased their agricultural production and income. The average additional net income to land and labor was found to be more than $100 per year per smallholder, and a significant percentage of them were making an extra $500 or more per year. The extra income enabled some treadle pump owners to graduate to a higher level of mechanization by purchasing engine driven pumps for irrigation.

Shah also pointed out that with treadle pumps, the cost of new irrigation development in these areas is only $100 to $120 per hectare, with the poorest farmers being the beneficiaries. In view of this success several NGOs are actively involved in the promotion of treadle pumps throughout Asia (including China) and Sub-Saharan Africa using the market creation approach to development.

## Low-Cost Drip Irrigation

Drip irrigation has the potential to be the most efficient irrigation technology when evaluated in terms of crop production per unit of water applied. This is because the water can be uniformly delivered to each plant through a closed pipe system. Thus converting from traditional surface irrigation to drip irrigation can significantly increase the area of land that can be fully irrigated with a given volume of water.

Figure 4 shows a schematic of an IDE low-cost micro-tube drip irrigation system. These drip systems are low-cost, require a minimum of filtration, are available in small packages, operate at low inlet pressure, and are easy to understand and maintain by smallholders. These low-cost drip systems are available with sizes ranging from 20m2 to 2 hectares (ha). They are very affordable, with an installed cost in India of between $0.03 and $0.05/m² ($300 to $500/ha) for the laterals with drippers plus the sub-main, depending on field size, lateral spacing and layout. Where as the standard commercial drip systems cost from $0.15 to $0.25/m² ($1,500 to $2,500 per ha).

The affordable design of the low cost IDE system is made possible because:

- The systems operate at inlet pressure heads of from 1 to 3 m, so lightweight tubing and inexpensive fittings can be used and leaks are easily repaired.
- The major system components are plain tubing and simple fittings and the microtube drippers and fittings are installed in the field.
- The plain tubing and simple fittings can be manufactured by utilizing inexpensive manually controlled extruders and simple molds; therefore,

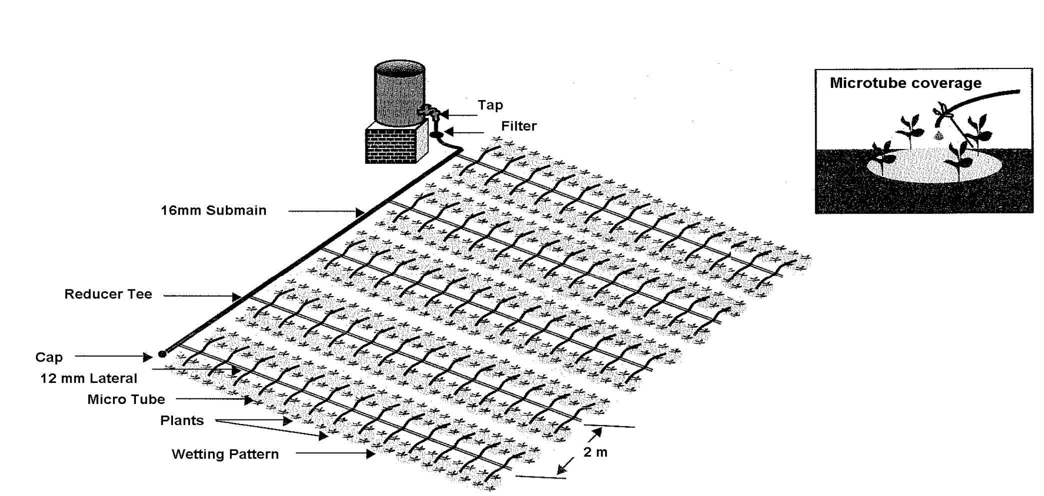


**Figure 4. Schematic an IDE low-cost micro-tube drip irrigation system.**

- the entry cost for manufactures is very low, which assures a competitive marketing environment.
- The systems are lightweight and the lateral and sub-main tubing is packaged in tight rolls; therefore, transportation and handling costs are low.
- The system components are simple and easy to assemble without sophisticated tools; therefore, farmers can install their own systems.

Besides being affordable the IDEal drip systems have the following other attributes that are important to smallholders: 1) under low operating pressure heads (1.0 to 2.0 m) the discharge rate from the micro tube drippers is about ideal for individual vegetable plants such as tomatoes; 2) dripper clogging is minimal even with little or no filtration when using water from dug wells; and 3) on relatively level small fields the application uniformity is comparable to that achieved by conventional drip systems used in developed countries (Keller and Keller 2003).

These low-cost drip systems only cost about fifth of standard commercial drip systems. The availability of these low-cost drip irrigation systems in small affordable packages unlocks their potential benefits for literally millions of resource-poor farmers. In addition, it opens the potential benefits of irrigation even where water supplies were considered insufficient or too costly to acquire for traditional irrigation methods to be practical. To date, more than 200,000 low-cost drip irrigation systems have been distributed through market channels in India, Nepal and other areas in Asia.

### Bagging Water for Irrigation

Cost effective storage of the runoff water from small catchments or water from perennial wells or streams to use for irrigation during the dry season has been a major challenge. A recent innovation developed by IDE that looks promising is to store water in low-cost plastic lined tanks. The first level of experimentation has already been completed and the tanks are now being tested in a pilot study in India. Each tank stores 10 cubic meters of water that is completely enclosed to eliminate evaporation losses. The installed cost is roughly $40 to $50 and the life expectancy is 5 years.

## 5. Conclusion

Ending poverty requires nothing less than four simultaneous revolutions in water, agriculture, markets and design; each centered on small farms and dollar-a-day farm families (Polak 2005).

- A revolution in water is needed to open access for the rural poor to income generating, affordable, small plot irrigation and domestic water supplies.

- A revolution in agriculture is needed to open opportunities for small farm enterprises to develop new varieties of fruits, vegetables, herbs and other labor intensive, high value crops optimized for small farms and the smallholder based agricultural practices required to produce them.

- A revolution in design is needed, based on the ruthless pursuit of affordability, to develop a whole new generation of income generating technologies and strategies that serve the rural poor.

- A revolution in markets is needed to create new markets that open smallholder access to affordable small plot irrigation and inputs, and to new markets for the high value crops they produce.

The PRISM approach is conceived, developed and promoted on the basis of these underlying revolutionary ideals. In collaboration with IDE, the Ethiopian Society for Appropriate Technology (ESAT) is introducing PRISM to Ethiopia. Introduction of the methodology and implementation of the low-cost, appropriate irrigation technologies are being done in partnership with donors, NGOs and the private sector. Achievements made in less than one year are very encouraging and indicated to us that the technologies are very appropriate to the Ethiopian smallholders farming systems and, thus, are well demanded.

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