New Irrigation Technologies

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Abstract

Lack of appropriate and affordable irrigation technologies geared towards poor farmers on small plots is a major constraint to the spread of irrigation in Kenya and elsewhere in sub-Saharan Africa. Most irrigation equipment used in conventional pressurised irrigation systems in Kenya is imported and costly. As equipment suppliers are few, farmers have to pay higher prices for equipment. To address these problems, therefore, appropriate technologies need to be identified and adapted to suit smallholder farmers. These technologies need to be a) appropriate, simple and, if possible, equipment should be made using local materials and skills, and b) affordable and have the potential to earn high returns on investment.

Small-scale drip irrigation systems and human-powered pedal pumps emerged in Kenya in the late 1980s. They have continued to gain popularity in the 1990s and are making a significant impact on rural communities. The potential for these systems is still unexploited (only less than 2% has been exploited) because of many factors, including rampant poverty and lack of information, but there is an upward trend in their adoption.

There is a need for continued development and adaptation of the technologies and programs to teach farmers how to use them, as has happened in Asia.

Introduction

In Kenya, as in many parts of sub-Saharan Africa, agriculture is the mainstay of the livelihood of the citizens. The country enjoys a variety of climates and soils but less than 20 percent of the land area is considered arable under rain-fed condition. The remaining 80 percent, classified as arid and semiarid lands (ASALs) experiences water shortage, which is a major constraint to agricultural production. Due to population pressure in the high- and medium-potential areas, people whose livelihoods traditionally depended on subsistence farming, moved to the ASALs and intensively cultivated them. However, this was not sustainable without external inputs such as water and nutrients. Irrigation was identified as the key to agricultural development in the marginal areas and the Government of Kenya initiated a number of large-scale irrigation schemes. The large schemes did not perform to expectations and depended on the government for subsidies for their O&M. This reliance could not last long and the policy slowly changed with the government shifting its focus to the development of smallholder group-based schemes and to irrigation development by individual holders. Although the schemes faced problems

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such as availability of inputs and marketing of produce, their performance has generally been better than that of the large schemes.

Low water use efficiency, soil salinity, insect-pest damage, plant diseases and poor crop husbandry negatively influence crop production under irrigated farming. Smallholder farmers tend to look for irrigation technologies that they can understand and afford to buy. Such technologies are found, for example, in traditional manual irrigation where water is hand-carried over a distance to be splashed on vegetable plots. The emergence of small-scale irrigation technologies that poor farmers could understand, invest in, and use to grow crops for food and cash was an important change in the irrigation sector in Kenya. The two main technologies, which have been adopted by Kenyan farmers, are the small-scale drip irrigation systems and treadle pumps. These technologies were designed to reduce the workload of women who are the people mainly involved in smallholder gardening, to improve their incomes as well as to provide gainful employment for youth in the rural areas. Also important was the realization that lack of transfer of technology to the smallholder farmer was a major constraint to irrigation development. Another important factor identified as a constraint to the adoption of these technologies was their inaccessibility to the farmers. The genesis of these systems in Kenya in the late 1980s was slow but progressed rapidly in the 1990s.

Two small-scale irrigation technologies introduced in Kenya will be described in terms of system descriptions, their impacts and challenges that need to be addressed for technology transfer to the targeted resource-poor farmers. These two technologies are the small-scale drip irrigation systems and manually operated treadle pumps, and they show promise in irrigation of small gardens. Women's groups have shown a high level of interest in these technologies, which make a direct impact at the household level.

Small-Scale Drip Irrigation Technologies

Drip Irrigation Systems

Drip irrigation is not a new technology in Kenya. Large-scale farmers have been using it for the past 25 years but it was within the last decade that its use was widespread, mainly in large-scale horticulture and in flower production for export. Conventional drip irrigation systems typically cost Ksh 200,000–300,000 (US$1=approximately Ksh 75) per hectare for infield equipment alone without considering filters and the water delivery system. They are expensive and require technological know-how in design, installation, management and maintenance. For this reason, drip irrigation has been used by wealthier farmers on high-value fruit, vegetable and ornamental crops. This has changed in recent years with the introduction of small-scale drip irrigation technologies revolving around low-head drip irrigation kits. Three types of small-scale drip irrigation systems (table 1)—bucket, drum and eighth-acre systems—have shown promise in Kenya. The basic small-scale drip irrigation unit is the bucket-kit. The kit comprises two 15-m long drip tubes, with 100 drip emitters and has a capacity to water 100 plants. The bucket-kit system can easily produce sufficient vegetables for home consumption with users even selling the excess. The drum system has a fivefold increase in the capacity over the bucket while an eighth-acre system equals a twentyfold increase in the capacity over the bucket kit to water plants.

Table 1. Specification of drip irrigation kit systems in Kenya.

System Characteristics	Bucket	Drum	Eighth-Acre
Working pressure required (m)	1	1	5–10
Average water required per day (liters)	40	200	2,000
Area coverage for vegetable systems (m^2)	15	75	450
Cost (Ksh [US$])	1,100 (15)	7,500 (100)	15,000 (200)

Water that is to be used in drip systems may come from wells, ponds, lakes, municipal lines or rivers. Before using dirty water containing bacteria, algae or other aquatic life it is necessary to use extra filtration such as sand filters. Water from wells and municipal supply lines is generally clean and only requires the screen filter supplied with the kit for filtration. The drip lines are installed with the outlets facing upward to minimize clogging risks.

Small-scale drip irrigation technology has attracted women's attention and support. Women's groups, NGOs and community-based organizations (CBOs) have shown a high level of interest in this technology and the demand for the kits is growing.

Genesis

Early activities in small-scale drip irrigation in Kenya can be traced to Good Samaritan in the 1980s. The small-scale drip irrigation technology at Good Samaritan started in 1988. Two World Gospel Mission missionaries from the USA, Mr. and Mrs. Gene Lewton, came to Kenya to preach the word of God to local communities living in the arid and semiarid areas. They realized that, to make their mission effective, they had to solve issues of food and nutrition constituting the most serious problem affecting the communities. Because of this, the Lewtons began to incorporate agricultural activities together with their religious work. They quickly put up a base at Karen in Nairobi, the present-day Good Samaritan, from where they demonstrated farming techniques to the community. They introduced bucket drip irrigation kits from Chapin Watermatics and later the eighth-acre kits. It was also at this early time that they introduced trays used for growing various types of seedlings. Farmers were also shown how to use the kits to plant various crops, how to construct greenhouses and how to use the trays for growing seedlings. The Lewtons originally used the first greenhouse, constructed at the site, as a church.

Before 1989, the kits were given free to the local people who came to listen to the word of God. In 1989, the Lewtons were able to have a demonstration stand at the exhibition held by the Nairobi Agricultural Society of Kenya where they demonstrated the technology after which many people came to know about it. They continued to sell the drip kits to both small- and large-scale farmers who were interested in them. By April 1994, the kits had been sold to farmers as far as Tanzania and Uganda, thus enabling the technology to spread in East Africa. In April 1994, the Lewtons left for their home country and the technology started to die off at Good Samaritan. Basically, the drip kits that were left behind were sold at cut-prices and the project could no longer sustain itself. There were also issues of poor management of the already installed kits. Problems of clogging in the drip lines were frequent and the community lacked simple innovative measures to maintain the drip systems.

The gap left by the missionaries was later to be filled by the Kenya Agricultural Research Institute (KARI) whose irrigation scientists had, since 1989, curiously followed the proceedings at Good Samaritan. KARI got officially involved in the small-scale drip irrigation technology in August 1996 through a community-development program in Eldoret. The Eldoret community is credited with this initiative as its members made inquiries and requested for assistance. Mr. Micah Cheserem, having seen the technology in Malawi, made the initial contact with KARI. The institute, making use of a grant from USAID, imported material and assembled hundreds of Chapin Watermatics bucket-kits and invited Mr. Stan Doer and Ms. Elizabeth Adams whose training program had shown a promising impact in Malawi. They initiated the Eldoret program, alongside KARI scientists, and followed it up for 2 weeks. For their contribution, the Eldoret farmers paid for the kits but were not charged for the training. The KARI scientists continued to make follow-up visits to assist the farmers to address new challenges in the technology. KARI also set up a demonstration at the National Agricultural Research Laboratories (NARL). After the initial project, KARI continued to set up other pilot areas and import the materials for the systems, making them into bucket-kits for sale. Initially, for demonstration and promotional purposes, KARI freely distributed kits to various women's groups and schools in pilot areas. This initiative could not last long and KARI started distributing the kits at cost and offered free or subsidized technology backup-services. By the end of 2000, over 5,000 bucket-kits and 450 eighth-acre kits had been distributed. In 1999, the Fresh Produce Exporters Association of Kenya (FPEAK) took the initiative and started importing drip irrigation material and selling kits.

Current Status

During the last few years, some international firms have developed an approach to small-scale, low-head drip irrigation. Chapin Watermatics has developed an eighth-acre drip irrigation system for third-world farmers, and Netafim has developed its "Family Drip System" in response to the demand from small-scale farmers in South America. Both systems are targeted to cover plots of 450–1,000 m^2, requiring a permanent supply of at least 1,000 liters of water per day at 1–10 m pressure. The initial investment in these systems ranges from KSh15,000 to KSh30,000. While the technological solutions for these "small-scale" systems may be brilliant, the overall cost of installing the systems is prohibitive for most subsistence farmers in Kenya, although these systems have become important as technologies for small-scale commercial farmers.

KARI now has on-station demonstration sites at the NARL in Nairobi, National Dryland Farming Research Centre in Katumani, Regional Research Centre in Mtwapa and Regional Research Centre in Perkerra. These research centers also stock the kits for sale to interested farmers.

KARI scientists have conducted preliminary research on smallholder drip irrigation practices including crops, nutrient management practices and economic evaluation. Scientists from the Department of Agricultural Engineering of the University of Nairobi have also conducted research on the efficiency of different bucket-kit drip irrigation systems. KARI has further developed the standard Chapin module and has scaled up the bucket-kit to a "drum-kit" where five bucket-kit drip lines are connected to a single 200-liter drum covering a larger plot. Along with the drum-kit, drip irrigation systems have been introduced to the small-scale farmers for use in orchards and tree nurseries. Meanwhile, a local NGO, Appropriate

Technologies for Enterprise Creation (ApproTEC) has embarked on a process of scaling down the standard Chapin eighth-acre kit by half to a 1/16-acre kit. They have selected a standard Roto 500-liter tank and are in the process of developing a collapsible stand for the drum. The entire kit will be packaged inside the drum for marketing. ApproTEC has experience in development and marketing of pedal pumps. Thus with KARI scaling up the bucket-kit and ApproTEC scaling down the eighth-acre-kit to plots of 125–250 m^2, soon the small-scale farmers may be able to purchase, at reasonable costs, kits that will enable a level of production higher than what is necessary as basic food security.

The Fresh Produce Exporters' Association of Kenya (FPEAK), established through a grant from USAID, has initiated the sale of the Chapin Watermatics drip irrigation kits. Through a grant, the FPEAK has purchased a container-load of bucket-kits and eighth-acre kits. In addition, it has set up a small demonstration section at its offices in Nairobi and sells the kits as an income-generating activity to help fund its activities. By the end of 2000, it had sold nearly 1,000 bucket-kits and 150 eighth-acre kits.

The Arid Lands Information Network (ALIN) has purchased 100 bucket-kits directly from Chapin Watermatics, and the ALIN officer has personally distributed them throughout Kenya and Tanzania (Dodoma and Shinyanga). To date, he has sold over 300 bucket-kits on his own initiative.

NGOs have played a key role in disseminating the kit technology. The Intermediate Technology Development Group (ITDG) has distributed some 80 bucket-kits in its agricultural projects in Tharaka and Makueni. More than ten other NGOs and CBOs are disseminating the kit technology in their project areas. One NGO has targeted more than 1,000 bucket-kits for the Kajiado farmers while a church-based organization has purchased over 900 bucket-kits for Meru and Tharaka. Other NGOs have supplied kits to their target farmers on credit.

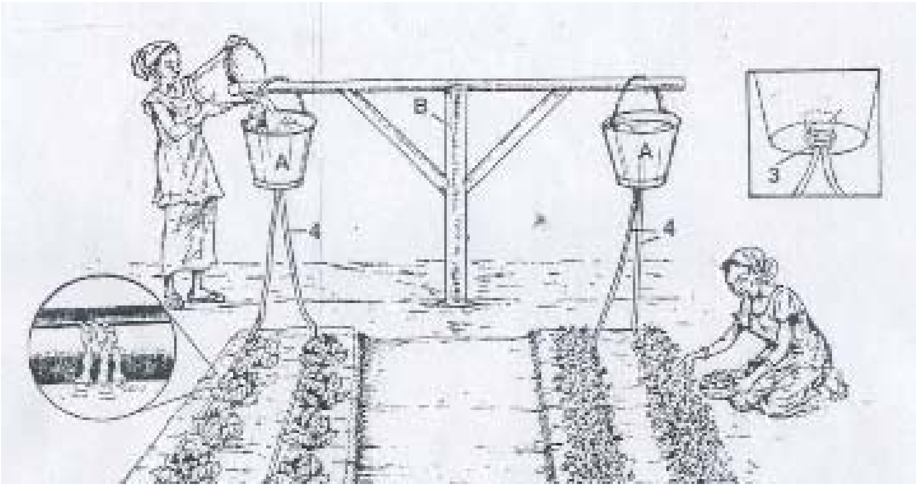
Local entrepreneurs have shown an interest in providing drip irrigation kits from locally available material, including drip tape that is manufactured in Kenya. This is advantageous because kits are thus readily available and can be produced at lower cost. Research has shown that locally available drip tape is suitable for use in low-head applications.

State of the Art

Bucket systems

Components of the system. The Chapin bucket-kits present the scaling down of drip irrigation technology to the level of small household vegetable gardens. The bucket system (figure 1) consists of a 20-liter bucket mounted 1 m above the level of the field, a filter stopper fitted into a hole at the bottom of the bucket, two connecting tubes, and two 15-m drip lines with outlets either spaced at 30 cm or 10 cm, depending on the crops intended to be grown. Water flows from the bucket through the filter into the lines, then drips onto the soil next to the plants. The system can be further adapted to suit smaller gardens by laying out 4 drip lines each 7.5 m long or 6 drip lines each 5 m long. The system is installed on raised beds 1-m wide and raised 15 cm above ground level with the bed lengths varying according to the length of drip lines.

Figure 1. Bucket-drip irrigation system.



Aspects of system management. The bucket-kit system is laid out according to instructions given in an instruction manual. It is important that the drip outlets face upward as this helps prevent sediment settling on the drip emitters and causing blockage. After installation, with the bucket full of water, the end of the drip line is opened to allow water to flow freely. This action creates a fast flow of water that helps flush out dirt from the drip lines. Flushing should be done periodically, every 2 weeks or more frequently, depending on the quality of water used for irrigation.

Agronomic aspects. The bucket-drip irrigation systems can be used to grow a variety of crops, depending on the spacing of the outlets on the drip line and plant spacing. Closely spaced crops such as onion, carrot, garlic, cowpea, etc., require a drip line with outlets spaced at 10 cm. The plant capacity is about 300 to 600. Crops like cabbage, spinach and kale require a plant spacing of 30 cm and utilize the 30-cm spacing drip lines. In this case, the plant capacity is 100. Crops such as tomato and eggplant require a spacing of 60 cm and are better adapted to the drip lines with outlets spaced 30 cm but with crops planted alongside opposing outlets. The water wasted when the plants are young is reduced as the plants grow due to the lateral spread of the roots. Farmers should keep a careful watch on soil and plant conditions and irrigate as needed. Under drip irrigation, water is applied frequently, every day, every 2 days or every 3 days.

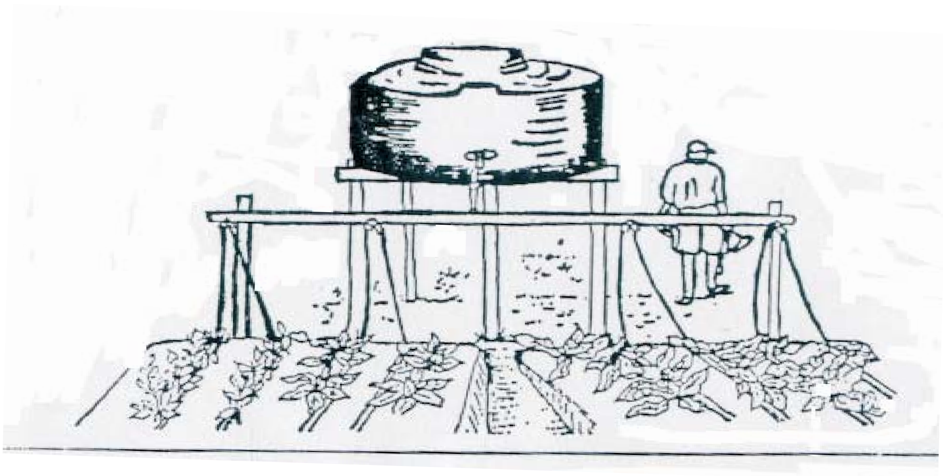
Economic aspects. Bucket-kits last 5 to 7 years if cared for properly. The total cost to the farmer for setting up the system is Ksh 1,100 ($15) depending on the cost of material for constructing a simple bucket stand and the cost of seedlings planted and other inputs. Economic analysis has shown that the kits are economically viable and that the full investment cost can be recovered within the first season of their use. Farmers have reported profits of

Ksh 2,000 to 3,000 ($26 to 40) per season producing high-value vegetables. The entire kit inclusive of the bucket is currently available in Kenya for about Ksh1,100 ($15). Therefore, many resource-poor smallholder producers can afford this technology.

Drum systems

Components of the system. From the bucket-kit, KARI has scaled up the technology to a drum-kit system (figure 2), a fivefold increase in capacity compared to the bucket system. It comprises a drum of approximately 200 liters placed 1 m above ground. A manifold is connected to the drum to distribute water to 10 drip lines each 15-m long, usually laid out in pairs on 5 beds. The manifold is made of ¾ inch PVC material (PVC pipes, tees and fitted bends). The length of the PVC pipe to be used depends on the design of the garden, especially the widths of the bed and paths between sections of the bed. Usually a 6-m length of PVC pipe is enough. Filters used in the drum-kit are the same as those in the bucket system. The length of each drip line used in the drum-kit system is 15 m. A drum-kit manual, packaged with the kit, contains information on installation and management of the system.

Figure 2. Drum drip irrigation system.



System-management aspects. The water is supplied to the plants using the same system process as in the bucket-kit. It is important to close the gate valve while filling the drum and then open it fully to irrigate. Usually, filling the drum once a day is enough, but this depends on the crop type, crop stage and season.

Agronomic aspects. The drum-kit system can be used to grow 500 plants if the outlets are spaced 30 cm apart. Closely spaced crops such as onion, carrot, garlic, cowpea, etc., require a drip line with outlets spaced 10 cm apart. Crops such as tomato and eggplant require a spacing of 60 cm and are better adapted to the drip lines with outlets spaced 30 cm apart. Farmers need to keep a careful watch on soil and plant conditions and irrigate as needed. Water is applied frequently, every day, every 2 days or every 3 days. Amounts of water irrigated vary with location, stages of plant growth and season.

Economic aspects. For a total investment of about Ksh 7,500 ($100) a farmer can install the complete drum system and therefore have a crop-production capacity that is five times that of the bucket system. Farmers have reported more profit margins per unit area than when the bucket system is used. Farmers, who used the bucket system earlier, have invested further and scaled up to the drum system.

Eighth-acre systems

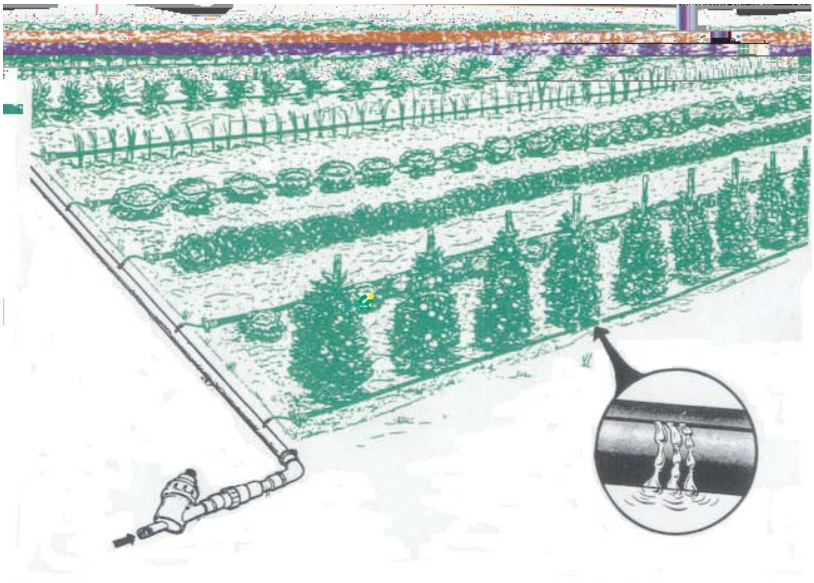
Components of the system. The third technology introduced to the farmers was the eighth-acre kit (1/8 acre or 0.05 ha) for vegetable production. The eighth-acre system (figure 3) has a 20-fold increase in plant capacity compared to the bucket-kit. The system comprises a flexible delivering vinyl flat hose to which 20 drip lateral lines are hooked via micro-tubes. The system comes packed in a box and includes instructions on kit installation and management of the system. The kit includes a head unit comprising a filter and pressure regulator, a 15-m flexible hose and 600-m roll of drip tube that is enough to set 20 drip lines of 30 m each. The conditions necessary to install the system are the availability of clean water, minimum water flow of 1 m^3/hr and minimum water pressure of 0.5 bar.

System-management aspects. Screen filters must be cleaned regularly. The ends of the drip lines should be flushed periodically to empty settled dirt from the system. Blocked outlets should be identified early and unblocked.

Agronomic aspects. The eighth-acre system presents an example of a 20-fold scaling up of the bucket system. It has a capacity to support 2,000 plants at a spacing of 30 cm between plants and 75 cm between rows or 1,000 plants at 60-cm spacing.

Economic aspects. The system, if cared for properly, can be used to grow crops for more than 5 years. The cost of the eighth-acre kit is Ksh 15,000 ($200). Farmers have reported profits of Ksh 15,000 to 30,000 ($200–400) per season on high-value vegetables.

Figure 3. Eighth-acre drip irrigation system.



Pumping for Micro-Irrigation

Pedal Pumps

In addition to drip irrigation that delivers water more efficiently to crops, pumping technologies can help the farmers to increase their irrigated area and production, especially if the water pumped is distributed and applied efficiently. Gasoline or diesel-powered portable pumps seem an obvious answer to the unending toil of small-scale farmers. However, there are two obstacles to the widespread use of these pumps. For one, the economic situation of the farmers can hardly allow for the price and maintenance of the pumps. For another, a 4-HP motorized pump will easily deplete the commonly found water resources in Kenya—shallow wells and water pans—making sustained irrigation impossible. With motorized pumping, extracted water is often delivered to plots in furrows, which is less-efficiently applied compared to hand-carried water that is carefully poured on to the vegetable gardens. Therefore, motorized pumping can become very inefficient, especially in the hands of unskilled irrigators.

Among the most exciting and potentially beneficial technologies is the range of manually operated pumps that have been (and continue to be) used in Kenya. Manual pumps seem to offer a more socioeconomic and technically balanced product to the farmers. Pedal pumps, which are also called treadle pumps, operate the same way. Holding a horizontal arm on a wooden frame or metal frame to steady the body, the operator pedals up and down on two long treadles. The pedaling motion activates two plungers, each positioned within a cylinder. A suction inlet at the bottom connects the water source to the pump's two cylinders. On the upward pumping stroke, water is sucked up into one cylinder while water from the previous stroke is expelled through the other cylinder. The volume of water pumped depends on a) the height and distance the water is moved, b) the diameter of pump cylinders, and c) energy expended by the operator

The range of human-powered pumps includes the MoneyMaker, Super MoneyMaker and Swiss concrete pumps, which have different attributes as shown in table 2.

Table 2. Specification of the pedal pumps in Kenya.

Pump Characteristics	MoneyMaker	Super MoneyMaker	Swiss Concrete
Date introduced in Kenya	1996	1998	1998
Construction material			
Pump body	Metal	Metal	Concrete
Cylinder	Metal	Metal	Plastic
Piston	Metal, rubber	Metal, rubber	Metal, rubber
Other components	Metal, rubber	Metal, rubber	Metal, rubber
Method of joining components	Welding	Welding	Bolts, nuts and screws
Maximum suction depth (m)	6	6	6
Maximum delivery head (m)	0	13	0
Discharge (l/min)	100	100	100
Weight (kg)	15	20	60
Cost (Ksh [$])	4,000 (54)	5,500 (74)	4,000 (54)

Genesis

In 1984, the Colorado-based International Development Enterprise (IDE), which is an NGO with regional offices in Asia and Africa, became involved in disseminating the pedal pump technology, which had originally been developed in Bangladesh. The organization stimulated market demand for the pumps and helped create a network of manufacturers and sellers of the technology. By the late 1980s, in Asia, the pumps had resulted in a large agricultural expansion with hundreds of thousands of farmers producing irrigated crops in the dry season.

A similar evolution started in Kenya in the nineties through a Kenyan NGO known as ApproTEC established in 1991. Before this, its functions were carried out under the then technical unit that used to operate under Action Aid (UK). Under Action Aid, the technical unit had identified the pedal pump and had started working with it. The pump adapted by ApproTEC was from a design developed and promoted in India by Bob Hyde who worked for the IDE. ApproTEC enlisted the services of Bob Hyde in August 1996 to help start the pedal-pump activities in Kenya.

ApproTEC adopts the following approach:
Economic research and feasibility studies
ApproTEC identifies new market/business opportunities by undertaking a subsector analysis to identify market demands in terms of the availability of materials, skills and technologies and the resulting profitability.
Technology and business-development packages
ApproTEC develops/adopts/designs technologies required to start such enterprises. In this respect, ApproTEC designs and develops standardized manufacturing techniques, trains manufacturers and develops required business-information packages.
Promotion, information and marketing
Since most of ApproTEC's designed/developed business opportunities are new, with donor assistance, it spends a lot of time and money promoting and marketing these new opportunities to encourage many entrepreneurs to invest and create new employment.
Monitoring and evaluation
ApproTEC continually monitors the performance of its technologies and responds to the needs for changes to suit local conditions.
It has used this approach to introduce and popularize the pedal pumps in Kenya.

Another organization has also worked with the pedal pump. The Swiss concrete pedal pump for small-scale irrigation is being introduced through an association known as Water for the Third World, based in Switzerland. The origin of this pump, which can be traced to India, is associated with Swiss engineers who started working on the pump with Indian farmers in 1992. The pump was introduced to Tanzania in 1997 in a training workshop and, to date, more than 200 pumps have been manufactured by a pump project at the Tushikamane training center in Morogoro, Tanzania. A participant from Kenya returned with the technology and, in 1998, initiated a local production workshop at ICIPE's Mbita point research center. He has manufactured 10 pumps. The pump promoters are in the process of popularizing this pump technology in Kenya and Uganda.

Current Status

Although costs in human energy are high, farmers have readily adopted the pump and ApproTEC has promoted the pump to an expanding market. Nearly 6,000 units have been sold in Kenya. ApproTEC has set up a network of pump manufacturers and distributors and frequently advertises the pump through national newspapers. The Super MoneyMaker pressure pump has replaced the MoneyMaker as farmers prefer to irrigate with it using sprinklers instead of furrows. ApproTEC has started scaling down the Super MoneyMaker to a product that is half its present cost.

State of the Art

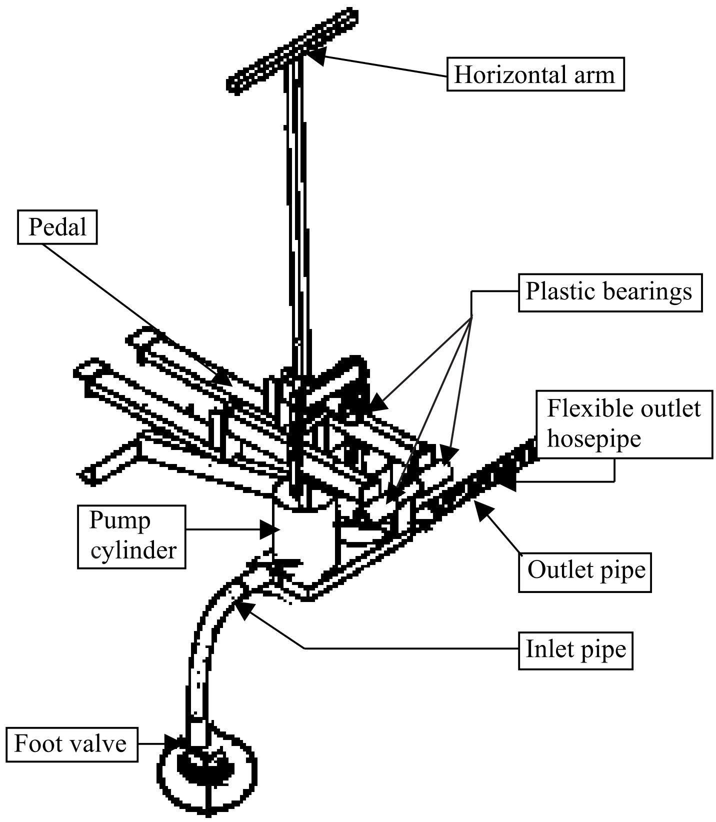
MoneyMaker and Super MoneyMaker pump

Components of the pumps. The MoneyMaker pump is placed above ground, is sufficiently light to be portable and can be moved from the production site at night, is adapted to fitting into existing wells since shallow wells and is guaranteed for 1 year. The pump body, which is the basic structure, is constructed from metal parts. Two pump cylinders each 4" in diameter are also made of metal. The metal parts used in the piston are joined together by welding. The pedals are of metal construction. Rubber products are used in the piston sleeve and valves.

The first generation of ApproTEC pumps was named MoneyMaker and started selling in the Kenyan market in 1996 at a cost of Ksh 4,000 ($54). The pump, which is portable, weighs 15 kg and draws water into a furrow and is capable of irrigating 2 acres of land.

In 1998, a manually operated pressure pump known as the Super MoneyMaker pump came into the market. The pump, which weighs 15 kg, is more powerful and able to irrigate 2.5 acres of land per season using sprinklers. The Super MoneyMaker pump costs Ksh 5,500 ($74).

Figure 4. Super MoneyMaker pump.



O&M aspects of pumps. The smaller MoneyMaker pump is used for suction lifts of up to 6 m and releases the water into furrows. The larger Super MoneyMaker, which has replaced the pump, can be used for suction lifts up to 6 m and a delivery pressure of 13 m. It is used with low-head sprinklers or a hose pipe to irrigate the crops. The pumps, each being 15–20 kg in weight, are light enough to be taken home for safety.

Because grease will damage the rubber cups in the pump it is not applied. Water should be drained from the valve box and foot valve when the pump is not in use to avoid rusting while rubber cups and plastic bearings need to be replaced when they are worn out.

Agronomic aspects. Many crops are grown with these pumps but farmers have selected crops with high payback including kale, tomato, cabbage, onion, French bean, spinach and tree seedlings.

Economic aspects. Both pumps have the potential to change the livelihoods of the farmers. With the MoneyMaker irrigating up to 2 acres, farmers have reported profits of Ksh 60,000 ($800) or more per season. The potential for micro-irrigation pumps in Kenya has been estimated to be over 360,000 units. So far, only about 2 percent of the potential has been exploited.

Swiss concrete pedal pump

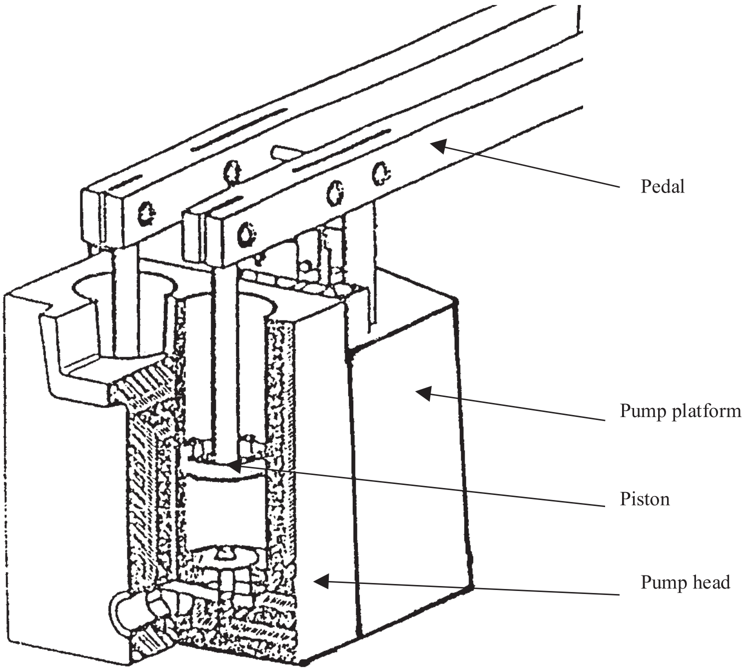
Components of the pump. The foot-driven Swiss pedal (figure 5) pump is a simple tool for manual irrigation of land. It contributes to increased food production and has demonstrated its value in alleviating poverty for smallholder farmers. The body of the pump, which has two parts—pump head and platform—is cast from steel moulds and is made of concrete. The cylinders are cut from 4-inch PVC pipes. After the mould is assembled, a mixture of cement, sand and gravel, in the ratio of 7:7:10, is prepared and carefully packed into the mould and allowed to cure in water for a minimum of 3 days. The piston, valves, equalizer and pedals are fitted. The piston comprises metallic parts that are connected together by bolts and nuts. Rubber is used in the piston sleeve and valves. The pedals used are made of timber. The pump may be fixed permanently or provided with a platform so that it can be moved.

O&M aspects of pumps. The pump draws water from a maximum depth of 8 m and discharges it directly for irrigation, usually by furrow, or leads to a water reservoir. The water should be free from sand, which causes excessive wear to the cylinders. The pump whose weight is about 50 kg cannot be easily stolen. By using concrete for construction, the pump can be used with salt water and requires minimum replacement of the metallic parts, which constitute about one quarter of the pump.

Agronomic aspects. The experience with the pump to date has shown that farmers prefer to grow tomato, kale, cabbage, onion and spinach, and tree seedlings.

Economic aspects. The pump, which is constructed locally in the village, costs less than Ksh 4,000 ($54), is easy to use and requires little maintenance. Farmers have reported good returns on investments when pumping for irrigation, with tomato and tree seedlings showing the highest return.

Figure 5. Swiss concrete pedal pump.



Challenges to Be Addressed

Research and Adaptation of New Technologies

Lack of appropriate and affordable technologies geared towards poor farmers on small plots is a major constraint to the spread of irrigation in Kenya. Most irrigation equipment is imported and costly. Equipment suppliers are few and products are usually too expensive for smallholders. To address this, therefore, appropriate technologies need to be identified and adapted to suit smallholder farmers. These technologies should be:

- appropriate, simple and, if possible, made using local material and skills
- affordable and attract high returns on investment

Therefore, there is a need for continued research, development and adaptation of the technologies as have occurred in Asia. This also calls for technology and backup-support to the farmers as they face new challenges.

Marketing New Technologies

After appropriate technologies have been identified, the challenge is to promote them to the potential beneficiaries. One problem is to not to over-promote the technology to farmers who also may be too ambitious, although they may not have the resources, and end up investing in pedal pump or drip systems when the water supply is inadequate. Small farmers should start "thinking big about small-scale irrigation." By farming on small gardens intensively, farmers maximize production according to available resources. Technology demonstrations should provide enough information, both technical and economic, including information on marketing outlets for the farm produce.

Capital for Small-Scale Farmers

Poverty is probably the greatest challenge to the adaptation of small-scale irrigation technologies. Resource-poor farmers living below the poverty line do not have resources to take off; the initial problem is access to capital. Along with the technologies, therefore, ways and means should be found for these farmers to access the necessary capital. Some possible avenues include:

- establishing merry-go-rounds, where a small group pools its money, to provide the capital for investment
- involving in other income-generating activities
- funding the dissemination of appropriate technologies for self-help in place of relief food
- ensuring that smallholder farmers have secure tenure over their land
- providing loans to smallholder farmers through micro-credit schemes

Information and Networking

As the small-scale irrigation farmers take off, they have to face new challenges. Information and networking are important to provide ready information for these new farmers. This should be addressed in the following possible ways:

- Provide information on who is who in the technology-dissemination sector so that the farmers will know where to go when things go wrong.
- Encourage farmers to form small groups to deal with emerging issues (new technology gaps and marketing) and development and maintenance of shared infrastructure.
- Encourage government extension to work with small-scale farmers and help the extension to keep abreast of development in extension.
- Set up regional outlets for dissemination of technology so that farmers can access technologies.

Cultural

African women, not men, bear the burden of fetching water. Men, not women, are often the heads of the home. Unfortunately, men may be comfortable in letting the women fetch water from a distance and even use it for hand-watering of plants instead of investing in affordable labor-saving technologies. This is because, culturally, men are not the ones who do the fetching. This problem needs to be addressed from a cultural perspective, in order to sensitize the heads of families on the advantages of adopting these technologies.

Market and Market Information

With the new technologies, farmers need to address the production strategies. For maximum return on investment, production has to be targeted for the market. Farmers should target their production to the off-season period targeting the local markets when prices are highest. As farmers get organized they should aim at other market outlets including producing for export. To avoid exploitation, by middlemen, farmers should have access to market information. It is necessary to strengthen FOs and networks to minimize the farmers' risks of being exploited by unscrupulous middlemen.

Bibliography

ApproTEC. *Annual reports.* 1996/97.

ApproTEC. *Annual reports.* 1997/98.

ApproTEC. *Annual reports.* 1998/99.

ApproTEC. nd. *Operation manual for the Super-MoneyMaker: Pessure irrigation pump.*

ETC East Africa. 1998. *Report of mid-term evaluation of the ApproTEC MoneyMaker pump.*

KARI. nd. *Garden dip irrigation kits (General manual for eighth-acre systems).* Nairobi: Small-Scale Drip Irrigation Development Poject.

Kihia, J. K.; and R. N. Kamau. 1998. *MoneyMaker suction pedal pump impact assessment in utilisation, job creation and income generation.*

Postel, S., 1999. *Pillar of sand: Can the irrigation miracle last?* Washington, D. C.: Worldwatch Institute.

Sijali, I.V. *Drip irrigation: Options for smallholder farmers in eastern and southern Africa.* Nairobi: (SIDA: Regional Land Management unit (RELMA). (In press)

IWMI/KARI (International Water Management Institute/Kenya Agricultural Research Institute). 2000. *Report on the low-head drip irrigation review workshop at the National Agricultural Research Laboratories, Nairobi.*

Winrock International. 1999. *Review workshop on drip irrigation in Embu and Mbeere districts.*

Zumstein, A.; and A. Kohler. 2000. *Swiss concrete pedal pump: Pedal pump 2000.*