Low-cost irrigation for poverty reduction

An evaluation of low-head drip irrigation technologies in Kenya

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Summary

Unreliable rainfall causes periodic droughts in Kenya. This unpredictability, coupled with the lack of local capacity to deal with the situation, creates a persistent threat of household food insecurity in the region. Low-head drip irrigation technologies were introduced to combat this problem and alleviate food insecurity for thousands of people. First indications from a variety of research sources are that these technologies are a formidable poverty-fighting tool.

IWMI research evaluated the low-head drip systems most commonly available in Kenya. The purpose of this research was to identify and address the technical constraints of the systems and to develop practical recommendations for smallholder farmers, so that they can maximize the benefits of this technology.

Low-head irrigation technologies were introduced in Kenya in 1995 by Christian Mission Aid. The Kenyan Agricultural Research Institute (KARI) has been promoting the technology since 1996.

Until recently, Kenyan smallholders, mostly women, struggled to maintain kitchen gardens, using hand-watering to cultivate vegetables for their families. Hand-watering of vegetable gardens is tedious and inefficient especially where water is scarce. It requires many trips back and forth to the water source (which is often some distance away), and it does not deliver water down to the root zone (Reaves 1995). Rather than go through this tedious and time-consuming irrigation process, many people chose to go without vegetables in their diet during the dry season.

Today, they use low-head irrigation technologies in the form of bucket drip kits to deliver water to their crops effectively, with far less effort and for a minimum cost. Hundreds of poor families that use bucket kits during the dry season have shown that it is possible to produce enough vegetables for their domestic use and even for sale (Lusaka 1999).

Use of the drip kit is spreading rapidly in Kenya and the majority of drip users (some 70-80%) are women (Winrock 2000). Women do most of the gardening in Kenya, and would often carry water from distant water sources to hand-water their vegetables.

Low head drip irrigation technology: Advantages and disadvantages.

Advantages	Disadvantages
• Water saving—a large reduction in the amount of water needed for growing vegetables • Labor saving—plots can be irrigated quickly, simply by filling the bucket • Fewer disease problems, such a mold and powdery mildew (fungal), caused by soil splashing onto plant leaves (Baobab 1998) • Low-cost—the system is priced to fit poor farmers' budgets • Simple to install, operate and maintain • Easy to adapt to meet farmers' particular needs; for example, Ouko (1998) reported that some farmers in the Suba district along Lake Victoria, are fixing 30-m drip lines (rather than the usual 15 m) to larger 50-liter buckets to accommodate longer growing beds • Profitable for small-scale farmers—enabling them to produce enough vegetables for their families and for sale	• Breakage of the filter plug due to brittleness of the plastic used • Less flexibility in terms of emitter spacing and lateral lengths • Easily punctured by sharp objects if poorly handled • Clogging of some emitters • Nonuniformity of emitter discharge along the lateral, especially where land is not well leveled • Lack of spare parts and inadequate extension services • Leakage, especially at bucket connections, if fittings are not done properly, i.e., if the hole is bigger than the adapter; other causes of leakage are punctures, cracks. • Insecurity: fear of theft if the system is installed far from the house • Pest attraction—being the only green spot, especially during the prolonged dry spells, insects, rodents, aphids, etc., find refuge in the drip gardens; porcupines in search of water have even been reported to puncture drip lines in the Suba district (Ouko 1998)

(Winrock 2000)

Improved household nutrition and incomes

Drip kits do have disadvantages *(see box)* but the positive socioeconomic impacts seem to outweigh them. Farmers reported gross profit margins ranging between Ksh. 4,000-10,000 ($80-200) with a single bucket kit per season, depending on the type of vegetable (Winrock 2000), and between Ksh. 20,000-30,000 ($400-600) per season with the 1/8 acre kit (Nyakwara et al. 2000; Winrock 2000). These kits enable farmers to grow high-value crops, and they create employment opportunities in the rural areas. This adds up to a significant potential for poverty alleviation.

Take the case of Mrs. Mutai (KARI 1998). She is one of 150 women who were members of a group that started using drip irrigation in Eldoret. The system was installed in December 1996. Four months later, she had already sold enough vegetables to invest in more lines and make her garden bigger. Another member of the women's group, Anne Butia, has sold Ksh 10,000 ($200) worth of vegetables in three months from her tightly-fenced garden. Neighbors used to walk 10 kilometers to another district to buy vegetables but now they buy them from her. She has used the extra income to pay school fees and buy clothes for her family.

These and other cases show that low-head drip irrigation is proving to be a promising technology for responding to shortages of water and food in arid and semiarid areas. Low-head drip irrigation technologies promise improved food security and increased incomes at the household level, ultimately culminating in a healthy national economy (Winrock 2000). Ndiritu (1999) goes further, saying that "the bucket kit is the salvation of our country, as it allows the poorest of the poor to produce vegetables under conditions that previously would have only produced starvation and death."

Types of low-head drip systems

With low-head drip irrigation the oversophisticated and overengineered control elements used in the conventional drip systems are minimized and replaced by simple do-it-yourself equipment—low-head drip irrigation technologies.

Low-head drip systems operate under pressures of 0.5-2 m water head compared to the 10-15 m water head needed for standard drip irrigation (Gilead 1985). Small reservoirs such as oil drums can be used as header water tanks. These are supported on blocks so that the water pressure falls within the required range. Perforated flexible plastic piping conveys water to the plants. Low-head drip irrigation technologies includes gravity drip irrigation and bucket and drum kits.

Gravity drip irrigation

Gravity drip irrigation makes use of very low pressures. It fits into the infrastructure of existing channels, ditches and gravity-irrigated fields. Due to the low pressures, the system is very sensitive to ground elevation differences and special drip laterals operating under the above-mentioned condition are used (Gilead 1985).

The low operating pressure has many advantages for the design of gravity drip irrigation. These include:

- Enables substantial enlargement of the cross-section of the labyrinth flow passage of each emission unit, which simultaneously will minimize or even avoid clogging.

Translating research into practical tools for farmers

From science to smallholder

'Smallholders' are those women and men farmers who use rainwater and sometimes irrigation water to grow crops on their own land, rented land, or common ground. The majority of farmers in developing countries are smallholders. Many of them have little land and water and little or no money or credit to manage, and they are not empowered to participate in management at village or district level. Smallholders often have no choice but to exploit their land and water resources in ways that lead to widespread and serious environmental damage.

Hundreds of millions of smallholders hardly benefit from past research on land and water management because they do not know about it, and because recommendations are too vague, tools are too impractical or solutions too expensive. Yet much relevant knowledge and expertise does already exist. The challenge before us is to bring practical knowledge and useful tools from research to the minds and hands of small farmers. Through IWMI's research on smallholder land and water management, we work for rural smallholders that farm sloping lands, for those that have no choice but to farm old, infertile soils in the upland parts of river basins and for farmers who are trying to make ends meet in peri-urban areas.

Water and nutrients from the soil are essential to grow crops. Providing an adequate balance of these 'inputs' maximizes the efficiency of investments in both.

Our research goal is to produce more appropriate knowledge and better-adapted tools specifically for smallholders, to help them achieve the optimum water/nutrient balance–consistently and on a long-term basis. Armed with these improvements, farmers can use their water and land resources more effectively and get reasonable returns on their investments. This increases their income and encourages investments in natural resources–to make their use sustainable.

To achieve this goal of putting practical interpretations of our research into millions of smallholder farmers' hands requires considerable 'reach'. We are doing this by building partnerships with National Agricultural Research and Extension Services (NARES), whose task is to do exactly this. We are developing recommendations and tools with NARES, testing and improving them with the help of farmers, and supporting NARES in their efforts to disseminate the results to smallholders and this synergy will create the conditions that substantially improve the well-being of many smallholders, and make use of natural resources sustainable.

Dr. Frits Penning de Vries, is the leader of IWMI's theme on sustainable smallholder water and land management systems.

- The drip rate can be reduced down to 1.2l/h/m, despite the large flow passage.
- Lower drip rate means larger lateral lines and diameter reduction of the distribution and main lines and also of the other control elements.
- It enables use of a lateral produced from a very thin but still very strong plastic film made from a specially tailored polymer, which helps to reduce gravity drip irrigation lateral costs to a minimum.
- Optimal growing conditions can be achieved because the very low drip rate enables round-the-clock irrigation at peak season.

Advances in drip irrigation technology have made it possible to develop a simple bucket/ drum kit system that low-income families can afford (produced by Chapin Watermatics). For several years, bucket kit drip irrigation has helped thousands of families provide fresh vegetables for their families. It has proved especially useful in water-scarce areas where water has to be carried for long distances—requiring that every drop is used in the most efficient way possible.

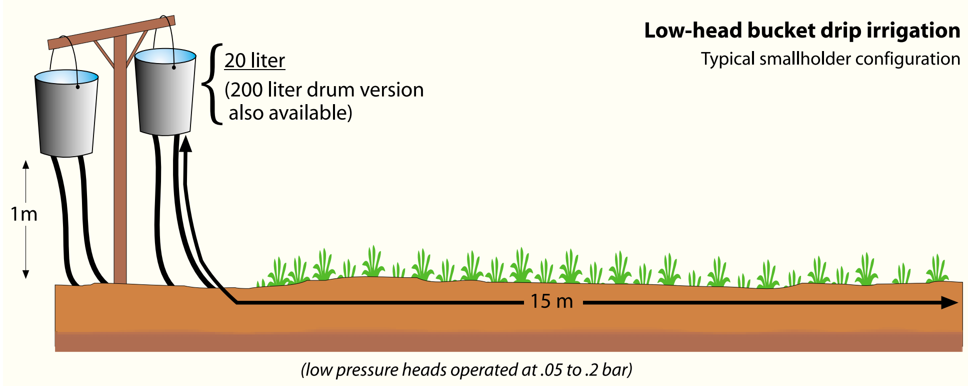
Overview of drip kits and lines available in Kenya.

Type of system/tape	Supplier(s)	Emitter spacing (cm)	Wall thickness (mm)	Tape diameter (mm)	Current cost (Ksh. and US$)
Chapin	KARI, FPEAK	30	0.25	16.0	950 per kit ($19)
T-Tape 520	Booth	20	0.50	16.0	12 per meter ($0.24)
Typhoon 25	Amiran	40	0.63	15.4	16 per meter ($0.32)
Victoria	ShadeNet Ltd.	30	0.50	16.0	9 per meter ($0.18)
Waterboys	KARI, for demonstration	30	0.15	16.0	2,800 per kit ($56)

In Kenya, this simple technology is being promoted by KARI and the Fresh Produce Exporters Association of Kenya (FPEAK) in cooperation with Chapin Third World Projects. The system is gaining popularity and is being used by many families in the Eldoret, Ngong, and Kajiado districts in the Rift Valley province; Gatundu and Ndeiya-Karai in the Central province; Tharaka, Machakos and Kitui in the Eastern province, and in many other drought- prone areas. In addition to Kenya, the bucket kit has also been implemented in Zambia, Mozambique, Malawi, Swaziland, South Africa, Namibia, Uganda and Nigeria (Chapin 1998).

Bucket and drum drip kits

The bucket kit is a small-scale drip irrigation system with high water use efficiency that operates at low pressure heads of 0.5 to 2.0 m (0.05-0.2 bar). It consists of a 20-liter



bucket or a 200-liter drum, drip tape, filters, rubber washers, male and female adapters, two supply tubes and barb fittings. A 0.75-inch screen filter with a flow ranging from 0.9 to 2.5 m^3/h is provided with the drip kit.

The bucket is mounted on a stand, which holds it one meter above the ground. The drip lines are supplied in lengths of 15 m, and, for best results, they are laid on level ground. If the drip lines go up a small slope, the bucket or drum should be placed on the highest side. The lines are laid with the emitters facing up to reduce the problem of sediment settling on the emitters. In the case of the drum system, the drum is connected to a manifold with five openings, each located to cover a bed. The manifold includes a PVC pipe, bends, gate valve, tees, and glue for fitting.

Comparison of the available drip lines in Kenya

There are many suppliers of different commercial drip systems in Kenya. The majority of existing drip lines are designed for high-pressure systems. There are few specifically designed low-head drip lines. These include Chapin, T-Tape and Waterboys. IWMI research evaluated these, and the most commonly available high-head drip lines for use with low-head systems.

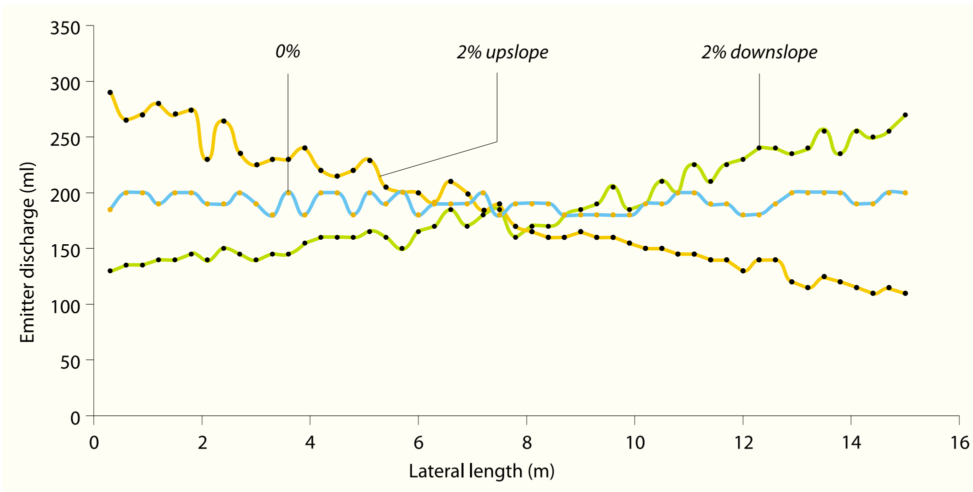
Two common problems experienced by farmers using low-head drip systems are uneven water distribution, especially on sloping land, which can drastically affect yields due to under-irrigation of some plants and over-irrigation of others; and the tendency of emitters to clog. IWMI research tested existing low-head drip irrigation systems in an effort to overcome or at least minimize some of these constraints.

Recommendations for farmers using low-head drip systems

Readily available high-head drip lines can be adapted for use with low-head systems. In addition to Chapin system drip lines, the existing high-head drip tapes, e.g., Typhoon, T-Tape and Victoria, can be used for low-head (as low as 0.5m) bucket kit systems without substantially affecting performance (water distribution uniformity along the drip tape for various supply head, lateral length and land slope). This means low-head drip kits can be assembled locally with readily available high-head drip tapes and fittings.

Land slope has more effect on water distribution uniformity than either head or lateral length. Different drip tapes perform differently with respect to the three parameters evaluated—land slope, lateral length, and water supply head. Thus discharge rates vary with head, slope, lateral length and type of drip tape. Water distribution uniformity decreases with the lateral length, though different tapes perform differently, e.g., for T-Tape, length increases beyond 20 m have no significant effect on water distribution uniformity. Although water supply head seems to have no significant effect on water distribution uniformity, there is a slight improvement with increase in head, especially for high-head-designed tapes. The effect of head is significant for sloping land. However, land slope has more effect on water distribution uniformity than either head or lateral length.

The effect of land slope on water distribution for Victoria driptape.



To adapt to the performance variation between the two drip lines of a kit, farmers should grow crops with higher water demand on the side of the higher performing line. Water distribution varies between the two drip lines of the bucket kit. The difference in performance could be attributed to either one line being a bit lower than the other, more leakage on one line or more clogging on one line. These factors could lead to pressure differences and hence the variations in water distribution. Farmers can adapt to this difference by growing the crops with higher water demands on one side.

For sloping land, the bucket should be placed up-slope; the crops with the highest water demand should be planted down-slope. Water distribution uniformity decreases with an increase in land slopes, whether up-slope or down-slope, but down-slope drip kit layout gives a better water distribution uniformity than up-slope layouts. If land is sloping, as is normally the case, it is advisable to place the bucket on the higher side, i.e., down-slope. For sloping land, high water-consumption crops should be planted on the downstream side while less water-consuming crops should be planted upstream.

Implications of combining any two parameters. The combined effect of any two parameters: water-supply head and land slope, water supply-head and lateral length, and land slope and lateral length revealed that:

- It is not advisable to use longer lengths (beyond 7.5 m) for sloping land.
- It is advisable to use higher head (1.50 m) for longer lateral lengths.
- Water uniformity distribution improves significantly with increase in supply head for sloping land, especially for up-slope layout. Up-slope layout is recommended with high water supply head.

Filters can be improv ised out of common household materials to prevent emitter clogging. To improve water distribution uniformity, a filter which is an important component of the drip kit, is used to prevent emitter clogging. Waterboys, which have no filter, seem to be prone to clogging. Locally available "filter" material, e.g., used lady's stockings, mosquito nets, etc., can be improvised as a form of *'jua kali'* filter.

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This research is part of a series of projects and investigations by IWMI and its partners, examining various aspects of small-scale and informal irrigation in southern and eastern Africa.

The research was carried out with support from the African Development Bank.