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# Can drip irrigation improve the livelihoods of smallholders? Lessons learned from Zimbabwe




International Crops Research Institute for the Semi-Arid Tropics

Science with a Human Face

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## Abstract

It is estimated that one third of the rural population in sub-Saharan Africa is malnourished. Strategies to mitigate the effects of poor agricultural productivity and drought involve developing the continent's unexploited irrigation potential. One intervention, based on successes from Asia, which shows promise in improving household nutrition in the rural areas through better vegetable production, is small-scale drip irrigation. This system is said to save water and labor. Since 2002, some 70,000 low-cost, low-head drip irrigation kits have been distributed through humanitarian relief initiatives in the rural areas of Zimbabwe.

In the dry season of 2006, a country-wide survey was undertaken in Zimbabwe to determine the impacts of drip kits that had been delivered to needy households. Survey results showed that disadoption of drip kits occurred as a function of time and after 3 years only 16% of the kits were still being used. Reasons for disadoption included lack of water, lack of understanding of the drip kit concept, and, more importantly, a lack of technical support and follow up by the non-governmental organizations that distributed the kits and the extension services. A cost-effectiveness analysis showed that drip kits are more cost-effective than traditional hand watering only when potential water savings are achieved. However, this was hardly ever the case due to the beneficiaries' lack of knowledge on crop water requirements when using the kits and a perception that the soil surface should be wet.

Consequently, the study concluded that a relatively complex technology such as drip kits should not be part of short-term relief programs, but should instead be embedded in long-term developmental programs that involve both the public and private sector. This will ensure that appropriate technical support is provided in terms of crop management and the development of supply chains for spare parts and additional kits.

**Keywords:** micro-irrigation, vegetables, drip irrigation, cost-effectiveness

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# Contents

## Introduction

Farming systems are shaped according to hydroclimatic conditions; for example, pastoral systems dominate areas with low annual rainfall and multiple cropping systems have evolved in humid agroecosystems (Rockström, 2007). Much of southern Africa, including Zimbabwe, is located in the semi-arid tropics with highly variable annual rainfall that directly affects crop production and grazing. To ameliorate the vagaries of the weather – which are expected to become more extreme due to global climate change – a range of options have been developed for various levels. One such option is to store water in dams; other options include increasing rainwater harvesting for field crops or growing drought-tolerant crops.

Water stored in dams can in many instances be used to irrigate crops. However, the technical potential for irrigation in sub-Saharan Africa is highly underutilized as only 16% of potential land is irrigated (FAO, 2006). This underutilization has many causes such as poorly developed infrastructure and mismanaged schemes, resulting in limited productivity, yield and income growth for smallholder communities (Moyo et al., 2006).

Besides the increasing unpredictability of the weather, many smallholder farmers in Zimbabwe have become extremely vulnerable as a result of prevalent socioeconomic conditions and the HIV/AIDS pandemic. Many of these vulnerable people have limited or no access to markets or else lack the buying power to purchase food. This has increasingly led households to rely on assistance from outside. Non-governmental organizations (NGOs), among others, have taken up the challenge to assist vulnerable households in food production.

One form of assistance is the drip kit – a small system of pipes, emitters and a drum that has the potential to reduce water use in crop production. Merry et al. (2006) argue that such micro-irrigation systems can lead to substantial gains in production for smallholder farmers because micro-irrigation technologies are relatively inexpensive, can be individually managed, and provide households immediate gains.

The concept of drip irrigation originates from the years after World War II (Sijali, 2001), and is successfully practiced on large commercial scales in the arid and semi-arid regions around the world, such as in Australia, Israel, Jordan, Mexico, South Africa, and USA. Water in such large-scale systems is distributed much more efficiently with drip irrigation than conventional flood and sprinkler systems, reducing the total amount of water required to grow a crop (Maisiri et al., 2005; Polak and Yoder, 2006). For smallholder farmers who carry water to their gardens in buckets or watering cans, any interventions that save water and reduce household labor demands have great promise. Drip irrigation kits that operate on small plots of 10−200 $m^2$ have been successfully adopted by thousands of smallholder farmers in Bangladesh, India and Nepal (Polak and Yoder, 2006). However, Namara et al. (2005) found that in the two Indian states of Gujarat and Maharashtra drip kits were more likely to be adopted by rich than poor farmers and higher levels of education also increased the likelihood of adoption (see Annex for more details on small-scale drip systems).

Based on these premises and successes in Asia, the concept of small-scale, low-cost drip irrigation systems has been seen by many as a panacea for the drought-prone regions of southern Africa, with a strong focus on vulnerable and HIV/AIDS affected households. The objective of distributing kits was to boost gardening activities and thereby improve household nutrition and food security. Since 2002, some 70,000 low-cost, low-head drip irrigation kits have been distributed to households throughout the rural areas of Zimbabwe as part of ongoing humanitarian relief initiatives.

However, emerging lessons from Asia (Namara et al., 2005; Polak and Yoder, 2006), Kenya (Kulecho and Weatherhead, 2005), and Zimbabwe (Moyo et al., 2006) raise major concerns about the appropriateness of drip kits as part of humanitarian relief initiatives. In India, the drip kits (among other technologies targeted at the poor) were subsidized and not given out for free. Farmers had to invest their own money (Namara et al., 2005), as opposed to the free handouts in Kenya and Zimbabwe. This resulted in higher rates of adoption in India than in Kenya and Zimbabwe. In fact, preliminary impact studies in both Kenya (Kulecho and Weatherhead, 2005) and Zimbabwe (Moyo et al., 2006) found that the majority of drip kits were abandoned within 1–2 years after distribution. The disadoption of the technology was ascribed to unreliable water sources, lack of access to spare parts for maintenance and a clash with the traditional culture of bucket irrigation.

The study presented in this paper is a follow up on the study by Moyo et al. (2006), and was expanded to cover both high and low annual rainfall areas of Zimbabwe. The survey focused on the determinants of success and failure and identified knowledge gaps that influenced either adoption or disadoption by beneficiaries. A cost-effectiveness analysis was also undertaken to compare drip kits with traditional bucket irrigation. Finally, the study draws some conclusions and lessons that can be extrapolated beyond Zimbabwe to ensure that interventions aimed at smallholder irrigated gardens have more sustainable impacts.

## Materials and methods

The data collection was done in the form of formal face-to-face interviews with both beneficiaries and non-beneficiaries of drip kits. The latter group was supposedly representative of practitioners of alternative micro-irrigation methods. A database from the FAO emergency office in Zimbabwe with distribution data of the 04/05 and 05/06 seasons was used to select districts and wards. Table 1 presents the sampling frame with distributing non-governmental organization (NGO) and number of interviews per district. The sampling frame was chosen to have a good representation of different distributing NGOs and low and high rainfall areas. Low rainfall areas receive on average less than 650 mm year$^{-1}$ and high rainfall areas receive on average more than 750 mm year$^{-1}$, with most of the rainfall occurring between November and March. Annual rainfall is believed to be a good proxy for water availability for a district, but could differ locally as a result of stored water in reservoirs and rivers.

The interviews were conducted in the local vernacular, Ndebele and Shona, in the winter season of 2006 from 17 July to 18 September. A group of enumerators was trained in distinguishing different drip kit types, translating the questionnaires, determining the different water sources, and identifying problems with drip kits. They were also made aware of the possibility of false responses. In most cases, gardens and water points were visited to follow up on the responses from the interviews. This was necessary because respondents came to believe that their answers might determine the amount of assistance they will receive in the future, despite a clear explanation that the purpose of the survey was to improve micro-irrigation practices.

Labor data on jobs, such as planting, weeding, fertilization, watering, and cleaning filters were collected on drip kit use and hand watering from 13 successful drip kit users. The labor figures are based on a 10 × 10 m plot for one season. Unusually high and low labor figures for each operation were left out.

All data were encoded and double entered in SPSS software. The analysis consisted of straightforward frequency distributions and cross tabulations.

**Table 1. Number of beneficiaries and non-beneficiaries of drip kits interviewed in the dry season of 2006 in Zimbabwe for low and high rainfall areas with details on district, ward number, and distributing NGO**

| District | Distributing NGO | Ward no. | Beneficiaries | Non-beneficiaries |
|---|---|---|---|---|
| | | **High rainfall (750–1200 mm year$^{-1}$)** | | |
| Zvimba | ZRCS[a] | 3 | 13 | 5 |
| | | 5 | 0 | 5 |
| Goromonzi | ZWB[b] | 2 | 10 | 5 |
| | | 3 | 14 | 4 |
| Makoni | GOAL | 16 | 10 | 5 |
| | | 27 | 0 | 6 |
| Mutasa | Africare | 4 | 15 | 5 |
| | | 6 | 11 | 5 |
| | | **Low rainfall (<650 mm year$^{-1}$)** | | |
| Insiza | WVI[c] | 3 | 8 | 0 |
| | | 17 | 12 | 0 |
| Beitbridge | WVI | 5 | 6 | 4 |
| | | 6 | 12 | 6 |
| Gwanda | ZRCS | 1 | 1 | 0 |
| | | 2 | 0 | 4 |
| | | 4 | 5 | 5 |
| Zvishavane | LDS[d] | 15 | 7 | 0 |
| | | 8 | 9 | 0 |
| Chivi | LDS | 23 | 10 | 0 |
| | | 24 | 7 | 0 |
| Binga | ADRA[e] | 17 | 12 | 5 |
| Tsholotsho | PLAN | 10 | 11 | 4 |
| | | 11 | 4 | 7 |
| Chipinge | PLAN | 27 | 20 | 0 |
| Chiredzi | PLAN, FACT[f] | 4 | 19 | 0 |
| Mangwe | WVI, LEAD[f], | 6 | 7 | 2 |
| | CADEC[g] | 7 | 9 | 8 |

[a] Zimbabwe Red Cross
[b] Zimbabwe Women's Bureau
[c] World Vision International
[d] Lutheran Development Services
[e] Adventist Relief Services Agency
[f] Family AIDS Caring Trust
[g] Linkages for Economic Advancement of the Disadvantaged
[h] Catholic Development Commission

## Results

It is increasingly difficult to obtain accurate pictures of farmer behavior in Zimbabwe because of the persistence of free handouts under humanitarian relief programs. Farmers have gained an understanding of the answers needed to qualify for assistance. Also, at least some farmers are wary of answering questions in the fear that they may be disqualified from receiving relief assistance in the future.

Nonetheless, the survey results present a reasonably consistent picture of the experiences of small-scale farmers with drip kits and their most common alternative irrigation practice – the use of buckets and watering cans. These results provide a basis for drawing a clear set of conclusions about this technology as it is currently distributed in Zimbabwe and opportunities for future investment.

The respondents received the drip kits from nine different NGOs or their implementing partners (Table 1). The total list of NGOs involved in drip kit distribution is actually much longer. In some districts and wards, such as Mangwe, there were multiple rounds of distributions by different NGOs. Most of the households interviewed during the course of this study received their drip kit in 2005 (Table 2).

The majority of kits were imported from India, Israel or South Africa, with about three quarters having online emitters (see Picture 1 for example); the remaining 25% had inline emitters (Table 3, Picture 2). Most of the kits were distributed with drums; some had barrels for water tanks. No buckets as water tanks were found.

*Picture 1. Example of online emitter system.*

**Table 2. Utilization of drip irrigation kits by year of distribution in wet and dry seasons ($N$ = 232)**

| Year distributed | No. of kits | Percentage of total sample | Percentage working in dry season of 2006 | Percentage working in wet season of 2005/06 |
|---|---|---|---|---|
| <2004 | 19 | 8.2 | 15.8 | 10.5 |
| 2004 | 61 | 26.3 | 38.2 | 23.6 |
| 2005 | 143 | 61.6 | 68.9 | 43.9 |
| 2006 | 9 | 3.9 | 100.0 | – |

*Picture 2. Example of inline emitter system.*

**Table 3. Manufacturer, emitter type and cost of drip kits that were encountered during survey ($N$ = 232)**

| Manufacturer | Type of emitter | Approximate cost (US$) | % sample |
|---|---|---|---|
| IDE[a] – India and UK | Online, micro-tubing | 15 | 75.1 |
| Netarfim – South Africa | Inline | 25 | 2.8 |
| Plastro – Israel | Inline | 25 | 22.1 |

[a]IDE kits were procured from IDE, India and Even Products, UK

The drip kits were often distributed together with other inputs such as seeds (nearly 100% of beneficiaries) and fertilizer (45% of beneficiaries). Most common seeds were tomato and rape followed by cabbage, carrot and onion.

Approximately 60% of the kits commanded 100 $m^2$ plots and 30% commanded 200 $m^2$ plots. The remaining 10% were said to be odd sizes, in part because households were uncertain about the proper configuration.

### Targeting of households

Most NGOs that distributed drip kits, claimed to target 'vulnerable' households. Two factors were commonly mentioned as main criteria underlying vulnerability – whether household members were "infected and affected by HIV/AIDS" and the wealth of the farm family.

Two measures were commonly used to designate households affected by HIV/AIDS. The first was whether or not the household had a chronically sick adult. The second was whether or not the household had any resident orphans. By these two measures, beneficiaries of drip kits were only marginally more likely to be affected by HIV/AIDS compared to non-beneficiaries (Table 4), the latter group representing ordinary vegetable growers. More than 90% of the kits went to households meeting at least one criterion. The proportion of households with orphans appears high relative to other survey data collected by ICRISAT. It is possible that beneficiaries of relief aid now recognize this as an important criterion in qualifying for assistance.

**Table 4. Health and social status of beneficiaries and non-beneficiaries of drip irrigation kits, winter 2006**

| Health and social status | Beneficiaries (*N* = 232) | Non-beneficiaries (*N* = 85) |
|---|---|---|
| % of households with at least one chronically ill adult | 34.5 | 30.4 |
| % of households with at least one orphan | 57.8 | 51.9 |
| % of households with at least one chronically ill person or orphan | 74.6 | 72.2 |
| % of female-headed households | 28.8 | 36.3 |
| Dependency ratio[a] | 1.75 | 1.59 |

[a] Number of children (aged 0–15) + number of elderly (over age 60) + number of sick adults (aged 16–60) all divided by the number of resident adults in good health.

Source: ICRISAT/UZ micro-irrigation surveys (2006)

In the past, NGOs have also sought to target female-headed households. The survey results indicate, however, that this was not consistently done in the case of drip kit distribution.

The dependency ratio of households that received drip kits was slightly higher than for households without kits, but these differences are not statistically significant.

Similarly, most comparisons of the wealth status of beneficiaries and non-beneficiaries show little difference (Table 5). If anything, beneficiaries were slightly wealthier than non-beneficiaries. They were marginally more likely to own cattle, a plow, an ox cart, a radio and a bicycle.

### Drip kit use

Most households tried the drip irrigation kits for at least one full cropping season following their distribution, but stopped using them within a year or two (Table 2). A disadoption pattern is

**Table 5. Asset ownership of households receiving drip irrigation kits versus non-beneficiaries, winter 2006**

| Asset ownership | Beneficiaries ($N$ = 232) | Non-beneficiaries ($N$ = 85) |
|---|---|---|
| % of households owning two or more cattle | 57.8 | 48.9 |
| % of households with goats | 73.3 | 74.8 |
| % of households with plow | 71.6 | 60.7 |
| % of households with ox cart | 49.1 | 34.4 |
| % of households with radio | 48.2 | 42.0 |
| % of households with bicycle | 50.4 | 35.9 |

Source: ICRISAT/UZ micro-irrigation surveys (2006).

clearly evident as a function of time since the year of distribution. After 2 years, only about a third of the kits that had been distributed in 2004 were still being used during the dry season of 2006 when the survey was carried out. After 3 years, only 16% of beneficiaries were still using the kit in the dry season. Kit use, as expected, was lower in the wet than in the dry season. So only some 10% of beneficiaries seem to have consistently used the kits for several years during the wet and dry seasons.

From a sub-sample of 29 households, a stricter effort was made to assess to what extent the kits were being used. Virtually all of the households had placed their kit in the garden and laid out their vegetable beds to correspond with the configuration of the kit (Table 6).

In almost all cases, farmers were adding supplementary irrigation with buckets (see Picture 3). Quantitative data showed virtually no difference in water use between plots where kits were laid out and plots that were watered entirely by hand. The potential water and labor savings of the drip kits could therefore not be attained.

**Table 6. Usage of drip irrigation kits split into several aspects**

| Task | Percentage of households ($N$ = 29) |
|---|---|
| Complete kit appears in the garden | 82.8 |
| Garden beds correctly laid out | 89.7 |
| Barrel has water | 44.8 |
| Kit appears to be commonly used | 55.2 |
| Supplemental water has been added | 82.8 |

Some 90% of the farmers who received drip kits were already practicing micro-irrigation before they received assistance (Table 7). The most common way is to use buckets and watering cans (see Picture 4); a few also irrigated with hosepipes and sprinklers.

The distribution of drip kits was commonly justified as a means to improve the nutritional status of the household by encouraging the production of vegetables. Yet 90% of the farm households receiving the drip irrigation kits had previous experience growing vegetables. In effect, most were already growing these crops. The survey data also indicate that there was no significant change in crops grown as a result of receiving the kits (Table 8).

*Picture 3. Saturated soil surface is a give away sign of supplementary irrigation with buckets.*

**Table 7. Range of irrigation practices applied by farm households, surveyed dry season 2006**

| Irrigation practice | Percentage of drip kit beneficiaries ($N = 232$) | Percentage of non-beneficiaries drip kits ($N = 85$) |
|---|---|---|
| Buckets or watering cans | 87.6 | 93.7 |
| Hose pipe | 6.0 | 0.7 |
| Dambo/flood | 3.2 | 3.5 |
| Other (sprinkler, irrigation pipes, etc.) | 3.2 | 2.1 |
| None | 6.9 | 0.0 |

**Table 8. Vegetable crops most commonly grown with and without drip irrigation**

| Drip irrigation ($N = 232$) | Non-drip irrigation among farmers who received a drip kit ($N = 220$) | Non-drip irrigation among farmers who did not receive a drip kit ($N = 85$) |
|---|---|---|
| 1. Tomatoes | 1. Tomatoes | 1. Tomatoes |
| 2. Rape | 2. Onions | 2. Onions |
| 3. Cabbage | 3. Rape | 3. Covo |
| 4. Onions | 4. Cabbage | 4. Rape |

*Picture 4. The most common way to water gardens is using buckets*

On the contrary, the variety of crops grown with alternative practices was higher than with drip kits. Most households continued to grow tomatoes, rape, cabbage, and onions (see Pictures 5 and 6). If there was an increase in nutrition, this would have been derived from an increase in the volume of vegetables harvested, not in the types of vegetables grown. This increase in volume, however, could not be established.

The percentage of people who were able to market their produce during the dry season of 2006 was higher among non-beneficiaries (55%) than beneficiaries (41%).

*Determinants of utilization of kits*

Disadoption was mostly caused by (i) distance to water source in combination with labor requirement and (ii) lack of understanding and follow up (ie, inadequate training and back-up services). Although most beneficiaries claimed to have only temporarily stopped using the kits, the fact that the interviews took place in the middle of the gardening season supported the idea that the stoppage was rather definitive (Pictures 7–13).

### Distance to water source in combination with labor requirements

Pictures 14–17 show the main type of water sources. NGOs generally sought to provide drip kits to farmers with favorable access to water. Almost 45% in drier and 60% of households in the wetter regions claimed to have access to water within 10 m of their garden plot (Table 9).

**Table 9. Distance to water among households with drip kits, 2006**

| Distance (m) | Percentage of households in the drier regions ($N$ = 159) | Percentage of households in the wetter regions ($N$ = 73) |
|---|---|---|
| 0–10 | 44.7 | 58.3 |
| 11–50 | 15.1 | 15.2 |
| 51–200 | 14.4 | 13.9 |
| +200 | 23.3 | 12.5 |

*Picture 5. Tomatoes and chomoulia are two commonly grown vegetable crops.*

*Picture 6. Tomatoes, onions and rape grown under drip irrigation.*

*Picture 7. Although two drip lines are in the field, no drum is being used and other drip lines are lying idle.*

*Picture 8. Drip lines taken from the field and stored in a shelter.*

*Picture 9. Drip lines hanging idle where a drum should be. Vegetables obviously being watered by buckets.*

*Picture 10. Drip lines crisscross through vegetable beds being watered by buckets.*

*Picture 11. This farmer (right) never received training on how to assemble a drip kit.*

*Picture 12. Drip lines lying idle.*

*Picture 13. Platform for drum is still in the field but drip kit is not being used anymore.*

Another 30% of households had to travel up to 200 m to fetch water for their gardens. Almost one quarter of the beneficiaries in the drier regions had to travel more than 200 m for their 'irrigation' water. This sort of journey would be very time consuming and difficult without access to an ox, donkey cart or wheelbarrow. A 100 $m^2$ garden easily requires 100–300 liters of water per day or the equivalent of 7–20 buckets of water if a bucket contains 15 liters of water. If the water source was not within the garden, more than 80% of beneficiaries decided to give up on drip irrigation (Table 10). This disadoption trend could also partly be explained by the inflexibility of the drip system to adjust the area under drip so that beneficiaries had to decide between a 100 or 200 $m^2$ area or no drip at all. Most decided the latter option and irrigated smaller plots that better matched their labor availability. Besides the distance to carry large amounts of irrigation water, filling the drums with water was considered to be a hassle. Vulnerable people may have found that filling the drums required too much energy.

Correspondingly, approximately 80% of households in both wetter and drier regions obtained their water by hand, carrying it in buckets to their garden plots (Table 11, Picture 18). A small proportion used wheelbarrows and a few households in drier regions used ox carts. Unexpectedly, more than 10% of households in the higher rainfall zones claimed to have pipes leading into their garden plots. Only 12% experienced restrictions on water

**Table 10. Percentage of beneficiaries using drip kits as function of distance to nearest perennial water source, 2006**

| Distance (m) | Percentage of household ($N$ = 173*) |
|---|---|
| 0–10 | 49.7 |
| 11–50 | 16.2 |
| 51–200 | 15.6 |
| +200 | 18.5 |

* only households without restrictions to water access

*Picture 14. Pit in riverbed as water source.*

*Picture 15. Borehole.*

*Picture 16. Dambo plot with shallow groundwater table; dambo plots are often too wet to grow vegetables in rainy season.*

*Picture 17. Water reservoirs behind dams provide plenty of water and make people move their garden to the shore.*

**Table 11. Principal means of carrying water for use in gardens, 2006**

| Means of carrying water | Percentage of households in the drier regions ($N$ = 159) | Percentage of households in the wetter regions ($N$ = 73) |
|---|---|---|
| Hand | 78.6 | 82.6 |
| Wheelbarrow | 13.3 | 5.4 |
| Ox cart | 4.1 | 0.0 |
| Other | 2.9 | 13.0 |

use for crop production. In almost all cases, these restrictions were defined as limited. Problems of water availability were more common than the imposition of community controls on water access.

### Lack of understanding and follow up

Nearly all the drip kit beneficiaries received some form of training in their use, which in 90% of the cases was provided when they received the kit. This training was often in the form of a demonstration on setting up the kit, the principles of irrigation practice, kit maintenance, dealing

*Picture 18. Most water for vegetables is carried by women on their heads.*

with blockages, and crop production practices and was in most cases provided by the NGO. Government extension workers belonging to the Agricultural Research and Extension Services (AREX) were involved in less than 10% of these sessions. After the initial demonstration, less than 50% of the beneficiary households received any follow-up visits or subsequent training to discuss and resolve emerging problems with the kits and often the AREX staff did not feel part of the drip kit program or lacked the means to provide assistance.

When households were asked what type of additional training they wished to have, almost 60% of households acknowledged a need for advice in the operation of their micro-irrigation kits. Many also sought more assistance in maintaining the kits, clearing blockages and the principles of irrigation practice. Also, some 20% of the respondents asked to receive additional advice on crop production practices.

However, even the aspects of drip kit use that were part of the initial demonstration were often not fully grasped by the beneficiaries. Although most beneficiaries (81%) had a good understanding of how to lay out and set up the drip irrigation kit, the frequency of irrigation was not fully understood as became apparent by the practice of adding extra water by hand. Many respondents raised concerns about dry soil in drip irrigated beds and dying vegetable plants, because they were apparently not getting enough water. This concern was particularly strong during the hottest months of the year. Some respondents argued that the emitters were not providing enough water to the plants when the weather was hot but this was not likely to be the case since the nominal discharge per emitter point is more than adequate to meet crop water requirements. However, it is also possible that households were not filling the water barrel often enough. In general, the initial training that most beneficiaries received was not sufficient to ensure beneficiary households could deal with all problems.

### Cost-effectiveness of drip kits relative to buckets

This analysis was difficult to conduct because of the many variables influencing both the costs of kit distribution and use. A small change in one or two of these variables can reverse the cost-effectiveness ranking. For example, the cost of the drip irrigation kits and buckets depends on a range of factors such as import and distribution cost. Importing kits has become the normal way for NGOs to purchase drip kits as the cost was much lower than buying them locally due to the high rate of inflation and the exemption of duty.

The cost analysis also requires an assumption about the lifespan of the various pieces of equipment. For the purposes of this analysis, both buckets and drip kits were assumed to last 2 years. The inline kits (Picture 2) cost approximately US$25 per unit. The online kits (Picture 1) were said to cost US$15 per unit, but require dripper replacements each year, raising the price to US$20.25 per unit. The budget analysis therefore assumes a kit cost of about US$22 per unit. A comparative figure of US$5 was assumed as the cost of a 20 liter bucket.

An approximate figure of US$20 was used for the distribution of each kit, including NGO staff time, transport and farmer training. A comparative figure of US$10 was assumed for the distribution of buckets, with the understanding that these require little training support. The labor coefficients are summarized in Table 12.

The main advantage of using a drip kit is the more efficient use of water. Less water is used per plant and this is reflected in the estimate of a 50% decline in labor costs in watering the plot. However, the survey highlighted the fact that many households were adding supplemental irrigation water to plots with kits. This would obviously increase the labor coefficient for watering.

**Table 12. Labor hours required to grow 100 m² of vegetables in the dry season of 2006 (130-day growing cycle for tomato, rape, cabbage and onions)**

| Task | Time spent – drip irrigation (h) | Time spent – bucket irrigation (h) |
|---|---|---|
| Setting up kit | 2 | 0 |
| Planting | 3 | 3 |
| Fertilization | 3 | 3 |
| Weeding | 6 | 7.5 |
| Filling drip kit or watering with bucket | 65 | 130 |
| Cleaning filter | 16 | 0 |
| Flushing pipes and nozzles | 28 | 0 |
| Harvesting | 11 | 11 |
| Totals | 134 | 154.5 |

The use of buckets also seems to marginally increase the demand for weeding. Again, if drip kit plots receive supplemental irrigation with buckets, as commonly occurs, this labor advantage is lost. Much also depends on the value attached to farm family labor, and the associated exchange rate applied. In this case, we assume a value of US$0.8 per day.

Table 13 summarizes the approximate results of the enterprise budget analysis. These suggest that bucket irrigation is marginally cheaper than drip irrigation. However, this difference is small relative to the variability in data underlying this analysis. By implication, the relative costs of distributing these alternative technologies should not be the major determinant of choice underlying their application. It can be argued that for drip irrigation, one would still require a bucket to fill the drums making the drip kits even less cost-effective than buckets alone.

**Table 13. Approximate costs of drip kit versus bucket irrigation, dry season 2006 (US$)**

| Cost | Drip irrigation | Bucket irrigation |
|---|---|---|
| Kit and spare parts (10 × 10 m) | 22 | 0 |
| Bucket (20 l) | 5 | 5 |
| Input distribution to farmers | 20 | 10 |
| Labor to manage the vegetable plot | 107 | 124 |
| Total cost | 154 | 139 |

## Discussion

The survey results indicate that most farmers who received drip irrigation kits tried to use them and eventually gave up. The majority of these households appear to have supplemented drip irrigation with bucket irrigation – raising questions about the underlying justification for the kit. A small minority, perhaps 10% of households, has tried to use the kits more consistently.

The failure of the drip irrigation investment reflects problems of inadequate training and uncertainty about how the kits should be used. When problems arose, farmers were more likely to abandon the kit than to try to figure out a solution. Since most of the training and backstopping was provided by NGOs, rather than AREX, sources of information about how to resolve problems or find spare parts were limited. The role of AREX was severely limited – mostly to the provision of advice on vegetable production per se.

The failure of drip irrigation also reflects the fact that water resources were less constraining than originally anticipated. Virtually all of the households receiving drip irrigation kits already practiced gardening prior to this handout. The main irrigation practice was the use of buckets to water vegetable beds. In general, gardens were placed close to a water source in order to avoid having to carry water for long distances; otherwise the size of the gardens was reduced. If a household did not have a pre-existing garden, this was a sign that water was too distant from a possible garden plot.

The main objective of most of the NGO programs promoting the use of drip irrigation was to improve the food security and nutrition levels of rural households through the establishment or expansion of vegetable production. The recent experience with drip kits suggests this objective ought to be pursued through alternative strategies. The main constraint to vegetable production for food security purposes does not appear to be the lack or high cost of water. In all probability, larger gains may be achieved through improved management. Only 45% of the households receiving drip kits also received fertilizer, mostly in 20 kg bags. While many households use manure on their vegetable plots, the nutrient content of this input tends to be low and the release of nutrients is slow. Supplemental fertilizer is essential for good crop growth and high productivity. Vegetable plots may benefit as much from microdosing technologies as grain crops. Many respondents also indicated the need for training in gardening and mentioned the lack of knowledge and means to combat pests and diseases and the lack of good seeds.

Almost all households received small packets of vegetable seed, though the range of seed crops varied. Some received only one or two seed crops whereas others received as many as seven different types of seed. It might be worthwhile to re-assess the varieties chosen and seek out seed of more productive varieties for these agro-ecologies.

The survey highlighted how only a few farmers receive vegetable production advice from AREX. Less than 5% of households received advice on crop production practices from the national extension service. It is possible that most extension agents are simply not trained to provide such advisory assistance, but it could also be that AREX officers are too resource constrained to go around and advise farmers on the spot, leaving farmers to develop gardening methods on their own.

Whereas water access appears less of a constraint than expected, the lack of consistent water supplies near a homestead also clearly limits even the possibility of a garden plot. Many households with limited access to water still try to grow a few vegetables near the homestead with waste water. But the practicality of a 100 $m^2$ irrigated plot is low. Most of these farm families will benefit more from the development of water resources nearer the household for drinking, washing, watering livestock, as well as gardening.

This investigation thus comes to the conclusion that the promotion of drip irrigation is generally not suitable as a component of humanitarian assistance programs. If the primary aim is to improve household nutrition, higher returns may be obtained from efforts to improve the productivity of vegetable production per se, for example, with improved seeds and fertilizer. Where water is most limiting, investments are warranted in developing supplies for the wide range of household uses.

If drip irrigation kits are to be promoted as a development intervention, several practices that improve the likelihood of their success should be adopted. Assuming water is readily available, the operation of the kit would undoubtedly benefit from the addition of a water-lifting device. Farmers commonly complained about the difficulty of lifting water into the barrels (Pictures 19 and 20), and this prevented the use of enough water to make the kits work successfully. The solution for many was to add supplemental irrigation with buckets directly to the plant.

*Picture 19. Pouring water into the drum for drip irrigation.*

*Picture 20. This drum is elevated far too high to be practical for this group of beneficiaries.*

The survey results also highlight the need for continuing monitoring and advisory assistance. Farmers commonly remain confused about how much water to use and how much water is needed for good crop production. But, in addition, many remain uncertain, despite their initial training, on how to maintain the kits and resolve blockages or breakdowns. When such problems arise, the kits are more likely to be abandoned than repaired. In effect, the drip kit is no different from any other complicated agricultural technology. Ongoing assistance is needed over several cropping seasons to diagnose problems and misunderstandings and ensure the appropriate application of the technology. As cited above, this advice should be extended to the provision of crop production methods.

If the drip irrigation kits are successfully used and vegetable production improves, marketing problems will eventually become more constraining. Considerable benefits may be derived from the provision of advice about market opportunities, market niches, product quality control and grading practices. As farmers produce for the market, greater assistance related to safe practices in the use of pesticides and fertility management will be required. Vegetable prices can also be improved through various interventions relating to supply chain management such as the development of production contracts with urban supermarkets.

Finally, improvements in the effectiveness of monitoring programs underlying these sorts of humanitarian interventions are needed. Problems with the application of drip kit technologies were identified several years ago. A presentation was made to local donors and NGOs highlighting many of the problems cited in this paper. Still, NGOs continue to distribute drip irrigation kits without due consideration of these issues. Donors and NGOs face a strong incentive to highlight their successes rather than diagnose their problems to justify more funding. However, if the difficulties with new technologies are not acknowledged and resolved, the payoffs to these investments will remain limited. Technologies meant to support sustained gains in household food security will instead lay the grounds for yet another round of relief.

Consequently, we believe that a relatively complex technology such as drip kits should not be part of short-term relief programs, but must be embedded in long-term developmental programs that involve both the public and private sector. This will ensure that the appropriate technical support is provided in terms of crop water requirements, pest and disease control and the development of supply chains for spare parts and additional kits.

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# Annex
# Characteristics of micro-drip irrigation

## System components

Drip irrigation kits designed for smallholder farmers usually command an area between 20 and 500 $m^2$ and use the same principles as larger scale drip irrigation. Drip kits usually consist of a water container, a tap, a filter, drip lines and emitters and require a low pressure head; usually lifting a water container 1.0–1.5 meters above the ground is enough. Water containers can be drums of considerable volume (up to 500 liters, depending on the manufacturer) but sometimes buckets or even bags are being used. The space between the drip lines can vary between 0.3 m to more than 2.0 m and the space between the emitters is usually between 15–50 cm. Figure 1 shows a schematic layout of a typical drip kit.

For drip irrigation to be effective it is important that the different components are assembled in a proper manner. Drip kits are suitable for dry areas with a perception of water scarcity. However, there should be a reliable source of clean water in close proximity and the soil texture should not be too coarse. Beginners need good technical and agronomic advice, training, and access to spare parts (IWMI, 2006).

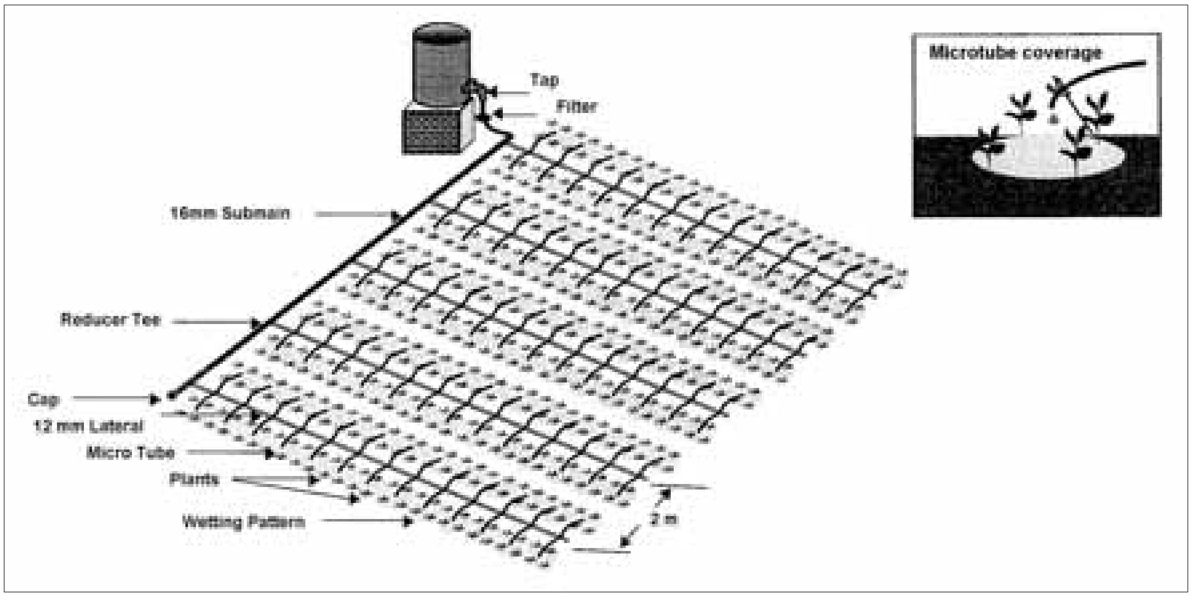


*Figure 1. Layout of small-scale drum and drip irrigation system (Moyo et al., 2006).*

## Commonly claimed advantages of drip kits

### Saves water

Drip kits have the potential to raise the productivity of water, land and labor by reducing water use. Higher water-use efficiency is attributed to the more targeted water supply to the plant's root zone, thereby reducing runoff and evaporative losses. Also, deep percolation losses are minimized because of a much higher degree of water control. Since the water requirement with drip irrigation systems is significantly lower than in other systems, smaller quantities of water can be used for the same irrigation area. Small systems operate under low pressure (0.3–2 bars) and usually lifting the water container 1 m above the ground provides enough pressure head to have a uniform emitter discharge.

### Suited to undulating land

Micro-drip irrigation systems are suitable for sloping or irregularly shaped pieces of land that are impossible to flood or irrigate using sprinklers. A relatively small decline in elevation is enough to operate a micro-irrigation system on gravity pressure.

### Increased yields

There is a claim of higher yields, better quality crops, with a shorter time span to maturity than more conventional ways of watering such as hand watering and flood irrigation. Higher yields can be achieved because of improved efficiency of water, fertilizer and labor use. Since only a small portion of the soil surface is wet, water uptake by weeds between the rows can also be significantly reduced. Micro-drip irrigation is suitable for most agricultural crops, although it is more often used for high-value products such as grapes, vegetables, nuts and fruits. Insect and disease damage can be reduced since the foliage of the plant is not wet.

### Efficient application of nutrients

Nutrients can be added to the drip system thereby precisely controlling the application rate and timing. Since nutrients can be applied directly to the root zone, there is a reduction in the total amount of fertilizer required because leaching of nutrients to the groundwater is minimized.

### Reduced labor cost

The systems save labor due to reduced water use, fewer weeding sessions, elimination of fertilizer application as a separate operation, and fewer harvesting rounds due to more uniform ripening. It is claimed that drip irrigation kits are very suitable for the poor, women, and even disabled people.

## Disadvantages of micro-drip irrigation

Micro-drip irrigation systems have to be correctly assembled and managed. Drip irrigation systems require a higher management level than other irrigation systems. Below are some specific problems that can be encountered.

### Clogging of system

Water quality has to meet biological, physical and chemical standards in order to be used in drip irrigation systems (Sijali, 2001). Emitters can easily clog when water quality is below these standards or when water is not properly filtered. Poor quality systems routinely spring leaks.

### Poor moisture distribution in some soils

Moisture distribution depends largely on the type of soil being irrigated. In deep sands, there is very little lateral water movement, resulting in a cylindrical rather than a hemispheric wetting front. Under such conditions, it is difficult to wet significantly in the lateral direction. Another difficulty with deep sands is the limited water retention in the top layers of the soil profile.

### Salt buildup

Although micro-drip irrigation systems can use saline water, problems may occur from salts accumulating at the edges of the wet zone during prolonged dry periods. Light rain can wash these salts out of the root zone thereby causing salt stress to the plants. In arid climates an additional irrigation system (sprinkler or surface) may be necessary to leach accumulated salts from the soil between growing seasons. In areas with heavy rainfall the salts will be washed out of the root zone before significant accumulation occurs.

### Initial cost

The initial investment and maintenance cost for a micro-drip irrigation system is usually higher than for more conventional micro-irrigation methods such as buckets. Small-scale drip kits may cost somewhere between US$10 and US$25, although some systems are as cheap as US$1. The cost is composed of the drum, filter, laterals and sometimes replacement parts such as emitters and spare filters.

### Requires physical human strength

The micro-drip systems require a head to create the necessary pressure, so that drums, buckets or bags have to be elevated above the garden. The filling of these is often perceived as laborious and even strenuous.

## Other problems

Rodents and insects can create additional maintenance problems by chewing holes in the plastic. In addition, persons unaware of the location of micro-irrigation systems can easily damage certain components. Theft of (parts of) micro-drip systems is yet another problem.

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