Keywords
Minor field study, low-cost drip irrigation, small-scale farmers, water scarcity, South Africa, food security, family nutrition kit, World Vision

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Preface

This master thesis forms a part of my Master of Science degree in Industrial Engineering and Management at Luleå University of Technology, Sweden. The study was performed in cooperation with International Water Management Institute, South Africa. The project has been carried out as a Minor Field Study and the fieldwork was performed in Sekororo area in the Limpopo province, South Africa. The financial funding was provided by the Swedish International Development Cooperation Agency (Sida).

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Lisa Andersson

Abstract

Sub-Saharan Africa, as many parts of the developing world, is facing increasing water shortages. Low-cost drip irrigation technologies can provide small-scale farmers with an affordable means to increase their agricultural production through more efficient water usage. Benefits of drip systems include increased crop output that can alleviate hunger and generate additional income, water savings, a reduction in labour-intensive hand-irrigation of crops, and flexible systems capable of accommodating a variety of plot sizes.

This project was conducted in Enable village, situated in Sekororo, a poor area in northern South Africa. Small-scale rural farmers' perceptions, attitudes and preferences of low-cost drip irrigation systems were investigated through a series of interviews conducted before, during and following their use of such systems. Responses were analysed to determine the technological, socioeconomic, and cultural suitability of the systems.

The farmers demonstrated an interest in and capacity to install and manage the drip systems. They also recognised a noticeable savings in water, time spent irrigating, and associated labour. Constraints of introducing drip irrigation systems to local markets include insufficient knowledge of the full advantages the technology offers, and long distances to markets that inhibit incentive to raise crop production. Successful introduction of drip irrigation systems in rural sub-Saharan Africa will require comprehensive training of farmers and support staff and appropriate timing of the introduction that coincides with the winter season when irrigation is crucial.

Sammanfattning

Södra Afrika är ett område som i likhet med många utvecklingsländer lider av en eskalerande vattenbrist. Droppbevattningssystem till en låg kostnad kan erbjuda småskaliga bönder en möjlighet att öka produktionen genom en mer effektiv användning av vatten. Fördelar med systemet är ökad produktivitet som kan minska hunger och generera extra inkomster, vattenbesparingar, minskning av arbetsintensiv manuell bevattning av grödor och flexibilitet vilket gör det möjligt att bestämma storlek på området som ska bevattnas.

Projektet utfördes i byn Enable beläget i Sekororo, ett fattigt område i norra Sydafrika. Småskaliga bönders åsikter, attityder och preferenser av droppbevattningssystem undersöktes genom en serie av intervjuer före, under och efter deras användande av systemen. Svaren analyserades för att kunna bestämma tekniska, socioekonomiska och kulturella aspekter av dessa system.

Bönderna visade ett intresse och kapacitet att installera och underhålla droppbevattningssystemen. De noterade besparingar av vatten, bevattningstid och associerat arbete. Begränsningar av ett införande av droppbevattningssystem till lokala marknader består av otillräckliga kunskaper om fördelarna med användningen av denna teknologi och långa avstånd till marknader vilket hämmar drivkraften att höja produktionen. En lyckad lansering av droppbevattningssystem på landsbygden i södra Afrika kräver utbildning av både bönder och instruktörer som sammanfaller med vintersäsongen då behovet av bevattning är som störst.

Acronyms

ADP-Area Development Programme
ALIN-EA -Arid Lands Information Network Eastern Africa
DWAF-Department of Water Affairs and Forestry
FAO-United Nations Food and Agricultural Organisation
IDE-International Development Enterprises
IWMI-International Water Management Institute
MFS-Minor Field Study
NGO-Non-government Organisation
UN-United Nations
UNEP-United Nations Environment Programme

TABLE OF CONTENTS

1 INTRODUCTION

Water scarcity and its links to food security are of major global concern, especially in the developing South. The latest estimates of the United Nations Food and Agricultural Organisation (2003) show that 798 million people in developing countries are undernourished, of which 198 million live in sub-Saharan Africa. The United Nations' Millennium Development Goals aim at eradicating extreme poverty and hunger. The targets include halving the proportion of both people living on less than a dollar a day and those who suffer from hunger by 2015. Today, there are 1.2 billion people surviving on less than US$1 per day and in sub-Saharan Africa half the population lives in poverty (UN, 2003). Such people are typically landless labourers or cultivators of very small plots, from which they get neither sufficient crop production nor income to ensure household food security.

Water scarcity is now the single greatest threat to global food production (Postel, 1999). The United Nations Environment Program (UNEP) states that about one-third of the world's population lives in countries or regions where there is insufficient water to meet modest food and material needs per person. If the same consumption patterns continue, two out of three persons on earth will live under water-stressed conditions by the year 2025. The path that food production follows depends to no small degree on water. Crops cannot reach their maximum yield potential if they do not get sufficient water. Worldwide, agriculture accounts for more than 70 percent of freshwater drawn from lakes, rivers and underground sources (UNEP, 2002). Most of that water is used for irrigation, but although only 17 percent of global cropland is irrigated, that part produces 40 percent of the world's food (FAO, 2003).

Postel (1999) noted that water productivity needs to be doubled (i.e., twice as much benefit needs to be gained from each liter of water removed) if we are to have any hope of fulfilling the water requirements of future generations. Meeting this challenge will involve making irrigation more effective, substituting knowledge and better management for water. It will involve spreading technologies that enable farmers to get more crops per drop, and it will require fixing the flaw of the modern irrigation age: the failure to provide technologies and methods that allow the smallest and poorest farmers to share in the benefits of improved irrigation. Particularly in sub-Saharan Africa, access to irrigation is a key to boosting food production and incomes for many of the hungry and undernourished.

New evidence from different parts of the world shows that, with affordable drip systems, small farmers can make the transition from subsistence production to higher value production for the market, thereby doubling their income and greatly enhancing household food security (Postel et al., 2001). In sub-Saharan Africa there are many constraints on the spread of low-cost drip irrigation, such as lack of basic infrastructure and the absence of developed markets. With its strong infrastructure and new water policy reforms focused on the poor, South Africa is a logical place to demonstrate the potential of low-cost drip irrigation in the region (Postel et al., 2001). Examples of where low-cost drip-irrigation has recently been implemented in sub-Saharan Africa include Zimbabwe (Chitsiko and Mudima, 2002), South Africa (du Plessis and van der Stoep, 2000), and Kenya (Kabutha et al, 2000). The recent implementation of drip systems in the region has meant a deficiency in knowledge of farmers' preferences concerning such irrigation technologies.

1.1 Aim and objectives

The aim of this study was to determine small-scale rural farmers' perceptions and attitudes towards low-cost drip irrigation systems through a series of interviews. Farmers' success in setting up and managing low-cost drip irrigation systems were monitored in order to provide recommendations on the suitability of using such systems for small-scale farmers in sub-Saharan Africa. More specifically, the objectives were to determine:

- If low-cost drip irrigation systems could be successfully set up and managed by small-scale rural farmers in South Africa.
- The opportunities and limitations (technological, economic, social, and cultural) regarding the implementation and management of such technology by small-scale rural farmers.
- Possible adaptations that might be made to the current drip system to make it more suitable or available to such farmers.

1.2 Prerequisites

This project was not commissioned but planned and performed by the preference of the author. The initiative was accepted and welcomed by local organisations and the people concerned with the project. The low-cost drip systems used were handed out free of charge to interested farmers. This is the first project of its kind in this specific area.

2 BACKGROUND

2.1 Irrigation's missing link

Irrigation has been credited with the rise and flourishing of civilizations such as those in ancient Mesopotamia, Sumeria and Babylon. Developed economies now exist in some regions of the world solely because of irrigation (Sijali, 2001). Over the last century the area of land under irrigation has increased more than sixfold, from approximately 40 million hectares in 1900 to more than 270 million hectares in 1999 (UNEP, 1999). However, as mentioned above, this accounts for only 17 percent of the world's cropland. Expanding irrigation to a larger proportion of cropland, most of which is currently only rain fed, is essential to increase global food production and to reduce rural hunger and poverty.

The irrigation sector has largely been focused on large-scale canal or groundwater projects or high-quality pressurized sprinkler and drip systems that are too expensive for small-scale farmers (Postel et al, 2001). Conventional western technologies have been too expensive to be affordable for most smallholders in developing countries and are difficult to scale down to fit the needs of small plots (Polak, 2004).

According to Postel et al. (2001), raising the productivity of small-scale farmers requires an entirely new approach to the design of irrigation systems. The missing link in global irrigation has been systems for smallholders who need access to irrigated water or a way to stretch a scarce supply of water. Such systems would meet the following criteria:

- Affordability: The commercially promoted drip irrigation systems are much too expensive for smallholders. There is a need for systems that place affordability before quality such that farmers earning as little as US$200 a year can purchase them.
- Divisibility and Expandability: Systems must be adaptable to varying farm sizes. For example, a variety of low-cost systems are now available that start at a size suitable for a 20 square meter kitchen garden. The farmers must be able to buy appropriate sized systems and be able to scale-up should their needs increase.
- Rapid payback: Most poor farmers are highly risk-averse and are reluctant to invest in innovations unless the returns are two- to threefold.
- Water efficiency: A majority of farmers live in water scarce areas. Systems that help stretch scarce water supplies can enable the expansion of cultivated areas, increase yields, and, thus, raise incomes.

2.2 Drip irrigation

2.2.1 History

The "plastic revolution" after World War II paved the way for drip irrigation. It made it possible to mass-produce plastic pipes easily and cheaply, and this sped up the use of drip irrigation systems. By the end of the 1960's, farmers in six countries – Australia, Israel, Mexico, New Zeeland, South Africa and the United States – were using drip irrigation (Sijali, 2001). While only a small portion of worldwide cropland was irrigated by drip systems at this time, the technology spread fast. According to Postel et al. (2001), this rapid expansion was attributable to the higher crop yields and water use efficiencies gained by drip irrigation. Drip systems have often been associated with capital-intensive commercial farms. The largest barriers to its expansion to small-scale farmers have been high capital costs, typically starting

from US $1500 per hectare, and the lack of system sizes suitable for small plots. The high cost of most commercially available drip systems is due to components that are optimized for fields of four hectares or larger and designed to minimize labour and management costs. By contrast, early drip systems were simple, but these designs were abandoned because they did not fit the needs of large-scale farmers in developed countries. They are, however, well suited for drip irrigating small plots.

2.2.2 Principles of the drip irrigation method

Drip irrigation is a water saving technology that delivers water through small holes or emitters in plastic tubes installed on or below the soil surface almost directly to the roots of plants (see Figure 2.1). Flow rates are slow, from 0.2-20 l/h, and regular application is the basic concept underlying this method to supply the amount of water needed by the plant (Dasberg and Or, 1999).

Figure 2.1 A tomato plant watered using drip irrigation.

There are a number of advantages of a drip irrigation system according to Sijali (2001):

- Higher crop yields: Since water is applied on a regular basis, the soil moisture is kept at an optimum level. Drip irrigation also applies water more evenly than other irrigation methods.
- More efficient use of water: The precise application of water to plants achieved by the drip system makes irrigation much more efficient. Because of the partial soil wetting (rather than saturation), less water is lost by direct evaporation from the soil surface. Also, loss of water due to uptake from weeds between the plants is minimized. Studies have shown a water reduction of up to 30 to 70 percent compared to conventional surface irrigation.
- Reduced cost for application of fertilizers and other chemicals: The ability to apply fertilizers along with irrigated water saves labor and costs. A more precise application of fertilizer, which is brought directly to the active root zones, translates to a more efficient utilization. Additionally, the concentration and amount of nutrients can be better timed to coincide with plant needs according to the stage of development and climatic conditions.
- Reduced labour: Weeds are reduced since there is no watering between plants, and weeding can be performed when plants are being irrigated. Adding fertilizer, herbicide and insecticide simultaneously with water reduce labor costs.
- Reduced salinity hazard: Reduced evaporation means less accumulation of salt on the soil surface. The salt that does accumulate tends to do so towards the edge of the

wetted area, such that the root zone remains relatively free from salt accumulation. This compares favorably to surface-irrigated fields in which salt tends to accumulate in the middle of the root zone. Also, applying water directly to the soil surface eliminates the opportunity for salts to be absorbed through leaves, as may happen with sprinkler irrigation.

There are also a number of disadvantages associated with drip irrigation:

- Cost: Conventional drip irrigation systems typically start at US $1500 per hectare. This is, however, changing.
- Technical limitations: The design, management and maintenance required for drip systems have been focused on the needs of larger farms. Good water management is necessary otherwise almost all benefits of using the system will be lost. Over-irrigation will make the soil too wet and will therefore promote disease, weed growth and nutrient leaching.
- Clogging of emitters: This is one of the biggest problems of any drip system. It causes poor water distribution, which affects plant growth.
- Restricted root zone: The plant's root activity is limited to the zone wetted by the emitters, which is usually smaller in area than with sprinkler or surface irrigation. Thus, if drip irrigation fails, the crops will suffer even more from drought than crops watered with sprinkler or surface irrigation.
- Salt accumulation in the root zone: Drip irrigation tends to accumulate salts to the outer edge of the wetted volume of the soil surface. In regions with an annual rainfall of less than 100 mm this can cause a problem if the rainfall is insufficient to leach the salts from the root zone. The rain can instead move the salts into the root zone which is damaging for the plant.

2.2.4 Affordable drip systems for small farmers

In recent years there have been efforts to promote irrigation technologies that have so far been perceived as exclusively for commercial farmers, but which are now available in forms that meet the above mentioned criteria such as increased affordability, divisibility, rapid payback and improved water efficiency. Chapin Watermatics, International Development Enterprises (IDE), Netafim, and some other actors have made pioneering efforts. All of these have developed and launched versions of drip systems, which are now showing promise for raising the water efficiency, land productivity, and incomes of smallholders (Shah and Keller, 2002). For example, IDE-India promotes drip kits costing almost 80% less than conventional drip systems and is thus bringing about a shift from subsistence farming to higher value production. This could translate into a doubling of the income of poor farmers, in addition to enhancing household food security and improving the nutritional status of farm families (IDE, 2004).

The drip irrigation technology frees the farmer from the limitations of rain-fed farming, enabling him/her to cultivate all year round, grow a wider variety of crops, have higher cropping intensity and do priority farming. Good irrigation technologies and agricultural practices coupled with enhanced participation of the poor in the markets is the key to income generation (IDE, 2004).

The drip irrigation systems described below are examples of the most common among the variety of low-cost systems (Sijali, 2001; Postel et al. 2001).

Bucket kits

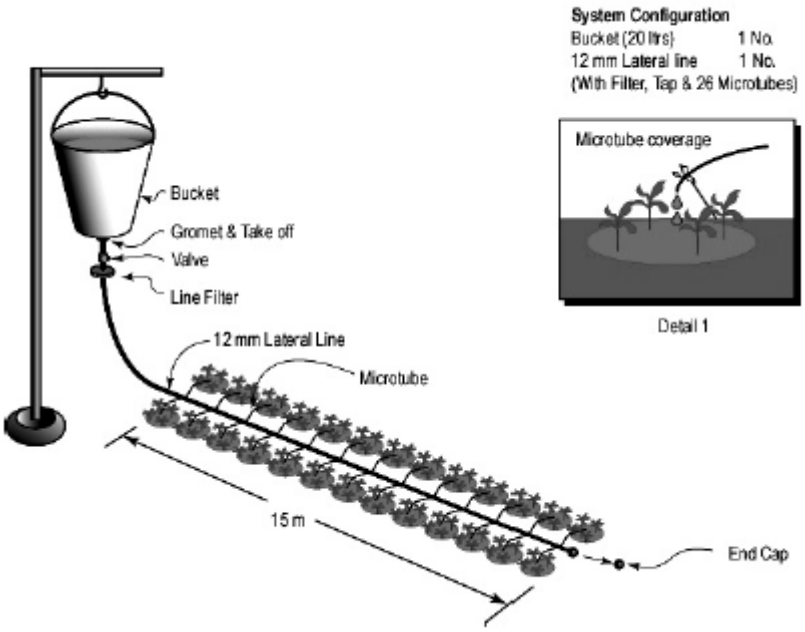

Figure 2.2 Bucket kit system. (Postel et al, 2001)

These consist of a bucket attached to a pole of around 1.5 meters with drip lines connected where the water flows (see Fig. 2.2). These systems can irrigate 10-20 m^2 depending on the length of the drip tube and the spacing of the plants. It can provide a family with the vegetables they need to add critical vitamins to their diet. It reduces the labour burden of hand-watering each plant and fetching precious water often carried from sources up to a mile away.

Drum kits

One step up from the bucket kit, these systems consist of a drum raised at least one meter from the ground (see Figures 2.3 and 2.4). The main advantage is that it can irrigate an area at least five times larger than the bucket kit.

Figure 2.3 Drum kit system

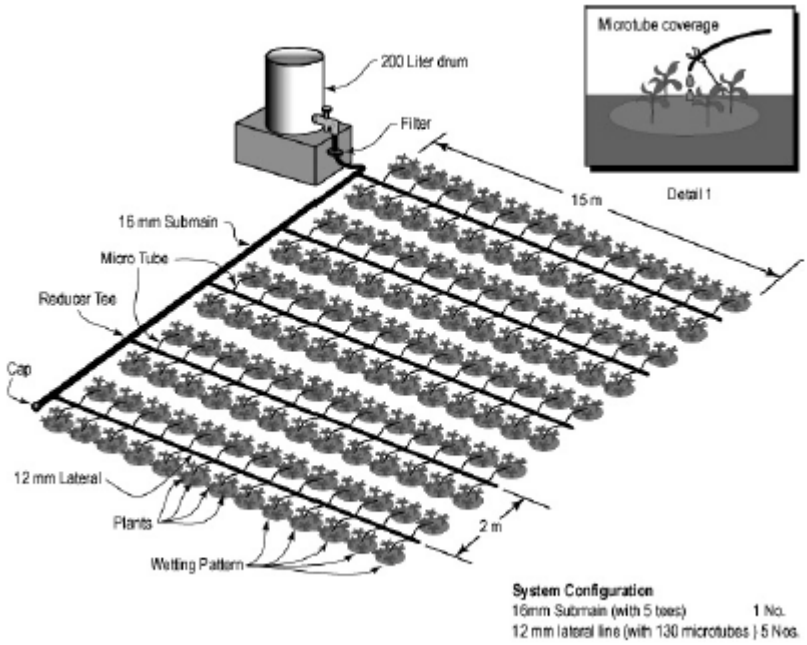

Figure 2.4 Schematic of drum kit. (Postel et al, 2001)

Moveable drip systems
These systems resemble more conventional drip systems, but have much lower capital cost. While a conventional system needs a plastic line for each row, these have shiftable lines that can irrigate many rows. A plastic tank placed two to four meters above the ground provides the right pressure. This system works very well for closely spaced, low-growing crops.

2.2.5 Worldwide market for affordable drip irrigation

Low-cost drip systems have begun to spread rapidly where they have been introduced. Maybe the best example is the spread of drip irrigation in South Asia through International Development Enterprises. They are a non-profit organization that employs market principles to strike at the roots of rural poverty in the world's least developed countries. IDE has developed a number of water technologies for small-scale irrigation, since water is a strategic entry point for helping the poor to improve their livelihoods and become more effective market participants. Over 100 000 IDE low-cost drip systems have already been purchased in India, Nepal, Sri Lanka and Zimbabwe (Polak, 2004). In India alone sales to this date exceed 85,000 kits (IDE, 2004).

In other parts of the world drip irrigation is also expanding, such as in China and Africa where the Israeli firm Netafim, the largest international drip irrigation company in the world, is marketing their systems. The non-profit Chapin Watermatics along with IDE is also distributing thousands of bucket kits for irrigating kitchen gardens to poor families in Africa and elsewhere (Postel et al., 2001).

2.2.6 Drip irrigation in sub-Saharan Africa

Agriculture is relatively more important to the economy of sub-Saharan Africa than in the rest of the world, but irrigation remains less developed there than elsewhere. However, many countries in the region have the land and water resources needed to increase irrigated agriculture (UNEP, 2002). The potential for poverty alleviation in this region through increased and improved irrigation in small-scale agriculture is large (Postel et al, 2001). In general, smallholdings dominate African agriculture and farmers there mostly depend on rain fed cereal crops (millet, sorghum and maize). In addition, groups of women and young men in many villages grow vegetables on small plots in order to improve the family diet, or for sale at markets. This is generally the only agricultural activity that uses irrigation. They usually irrigate by hand with water carried form wells, reservoirs or rivers to their plots (van Leeuwen, 2002).

The majority of these smallholders could not until recently benefit from drip irrigation due to the hesitancy to promote this technology (Savva, 2000). Irrigation specialists recognized the fact that, in view of future water shortages, drip irrigation would play an important role; still they had reservations as to the appropriateness of these systems under circumstances typically faced by small-scale farmers (du Plessis and van der Stoep, 2000). These reservations were based on several limitations often faced by small-scale farmers, including a lack basic infrastructure, isolation from equipment suppliers and support services, a lack of electricity, and that many are part-time farmers with other obligations that make demands on time and resources. The absence of developed markets and cultural biases against women, who do 80 percent of farm work in this region, are also great constraints (Postel et al, 2001). The idea of ignoring or actively discouraging traditional irrigation practices and replacing them with modern systems were not perceived to be the ideal solution (du Plessis and van der Stoep, 2000).

There have been some examples of successful irrigation implementations in countries in sub-Saharan Africa. In Zimbabwe, production by smallholder irrigators increased 300 percent over rain-fed agriculture (Chitsiko and Mudima, 2002). In the East African region, low cost small-scale drip irrigation systems manufactured by Chapin Watermatics were introduced by World Gospel Mission in the early '80s. By 1996, the Kenya Agricultural Research Institute (KARI) in collaboration with Chapin Watermatics introduced bucket drip irrigation technology to farmers. At the same time, Christian Mission Aid was involved in disseminating the technology to farmers and schools within Kajiado district. There have been over 3000 kits sold from 1996 through 1999 (Kabutha et al., 2000). Arid Lands Information Network Eastern Africa (ALIN-EA) arranged an experience-sharing workshop in September 1998 that brought together 30 drip users and officials from governments and NGOs. The aim was to expose them to the technology and plan strategies of implementing pilot programs in Kenya. Following this workshop, the use of bucket drip irrigation gained momentum and many organizations are now promoting the technology in Kenya and Tanzania. ALIN-EA continues to support drip irrigation activities to its partners and members through training, demonstrations, evaluations and provision of updated information on the systems (ALIN-EA, 2002).

2.3 Focus on South Africa

South Africa is located in a predominantly semi-arid part of the world. The average rainfall for the country is around 450 mm per year, well below the world average of about 860 mm per year, with a fairly high evaporation rate. Because of poor and uneven distribution of rainfall over South Africa, the natural availability of water across the country is inconsistent. There is also a strong seasonal influence of rainfall. As a result, South Africa's water resources are, in global terms, scarce. Further complicating the situation is that the historical establishment of settlements was dominated by the occurrence of mines and influenced by the political circumstances of the past, rather than by the plentiful availability of water (DWAF, 2003). The result is that most settlements, both urban and rural, have been established in locations far from large watercourses. As a consequence, the requirements for water already far exceed the natural availability in several areas (DWAF, 2003). Thus, South Africa is marginally capable of meeting its population's water demands.

Agriculture represents less than 4% of South Africa's Gross Domestic Product (GDP) and only 14% of the nation's labour force, while agricultural irrigation consumes about 50% of the country's total water usage (Perret, 2002). The agricultural sector is likely to start having to reduce its water use in the near future to reallocate water to other sectors. In the past, attention was mainly focused on the development of new resources as the demand for water increased, partly because large unused potential was still available. The inability of the resource management sector to keep up with the growing and inefficient utilization of water has resulted in the need for substantial improvements in water efficiency (DWAF, 2003).

South Africa, with its strong infrastructure and new water policy reforms focused on the poor, would be an ideal place to demonstrate the potential of low-cost drip irrigation in the region (Postel et al, 2001). The most advanced equipment in this field is available on the South African market, since the irrigation industry in the country is an attractive and significant market to suppliers of irrigation systems. There are also a number of affordable options for small-scale farmers. A limited number of studies on low-cost drip irrigation in South Africa have been completed to date, and experts responsible for advising communities are uncertain about where to start and what kind of systems to implement (du Plessis and van der Stoep, 2000). The frustration of extension officers, operators, and farmers involved in smallholder irrigation due to the lack of knowledge and practical understanding is described by De Lange (1994).

According to De Lange (1994), small-scale irrigation farmers can be divided into several groups:

- Independent farmers: grow crops on land that does not belong to any irrigation scheme, but which usually does not belong to them either.
- Scheme farmers: grow and irrigate crops on an irrigation scheme where they share a water source, infrastructure, and sometimes irrigation equipment.
- Vegetable garden farmers: usually found in community gardens, they have very small plots and share water resources and equipment.
- Backyard farmers: farm on the same scale as the vegetable garden farmers but are not grouped together. They have access to water for domestic purposes and allocate some of this for farming.

Shah et al. (2002) conclude that, of the total of around 37 000 farmers involved on 202 smallholder schemes in the former homelands, 63 percent are small food plot cultivators.

Most farmers are women since it is common for men to seek urban jobs while women cultivate plots. Many plot-holders keep cultivating their plots until they are too old to work them. A large number of them depend on pensions as their main source of income. The farmers usually have several strategies of livelihood activities including rain fed farming, migrant labor and animal husbandry.

De Lange (2000) notes that it is fundamentally important to understand the difficulties involved in escaping from the poverty trap and the resistance to change in the face of established survival strategies. The farmer's desires, fears and perceptions, which emerge when they are faced with new challenges, need to be understood to ensure that implementations of new technologies are sustainable. The following fears among rural farmers in South Africa are likely to be encountered by developers and trainers of new technologies:

- Fear of making decisions: Many farmers may be elderly and illiterate, and 80 percent may be female, especially in community gardens. Although women are traditionally responsible for farming, custom may sometimes not allow them to make decisions without first consulting their husbands.
- Fear of hunger: The majority of rural people are unable to satisfy their basic needs. They have low self-esteem and feel that they have failed in life. This, together with the fear of hunger, the fear of the unknown, and the fear of losing the little they still have, often leads to a resistance to change.
- Fear of training: Illiteracy and poor self-esteem make people sensitive and unsure of themselves. They might therefore be afraid of training, especially in the beginning.
- Respect for ancestral spirits: Most rural people are very aware of their ancestral spirits and have strong cultural traditions.
- Fear of family break up: The migration of men towards job opportunities in the cities has tended to weaken the family structure. People who are unable to feed their families often have no option but to send their children to relatives with access to sufficient food. This shatters their self-esteem even further as they feel that they have failed in life when they are unable to provide their family's most basic need, food.
- Fear of losing land: Relates to South Africa's history of forced removals as well as land acquisition in the former homelands for agricultural projects.

In conclusion, there is a need for improving crop yields and irrigation efficiency in sub-Saharan Africa. Drip irrigation may be one option for resource poor farmers in water scarce areas. South Africa has sufficient infrastructure for drip irrigation to be feasible; however, there are several potential constraints to successful implementation.

3 STUDY AREA

The focus of this study was Enable village situated in the Sekororo area, Maruleng municipality. It is located in the northeastern part of Olifants river basin in northern South Africa (see Figure 3.1).

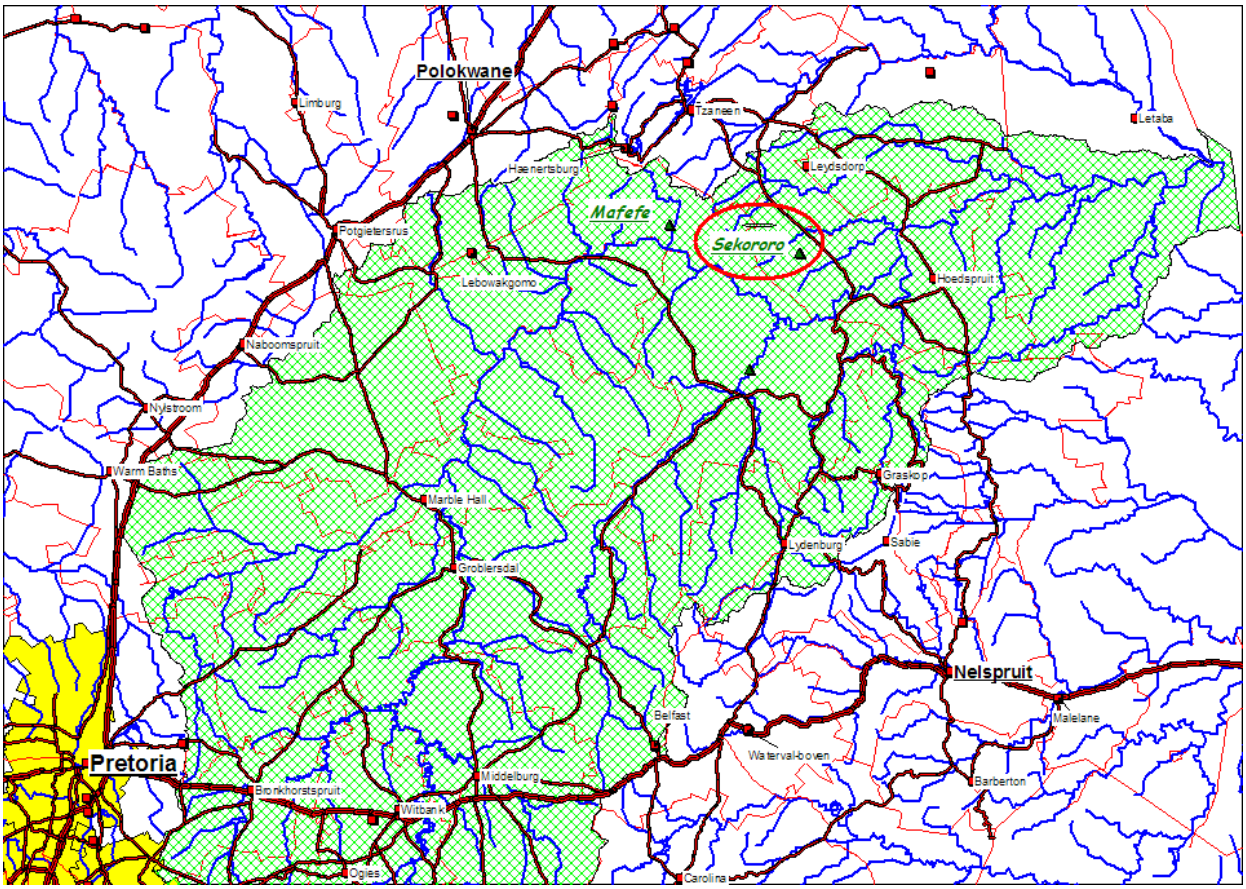

Figure 3.1 The Olifants river basin

IWMI has selected the Sekororo area to conduct different research projects together with several other organisations. This choice was made because of:

- The presence of World Vision, a non-government organisation (NGO) that is a partner in this research, together with the municipality and tribal authorities.
- Its location in the Olifants river basin, IWMI's benchmark basin in the Limpopo river basin.
- The major issues in this area: Increasing water scarcity, rural development and food security.
- The multiple stakeholders: Commercial and emerging farmers, smallholders, and nature conserves.

This research area is newly established and the first workshop for the stakeholders was held on October 21-22, 2004. The purpose of the workshop was for stakeholders from various levels, from local to provincial, to discuss challenges and issues related to water supply and management within local communities for household and irrigation purposes.

3.1 History

According to the villagers of Enable the first people in the area were the northern Sotho. They traditionally relied on a combination of livestock raising and crop cultivation for subsistence. Most Sotho people were herders of cattle, goats, and sheep, and cultivators of grains and tobacco. In addition, they were skilled craftsmen, renowned for their metalworking and wood and ivory carvings. As recalled by elders of Enable, their ancestors preferred to stay in the mountains where the pasture was green, the land fertile and the enemies easy to discover from far away.

By the end of the 1940s, significant changes took place in the Sekororo area. White war veterans were given land as compensation for their military services in the Second World War. They started farms and grew mangos and other fruits but also vegetables, while the black inhabitants provided the agricultural labor. Some elders, who were laborers, remember the hard working conditions. Everybody was forced to work, even children, in exchange for only a place to sleep. After some time a small salary was given and if they were lucky they received a bit of land to cultivate from the white farmers.

The victory of the National Party in the 1948 general election enhanced the apartheid policies, which further reinforced segregation and people's displacements. In 1950, the Group Areas Act led to forced physical separation between races by creating different residential areas for different races. These African reserves, known as "homelands," were independent states to which each African was assigned by the government according to their record of origin. All political rights including voting held by an African were restricted to the designated homeland. The idea was that they would be citizens of the homeland, losing their citizenship in South Africa and any right of involvement with the South African Parliament that held complete control over the homelands.

The forced removals of black people from white areas resulted in a huge inflow of people into Sekororo during the next decades. The even stricter cutting up of South Africa into white and black areas led to an increase of population in search for a new place to live, farm, and herd their cattle. The tensions of continuous displacements and mounting population pressure in an increasingly overexploited area have been significant in shaping Sekororo into what it is today.

3.2 Natural characteristics

The Olifants catchment is divided into two by an escarpment, orientated north to south. To the west of the escarpment the landscape is known as the highveld (i.e., altitude > 1,200 m) and to the east, it is known as the lowveld (i.e., altitude < 800) (McCartney et al., 2004). According to DWAF (2003), the climate in the eastern part of the Olifants catchment is sub-tropical with rainfall mainly occurring in the summer and a mean annual rainfall of 700 mm (Figure 3.2). However, that can also vary considerably between years with droughts occurring frequently (McCartney et al., 2004).

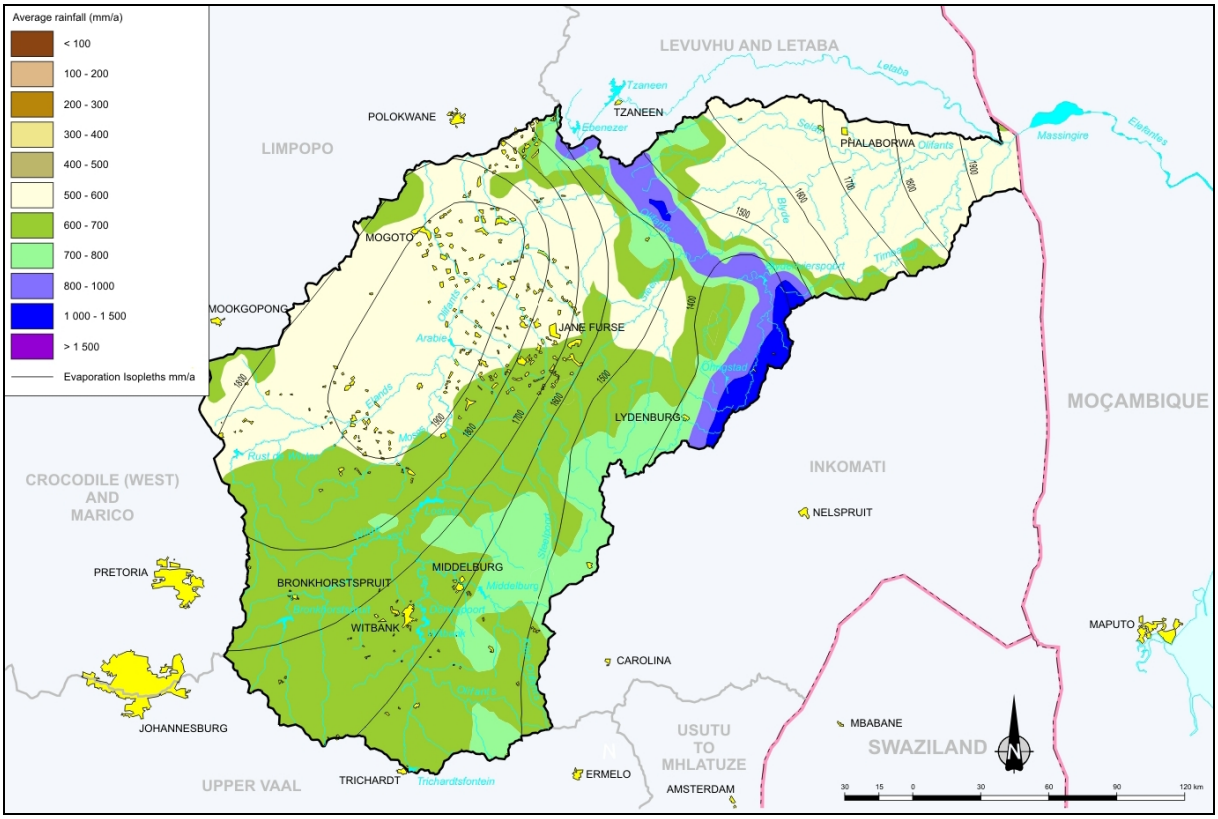

Figure 3.2 Rainfall and evaporation in Olifants river basin. (DWAF, 2003)

Sekororo lies in the lowveld, at the foot of the Drakensberg Mountains that borders the area at the west (see Figure 3.3). The eastern border is road R36 that runs north-south from Tzaneen. Beyond the road further east are nature reserves and Kruger National Park. In the north there are commercial farmers.

People are settled in villages scattered in the area and each community has a leader, called the *n'duna*. He is the representative of Chief Sekororo, who is the traditional leader who owns the land. When people want to settle on the land they need permission obtained from the local leader, the n'duna who is acting on behalf of the Chief. The households do not get title deeds for the land they occupy. This traditional way of land ownership accommodates 90% of the inhabitants in the area (Maruleng municipality, 2003).

Sekororo is relatively well endowed with fertile soils and rainfall especially higher up on the hills, where there is moisture year-round. However, the soil becomes dryer and less fertile with increasing distance from the mountain. The climate is favorable for growing sub-tropical fruits, vegetables and grazing livestock.

Figure 3.3 Enable village and the Drakensberg Mountains

Enable village is situated on the eastern side of Sekororo, opposite the mountain and with a newly constructed road acting as a border between Enable and the mountains. Numerous small streams flow from the escarpment towards the Olifants River further downstream and by the time they reach Enable they have passed many villages. The extensive farming on the mountain slopes where the land is fertile makes the soil erode and contributes to rapid siltation of the stream beds, which further reduces the water flows.

3.3 Demography

The total population of Sekororo area is around 50 000 people and Enable village has 2800 inhabitants with almost half the population under 16 years old (World Vision, 2004a). There are more females over 16 years than males, which primarily can be ascribed to the larger number of male migrant workers employed in the cities and the mines. Most of these migrant workers have a family left in the village.

3.4 Employment and household income

Income from employment is a critical factor as it determines the overall living standard of people. The unemployment rate is high, 64% in 2001, which leaves many families without a regular and reliable source of income. Of the households in the municipality, 70% are dependent on subsistence income and this includes around 22% with no income at all. These households have an income of less than R950[1]/month, which is generally regarded as the minimum for households to survive (Maruleng municipality, 2003). The occupations of community members in Enable are 70% farmers, 23% labourers in mines and factories and 7% professionals such as teachers, nurses and police officers (World Vision, 2004a).

3.5 Water

In Maruleng Municipality, 73% of the population receives only 0-10 litres of water per person per day and in Enable, as with surrounding villages, this is a fact the whole population is

[1] R = South African rand, the local currency. R1 ≈ US$0.17 in 2005-03-10

facing. The low availability of water is also a cause of concern since residents do not have reliable access to that water (Maruleng municipality, 2003).

In Enable village there are two boreholes that supply water. One was constructed in 1984 and runs with a diesel engine, which the former government sponsored; however, it only supplied parts of the village during that time and the government no longer pays for the diesel. There is also a second borehole constructed more recently which is connected to an electrical pump, but this borehole is not sufficient to cover the demand either. Most times there is no water in the taps, especially during winter when it is very dry, and people are forced to go to the river to fetch water. River water is transported in containers either carried on people's heads or pushed with wheelbarrows, which is very time consuming and labour intensive. Since there is a lot of sediment in the river, people have to dig holes in the riverbank to reach the water (see figure 3.4). The river water is utilised for many purposes including household uses such as drinking, cooking and cleaning, but also for watering animals or for irrigation. There is no form of purification taking place and the water is not protected against contamination.

Figure 3.4 Child fetching water from the riverbank

3.6 World Vision

World Vision, a Christian relief organisation, has been working in the Sekororo area since 1995. There are two Area Development Programmes (ADP's) and one of them is Enable ADP. It consists of four villages: Enable, Worcester, Turkey and Butswana which together have 25 000 inhabitants. World Vision seeks to help communities become more self-reliant and children are at the centre of their work. World Vision believes that by helping families nurture their children, they are helping communities build their future. In their program in Enable ADP there are 1000 children. The overall goal is "To improve the well-being of children in Enable ADP communities by 2017 through appropriate community development initiatives." The goal will be achieved by involvement in the agricultural, economical, spiritual, educational, health, and HIV/AIDS sectors. World Vision supports the communities in the transformation from poverty to abundance through different interventions in those sectors such as helping the community to build a pre-school, starting a project for the AIDS-orphans that provides them two meals a day, and initiating community gardens.

According to World Vision (2004b) there are some stages of transformation a community goes through during an Area Development Project:

- **Build Trust**: Social transformation starts with building trust - trust between World Vision staff and the community. This involves building and nurturing relationships across religious and ethnic lines in the community and between the village leadership and women and children. This step can last from two months to two years.
- **Come Together**: Community participation is central in this phase. Local leaders and the people are encouraged to participate together in activities. As the community works together, relationships are strengthened. These stronger ties become critical to the success of the steps that follow.
- **Make Decisions**: During this phase, community members assess their needs and priorities and develop a plan of action. Together they determine how a large portion of the project budget is to be allocated. World Vision encourages traditional leaders to involve women and youth in this process.
- **Design Solutions**: Now that a community has decided what they want to change, they begin designing practical steps to take them there. These can include agricultural, health, and educational activities. World Vision provides oversight and assistance as needed, but lets the community work together to design its own solutions.
- **Take Ownership:** The final step in this transformation marks the beginning of true self-sustainability for a community. Communities experience ownership as they create durable community structures such as a Water Committee, Food Marketing Co-ops, a Parent Teacher Association and Community Banks. Economic and productive activities become the engine that sustains and maintains these structures for years to come without the need for external assistance.

Enable ADP is only in the initial steps of this transformation since it only started in 2002 and it is in its third year of implementation. In 2005, the main focus will be on health and food security, which are the main sectors that improve the quality of life of the community. The ADP's interventions in the agricultural sector have a significant impact on the lives of the community members since a high percentage of people rely on products from their own farming practices. By securing their own sources of year-round food, a community is able to cut death rates among vulnerable families. The proper seeds and tools, training in agriculture and animal husbandry, enable a community to increase its production of meat, vegetables and grains for healthy diets.

In Enable village there is one community garden (see figure 3.5) at the ADP office and some more in the surrounding villages. These existing community gardens will continue to be supported and there will also be school gardens established to involve children in agricultural activities at an early stage of their lives. Surpluses from the gardens will be sold outside and within the villages to increase household incomes.

World Vision is interested in introducing drip irrigation systems to people in their program. Most of the parents, predominantly mothers, cultivate vegetables in their backyards or at the community garden to raise the food security in their home or to gain an extra income. World Vision wants to support this interest by helping people with techniques that will save water and time. World Vision's ADPs are usually situated in areas where water is very scarce and any water-saving activity is regarded as a great help. By introducing drip irrigation systems they are hoping that people can raise the food security in their homes and save water. In the long term, they think that children will also be able to manage these simple systems and can help with food production.

Figure 3.5 Community garden at World Vision

For 2005/2006 World Vision is planning to hand out one low-cost drip irrigation system to each of the children in their program as a direct benefit. This includes distribution to 1000 children in Enable ADP and some 36 000 other children in ADP's all over South Africa. At Enable ADP they have already started to promote drip irrigation by purchasing a drum kit system that is displayed and used at the community garden at the World Vision office (see figure 3.6).

Figure 3.6 Drum kit at a community garden.

4 METHODS

4.1 Initiating the project

To find farmers interested in testing the drip irrigation systems, World Vision helped me to arrange a meeting with small-scale farmers at the ADP office. The meeting was held in the beginning of November 2004 and 15 people attended. It was mostly women with a few exceptions.

The aim of the study was explained and a demonstration of a drip irrigation system was held at the community garden with an introduction of how to use it (see figure 4.1). The drip kits that were distributed were acquired through IWMI from IDE-India's regular production line. As I had only ten drip kits, which were not enough for everyone, some people decided to share.

Figure 4.1 Demonstration of drip kit to farmers.

During the field study of the village, the main part of the data was collected by participatory observation. I got to know the area and the people simply by being there and getting acquainted with the inhabitants. The personnel working for World Vision contributed a lot of information such as statistics, but also professional knowledge and personal experience.

Subsequently, a community walk was arranged with a local farmer who was the leader of a community garden, chairmen of Enable Stock Association and also the priest. Through his knowledge of the village and its surroundings he provided information about all the important places for the people, such as the river where they fetch their water for household consumption and irrigation most of the year and especially during winter.

4.2 Mixed research

Mixed research is a general type of research in which quantitative and qualitative methods, techniques, or other characteristics are mixed in one overall study (Johnson and Christensen, 2004). In this study *mixed model research* was used which means that the researcher mixed both qualitative and quantitative research approaches within one stage of the study, in this case using interviews composed both of open-ended qualitative type questions and closed-ended or quantitative type questions as well.

4.2.1 Informal interviews

Some informal interviews were held with World Vision staff, the agricultural extension officer, the local traditional leader, and the municipality officer. The farmers involved were interviewed using semi-structured interviews. The interviews were conducted during a two-month period, during which each farmer was interviewed on more than one occasion, usually within a two-week interval. In this way, the progress of the implementation and management of the drip kits were documented.

4.2.2 Semi-structured interviews

According to Barton et al. (1997) semi-structured interviews are guided conversations where broad questions are asked and performed in a relaxed and informal way. They are conducted with a fairly open framework which allows for two-way communication. The set of questions can be prepared but are open, allowing the interviewees to express opinions through discussion. Questions are generally simple, with a logical sequence to help the discussion flow. Semi-structured interviews can be used to obtain specific, quantitative and qualitative information like household features, use of natural resources or, as in this study, opinions about the drip irrigation system.

The method involved the following steps:

- Design an interview guide (see Appendix 1) and choose interviewees.
- Pre-test the interview guide on someone that is representative of the types of persons to be interviewed in the actual study.
- Take brief notes during the interview and make a summary immediately after the interview.
- Do daily editing for completeness of interviews.

4.2.3 Analysis of interviews

The interviews contained both quantitative and qualitative data, which were analyzed separately. According to Kvale (1997) there are different methods of qualitative analysis of interviews. In this study the categorization method was used, meaning that the interview was coded in different categories to reduce long statements to simple categories. The categories can either be decided upon beforehand or later developed by the researcher. In this study the categories were made by directly examining the data. No statistical analysis was performed on the quantitative data due to the small sample size.

4.3 Material

The drip systems used in this study are manufactured by IDE in India and are called the *Family nutrition kit*. It is designed to irrigate an area of 20 square meters expandable up to 40 square meters (see figure 4.2). It consists of one 20 litre double-layered plastic bag as a water storage unit, a screen filter, an on/off valve, and one sub-main pipe with four rows of 5 meter length lateral pipes with micro tube emitters. The drip kit provides irrigation to 44 to 88 rows of vegetable plants depending upon the plant and the spacing. The family nutrition kit is suitable for garden plots and landless farmers to grow fruit and vegetables primarily for home consumption and nutritional upkeep. The price is US$1 in India.

Figure 4.2 The area irrigated is 20 square meters.

Figure 4.2 Woman using the drip kit.

5 RESULTS AND DISCUSSION

5.1 Background of the drip kit users

The group of volunteers that decided to join this study included four women, five men and one couple. A summary of their background, such as age, sex and experience in farming, plot sizes and irrigation time, is showed in Table 5.1.

All of the farmers were growing vegetables at small garden plots either at their own house or at the community garden. They used the crops mainly for subsistence food to raise the food security in their household or in a few cases for selling to generate a small income. In the summer they mostly rely on rain fed cultivation, while in winter when it is very dry they need to irrigate to get a harvest. The most important summer crops are "millies" which is maize, pumpkin and tomatoes, while in winter different kinds of vegetables such as beetroot, spinach, cabbage, tomatoes and onion are very dominant.

Table 5.1 Background of the interested farmers.

Farmer	Sex	Age	Family members	Occupation	Income per month (rand)	Years of experience	Plot size (m^2)	Usage of crop	Location of plots	Water use (l/day)	Irrigation time (h/day)
1	female	38	7	yes	1000	3	32	subsistence	home	200	4
2	male	58	6	yes	900	4	50	subsistence	home and community garden	160	3
3	female	20	5	no	4000	1	200	subsistence	home and community garden	180	4
4	male	31	10	no	2000	3	400	subsistence	home	70	4
5	female	32	9	no	1000		1500	subsistence	home and community garden	100	3
6	female, male	65	5	no	3500	44	250	subsistence and income	home	200	8
7	male	60	13	no	1000	18	20	subsistence and income	home and community garden	80	2
8	male	25	7	no	1500	3	200	subsistence and income	home	150	2
9	female	69	5	no	900	30	200	subsistence	home and community garden	80	8
10	male	57	9	no	800	2	-	subsistence and income	community garden	45	4

Half of the farmers had plots both at home and at the community garden, while the other half only cultivated at home. The people growing crops at home were forced to fetch water at the river, which is at least 30 minutes away for most people in the village, or in smaller streams closer to their house. During the winter those streams dry up early and the river also becomes very water scarce making the fetching of irrigation water a hard and time consuming task. This is due to the fact that they need to dig holes in the riverbank to reach the water and there are usually queues for fetching water from those holes. The water is brought back home in plastic containers either with the help of a wheelbarrow or carried on one's head.

The farmers growing at the community garden get water from the tanks at the World Vision office where the water is pumped from a borehole using a diesel pump. Everyone growing crops there need to pay 5 rand per month to buy the diesel, but it is common that this is not followed, causing a lack of water since the pump cannot run when there is a lack of diesel. World Vision also gathers water through rainwater harvesting from the rooftops of the office and pre-school, which is used for irrigation. The farmers at the community garden number around 50 persons, all of which are parents, mostly mothers, of the children in World Vision's program. They come there once a day to plant, weed and irrigate. As well as providing a space for a plot World Vision also gives seeds and seedlings and supplies tools. The community garden is also an important social structure where people meet and learn from each other.

Some interesting facts emerged from the interviews about the background of the interviewees (see Table 5.1):

- Half of them were in the age group of 20-39 years old
- All of them had five or more family members in their household
- 8 of 10 were unemployed
- 6 of 10 households had an income of 1000 rand or less per month
- 6 of 10 were growing only for subsistence
- They spent on average a little more than 4 hours per day irrigating

5.2 Categorisation results

The categorisations of the answers from the interviews of all ten farmers are in Table 5.2. These results are analysed and discussed in detail in the following sections.

Table 5.2 The results of the categorisation from all ten farmers.

Question	Categories	Farmers
What is the source of income in your family? *While the farmers themselves may not have had an occupation, a family member might have.	Work Pension Child support Selling produce + other	4 2 1 3
If you use your crop only for subsistence, what are the constraints hindering you from selling your produce?	Water Lack of seeds No fence Too hard work	3 2 1 1
Where are your plots?	House Community garden Both	4 1 5
Which season do you irrigate in?	Summer Winter Both	1 6 3
Where does your irrigation water come from? *Farmers had more than one water source.	River Stream Dam Natural well	3 3 4 2
How do you irrigate?	Flood irrigation Hose Others	7 2 1
Do you know any other irrigation method than how you normally irrigate?	Sprinklers None	3 7
Why are you interested in trying out the drip kit?	Needs less water Needs less time Both Reduced soil erosion	3 2 2 1
Would you buy the system if it was available?	Yes Don't know	5 5
What would you pay?	R20 R60	1 4

5.3 Factors that affect who starts using the drip kit

Four out of ten farmers started using the drip kits straight away after they had been handed out, while the rest decided to wait. The results from the adoption of the systems is based upon the answers from the farmers who tested the drip kits immediately (see Table 5.3), whereas the results about general perceptions of the drip kits are sometimes based on the answers of all farmers.

Table 5.3 The results from the interviews of the four farmers who started using the drip kits.

Questions	Farmer 1	Farmer 2	Farmer 3	Farmer 4
How was the system to set up?	"I found the system easy to set up."	"I set up the system myself and it was easy."	"I set up the drip system myself, reading the instruction and looking at the picture."	"It was easy to understand and simple to do."
Did you use the instruction paper?	Read it	Read it and looked at picture	Looked at picture (can not read)	Looked at picture (can not read)
Do you experience any change in how much water you use to irrigate?	Less water	Don't know	Less water	Less water
Do you experience any change in how long time it takes to irrigate?	Less time	Don't know	Less time	Less time
Did the system clog or brake?	No	No	No	No
What would you change with the system if you had a possibility?	Smaller spacing between drip lines	No drip emitters; Stronger material	Nothing	Smaller spacing between drip lines. Stronger material
Did you notice any difference in your crops compared to using your normal way of irrigation?	No	No	Faster growth	Faster growth No soil erosion
Will you continue using the system?	Yes	Yes	Yes	Yes

Three out of four of those who started using the drip kits were men. This could imply that men have a greater tendency for trying out new technologies compared to women. However, this group was also different from the group that did not start using the drip kits in terms of experience. All four were fairly new farmers with an experience of four years at most while in the other group four of the farmers had an experience of ten years or more.

All but one of the six farmers who did not start using the drip kits wanted to save them to use during the winter season, rather than in the summer when rain is plentiful. One farmer expressed the seasonality of water supply and irrigation requirements as follows:

"I would use it in the winter because in the summer there is enough water."

In winter nine of the ten farmers irrigate. The need for irrigation is highest during the time water is most scarce in this area, which means that any kind of water saving activity is seen as a great assistance. Only three of the ten farmers use supplementary irrigation normally during summer, and of them two started using the drip kit. These farmers would not irrigate with the drip kit when it rains. Expressed by one farmer:

"The drip system and rain help each other."

The other seven farmers rely only on rain-fed agriculture during summer.

Therefore, one conclusion could be that the farmers with longer experience knew when the drip kits really would be useful to them, while the more inexperienced start irrigating as early as the summer. However, it could also be so that the less experienced are not as trapped in the traditional way of farming but see this as an opportunity to try something new.

Two of the farmers used the drip kit at home and two at the community garden. The two that were cultivating at home lacked access to the water in the reservoirs at the community garden, which makes irrigating harder because of the need to fetch water at the river. Also, only one of them farmed in the community garden at the ADP office where the reservoir is, while the last one was farming in a second community garden also started by World Vision, but where there was no water reservoirs installed yet. This means that three of the four farmers had difficult time bringing water for irrigation.

Of the other six farmers that postponed using the kits for the winter, four wanted to place it in the community garden and two at home. Thus, the easy access to water in the community garden it attractive to the farmers when using drip irrigation. Even though there might not be water in the reservoirs all the time because of problems with getting everyone to pay the diesel fee for the pump (R5/month), it is still more reliable than the river, which is dry in the winter and requires digging in the sand to reach the water.

The mean monthly household income of the farmers partaking in this study was R1660, but for those who actually started using the drip kits it was only R900. Increasing income could be a strong incentive for a farmer to acquire a technology that enables him/her to scale-up production through water and time savings and, in addition, to decrease the risk of crop failure due to dry spells that frequent the area. Another interesting point is that three of the farmers who used the drip kits showed a strong interest in being able to expand their crop production with the possibility of selling excess vegetables to the people in the village or at the market. This was expressed by one farmer who stated that:

"I like the drip kit, want to have some more, then I can make more plots and use it on all with different crops".

5.2 Setting up the system

All farmers that started using the drip kits found the system easy to set up. To get information about how the drip kits are assembled and managed, they used the instruction paper that accompanied the drip kits. Two farmers read the instruction and looked at the explanatory picture, while the other two could not read and therefore relied only on the illustrations. Even though only one of them was present during the introduction at the ADP office, none of them had any problems with setting up and running the system, indicating the ease of use of the drip kit systems.

5.3 Choosing the crop

Three of the four farmers that used the drip kits were growing tomatoes and one of them was growing millies, which are typical summer crops in the area. Tomatoes and other vegetables are well suited for drip irrigation, since the spacing between the drip emitters fits medium sized, solitary plants. Millies, on the other hand, are usually planted in bigger fields and grown at greater densities, making drip irrigation more difficult. In addition, tomato is a cash crop that can be sold at the local market place, to make up for the money spent on buying the drip kits. Two farmers complained that the space between the drip lines was too big. They indicated that there would be enough room to make eight lines instead of four on the 20 square meters, making it possible to double the crop production on the same space.

5.4 Irrigation practices

Two of the farmers irrigated twice a day, once in the morning and once in the afternoon, filling up the bag each time. The other two irrigated only once a day, also with one full bag. Using the drip kit resulted in a water reduction of between 30-50%, as estimated by the farmers. The farmers were able to use less water every time they irrigated, and could also irrigate fewer times per day. In fact, two of the drip kit users reduced their frequency of irrigation from once per day to once every second or third day. A farmer commented about the water savings:

"Before I used 25 liters for one line, now I use 25 liters for the whole plot".

In addition, these farmers made great time savings, since they did not need to go to the river as many times to fetch water and to manually irrigate the plants as before. For three of them their every day irrigation time was even halved:

"Before I had to go to the river 3-4 times, now only once".

Thus, using drip irrigation to save water and time comprises a strong incentive for farmers to start using the systems.

5.6 Productivity results

The farmers also noticed a change in the productivity of their crops. Two of them pointed out that their tomatoes were growing faster than normally and were looking green and healthy. One of them had planted an extra line with tomatoes next to the drip lines because he had more plants, and there was a difference between the plants to be noticed. As the farmer expressed:

> *"I see a difference because the tomatoes with the drip kit grow faster than those without."*

One farmer also said that he had no problem with soil erosion any more.

5.7 System performance

None experienced any problem with breaking or clogging of the system. One farmer cleaned the inside of the bag and the filter every week since the water he used was full of algae and he wanted to prevent clogging. However, there were some other complaints regarding the design of the drip kits. As mentioned before, the farmers perceived the spacing between the drip lines to be too big. Two farmers also complained about the material being too soft and they did not think that it would survive the strong sun very well. A structure that provides shading of the drip bag would be a plausible solution; however, this will cause problems when the farmer wants to move the drip kit between different plots, because then he also needs to bring the shading structure along. One farmer did not like the drip emitters, since he was not satisfied with the water dripping so slowly. This is an example that the farmers need training in why drip irrigation is efficient and why there needs to be drip emitters at every plant. The farmers thought that the possibility of detaching the drip bag from the drip lines was very useful, because it made it possible to bring it inside when it was not in use. They were afraid that their neighbours might steel it.

5.8 Future

All four farmers said that they would continue using the system. Half of the farmers expressed that they wanted to buy drip kits and this also includes those who did not start using it yet. Most of them felt that they could spend around R60 for a drip kit. The willingness to buy the kits was not dependent on whether they were growing only for subsistence or for selling excess crops, but was fairly equally distributed amongst both groups. However, it seems that those that are most interested in buying a drip kit want to upscale their production if they are not already selling their excess.

Most people interviewed said that they were mainly interested in using the drip kits because they thought the kits would save them water and time. In a water scarce area like this, when there is no water in the taps during winter and only very irregularly during summer, the people are dependent on the river and the streams as their main water source not only for irrigating but for household supply, cleaning and stock watering. Farmers were thus willing and interested in new techniques that offered to reduce the burden of fetching water. None of them knew about any kind of irrigation method except for the sprinklers they have seen at the commercial farms, which is out of reach for a small-scale farmer because of the price and their need for pressurized water, which requires pumps and is more difficult to operate.

5.9 Implementation

As mentioned earlier, World Vision is planning to distribute drip kits to all the children in their program, which corresponds to 1000 children in Enable ADP, and to some 36 000 children in other ADP's all over South Africa. To be able to succeed with this implementation of drip irrigation there is a significant need of providing training. This would include both the World Vision staff which would be responsible for the drip irrigation project as well as the parents and children. The trainer must be knowledgeable about the systems to in turn provide good information and training to the farmers. The farmers need to understand the benefits of the systems to awaken their interest. The most important message to reach out with is that there are affordable solutions accessible to them, which would be helpful in daily life.

World Vision will play a crucial role with their resources to act as an information centre. The community garden is an important structure for the people since it allows old and young, experienced and inexperienced farmers alike to meet and learn from each other. It is a perfect place to demonstrate the usefulness of drip irrigation and where people can get familiar with the system at their own pace. Even though the greatest benefit will be to use the drip kit at home in terms of water and time savings it will also benefit the community garden by spending less water from the reservoirs, since one of the problems has been that the water is not always enough for all of the cultivators.

It would also have great potential in combination with rain water harvesting since very labor-intensive efforts go into capturing and storing rainwater runoff, for example by constructing dams or tanks. Usually this valuable captured water is then applied very inefficiently to the fields but in combination with drip systems one could raise the productivity of harvested rainwater, thereby making it more economical

The farmers are knowledgeable enough to set up the systems themselves but there is still need for training to fully understand the benefits of using a drip irrigation system and to successfully manage it. Conducting small meetings where a drip kit is being assembled together with the farmers who are interested in trying the systems will provide a lot of help to the persons who are going to use them. It is also important to remember that since most people would like to use the drip kits in winter, training and distribution of the drip kits must coincide with ploughing and sowing for that season. Providing seeds and seedlings, as well as fertilizers and pesticides and other garden supplies is also of importance. This is already to some extent in practice, but this could be further extended within the program so that all people that receive a drip kit will also get training, seedlings and fertilizer. In addition, this will be an incentive for the farmers to actually start using the drip kits.

5.10 Supply services and infrastructure

Even though the first drip kits will be handed out for free it is important that there are supplier services if the farmers wants to buy more systems to expand the irrigated area or if the systems break. In addition, it is likely that there are more farmers interested than only those who have children in the ADP programme.

The IDE drip irrigation system that was used in the study is not for sale in South Africa. Instead, World Vision is planning to distribute drip irrigation systems produced locally. The manufacturer of those is in the implementation phase of starting up a manufacturing facility in Pretoria. However, the company is planning to have small franchise facilities in the rural areas in cooperation with World Vision where farmers can buy drip kits. This would make it possible for the farmers to buy new drip kits and get access to spare parts. The company

manufactures a similar system for the IDE family nutrition kit. The durability of the bag is such that it has a lifespan of around two years, provided the material of the bag is rubber instead of plastic. The system will cost around R75 and it will also be possible to buy a combination package with seeds included for a higher price.

There are other garden sized drip irrigation systems for sale in the larger towns, and also systems that could be used for larger plots. However, the latter systems rely on relatively expensive and complicated pressure compensation devices to ensure high distribution uniformities, which therefore make them unsuitable for small-scale rural farmers.

The importance of the new road cannot be stressed enough, since it significantly facilitates the journey to the nearest town, Tzaneen. While it previously took several hours to the villages in the Sekororo area, it is now possible to reach the town in less than an hour. However, Enable village is still situated around 3 km from this road, which makes it harder for the inhabitants to access the bigger markets compared to the people living in the villages close to the road. They are also restricted to taking buses or taxis making it difficult to bring their crops along for sale. Therefore, they usually sell their excess produce within the village, either by walking around selling it or by people coming to the community garden to buy. The community garden at the ADP could very well function as a market place where people from the neighbouring villages come to buy fresh produce, but then there needs to be an increase in the cultivation of cash-crops.

6 Conclusions

This study aimed at determining the perceptions of low-cost drip irrigation systems by small-scale rural farmers' in rural sub-Saharan Africa. The following conclusions can be made from the results of this study:

- Small-scale rural farmers are capable of successfully setting up and managing low-cost drip irrigation systems. They can assemble the system themselves with the help of the instructions accompanying the drip kit and are able to handle the every day maintenance of the systems.
- The opportunities drip systems offer small-scale farmers, as perceived directly by farmers, include improved water efficiency, time and labour savings, and reduced soil erosion.
- The constraints on using drip kits include lack of knowledge; limited capital to buy seeds, seedlings, and fencing for gardens at farmers' homes, leaving crops and drip kits unprotected from animals and thieves; and little or no incentive to raise crop production since the market is distant and relatively inaccessible to farmers carrying their produce.
- To succeed with implementation of drip kits there must be a focus on introduction and training of the drip systems for both staff at World Vision so they can provide the support and knowledge to farmers, and to the farmers themselves. This is crucial to awake the farmer's interest of the benefits of using drip systems and to inspire them to try a new irrigation method.
- The training should coincide with the winter season when the use of drip irrigation is most needed. The implementation should be timed with when farmers perform ploughing and sewing.

It also should be mentioned that consideration needs to be taken into the possibility that the small number of users in this study affected the results. However, it was interesting to notice that it was not only the farmers involved in this study that were interested and had opinions and ideas about the drip irrigation systems. Many people in the village were interested in the project and the adaptation to the technology was fast. One example is that the leader of a community garden which started in 1984 was very interested and asked for ten drip kits which he also received at my last visit to the village. He wanted to show it to the members in the community garden and he was convinced that they would use it and be greatly assisted by it.

REFERENCES

ALIN-EA. 2002. Technologies: Affordable drip irrigation for small-scale farmers. Retrieved April 23, 2005 at http://www.alin.or.ke/data/technologies/drip.htm.

Barton, T., Borrini-Feyerabend, G., de Sherbinin, A. and P. Warren. 1997. *Our People, Our Resources*. IUCN, Gland, Switzerland and Cambridge, UK.

Chenje, M. 2000. State of the Environment Zambesi basin 2000. SADC/IUCN/ZAR/SARDAC, Maseru, Lusaka, Harare.

Chitsiko, R.J., and Mudima, K.T. 2002. Adapting modern irrigation technologies for use by smallholder farmers - the Zimbabwean experience. Paper presented at the seminar: *Smallholder Land and Water Management Systems - Sharing Lessons from Experiences in Africa and Asia*, 1-5 July 2002, Bangkok, Thailand. 11 pp.

Dasberg, S. and Or, D. 1999. *Drip irrigation*. Springer-Verlag, Berlin, Germany. 162 pp.

DWAF. 2003. Olifants Water Management Area, overview of water resources availability and utilization. Department of Water Affairs and Forestry, Pretoria, South Africa.

Enable ADP. 2004. PRA Analysis and community feedback report. World Vision, Enable ADP, South Africa.

FAO. 2003. The state of food insecurity in the world. United Nations Food and Agriculture Organisation, Rome, Italy. 37 pp.

Indian National Committee on Irrigation and Drainage. 1994. Drip irrigation in India. New Dehli, India.

International Development Enterprises India. 2004. ADITI program. Retrieved April 26, 2005 at http://www.ide-india.org/ide/aditi.shtml

Johnson, B and Christensen, L. 2004. *Educational research: Quantitative, Qualitative and Mixed Approaches.* Allyn & Bacon. USA. 592 pp.

Maruleng Municipality. 2003. Maruleng IDP Review Final Draft. Maruleng Municipality, South Africa

McCartney, MP., Yawson, D.K., Magagula, T.F. and Seshoka, J. 2004. Hydrology and water resources development in the Olifants River Catchment. Working paper 76. Colombo, Sri Lanka: International Water Management Institute (IMWI), South Africa.

Kabutha, C., Blank, H. and van Koppen, B. 2000. Drip irrigation kits for small-holder farmers in Kenya: experience and a way forward. 6th International Micro-Irrigation Congress, *Micro-irrigation Technology for Developing Agriculture*, Conference Papers, South Africa. 7 pp.

De Lange, M. 1994. Small-scale irrigation in South Africa. MBB Consulting Engineers/Water Research Commission of South Africa, Pretoria. 29pp.

Van Leeuwen, N.H. 2002. Affordable small-scale drip irrigation in Africa: Potential role of the private sector. Regional Seminar on *Private Sector Participation and Irrigation Expansion in sub-Saharan Africa*. Conference paper, Accra, Ghana. 7pp.

Perret, S.R. 2002. Water policies and smallholding irrigation schemes in South Africa: a history and new institutional challenges. Water Policy, 4: 283-300.

Du Plessis, F.J. and van der Stoep, I. 2000. Evaluation of the appropriateness and management requirements of micro-irrigation in small-scale farming. 6th International Micro-Irrigation Congress, *Micro-irrigation Technology for Developing Agriculture*, Conference Papers. South Africa. 11 pp.

Polak, P. 2004. Water and the Other Three Revolutions Needed to End Rural Poverty. International Development Enterprises. USA. 12pp.

Postel, S. 1999. *Pillar of sand: Can the irrigation miracle last?* W.W. Norton and Co. New York, USA. 330pp.

Postel, S., Polak, P., Gonzales, F. and Keller, J. 2001. Drip irrigation for small farmers. A new initiative to alleviate hunger and poverty. Water International, 26(1): 3-13.

Savva, A. 2000. The need to adapt systems to smallholders conditions in sub-Saharan Africa. 6th International Micro-irrigation Congress, *Micro-irrigation Technology for Developing Agriculture*, Conference Papers. South Africa.

Sijali, I. 2001. *Options for smallholder farmers in eastern and southern Africa*. Regional Land Management Unit, RELMA/Sida.

Shah, T and Keller, J. 2002. Micro-irrigation and the poor: A marketing challenge in smallholder irrigation development. Regional Seminar on *Private Sector Participation and Irrigation Expansion in sub-Saharan Africa*. Conference paper, Accra, Ghana.

Shah, T., van Koppen, B., Merrey, D., de Lange, M. and Samad, M. 2002. Institutional alternatives in African smallholder irrigation: Lessons from international experience with irrigation management transfer. Research Report 60. Colombo, Sri Lanka: International Water Management Institute.

UN. 2003. Why Do The Millennium Development Goals Matters? DPI 2321, United Nations Development Programme and United Nations Department of Public Information.New York, USA.. 7pp.

UNEP. 1999. Global Environmental Outlook 2 *(GEO-2)*. United Nations Environment Programme, UNEP, Nairobi, Kenya. 398 pp.

UNEP. 2002. Global environment outlook 3 (GEO-*3)*. United Nations Environment Programme, UNEP. Earthscan, London, UK. 416 pp.

World Vision. 2004a. PRA Analysis and community feedback report. World Vision, Enable ADP, South Africa.

World Vision. 2004b. About World Vision. Retrieved March 10, 2005 from http://www.wv.org.za/aboutus.html

APPENDIX I

Interview questions

Demographic Information:

1. Name:
2. Village:
3. Village section:
4. Sex: (male/female)
5. Education:
6. Current occupation:
    a. Fulltime
    b. Part time
    c. None
7. Family members:
    a. Adults:
    b. Children:

8. Household headed by:
    a. Male-headed household (male head is permanently at home)
    b. Migrant husband household (male only home on occasion, i.e., once a month)
    c. Female-headed household (husband is permanently absent, divorced, widow etc)

9. What is the source of income in your family?
10. What is your family's monthly income?
11. Who takes financial decisions in the family?

Small scale farmers:

12. How many plots do you have?
13. Where are your fields?
14. What is the size of your plot?
15. Who does the work on the plots and if there is more than one person, how much does every person do?
16. What crop do you grow in the summer?
17. What crop do you grow in the winter?
18. Do you use any fertilizer and, if so, what do you use?
19. Do you use any pesticides?
20. How many years have you been farming?
21. Is your farmland titled to you? If not, then who has title to it?

Water supply:

22. Which season do you irrigate in?
23. How do you irrigate?
24. Where does the water come from?
25. Who brings the water?
26. How long does it take to bring water to your plot?
27. How often do you irrigate?
28. How long does it take to irrigate your plot?
29. Do you pay anything for the water?
30. Are you satisfied with your current irrigation method? If not, why?

Drip irrigation system:

31. Why were you interested in trying out the drip kit?
32. How was the system to set up?
33. Did you use the instruction paper?
34. How is the system to manage?
35. How do you fill water into the bag?
36. How many times per day do you fill the bag?
37. Do you experience any change in how much water you use to irrigate?
38. Do you experience any change in how long it takes to irrigate?
39. Did the system clog?
40. Did the system break?
41. What would you change with the system if you had the chance?
42. What is your general opinion about the drip system?
43. Did you notice any difference in your crops compared to using your normal way of irrigation?
44. Will you continue using the system?
45. Do you know any other irrigation method?

Economic and infrastructural factors:

46. Would you buy the system if it were available?
47. What would you pay for it?
48. What do you use your crop for?
    i. If only for subsistence then:
        a. What are the constraints hindering you from selling your produce?
        b. Where would you sell your produce?
        c. How far is it?
        d. How would you transport the crop?

    ii. If both subsistence and selling, then:
        a. What makes it possible for you to sell your produce?
        b. Where do you sell it?
        c. How far is the market?
        d. How do you transport your crop there?
        e. How much do you earn?