UNIVERSITY OF ZIMBABWE

Impact and sustainability of drip irrigation kits, in the semi-arid Lower Mzingwane Catchment, Limpopo Basin, Zimbabwe

By

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A thesis submitted to the University of Zimbabwe (Faculty of Engineering, Department of Civil Engineering) in partial fulfilment of requirements of Master of Science in Water Resources Engineering and Management

Integrated Water Resource Management For Improved Rural Livelihoods
CGIAR Challenge Program on WATER & FOOD

WATERnet

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ABSTRACT

Smallholder farmers in the Mzingwane Catchment are confronted with low food productivity due to erratic rainfall and limitations to appropriate technologies. Several drip kit distribution programs were carried out in Zimbabwe as part of a global initiative aimed at 2 million poor households a year to take major step on the path out of poverty. Stakeholders have raised concerns of limitations to conditions necessary for sustainable usage of drip kits, such as continuing availability of minimum water requirement. Accordingly, a study was carried out to assess the impacts and sustainability of the drip kit program in relation to water availability, access to water and the targeting of beneficiaries.

Representatives of the NGOs, local government, traditional leadership and agricultural extension officers were interviewed. Drip kit beneficiaries took part in focus group discussions that were organised on a village basis. A survey was then undertaken over 114 households in two districts, using a questionnaire developed from output of the participatory work. Data were analysed using SPSS.

The results from the study show us that not only poor members of the community (defined for the purpose of the study as those not owning cattle), accounting for 54 % of the beneficiaries. This could have been a result of the condition set by some implementing NGOs that beneficiaries must have an assured water source - which is less common for poorer households. Only 2 % of the beneficiaries had used the kit to produce the expected 5 harvests over 2 years, owing to problems related to the water and garden problems. 51 % had produced at least 3 harvests and 86 % 2 harvests. Due to water shortages 61%, cropping using the drip kit was done during the wet season, meaning that the drip kit was mostly used for supplementary irrigation. Conflicts between beneficiaries and water point committees, or other water users developed in some areas, especially during the dry season.

Low cost drip kit programs can only be a sustainable intervention if implemented as development (not relief), where all stakeholders are involved and the implementing agents ensure that the benefits reach the intended beneficiaries. Issues of water access and availability, which confront the poor in the water scarce regions such as Mzingwane, catchment have to be adequately investigated and addressed, prior to distribution of drip kits.

ACKNOWLODGEMENTS

I wish to thank my supervisor Steve Towmlow for the guidance and supervision during the course of this study.

Special thanks to Marloes Mul, David Love and Walter Mupangwa for their worthy comments and criticisms.

I am also grateful to Water Resources Engineering Management (WREM) programme of University of Zimbabwe, Waternet. RELMA, ICRISAT and Limpopo Challenge Program for the financial support offered during my study.

I also wish to thank the following;

ICRISAT staff for their support
Mr Mpala and Alibaba (LEAD- Bulawayo)
District Development Fund staff
Beitbridge Rural District Council
Gwanda Rural District Council

LIST OF ACRONYMS

AGRITEX	Agricultural Extension Services
CSO	Central Statistics Office
DDF	District Development Fund
DFID	Department for International Development
IDE	International Development Enterprise
ITDG	Intermediate Technology Development Group
LEAD	Linkages for the Economic Advancement of the Disadvantaged
LDS	Lutheran Development Services
NGO	Non Governmental Organisation
ZINWA	Zimbabwe National Water Authority

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1.1 GENERAL BACKGROUND

Due to decreasing investments and declining performance of many large-scale irrigation schemes, interest has been developing in recent years for seeking ways to improve productivity and livelihood of small-scale farmers. Comprising the majority of farmers in developing countries, small-scale farmers should be perceived as key players in increasing global food production and achieving food security (Frausto, 2000). It is in this context that a global initiative has been developed for small- holder irrigation. This initiative for small-holder irrigation is world's most ambitious poverty reduction plan aimed at 2 million poor households a year to take a major step on the path out of poverty. The pro-poor technologies successfully tested so far include treadle pumps, rope and washer pumps, low cost drip and micro-sprinkler and bucket kits. This initiative is expected to benefit 30 million poor and landless households around the globe and would bring 1 million hectares under cultivation over the next 15 years (Hussain et al, 2002)

As rural families struggle to maintain their lives in face of HIV/AIDS in Zimbabwe (where one-third of adults are HIV positive) recurrent droughts and economic decline have undermined families' ability to grow food for their own consumption or sale (Kadiyala and Gillespie, 2003). Illness and death due to HIV/AIDS result in sub-optimal changes in livelihood strategies to deal with increased vulnerability, including changes in production decisions concerning crops and farming techniques. There is often a move to less labour intensive crops and techniques and in area devoted to cash crops (Muelda A, 2004). USAID through the LEAD has provided a good opportunity for policy makers to promote an HIV/AIDS context. USAID has provided simple low cost drip irrigation kits to AIDS affected families in Zimbabwe, allowing orphans and grand children to garden vegetables for home consumption or resale. Each drip garden is expected to produce up to 600kg of vegetables per year, enough to feed a family of six with their complete vegetable needs plus have surplus to sell for cash (Fabunmi, 2004)

1.2 JUSTIFICATION OF STUDY

Low cost drip kits distribution in the "Home nutrition garden" project have been hailed as a way of improving livelihoods, incomes, food security and nutritional health of poor families in drought prone areas of Zimbabwe. Since kits make an efficient use of water, the introduction of drip kits in these semi-arid areas was meant to overcome the water supply limitation and to increase crop productivity so that the farmers could be able to meet their food requirements and possibly a reasonable income to improve their livelihoods. Linkages for the Economic Advancement of the Disadvantaged (LEAD) program under USAID has helped 20,000 food-insecure families by installing low-cost drip-irrigation kits for household nutrition gardens (USAID/Zimbabwe Report, 2004). This programme was initiated to help mitigate the effects of droughts and HIV/AIDS in the communal farming areas of Zimbabwe. In the studies done in Zimbabwe and India in the pilot projects it was seen that many requirements for the sustainable distribution of drip kits were not in place in Zimbabwe. These included the condition of continuing availability of minimum water requirements (IDE, 2003). The ability to access and transport sufficient water was also deemed one of the important conditions to ensure that the users have a hope of enhancing their livelihoods through the use of the drip kits. Thus in Zimbabwe the program was undertaken against the background of failing to meet these conditions among others. It will be important to investigate how these challenges have impacted on the program in particular the usage of the distributed kits especially in water scarce regions like the Mzingwane catchment. The water sources that already exist were also meant for household and livestock needs it has to be seen how much access the beneficiaries of the drip kits have to these sources. This is important in light of the fact that kits are supposed to be used through out the year with farmers growing up to three cycles of crops, including at least one cycle of vegetable crops during winter and early maize or bean crop that can be harvested in December (Intermediate Technology Development Group-ITDG, 2004). Mzingwane catchment being a water scarce area, beneficiaries could find themselves in circumstances where at times they are not able to meet their water requirements for the garden projects due to critical shortage of water. The water supply situation could be critical during the dry season when some of the water sources would have dried out. The coming of these kits on the other hand could have resulted in the possibility of conflicts

occurring as the finite water resources became stretched as these sources were also meant other uses, which include livestock and domestic needs. There is a need to come up with ways in which the beneficiaries can derive reasonable benefits at all the times without compromising these other users. It is thus critical to understand the current usage of these drip kits so that lessons can be learnt and subsequent changes in the distribution of these drip kits can be developed.

The advent of the inexpensive drip kits under the home garden project had been expected to tremendously improve the livelihoods of poor families in the rural areas through enhanced nutrition and incomes. A home nutritional garden is expected to produce up to 600 kilogrammes vegetables per year, enough to provide a household of six with their complete vegetable needs plus surplus to sell for cash (Sahara Resource Network, 2004). These can only be achieved if the beneficiaries are able to utilise the drip kit through out the year. Utilisation of drip kits will depend on factors such as the availability and access to water, availability of technological advisory services, water quality and the level of training among others. Emerging evidence suggests that access to agricultural water through low cost technologies offers tremendous potential to improve the livelihoods of millions of the poorest (Hussain et al, 2002). Availability and access to water could be critical factor especially in drought prone areas such as the Mzingwane catchment. It will thus be important to assess the level of utilisation of the drip kits distributed in the catchment. For beneficiaries of these kits to derive the desired benefits there is need for assured rights to water by the drip kits users. It will thus be also important to investigate the rights to water of drip kits users and the possibility of conflicts as a result of the advent of these drip kits. The rights to water are considered on the basis that most of the beneficiaries of these kits are said to be mostly the marginalised members of the community who may not have much say in the management of their water resources

For security reasons the garden project were set up in the homesteads but the coincidence of water source and homesteads is not expected considering that those targeted could be poor families who may not own their own water resources. The distances travelled to water sources can also impact on the utilisation of these drip kits. It thus important to assess if

this could have affected the utilisation of the kits distributed in Mzingwane catchment. For the kits to be operating and for that matter efficiently there is need for the beneficiaries to be adequately trained from the installation and the maintenance and that there is adequate technological backup service. This means that there is also a need to assess the level adequacy of services offered of the NGOs.

From the studies undertaken in Zimbabwe and other geographic regions, which include India West and India East between April 1999 to December 2002, it was found that households of average or above average wealth, with access to their water source that showed greatest interest in using low cost drip kits. Considering that quite a number of NGOs where involved in distribution of these kits in Gwanda and Beitbridge it will be interesting to investigate the type of targeting done by different NGOs and how this has affected the utilisation of these kits. Rohrbach (2005) concludes that to improve the efficiency relief programmes one of the issues that need to be addressed is that of targeting. In theory, relief assistance is targeted at the poorest or most vulnerable households but selection criteria are often impractical to implement; so the beneficiaries are not necessarily the poorest in the community. It has to be noted that for whatever targeting done there are challenges associated with it and it is those challenges that have to be overcome for the beneficiaries to derive maximum benefits from the use of these kits. It is against this background that there is need to assess the adoption and use of drip technology in Zimbabwe especially in water scarce areas such as the Mzingwane catchment.

As it will be seen most studies in Zimbabwe have concentrate on the technical evaluation of drip kits but little has been done on the impacts and sustainability of the kits. In this study the sustainability which is the ability of the program to continue benefiting the communal farmers in livelihood improvements was considered in relation against the conditions that were said to enabling for such programs which include the continued availability of minimum water, the distances water sources, the availability of spares, technical; and agronomic advice and the availability of viable markets for the produce.

1.3 RESEARCH OBJECTIVES AND QUESTIONS

1.3.1 Overall objective

To assess the impact and sustainability of household drip kits, in semi-arid lower Mzingwane subcatchment.

1.3.2. Specific objectives

1.To assess the access and availability of water to household drip kits gardens
2. To assess the criteria used in selecting the beneficiaries of low-cost drip kits.
3. To assess the farmer training and the level technological back up.
3.To compare the purpose of the drip kit distribution with actual use
4. To identify sources of water for drip kits and levels of competition/ conflicts arising due to the use of water from these water sources for drip kits.

1.3.3. Research questions

1. What are the sources of water for the drip kits and critical periods in which there acute shortage of water from identified sources?
2. What are the number of kits and their proximity to the water sources and the level of usage of the kits distributed among communal farmers in the catchment and study area?
3. What are the criteria used by different NGOs in identifying the beneficiaries?
4. What are the policies governing the use and the management at water point/village level of water sources and the conflicts arising from the use of drip kits?
5. How are the conflicts being solved and how can such conflicts be avoided in future projects?

2 LITERATURE REVIEW

2.1 LOW COST DRIP TECHNOLOGY

Irrigation agriculture sector is facing increasing challenges in face of rapid population growth, decreasing availability of land, and competition for scarce water resources (Frausto, 2000). In Zimbabwe only 2% of rural subsistence farming household are involved in formal small-scale schemes 20 years after independence (Robinson, 2002). To overcome these challenges and improve productivity and livelihoods of world's small scale farmers who comprise the majority of farmers in developing countries, IDE has redesigned conventional irrigation systems to produce a series of dependable and affordable systems that more adequately meet small farmers' needs (Behr and Naik, 1999). Low cost drip technology, which is at 'market take-off', holds a great promise both in terms of water consumed and reducing rural poverty. The resultant drip systems require a minimum filtration, are available in small packages, operate at low inlet pressure, and are easy to understand and maintain by small-scale farmers. It is worth noting that 'low cost' does not imply low cost per ha, but rather refers to low initial capital outlay. The initial purchase of number of kits required to cover one hectare is as costly as conventional drip irrigation systems (Haile et al., 2003). This means that this technology allows entry of poor farmers into irrigation agriculture at reduced initial capital costs. Farmers have an option of gradually increasing their irrigated area up to 1000m^2 to 2000m^2 as they realise financial benefits from the use of kit. Low cost drip kits have been promoted as KB Drip – KB standing for 'Karishak Bandhu', which means 'farmer's friend'. It has to be seen if indeed these kits have indeed become the farmer's friend in this part of world. Standard conventional drip systems have proved both inappropriate and unaffordable for most small-scale farmers due to high cost (US$1,500-2,500 per hectare), expensive and complicated water filtration, high operating pressure (20-30m) and the need for very careful maintenance to avoid clogging (Keller, 2004). Thus low cost drip kits were designed to conform to the constraints and needs of farmers and complement their terrace sizes, water limitation and personal investment risks.

The International Development Enterprise (IDE), which is an international non –profit NGO which has been involved in the design and manufacture of the drip kits has done intensive studies on this new technology in Asia and Africa. In early 2003, Linkages for Economic Development for the Disadvantaged (LEAD), a US sponsored AID NGO, launched a tender to distribute 50,000 low head irrigation kits of $100m^2$ plots for marginalized communal farmers of Zimbabwe (Chigerwe, et al, 2003). In the past two years 20,000 low cost drip kits have been distributed in Zimbabwe (ITDG, 2004). The LEAD has been working with over 10 NGOs in the country to distribute these kits. Studies carried out in Zimbabwe have so far focussed on the technical evaluation of the low cost of drip kits. Maisiri (2004) focussed on the scheme level evaluation of low cost drip irrigation in terms of water and crop productivity while Chigerwe (2003) looked at laboratory technical evaluation of all the low cost drip kits available in Zimbabwe.

It has to be noted though that low-cost technologies such as drip systems are not widely reported in literature, this could be a consequence of the nature of organisations and agencies involved in their development and promotion, which are main development NGOs, rather than reflection of potential value to small plot holders (FAO, 2002)

2.2 TYPES OF LOW HEAD DRIP SYSTEMS

'Drip kit' is the name that was coined by Chapin who has developed and promoted, low cost, and efficient drip irrigation (FAO, 2002). To come up with affordable drip systems for small-scale farmers low cost drip kits were designed to operate at pressure as low as 0.5-2.0m water head unlike the standard conventional drip system are operated at pressures as high as 20-30m water head. Thus it has been possible to use small reservoirs such as oil drums or buckets as header water tanks, which are supported above ground so that pressure falls within specified range. Also due to low head pressure light perforated flexible piping and inexpensive fittings are used and this makes it easy to repair any possible leaks. Based on KB Drip lateral tubing is expected to last for about four growing seasons, which about

two years with double cropping (Keller, 2004). Low head drip systems include gravity drip irrigation and bucket and drum kits (Ngigi et al., 2000).

2.2.1 Gravity drip irrigation

The type of irrigation fits into infrastructure of existing channels, ditches and gravity-irrigated fields. It also uses a very low-pressure. Due to the very low pressure of operation, these systems are sensitive to ground elevation differences and these require special drip laterals (Gilead, 1985).

2.2.2 Bucket kits

These have been designed for home gardens and were based on Chapin's bucket system (FAO, 2002). These kits are particularly suitable for field crops and orchards. This type of kit operates at a low-pressure head of 0.5 to 2.0m(Ngigi. et al, 2000). A bucket kit consists of a bucket of capacity ranging from 20 litres to 200 litres installed at a shoulder height. The bucket is fitted with 10m lateral line, filter, rubber washers, adaptor, water delivery pipes and barb fittings. The emitters that can be used with the include in-line drip emitters, integral emitters and online emitters or micro tubes.

2.2.3 Drum kits

Drum kits have greater irrigation area coverage than the bucket kits. IDE –designed kit have coverage of $100m^2$, $500m^2$, $1000m^2$ and $2000m^2$.Operating pressure for these kits ranges from 0.5-5m.It consists of mainly the drum, tap, manifold and drip laterals.

2.2.4 Types of drip emitters

There are basically three types of drip emitters namely inline-drip emitters, integral emitters and the micro-tubes. In-line drip emitters are individual emitters inside the drip tubing flow path with dripper emitter ends on either side. Integral emitters have drip emitters welded to the inner wall of the tube and come as continuous rolls with outlets at predetermined intervals. Micro-tubes are designed to be inserted into the wall of tube or 5mm micro-tubes.

2.2.5. Drip kits found in Zimbabwe

Chigerwe et al, 2003 looked at different local and imported drip kit sets that are found in Zimbabwe as shown in Table 1. From the studies carried in the water scarce region of Zimbabwe it has to be seen which type of kits have been predominately distributed by the NGOs.

Table 1. Summary of Drip kits found in Zimbabwe (Chigerwe, 2003)

Type of kit	Country of Manufacture	System type	Cost (US$)
IDE	USA/Nepal	Microtubes	38.22
Forster	Zimbabwe	Microtubes	39.32
Automated (Small diameter)	Zimbabwe	Microtubes	39.22
Automated (Large diameter)	Zimbabwe	Microtubes	46.09
Plastro (Water wise)	Israel	In –line emitters	52.04
Plastro (Ronfleur)	Israel	In-line emitters	52.04
Netafim	Israel	In-line emitters	57.43
EINTAL	Israel	In –line emitters	59.34

2.3. LOW COST DRIP KIT PROGRAMMES IN LOWER MZINGWANE CATCHMENT

Over 5 NGOs mostly co-ordinated by the LEAD programme have distributed over 2000 drip kits in the Lower Mzingwane catchment. The drip kit programmes have come mostly as relief programmes to alleviate effects of drought and HIV/AIDS in these communal areas.

2.3.1 USAID LEAD PROGRAMME

The USAID / LEAD programme has distributed over 20, 000 kit to Zimbabwean rural communities mostly to food insecure households and HIV/AIDS infected and affected families through a network of NGOs. In Mzingwane catchment since 2003 LEAD has worked with ITDG, Hlekweni , LDS, Dabane, Compassion Ministries and Mvuramanzi to distribute kits to deserving communities.

2.3.2. WORLD VISION PROGRAMME IN BEITBRIDGE

World Vision drip kit programme in Beitbridge began in 2004 with an objective of distributing about 1600 kits. At the time of this research over 60 kits had been given out to rural communities in the district since the beginning of the programme. The target number of kits was still to be met due late delivery and distribution of drums. It has to be noted though that, unlike the other NGOs involved in the distribution of kits, World Vision sourced its kits directly through IDE.

2.4. OPERATION AND MAINTENANCE

2.4.1. Clogging of kits

Very little has been done to investigate emitter clogging for low cost drip kits besides claims by manufacturers themselves (Chigerwe, 2003). Literature on clogging which is available is only for commercial large-scale large emitters. Chigerwe (2003) managed to carry out trials on few low-cost drip kits, which had deviation of less than 10%. Those that were tested include the Forster and the Plastro drip kits. Those that were not tested due to the failure to meet deviation specification include the Netafim, EIN-TAL and IDE. Systems with in-line drippers rely on the farmers using a pin or fine wire to clear any clogged emitter. This practical on farm of 0.1ha which may have 2500 emitter that require to be maintained but would be unrealistic on large systems (FAO, 2002)

From studies carried out in Hagaz and Hamelmalo schools and at Halhale Reaearch Station of the IDE drip kits, serious clogging of microtubes was reported, mainly due to salty water and / or suspended sediments (Stillhardt et al, 2003). This was said to be inevitable as the IDE kits are supplied with a simple mesh filter. The problem of clogging can even be witnessed in conventional drip kits where expensive graded filter network is furnished making flushing or cleaning with acids a routine operation practice.

2.4.2. Labour requirements

Maisiri(2004) found out that labour requirements related to the use of drip kit were high and that up to 80% of the farmers that were interviewed at that particular scheme complained that it was labour intensive. It has to be investigated if this could be true at a setting were it is not in a scheme and were farmers use different water sources for their drip kits, which are varying distances from the gardens. Upadhyay (2003) reported from a study in Nepal that 66.7 % of those interviewed felt that the use of drip kit had not increased their workload.

2.5. ENABLING CONDITIONS FOR LOW COST DRIP TECHNOLOGY

The degree of sustainability of technical and financial benefits will depend among other factors on availability of spares, technical and agronomic support from supply chain, continuing availability of minimum water requirements, the presence of viable market for drip produce (IDE, 2003). The possibility of livelihood improvement via drip kit through either food security benefits, nutritional gains or income will depend on the mentioned factors. It has to be seen if the current low cost drip kit programmes in Zimbabwe especially in water scarce regions are sustainable.

2.6. Water use

Drip irrigation has been proven that it uses less water than other systems such flood irrigation. Drip irrigation kits were found to use just over 32% of water used in flood irrigation (Maisiri, 2004). For drip kit 500 litres would be required twice per given week compared to 2500 litres per irrigation event once per week for surface irrigation. This means that the introduction of drip kit holds a great potential for water savings, which is particularly important in semi-arid areas, such Mzingwane catchment.

2.6.1. Water scarcity

From the studies carried out in East and West India and Zimbabwe it was concluded that one of the enabling conditions is that farmers face water scarcity –actual and perceived for at least one season i.e. summer (IDE, 2003). It was also seen that those with enough water normally prefer to flood irrigate even if drip has high yield potential. On the other hand in extreme water scarce conditions drip irrigation is one of the few possibilities to sustain crop growth.

2.6.2. Distances to water sources

For sustainable use of low cost drip technology it was recommended that the water source for the kit should be within 15-30m (IDE, 2003). The water source should also not become completely dry during the summer. It will be interesting to see if these recommendations were at all met and how these factors have influenced the usage pattern of the drip kits especially in water scarce areas.

2.6.3. Access to irrigation water

Hussain et. al (2002) found out that antipoverty of irrigation could be enhanced by creating conducive conditions that included access to and adequacy of good quality surface and ground water. From the study carried out in East India which is highlighted in the IDE report it was seen that better-off farmers used drip kits from their own wells while on the other hand the poorer, did not possess their own water sources had to fetch water from community water sources. This was seen as a major constraint in the adoption of the technology as many communities did not allow the use of water from common resources for irrigation, especially during the dry seasons. It has to be seen how much access the poor farmers who are targeted in the drip kit program have to the water resources considering that Mzingwane catchment is semi–arid and has severe dry seasons.

2.6.4. Drip irrigation water and crop productivity

According to the manufacturers and promoters of the drip kits (IDE) after carrying out tests where the kit was compared ‘side by side’ with flood irrigation the kit showed water saving of 50% and the yield increases of 30%, with no substantial differences with conventional systems (IDE, 2002). Maisiri (2004) in Zimbabwe found out that the water saving of more than 50% could be achieved by the use of drip kit but it did not result in significant high crop production. A higher crop production could only be achieved with an integrated approach that involved nutrient management and proper water management. Adoption of

drip irrigation on a piece of land also resulted in increase of 20 to 50% in production per unit land area (Keller, 2004). This increase in production results from the more precise timing, higher uniformity and accurate amount of water applied made possible by using drip irrigation.

2.7. Gender perspective of drip irrigation

Upadhyay (2003) from studies carried out in Nepal, India, notes that before adoption of drip kits women did not have any income source, but with the adoption of drip technology they not only had access to financial resources but also control over it. This helped increase their bargaining power in both household and community. Women were also able to successfully broaden their roles from those of being domestic water users to productive water users by simply making water work. There was also some 75% saving of time due to adoption of drip technology in cases where water sources were near the gardens, as result women could now utilise the time saved for other important household chores. On the other end savings of water over flood irrigation meant that for women meant less water carried from wells to their gardens (Frausto, 2000).

2.8. PREVIOUS STUDIES IN ZIMBABWE

Since 1997 studies have been carried out in Zimbabwe on the low cost drip technologies have been mostly concentrated on the technical evaluation of the drip kit both in the field setting and in the laboratory where a great potential for application by smallholder farmers. Little has been done with relation to the impacts and sustainability of the kits in relation to conditions ideal for the implementation of such programs since the distribution of over 20,000 kits in 2003 especially in water scarce semi-arid areas such as Lower Mzingwane.

2.8.1 Developing and testing Irrigation systems technologies for smallholder farmers/

Senzanje (1997) conducted a study to determine the characteristics of hydraulic performance of low cost emitter s under laboratory conditions. The emitters were string type, sponge and slit type tested over 9 operating pressures ranging from 10 to 250kpa.Overall, the sponge emitter appeared to be better than slit type which was better string type.

2.8.2 Evaluating the technical performance of a low cost drip irrigation system for smallholder farmers

Senzanje(1998) as follow up to the above study undertook a study to evaluate the technical performance of low cost drip systems suitable for smallholder farmers under field conditions. The low cost drip system comprised of a 210 litre drum with a 1m by 25mm diameter manifold to which three 20m long drip lines were attached. The emitter comprised of 5mm diameter holes on dripline covered with sponge and secured by elastic rubber bands spaced at 0.5m apart on the dripline. From the performance measures it was found that the low cost drip systems had a potential to be improved and could be adopted by smallholder farmers for them to realise the benefits of modern irrigation technologies.

2.8.3. Technical laboratory evaluation of drip kits in Zimbabwe

Chigerwe (2003) undertook a laboratory evaluation of low cost drip kits found in Zimbabwe. The parameters that were considered in the evaluation include the average discharge rate of individual emitters, the emitter distribution uniformity along laterals, emitter co-efficient variation along a lateral and the sensitivity of kits to clogging and ease of declogging. He recommended an ideal kit with elements from different kits found in Zimbabwe. This ‘ideal’ kit had laterals of a Forster, a line and manifold from Plastro kit

including in the in-line filter, a tap from the drum from Netafim kits and pegs for holding the micro-tubes from IDE kit. The study concludes that well designed micro-tube systems with high flow rates such as Forster system generate high uniformity, even at extremely low head (0.1m) and present lower clogging problems and higher placement flexibility than the low flowing systems. This was viewed as an indication that micro-tube systems are appropriate for smallholder farmers although the study did not assess the impacts on crop growth of different emitter rates and the relationship between emitter discharge and non-productive soil evaporation.

2.8.4. On-farm evaluation of effects of low-cost drip irrigation on water and crop productivity compared to conventional surface irrigation.

Maisiri(2004) investigated at a scheme level the effect on crop productivity of low-cost, low-head irrigation compared to conventional surface irrigation , the effect of low cost drip fertigation on water and crop productivity and the operational and management requirements. It was concluded water savings of more than 50% were achieved in low-cost drip systems compared to surface although there was no significant differences in crop productivity due to the type of irrigation but the differences were caused by the method of fertiliser application. It was also seen from this study that with proper marketing and agronomic and technical support, low cost technologies could be adopted well by smallholder farmers

2.8.5 Assessment of the technical performance and operational limits of low cost drip irrigation system for peri-urban and smallholder farmers.

Senzanje et al (2004) carried out a study to assess the technical performance and determine the operational limits of low cost drip drum kit with three types of low cost emitters (sponge, string and sleeve). The study showed that low cost drip systems could perform

reasonably well and a practical combination of operational parameters exists that maximise technical performance. It was noted though in the study that there was need to develop standards to be used in the evaluation of low cost technologies such as the low cost drip kits and treadle pumps.

3. STUDY AREA

3.1.Location

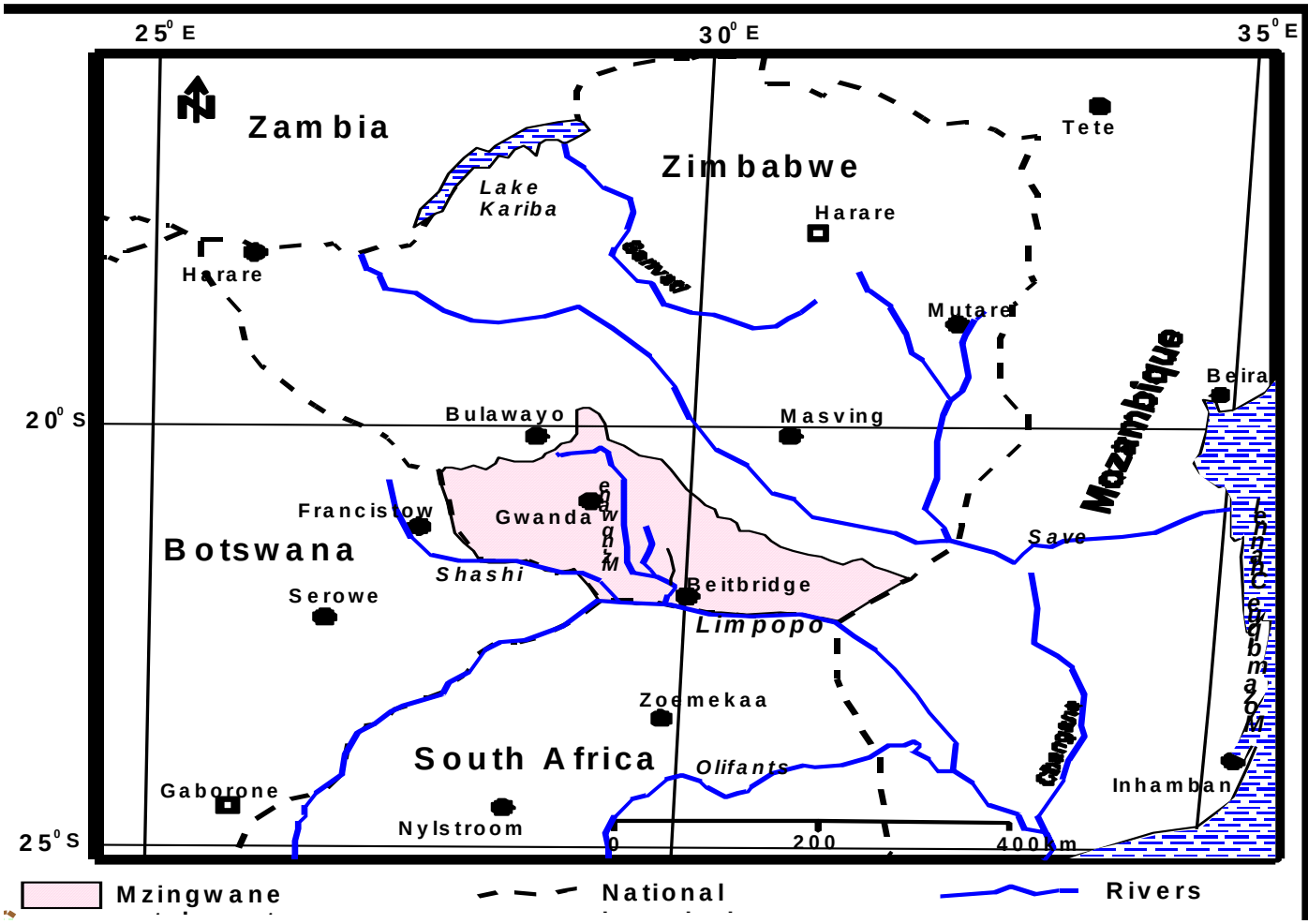

Figure 1.Map of Zimbabwe showing the Mzingwane Catchment.

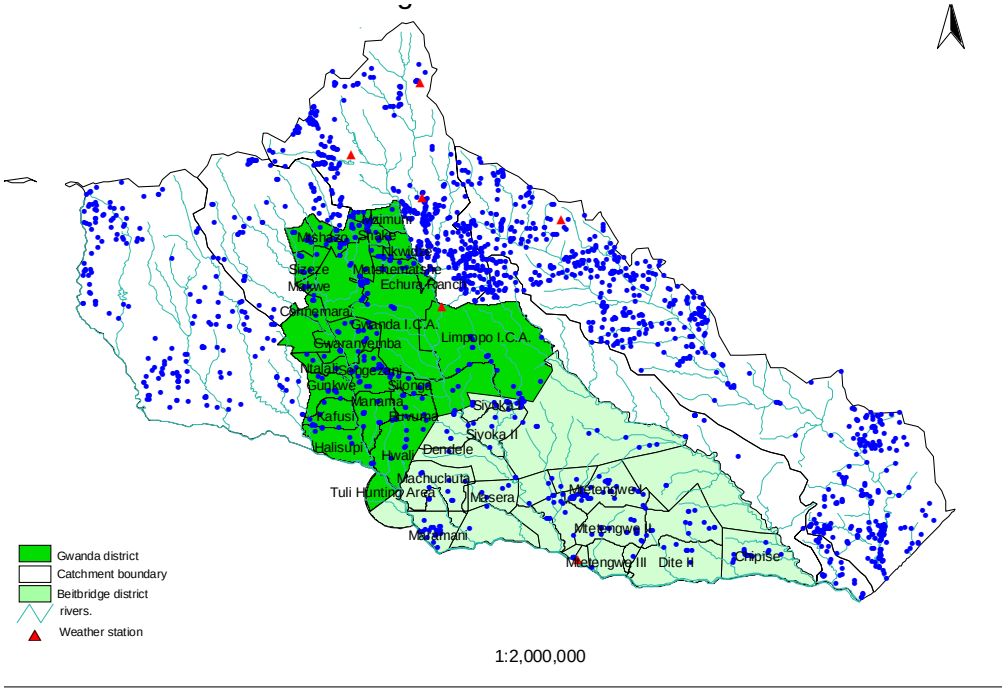

Figure 2. Map of Mzingwane catchment showing the boundaries of Gwanda and Beitbridge and the borehole distribution (GIS unit ICRISAT-Bulawayo).

Mzingwane catchment forms one of the six hydrological zones found in Zimbabwe. Figure 1 shows the location of Mzingwane catchment in Zimbabwe.Mzingwane catchment if found in the administrative Matabeleland South province. The major town in this province is Gwanda, which is also the provincial capital. Gwanda and Beitbridge are districts found in the Matabeleland South province. In Gwanda the study was done in the drier southern part in Wards 14,17 and 18 while Beitbridge the study was done in Wards 4,5,6 and 7.The boundaries of the study area are shown in Figure 2.

3.2 Climate

Mzingwane catchment, which is in the semi-arid region, is characterised by unreliable rainfall with frequent dry spells which cause droughts. The rainfall average in the range from 250 mm/year in the south to 550 mm/year in the north of the catchment, with average of about 350 mm/year over the entire catchment area. Rainfall average for Gwanda and Beitbridge two weather stations in lower Mzingwane in the study area fall within this range .The wet season stretches from late October/early November to latest early April. Highest

temperatures are recorded during the summer while the coldest months are in the months of June and July.

3.2.1. Temperature

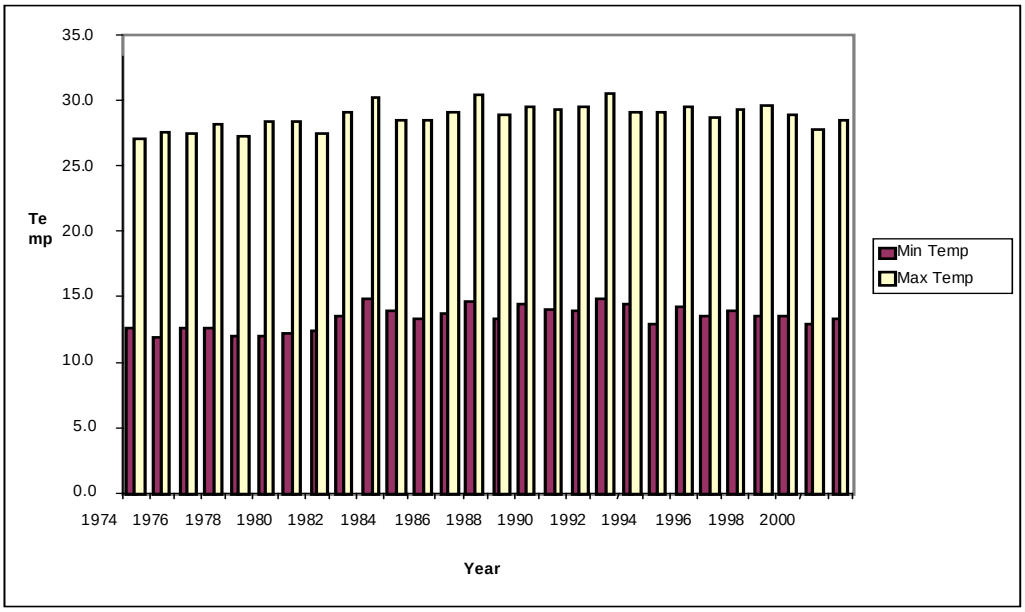

Figure 3. Maximum and Minimum Temperatures recorded for West Nicholson (Gwanda).

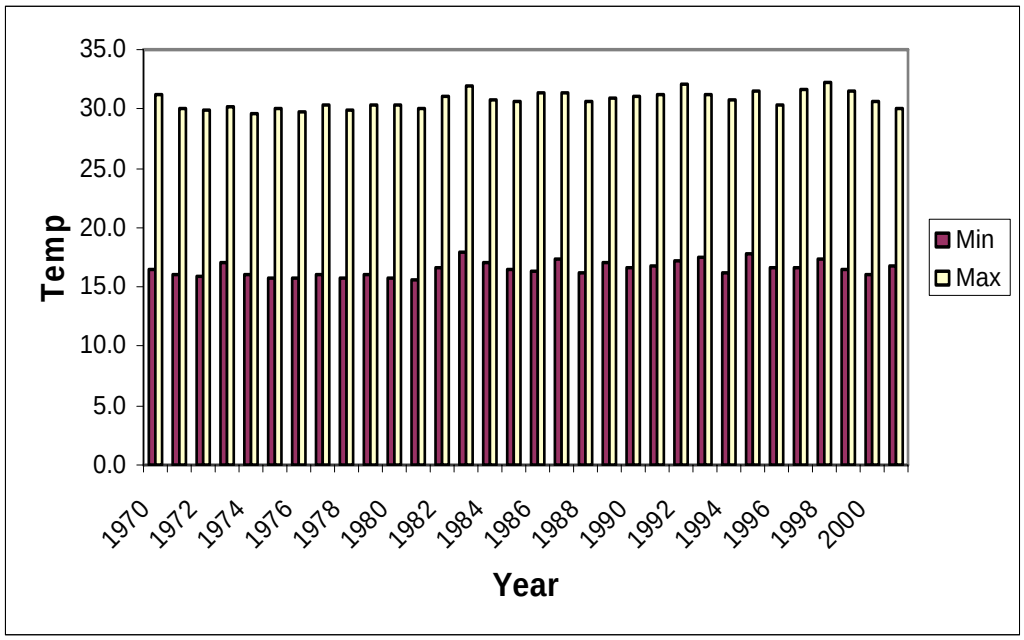

Figure 4 Maximum and minimum temperatures for Beitbridge station.

As shown in the Figure 3 and 4 above temperatures in Beitbridge are general higher than those recorded in Gwanda. Average maximum temperatures for Beitbridge is 30.8°C while that of Gwanda was 28.8°C. Temperatures in winter for Beitbridge are also higher than those of Gwanda with Beitbridge recording 16.6°C on average and Gwanda being 13.4°C as minimum temperatures. Highest temperatures in two districts are recorded in the months of September, October and November when temperatures are above 30°C. Lowest temperatures are in the months of June, July and August.

3.2.2. Rainfall

As shown in the figure 6 below rainfall figures in Gwanda(West Nicholson) have ranged from 180 to 950 mm/year with an average of 496mm/year while the variance in rainfall figures for Beitbridge is high with lowest rainfall figure being 150 to a highest of 1020mm/year as shown in Figure 5. The average rainfall for Beitbridge is345mm which

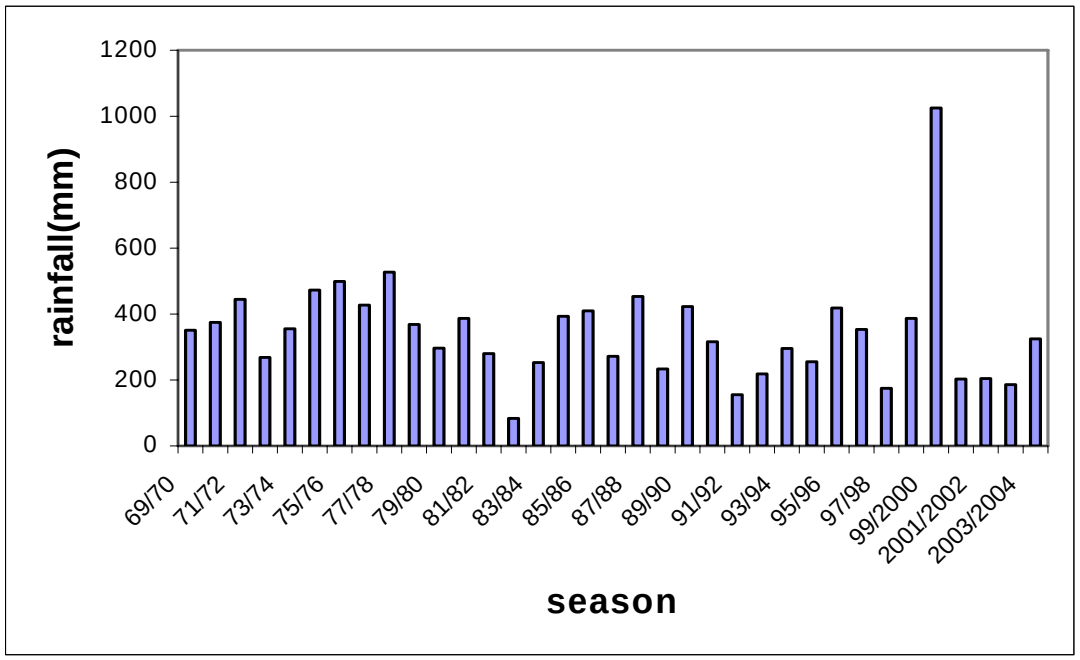

Figure 5. Rainfall graph for Beitbridge station (Source:Met Department**)**

means that Beitbridge is much drier compared to Gwanda. The rainfall pattern in the lower Mzingwane subcatchment is unreliable as shown by the high differences between the highest and lowest rainfalls and this seriously impacts negatively on the crop productivity.

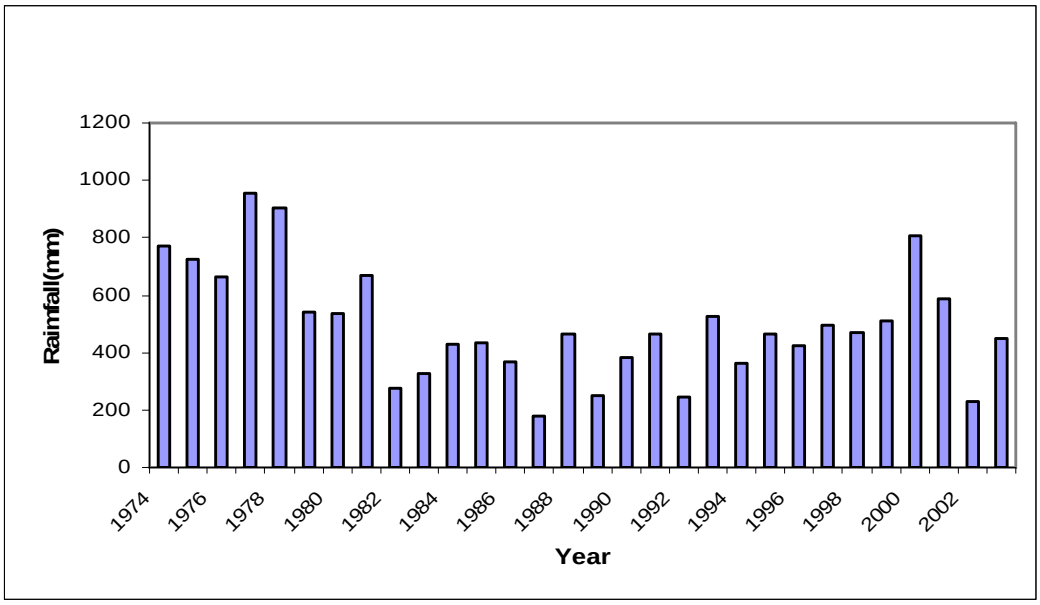

Figure 6. Rainfall graphs for West Nicholson (Gwanda).

3.2.3. Evaporation

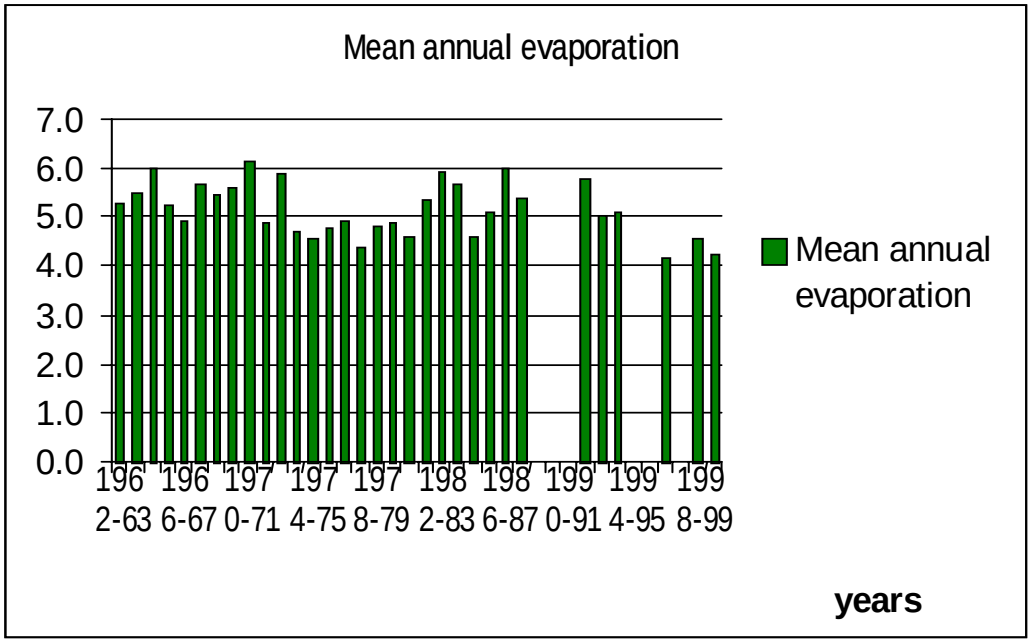

Figure .7. Graph showing the mean pan evaporation rates (mm/day) from West Nicholson, Gwanda(Omena,2004)

High pan evaporation rates are recorded during the months of September, October and November. These dry months of the year result in reduction of water levels from reservoirs and soil moisture. The above Figure 7 shows evaporation rates from open surfaces from a station in Gwanda. High evaporation rates result in reduction of water that could be available for domestic use, livestock watering and irrigation.

3.3. Population

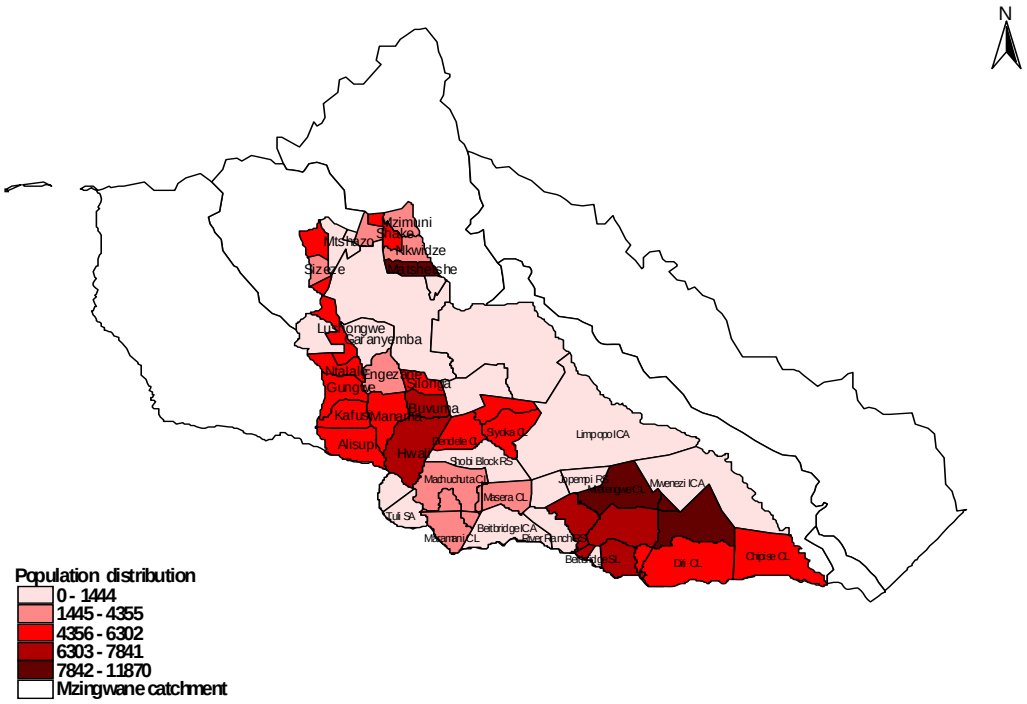

Figure 8.**Map showing the population figures for the wards in Gwanda and Beitbridge.** Map prepared using figure from the Population Census 2002 results (CS0, 2002) (GIS Unit ICRISAT –Bulawayo)

Gwanda and Beitbridge have a combined population of over 220,000 with an average growth rate of 5.63%. There are close to 50,000 households in the two districts with an average household size of 4.4. (CSO, 2002). Rural households in this subcatchment are poor with low incomes earning when compared to those in northern part of the catchment. (Love et al, 2005). Variations in population totals are seen from the wards in Beitbridge where the study was carried out with Ward 4 being densely populated with a population of close to 14,000 while the least populated being Ward 7, which has close to 3,000 inhabitants as shown in Figure 8. The variations in wards of study area in Gwanda are not so pronounced with an average of 6,600 people/ward.

3.4. Agricultural systems

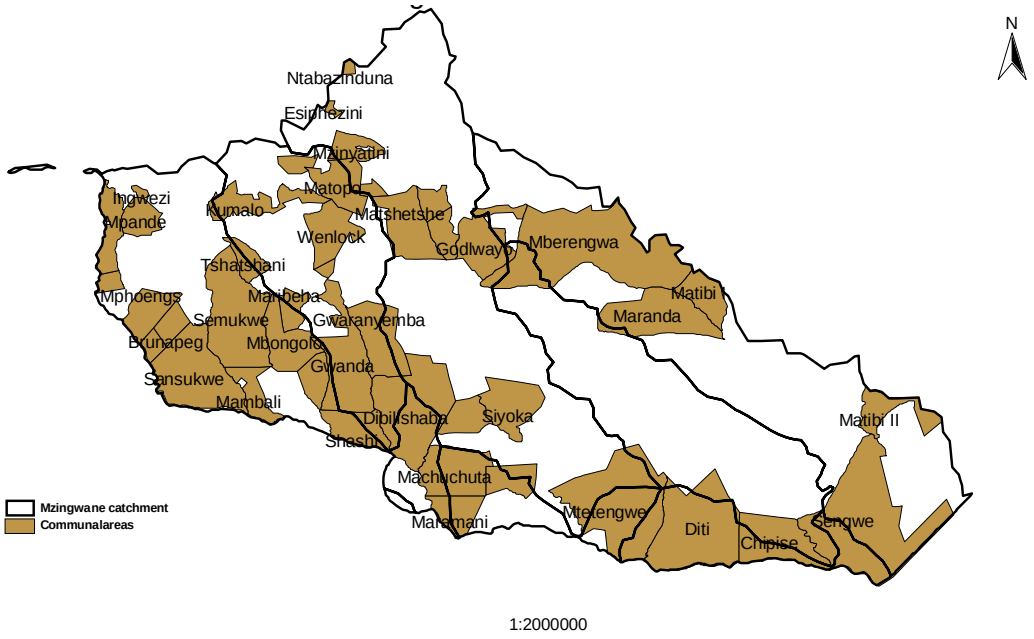

Figure 9.Map showing distribution of communal systems in Gwanda and Beitbridge by GIS unit ICRISAT- Bulawayo

According to the agro-ecological classification of Zimbabwe the subcatchment falls under Natural Regions IV and V. There two major farming activities in the subcatchment are namely large-scale commercial farming and smallholder farming. Smallholder farming systems are carried out in the communal areas as shown in the Figure 9 and the rest of the land in the catchment is under commercial farming. The main activities under commercial farming include crop production under large-scale irrigation and rainfed, cattle and game ranching. The crops grown in commercial agriculture include maize and wheat. The activities carried out under smallholder farming include crop production and livestock farming. Crop production is under mostly rainfed and community irrigation schemes, nutritional drip kit gardens. The crops grown under smallholder farming include grain crops such as maize, sorghum and millet. Livestock farming is predominantly consists of goats and cattle.70% of land in the communal areas of Gwanda and Beitbridge are heavily grazed (Anderson et al, 1993). As shown in Figure 10, Gwanda and Beitbridge are mostly grazing areas as seen by the high densities of livestock.

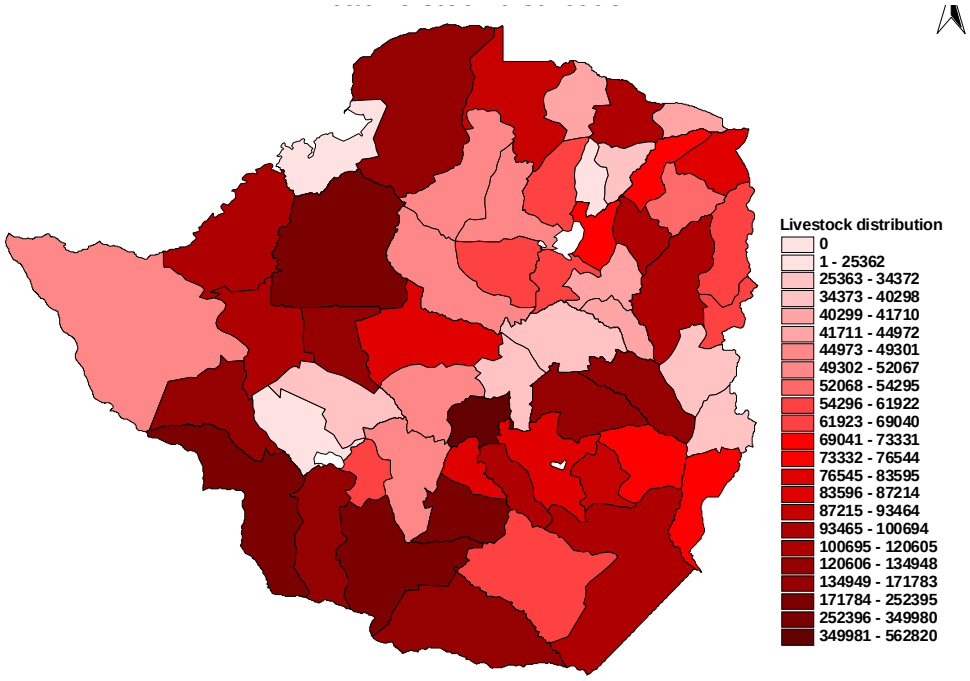

Figure 10.**Map showing livestock distribution in Zimbabwe** (GIS unit, ICRISAT-Bulawayo)

3.5. Soils

Table 2. Classification of soils found in the study area.

District	Ward	Soil class	Comments
Gwanda	14	2,4P,5G	Well to very well-drained, very moderately shallow
	17	2,4P,5G	As above
	18	2,4P,5G	As above
Beitbridge	5	2,4P,5G	As above
	6	2,4P,5G	As above
	7	2,4E,3B	Mainly well-drained, extremely to moderately shallow

Using the Zimbabwe soil classification system in Appendix 4 soils in the study area were classified as shown in the Table 2 above. Soils in all the three wards of Gwanda and two of the wards in Beitbridge(Wards 5 and 6) are classified as 4P, 5G and 2(Lithosols). The soils found in Ward 7(Masera) of Beitbridge were classified as 2,3B and 4E.

3.5.1 Irrigability

Soils in Gwanda and Ward 5 and 6 of Beitbridge are considered to be unsuitable according to conventional criteria for commercial irrigation. For traditional forms of small-scale irrigation, the soils are perfectly adequate, water availability being the major constraint. The deeper vertic and alluvial soils found in Masera communal areas of Beitbridge are suited to irrigation although they constitute about 5% of the soils found in the area.

It has to be noted though the land capability system developed by the then AGRITEX is not applied in the Natural Region V as commercial dry land cropping is not viable proposition and land can only be assessed according to criteria developed for ranch planning.

3.6. Water Resources

3.6.1. Hydrology and water availability

Umzingwane River drains into Limpopo and contributes 9.3% of Limpopo Basin's mean annual run-off (Love, 2005). During the dry season the river does not flow and the riverbed has sandy alluvial of considerable thickness providing enormous storage of water (Waternet CN133, 2003). Streams that drain into Umzingwane River also experience high flows due to high intensity rains during the wet season. As of 1984, 40% of the potential water resources had been developed in the catchment (Kabell, 1984). This means that the catchment could be overdeveloped in the near future. Downstream of the catchment, which forms the study area major water development projects such as Zhove -Mtetengwe irrigation canal are faced with uncertainties of water availability due low rainfall and increased abstractions upstream.

3.6.2 Communal dams

There are two major dams that are found in the study area, one in each districts. Zhove dam is the largest in subcatchment and supplies water to commercial farmers who use for irrigation and livestock and game ranching. Plans are at an advanced stage to construct a communal irrigation scheme in Zhove. Thuli –Makwe is used mostly to irrigate the communal irrigation scheme and livestock watering. The other 4 dams shown in the Table 3 have small capacities and are used for mostly domestic purposes and the watering of livestock.

Table 3. Major dams found in Gwanda and Beitbridge communal areas

Name	River	District	Capacity MCM	Purpose
Thuli-Makwe	Thuli	Gwanda	6.122	Irrigation Livestock farming
Zhove	Umzingwane	Beitbridge	130.46	Irrigation Livestock and game ranching
Siyoka 2	Umzingwane	Beitbridge	0.115	Domestic Livestock farming
Dibilishaba 1	Denderi	Beitbridge	0.140	Domestic Livestock farming
Dibilishaba 2	Hunga	Beitbridge	0.150	Domestic Livestock farming
Mtetengwe	Tongwe	Beitbridge	3.300	Domestic farming Livestock farming

Source: ZINWA database. (2005)

Small dams that are not captured in ZINWA database include

- ✓ Buvume (Gwanda)
- ✓ Fumukwe (Gwanda)
- ✓ Paye
- ✓ Munyabezi
- ✓ Magaya
- ✓ Sukwi
- ✓ Sinayi

3. 6.2. Groundwater Development

Ground water reserves are low in most of the communal areas of Zimbabwe which is a result of greater Zimbabwe being composed of ancient igneous rock formations which have comparatively low potential.The extent of the availabilty and development of ground water

in communal areas is not known and is beyond the scope of this study. There have been programs spearheaded by government and donor community to drill boreholes and develop shallow and deep wells in communal Nonetheless data was sought from the District Development Fund (DDF) which is responsible for the maintenance of community ground water sources in communal areas as shown in Table 4.

Table 4. Community ground water sources

DISTRICT	**BOREHOLES***	**DEEPWELLS***
Gwanda	513	561
Bietbridge	409	625

*The figures are for ground water sources that are being maintained by DDF and exclude.privately owned sources.These figures are also district totals.

Source:DDF(2005).

4. METHODOLOGY

4.1 SELECTION OF STUDY AREA

The major factors that were considered in the selection of the study area were water scarcity and the involvement of various implementing agencies. It is on this basis that the Lower Mzingwane catchment, which is seriously water scarce, was selected. The area of study was south of Gwanda and Beitbridge, which is in Natural Region V. It falls in the area with the most arid climate in Zimbabwe (Anderson, 1993). Wards in these two districts with high concentration of drip kit were preferred. Gwanda had the highest number of kits distributed with most of the kits concentrated in Wards 14,17 and18. The study area selected had over 5 NGOs, which were involved in the selection and implementing of the drip kit program. The variety of NGOs was preferred as it was considered important to understand their targeting and how they tackled various challenges related to the program.

4.2. RESEARCH APPROACH

Table 5 summaries the major tasks and associated activities undertaken in the study to ensure that the evaluation of drip kits was comprehensive as possible.

Table 5. Showing the task and activities carried out in the research study

Task	**Activities**
Preliminary Appraisal	1.Consultations with distributing NGOs, local authorities, water point committees and relevant government departments. 2.Focus group discussions
Field Survey	Questionnaire interviews of beneficiaries
Data Analysis	1.Data entry 2. Analysis using SPSS

4.3. Focus Group Discussions

Focus group discussions were organised in a single village in three wards of study area. For the ease of movement the wards were only selected from one the districts i.e. Gwanda. The three villages were namely Sengezane, Munyabezi D and Majiya. An effort was made to have at least 10 participants take part in each of the focus group discussions. The objective of these focus group discussions was that of collecting in-depth qualitative information about groups' perceptions, attitudes and their experiences on the use of kit. In open exchange of ideas participants were asked of their successes in relation to the drip kits, their fears, constraints and their ideas on how the programme could be improved and how it should be implemented in future. Participants were also asked if they had been able to use the kit throughout any given year and if indeed the adoption of the drip kit had improved their livelihoods. The interview guide used in the group discussions is Appendix

1. The result from these discussions was later used in designing a relevant questionnaire, which was used in the next stage of the research, the survey.

4.4. Survey

Field survey was done in the villages in the six wards of Gwanda and Beitbridge where there was evidence of activity of the NGOs in terms of drip kit distribution. An effort was made to avoid those villages where the focus group discussions were done to avoid interviewing those with pre-conceived answers to the questionnaire. Lists of names of beneficiaries were collected from respective implementing NGOs and where possible the names of contact farmers who helped in locating the beneficiaries to be interviewed on the ground. In the Figure 11 an interview is being carried out with one of the beneficiaries at the garden site. The questionnaire used in this task is as shown in Appendix 2. The beneficiaries were asked if they had used the kit, the crops they grew, problems related to the gardens, water sources, their knowledge on the operation and maintenance of the kit, their perceptions on the kit and the pieces of advice to the implementing agents.

Figure 11. Interview with Mr Nkomo of Ward 17 who had water sources just outside the garden.

4.5. Data analysis

The data, which was collected through the survey using the questionnaire, was coded, entered and statistical analysed through the SPSS. The Excel spreadsheet was utilised in carrying out the correlation analysis between different factors relating to the use of the kit and drawing of graphs.

5 RESULTS AND DISCUSSIONS

5.1 Focus Groups Discussions outcome

The attendance to the focus groups in Sengezane, Munyabezi D and Majiya villages of Gwanda was an average of 12 with most of those in attendance being women. They were motivated to adopt because it was new technology that they needed to try, it was ideal for them in semi-arid as it was water saving and that there were nutritional and economic benefits. From the discussions in Sengezane and Munyabezi it was clear that the beneficiaries were not been able fully utilise their drip kit due to reasons related to water shortages. It was also apparent that most the beneficiaries in these villages were dependent on community boreholes for their water. Most of beneficiaries from the Munyabezi D of Ward 17 had their own water sources and the issue of water shortages did not come out strongly but there were concerns related to clogging of the drip kits as the water was said to be saline. The beneficiaries in the Wards 14 and 18 were also concerned by the long distances that they had to travel to fetch water and they felt this took most of their time. The low priority status of the drip kits in water allocation from the boreholes came out in the discussions, which resulted in some beneficiaries being denied access to water during the dry period. The drip had not met the expectations of meeting their nutritional needs and economic empowerment due to the water shortages, lack of markets for their produce, technical problems and lack of follow up visits by the implementing agencies.

The technical training received from the implementing agencies was adequate although there was a consensus that they needed to be trained on crop production techniques especially on the high value crops such tomatoes, peas, onion and butternut. They also needed to be advised on the cropping calendar so that they could plan properly their cropping seasons. Beneficiaries also needed to be trained on the pest control as they the pests and diseases reduced their yields.

Beneficiaries also felt that they needed to be consulted before such programs with massive implications were implemented. In wards 14 and 18 there was a strong feeling among the participants was that it would have been ideal for the implementing agencies to first drill

boreholes that would have been used by the drip kit users. Beneficiaries also needed to be provided with the inputs such as seed, fertiliser and pesticides.

5.2 Targeting by NGOs

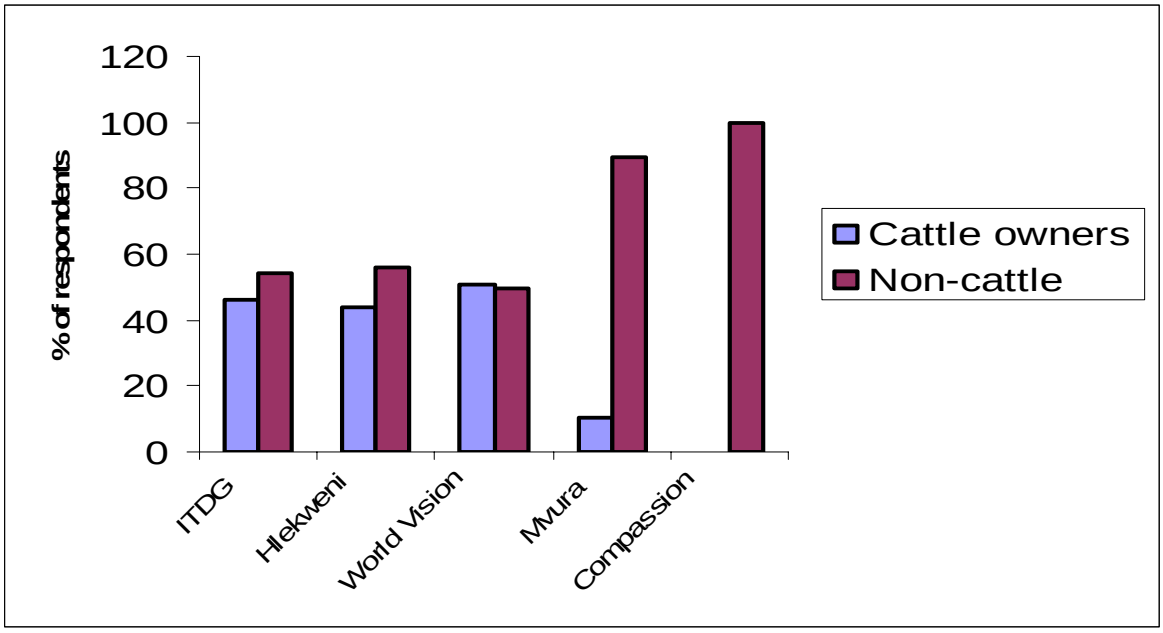

Figure 12 Socio-economic status of beneficiaries as given by different NGOs.

From the interviews with the NGOs' representatives it emerged that all the NGOs used the same criteria of targeting the vulnerable member households as beneficiaries except for the ITDG, which used an ability-based criteria. For one to receive a kit from the ITDG one had to show evidence of well-fenced garden and water source not more than 300m from the garden. This was what the NGOs representatives said was their targeting criteria, which that had to be investigated on the ground to determine if it came to that. The farmers were divided into two basic socio-economic classes with one class consisting of those who owned cattle being the well –to –do farmers and those who owned no cattle being the poor farmers. Of the 114 respondents 46% owned cattle and the rest did not own any. This means that the NGOs as found on the ground failed to meet their targeting criteria , as just over half of those who benefited were poor households. Figure 12 shows the targeting done by the different NGOs.

5.3 Gender analysis of the beneficiaries

The differences in drip ownership were significant($p<0.05$ chi-squared test) between the female and male with over 65% of the beneficiaries being women. Also as could be expected 75% of those who did not own any cattle were women. This reveals a picture, which is becoming common in rural areas where crop productivity is a responsibility of the women. This means that besides the domestic chores that women have there are also expected to provide for the vegetable nutritional needs of their households. This is against the background that the women constitute a large proportion of the poor farmers as has been shown by lower numbers in cattle ownership.

5.4 Water sources

5.4.1 Water sources used by the beneficiaries

Water sources that were being used by the beneficiaries included boreholes, deep and shallow wells, dams, streams or rivers and the taps, which had water, supplied from a dam. The secondary water sources were also captured for those with more than one. As shown in Figure 13 below 73% of the respondents are dependent on ground water sources for their drip kits.

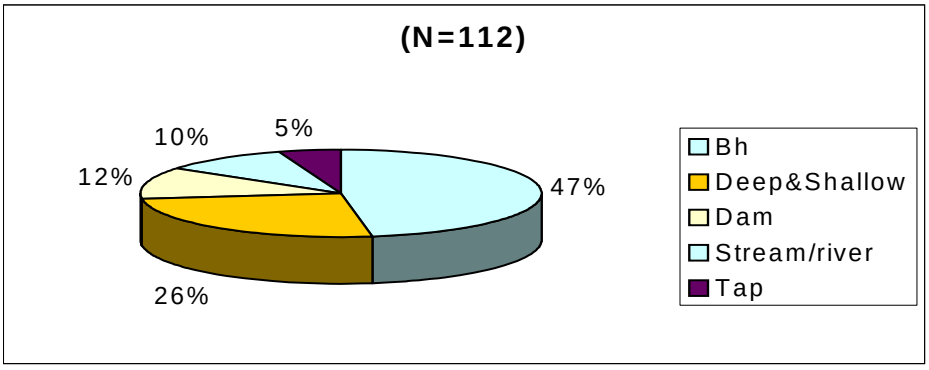

Figure 13. Water sources for drip kits in Gwanda and Beitbridge**.**

5.4.2. Distances to water sources

Among those beneficiaries with at least one water source, 52% of them travelled over 100m with a substantial 25% travelling over 1km to fetch water for their drip kit nutritional gardens. Analysis of distances travelled by the beneficiaries reveals the influence of targeting by NGOs as shown in Table 6. For ITDG, which implemented ability-based criteria over 63% of their beneficiaries had water sources just less than 100m from their gardens and only 5% had water sources more than 1km. This was stack contrast when compared to the Hlekweni, which had only 23% of their beneficiaries fetching water less than 100m from the garden and over 54% travelling over 1km to their water source. It has to be noted though considering the two groups of farmers there was a significant difference between the cattle owner and non-cattle owners. More cattle owners were travelling long distances than the non –cattle owners which could be attributed to them owning means of transportation.

A comparison between the two districts shows that beneficiaries in Beitbridge were moving shorter distances when compared to those in Gwanda. 69% of the beneficiaries in Beitbridge fetched water from water sources that were less than 100m from their gardens compared to 38% for the beneficiaries in Gwanda. There were no beneficiaries who fetched water from distances of more than 500m in Beitbridge compared to 50% who fetched water from this same distance in Gwanda.

Table 6. Distances of water sources from nutritional gardens in Gwanda and Beitbridge(N=112)

Distance	**Percent**	**Cumulative percent**
< 100m	48	48
100-500m	20	68
500-1000m	7	75
>1000m	25	100
Total	**100.0**	

5.4.3. Water availability

69% of respondents have water available from their sources through out a given calendar year while the rest have water for period less than a year to less than a quarter of the year as shown in Table 14. This means that 31% of the farmers interviewed are unable to do three cropping seasons in any given year with some 4% of them managing just one crop season.

Due to differences in climatic conditions in the two districts only 51% of beneficiaries in Beitbridge had water available all year round compared to 74% in Gwanda.

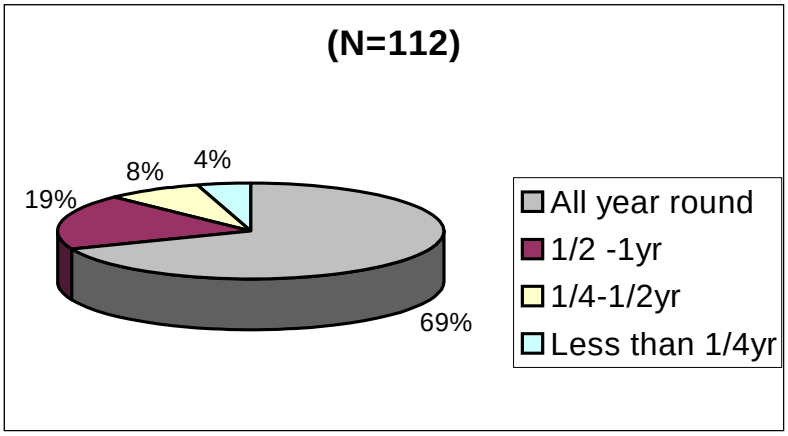

Figure 14. Water availability from water sources in Gwanda and Beitbridge

5.4.4. Water access problems

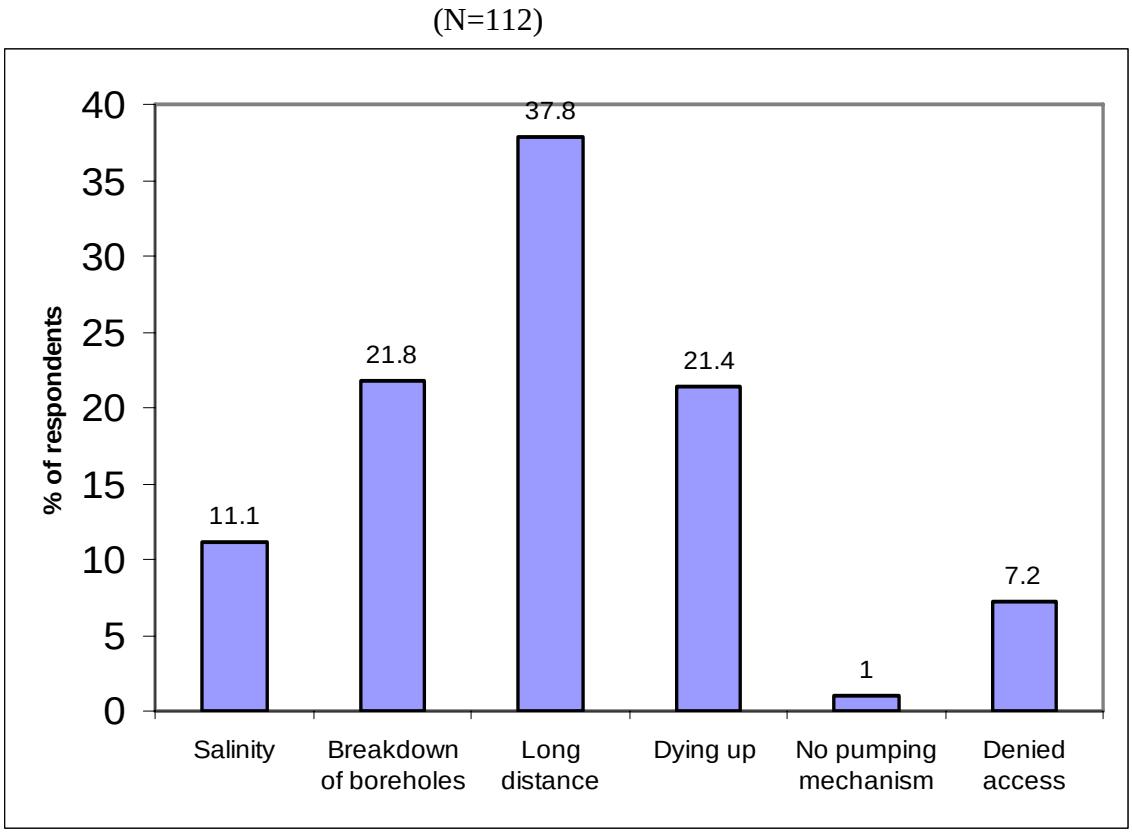

Figure 15. Water access problems faced by the beneficiaries

Of those beneficiaries who had problems in accessing water, the major problem faced was that of travelling long distance (38%) to fetch water for the gardens as shown in Figure 15. The differences between the better off (cattle owners) and poor (non-cattle owners) were not significant but the poor farmers were faced with breakdown of community boreholes, which they were dependent on. This group of farmers complained that when these boreholes broke down it took too long for them to be repaired thereby affecting their crop production. These poor farmers also faced the problem of being denied access to water for their drip kit gardens especially during the dry season where high priority is given to livestock watering.

As a result of differences in climatic conditions between the two districts a higher percentage of beneficiaries (45) in Beitbridge had their water sources drying up at any given time of the year compared to 12% in Gwanda.

5.5. Problems encountered in gardens

The problems encountered in gardens by the beneficiaries that are directly related to the use of the kit include nozzle clogging, water shortages and the malfunctioning of the kit with 37% of the beneficiaries facing water shortages during the cropping seasons. The other problems faced in gardens include crop pest and diseases and livestock damage due to lack of fencing As shown in Figure 16, about 48% faced the problem of pests and diseases and 37% had water shortages during their cropping seasons. The differences in problems faced by the two groups of farmers were not significant, although the poor farmers faced more problems related to acquiring of inputs such as pesticides and the fencing material.

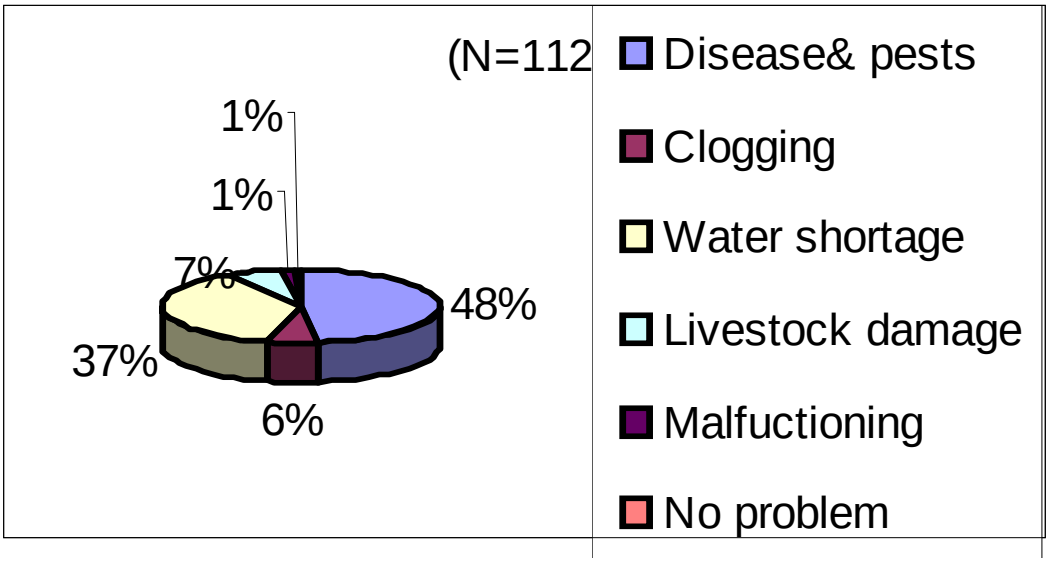

Figure 16. **Shows the garden problems faced by the beneficiaries**.

5.6. Use of kit

Only 2 of the 114 beneficiaries were still to use their kit since being given some 2 years ago as shown in Figure 17. There was no significant difference in number of times or crop seasons that had been done using the kit between the poor and the rich although the poor tended to use it more than the rich probably seeing the potential in drip kit to economically empower them. Most of the cropping (61%) by the beneficiaries was done during the wet season. This means that the kit was used mostly for supplementary irrigation during the wet season and on fewer occasions during the dry season owing to the water shortages. Just over 11% of the beneficiaries used it for more than 3 cropping seasons as compared to the expected 5 seasons (3 cropping season/year).

Beneficiaries in Beitbridge used the kit less number of times compared to those in Gwanda. This could be attributed to that most (49%) of their water sources dried up during the dry season compared to only 25% in Gwanda. Only 5% of the beneficiaries in Beitbridge used the kit for more than 3 times compared to 30% of the beneficiaries in Gwanda.

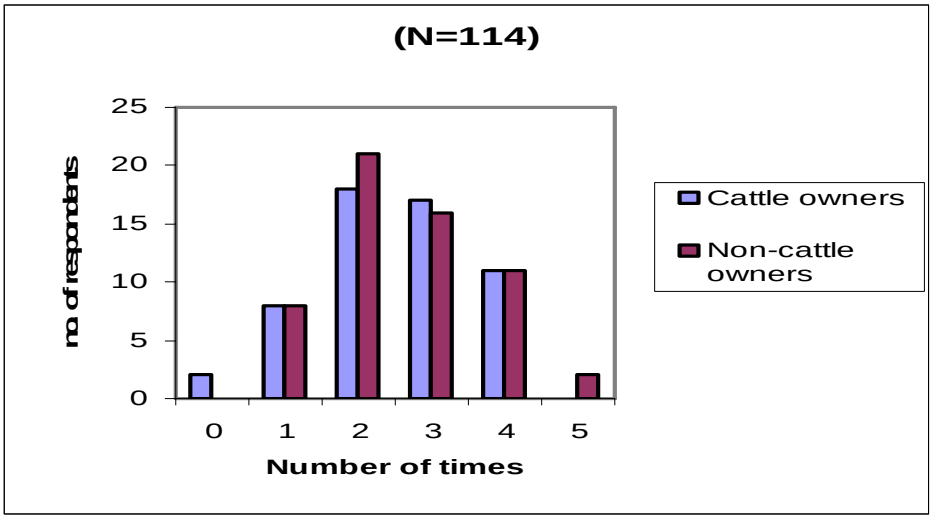

Figure17. Graph showing the level of usage by the drip kit beneficiaries

The targeting of beneficiaries did not have much influence on the usage of the kit as only 28% of beneficiaries from the ITDG (ability based criteria) had used the kit for more than 3 times compared to 36% of beneficiaries from Hlekweni (non-ability based criteria)

5.7. Crops grown by beneficiaries

The crops grown by the farmers were grouped into five categories for ease of analysis as shown in Figure 18. Group Crop1 consists of maize and wheat, which are staple food and cereals. Crop2 consists of sweet potatoes, which can be substitute for staple food. Crop 3 consists of groundnuts and beans, which are source of proteins. Crop4 consists of tomatoes and leaf vegetables, which are high value crops with short shelf life. Crop5 consists of onion carrots and butternut, which are high value crops with a longer shelf life. At any given cropping season beneficiaries could grow up to a maximum of 3 crops. In all the seasons the farmers grew maize and wheat in an attempt to improve their food security which is always under threat due to erratic rains. In all the seasons the farmers also grew the high value crops .The farmers could employ the virtual water concept by growing more of high value with longer shelf life for sale in distant markets and utilise the proceeds to purchase their staple food.

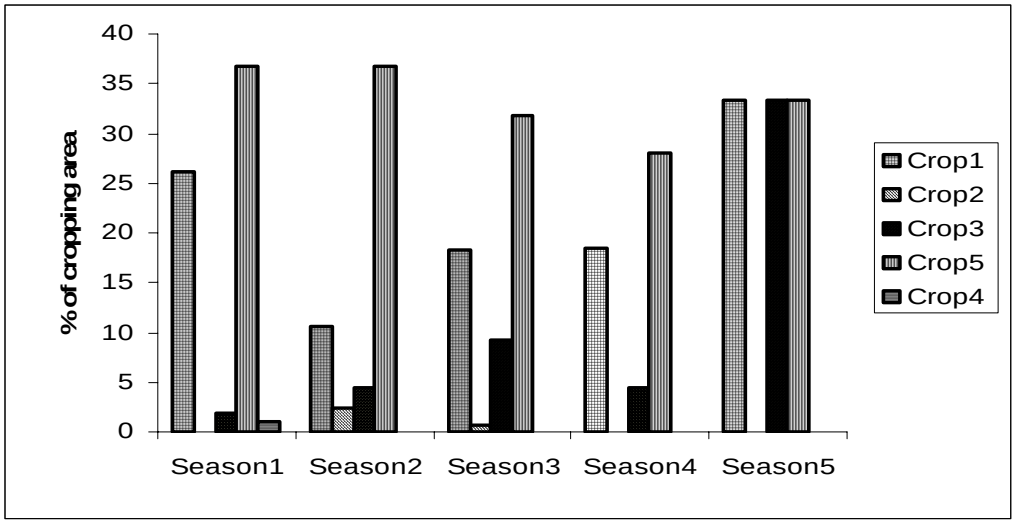

Figure 18. Shows the percentage of cropping areas in the 5seasons..

*****Note: Crops were grouped in the following; Crop1 consists of maize and wheat, Crop 2 consists of sweet potatoes, Crop 3 consists of groundnuts and beans, Crop4 consists of tomatoes and leaf vegetables,Crop5 consists of onion, butternut, carrots.

5.8 Perceptions of beneficiaries towards Drip Technology

Table 7: Showing the perceptions of beneficiaries.

STATEMENT		AGREE*	NEUTRAL*	DISAGREE*
P1	Applies enough water	78.6	3.4	18.0
P2	Use of Drip kit is labour saving	68.3	2.2	29.5
P3	Use of Drip kit is time consuming	29.4	5.3	65.3

*Agree=3, Neutral=2, Disagree=1

Figures are percentages

Majority of beneficiaries (76.8%) agreed to the statement that the drip kit applied enough water as shown in Table 7. There was a significant difference between the poor and the well-to-do farmers with more well-to-do farmers disagreeing with the statement. Likewise the majority of respondents (68.3%) agreed to the statement that the use of kit was labour saving although there was a significant difference between the two groups of farmers with more poor farmers disagreeing. This source of disagreement could be as a result of long distances that were travelled to fetch water for their drip kits. In fact most of those who said the kit was labour saving felt that the only laborious task was that of fetching water from long distances. This could be explained in relation to the distances that they had to travel to fetch water and the lack of means to transport water. Majority of beneficiaries (65.3%) felt that the use of kit did not take much of time. Still there were some significant differences between the two groups of farmers with more well-to-do farmers agreeing that it was time consuming. This could be attributed to the opportunity cost they attached to the use of drip kit. This could in way explain the earlier observation on why less well-to do farmers used the kit less than the poor farmers.

5.9. Spares availability

33% of the beneficiaries were not aware of the parts of the kit that needed to be frequently replacement. This could be as result that most them had used the kit on few seasons to warrant any breakdowns. Of those who were aware the majority (29%) felt that the nozzle tubes needed to be frequently replaced as they broke or got blocked. This applied to those who were using the IDE kit. Some felt the pipes (18%) needed to be frequently replaced as they either broke or were attacked by the rodents while 12% felt they needed to have an extra filter with, as it was delicate. Other parts that featured to a lesser extent include the tap, rubber washers, t-piece, and the tank itself. Despite apparent need for back up spares, all the beneficiaries except 4 that came to 96% did not know where to get them if their kit broke down. The differences between the two groups of farmers were not significant.

5.10. Training of beneficiaries

All the farmers had one training session mostly done by the implementing agencies (74%) and the appointed contact farmers (18%) with rest being done by the extension officers. The farmers were trained on installation of the kit, operation and maintenance of the kit and crop production techniques and few were trained on the fertilisation of their fields. There was no training on marketing of produce.

The assessment on level of training of beneficiaries was done on the operation and maintenance of the drip kit. The beneficiaries were tested on their knowledge of the frequency they cleaned their pipes, nozzles, filters and the tanks. They were also asked to demonstrate how they performed each of the tasks. 55% were knowledgeable on how often they carried each of the tasks while 35% wrongly stated the frequency of tasks and the rest of the beneficiaries were not sure. However the majority (80%) of the farmers were able to demonstrate how the tasks were carried out practically.

Of those beneficiaries needing further training 44% felt they needed to be equipped on the crop production techniques for various crops especially the high value crops. As could be expected, as result of lack of training on the marketing of crops, 38% of those needed training on how could market their produce. The differences between the two groups of farmers were significant with more poor farmers requiring marketing skills, as they needed to economically empower themselves.

5.11 Advises from the beneficiaries

Table 8. Farmers' suggestions for improvement of drip irrigation program.

Advice given	*Advice as % of total advises given*
Follow ups	11
Provision of seed, pesticides & fertilisers	32
Provision of suitable kits (water quality)	2
Provision of pumping equipment	2
Provision of food assistance	1
Provision of smaller cans and farming tools	4
Provision of fencing material	6
Drill/ Maintenance of boreholes	22
Marketing assistance	2
Provision of bigger tanks and more drip line to irrigate larger area	4
Increase nozzle size	3
Spare parts provision	5

As shown in the Table 8, the pieces of advice from the farmers were more of requests. Most (32%) farmers felt they needed to be assisted in the procurement of inputs such as

seed and fertiliser, pesticides. Due to the problems related to access and the water availability the most farmers (22%) requested for provision of additional water sources through the drilling of more boreholes. Those who faced problems in the clogging of the kits felt there was need to consider water quality when giving out the kits. They felt the kits that they had were been given were not suitable for their water quality. 4% of the respondents felt the NGOs needed to provide additional drip lines and tanks to enable them to increase the area under irrigation and increase on their incomes.

5.12. Factor Analysis

Table 9. **Correlation coefficients for various factors (significant at p<0.05)**

Factor	NGO	Cattle	Demonstration Nozzle	Pipes	Filter	Tank	Third season crop	Fifth season crop	Times used	Distance	Water Quality
Further training	0.227										
Sex		0.228									
Knowledge											
Nozzle	0.297		0.439								
Pipes				0.309							
Filter					0.431						
Tank						0.465					
Times used							0.509	0.576			
First access problem										0.342	
Second problem accessing											0.632

Table 9 shows factors that had some correlation above 2.00. A correlation matrix was done using Excel and is shown as Appendix 3. The correlation coefficient for various factors related to drip kits as found in the survey. There was some correlation between the NGO and the need for further training (0.227) and the knowledge of the respondent to the frequency if cleaning the nozzle (0.297). The was a strong correlation between the knowledge of the frequency to cleaning the nozzle, pipes, filter and tank, and the ability to demonstrate the cleaning of each as shown by figures close to 0.5 in the above table. This means that the beneficiaries were equally trained both in the practical and theory. A correlation was also seen between the distance travelled to fetch water (0.342) and problem

associated with water access. . This means that the distance travelled were a indeed serious water access problem faced by the farmers. There was also a correlation between water quality and problems also associated with water access (0.632). This means that water quality in a way affects the access to water.

5.13. Water conflicts related to use of drip kit

5.13.1. Water resources management

Water resources at the lowest point are managed by a water point committee which constitute a chairman, secretary, treasurer and a committee member. The committee is responsible for the decision-making related to the maintenance of the water point, and decision related to the water withdrawals especially during the dry period. They also ensure that some funds are set aside for the emergencies in case the borehole breaks down. The committee is answerable to the village head while the village head is reports to the councillor. The committee members are chosen by the community and usually are the affluent members are selected due the their socio-economic status. As such the decision made by the committee tend to favour those who are affluent and own cattle. The drip kit beneficiaries who comprise the mostly poor farmers found themselves without any representation on water related issues. The position of the drip kit users was made worse due to the fact that they were not an organised force to articulate their rights to water for their gardens. Individually most of the beneficiaries were also not aware of the channels to follow when they had grievances relating to water issues.

5.13.2. Period of occurrence of conflicts

It was seen that the conflicts occurred in months in dry season when most water sources would have dried up. This is time when most of ephemeral streams would have dried and the only sources become the boreholes and the dams. Conflicts occur between July to late

October. But drought years such as the one when this study was carried, conflicts set in just after March.

5.13.3. Nature of the conflicts

During the dry season, allocation priority is revised to reflect the water shortages with the domestic water use being ranked highest followed by the livestock water use and irrigation being ranked the lowest. The conflicts have culminated in the barring of those with drip gardens from drawing water sources such as the dams and boreholes. The conflicts also occurred as a result of breakdown of boreholes. With the high cost of repairing boreholes the drip kit users found themselves accused of causing the breakdown of boreholes as they frequently fetch water for their gardens.

5.13.4 Conflict areas

Conflicts associated with the use of drip kit were encountered in areas there was a high concentration of drip kits and where the beneficiaries and were mostly dependent on community water sources for their gardens. A particular example is that in Gwanda where 525 drip kit were distributed in two wards namely Ward 14 and 18.The conflicts in these wards resulted in beneficiaries being sometimes denied access to community boreholes. In Buvuma Village of ward 18 some beneficiaries confessed that they had already been asked to stop drawing water from the boreholes as the boreholes water levels had gone critically low. In the same village where a borehole had broken down and required millions to be repaired, drip kit users were being accused of causing the breakdown .A solution was already being sought at village through the village head.

In Beitbridge the conflicts were not so pronounced as in Gwanda although there were instances when the beneficiaries were denied access to water sources. Most of the beneficiaries in the 4 Wards where the study was carried depended on the community boreholes. The most striking case was that of group of women who had received a kit from

one of the NGOs were being denied access to the community during the dry season. The group had made attempted to dig a well for themselves without success though.

5.14. Stakeholder participation in the drip kit program

From the interviews that were held with the various stakeholders, which included the rural district council officials, extension officers DDF officers, traditional leadership and the implementing agencies it was seen that the program had not been co-ordinated well enough. Some the stakeholders were not aware that there was such program in their areas, which required their attention. An example is that of the Beitbridge district agricultural official who was not even aware that a certain NGO had distributed the some kits in the district. The official mistakenly thought that the program, which was being implemented in the area by that NGO, was a sanitation program. The non-involvement of important stakeholders was later to be explained by a World Vision official who admitted that they had found it difficult to involve extension officials due to budgetary constraints as the program was done on a relief basis. The District Development Fund officials tasked with the drilling and maintenance of the boreholes and small dams were also not involved in the program. It has to be noted though that some NGOs despite these budgetary constraints made an effort to involve some local extension officers in the training of the beneficiaries. To ensure that the program was favourable received by the local leadership Hlekweni gave some kits to local councillors and Village Heads.

5.15. Protocol development

During the coarse of this study a protocol (Box1) was developed for use by the NGOs involved the implementation of the drip kit program. The protocol has since been adopted by DFID for use in drip kit programs. The protocol comes from the realisation that most of the conditions necessary for the sustainable implementation of such programs have not been met by the implementing agencies. It addresses the issues that are faced in the drip kit

programs, which include the distances to water sources, targeting, reliability of water sources, training and monitoring through follow up visits.

Box 1. Protocol developed for use by the NGOs involved in drip kit distribution

Protocol for drip irrigation kits distribution

For the programme to sustainable, it is important that the NGOs to take aboard relevant government organs right from the inception of the program to the end so that by the time the NGOs conclude their work the programme can be handed over to such government institutions.

1.Distance of water source
Objective: Ensure that the drip kit garden is close to the water source.
Drip kit garden should be within 50m of the water source or
Provide wheelbarrow or simple water cart to assist with transport of water for distances up to 250 m

2.Reliability of water source
Objective: Ensure that the beneficiaries have a reliable water source
Before a kit is given the NGOs in collaboration with relevant Government Departments should make an effort to determine the reliability of the potential water sources.
The potential water sources should be able to supply water for the kit all year round.

3.Follow up visits
Objective: Ensure that the beneficiaries get prompt technical advisory service on the use of kit.
During the year of inception the NGO should make high frequency follow-up visits to beneficiaries i.e. at least once every two weeks for the first crop, and then monthly.
During the second year follow-up visits should be made once every cropping season, and then once every year thereafter

4.Training
Objective: Adequate training of beneficiaries
The NGO in collaboration with Government Extension Services should undertake the training.
Training should be done in the following areas:Installation, repair and maintenance of drip kit
NB. Maintenance of the kit training should take cognisance of quality of water available for the drip kit in different areas.
Cropping techniques including the cropping calendar
Irrigation scheduling
Pest control using cheaper traditional methods
As a way of motivating the beneficiaries field days and exchange visits by beneficiaries especially during the inception year.

5. Targeting
Objective: Beneficiaries are people who are able work in their respective gardens
NGO should ensure that the beneficiaries are able bodied persons who can work in their gardens
Provide water containers relevant to size and age of beneficiary – it is hard to lift a 20 litre bucket

6.Spares
Objective: Beneficiaries are able to carry out repair works in time on their kit without compromising their crop production
NGO should identify a local trade storeowner willing to stock the necessary spares, so that the beneficiaries can purchase them when they need them.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

The drip kit programmes in their current format in Lower Mzingwane catchment are not sustainable as has been shown by the shortcoming relating to the unreliable water sources, distances of water sources from the gardens, lack of monitoring by the implementing agencies and lack of backup spares. The shortcoming are as result of the program being carried out as relief and not as development one. It has to be noted though that low cost drip technology holds a great potential for the poor as seen by entry of farmers into the production of high value drops despite the water constraints. The farmers could improve their wellbeing by growing more of high value crops and reduce the area under maize. In this way the beneficiaries would economically benefit from the use of kit and indeed improve their livelihoods.

As has been seen there were not only the poor and vulnerable rural community members who benefited from the program but also the well-to-do who benefited from this relief program. What made the selection criteria difficult was the need for the beneficiaries to have an assured close water source, which most of the poor people did not have. This condition for such water sources was particularly important since the drip kit were being given to people in semi-arid areas such as a Mzingwane catchment where water is scarce.

The drip kit program was implemented against the background of lack of co-ordinated effort from the relevant stakeholders with some important stakeholders who are paramount for the sustenance of the program such agricultural extension officers missing out.

The drip kit has indeed become ‘a farmer’s friend’ as seen by the perceptions by the farmers on it. The farmers were particularly impressed that despite the water coming out slowly it still applied the required crop water requirement as seen by 79% who agreed to this. This means that the beneficiaries have shifted from water wasting systems such as flooding and are able to make savings on their scarce water resources.

The introduction of drip kit has resulted in occurrence of conflicts especially in areas were the kits are highly concentrated and the beneficiaries are dependent on community water sources.

6.2 Recommendations

In addition to the guidelines in the protocol (Box1) developed in the study there is need to redefine the targeting criteria, which should be used when selecting drip kit beneficiaries. The criteria should take into consideration the water limitations found in the semi-arid areas such as Lower Mzingwane subcatchment.

For the minimisation occurrence of conflicts the following are recommended

- There is need to approach the water management even at the lowest point in an integrated manner by the involvement of all water users including the drip kit users

- Drip kit users should be recognised as important water users who have a socio-economic contribution to the well being of rural communities.

- In recognition of water scarcity especially in areas such as Lower Mzingwane there is need for drip kit users to use the kit more in the wet season and possible reduce on the area under irrigation during the dry season.

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Appendix 1.Interview guide used in the focus group discussions

FOCUS GROUP DISCUSSIONS INTERVIEW GUIDE

1. What motivated you to adopt this technology?
2. Given an option, what technology would you have wanted at the time?
3. Were you consulted as to the technology you wanted?
4. What were your expectations as you received these kits and have these expectations been so far met?
5. Have you been able to use to use the kits through out a given year? If NOT, what would you attribute that to?
6. How has the issue of water shortages affected the usage of the drip kits?
7.Have been cases when the drip kit users have been denied access to water by other users
8. How has the problem of inputs affected the your operations
9. How has the adoption of these kits financial benefited you? If NOT, what have been major stumbling blocks in the usage of the kits?
10. What has been the technological challenges related to the use of these kits and have they been addressed?
11. How would you access the training given by implementing agents in relation to the following?
   a) Installation
   b) Maintenance
   c) Cropping
   d) Marketing of the produce

12. In future if how would you like the program to be implemented if it is to be extended to other people who did not benefit from it?

Appendix 2.Questionnaire used in the survey
Respondent code_____
Gwanda South Drip Kit Household Survey
CONFIDENTIAL

Ward _____ Village _____

Date _____ Enumerator _____

Name of Recipient_____

Name of NGO Providing Drip Kit_____

Date Drip Kit Provided: (Month/year) _____

Type of drip kit received: _____
IDE = 1, Netfim=2, Plastro=3 Other (SPECIFY)=4

Size of resevoir: _____ lt

Explain purpose of survey and how long this will last. Be sure to explain that the survey results for this household will be kept confidential and only be used as part of a general assessment about how to improve these sorts of drought relief programs. Please interview husband and wife together – or the main user of the kit (if only one is available) at the garden site.

Name of Respondent 1: _____ Gender_____

Name of Respondent 2:_____ Gender _____
Male=1, Female=2

Do you own cattle _____ yes= 1, no = 2

Did you have a garden before you received the drip kit _____ yes= 1, no = 2

A. Use of Kit
1. Did you use the drip irrigation kit provided to you _____ yes=1, no=2
2. If yes, what months during the past year did you use this, and for what crops? Did you encounter any particular problems? *(NB. use separate entry for each crop)*

Months used *(state months and year)*	Crops grown	Problems encountered

2b If No, why not _____

_____

B. Water access

3. Please explain where you obtained water for running this kit and what problems you encountered in water access.

Source (only those actually used)	**Distance** (minutes walking)	**Months Available** (potentially)	Quality of water Good=1 Fair (explain why)=2 Poor (explain why)=3	**Other problems encountered in water access**
Primary				
Secondary				
Tertiary				

C. System Maintenance

Maintenance Task	**Frequency per year**	**Date last done**	**Problems encountered?**	Can Respondent Demonstrate - Yes= 1, No=2
Cleaning nozzles				
Cleaning pipes				
Cleaning Filters				
Other:				

5. Where do you obtain spares for this kit? (if not known, state this)

a) new nozzles _____

b) new pipes _____

c) water filter _____

d)Which of parts need to be replaced most frequently?

_____

e) What problems do you face obtaining spares?

_____

D. Training and Technical Knowledge

6. What training was provided for the use of this irrigation kit?

(Cite more than one response where appropriate)

Date of Training (month & year)	Who provided training *AREX=1* *NGO (name this)=2* *Contact farmer=3* *Other (Specify)=4*	Type of training Group=1 Individual=2	**Issues covered** *Layout of kit=1* *Cleaning and maintenance of kit=2* *Repair of kit=3* *Crop production techniques=4* *Crop marketing=5* *Other (SPECIFY)=6*

7. What other sorts of training would you like to receive?

a)

_____

b)

_____

c)

_____

8.From the experience you have had in using the drip kits how do you respond to the following statements

	Strongly disagree=1 Disagree=2 Neutral=3 Agree=4 Strongly Agree=5 Not sure=6
The drip kit applies enough water to the crops	
Irrigating using a drip kit is time consuming	
Irrigating using drip kit is labour saving	

9. What 3 pieces of advice would you provide to NGOs providing these sorts of kits to other farmers?

a) _____

b) _____

c) _____

Finally, thank the farmers for their participation and ask if they have any questions

Appendix 3.Correlation Matrix

Correlations (new.sta)
Marked correlations are significant at p < .05000
N=109 (Casewise deletion of missing data)

	NGO	TYPE	RESERVC	SEX	CATTLE	GARDEN	NOZZLE	PIPES	FILTER	TANK	NOZZLE2	PIPES2	FILTER2	TANK2	TIMEEUSI	CRPFIST1	CRPFIST2
NGO	1.000																
TYPE	0.477	1.000															
RESERVC	0.228	0.323	1.000														
SEX	-0.146	-0.183	0.047	1.000													
CATTLE	0.382	0.399	0.155	-0.228	1.000												
GARDEN	0.096	-0.015	-0.055	0.070	-0.009	1.000											
NOZZLE	0.271	0.256	0.055	-0.238	0.078	0.047	1.000										
PIPES	0.091	-0.115	-0.015	-0.256	0.150	0.040	0.076	1.000									
FILTER	-0.079	-0.195	0.125	-0.090	-0.147	-0.043	0.077	0.253	1.000								
TANK	-0.185	-0.185	-0.042	0.004	-0.058	-0.027	0.071	0.253	0.364	1.000							
NOZZLE2	0.297	0.265	0.164	-0.026	0.159	0.103	0.439	-0.019	-0.006	-0.021	1.000						
PIPES2	0.204	0.033	0.129	-0.203	0.046	0.174	0.303	0.309	0.162	-0.030	0.460	1.000					
FILTER2	0.116	0.059	0.093	-0.041	0.076	-0.065	0.323	-0.036	0.431	0.072	0.281	0.218	1.000				
TANK2	0.094	0.033	0.179	-0.140	0.020	-0.059	0.222	0.232	0.298	0.465	0.121	0.215	0.342	1.000			
TIMEEUSI	-0.213	0.051	-0.173	-0.145	0.055	0.127	-0.083	-0.253	-0.133	-0.103	-0.233	-0.067	-0.138	-0.277	1.000		
CRPFIST1	0.149	-0.043	0.111	0.067	-0.041	-0.106	-0.045	-0.199	0.106	0.047	-0.021	-0.080	-0.022	-0.105	0.008	1.000	
CRPFIST2	0.298	0.188	0.153	-0.096	0.174	-0.071	0.109	-0.082	0.007	-0.016	0.176	0.045	0.145	0.072	0.057	0.116	1.000
CRPFIST3	0.134	0.064	0.121	0.056	0.143	0.082	0.083	-0.113	0.028	-0.161	0.146	0.068	0.165	-0.079	-0.040	0.021	0.367
CRPSEC1	-0.113	-0.038	-0.203	-0.007	0.004	0.203	-0.030	0.070	0.038	-0.093	-0.082	0.065	-0.087	-0.165	0.495	-0.087	-0.027
CRPSEC2	0.193	0.172	0.099	-0.154	0.138	0.023	-0.135	-0.114	-0.092	-0.065	0.355	0.245	0.140	0.013	-0.016	0.015	0.349
CRPSEC3	0.200	0.092	0.033	-0.162	0.135	-0.056	0.077	-0.127	0.021	-0.026	0.196	0.184	0.216	0.164	0.018	0.072	0.383
CRPTHD1	-0.208	-0.036	-0.109	-0.129	-0.044	0.015	-0.074	-0.113	0.039	-0.014	-0.197	-0.121	-0.064	-0.150	0.509	0.179	0.047
CRPTHD2	0.081	0.207	0.078	-0.105	0.152	-0.076	-0.003	-0.159	0.014	-0.066	0.005	-0.088	0.095	-0.048	0.246	0.088	0.361
CRPTHD3	0.202	0.335	0.270	-0.148	0.202	-0.041	0.117	-0.114	-0.050	-0.121	0.133	0.096	0.234	0.070	0.131	-0.062	0.407
CRPFTH1	-0.181	0.088	-0.141	-0.118	0.039	0.076	-0.051	-0.127	0.071	0.014	-0.214	0.002	-0.128	-0.115	0.576	0.047	-0.096
CRPFTH2	-0.075	-0.054	-0.101	-0.068	0.114	-0.033	-0.103	-0.007	0.064	-0.056	-0.103	0.018	-0.057	-0.051	0.238	-0.026	-0.106
CRPFIF1	-0.044	-0.068	-0.304	-0.076	0.103	-0.021	0.063	0.022	-0.067	-0.041	-0.065	-0.076	-0.036	-0.032	0.257	0.106	0.065
CRPFIF2	-0.031	-0.061	-0.297	-0.068	0.092	-0.019	0.056	0.020	-0.060	-0.055	-0.058	-0.068	-0.032	-0.029	0.230	0.116	0.023
PROB1	0.085	0.141	0.082	-0.011	0.125	-0.023	0.078	0.030	-0.062	-0.009	-0.048	-0.111	-0.028	-0.096	-0.119	-0.051	-0.136
PROB2	0.002	0.018	0.007	0.133	-0.056	-0.046	-0.050	-0.157	-0.106	-0.100	-0.017	-0.165	-0.062	-0.125	0.030	0.091	0.048
PROB3	0.066	0.012	0.014	-0.090	-0.085	-0.047	0.179	-0.219	0.030	-0.138	0.106	0.067	0.165	-0.072	0.142	-0.024	0.119
WATER1	-0.172	-0.056	0.205	0.188	-0.120	0.020	-0.123	-0.154	-0.161	0.057	-0.208	-0.192	-0.166	-0.132	0.193	0.079	-0.149
WATER2	-0.096	0.017	0.071	-0.008	0.120	0.136	-0.235	-0.049	0.047	-0.064		-0.078	-0.001	-0.068	0.072	-0.013	-0.167
DISTANC1	-0.057	0.053	-0.047	-0.187	-0.098	0.083	-0.007	0.114	0.081	0.035	-0.040	-0.058	-0.002	0.018	-0.038	-0.259	-0.053
WATERA\	0.118	0.023	0.304	0.129	-0.060	-0.056	0.067	-0.050	0.206	0.259	0.072	0.082	0.207	0.226	-0.062	0.010	0.091
WATQUAI	-0.267	-0.150	-0.101	0.089	-0.144	0.032	-0.199	-0.007	0.012	0.137	-0.034	-0.095	-0.037	-0.119	0.100	0.017	-0.102
FPROAC1	-0.029	-0.077	0.185	0.033	0.003	-0.184	-0.167	0.025	0.077	0.075	-0.093	-0.136	-0.068	-0.046	-0.230	-0.015	0.058
SPROAC1	0.102	0.085	0.011	0.023	-0.032	0.026	-0.079	0.170	0.076	0.010	0.114	-0.008	-0.019	0.128	-0.217	-0.166	-0.130
DISTANC2	-0.182	-0.033	-0.055	-0.108	0.073	0.156	-0.208	0.034	-0.021	-0.004	-0.177	-0.057	-0.054	-0.046	0.125	-0.089	-0.214
WATERA\	-0.098	-0.018	0.009	-0.045	0.081	0.043	-0.159	0.010	0.130	-0.037	-0.153	-0.027	0.095	-0.019	0.073	-0.047	-0.140
WATQUAI	-0.218	-0.107	-0.099	-0.096	-0.073	0.109	-0.105	0.033	0.028	0.120	-0.205	-0.015	0.049	0.040	0.055	-0.072	-0.121
FPROAC2	-0.178	-0.018	-0.047	-0.044	0.086	0.150	-0.166	-0.013	0.072	-0.018	-0.138	-0.088	0.038	-0.038	0.104	-0.044	-0.177
SPROAC2	-0.122	0.110	0.066	-0.100	0.020	0.086	-0.172	0.075	-0.059	-0.022	-0.062	-0.027	-0.012	-0.093	0.035	-0.136	-0.197
SPARES	0.010	0.131	-0.033	-0.001	-0.060	0.041	0.118	-0.042	0.073	0.119	0.125	-0.001	0.070	-0.063	0.089	-0.008	0.054
FREQREF	0.059	0.141	0.094	0.067	-0.032	-0.060	0.063	-0.154	-0.026	-0.157	0.047	0.131	0.158	-0.027	0.142	0.219	0.062
FREQREF	0.222	0.132	0.057	0.170	0.052	0.066	-0.111	-0.042	-0.025	0.067	-0.043	-0.072	0.027	0.120	0.030	0.109	-0.079
PROBSPA	0.202	0.025	-0.060	0.160	0.035	-0.025	0.045	-0.169	-0.235	-0.125	0.281	0.255	-0.031	-0.052	-0.022	0.102	0.163
FPROVID1	0.178	0.123	0.105	0.052	0.025	0.025	0.079	0.037	-0.039	0.042	0.120	0.052	0.105	0.174	-0.200	-0.055	-0.183
SPROVID1	-0.119	0.020	-0.151	-0.150	0.124	-0.084	-0.047	-0.035	-0.036	-0.060	-0.070	0.054	-0.144	-0.129	0.220	0.143	0.104
TRYPTR1	0.096	0.093	-0.023	-0.137	0.186	-0.038	0.114	0.123	0.036	-0.112	0.324	0.278	0.259	-0.059	-0.067	-0.106	0.047
ISSUE1	-0.116	0.145	0.059	0.010	-0.014	-0.121	-0.065	-0.018	-0.057	0.130	0.028	-0.015	-0.063	0.205	0.064	-0.013	-0.138
ISSUE2	0.031	-0.114	-0.099	-0.060	0.044	-0.104	0.078	0.028	-0.025	0.024	-0.142	-0.015	0.014	-0.026	0.025	0.150	0.117
ISSUE3	-0.001	-0.238	-0.107	0.077	-0.038	-0.124	-0.124	-0.006	-0.055	-0.039	-0.137	-0.147	-0.145	-0.159	-0.094	0.080	0.103
ISSUE4	-0.084	-0.181	-0.047	0.087	-0.038	0.112	-0.115	-0.126	-0.107	-0.003	-0.003	-0.174	-0.108	-0.176	0.018	0.132	0.099
ISSUE5	0.047	-0.061	0.100	-0.068	0.092	-0.019	-0.077	0.020	0.095	-0.055	-0.058	-0.068	-0.032	-0.029	-0.057	0.020	0.081
FURTHER	-0.117	0.006	-0.036	0.023	-0.142	-0.004	0.052	-0.109	-0.068	-0.032	-0.058	-0.088	-0.016	0.046	0.082	0.063	-0.128
FURTHER	0.143	0.164	-0.010	-0.064	0.099	0.049	0.103	0.002	-0.053	-0.023	0.196	0.308	0.037	0.085	0.163	-0.096	0.042
FURTHER	0.227	0.266	0.210	-0.008	0.127	-0.052	0.107	-0.136	-0.075	-0.079	0.251	0.214	0.096	-0.079	0.037	0.114	0.249
ENOUGH\	0.028	-0.175	0.025	0.019	0.023	0.070	-0.065	-0.164	0.128	0.031	-0.079	-0.040	-0.116	-0.134	0.157	0.166	0.081
TIMECON	-0.010	-0.105	-0.090	-0.033	-0.111	-0.077	0.062	0.080	-0.072	-0.014	0.055	0.134	-0.013	0.064	-0.084	-0.184	-0.145
LABSAVIN	-0.001	0.023	0.046	-0.190	-0.100	0.020	-0.093	-0.001	-0.097	-0.034	-0.138	-0.091	-0.157	-0.039	0.066	-0.070	-0.040

Appendix 4.**The Zimbabwe soils classification systems.**

Order	Group	Typical soil families
I Amorphic	1.Regosol 2. Lithosol	1K(deep sands from Kalahari and karoo sediments 2E (soils less than 25cm deep, derived from mafic rocks
II Calcimorphic	3.Vertisol 4.Siallic	3B(dark brown to black cracking clays, formed on basalts) 4U(alluvial soils with active clay fraction)
III Kaolinitic	5.Fersiallic 6.Paraferrallitic 7.Orthoferrallic	5G(coarse grained sandy soils with mixed clay fraction. derived from granitic rocks) 5E (reddish clay soils with mixed clay fraction. Derived from mafic rocks) 6G(coarse grained soils with an inert clay fraction. Derived from granitic rocks) 7G(coarse grained sandy soils with an inert clay fraction. Derived from granitic rocks)
IV Natric	8. Sodic	8n(weakly sodic soils) 8n(strongly sodic soils)