

EXECUTIVE SUMMARY

Rainwater harvesting (the accumulation and storage of rainwater) is already widely used throughout the world as a method of utilising rainwater for domestic and agricultural use. Although it has wide application for the provision of drinking water, water for livestock and water for irrigation, the percentage of households using rainwater harvesting in rural areas of South Africa is low. However, with increasing populations and high unemployment there is more pressure on agriculture to provide food. Rainwater harvesting has the potential to improve food production for communities who have a high dependence on agriculture. One of the areas where this potential can be realised is the Umlazi River catchment, situated in the eastern region of KwaZulu- Natal near Pietermaritzburg. There is no piped water in this area and the rural communities are entirely dependent on rainwater. The aim of this project was to select and implement water harvesting and conservation techniques that would assist the communities in this catchment area to improve their livelihoods by increasing their food production.

2 PROJECT OBJECTIVES

The specific objectives of the project were:

- To do a baseline study to determine the status quo of crop and livestock production systems.
- To conduct on-station experiments at the Zakhe Agricultural College to introduce/implement and test one or more promising (existing/new) water harvesting and conservation techniques.
- To evaluate the impact of the selected water harvesting techniques on the crop and livestock production systems.
- To measure the impact of increased water use efficiency on the crop and livestock production systems.
- To measure the technical feasibility, risk, economic viability, social acceptability (including gender issue), environmental impact of the selected water harvesting and conservation techniques.

3 STUDY AREA

The study sites where detailed water harvesting experiments were undertaken were situated in the Umlazi River catchment, approximately 20 km southeast of Pietermaritzburg. Four rural communities live within this catchment: Ntembeni, KwaMncane, Hopewell and Baynesfield.

The annual rainfall of the region, which ranges from 800 mm to 1000 mm, falls mostly in summer. Winters are dry with an average rainfall of 12.5 mm. The region has a temperate climate, with a mean January maximum temperature range of 24.8-26.0°C and a mean July minimum temperature range of 4.4-7.6°C.

Opportunities for extending the growing season of crops in the area are in April to May when temperatures are favourable and additional moisture can still be obtained, either through soil conservation measures or water harvesting techniques.

The planning of water harvesting techniques needs to account for the appropriate "design" rainfall, according to which the ratio of catchment or "run-on" to planted or "run-off" area will be determined (FAO, 1991). Design rainfall analyses for Zakhe and KwaMncane showed that for Zakhe the seasonal rainfall amount for a probability of exceedance of 66% (two out of three years) was only 600 mm and for 33% (one out of three years) 800 mm. For the same probabilities of exceedance for KwaMncane the rainfall amounts were approximately 900 and 1100 mm for the 66 and 33% exceedance levels respectively. These data showed the importance of recognising the site differences in design rainfall amounts, even in sites situated relatively closely together (<15 km). For an equivalent crop area and water use the "run-on" area at Zakhe would need to be 33% larger than at KwaMncane. The vegetation is grassland of low grazing value with *Aristida junciformis*, an unpalatable grass, being the dominant species. Livestock production is therefore limited by the low quality of natural veld. The land use of the area has a high potential, mainly because of its favourable climate and high potential soils.

4 BASELINE SOCIOECONOMIC STUDY

4.1 Introduction

One of the critical factors affecting the productivity in farming at the household and community level is the shortage of water. The main aim of this baseline study was to describe the socio-economic situation in relation to how households and communities manage their water supplies and the potential impact of improved water harvesting on food security. In particular, the study focused on determining the following:

- The structure and composition of households and the role of gender and generation in agricultural production;
- The effect of seasonality on agricultural activities;
- The current practices and techniques used in water harvesting and conservation;
- The attitudes and constraints of households concerning water harvesting and conservation;
- Opportunities available to support socio-economic development.

4.2 Methods

The socio-economic survey was an applied, descriptive study employing both qualitative (focus group discussions, key informant interviews and transect walks) and quantitative (questionnaires) research techniques (n=37 for Ntembeni, n=43 for KwaMncane).

4.3 Results

Households in Ntembeni and KwaMncane communities are headed mainly by women (76-95%). The region is characterised by extreme poverty with 68-74% of the households earning <R1000 per month and 34-37% having 6-10 dependents. Increased food production through water harvesting is therefore likely to have a major impact on livelihoods. Factors that may impact negatively on the participation of community members in the project are the low level of education (34% have no education), long distances (up to 5 km) to facilities and poor access to media.

The land is under common property and is controlled by the traditional authority (tribal council). The majority of the residents (91.9%) have land-use rights for cultivation and have been allocated less than a hectare of land for agricultural production. However, only 70.3% of the residents use this land for farming. Individual homestead gardens are mainly used for summer production due to water unavailability in winter. There are 32.4% of the residents who use less than one hectare of the land for communal gardens. The main vegetable crop grown is potatoes.

The main source of water supply for agricultural production to the majority of the farmers (70.3%) is the Umgeni pipe system, followed by streams, which are used by 10.8% of the farmers. Fifty one percent of respondents stated that shortage of water is a result of poor supply systems. Participants of the water-harvesting project indicated that their greatest expectation was profit (43.2%) followed by a good harvest (10.8%).

5 THE EFFECT OF SELECTED WATER HARVESTING AND SOIL CONSERVATION TECHNIQUES ON SOIL WATER AND CROP YIELD

5.1 Introduction

There are two major forms of water harvesting that are generally recognised in agriculture: (1) Micro-catchment (In-field rainwater harvesting), collecting rainfall on the surface where it falls, and (2) Macrocatchment (ex-field water harvesting) which is a system that involves the collection of run-off originating from rainfall over a surface elsewhere. The focus of this study was on in-field rainwater harvesting for vegetable production at Ntembeni community and at Zakhe farm in KwaZulu-Natal. The project team investigated the effect of raised seedbeds, ridges and infield run-on/off plots on available water for production of cabbage and Swiss chard at the two sites.

5.2 Methods

5.2.1 Climate monitoring (automatic weather station)

Measurements of precipitation, air temperature, relative humidity and incoming solar radiation were recorded at Zakhe in 2005 and 2007, and at the community vegetable garden in 2006 using an automatic weather station (AWS). The watermark system was selected as an appropriate technique for the measurement of soil matric potential for plots where continuous measurements were required. All sensors were wired via a Campbell AM416 multiplexer to a Campbell CR10X data logger programmed to record soil water potential every 12 minutes.

5.2.2 Effects of mulching at Zakhe

In June 2005, an experiment to evaluate the effect of mulching on soil water content was carried out at both the Zakhe Agricultural College and the Ntembeni community garden. The contours at Zakhe were disked to incorporate residual material and fertiliser into the top 0.30 m of soil. Four blocks per contour were marked out. Each plot measured 1 m x 2 m. Soil collected from within the contour was added to each plot such that the height of the bed was raised by 0.20 m. In total, 96 individual plots were created comprising four blocks of 12 plots on a

high and low contour planted to peas, peas with mulch, cabbage, cabbage with mulch, spinach and spinach with mulch. Grass was used as the mulch cover. Access tubes for the weekly measurement of soil water content, using the Diviner 2000 system of measurement, were installed across the two contours. A similar experiment was repeated at Ntembeni.

5.2.3 Run-on plot experiment

In November 2005, a new summer experiment was undertaken where the focus was to harvest rainwater in a field plot. The technique was designed to increase run-off from the adjacent slope making this additional water available for the crops. A suitable contour strip was selected at the Ntembeni community garden for this trial. This contour was then divided into four sections. In section one run-off and field plots were set up, section two included the control plots and sections three and four were a repeat of the winter experiments with raised and flat beds. Both the experimental plots and the control plots were instrumented with 12 Diviner 2000 access tubes to a depth of 1 m. Soil water content was recorded at 0.10 m intervals. Watermark sensors to monitor the matric potential were also installed and connected to the automatic weather station to record soil moisture every 12 minutes.

5.2.4 Micro-catchment water harvesting (the in-field runoff plots – modified Free State method)

In May 2006, a new trial was designed to test the applicability of micro-catchment water harvesting (Free State in-field runoff plot, Hensley et al., 2000) technique in the Ntembeni community garden. Cabbage and Chinese cabbage seedlings were planted in a completely randomised field experiment. The treatments were two water harvesting techniques: ridged planting and the run-off system. Ridged planting consisted of planting seedlings on 0.20 m ridges and the run-off plots consisted of two rows planted at 0.50 m spacing, with 1 m run-off spaces on both sides. Flat beds were used as a control treatment. Mulching (straw) was superimposed as a sub-plot on the land modification treatments (ridging and run-off plots) and the flat beds. The experiment was replicated three times and the crops were grown in separate but adjacent blocks.

5.3 Results

5.3.1 Climate

The climate data showed wet and dry seasonal trends with the summer being wet and humid and the winter dry. Regular rain events were recorded in summer. January to March was characterised by small rainfall events, with totals seldom exceeding 10 mm.day⁻¹. Only 328 mm of rain was recorded between January and September 2006, showing that conditions were relatively dry when compared with the long term mean of 475 mm. Average daily temperatures in summer often exceeded 25°C and were indicative of the hot dry conditions experienced late in the 2005/06 summer season.

5.3.2 Soil water studies

5.3.2.1 Soil water measurements at Zakhe

During summer the matric potential of the soil remained fairly low and rarely decreased to below -70 kPa. From late April, a progressive decrease in soil matric

potential occurred and by the end of May to early June the soil was probably at its driest. Individual winter rainfall events generally have little influence on the soil water content of the deeper layers. These results are important in that they suggest the timing of rainwater harvesting practices should be during summer when water can be “harvested” for its use later in the season.

5.3.2.2 Effects of mulching

The experiment to evaluate the effect of mulching on soil water content showed that the surface soil was generally wetter than at depth, owing mainly to the irrigation of the plots. As winter progressed, the water content near the surface decreased progressively, presumably in response to the direct uptake of water by the increasing root system of the crop. From the results it was evident that adding mulch maintained higher water contents in the soil from a depth of 0.2 m to 0.5 m due to its role in decreasing evaporative losses. From a depth of 0.5 m downwards, for both the mulched and no mulch plots, the water content ranged between 0.32 m³.m⁻³ and 0.35 m³.m⁻³. Mulching as a technique of soil water conservation is, therefore, a useful strategy in sustaining soil water contents within the root zone.

5.3.2.3 Run-on plot measurements

Establishment of plants on all plots was completed on the 20/12/2005, but due to a severe hailstorm in the area all the crops (with the exception of the cabbages) were replanted. It was found that in the winter months the run-off plots tended to have higher soil moisture than the control plots. Recharge events were evident when either irrigation or rain occurred. On average the run-off plots had 10-20 mm more water (15% of plant available water content) in the upper 500 mm soil profile than the control plots.

5.3.2.4 Micro-catchment technique – the infield run-off plots (modified Free State method)

The introduction of the micro-catchment (Free State) run-off technique showed that mulching improved the soil water content by 50 mm when compared with the control plot. The run-off mulched plot had the highest water content with approximately 200 mm in the top meter of the soil profile.

However, the run-off plot with no mulch showed very poor soil water retention. Comparison of the various treatments without mulch showed that the method of having ridges and troughs increased the total profile soil water content (1 m profile) to 125 mm compared to the control plot that had an average of 90 mm.m⁻¹. The run-off plot without mulch had the lowest water content. It was also evident that the ridge mulch treatment had the highest total profile water content (> 200 mm) when compared to other treatments (generally < 150 mm). A comparison of the various treatments with mulch showed that the method of having ridges and troughs increased the surface soil water content (<0.1 m) to 33%, compared to the control plot that had a surface soil water content of 20%. The run-off plot also performed better than the control plot with a surface soil water content of approximately 25%.

5.3.3 Plant growth (Free State adopted method) – May 2006

5.3.3.1 Leaf number and plant height

For both cabbage and Chinese cabbage leaf number and plant height were improved by all the water harvesting techniques. However, there were no significant differences between the various water harvesting techniques.

5.3.4 Yield

For cabbage, water harvesting techniques increased the yield by 50-60% and mulching increased the yield by a further 10-20%. For Chinese cabbage, there was a 40-50% increase in yield due to water harvesting and mulching caused a further 10% increase.

5.3.5 Gravimetric soil water content (upper 0.15 m soil layer)

Both ridges and run-off treatments improved soil water content regardless of the crop grown. Mulching improved the soil water content in the flat beds (control vs. control + mulch) by approximately 37% in cabbage and 12% in Chinese cabbage. The soil water contents in both the run-off and ridge water harvesting treatments were 5-15% higher than the control throughout the growing period.

5.4 Conclusion

The rainwater harvesting (RWH) techniques that were implemented to increase water availability included raised seedbeds, ridges and run-off plots. In addition, the study demonstrated the effectiveness of the micro-catchment (modified in-field RWH) technique that was adopted from the Agricultural Research Council at Glen in the Free State. The comparative study between the control (flat), ridged and run-off plots showed that the soil moisture profile for the run-off plots was consistently higher when compared to the control plots. On average, the run-off plots had about 10-20 mm more water (15% of the plant available water content) in the upper 500 mm soil profile.

Adding mulch also maintained higher water contents in the soil from a depth of 0.1 m to 0.3 m due to its role in decreasing evaporative losses. The soil moisture in the top 0.2 m of the mulch plots was about 30% compared to the no mulch plots (13%). This is an important soil conservation strategy as vegetable crops mainly have roots in the top 0.2 m to 0.3 m of the soil layer. Mulching as a technique of soil water conservation is therefore a useful strategy in sustaining soil water contents within the root zone. The studies also showed that, regardless of the crop used, micro-catchment techniques or in-field water harvesting using ridges increased biomass. For example, water harvesting techniques increased the yield of cabbage by 50-60% and mulching increased the yield by a further 10-20%. For Chinese cabbage, there was a 40-50% increase in yield due to water harvesting and mulching increased yield by a further 10%.

6. APPLICATION OF WATER HARVESTING TECHNIQUES IN RANGELAND/LIVESTOCK PRODUCTION SYSTEMS

6.1 Introduction

When the quality of natural forage falls below the level required to maintain bodyweight, animal production declines. Cattle kept by the communities in the study area are dependent on the rangelands for forage. Shortage of fodder is a major constraint to livestock production in the study area. The aim of this study was to determine the effect of water harvesting techniques on fodder production for communal livestock systems. The specific objectives were:

- To carry out a baseline study to determine the status quo of livestock production systems.
- To determine whether *Dolichos*, a fodder legume, can be grown and utilised in the Ntembeni communal production system using water conservation techniques.
- To examine the effect of mulching and soil preparation on the germination, survival, dry matter production, and infestation by weeds of *Dolichos*.

6.2 Methods

6.2.1 Veld condition

The veld condition was assessed by comparing the species composition at the Ntembeni and KwaMncane study sites to that of a benchmark in which the veld is considered to be in optimal condition. The benchmark site selected was Moist Midlands Mistbelt. The relative frequency of the above-ground species in each of the wards was estimated using the descending point technique (Levy and Madden, 1933).

6.2.2 Fodder production

Dolichos was grown in experimental plots in a randomised block design. The two factors (basin size and mulching), each at two levels, were replicated three times resulting in four treatments and twelve plots. Each plot comprised two 1 x 1 m subplots, 2 m apart, which were cleared of all above-ground vegetation. Plots were positioned along a fence (that was approximately perpendicular to the contour of the land) to maximise production from marginal land. The land was contoured, giving rise to nearly level ridges separated by steep contour banks. Plots were located only on the ridges. For factor 1 (basin size), the first level was large basin size in which the soil across the whole subplot was loosened with a pick and spade, and shaped to form a large open basin designed to dam water following rain. For level 2, small basin size, only a small area (approximately 20 x 20 cm) was loosened but not shaped. For factor 2 (mulching) the first level comprised entire subplots which were mulched with hay to a depth of approximately 15 cm and the second level comprised plots which were not mulched.

6.3 Results

6.3.1 Veld condition

In the baseline survey, both fodder shortage and animal diseases were highlighted by the Ntembeni community as major constraints to livestock keeping. Fodder shortage was due to the absence of palatable Decreaser species at the study sites and the dominance of low quality Increaser II species (14.0-74.5%) when compared to the benchmark value (5%).

The poor veld condition (30.3-63.4%) indicates that livestock owners need to supplement their livestock with additional forage to prevent the animals declining in productivity.

6.3.2 Fodder production

The experimental results indicated that *Dolichos* can be successfully established in community gardens. Livestock control was sufficient to ensure that animals did not eat the young plants. The average length of mulched plants was higher (74 mm) than that of no mulch plants (53 mm), although the effect was not significant ($P=0.19$).

The infestation of weeds (all species) was significantly lower on mulched (1.5/5) than on no mulch (2.4/5) plots ($P=0.024$). The number of allelopathic *Cyperus* plants in each plot was significantly lower on mulched than on no mulch plots ($P<0.001$).

Hole size had no significant effect on weed infestation or plant length.

6.4 Discussion

Hole size and mulching did not have a statistically significant effect on the size of plants. This indicates that plants grown in relatively hard soils next to boundary fences can achieve (initial) growth rates similar to that of plants in cultivated soil. This is highly relevant to the communities in the study area where there is a shortage of land for growing vegetables and fodder. In many production systems, the area immediately adjacent to the boundary fence is unproductive, so this provides an opportunity to make better use of resources.

Mulching proved an effective way of reducing competition from weeds and, therefore, will save costs in terms of labour input to keep the plants weed-free while they are young and susceptible. Since some weeds can compete directly with plants through allelopathy, particularly the nutsedges (*Cyperus* species), mulching was effective against these weeds which were highly abundant around no mulch plants. Although the dry-matter production of the *Dolichos* was too low to run a feeding trial, the results indicate that water conservation techniques have the potential to increase fodder production.

7 SOCIO- ECONOMIC IMPACT ASSESSMENT

7.1 Introduction

The three communities in the study area (Ntembeni, KwaMncane and Baynesfield) were trained in rainwater harvesting and soil conservation techniques to improve their livelihoods through vegetable production. The main objective of this study was to assess the socio-economic impact of the project on the participating farmers, non-participating community members and the buyers of the produce from the community gardens. This study adopted the socio-economic impact assessment framework developed by the Commonwealth of Australia (SEIA, 2005). A semi-structured questionnaire and focus group discussions were used for data collection.

7.2 Results and Discussion

The questionnaire survey indicated that 75% of the respondents ($n=18$) were convinced that the community garden was the solution to alleviate poverty and promote food security. The majority of farmers (75%) cited that they had become more food secure at household level since the introduction of the project. The other

25% stated that the main hindrance to the success of community gardens was inadequate water supply for irrigation. At least 50% of the participants were involved in project activities including design, planning, decision making and assessment.

At the end of the study adoption of water harvesting techniques and practices by the farmers involved in the project was high (70-100%). All farmers adopted the use of a cropping calendar and application of fertilisers to their crops. Use of certified seed, recommended plant populations, integrated pest management and keeping of financial records were adopted by the majority (95%) of farmers. Seventy percent of farmers noted an improvement in the management of water when they adopted timely irrigation. Before the introduction of the project, most farmers used to irrigate at any time of the day, even when it was too hot. The adoption of correct time of planting by 80% of the farmers resulted in increased production when compared to planting at any time depending on convenience.

The survey showed that currently 75% of the farmers spend more time in the field compared to the previous three years, with 55% farmers working full time. This time commitment is an indication of the success of the project.

The majority of farmers (75%) marketed their produce as individuals, while only 25% practised group marketing. All farmers (100%) cited lack of formal contracts as a major hindrance to marketing their produce. Regarding access to input suppliers, 25% acknowledged an improvement while the other 75% did not witness any improvement in input suppliers since the inception of the project in 2003.

The project had a positive impact on regulatory institutions. In 2005, the management structure of the farmers was almost dysfunctional (no meetings were planned and scheduled project meetings were not honoured). After the baseline study in 2005, the project team facilitated the formation of a farmers' committee to coordinate all activities. In 2008, 85% of farmers stated that regular attendance of meetings resulted in the strengthening of their organizational structures. However, the other 15% were not convinced that meetings were bearing as much fruit as anticipated. Positive initiatives resulting from the organizational development were the organisation of training courses, collaboration and co-operation between farmers to establish markets and liaise with buyers and hawkers, the organisation of tractors for land preparation and the exchange of knowledge and skills on gardening activities and general farming. The majority of respondents (80%) indicated that there was an improvement in economic well-being. In addition, their agricultural skills had improved. Evidence for improved skills was that they sold produce and bought seeds, they earned more money, had access to more land and gained better knowledge in water harvesting techniques. The respondents who cited that they had not gained any skills since the introduction of the water harvesting techniques (WHT) project attributed this to lack of adequate resources. For instance, they cited that they could not adopt correct times to irrigate due to lack of adequate water for irrigation.

The survey revealed that 85% of farmers had adopted financial record-keeping in order to ascertain whether they were making a profit or loss. With respect to farming inputs, 65% of the farmers indicated that their farm input expenditure (e.g. the purchase of fertiliser, chemicals and seed) had increased since 2005. All

respondents indicated that there was not much change regarding hiring labour due to financial constraints. In 2008 there was a significant drop (40%) in farmers buying food from the urban market compared to the baseline in 2005.

This was attributed to a significant improvement in the number of farmers producing their own food (cabbage, potatoes, spinach, beetroot, carrots, onions and beans). Fifty-five percent of the respondents indicated that there was evidence of positive changes in terms of using various water harvesting techniques after the training offered to them. Farmers mentioned that Zakhe Agricultural College had played a significant role by providing pipes to facilitate in watering their gardens. This led to a conclusion that rural development can be meaningful when the farmers have the right attitude to learning and implement the concepts they have learned.

This change in attitude was apparent in the 2008 survey which showed that farmers had acquired more land (up to 75%) for cultivation. Factors that motivated farmers to obtain more land were the success in farming (which was associated with profit making and other gains) and training which equipped farmers with new knowledge. Previously, farmers used to cultivate very small garden plots averaging less than 1000 square metres. According to the respondents, farmers now had the desire to increase their land holding to increase their production and profits. With respect to farmers' information days, 40% of the respondents said that they had learnt a lot from the events. As a result, they were keen to be involved in growing vegetables and later join the farming community. However, 60% of the respondents indicated that they were not aware of the farmers' information days because of not being updated by the farmers. This may be due to long distances to communication facilities which were highlighted as a constraint in the baseline study. The majority (80%) of respondents indicated that it was not easy to join the community garden if one did not know someone who was already participating in the project. Another constraint was the joining fee of R100 which was not affordable to many respondents.

Although the majority of respondents (70%) indicated that the poverty levels had decreased as compared to 2005, it was apparent from this unaffordability constraint that poverty was a major limiting factor for the project. It is, therefore, recommended that farming subsidies be re-introduced to enable farming to become more profitable.

The majority of the respondents (95%) confirmed that the community gardens at Ntembeni and KwaMncane had positively affected the surrounding communities. The community benefited by obtaining food (vegetables) from the gardens as well as limited employment. They were able to access vegetables as part of their payment. Other positive factors were reasonable prices for vegetable buyers and hawkers, good quality vegetables and sharing of ideas regarding farming. Some of the surrounding community members observed that although they had homestead

gardens they could not produce as much as their counterparts at the community gardens because they lacked skills to produce more vegetables and had no fences to prevent cattle from consuming their crops.

The main buyers of the vegetables were the local Thabethe, Nkabini and Happy stores and two stores in Pietermaritzburg, ¹Evergreen and Southgate Spar. Other main

buyers were hawkers from the surrounding community. The buyers stated that the general quality of produce was good except for onion which was fair. The wide scope of crops contributed to the improvement of the market.

During interviews, these buyers reaffirmed their desire to support the farmers at Ntembeni and KwaMncane by buying their produce. However, problems that they had encountered with the farmers included insignificant supplies, poor capacity to supply constantly and high prices. It is apparent that further development of the marketing and irrigation strategies for the farmers is required to produce food throughout the year and to plan, fix prices and control the marketing of vegetables.

8 CAPACITY BUILDING AND TECHNOLOGY EXCHANGE

8.1 Community

- Two workshops were conducted; an initial stakeholder planning workshop at Zakhe to introduce the project followed by workshops in each community to engage both the participating and non-participating community members.
- Four farmer information days were held in 2004-2007 in each of the two communities to give a total of eight.
- Educational tour: 12 project participants were exposed to best practices in different provinces (Gauteng and Limpopo) in the initial implementation of the project in 2004.
- The community benefited from learners through technology transfer whereby the Zakhe learners went to nearby communities to demonstrate skills learnt during the implementation of the project.
- The child of a KwaMncane participating farmers, the Khenisa family, became interested in water management issues and ended up pursuing a degree in Hydrology at the University of KwaZulu-Natal.

8.2 Staff

- The project team went to the University of the Free State to learn from Prof Leon van Rensburg who had successfully completed a similar project in water harvesting.
- Zakhe staff who acted as junior researchers were mentored on scientific methods of data collection by the senior research team.

8.3 Zakhe Learners

- Zakhe learners were introduced to basic research principles and different water harvesting techniques.
- Learners learnt to volunteer and transfer knowledge to the community.

8.4 Zakhe Agricultural College

- Financial resources helped in the development of Zakhe as an organisation.
- Learner exposure to scientific research methods instilled in them the desire to

love farming and working with the community. As a result, many boys were employed on commercial farms as farm workers, with some developing into farm managers when they obtained their Matric certificates. Two learners are currently farm managers and four are assistant managers on commercial farms.

- Production at Zakhe improved significantly due to the involvement of the learners in the project.

9 RECOMMENDATIONS FOR FUTURE RESEARCH

Mulching may not always be a feasible technique as the residues used have greater value for other uses such as animal fodder or thatching (Rockström and Steiner, 2003). The labour inputs required for collecting mulching material, as well as the increase in insect pest populations, bacterial and fungal diseases may in the long-term bring unanticipated crop losses.

These aspects require further investigation. Another area not investigated by the project team was the role of conventional versus minimum tillage. Besides the beneficial water holding impacts of minimum tillage, further research is required on its effect on increases in soil organic carbon. This has the potential to have positive impacts not only on sustainable food production but also on global climate change.

10 DATA

All processed data have been catalogued and stored at UKZN, BEEH, P/Bag X01, Scottsville, 3209.

Contact person: Prof CS Everson.

These data are held on non-flexible diskette. All data can be supplied to researchers and managers on CD-R diskettes.
